EAI/Springer Innovations in Communication and Computing

Syed Abdul Rehman Khan
Zhang Yu

Strategic Supply Chain Management

EAI
RESEARCH MEETS INNOVATION

Springer

EAI/Springer Innovations in Communication and Computing

Series editor

Imrich Chlamtac, European Alliance for Innovation, Gent, Belgium

About EAI

EAI is a grassroots member organization initiated through cooperation between businesses, public, private and government organizations to address the global challenges of Europe's future competitiveness and link the European Research community with its counterparts around the globe. EAI reaches out to hundreds of thousands of individual subscribers on all continents and collaborates with an institutional member base including Fortune 500 companies, government organizations, and educational institutions, provide a free research and innovation platform.

Through its open free membership model EAI promotes a new research and innovation culture based on collaboration, connectivity and recognition of excellence by community.

More information about this series at http://www.springer.com/series/15427

Syed Abdul Rehman Khan • Zhang Yu

Strategic Supply Chain Management

Springer

EAI
RESEARCH MEETS INNOVATION

Syed Abdul Rehman Khan
School of Economics and Management
Tsinghua University
Beijing, China

Zhang Yu
School of Economics and Management
Chang'an University
Xi'an, China

ISSN 2522-8595 ISSN 2522-8609 (electronic)
EAI/Springer Innovations in Communication and Computing
ISBN 978-3-030-15057-0 ISBN 978-3-030-15058-7 (eBook)
https://doi.org/10.1007/978-3-030-15058-7

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Authors dedicate this first edition to their brave parents:

Syed Hameed Khan
Rasool Syeda
Zhang Hongxu
Li Xiaoling

Preface

Writing this book is primarily to provide an up-to-date text at a reasonable cost. The scope of supply chain and logistics has continued to grow with a rapid speed, which is reflected in the content of this book. This book has included core aspects of supply chain and logistics philosophy and practice.

Besides, it is necessary to note that we have covered the general principles of supply chain and logistics that can be applied in any country of the world. Simply, for some aspects, there are differences that are difficult to generalize. Under this situation, we have tended to use the European approach or model, but we have also added some international material and examples from China, Pakistan, India and the United States. Within the scope of this book, it is impractical to include all issues in detail from a global perspective.

Undeniably, the logistics industry continues to change radically and to grow with a rapid speed. The quality of supply chain and logistics managers and personnel has been also improved with the growth in scope that a job in supply chain and logistics entails. We believe that this book will help significantly in the quest of supply chain and logistics to reduce cost and improve service, as well as to keep up-to-date the different facets of supply chain and logistics. In addition, this book will help candidates who are undertaking examinations for the many universities and professional institutes and bachelor and master students who are studying for degrees in supply chain management.

This book is divided into 13 chapters, each covering a key subject area in supply chain and logistics:

1. Introduction to supply chain management
2. Key issues in logistics and supply chain
3. Global sourcing
4. Warehousing and storage equipment
5. Inventory management
6. Warehouse design and management
7. Domestic and global logistics
8. Procurement

9. Performance measurement and evaluation
10. Environmental and ethical issues in SCM
11. IT in supply chain management
12. Future trend of supply chain
13. Case studies

Chapter 1: In the first chapter, an introduction to the subject is provided, and some definitions are given. This chapter covers the following topics:

- Definitions of supply chain management
- Value chain and supply chain
- A generic view of supply chain
- The umbrella of supply chain
- Why vertical integration failed
- What are the bullwhip effect and snowball effect?
- Latest trend in supply chain management

Chapter 2: The second chapter includes the following topics:

- SCM issues and suggested problem-solving approaches
- Network configuration and competition
- Information sharing
- Developing collaborative planning activities
- Key issues and challenges for logistics

Chapter 3: The third chapter discusses the following topics:

- Differences between international purchasing and global sourcing
- Supplier selection issues
- Organizational issues
- Supplier selection and evaluation process
- Key supplier evaluation criteria
- Developing from international purchasing to global sourcing
- Global sourcing success elements
- Future trend of global sourcing

Chapter 4: The fourth chapter discusses the following topics:

- The role of warehouses
- Types of distribution centre and warehouse
- Operations of warehouses
- Objectives of good warehouse design and management
- Palletized storage

Chapter 5: The fifth chapter discusses the following topics:

- Independent and dependent demand
- Tools of inventory management
- The basic types of inventories
- ABC inventory control system

- Inventory models
- The continuous review system and the periodic review system

Chapter 6: The sixth chapter includes the following topics:

- Warehouse design procedure
- Prepare site layouts
- Warehouse management and information
- Data transmission and capture

Chapter 7: The seventh chapter includes the following topics:

- Objective of transportation
- Legal forms of transportation
- Different modes of transportation
- Transportation regulation and deregulation
- Global logistics intermediaries
- Environmental sustainability
- The impact of reverse logistics

Chapter 8: The eighth chapter discusses the following topics:

- Importance of procurement
- Goal of procurement
- Choosing and monitoring supplier performance
- Procurement cycle
- Types of purchase

Chapter 9: The ninth chapter is all about performance measurement and evaluation in supply chain management. This chapter broadly covers the following topics:

- Why measurement performance?
- Problems with supply chain measurement and evaluation
- Procurement and supply chain performance measurement classifications
- Developing a system of performance measurement and evaluation
- Benchmarking of performance
- Balanced scorecard for supply and purchasing

Chapter 10: The tenth chapter discusses the following topics:

- Why should purchasing be concerned?
- Green, sustainable and environmental soundness
- The triple bottom line
- Developing policy on environmental soundness
- The hierarchy of waste
- The concept of product stewardship
- The development of Kraljic's model
- Senior management commitment

Chapter 11: The 11th chapter covers the following:

- Basic communication, e.g. EDI and barcodes
- Software use in supply chain, e.g. WMS
- Inventory and transport management systems
- Integrating supply chain IT
- Implementation of DSS and ERP

Chapter 12: The 12th chapter discusses the following topics:

- Emerging mega-trends
- Shifting centres of gravity
- The multichannel revolution
- Structural flexibility
- Trends of future SCM

Chapter 13: The 13th chapter covers the following case studies:

- Case 1 The Global Sourcing Wire Harness Decision
- Case 2 Negotiation-Porto
- Case 3 Purchasing Ethics
- Case 4 Insourcing/Outsourcing: the FlexCon Piston Decision

Beijing, China Syed Abdul Rehman Khan
Xi'an, China Zhang Yu

Acknowledgements

First of all, we would like to thank those people who have had direct involvement in the production of this book. One of the most important persons in helping, supporting and encouraging us in the organization of this book was my respected teacher *Ms. Sharon Miller*. She has helped to edit and moderate this book and to that end improved the manuscript significantly. We are very grateful to Ms. Miller for her help and professional attitude; thank you, Ms. Miller.

Second, we would like to thank Prof. Dong Qianli. Mr. Dong has helped me to understand the concept of integration and development logistics from the perspective of Shaanxi Province, P.R. China. We also thank the famous Sufi Scholar Sahibzada Asim Maharvi for his encouragement.

Finally, we would like to thank our families, friends and partners for supporting us during the writing of this text. Specifically, we would like to thank our lovely parents, whose care and prayers for our success have seen this project to fulfilment.

Contents

About the Authors

Syed Abdul Rehman Khan is a teacher of Supply Chain and Logistics Management. Dr. Khan achieved his Certified Supply Chain Professional (CSCP) certificate from the United States and successfully completed his Ph.D. in China.

Since 2018, Dr. Khan has been affiliated with Tsinghua University as a postdoctoral researcher. He has more than 9 years' core experience of supply chain and logistics at industry and academic levels. He has attended several international conferences and also has been invited as keynote speaker in different countries. He has published more than 55 scientific research papers in different well-renowned international journals and conferences. He is a regular contributor to conferences and workshops around the world. In addition, Dr. Khan has achieved scientific innovation awards for two times, consecutively, from the Education Department of Shaanxi Provincial Government, China.

Also, Dr. Khan holds memberships in the following well-renowned institutions and supply chain bodies/associations: APCIS, USA; Production and Operations Management Society, India; Council of Supply Chain Management Professionals, USA; Supply Chain Association of Pakistan; and Global Supply Chain Council, China.

Zhang Yu is a post-graduate student of Chang'an University, Xi'an, China. Her research interest is reverse logistics and packaging. She has published 15 research papers including ISTP, SCIE, and EI indexed. Ms. Zhang also has attended several international conferences in China and Hong Kong.

Abbreviations[1]

3D	Three-dimensional
3PL	Third-party logistics
4D	Four-directional
4PL	Fourth-party logistics
ABC	Activity-based costing
ABC curve	Pareto or ABC inventory analysis
ADR	Accord Dangereux Routier (European agreement regarding the road transport of dangerous goods)
AFRA	Average freight rate assessment (system)
AGV	Automated guided vehicle
AMR	Advanced Manifest Regulations
APR	Adjustable pallet racking
APS	Advanced planning and scheduling
artic	Articulated (vehicle)
ASEAN	Association of South East Asian Nations
ASME	American Society of Mechanical Engineers
ASN	Advance shipping notice
AS/RS	automated storage and retrieval system
ATA	AIR Transport Association of America
ATP	Accord relative aux transports internationaux de denrées périssables (European agreement regarding the international transport of perishable goods)
AWB	Air waybill
BAF	Bunker adjustment factor
B2B	Business to business
B2C	Business to consumer
BL	Bill of lading

[1] NB: This section is designed to clarify and demystify many of the more common abbreviations and acronyms used in the industry. Most, but not all, of these appear in the text. Readers may consult this section quite independently.

BOM	Bill of materials
BS	British Standard
BSI	British Standards Institution
CAD	Computer-aided design
CAF	Currency adjustment factor
CASS	Cargo accounts settlement system
CB truck	Counterbalanced truck
CBFLT	Counterbalanced fork-lift truck
CBM	Cubic meter
CBP	US Bureau of Customs and Border Protection
CCTV	Closed-circuit television
CD	Compact disc
CDC	Central distribution centre
CFR	Cost and freight
CFS	Container freight station
CIF	Cost, insurance, freight
CILT (UK)	The Chartered Institute of Logistics and Transport (UK)
CIM	Computer integrated manufacturing; Convention internationale concernant le transport des marchandises par chemin de fer (European agreement regarding the international transport of goods by rail)
CIP	Carriage and insurance paid to
CIPD	Chartered Institute of Personnel and Development
CIPS	Chartered Institute of Procurement and Supply
CM	Category management
CMI	Co-managed inventory
CMR	Convention relative au contrat de transport international de marchandises par route (European convention regarding international transport contracts of goods by road)
CNG	Compressed natural gas
CO	Certificate of origin
COD	Cash on delivery
COI	Cube per order index
CPFR	Collaborative planning, forecasting and replenishment
CPT	Carriage paid to
CRM	Customer relationship management
CRP	Continuous replenishment programme
CSCMP	Council of Supply Chain Management Professionals
CSI	Container Security Initiative
CSCP	Certified Supply Chain Professional
CT	Community transit
C-TPAT	Customs-Trade Partnership Against Terrorism
DAF	Delivered at frontier
dB (a)	Decibel
DC	Distribution centre

DCF	Discounted cash flow
DCM	Demand chain management
DDP	Delivered duty paid
DDU	Delivered duty unpaid
DEQ	Delivered ex-quay
DERV	Diesel-engined road vehicle
DES	Delivered ex-ship
DfT	Department for Transport
DMAIC	Define, measure, analyse, improve and control
DME	Dimethyl ether
DO	Delivery order
DPP	Direct product profitability
DRP	Distribution requirements planning
DWT	Deadweight ton
EAN	European article number
EBQ	Economic batch quantity
EC	European Commission
ECR	Efficient consumer response
ECS	Equipment control system
EDI	Electronic data interchange
EEE	Electrical and electronic equipment
EFTA	European Free Trade Area
ELA	European Logistics Association
EOQ	Economic order quantity
EPOS	Electronic point of sale
ERP	Enterprise resource planning
ES	Exponential smoothing
ETA	Estimated time of arrival
ETD	Estimated time of departure
EU	European Union
EXW	Ex works
FAS	Free alongside ship
FAST	Free and Secure Trade
FCA	Free carrier
FCL	Full container load
FCPA	Foreign Corrupt Practices Act (USA)
FCR	Forwarder's certificate of receipt
FEM	Fédération Européenne de la Manutention (European Federation of material handling)
FEU	Forty-foot equivalent unit
FG	Finished goods
FGI	Finished goods inventory
FGP	Factory gate pricing
FIBC	Flexible intermediate bulk container
FIFO	First in first out

FILO	First in last out
FLT	Fork-lift truck
FMCG	Fast-moving consumer goods
FMS	Flexible manufacturing systems
FOB	Free on board
FOC	Fire officer's committee; free of charge
FOT	Free on truck
FRES	Federation of Recruitment and Employment Services
FTA	Freight Transport Association
FTL	Full truck load
GA	General average (maritime shipping insurance)
GATT	General Agreement on Tariffs and Trade
GCC	Gulf Cooperation Council
GDP	Gross domestic product
GIS	Geographic information systems
GMOs	Genetically modified organisms
GPS	Global positioning system
GRI	General rate increase
GRN	Goods received note
GSM	Global system for mobiles
GTIN	Global trade item number
GVW	Gross vehicle weight
HAWB	House air way bill
HGV	Heavy goods vehicle
HS	Harmonized system (customs)
HSE	Health and Safety Executive; health, safety and environment
HSWA	Health and Safety at Work Act
IATA	International Air Transport Association
IBC	Intermediate bulk container
I2M	Inbound to manufacturing
ICT	Information and communications technology
IGD	Institute of Grocery Distribution
IJPDLM	*International Journal of Physical Distribution & Logistics Management*
IMDG	International Maritime Dangerous Goods Code
IMF	International Monetary Fund
ISO	International Organization for Standardization
IT	Information technology
ITS	Intelligent transport system
ITT	Invitation to tender
IWW	Inland waterways
JIC	Just-in-case
JIT	Just-in-time
KD	Knocked down (dismantled)
KPI	Key performance indicator

LC	Letter of credit
LCL	Less than container load
LED	Light-emitting diode
LGV	Large goods vehicle
LIFO	Last in first out
LLOP	Low-level order picking truck
LNG	Liquefied natural gas
LOLO	Lift on lift off
LPG	Liquefied petroleum gas
LPN	License plate number (e.g. on pallet)
LSP	Logistics service provider
LTL	Less than truck load
MAM	Maximum authorized mass
MAWB	Master air way bill
MBO	Management by objectives
MHE	Materials handling equipment
MIS	Management information systems
MOU	Memorandum of understanding
MPG	Miles per gallon
MPS	Master production schedule
MRO	Maintenance, repair and overhaul
MRP	Materials requirements planning
MRPII	Manufacturing resource planning
MSDS	Material safety data sheets
NA	Narrow aisle
NAFTA	North American Free Trade Association
NCPDM	National Council of Physical Distribution Management
NDC	National distribution centre
NPV	Net present value
NVOCC	Non vessel operating common carrier
OCR	Optical character recognition
OEM	Original equipment manufacturer
OSD	Over, short and/or damaged (upon delivery)
OTIF	On time in full
P & D	Pick up and deposit station
PCs	Personal computers
PEST analysis	Political, economic, sociocultural and technological analysis
PLC	Product life cycle
PM	Particular matter
POD	Proof of delivery
POE	Point (or port) of entry
POS	Point of sale
PPE	Personal protective equipment
PPT	Powered pallet truck
PRC	People's Republic of China

PSI	Pounds per square inch
PSS	Peak season surcharge
QA	Quality assurance
QC	Quality control
QFD	Quality function deployment
QR	Quick response
R&D	Research and development
RDC	Regional distribution centre; radio data communication
RDT	Radio data terminal
RF	Radio frequency
RFI	Request for information
RFID	Radio frequency identification device
RFP	Request for proposal
RFQ	Request for quotation
RES	Road-friendly suspension
RH&D	Receipt, handling and dispatch
RM	Raw materials
ROCE	Return on capital employed
RofW	Rest of world
ROI	Return on investment
ROL	Reorder level
RORO	Roll on roll off
ROS	Return on sales
RT	Research truck
SAD	Single administrative document
SC	Supply chain
SCEM	Supply chain event management
SCM	Supply chain management
SCOR model	Supply chain operations reference model
SCP	Supply chain planning
SED	Shipper's export declaration
SEM	Single European Market
SEMA	Storage Equipment Manufacturers Association
Semi	Semi-trailer (articulated truck trailer)
SFI	Secure-keeping unit
SLA	Service level agreement
SLI	Shipper's letter of instruction
SLSC	Shipper's load, stow and count
SOP	Sales order processing
SOW	Scope of work
SRM	Supplier relationship management
SSAP 21	Statement of Standard Accounting Practice 21
STC	Said to contain
STGO	Special types general order
SWL	Safe working load

SWOT	Strengths, weaknesses, opportunities and threats
tare weight	Unladen or empty weight
TEU	Twenty feet equivalent unit
THC	Terminal handling charge
TIR	Transport International Routier (international road transport convention)
TL	Truck load
TLC	Total logistics concept
TQM	Total quality management
TUPE	Transfer of Undertakings (Protection of Employment)
ULCC	Ultralarge crude carrier
ULD	Unit load device
UN/EDIFACT	United Nations/Electronic Data Interchange for Administration, Commerce and Transport
UPC	Universal Product Code
VAS	Value-added services
VAT	Value-added tax
VIN	Vehicle identification number
VLCC	Very large crude carrier
VMI	Vendor-managed inventory
VNA	Very narrow aisle
WEEE	Waste electrical and electronic equipment
WIP	Work-in-progress
WMS	Warehouse management system

List of Figures

List of Tables

Chapter 1
Introduction to Supply Chain Management

In today's operating environment, successful companies need to become involved with their customers and suppliers. As international markets have been expanding and competitive pressure has also been increasing, companies must produce those items and services that customers want and need. Today's market is a customer's market; if companies are not clearly focused on customer requirements, ultimately they will lose their valuable customers.

Over the last 30 years or longer, many big organizations and firms believed that it is difficult to manage the entire business unit in a **vertically integrated company** (a firm possessing its own suppliers and/or customers) effectively. Hence, companies were merging and selling off their business departments. In simple words, companies are diverting from their core capabilities due to involvement in several business (vertically integrated) activities. Alternatively, companies may try to create strategic partnerships or alliances with suppliers, distributors and other companies who have capabilities similar to their own. This approach has made and distributed services and products the most efficiently and effectively helping companies to stay successful.

There is no doubt that several factors are at play and are influencing companies to enhance teamwork more. IF (Information) is exchanged by ERP (enterprise resource planning), EDI (electronic data interchange), RFID, GPS, Internet, etc. Communication technology is rapidly and continuously changing. Due to technology, team work is becoming easier than ever before.

1.1 What Is Supply Chain?

Several definitions exist in different books and research papers. A few of these are given below.

The term of SCM can be understood as,

S. A. Rehman Khan, Z. Yu, *Strategic Supply Chain Management*, EAI/Springer Innovations in Communication and Computing,
https://doi.org/10.1007/978-3-030-15058-7_1

SCM is a complete set of approaches utilized to integrate all partners of a supply chain efficiently, including suppliers, manufacturers, stores and warehouses, so that products are manufactured and distributed to the right place at the right time with the right quantities, in order to minimize system-wide costs, meanwhile meeting service level requirements—(Designing & Managing the Supply Chain by: Simchi-Levi et al. 2000)

OR

The design and management of seamless, value-added processes across organizational boundaries fulfil the real needs of the final customers—(The Institute of Supply Management—ISM)

OR

The planning and management of all activities involved in sourcing and procurement, conversion and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers and customers—(The Council of Supply Chain Management Professionals—CSCMP)

Supply Chain Management in Action: Where Does the Coal Go?

At the same time most every year my dad would be asking, "But where does the coal go?" We'd be on our family vacations on Lake Erie, and as a lover of ships, he'd closely observe the comings and goings of the big freighters that moved ore, coke, iron, coal and other goods and materials east and west across the Great Lakes. He'd explain why certain ships rode heavy (low in the water and slow) /light (high in the water and fast), and what goods/materials were in the ones coming from the west, where they came from and what part they played in making steel—and in turn, what was carried in the bowels of these big ships, a couple of them one thousand feet long.

One of those cargoes was coal, and the coal-bearing freighters would always pull in and unload at the harbour three miles east of us. But the one piece of all this activity—shipping, delivery and transfer and supply puzzle that my father could not quite figure out was what happened to the coal after it was delivered (unloaded) at the harbour in Conneaut, Ohio.

Oh, he knew what its ultimate fate would be and the role it would play in making products, steel etc., but he could not figure out the physical steps involved with the movement and transfer of that coal inside of the harbour, and that really bugged him.

He and I would try to find secluded roads leading into the back of this enormous industrial harbour so we could see where the coal went, but we would always be caught short by fences bearing grim warnings. We tried hiking in from the far shore, hacking our way through thick woods, but always the fence would stop us.

So I took my fellow seeker on a surprise outing. We parked at the little airport in Erie, Pennsylvania, where I chartered a private airplane. For a few hours, the pilot flew us all over Lake Erie, swooping down over the decks of some of the freighters as they made their way across the lake and circling sometimes over the Conneaut harbour.

I will never forget the sound of my father laughing and slapping his knee as he looked out the window at the massive expanse of the harbour that we had never been able to see from the ground as he said; "Now I see where the coal goes!" We had to go a half mile up in the air to get the complete overview of all activities and perspective we needed, but finally, we got it.

He saw the railroad shunt that moved the coal from the big ships to machines that transferred it to a massive web of railroad cars that linked up with rail lines heading south and thence all over the country. I suspect at some level he always knew this is what went on, but he had to see it; he had to really know; he had to be able to tangibly put into place that last piece of the puzzle that ran across thousands of miles of water and rail lines and touched hundreds of industries and sectors.

I have been thinking about this a lot recently because firms of all sorts seem to be striving for the same kind of complete view (end-to-end) of their supply chain, from their farthest-flung suppliers through their partners to their customers and even out to their customers' customers. The need to know, to really know and to have complete vision, is becoming increasingly vibrant in this business world that moves and changes so quickly.

Thanks for indulging me in this mostly personal tale of complete (end-to-end) vision. I would like to close by adding that several weeks after our plane ride, my father died quite unexpectedly. But before he left us, he got to see where the coal went.

Source: Evans, B., "Remembering My Dad", Information Week, 2010 July, 26: 6–7

1.2 Value Chain and Supply Chain

Usually many students are confused by the difference between SC (supply chain) and VC (value chain). In fact, there is no definite answer to this question. In the 1980s, Michael Porter first articulated the concept of VC; he believed that primary and supportive activities comprise a company's VC and these activities can create competitive edge when configured properly.

One school of thought to distinguish a supply chain from VC is conceptualizing the SC as a subcategory of the VC. In an organization, all personnel are part of the VC, but all personnel within a company are not part of a SC. Compared with the SC, the VC is much wider, because it covers (includes) all activities in the form of basic activities and supportive activities. In addition, the VC's original concept is mainly emphasized on international participants, whereas a SC, by definition, is both externally and internally highlighted.

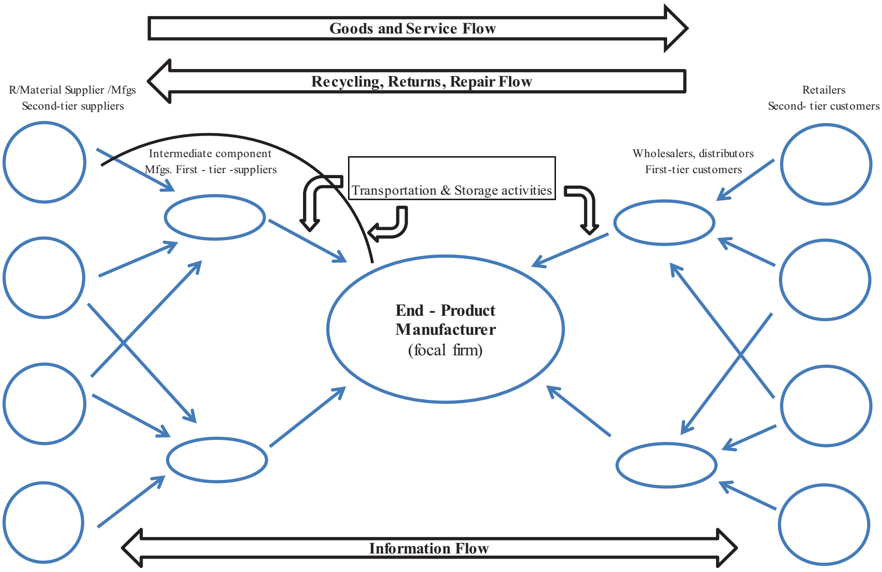


Fig. 1.1 A generic view of supply chain

1.3 A Generic View of Supply Chain

A generic picture of supply chain has been shown in Fig. 1.1. Raw materials such as iron and wood are extracted from the ground by companies and then sold to suppliers of raw materials, for example, lumber companies or steel mills. These companies act on POs (purchase orders) and specifications they have received from component producers, and then these producers convert raw material into materials that can be used by these customers (such as lumber and sheet steel). Then manufacturers of components, responding to the orders from their customers (the finished goods manufacturers), produce goods and sell intermediate products their customers want. The final goods producers (firms like General Motors, Coca-Cola) assemble the intermediate products they have received and sell the final products to wholesalers/ distributors, who resell products to retailers as their orders. Then finally, retailers sell those products to end consumers.

Consumers buy products and services from companies based on select criteria. Each and every consumer has its own requirements and criteria. But generally consumers buy products on the basis of the following criteria.

1. Quality
2. Cost
3. Range of the products
4. Availability
5. After-sale service

Those companies who fulfil the wants and requirements of the consumers become successful leaders in the market. That's why now many companies have one product in different SKUs (stock keeping units) in terms of depth and breadth of products, and use a broad range of distribution to make sure of availability, etc. In the whole supply chain, several times customers need to return products due to defects in the products, warranty repairs or recycling. All these activities are related to reverse logistics, which will be further discuss in Chap. 7.

The series of firms eventually producing and making services and products available for the customers—including all the functions that enable purchasing, manufacturing, storage and delivery, return or recycling of materials, end products and services—in the broader aspects, are all called supply chain. Nowadays, in supply chain, several companies have multiple supply chains for their multiple products to fulfil the requirements and needs of customers. The idea of today's supply chain is to make the "customer delighted not only satisfied". Nowadays supply chain is more complex compared to traditional supply chains, where only a few suppliers and retailers exist and manufacturers produce a limited range of products. But today's manufacturers have multiple products under one roof, and several suppliers, distributors/wholesalers and retailers are involved in each product's supply chain. There is only one source of income for complete end-to-end supply chain organizations—end consumers or customers. In the words of Steve Darendinger, VP (vice president) of Ciscom Systems of California, "companies must develop effective SCM programs keeping the customer in mind". Whenever one individual company ignores the interests of remaining supply chain members or final customers/consumers, ultimately these suboptimal decisions transfer higher level risk and cost along the supply chain. For example, generally the higher prices of end products will lead to lower customer service levels or may lower end-customer demand.

1.3.1 A Simple Example of Supply Chain

In this complex model, multiple companies are involved as supply chain members and several companies belong from other regions or countries. But in a simple SC, companies pull raw materials from their source, process, package and finally ship to the customers.

The example of cereal producers will explain well the simple SC. As displayed in Fig. 1.2, a cereal manufacturer purchases the grain from a farmer and then processes it into cereal. The firm also purchases paperboard from a paper producer, who bought the trees for making the paper, and labels from a label producer, who purchased semi-product label stock to produce the labels. After packaging, the cereal is dispatched to a distributor, and then the distributor ships/dispatches the material to a store; then the store sells it to a final customer. Even for an ordinary product like cereal shown above, the number of business transactions and raw materials and flow of information can be considerable.

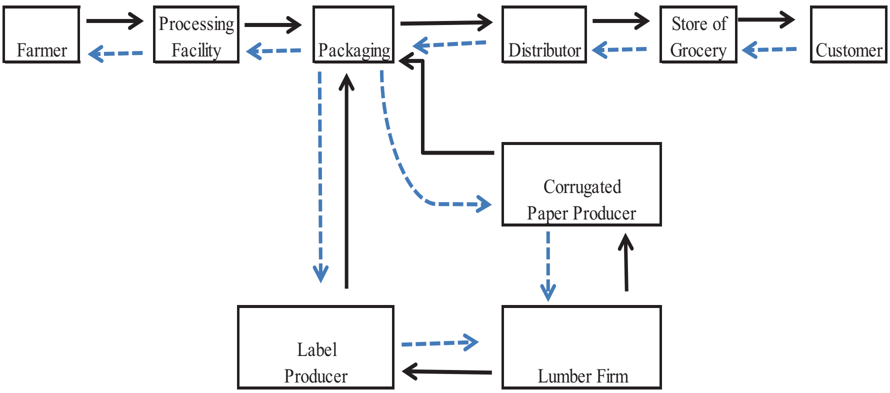


Fig. 1.2 A supply chain of cereal producer

The cereal manufacturer's SC features a widespread distribution network, which is engaged in delivering the packaged cereal to the end customer/consumer. Inside the portion of downstream SC, mainly it is logistics managers' responsibility to move goods/materials between locations.

Transportation management is one important role of logistics, involved in the screening, checking, selection, and management of external carriers such as airlines, shipping firms, trucking firms and railroads or the management of private fleets (internal) of carriers. Distribution side management involves the handling of materials, packaging, storing, moving, receiving, warehousing and retail outlets.

1.4 The Umbrella of Supply Chain

A broader set of activities in addition to purchasing is part of SCM (supply chain management). Every activity looks diverse, but all these activities have one significant characteristic in common—they are part of a network, which will describe how effectively and efficiently goods, products and information flow across a SC. While the related activities SC needs to perform have existed for several years, it is a company's enthusiasm, willingness to align, integrate, coordinate and synchronize all these activities and the flow that is relatively new. What kind of activities do act as a part of this SCM concept?

1.5 Management Activities

1.5.1 Purchasing

Many companies implement purchasing as a main activity of SC because companies purchase a raw material from supplier and then process it further for value-addition. Since the 1980s, many companies have started work on cost minimization and elimination of waste in different parts of the purchasing process, including paperless purchasing, supplier relationship management and supplier development. There is no doubt that the purchasing role is very crucial and companies can save millions of dollars through good negotiation techniques, elimination of waste, supplier relationship management and building trust.

1.5.2 Inbound Transportation

Usually multinational firms have a specialized traffic and transportation function to manage the informational and physical links among the buyer and the supplier. For many companies, transportation is the single biggest classification of costs, especially for greatly diversified companies. While a company may have minimal common requirements for purchasing among its operating units, usually there are opportunities to coordinate and manage the purchase of transportation services.

1.5.3 Quality Control

Due to the tough competitive environment of the last couple of decades, companies are emphasizing quality control. In the new practices of supply chain, companies detect defects at the time of receipt of the material. One step more, companies are closely working with supplier to minimize the cost and increase the quality of products.

1.5.4 Planning of Demand and Supply

Demand planning contains forecasts of anticipated demand, adjustment of inventory, orders taken but not filled and spare parts and aftermarket requirements. Monitoring demand data and developing a supply, manufacturing and logistics network capable of fulfilling the requirement of demand comprise supply planning.

1.5.5 Receiving, Storage and Material Handling

All in-bound raw material/goods should be physically received when it transports from a supplier to a buyer. Generally, except in a JIT system environment, material must also be staged, received, handled and stored. These activities are commonly part of the material management function due to the requirement to manage the physical handling and processing of inventory. Receipts from users showing that services have been completed are also reviewed by receiving to trigger payment of related invoices.

1.5.6 Material Control or Inventory Control

The material control term includes responsibility for determining suitable quantities to order on the basis of forecasted demand and then managing materials released by suppliers.

It is usually the inventory control group's responsibility to determine the level of inventory of final goods required to support customer needs and requirements, which focuses on the physical distribution side (downstream) of the SC. Integrated SCM means that the inventory and material control groups coordinate their efforts to guarantee an uninterrupted and smooth flow to customers/consumers.

1.5.7 Order Processing

Order processing supports and helps to ensure that customers receive materials where and when customers require them. Order processing is a vital role of SCM (supply chain management). It shows a link between the manufacturer and the customer (external).

1.5.8 Production Scheduling, Planning and Control

These activities involve determining a time-phased production schedule, developing short-term schedules of production and managing WIP (work in process) production. The plan of production usually depends on forecasts from the marketing department to evaluate the quantities of materials that are needed over the upcoming term.

1.5.9 Warehousing or Distribution

Products need to be stored in a DC (distribution centre) or warehouse before being dispatched towards customers. This is specifically true for firms that manufacture per the expectation of future sales.

1.5.10 Shipping

The shipping activity includes physically receiving goods/products ready for distribution towards the customer. This function includes packing to make products safe from damage, pilferage and meeting labelling requirements, completing the shipping documents and arranging transportation. There is no doubt that, outbound transportation and shipping must work closely.

1.5.11 Customer Service

Currently, in competitive environment, CS (customer service) means not only keeping customers satisfied, but also delighting them. The basic three factors of CS are: first, "pre-transaction"; second, "transaction"; and third, "post transaction" activities.

1.6 Supply Chain Integrations

Supply chain integration is one sustainable approach for minimizing cost and improving service levels. But unfortunately, integration is not easy.

In the whole supply chain different entities may have different targets. For example, suppliers want manufacturers to commit themselves to buy large quantities with stable volumes and flexible delivery dates. But most producers want to implement long-run production; it is necessary for them to be flexible to their customers' requirements, needs and dynamic/changing demands. So the goals of suppliers are in direct conflict with the producers' desire for flexibility. Certainly, as decisions of manufacturing are typically made without exact information of customer demand, the manufacturers' capability of meeting supply and demand are mostly dependent on their ability to change volume of supply when information on demand arrives. Likewise, the objectives of producers making large batches of production typically conflict with the goal of distribution centres and warehouses to minimize inventory. Finally, this latter objective of minimizing inventory levels typically suggests higher transportation costs.

1.6.1 Example of Korean Manufacturer

A manufacturer of electronic products such as industrial relays is facing a service level of about 70%; that is, only about 70% of all orders are delivered in time. On the other side, inventory keeps piling up, mostly of items that are not in demand. The inventory turnover ratio, defined as the ratio of the annual flow to average inventory at the manufacturer's main warehouse, is about 4. However, in the industry of electronics, leading firms turn inventory over about 9 times a year. If the manufacturer can increase its inventory turns to this level, it will be able to significantly minimize inventory levels. The manufacturer is thus searching for new strategies that will increase service levels over the next 3 years to about 99% and, at the same time, significantly decrease cost and inventory levels.

A couple of decades ago, several authors said these two objectives cannot be achieved at the same time.

1. Improved service levels
2. Inventory levels

Indeed, from the traditional theory, we know that, for higher service level, the company should keep a higher inventory level. Interestingly,

1.7 Why Vertical Integration Failed

In the light of SC theory, supply chain works as a singularly competitive unit, interconnected, accomplishing what many big, vertical integrated companies failed to achieve. There are several examples of different companies', such as Ford Motor, vertical integration. The major reason for failure is "lack of capability and diverting from their core business". Supply chains are evolving; new entrants are coming in the market with more capabilities and skills, and every company is shrinking and minimizing its expenses and waste for healthy profits or survival in the market.

Vertical integration (VI) also has some advantages like control over the whole business, in order of quality, schedule planning and forecasting, etc. But, generally, vertical integration has more disadvantages than advantages, such as lack of capability, lack of knowledge about raw-material business, difficulty in managing big operations, diverting from the core business of the company. According to several academic researchers, whenever a company moves two or more steps from its core business, it fails 2/3s of the time.

Vertical integration strategy is too risky, difficult to reverse and involves huge cost. Sometimes vertical integration is necessary, but more often than not it is unnecessary. The reasons used by senior managers to justify these strategies are usually invalid. Examples are "assuring market access, building closer relationships with customers, gaining customer trust, and reducing cyclicality". These reasons are sometimes valid, but often not. Finally, whether vertical integration is profitable or not is a challenging question and depends on several factors, including capabilities of company management, knowledge of businesses and employees' skills. In simple words, vertical integration strategies are not "fit to all". However, there are some success stories behind vertical integration, such as Du-Pont acquiring Conoco Inc. in the year of 1981, a $7.3 billion transaction. The chairman of Du Pont stated that the merger would give the firm "a captive hydrocarbon feedstock source" and would minimize the exposure of the combined firms to fluctuations in the price of hydrocarbon and energy.

1.8 What Is the Bullwhip Effect?

The Bullwhip Effect has been one common issue in businesses. It starts from the downstream (end customers) side of the supply chain and swings in larger and larger "wave" hits to the upstream manufacturer/supplier. As a result of these waves end-to-end, all supply chains are disturbed and huge inventory pile-ups occur in the different stages of supply chain, which results in huge cost. According to the APCIS

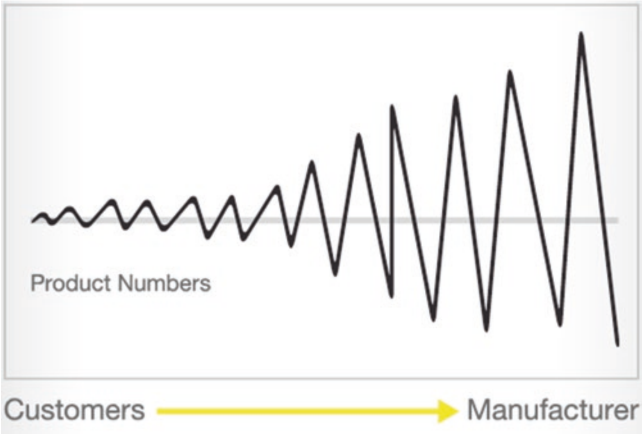


Fig. 1.3 Bullwhip effect

and SCC (Supply Chain Council) USA, (2014) inventory cost in the supply chain is approximately 60–70% of all business. Finally, "Inventory is the Killer" because all this inventory also has its own expenses, such as carrying cost, pilferage cost and expiry cost, which creates unnecessary burden over the supply chain.

For example, if the actual order received from a customer is 8 units, the retailer's order sent to distributor may then be 8 + 3 = 11 units (the retailer may then order 8 + 3 = 11 units from the distributor). Similarly, the distributor will give an order of 8 + 3 + 20 = 31 units to the manufacturing company, so ultimately the real demand of product has been changed. Now 23 units have been manufactured as an excess inventory. This is called the bullwhip effect (Fig. 1.3).

1.8.1 The Causes of Bullwhip Effect

There are several factors, which play a role in the bullwhip effect. But here, we have listed some of the major factors which contribute to the bullwhip effect.

- Lack of Communication

- One major reason for the bullwhip effect is lack of communication. Under its impact, it is difficult to run the processes smoothly. Due to the improper/lack of communication among supply chain partners, the managers can receive product demand quite different from the real demand of end customers.
- Disorganization
- Disorganization among each supply chain link results in ordering smaller/larger amounts of a product than is needed due to an under-/over-reaction to the supply chain beforehand.
- Order Batching

- Firms may not place orders to the suppliers in real time, often accumulating the demand first. Mostly companies order on weekly or monthly bases. This creates variability in the demand of products as, for instance, a surge in demand may take place at some stage followed by no demand after.
- Price Variation
- The one reason of bullwhip effect is "price variation". Mostly, companies start their promotion activities, special discount offers. This can increase the consumer's regular buy patterns. Due to the special discounts, consumers want to take more and more advantage of special offers, and they may store products in huge quantities. This can cause uneven production and distorted demand information.
- Demand Information
- Several companies may rely on past demand information of products to forecast future demand information without involvement of customer requirements, market feedback or simply without any fluctuation that may occur in demand over a period of time.
- Free Return Policies
- Intentionally, customers can overstate demand due to expected shortage of products and can cancel the orders. When the supply is adequate again, without return forfeit, retailers will continue to exaggerate their needs and cancel orders, resulting in excess inventory.

1.9 The Snowball Effect

The snowball effect starts from the upstream side. Variability of supply quantities and supply delays increase as one moves downstream. For example, a small fault in a supplier machine can cause a 3-day delivery delay to the manufacturer in China, and it will result in a 6-day delivery delay to the Distributor in Malaysia, finally, snowballing into a total 12-day delay in delivery to the retailers/customers in Europe (Fig. 1.4).

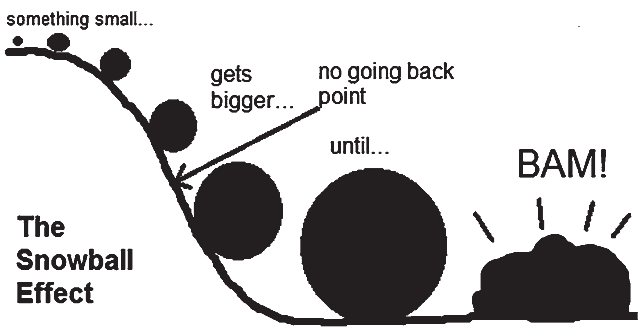


Fig. 1.4 The snowball effect

You have no choice other than to roll until it stops.

1.10 The Importance of Information Sharing

According to Gumaer (1996) and Davenport (1998), in today's competitive environment, firms cannot survive successfully without IT (Information Technology).

Visibility and speed (velocity) is the one major competitive edge in the SC, which can be obtained by usage of latest technology and information sharing.

In the SC, information sharing plays the role of backbone. According to the APCIS–USA–CSCP Module Books (2013), information sharing has solved several complex and difficult supply chain problems. There is no doubt, IT (Information Technology) has its own importance in the sharing of information among all supply chain partners.

According to Gumaer (1996), in today's competitive market, companies cannot survive without information technology. In the SC, speed is one of the major competitive edges, and this advantage can be achieved by investment in information technology like ERP (enterprise resource planning) (Davenport 1998).

When organization, its suppliers and customers all know each other's future plans and are willing to work together. Ultimately the planning process is more productive and easy, in order of improvement in quality, cost savings as well as higher service level. All these objectives can be achieved by information sharing.

As per the knowledge of APCIS–USA–CSCP Module Books (2013), the concept of 3Vs explains the importance of information sharing. Visibility and velocity play a critical role in minimizing variability in the SC. Variability is called the error or variation.

The concept of 3Vs explains how to minimize variability from the whole supply chain. If visibility and velocity are higher, ultimately variability in the SC will be minimized (Fig. 1.5).

For instance, as in one company, a sales or marketing person knows the actual level of inventory in finished products warehouse, then he can commit (sooner and

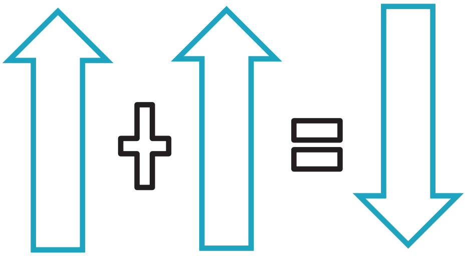


Fig. 1.5 The concept of 3Vs

more timely delivery) with customers, and there will be fewer chances of error, miscommitment and disruption in the chain of supply. Finally, variability in the end-to-end SC of the company will be minimized. Similarly, if all supply chain partners know each other's future plans, then actual demand disruption in the end-to-end supply chain will decrease.

Visibility and velocity have a negative proportion of variability. So here, one simple question comes to the student's mind: how can we increase information sharing between SC partners?

Generally, information sharing can be enhanced in the supply chain by the following ways:

1. Willingness of SC partners to share their information
2. Usage of latest IT (Information Technology) for real-time information sharing.

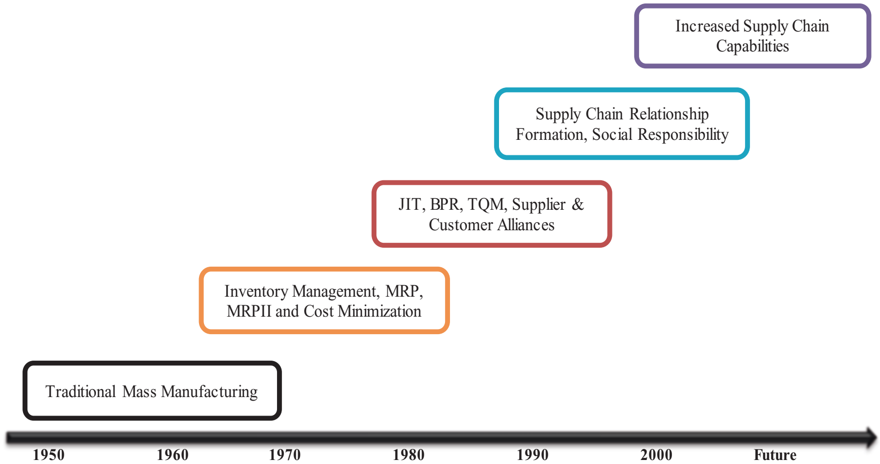
But, these two points are well integrated. Firms cannot achieve information sharing goals simply by using the latest technology. The firms' management should be willing and open to sharing information with their supply chain partners. There is one school of thought that somehow firms can achieve information sharing goals by only "willingness to share information". On the other hand, this approach will not be very effective (especially for the large, medium organizations) or reliable.

1.11 The Beginnings of SCM in the USA

During the 1950s–1960s, the American manufacturers were employing and focusing on mass manufacturing techniques to minimize costs and promote productivity; however, very little attention was paid to construct positive relationships with suppliers, improving processes and quality, etc. (Table 1.1).

It was slow to design and develop the new product, which was dependent exclusively on in-house resources capacity and technologies. Information sharing and expertise through strategic buyer-supplier relationships were basically unnoticed. In factories, the floor was cushioned with material inventory to keep machinery in smooth running as well as maintain balanced flows of materials, resulting in huge investment in WIP (work in process) inventories.

Table 1.1 Supply chain management events in the USA



In the 1960s–1970s, computer technology enabled MRP (material requirement planning) software applications, and MRPII (manufacturing resource planning) software applications were developed. Finally, these technologies helped firms in effective materials management.

The 1980s were the breakout years for SCM (supply chain management). During the 1980s, several research results were published in numerous journals, and intense global competition was beginning. Companies were emphasizing TQM (total quality management), JIT (just-in-time), production efficiency and delivery times, BPR (business process re-engineering), supplier and customer alliances, etc. But since the 1990s, the competition has become more intensified, accompanied by increasing inventory costs, transportation costs, the challenges associated with manufacturing efficiency, new product design and development, improving quality, customer service and delighting customers.

Finally, the companies (manufacturers) started buying material from selective certified suppliers to ensure the quality of materials as well as involving these suppliers in the company's new product design and development activities. These practices help manufacturers to minimize the cost, and make improvements in quality, delivery time and customer service. On the other hand, suppliers enjoy the large amount of consistent orders from manufacturers. According to several works of research, buyer-supplier alliances have turned out to be a success.

1.12 3PL Logistics and 4PL Logistics

3PL logistics and 4PL logistics are not the same. Generally, students are confused about both terminologies. According to the APCIS–USA–CSCP Module Books (2013), 3PL is identified as "Entity that provides product delivery services for a company (buyer and supplier). The third party actually performs/manages one or more logistics services".

4PL is defined as "One logistics specialist that plays the role of general contractor takes over the complete function of a logistics manager for a company and coordinates the combination of divisions/subcontractors necessary to perform the specific task involved."

In light of the above explanations, third parties have little/limited resources and cannot provide complete solutions for organizations. On the other hand, 4PL logistics can provide complete and comprehensive SC solutions which combine the capabilities of management consulting, IT and third-party providers for their customers/clients (organizations), and fourth-party logistics companies can do subcontracting if necessary. But third-party logistics companies cannot do subcontracting. Fourth party does not mean that four parties are involved in all activities. The number of "4" refers to the fact that this kind of logistics is more specialized and higher than third-party logistics (3PL). In simple words, 4PL companies can play the role of 3PL. But 3PL companies cannot play the role of 4PL.

There are several benefits and a couple of risks associated with 3PL and 4PL (Fig. 1.6). Some major benefits and risks are given below.

Benefits of 3PL logistics

- Flexible workforce
- Focus on core competencies
- Efficient warehousing
- Improved customer service
- Latest technology and technology flexibility

Benefits of 4PL logistics

- Focus on core competencies
- Higher quality logistics reduced costs
- Greater business flexibility

There are also a couple of risk factors involved in 3PL and 4PL logistics including:

- Less or weak control over logistics
- Risk of inefficient service

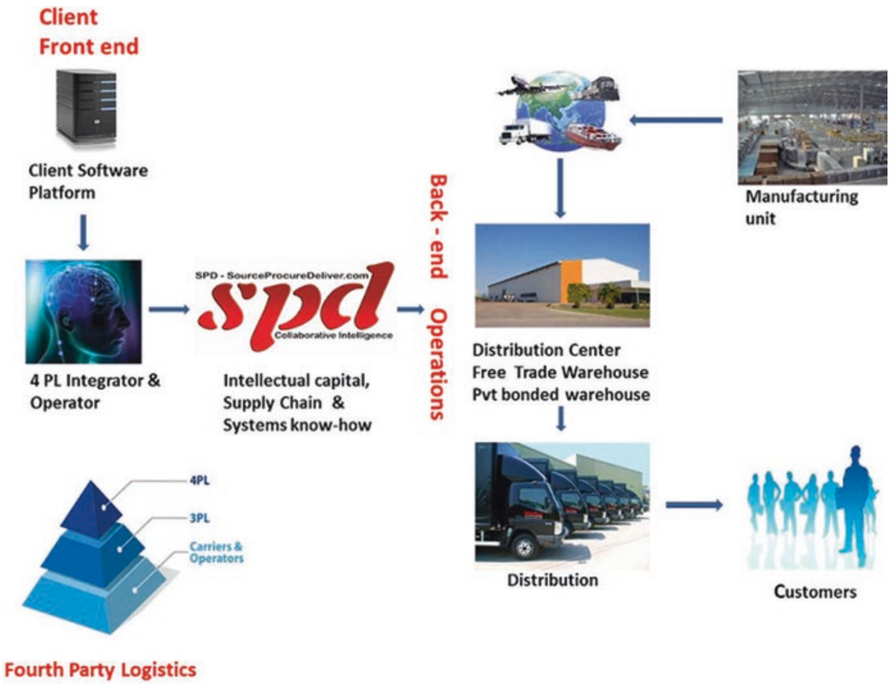


Fig. 1.6 Fourth-party logistics. Supply chain practitioners and researchers are debating over 5PL

1.13 Latest Trend in Supply Chain Management

SCM practice is a fairly recent phenomenon, and several companies are starting to realize both the problems and advantages accompanying integrated SC (supply chain). There is no doubt, SCM is a time consuming and complex undertaking, involving cultural change and difference among all of the participants or most of the participants, investment in latest technology (communication systems and software), the trust building among SC partners and a realignment/change of the competitive strategies employed among at least a couple of the participating companies. However, as competitors, customers, customer requirements and technologies change, the priorities in SC also must be changed; managers need the SCM structure to be more flexible to respond to all these unanticipated challenges.

When we look at the latest trends and practices in SCM, several issues arise themselves as areas that should be discussed covering supply chain responsiveness, reducing total cost of supply chain, building trust and collaboration among SC partners, green SC, expanding the SC.

1.13.1 Supply Chain Responsiveness

In the responsive SC, *agile manufacturing, lean manufacturing, mass customization, quick response* and *Just-in-Time* are all terms referring to ideas which intend to make the company more responsive and flexible to fulfil customers' requirements and make them satisfied.

If companies really want to achieve a greater level of responsiveness, they need to identify their final customers' wants and needs, and look at what the competition is doing to determine their SC services and products to compete successfully. And lastly, companies must consider the effect of these requirements on each of the SC participators. Once the companies in the SC sufficiently identify these requirements, additional improvement in responsiveness comes from faster product delivery systems, designing more effective communication and information sharing systems as products and information pass through the SC. SC partners must also continuously observe changes occurring on the ground (marketplace) and then use this latest information to reposition SC partners and output to stay competitive in the market.

Supply chain responsiveness requires companies to check and re-evaluate their SC relationships, reposition and automate warehousing, utilize business process re-engineering, minimize new product design cycles, design new products, standardize processes, train workers in multiple skills, factor in customer feedback, and finally link all of the SC members' real-time information systems together through use of modern technologies. So, very soon, it is seen that achieving higher levels of customer satisfaction by responsiveness is likely to require significant changes in technical aspects of providing services, products throughout the SC .

1.13.2 Reducing Total SCM Costs

Today's supply chain has several challenges and one of the big challenges is "Total Cost Minimization in the Supply Chain". In several companies, top priority is Cost Reduction, and to achieve this objective, companies are using different strategies, approaches and techniques, such as lean manufacturing, elimination of waste, strong buyer-supplier relationships, reducing extra inventories, minimizing the cost of procurement and distribution. As SC becomes mature, it tends to improve performance as a result of these cost minimizations through the use of CI (continuous improvements) efforts, integration processes, usage of latest technology to manage inventory, increased inventory visibility capabilities, better communication and relationships building among supply chain partners

According to a recent survey conducted in *Chicago*, 82% of company CEOs (Chief Operating Officers) said their firm's present SC initiative was directly related with cost reduction.

Companies are also investing a huge amount in different software applications to streamline their SC, and several firms are hiring 3PL consultants (spend management) to minimize SC costs. In light of research findings, Greg Aimi, research director at Boston-based business research specialist AMR Research, firms using TMS (transportation management system) software application right now account for lower than 40%. "If you do not use TMS, and if you are using traditional approaches, such as spreadsheets to handle the routing and transportation, then a large part of the savings identified during purchasing will vanish and be lost".

1.13.3 Trust Building and Collaboration

In the modern SC, coordination with supply chain partners is significant in the whole SC business. The relationship building, cooperation and collaboration concepts began during the 1980s in response to a competition rise in the market and cost pressures from the customer side. The supplier relationship and collaboration give several advantages—primarily cost cutting, supplier involvement in product design, improved customer service, quality improvement, etc.

According to Khan and Dong (2017a, b) information sharing throughout the SC depends on IT, as well as on improved information through collaboration and trust building techniques. These collaboration techniques have several benefits, including cost minimization, improvement in scheduling and planning, higher customer service level.

Unquestionably, in the last couple of decades several researchers and practitioners have richly discussed buyer-supplier relationships, collaboration, partnerships, trust building among SC partners, sharing information with SC partners. But still trust deficits exist in many supply chains; partners need to improve their relationships and trust building.

In the words of C. John Langley, a professor of Georgia Institute of Technology, *"The idea that firms should work together and coordinate activities has always been around, but ask people today what one of the major killer problems with companies' supply chains is today, and they say firms do not work together very well"*.

1.13.4 Green Supply Chain Management

Manufacturing, purchasing, storing, moving, packaging, delivering, and after-product life cycle or returning products would present a very crucial threat to the environment in order of waste scrapped toxic materials, emissions, traffic congestion or other forms of industrial pollution. As time passes, the practices of SC matures; government officials and authorities together with companies and their SC (supply chain) members are struggling to minimize hazardous chemicals or, on a broad perspective, to avoid "environmental pollution".

According to the large supermarket groups and researchers, there is a significant business reason for succeeding in sustainable/green SC initiatives.

There are several companies shifting towards green supply chain due to the potential in the market, for commercial reasons, and to attract their customers and communities. A big example is Wal-Mart during 2007, when Wal-Mart began shifting the firm's emphases to its customers, suppliers and their communities. As we can see, they have made marvellous and great contributions to sustainable supply chain practices. Due to their big size and influential factor in their SC, they have made a crucial and remarkable change in the way their logistics firms, customers, and suppliers consider sustainable supply chain (Fig. 1.7).

One very famous example of Wal-Mart commitment along environmental supply chain is "lots of stores as early as 2010 were using the waste oil from their deep-fryers to fuel Wal-Mart trucks. Wal-Mart is hip to biodiesel? You bet".

As per several authors and researchers, relationships among firms in a well-managed SC are much more conducive to taking a proactive approach to minimizing the harmful environmental consequences of manufacturing, storing and moving goods and products as they wend their ways through the SC. Over time, end-customer sentiment with green processes and the prevention of global warming has tended to increase this hot-topic concern for firms to manage their SCs.

Unfortunately, increasing demand for green or sustainable goods and services is misleading. Several firms nowadays are flooding the market with environmental products. During the years 2007–2009, there was almost 79% increase in green products, according to the TerraChoice (environmental marketing company) based in Canada. In reality, a research study of TerraChoice of 2219 commodities claiming to be sustainable/green products found 98% to be misleading in their claims.

Fig. 1.7 Green supply chain management

1.13.5 Expanding the Supply Chain

Today, companies are trying to increase their business partners (especially foreign organizations) to accommodate market expansion plans and to achieve higher responsiveness in foreign markets. In the modern supply chain, firms are working with companies located all around the world to integrate various activities, including manufacturing, logistics and purchasing.

However global expansion of SC is occurring, companies are trying to expand their control over the SC to include 2nd and 3rd tiers of customers and suppliers. This SC expansion happens on two fronts:

- Increasing the SC's breadth to cover foreign sales offices, manufacturing facilities and retail sites, etc. with foreign customers and suppliers
- Increasing the SC's depth to cover the influence of 2nd and 3rd tiers customers and suppliers.

As companies become more experienced with their SC trading partner relationships, there is a trend to expand the breadth or depth of the SC by building relationships with their 2nd and 3rd tiers customers and suppliers. This span expansion trend and phenomenon has happened since the 1990s in various industries and is expected to continue to increase as the practice of SCM matures.

Discussion Questions

1. What is supply chain management?
2. Explain the value chain and supply chain.
3. Draw and explain the generic view of supply chain.
4. What are the activities included in the concept of supply chain management?
5. What are the advantages of supply chain management?
6. Explain vertical integration in your own words, and the benefits and disadvantages of vertical integration.
7. What is the bullwhip effect? What are the major causes of bullwhip effect?
8. Explain the snowball effect with an example.
9. Explain the 3Vs concept and importance of information sharing in supply chain management.
10. What is the difference between third-party logistics and fourth-party logistics?
11. Discuss the major advantages and disadvantages of third-party logistics and fourth-party logistics.
12. What is the latest trend in supply chain management? Discuss with examples.

References

Apergis, N., & Ozturk, I. (2015). Testing environmental kuznets curve hypothesis in Asian countries. *Ecological Indicators, 52*, 16–22.

Bensassi, S., Marquez-Ramos, L., Martinez-Zarzoso, L., & Suarez-Burguet, C. (2015). Relationship between logistics infrastructure and trade: evidence from Spanish regional exports. *Transportation Research Part A: Policy and Practice, 72*, 47–61.

Davenport, T. H. (1998). Putting the enterprise into the enterprise system. *Harvard Business Review, 76*(4), 121–131.

Gumaer, R. (1996, September). Beyond ERP and MRP II—Optimised planning and synchronised manufacturing. *IIE Solutions, 1996*, 34.

Khan, S. A. R. (2018, November 5). Introductory chapter: Introduction of green supply chain management [Online First]. *IntechOpen*. https://doi.org/10.5772/intechopen.81088. Available from https://www.intechopen.com/online-first/introductory-chapter-introduction-of-green-supply-chain-management

Khan, S. A. R., & Dong, Q. (2017a). Impact of green supply chain management practices on firms' performance: an empirical study from the perspective of Pakistan. *Environmental Science and Pollution Research, 24*(20), 16829–16844.

Khan, S. A. R., & Dong, Q. (2017b). Does national scale economic and environmental indicators spur logistics performance? Evidence from UK. *Environmental Science and Pollution Research, 24*(34), 26692–26705.

Khan, S. A. R., Jian, C., Yu, Z., Golpîra, H., & Kumar, A. (2019). Impact of green practices on Pakistani manufacturing firm performance: A path analysis using structural equation modeling. In H. Anandakumar, R. Arulmurugan, & C. Onn (Eds.), *Computational intelligence and sustainable systems* (EAI/Springer innovations in communication and computing). Cham: Springer.

Khan, S. A. R., & Yu, Z. (2019, March 25). Introductory chapter: Purchasing and supply management [Online First]. *IntechOpen*. https://doi.org/10.5772/intechopen.85380. Available from https://www.intechopen.com/online-first/introductory-chapter-purchasing-and-supply-management

Khan, S. A. R., Yu, Z., & Qianli, D. (2019). Study on the supply chain integration: In the perspective of Pakistan. In H. Anandakumar, R. Arulmurugan, & C. Onn (Eds.), *Computational intelligence and sustainable systems* (EAI/Springer innovations in communication and computing). Cham: Springer.

Khan, S. A. R., Zhang, Y., Anees, M., Golpîra, H., Lahmar, A., & Dong, Q. (2018). Green supply chain management, economic growth and environment: A GMM based evidence. *Journal of Cleaner Production, 185*(6), 588–599.

Simchi-Levi, D., Kaminsky, P., & Simchi-Levi, E. (2000). *Designing and managing the supply chain: Concepts, strategies and case studies*. New York: McGraw-Hill.

Chapter 2
Key Issues in Logistics and Supply Chain

The main concept of SCM (supply chain management) used in this book refers to the means by which companies are engaged in producing, distributing and selling products. As well, this includes coordination and cooperation efforts among all supply chain partners to achieve high market intelligence by more exact market information sharing, product development, product design, product research and value analysis of the whole system. In today's competitive environment, businesses have more cost pressure from the consumer side. Companies are trying to make customers delighted through fast delivery of products, low cost and higher quality. To achieve these objectives several companies are using outsourcing, 3PL or 4PL services, and companies focus much more on their core competencies. According to the APCIS–CSCP-BOOK (2013), competition between companies has shifted towards supply chain *vs.* supply chain. Keeping the above discussion in mind: what the main supply network capabilities are required to make customers delighted and control or minimize cost pressure as well; how we can integrate capabilities through agreements, contracts, portfolios, relationships, etc. These major problems of strategic and tactical SC (supply chain) will be discussed in this chapter.

There are long lists of supply chain management issues and problems to be found in published and unpublished literature. Researchers Chandra and Grabis (2007) mentioned the list of problems and issues identified in Table 2.1 below. However, Chandra and Grabis also suggested problem-solving approaches for all these issues and related problems of supply chain.

2.1 Network Configuration and Competition

Researchers Rice and Hoppe (2001) analysed how SCs may compete with each other. Three different situations have been considered, since no single situation gives a common and valid characterization of competition:

S. A. Rehman Khan, Z. Yu, *Strategic Supply Chain Management*, EAI/Springer Innovations in Communication and Computing,
https://doi.org/10.1007/978-3-030-15058-7_2

Table 2.1 SCM issues and suggested problem-solving approaches

S. no	SCM issues and related problems	Problems-solving approaches
1.	Distribution network configuration	Network flow optimization
2.	Supply contracts	Global optimization
3.	Supply chain integration and strategic partnering	CPFR (Collaborative Planning, Forecasting and Replenishment)
4.	Inventory control	Forecasting and inventory management
5.	Distribution strategies	Warehousing and transportation cost management
6.	IT and decision support system	ERP implementation and Decision support system
7.	Outsourcing and procurement strategies	Managing risk, payoff / trade-off with outsourcing *vs.* buying
8.	Customer value	SPC (statistical process control), TQM , and service level maximization

1. Competing as supply chain *vs.* supply chain literally. Competition among different firms across the network of supply competing as a single entity, formally or informally. This competition applies when the conditions given below exist.*
   *Note: These conditions can implement only one of the competitors.
   - When the supply chain is a vertically integrated firm competing with another similar company (vertically integrated)
   - When the network of supply is in a greatly integrated firm without common suppliers
   - When the network of supply is composed of enterprises that have solve-source associations
   - When the industry is fragmented in such a way that there are no common strategic suppliers shown in more than one supply network, and most strategic suppliers are committed to one supply network
2. Competing on capabilities of supply network. Competition among individual firms on their internal capabilities of supply network, essentially and especially over the efficiency, responsiveness and effectiveness of the network as well as the design of network used (for example, introducing new distribution channels).
3. Competing capabilities of a supply network led through a “Channel Master”. Mostly influential and powerful firms in a supply network denoted as the channel master. In today’s marketplace, this situation is normal.

These above-mentioned three situations are not mutually exclusive; researchers Rice and Hoppe (2001) illustrated cases of vertically integrated firms (ZARA) competing against “Channel Master” (The Limited) and against other parts of interconnected network of supply, competing on the basis of their capabilities of network (The GAP).

Figure 2.1 illustrates disconnected network of supply, competing with each other without overlaps at any tier (for instance, in the 1970s, manufacturing of automobile supply chains in the countries of Germany, Japan and the United States).

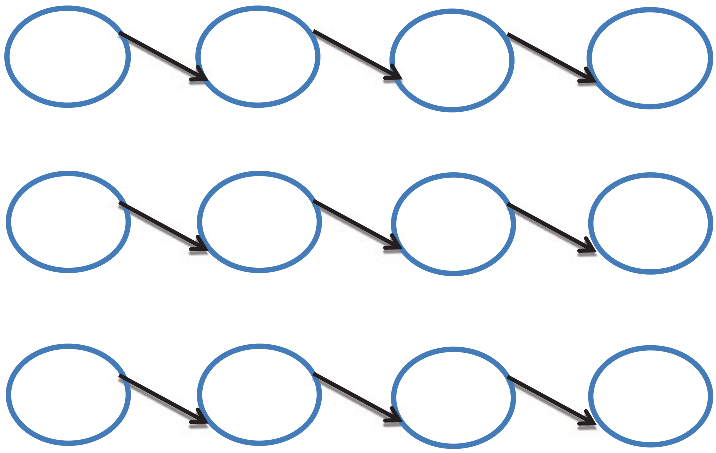


Fig. 2.1 Totally disconnected network of supply (Rice and Hoppe 2001)

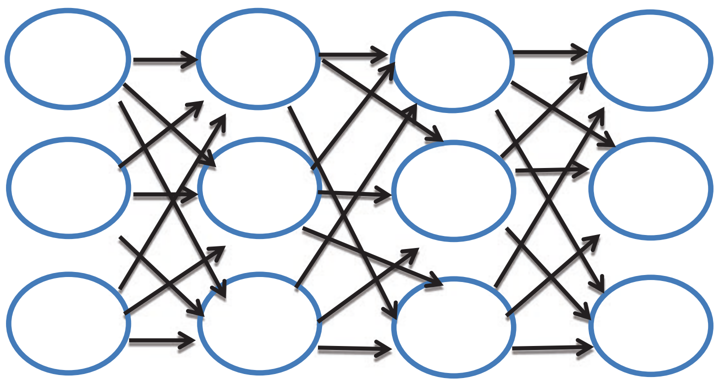


Fig. 2.2 Totally connected and overlapped network of supply (Rice and Hoppe 2001)

Figure 2.2, each of the three supply networks overlaps with every other one, and each firm at every layer sells its goods to every layer ($n + 1$) firm.

In Fig. 2.3, competition in the industry of high-tech is, as in various other industries, somewhere mid of these two extremes (Figs. 2.1 and 2.2) with some overlaps and some totally disconnected layers within the networks.

Usually it is very common that the commodity-type products procured efficiently from many members in the open market have overlaps to some extent. For example, HP and Dell (and also Compaq before the merger with HP) compete in modular item architecture, and they have a fragmented supplier base building significant overlap.

According to the researchers Rice and Hoppe (2001), in many cases several of the potential connections or links are eliminated due to closer associations with some firms, depending on the product's nature, capacity of the supply network and also price; for example, two supply chains (high-tech) can overlap partially to memory, engine and software.

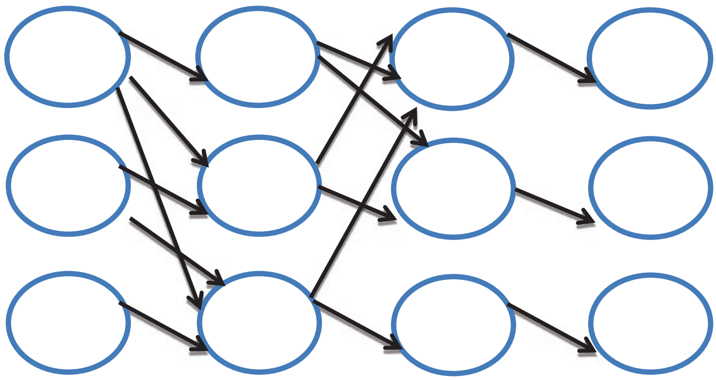


Fig. 2.3 Semi-overlapped network of supply (Rice and Hoppe 2001)

Once capabilities that will be developed and/or improved are decided, we must make plan of actions and implement them into work. In this phase, we also need to understand that it is not really an easy task to build/create the strengths of network while fulfilling customer requirements (needs and wants). And understanding customer requirements requires deeper levels of analysis, coordination, cooperation and information sharing among all the SC partners to ensure that some exclusive value for customers is created.

2.2 Information Sharing

Information technology and latest communications devices play a significant role to increase the information sharing, coordination and communication among the companies and supply chain partners. According to many researchers and practitioners, sharing critical real-time information has been used to minimize the inventory in all stages of SC, to make demand forecast more realistic and accurate, and to promote the overall performance of SCM.

According to one researcher (Shore 2001), the development of IT and communication in SCM (supply chain management) can be divided into four phases:

- In the first phase, inter-organizational info exchanges travelled by fax and/or postal system
- In the second phase, management focuses on the automation of info flows and elimination of various human intensive data entry as well as re-entry processes between suppliers and retailers
- In the third phase, the focus was on a more integrative strategy through executing Enterprise Resource Planning (ERP) systems
- In the fourth and last phase, a SC is characterized through strategic alliances of suppliers with extensive mutual information sharing flows

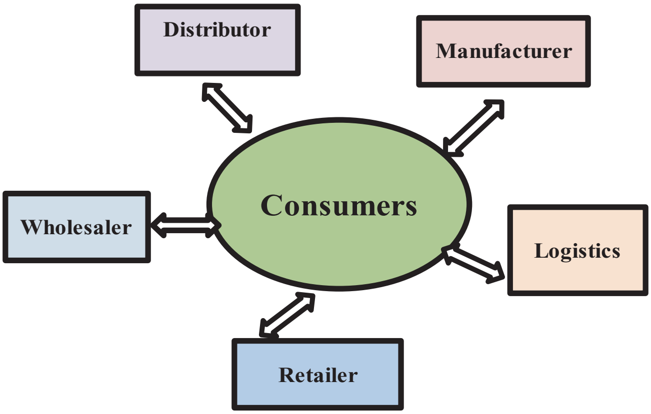


Fig. 2.4 Information sharing

Collaboration and information sharing have joined the automation ranks and integration as hallmarks of competitive edge in the whole supply chain network (Fig. 2.4). Gartner (1999) defines information sharing as obtaining "…dynamic collaboration among business partners, customers, and employees throughout a trading community/market…". The capacity for companies/businesses to morph/transform into whatever the requirements and needs of the market are involves more than only the business transactions (buy, sell and auction events).

Definitely, the e-commerce's advantages are almost the same as those obtained through concurrent engineering in the 1980s (increase market share, minimize time to market and quick responses, etc.). The main differences between in-house concurrent engineering and e-commerce are pervasive info sharing, integrated processes, trust building and cooperation among all supply chain partner companies (across-the-board).

The main possibilities for the sharing of information with supply chain partner companies include sales data, inventory, forecast and demand, production, product planning, order status, transportation, etc., and can be consolidated into three main categories:

- Product Information: Original exchange and sharing of product-related information with SC members was implemented through fax, catalogue, some kind of paperwork, etc. The basic issue caused by such exchanges included miscommunication, higher chances of error (due to extensive human intervention) and delays in sharing information with the trading partners. As per several researchers and practitioners, usually the exchange of data between the upstream (supplier) and downstream (retailer) doesn't tally/match because of the convoluted processes and inefficiencies of manual entry. In addition, only using the latest technology without changing the business processes and proper training of employees, the system will work as "Garbage-in-garbage-out".

- Transaction Information and Customer Demand: Transaction information and customer demand serve as critical sources of information about future expected business, and such information is also used in demand forecasting, transportation planning, production scheduling, etc.
- Information of Inventory: Inventory information includes level (quantity) of inventory, inventory decision models and inventory requirements, all information directly affecting the order placed to the supplier. On the other hand, it seems that information related to inventory is more sensitive than transaction information and customer demand, and the trading partner usually is almost unwilling to disclose it to other supply chain partners. For instance, producers may be unwilling to disclose their real level of inventory/inventory status and/or may share false information of inventory data and sales data to discourage competitors from manufacturing excess products or adding capacities in their system, and suppliers also may use sales and inventory data to achieve better negotiation leverage. In fact, information sharing about inventory has been implemented in many forms. Continuous Replenishment Programs (CRP) and Vendor-Managed Inventory (VMI) are practices usually adopted by two neighbouring supply chain partners. In a typical relationship of CRP, the buyer shares his inventory data with the vendor and asks its vendor to adjust his inventory within a guideline. As per the findings of Lee and Whang (1998) and Gill and Abend (1997), Apple-Fritz Supplier Hub and Wal-Mart's Retail Link Program are excellent examples of sharing inventory information. Vendor Managed Inventory system allows the producer to maintain retailers' inventory levels. The producer has full access to retailers' inventory system, and generating POs (purchase orders) is the responsibility of producer, not retailer, the fundamental difference between regular information sharing and Vendor Managed Inventory (VMI).

2.3 Developing Collaborative Planning Activities

The information sharing systems are very important to managing end-to-end supply chain and there is complete consensus on the idea that it is necessary to integrate information systems (Ellram and Cooper 1990) for successful supply chain management.

According to several researchers, including Houlihan (1985), Stevens (1989), Ellram and Cooper (1990) and Ellram (1991a, b), a significant effort is needed to achieve both effectiveness and efficiency of the information management along the whole SC.

In a traditional culture of supply chain management, flow of demands goes upstream in the chain, and products move in the downstream side (see Fig. 2.5). Distorted demand signals, delay times, and poor or limited visibility of exception situations lead to serious and critical information gaps, and misinformation, which, in turn, creates mistrust over the entire information sharing system mechanism, etc. For instance, when supply chain partners lose their trust in the demand forecast they receive, then typically they start to build up inventory (extra buffer/safety-stock) to protect and deal with demand fluctuation. Finally, these disruptions create bigger

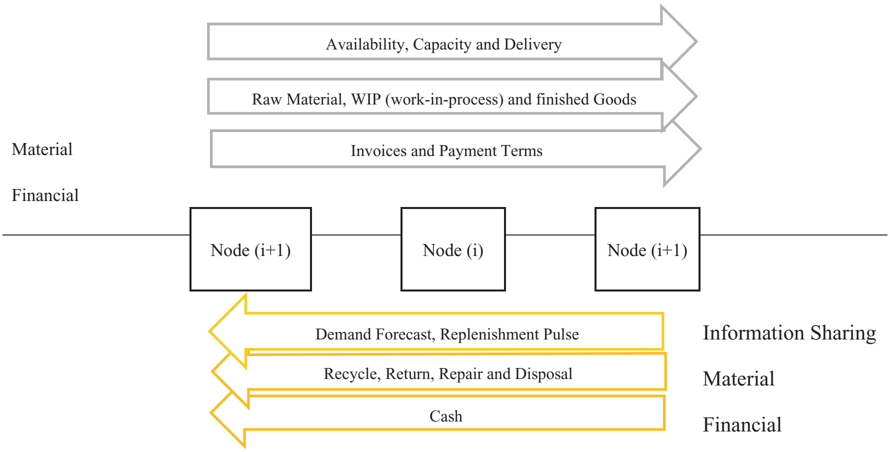


Fig. 2.5 Supply chain flows

changes in forecast demand as they travel upstream in supply chain management (Chen et al. 1999). These disruptions collectively are called "bullwhip effect" and are the result of the inefficiencies in the whole chain of supply.

It is the opinion of many researchers and authors that the advantages of reducing information gaps to form collaborative and productive partnerships is much more valuable than the risk (financial analysts maintain/observe that collaborative planning may minimize up to 50% of inventory for each of the supply chain partners).

According to researchers Gartner (1999), Raghunathan (1999) and Bauknight (2000), the latest collaborative technology enables the supply chain partners to share their business information in SC operations in an organized, stable, agile (real time) and leveraged way. While the synchronization and collaboration of all supply chain members, both outside a firm and within the firm, is now feasible, such integration of SC requires to be carefully studied so as to improve its execution.

From multiple and distinctive perspectives, problems and issues involving the improvement of the integration of supply chains have been studied in existing research literature. The reader, for example, is referred to the given examples below:

Certain research (Chen et al. 1999) studied the significance of having access to demand information for the supply chain upstream partners.

Gavirneni et al. (1997) examined and analysed the advantages of the integration of information flows for a capacitated SC (two-echelon).

Researchers Wikner et al. (1991), Chen et al. (1999) and Towill et al. (1992) have studied the advantages of integrating the supply chain and shrinking, minifying the demand fluctuation transmission along the supply chains (the bullwhip effect).

Several researchers, including Jones and Riley (1985), argue that, supply chain activities of planning and control are required to be taken into consideration for appropriate supply chain integration, because planning and control activities significantly impact the efficiency and effectiveness of the whole SC.

When considering SC activities of planning and control, the SC integration effectiveness can depend on the tools and processes that are used for the integration. This matter deserved attention in the research literature. For example, researcher Stevens (1989) illustrated a model of integration with four phases, which are given below:

- Baseline
- Internal functional integration
- Integrating of demand and supply along the firm's own chain
- Full integration of SC described in order to reach a customer-driven SC instead of a product-driven SC

Hewitt (1994) developed the Stevens' model with a 5th phase which would be dedicated to better re-engineering and administration of the business (global) processes, and pursuing the total efficiency and effectiveness of those processes.

The research of Bowersox (1997) discusses the concept of two different types of integration:

- External integration
- Internal integration

Bowersox summarizes that the firms require an advance level of internal integration to be qualified candidates for external integration (extensive) under SCM. Under the perspective of integrated SC, by reviewing the latest trends and practices in the industry, he found two generic types of integration schemes:

- *The basic integration scheme*, where the supply chain management has made a set of agreements and initiatives to make better relationships with suppliers and customers. With this scheme, advantages are achieved by the sharing of information, planning and common forecasts. Such agreements have been executed several times by establishing new venture firms or specific contracts with distinctive supply chain members.
- *The advanced integration scheme.* Mainly, the concept is to integrate the value creation processes with a total terminal-customer-driven orientation. The objective is collaboration so as to develop and enhance competitiveness by a coordinated effort which is feasible even in a lean environment (it leads to a minimization of the total number of supply chain resources). This integration is usually executed by profound long-term agreements and by contracts between firms, and positions the SC as an effective and efficient competitive unit. Lastly, researcher Bowersox (1997) suggested that the creation of location advantages and time benefits needs information sharing to permit appropriate business contracts related with that objective, and likewise needs an appropriate environment to secure financial transactions.

Another integrated SC model is shown by Scott and Westbrook (1991), recommending the following phases:

- *Study phase,* consider all the things related to lead-times, analyse level of inventory for improvements

- *Positioning phase,* recognize opportunities emerging as significant collaborative activities among the supply chain partners
- *Action phase,* implement former plans

The research of Towill et al. (1992) shows an integration supply chain approach which is somehow similar to that illustrated by Scott and Westbrook (1991). As in the research of Scott and Westbrook (1991), the researcher Towill and his colleagues use the principles of operation management to minimize the amplification of the demand signal along the chain of supply, as the integration is generated.

The research of Ellram and Cooper (1990) recognized some characteristics which would affect a firm's decision to be a member of an integrated SC. However, these characteristics are in connection with the current level of internal process and desired levels of competition with other supply chains. For that reason, the significance of those characteristics may vary during the whole supply chain integration process.

2.4 Supplier Management

In technological-related industries and other industries with innovative products (due to unpredictable demand and short life cycle span), companies build flexible strategies for procurement to cope with demand uncertainty related issues.

To fulfil the requirement and need of flexibility, it is very critical to have the large numbers of suppliers and a wide range of tiered structures of contracts at hand. In some industries, given the demand of a commodity's technology life cycle, global capacity for certain parts can be limited. There is no doubt that global supply chain is very dynamic, vulnerable due to the various causes such as natural disasters (earthquake, flood, etc.), economic disasters, terrorism/terrorist attacks, etc. All these factors play a significant role to create scarcity of material, components, etc.

When products are strategically significant for the organizations, multiple sourcing (for strategic components or parts) is used to decrease exposure to possible loss, but firms are now also consolidating supplier contract types to assure the availability of supply (as well as lowest cost), and these roles are also creating the trend of "tiered contract structures" (Scott, 1987).

Strategic parts or components play very crucial roles in the success of products. As noted by Clark and Fujimoto (1991), firms need to develop functional specialization for purchasing strategic parts/components and this specialization can also be shared between various projects. However, it is also very essential for a better and effective structural design of the firm. In simple words, it is significantly important to take into account functional specialization along external and internal integration.

The research of Giunipero and Brand (1996) developed a framework defining the phases of the evolution towards SCM and, in that framework, how procurement would change. They also defined four development levels of the purchasing role, which are given below:

- Traditional: emphasizing selection of vendor and low price
- Partnership: developing closer association with a supplier to minimize risk and total cost under the cover of trust
- Operational: coordinating material and information sharing to minimize overall cost, improve quality, etc.
- Strategic: applying flexible processes of business to certain circumstances and thereby accomplishing flexibility, competitive edge and velocity/speed in the market

As per Spekman (1989), competitive strategies of procurement focus on purchaser core bargaining power, which allows the purchaser to leverage purchasing on a global scale, improve competitive edge of the firm and reduce internal cost. In the perspective of Arnold (1989), global sourcing is a basic corporate strategy, the aim of which is to "take full benefit of world-wide material resources".

2.5 Approaching the Marketplace

In the last couple of decades, many firms have placed major emphasis on the re-engineering or improvement of their products and processes as well as tried to develop their technology through innovation. Unfortunately, this sometimes caused a poor strategy to retain customers or attract new customers, due to the lack of understanding with customers and external view of "what the customers' need and want". For another side, a good association with customers, customer feedback and marketing intelligence will help not only to improve the prediction precision of demand but also to capture new market share (especially in innovative products), sustain existing customers, promote upselling and attract new customers.

2.6 Key Issues and Challenges for Logistics

During the last couple of decades, the theory of supply chain has become very important, and new developments in structure, such as continuous improvements, collaboration and relationship, information sharing in supply chain integration and end-to-end supply chain. For another side, new challenges and hurdles in supply are also occurring, including cost and quality pressure from the consumer side, low profit margins (due to tough competition), inventory-related issues, environmental-related issues, etc. (Rushton et al. 2000; Zhang et al. 2018; and Khan et al. 2019). The author (Rushton et al. 2000) has divided all key issues into the following parts:

1. Supply
2. Distribution

3. External environment
4. Retail
5. Consumer

2.6.1 Supply

According to several researchers, including Rushton, in the last twenty years, major and crucial developments have arisen in supply chain and inbound logistics. There is no doubt most developments are due to technological innovations. With respect to raw material sourcing and manufacturing, developments are the following:

New supplier relationships, due to supplier development. Lean supply and single sourcing enables buyers and suppliers to work closely.

Manufacturing technology. Technology in the manufacturing area can accommodate more product variations and complicated production requirements.

Transnational sourcing. Companies are moving from local sourcing to global sourcing.

Postponement. Companies use this strategy to delay a product's final configuration until demand occurs (minimization of finished goods inventory in the SC).

Co-makership: partnership between the supplier and buyer to cut down the costs of the SC through information sharing and quality. This is a milestone development in the supply chain.

Co-location. The shared physical location (buyer and supplier) or supplier operations is near the customer manufacturing area/sites.

Related to all of the developments discussed above has been the significant impact of changes in product range such as product's short life cycles, the broad range of products (expected), and also significant increase in demand for sensitive products, e.g. fresh meat and foods. These changes can add some logistics problems under the cover of "speed/fast delivery, temperature control during inventory and transportation, etc."

2.6.2 Distribution

With reference to distribution, again, technology plays a vital role, especially in an operational context:

- Vehicle system (low pollution), demountable bodies
- Limited use of paper (almost paperless environment), especially in depots
- Cross-docking arrangements, operating by stockless depots
- Interactive routing

In many European and Asian countries, the 3PL (third party logistics) industry is in a boom. The main benefits of that outsourcing allow a firm to focus on its core business, without involving and engaging resources in noncore business activities.

On the other hand, outsourcing (without proper analysis) can effect disaster over the whole company's performance. That is why the important question for organizations is "what to outsource".

2.6.3 External Environment

In latest developments of different economic unions, including ASEAN, NAFTA and EU, one of the main consequences is deregulation within these internal markets as well as specific impacts on firms' strategies of logistics. There have been important developments in the European Union (EU) as compared to other unions.

- The harmonization of legislation (across different countries)
- Tax harmonization
- Transport deregulation
- Minimization of traffic barriers
- Elimination of cross-border requirements of customs

Within logistics, many firms have been led to reassess their whole logistics strategy to a new non-national cross-border structure. (Many firms significantly minimized inventory cost, storage cost and depot numbers while improving customer service.)

Second, significant developments are increased importance of environmental issues and green logistics. This development has occurred by "activity of pressure groups and also public awareness" which includes:

- Promotion of rail-transport over road-transport
- Awareness of green products, reverse logistics (reuse, refill, recycling, remanufacturing and disposal)
- Design of environmental-friendly products or product design to facilitate recycling and repair, etc.

Road congestion: one of the external impacts, which creates negative effect on some of the latest concepts of logistics, including quick-response and just-in-time. In western countries, government and firms try to minimize congestion through lorry bans, combination of road tolls, time restrictions, taxes, etc., but, unfortunately, these all are not permanent solutions and also increase the logistics cost.

Scarcity of skilled labour: According to several researchers, including (Khan et al. 2019; Zhang et al. 2018), the latest knowledge of best practices was known to few logistics managers and some managers do not have relevant experience. There are a couple of reasons to hire low-skilled employees. One major reason is scarcity of skilled people in the market (Zhang et al. 2018). Secondly, sometimes firms hire both low-skilled and experienced employees due to limited budget or cost minimization/cost-cutting schemes.

2.6.4 Retail

Overall, there has been a growth in multiple chain stores such as hypermarkets and superstores. On the other hand, there has been a corresponding decline in independents or small stores. These changes have had an influence on strategies of operations and logistics. Perhaps the broad effect, however, has been from the consolidation of inventory minimization policies:

- Just-in-Time concepts and philosophies
- VMI (vendor managed inventory) policies
- Minimization of the number of stock-holding depots
- The maximization of retail selling space (at the expense of retail stock rooms)
- The minimization in depot inventory-holding due to policies of cost saving

Information technologies also have a significant role in the retail system such as POS (point-of-sale), which provides (information sharing) accurate and timely signal of stock replenishment requirements. The consequences are the minimization of buffer stocks and safety stock in favour of continuous product flow into the stores, increases in efficiency and fewer defects or errors (due to information sharing and usage of latest technology).

2.6.5 Consumer

In the last couple of years, the phenomena of "home shopping, mail-order catalogues and direct selling" dramatically have increased, especially in the USA, Europe and China. It now seems likely to break through and create important and significant in-roads into conventional retail shopping. Again, such change is taking place through the development of technology and consumer awareness (home computers, internet, online banking, self-service banking, etc.). Simply, any important and significant change will have an impact on logistics. Typical implications will be the following.

- Increase in direct-sell (home delivery)
- Shops become showrooms, where replenishment of stock is no longer an issue
- Traditional/existing delivery systems will grow, such as post-delivery
- Online order systems (more accurate and reliable information sharing between customer and manufacturer)
- A high rate of returns (no or limited involvement of intermediary)

Finally, the main change is that non-store shopping has economically turned the corner, with important and significant advances in the spread of "internet and computer technology".

Discussion Questions

1. Discuss the disconnected network, connected network and semi-overlapped network of supply.
2. Draw a diagram for disconnected and connected networks.
3. How can information sharing play a role in solving issues in complex supply chain?
4. Draw and discuss the supply chain flows.
5. What are the key issues and challenges for logistics? Discuss in detail.

References

APCIS-CSCP-Book. (2013). Certified supply chain professional books. In *American Production and Inventory Control Society*. http://www.apics.org/credentials-education/credentials/cscp/preparation

Arnold, U. (1989). Global sourcing—An indispensable element in worldwide competition. *Management International Review, 29*(4), 20.

Bauknight, D. N. (2000). The supply chain future in the e-economy. *Supply Chain Management Reviews, 4*(1), 28–55.

Bowersox, D. J. (1997). Integrated supply chain management: A strategic imperative, presented at the council of logistics management. In *1997 Annual conference*, 5–8, October, Chicago, IL.

Chandra, C., & Grabis, J. (2007). *Supply chain configuration. Concepts solutions and applications*. New York: Springer.

Chen, F., Drezner, Z., Ryan, J. K., & Simchi-Levy, D. (1999). *Quantifying the bullwhip effect in a supply chain: The impact of forecasting, lead-times information*. Northwestern University.

Clark, K. B., & Fujimoto, T. (1991). *Product development performance: Strategy, organization and management in the world of auto industry*. Boston: Harvard Business School.

Ellram, L. M. (1991a). A managerial guideline for the development and implementation of purchasing partnerships. *International Journal of Purchasing and Materials Management, 27*(3), 2–9.

Ellram, L. M. (1991b). Supply chain management: The industrial organization perspective. *International Journal of Physical Distribution and Logistics Management, 21*, 13–22.

Ellram, L. M., & Cooper, M. C. (1990). Supply chain management, partnership, and the shipper—Third party relationship. *The International Journal of Logistic Management, 1*(2), 1–10.

Gartner Group. (1999). C-commerce: The new arena for business applications. *Business Wire*, 16.

Gavirneni, S., Kapuscinski, R., & Tayur, S. (1997). The bullwhip effect in supply chains. *Sloan Management Review, 38*(3), 93–102.

Gill, P., & Abend, J. (1997). Wal-Mart: The supply chain heavyweight champ. *Supply Chain Management Review, 1*(1), 8–16.

Giunipero, L., & Brand, R. R. (1996). Purchasing role in supply chain management. *The International Journal of Logistics Management, 7*(1), 29–38.

Hewitt, F. (1994). Supply chain redesign. *The International Journal of Logistics Management, 5*(2), 1–9.

Houlihan, J. B. (1985). International supply chain management. *International Journal of Physical Distribution and Materials Management, 15*, 22–38.

Jones, T. C., & Riley, D. W. (1985). Using inventory for competitive advantage through supply chain management. *International Journal of Physical Distribution and Materials Management, 15*, 16–26.

Khan, S. A. R., & Dong, Q. (2017a). Impact of green supply chain management practices on firms' performance: an empirical study from the perspective of Pakistan. *Environmental Science and Pollution Research, 24*(20), 16829–16844.

Khan, S. A. R., & Dong, Q. (2017b). Does national scale economic and environmental indicators spur logistics performance? Evidence from UK. *Environmental Science and Pollution Research, 24*(34), 26692–26705.

Khan, S. A. R., Dong, Q., SongBo, W., Zaman, K., & Zhang, Y. (2017). Environmental logistics performance indicators affecting per capita income and sectoral growth: evidence from a panel of selected global ranked logistics countries. *Environmental Science and Pollution Research, 24*(2), 1518–1531.

Khan, S. A. R., Dong, Q., SongBo, W., Zaman, K., & Zhang, Y. (2017b). Travel and tourism competitiveness index: The impact of air transportation, railways transportation, travel and transport services on international inbound and outbound tourism. *Journal of Air Transport Management, 58*(1), 125–134.

Khan, S. A. R., Dong, Q., Zhang, Y., & Khan, S. S. (2017). The impact of green supply chain on enterprise performance: In the perspective of China. *Journal of Advanced Manufacturing Systems, 16*(3), 263–273.

Khan, S.A.R., Zaman, K., and Zhang. (2016). The relationship between energy-resource depletion, climate change, health resources and the environmental Kuznets curve: Evidence from the panel of selected developed countries. Renewable and Sustainable Energy Reviews, 62(9), 468-477.

Khan, S. A. R., Zhang, Y., Anees, M., Golpîra, H., Lahmar, A., & Dong, Q. (2018). Green supply chain management, economic growth and environment: A GMM based evidence. *Journal of Cleaner Production, 185*(6), 588–599.

Khan, S. A. R., Zhang, Y., Golpîra, H., & Sharif, A. (2019). The nexus between corporate social responsibility and corporate performance: An empirical evidence. *LogForum Scientific Journal of Logistics, 15*(2), 291–303.

Lee, H., & Whang, W. (1998). *Information sharing in a supply chain*. Research Paper No. 1549, Stanford University.

Raghunathan, S. (1999). Interorganizational collaborative forecasting and replenishment systems and supply chain implications. *Decision Sciences, 30*(4), 1053–1071.

Rice, J. B., & Hoppe, R. M. (2001). SC vs. SC: The hype and the reality. *Supply Chain Management Review, 5*(5), 46–54.

Rushton, A., Oxley, J., & Croucher, P. (2000). *The handbook of logistics and distribution management* (2nd ed.). London: Kogan Page.

Scott, W. R. (1987). *Organization: Rational, natural and open systems* (2nd ed.). Englewood Cliffs, NJ: Prentice-Hall International.

Scott, C., & Westbrook, R. (1991). New strategic tools for supply chain management. *International Journal of Physical Distribution and Logistics Management, 21*(1), 23–33.

Shore, B. (2001). Information sharing in global supply chain systems. *Journal of Global Information Technology Management, 4*(3), 27–50.

Spekman, R. E. (1989). A strategic approach to procurement planning. *Journal of Purchasing and Materials Management*, 25th Anniversary, 4–8.

Stevens, G. C. (1989). Integrating the supply chain. *International Journal of Physical Distribution and Materials Management, 19*, 3–8.

Towill, D. R., Naim, N. M., & Wikner, J. (1992). Industrial dynamics simulation models in the design of supply chains. *International Journal of Physical Distribution and Logistics Management, 22*(1), 3–13.

Wikner, J., Towill, D. R., & Naim, N. M. (1991). Smoothing supply chain dynamics. *International Journal of Production Economics, 22*(3), 231–248.

Zhang, Y., Golpîra, H., & Khan, S. A. R. (2018). The impact of GSCM on Manufacturing enterprise's performance. *Journal of Advanced Manufacturing Systems, 17*(4), 445–459.

Chapter 3
Global Sourcing

Globalization and *worldwide* sourcing are terms sometimes used interchangeably. In the last couple of decades, the trend towards global sourcing has increased dramatically. Developing countries, including India and China, show us a new seller's market, and, on another side, also represent opportunities on the side of buying, such as cost savings. In the seller's market, customers with more wealth desire high-standard brands. For instance, the French company L'Oreal badly failed to earn a healthy profit competing in the Indian market of low-priced shampoo. But when L'Oreal shifted its efforts to the middle class, healthy profits followed, with product retail price 4–20 times higher than their competitors. In India, almost 200 million middle-class people desire foreign brands.

On the side of supply, cost advantages are associated with sourcing from developing countries. According to many researchers, cost advantage is the major and basic reason for global sourcing. However, other crucial advantages recognized are quality, innovation and availability. From the United States perspective, one reason for increased international sourcing is the "large United States merchandise trade deficit", and this deficit in the year of 2006 was beyond 700 billion dollars. China is bearing much pressure from outside for the growing deficit. United States has stepped up pressure on China to allow its currency to float freely and also to open its markets. And the pressure is justified; a look at the top United States trading partners demonstrates that Canada is in the lead, with China second (see Table 3.1). Other countries include Japan, Mexico, the United Kingdom, Malaysia, France, Germany and South Korea. Interestingly, India is not mentioned as the US top trading partner because services like call centres cannot be captured through the data. In the strategies of global sourcing, offshoring and outsourcing of services are a big part.

S. A. Rehman Khan, Z. Yu, *Strategic Supply Chain Management*, EAI/Springer Innovations in Communication and Computing,
https://doi.org/10.1007/978-3-030-15058-7_3

Table 3.1 Top 10 United States trading part ners

Canada	534
China	343
Mexico	332
Japan	208
Germany	130
United Kingdom	99
South Korea	78
Taiwan	61
France	61
Malaysia	49

[a]All amounts are in billions of US dollars

3.1 Difference Between International Purchasing and Global Sourcing

International purchasing means a commercial purchasing transaction between a supplier and a buyer located in different regions or countries, and this purchasing is somehow more difficult than a local purchase (domestic purchase). Companies must deal with several challenges, including currency fluctuations, longer lead-times, huge in-transit inventories, higher risk or threat of terrorism, time differences and communication barriers. On the other hand, in the perspective of complexity and scope, global sourcing is different from international purchasing, involving coordinating and integrating processes, technologies, materials, design and suppliers across the globe.

3.1.1 Overview of Global Sourcing

Over the last four decades, the United States firms that practice global sourcing have increased radically. In the year of 1973 almost 21% of firms were purchasing internationally, and this percentage increased dramatically to approximately 45% in the year of 1975. In 1970s, the oil embargo, together with other basic materials shortages, forced buyers to find foreign suppliers. Several foreign manufacturers also became cost leaders and quality leaders across many industries. United States companies seeking after the imported items significantly in the year of 1975, for instance, were manufacturing machinery and equipment followed by mechanical, electrical and chemical components.

In the years 1975–1982, the US firms involved in global sourcing increased from 45% to 56% approximately. This increase was due to the inability of local manufacturers and suppliers to compete on quality, delivery and price/cost. Usually, foreign suppliers could provide relatively high quality parts at a lower total cost. For some, survival against competitors (foreign) led to sourcing from the same suppliers that have the ability to support the competition.

In the years 1982–1987, many companies were looking to foreign suppliers to fulfil their purchase requirements, and the percentage increased from 56 to 71%. Additionally, at this time dollar (US) appreciated dramatically, compared to other currencies. The imports to the United States became less expensive, and United States firms found it difficult to compete and export to international markets.

Since the year of 1987, international trade and purchasing has accelerated rapidly. With the end of the Cold War, the opening of trade with new markets in Eastern Europe was coming, Russia and China, which in turn has promoted the development of new sources and new markets of suppliers. In addition, restrictions of export and imports were decreasing, partly as a function of the General Agreement on Tariffs and Trade (GATT) agreement on free trade, which was signed in Uruguay in late 1993. Additionally, North American Free Trade Agreement (NAFTA) passed in the year of 1993 had forced and increased trade among Canada, Mexico and the United States. Furthermore, trade talks between the USA and other countries like China and Japan also minimized restrictions of trade.

According to several researchers, the trend towards international sourcing and global sourcing are increasing continuously rather than decreasing. There are many business drivers that will influence firms' purchasing strategies in the upcoming 13 years of cost leadership and globalization (Locke 1996; Khan 2015a, b, c). Besides lowering cost, there are several significant reasons for companies will continue to buy from outside countries.

3.2 Why Global Sourcing?

Although the above discussion gave several brief reasons for international purchasing, let's discuss in detail and formally why firms pursue global sourcing.

Price/Cost Advantages

After including all the costs which are associated with international purchasing, final savings of approximately 20–30% may be available. Cost differences between different countries occur due to the following reasons:

- Different productivity levels
- Lower labour rates
- Agreement to accept a low profit margin
- Government subsidies
- Differences of exchange rate
- Lower-cost input for materials

During the buying process, purchasers should consider only those suppliers that have ability and capability to meet rigid delivery schedules and high standards of quality, while far too often cost/price differentials become the basic criteria behind global sourcing. But it is very significant that except for acquisition cost, buyers cover all the costs related to sourcing materials/components.

Total Cost of Ownership

Total cost of ownership needs a buyer to identify and calculate cost beyond only the acquisition price of an item and transportation costs. Formally, total cost of ownership (TCO) is defined as the present value of all costs related with a material, component or service that are incurred over its forecasted life.

A majority of large companies' base purchase decisions and evaluate suppliers on cost elements but not the unit price, and transportation. Research illustrates, however, that firms differ broadly as to the cost components to be added in a total cost of ownership analysis.

Typically following costs can be distributed into four main categories:

- Purchase Price: how much needs to be paid to the supplier for the service, capital equipment or material.
- Acquisition Costs: all costs, which are correlated with delivering the service, capital equipment or product to the location of the customer, for instance, administration cost, taxes, freight and product/service itself.
- Usage Costs: in the case of a supply-chain service, those costs which are in connection with the performance of the service that are not contained in the price of purchase. In the situation of a product, those costs which are connected with converting the materials/parts that have been purchased into the final products and supporting it during its life. In the situation of capital equipment, all costs which are related to operating the equipment during its life. For instance, usage costs include conversion, inventory, scrap, installation, warranty, opportunity costs and downtime.
- End-of-life costs: all costs incurred when a service, product or capital equipment reaches the final/end of its service life, net of amounts received from the sale of remaining equipment/product (salvage value). For instance, end-of-life costs are disposal costs, project termination costs, obsolescence and clean-up costs.

Access to Process Technology and Product

In the world, the United States is not the incontestable producer of technology and product leader any more. Some other countries have developed themselves in leading edge technologies in several areas, and components of electronics is one of them. Buyers that need these parts/components have known that Asian suppliers are technology leaders. Obtaining access to the latest technologies leaves several firms with no or limited choices except to go towards global sourcing.

Quality

There is no doubt, some countries are obsessed with quality of products, including Germany, Japan, and manufacturers within these countries have captured higher shares of the world market covering a wide range of industries. Many manufacturers of United States are stuck with local suppliers, and those manufacturing companies produce poor or low quality products. In addition, if those manufacturing companies begin to source components from foreign suppliers, it would involve the hope of improving final product quality. In the perspective of the United States, the increasing trend in global sourcing is basically due to lower overall price and higher quality.

Access to the Source Available

Strict environmental regulations and economic recessions or mergers usually result in suppliers quitting certain lines of business because of the loss of business volume and higher costs. This capacity minimization makes it more and more complex and harder for purchasers in the United States to source locally/domestically. While today copper manufacturers are enjoying the fruitful advantage of tight capacity and higher prices, this was not always the case. In the beginning and during the mid-1980s, United States copper manufacturers shut down several mines due to "inefficient process technology and lower prices". Many buyers of copper turned to foreign suppliers to fulfil their requirements. With the shortage of supplier availability and capability in the machine tool, electrical product and automotive industries often leave local buyers without possible supply alternative except to source from other countries.

Introduction of Competition in Local Markets

Many companies also use global sourcing to introduce competition in domestic markets to maintain service levels and combat prices of domestic suppliers in their industry. On the other hand, in those industries which are characterized by limited local supplier competition, this can weaken a local supplier's power, as well as break certain practices, which is not favourable for buyers.

Reaction to Competitors' Buying Patterns

This is one of the least-mentioned reasons in many research papers and books. Also, many companies do not want to acknowledge that they are only reacting to the competitors' practice of global sourcing or international purchasing. Firms only try to copy the factors that give a benefit to their competitors. Simply put, companies source from the same country, regions or suppliers that a competitor uses.

Establishment of a Presence in Foreign Country

In order to establish a presence in foreign countries, many companies begin sourcing from different parts of the world. But global sourcing or international purchasing depends on company-to-company policies. Although the exact reasons for every firm sourcing globally or buying internationally will differ, major reasons for sourcing from foreign countries have been discussed here.

Barriers to Global Sourcing

According to several researchers, companies with no or little experience of global sourcing face several hurdles and barriers when they want to begin global sourcing, and mostly these hurdles and barriers are the following:

- Lack of knowledge and skills
- Resistance to change
- Longer lead-times
- Time differences
- Different customs rules
- Cultural differences
- Currency fluctuations

- Supplier selection and evaluation problems

The lack of skills and knowledge added to the complexities of sourcing from other countries makes barrier for a firm to consider global sources. These disadvantages involve primary lack of skills and knowledge to develop potential sources of supplies and a lack of understanding of the additional requirements of documentation for sourcing from other countries. Given below are the following requirements of documentation.

- Bills of lading
- Import licences
- LCs (letters of credit)
- Inspection certificates
- Packing lists
- Certificates of insurance
- Certificates of origin
- Commercial invoices

Longer lead-time is also one of the major barriers in global sourcing due to material forecasts becoming more difficult and also huge inventories being in transit. In global sourcing or international purchasing, because of the probability of delays in customs or any other delays from supplier side, buyers should manage delivery dates as closely as possible. Sourcing from other countries also brings about an excess degree of logistical, financial and political risk (Khan 2015a, b, c).

Resistance to change is a natural phenomenon. Whenever companies shift their sourcing strategy from domestic sourcing to global sourcing, they face resistance from different forces mostly from employees, due to the new and complex procedure of global sourcing, and sometimes from domestic suppliers and customers.

According to research findings of Khan (2015a, b, c), currency fluctuations play a significant role in global sourcing. Many companies use hedging to deal with currency fluctuations. Other barriers related with the lack of knowledge about suppliers (foreign) are customs rules and regulations of supplier countries, business practices, cultural differences, communication and time differences across countries of the world. In global sourcing, lack of knowledge and understanding of suppliers' country laws can create serious problems in various stages of supplier–buyer relationships. These barriers will be discussed in more detail in the next section.

The simplest way to overcome or minimize these hurdles and barriers is to provide education and training programs to the buyer firm's employees, which can serve to generate support for the process and help to reduce and overcome "anxiety of change". Furthermore, communication-related barriers can be minimized through the usage of latest technology, such as email, GPS and barcoding. These systems will help in tracking materials and components, and they will also increase data accuracy. Finally, all the techniques to minimize and overcome challenges of global sourcing will be effective when senior management will show their seriousness and demonstrate their support for global sourcing.

3.3 Information of Global Supplier

After identifying products/materials to buy internationally, a company needs to gather information and evaluate information of the potential suppliers or maybe find an intermediary firm to perform this task. This will be very difficult and harder for the company, if a firm has no or limited experience with foreign suppliers. The following directories given below can provide valuable information about suppliers.

3.3.1 International Industrial Directories

Industrial directories are primary sources of information about suppliers by region and by industry. On the Internet, hundreds of directories are available, which can provide international supplier contacts. Some examples are given below:

- *The World Marketing Directory* having almost 50,000 key businesses in all lines having high sales volume and at least an interest in foreign trade; it is published by Dun and Bradstreet.
- *ABC Europe Production* includes contact information for 130,000 European manufacturers that export their products.
- *Marconi's International Register* covers around 45,000 worldwide company contacts.
- *The Hong Kong Business Directory* covers almost all exporters, manufacturers, importers and services companies of Hong Kong.

These and many other directories are available on CD-ROM.

3.3.2 Trade Shows

Trade shows also provide a great opportunity to collect suppliers' information and detail. Usually these shows are conducted on a yearly basis. Internet searches will provide complete detail of trade shows, including time, place and how to register. For instance, the International Manufacturing Technology show is conducted every 2 years in the United States.

3.3.3 Trading Firms

Trading firms also provide a way to overcome the barriers and hurdles that buyer companies face due to no or limited experience of purchasing from foreign suppliers. Trading firms offer a wide range of services to fulfil buyer requirements, including issuing LCs (letters of credit), paying customs charges, paying brokers fees, insurance, ocean carrier, dock fees and domestic freight bills. Finally, one detailed invoice for all services will be received by customers/clients, which are performed by trading firms.

The use of a trading company for complete services may actually achieve a relatively low total cost for international buyers as compared with performing every service individually.

3.3.4 Third-Party Services

Third-party companies are available as in foreign countries to fulfil the buyer's requirements. They select supply sources, evaluate the sources and complete all the paperwork/documentation, which is required in the international purchasing process. If a buyer company lacks knowledge and experience in international purchasing, these agents and brokers can provide services and act as intermediaries between buyers and sellers.

According to several researchers, the selection and evaluation of their suppliers is one of the most significant processes which companies perform. Many companies usually evaluate their suppliers on a yearly basis. But it is not any hard and fast rule; the evaluation process depends on company-to-company policies. Traditionally, most firms select suppliers only on the basis of price/cost. But over the last four decades, the supplier selection process has not only depended on prices/cost. Supplier evaluation and the selection process and related decisions are taking on higher importance today.

3.4 Supplier Selection Issues

The supplier selection process is very important to identify and recognize a right supplier for a company, because only the right supplier can fulfil the buyer's requirement and satisfy its needs. There is no doubt, foreign supplier selection is more difficult and complicated than selection of domestic suppliers. During the selection and evaluation process of foreign suppliers, the following questions should be considered:

- Is there a major total cost difference between the foreign and domestic suppliers with factoring in additional cost elements?
- Will the foreign suppliers sustain any price difference over time?
- What kind of effects will longer pipelines and increased levels of average inventory have?
- What are the supplier's quality and technical level?
- Can the supplier have the ability to back the latest designs?
- What is the supplier's quality performance?

- What types of quality systems does it have?
- Is the supplier capable to give stable and consistent delivery schedules?
- How much lead-time does the supplier require to deliver materials/products?
- Can the company construct a long-term relationship with its supplier?
- Is the supplier trustworthy?
- What is the supplier's financial background?
- What is the supplier's reputation in the market?
- What are the payment terms of the supplier?
- How can the supplier deal with and manage currency exchange issues?
- Are proprietary and patents technology safe with this supplier?

Initially, buyers use trial orders to evaluate a new supplier. After successful evaluation, buyers give big orders to the supplier and make records of a supplier's performance.

3.4.1 Cultural Differences

One major barrier in global sourcing is the cultural difference that usually happens when trade across the border. Well, culture of a nation is a multidimensional idea composed of various factors, including:

Religion
Customs
Values and attitudes
Language
Education
Social institutions

Behaviour and values are the two important cultural differences that will have an effect on the supply manager.

Values: values are common group norms or beliefs that are internalized; they will impact the people's way of thinking.

Behaviour: behaviour is mainly on the basis of attitudes and values; it has an effect on the way people act.

Good understanding of culture will definitely better a buyer's effectiveness and comfort level when doing business globally.

The differences in culture between two countries can lead to some rude or unwelcome obstacles or events when purchasing globally. For example, in the Asian region, standard procedures for contracting and negotiation are totally different as compared to the USA. Dealing with cultural issues and hurdles requires companies and buying personnel to manage different beliefs about contracting. In some developing countries, including India, Nepal and Bangladesh, ethical issues such as bribery, speed money and other practices differ totally from those in American organizations.

3.4.2 Communication Differences

In global sourcing, language and communication differences are not a new barrier. Due to communication barriers, buyers are unable to deal or negotiate with suppliers effectively and efficiently. Most differences of communication styles among many nations or regions are the speed of information transmission and levels of content. For instance, American people tend to provide short messages with the conclusions expressed first. Usually this style is not suitable in many Asian countries and some European countries.

Dick Locke, a senior manager of procurement, who has managed purchasing operations in multiple countries, including Mexico, Tokyo, the Middle East and Europe, gives the following advice about communication and language differences.

- If a supplier's first language is not English, then the purchaser should be responsible for preventing problems of communication.
- Use an interpreter to avoid problems.
- To aid in communication, try to use simple words and speak slowly. Avoid using jargon, military and sports metaphors in your language.
- Finally, the conclusion of a meeting and decisions should be in written form to avoid misunderstanding.

3.5 Logistical Problems

In global sourcing, the purchaser should take the potential effects of long lead-time on management's capacity to plan and manage SC into account. While developed industrial countries have the latest developed infrastructure, in many countries shipping delays are a possibility. For instance, China has 6.5 km of railways, 25 km of paved roads, 17 km of runways per 1000 km^2 of land. On the other hand, the USA has 612 km of paved roads 22.7 km of railways and 189 km of runways per 1000 km^2.

Usually, the fewer paved roads, railroads and airports are, the higher cost of logistics and less reliable deliveries can be. In United States, the percentage of logistics costs to total GDP is almost 10%, but it may be as high as 25% of total GDP in developing countries. So this becomes a factor when calculating the total landed cost for the products from outland. One researcher concluded that it takes as high as 50% more cost to carry goods in China than in Europe or the USA. The land transportation density in China is 22% of that in the USA and 5% of that in Japan, and many roads are in poor or unpaved condition, which adds extra transit times. What is more complex is that China lacks a cross-country carrier and the size of the average Chinese trucker's fleet (two vehicles) is small. In addition, rules and regulations between different provinces require frequent changes of trucks when passing, crossing the boundaries of provinces.

All global goods moved by a standard set of terms are called *incoterms*. Terms are internationally recognized standard definitions explaining the accountabilities of a seller and buyer in a transaction (commercial). Incoterms are used coordinated with an agreement, contract of sales. The seller and buyer have an array of terms from which to choose, depending on the extent to which each party wants to be involved in the insurance and transportation, etc. One of the complications is determining the modes by which global godos will move from origin to destination (Table 3.2). Usually, in global sourcing, multiple modes of transportation are involved.

Modes of Transportation

There are many incoterms which are used only for inland and sea transportation, for example, FOB, CIF, DES, CFR, FAS and DEQ. In addition, there are many incoterms, such as CPT, DAF, EXW, CIP, DDP and DDU, which are generally used for any mode of transportation.

Table 3.2 Incoterms 2000

Service	Ex works (EXW)	Free on board vessel (FOB)	Free alongside ship (FAS)	Free carrier (FCA)	Cost and freight (CFR)	Carriage insurance paid to (CIP)	Carriage paid to (CPT)
Warehouse storage	Seller	Seller	Seller	Seller	Seller	Seller	Seller
Warehouse labour	Seller	Seller	Seller	Seller	Seller	Seller	Seller
Export packing	Seller	Seller	Seller	Seller	Seller	Seller	Seller
Loading charges	Buyer	Seller	Seller	Seller	Seller	Seller	Seller
Inland freight	Buyer	Seller	Seller	Buyer/ Seller [a]	Seller	Seller	Seller
Terminal charges	Buyer	Seller	Seller	Buyer	Seller	Seller	Seller
Fowarder's fees	Buyer	Buyer	Buyer	Buyer	Seller	Seller	Seller
Loading on vessel	Buyer	Seller	Buyer	Buyer	Seller	Seller	Seller
Air/Ocean freight charges on arrival	Buyer	Buyer	Buyer	Buyer	Seller	Seller	Seller
At destination duty, customs	Buyer	Buyer	Buyer	Buyer	Buyer	Seller	Seller
Clearance and taxes	Buyer	Buyer	Buyer	Buyer	Buyer	Buyer	Buyer
Delivery to destination	Buyer	Buyer	Buyer	Buyer	Buyer	Buyer	Buyer

(continued)

Table 3.2 (continued)

Service	Cost freight and insurance (CIF)	Delivered at frontier (DAF)	Delivered duty unpaid (DDU)	Delivered ex quay duty unpaid (DEQ)	Delivered ex ship (DES)	Delivered duty paid (DDP)
Warehouse storage	Seller	Seller	Seller	Seller	Seller	Seller
Warehouse labour	Seller	Seller	Seller	Seller	Seller	Seller
Export packing	Seller	Seller	Seller	Seller	Seller	Seller
Loading charges	Seller	Seller	Seller	Seller	Seller	Seller
Inland freight	Seller	Seller	Seller	Seller	Seller	Seller
Terminal charges	Seller	Seller	Seller	Seller	Seller	Seller
Fowarder's fees	Seller	Seller	Seller	Seller	Seller	Seller
Loading on vessel	Seller	Seller	Seller	Seller	Seller	Seller
Air/Ocean freight charges on arrival	Seller	Seller	Seller	Seller	Seller	Seller
At destination duty, customs	Buyer	Buyer	Seller	Seller	Buyer	Seller
Clearance and taxes	Buyer	Buyer	Buyer	Buyer	Buyer	Seller
Delivery to destination	Buyer	Buyer	Seller	Buyer	Buyer	Seller

Incoterms 2000 are internationally accepted commercial terms that define the respective roles of the seller and buyer in the arrangement of transportation and other responsibilities and clarify when the ownership of the merchandise takes place. They are used in conjunction with a sales agreement or other method of transacting the sale

[a]There are actually two FCA terms: FCA Seller's Premises, where the seller is only responsible for loading the goods and not responsible for inland freight; and FCA Named Place (International Carrier), where the seller is responsible for inland freight. (Source: www.i-b-t.net/incoterms.html)

3.5.1 Legal Issues

Every country has its different legal system. In the USA, case law usually results in detailed contracts as compared to other countries which use civil law. In IBM, before the purchasing process redesigned in the 1990s, it was very common for purchasing agreements to be 30–50 pages in length. After redesigning the agreements, the documents were minimized to approximately six pages. Some countries are unwilling to do transactions or cope with the American legal system or lengthy agreements/contracts.

A legal system in advanced industrial countries provides the purchaser protection. On the other hand, this is not true in many developing or underdeveloped countries. For example, various countries do not provide enough protection against the piracy of material/intellectual property.

3.5.2 *Organizational Issues*

In global sourcing, usually firms face multiple organizational issues, some of which can be solved through international purchasing offices (IPO). IPOs are a logical way to fulfil a firm's increasing global sourcing requirements. Companies open IPOs in different parts of the world and these IPOs handle the sourcing needs of the whole company, not only one division or buying unit. Compared with smaller or medium ones, multinational companies are more likely to operate IPOs. In the year of 2006, one research study on global sourcing showed that the increase in International Purchasing Offices within the previous 5 years corresponded to an increase in higher-level worldwide sourcing. Companies give operational support from the development phase by using their International Purchasing Offices through contract management of the global agreement. Specific International Purchasing Offices activities cover export and import requirements, measuring performance of suppliers, resolving issues of quality and delivery. The major functions of IPOs have been illustrated in Fig. 3.1.

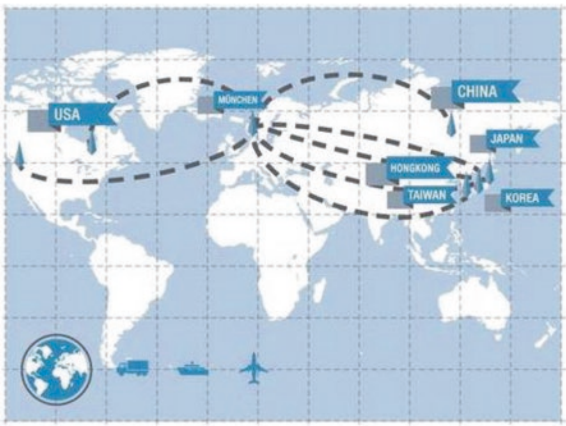


Fig. 3.1 Role of IPOs (International Purchasing Offices)

3.6 The Selection and Evaluation Process

It is widely deemed among many researchers and experts that there is no one best approach or technique for selection and evaluation of suppliers; companies use a wide range of approaches for supplier selection and the evaluation process. Regardless of the approach adopted, the main aim of the assessing process should be to minimize risk and increase value to the firm.

A firm must select appropriate suppliers it can deal with over an extended period. The efforts of supplier selection and evaluation are in connection with the importance and significance of the required services and goods. Relying on the supplier evaluation approach used, the process can be a rigorous effort demanding the highest commitment of resources. This part will focus on the multiple issues involved in efficiently and effectively selecting and evaluating suppliers. Following are the major steps covered in the process of supplier assessment and selection as shown in Table 3.3.

Table 3.3 Supplier selection and evaluation process

1. Recognize the need for selection of supplier
2. Classify key sourcing requirements
3. Determine sourcing strategy
4. Identify potential sources of supply
5. Limit suppliers in selection pool.
6. Determine method of supplier selection and evaluation
7. Select supplier and reach contract

3.6.1 Recognize the Need for Supplier Selection

Usually the first step in supplier selection and the evaluation process involves identifying that there is a requirement to evaluate a supplier and then select it for goods and services. A manager of purchasing might start the process of supplier assessment in anticipation of an expected future requirement of purchase. Purchasing may have early insight into new product development plans through participation on a product development team. In this scenario, engineering staff can give some initial specifications on the type of service, process and material, but not in specific details. This initial information as to material, service and process may be enough to validate commencement of initial evaluation of supply sources.

3.6.2 Classify Key Sourcing Requirements

During the assessment and selection of supplier, it is significant to understand the requirements that are essential to that purchase. Usually these requirements, decided by external customers and internal customers in the value chain, can differ broadly from product to product. Even though different requirements may exist for each and every evaluation, certain categories—supplier cost, delivery and quality—are always included in the process of evaluation.

3.6.3 Determine Sourcing Strategy

No single sourcing strategy method can satisfy all the requirements of the purchaser, because the purchasing strategy adopted for a specific product or service will influence the method taken during the process of supplier assessment and selection. Usually there are several major decisions that a buyer initially makes when developing a strategy of sourcing. However, as a result of user preferences, these change business goal and market situations. The considerations developed throughout the phase of strategy need to be re-evaluated during the process of selection. The strategy options selected will significantly influence the evaluation and selection process of supplier. Critical and important decisions include the following bullet points:
Single versus multiple sources of supply

- Short-term versus long-term contracts of purchase
- Selecting suppliers that offer design support versus those that lack design capability

- Full-service versus non-full-service suppliers
- Foreign suppliers versus domestic suppliers
- Expectation of a close working relationship versus arm's-length buying

3.6.4 Identify Potential Sources of Supply

Buyers depend on many sources of information when they recognize or identify potential supply sources. The degree to which a purchaser must search or the effort put forth towards the search is a function of many factors or elements, including how well suppliers (existing) may satisfy quality, cost and other variables of performance. The strategic significance of the purchase requirement also impacts the intensity or force of the search. The following provides various recommendations about the intensity and effort of search required during the process of supplier evaluation:

- High capability of existing suppliers + High strategic significance of requirement = Minor to moderate info search
- Strong capability of existing suppliers + Low strategic significance of requirement = Minor info search
- Weak capability of existing suppliers + Low strategic significance of requirement = Minor to moderate info search
- Weak capability of existing suppliers + High strategic significance of requirement = Major info search

The following part will discuss many resources which may be beneficial when trying to identify sources of supply.

Existing Suppliers

Existing suppliers can be a basic source of information. The purchaser usually looks to existing suppliers to meet a new requirement of purchase. The fruitful benefit of this approach is that the buyer does not have to add or maintain an additional supplier. Also, the purchaser can fulfil the requirement and buy from existing, already familiar suppliers that may not only save time but also resources that would otherwise be required on the process of evaluation and selection of new suppliers.

On the other hand, using existing or current suppliers, even though perhaps quicker and easier, may not be the best approach in the long run. A purchase manager may never know if better suppliers are available in the market without information related to other sources. Hence, most companies are regularly finding new supply sources and are expanding this search to add foreign-based suppliers.

Selecting a current or existing supplier for a new requirement of purchase may be an attractive and advisable option if a list of preferred suppliers is well maintained. In simple words, the "preferred supplier" means that a supplier consistently performs very well and satisfies the buyer requirement. A list of preferred supplier status conveys fast and quick detail information of about the supplier's competency and overall performance. However, the purchaser must still identify if a preferred supplier has the ability to offer a specific new requirement of purchase (Table 3.4).

Sales Representatives

All buyers receive marketing and sales information from representatives of sales. Those contacts can turn out to be an important and valuable information source about supply. In fact, as an instant need doesn't exist, the purchaser may file and record the information for future use.

Information Databases

Some firms maintain supplier databases that are able to support a product line or industry. For instance, NCR maintains extensive data on more than 30,000 firms serving the computer industry. The firm searches journals of trade, financial newspapers to collect and record information about potential suppliers.

Maintaining a supplier database is particularly crucial and significantly important for an industry where technology changes very fast. The database may cover current product information, process capability ratios, past performance and future technology roadmaps of suppliers.

Databases of potential sources of supply are also available in the market for purchase from third parties. These external parties can be especially valuable and significantly important when a company is seeking supply sources in foreign countries.

Experience

Usually purchasing staff have strong and complete knowledge about suppliers' performance. A purchase staff may have worked within a company or within an industry over many years or maybe is very familiar and has very close relationships with suppliers. There is no doubt that knowledge and experience become more and more valuable since very few purchasing companies have developed an intelligence database regarding suppliers.

Trade Directories

Trade directories—usually all industries publish these directories of firms that provide information about companies whether or not the companies provide services or produce products within an industry. Some directories may be a significantly valuable source of beginning information for a purchaser who is not familiar enough to an industry's suppliers. Elsewhere in this chapter, we have already discussed in detail the topic of industrial directories. In the United States, a most popular directory for local purchasers is the *Thomas Register of American Manufacturers.*

Trade Journals/Magazines

Many industries have a council or group that publishes magazines or trade journals which feature articles about different companies within the industry. These papers usually stress a firm's innovative and technical development of components, process, services, materials or products. Suppliers also use magazines and journals to promote their services or products.

Table 3.4 When do selection and evaluation decisions arise?

During new development of product
Due to poor external and internal supplier performance
At the end of a contract
When expanding into product lines or new markets
When purchasing new equipment
When performing market tests
When internal users submit requisitions for services and goods
When faced with countertrade requirements
When consolidating volumes from a business
During analysis of outsourcing
When going towards or conducting a reverse auction
When existing suppliers have insufficient capacity

Trade Shows

In this chapter elsewhere, we have already discussed trade shows. Here we briefly explain. Trade shows can be an effective method to achieve exposure to a wider range of suppliers at one time. Purchasers joining trade shows may collect information about suppliers. At trade shows, several contacts are initiated between sellers and purchasers/buyers.

Second Party or Indirect Information

The information source, second party or indirect information, covers a broad range of contacts not directly part of the buyer's company. A purchaser can gather relevant information from other suppliers, such as knowledge about a non-competitor that may create value. Other purchasers are another second party source of information. In the meetings of Institute of Supply Management (ISM), attendees can develop information networks which provide information about potential sources of supply. Other professional councils or groups contain the council for Supply Chain Management Professionals, the American Production and Inventory Control Society (APICS), and the American Society for Quality Control. Some buyers publicly identify their good suppliers. Recognition can come in the procedure of advertisement in a newspaper, which highlights the success stories of top suppliers. For instance, Ford Motor Corporation periodically buys a complete page advertisement in the *Wall Street Journal* in recognition of its good and excellent suppliers, and Ford also lists every best supplier by name and the reasons for the recognition of them. Due to this approach of Ford Motor recognizing its excellent suppliers, a purchaser achieves visibility to a blue-chip suppliers group.

Internal Sources
Several bigger firms divide the organization into different units, each with a separate purchasing operation. Information sharing across units can take place through strategy development sessions, informal meetings, purchasing newsletters and/or the development of a comprehensive database covering information about sources of supply. Internal sources, in fact, those from diverse business units, also can offer abundant information about sources of supply.

Internet Searches
Purchasers are making more and more use of the Internet to help locate and select potential supply sources that might qualify for a next stage of evaluation. Many sellers are using the Internet as a significant and crucial portion of their efforts of direct marketing.

After gathering and collecting supply source information, the manager of purchasing must start to sift through and consolidate the information. Usually this can be a big task; it depends on the information obtained and also the number of suppliers.

Sourcing Alternatives
Once the list of current and potential suppliers enters a database, it is then further refined considering the type of supplier a company may hope to contract or deal with the given initial strategy of sourcing. Main sourcing alternatives cover whether to buy from a distributor or manufacturer; international, national or domestic source; large or small supplier; and single or multiple suppliers for the commodity, item or service.

Distributor Versus Manufacturer
The decision-making on buying from a distributor vs. manufacturer often depends on the following criteria:

1. The purchase size
2. Policies of manufacturer regarding direct sales
3. Storage space availability
4. The extent of services need

Honestly speaking, if all other variables are the same, the lowest unit price will be available from the Original Equipment Manufacturer (OEM). The distributors purchase from the manufacturer (OEM) and then resell, so, ultimately, distributors' prices include a little profit. Regardless of the exchange cost, in the last couple of decades the role of distributors in offering the purchaser a low-cost solution has been enhanced. First of all, many manufacturers (OEM) cannot handle the large volume of transactions required for selling directly. Secondly, purchasers require more services from their distributors, and suppliers have started to fulfil this requirement. Vendor managed inventory (*VMI*) is a program in which the distributor offers to handle and manage his customer's inventory for them. Many companies are using *integrated supply*, where a distributor is awarded a long-term agreement. In the integrated supply model, suppliers have access to the demand data of purchasers, and suppliers also keep customer service levels and inventory levels.

International, National and Domestic Suppliers
There is no doubt that usually national and international suppliers offer the best price and great technical services. On the other hand, domestic suppliers are quicker to respond and also can make frequent and small deliveries. The popularity of quick replenishment and Just-in-Time systems favours using more domestic sources of supply.

International suppliers offer opportunities to attain dramatic price savings. These savings need to be checked and evaluated against the extra inventory cost, logistics and communication costs.

Small/Large Suppliers
All suppliers once were small suppliers. Due to offering great service, high quality and appealing price compared to their competitors, they start to grow. Some buyers prefer to stress "the ability to do the job" rather than the size of suppliers. Size of suppliers does matter when a company decides to leverage its purchases from a few or one supplier. This leveraging means that the suppliers must have a broad and wide variety of their service or product offerings and have the capability to offer services or products all around the globe. But usually buyer firms do not want to be dependent on one supplier.

Single Sourcing or Multiple Sourcing
Whether companies avail themselves of multiple or single sourcing, both approaches have advantages and disadvantages. Certainly there is a tendency to minimize the number of suppliers. Single source offers optimum leverage, while multiple sources offer assurance of supply.

3.6.5 Limit Suppliers in Selection Pool

The result of this information filtering is that, depending on the product under consideration, a buyer can have several sources to choose. However, supplier performance capabilities vary widely. Limited resources also prevent in-depth and thorough assessment of suppliers. Buyers usually perform an initial cut evaluation of potential suppliers to shortlisting before going towards the thorough and detail formal process of supplier evaluation. There are many factors which support the shortlisting supplier list, including:

- Financial Risk Analysis
- Evaluation of Supplier-Provided Info
- Evaluation of Supplier Performance

Financial Risk Analysis

Many buyers perform at least a superficial and quick financial analysis of potential suppliers. Even though a supplier's financial condition is only one criteria of evaluation, poor financial history of the supplier can indicate serious problems. A financial analysis performed during this stage is much less comprehensive and detailed than the one performed during a final phase of supplier evaluation. Usually buyers consult external information sources such as D&B (Dun and Bradstreet) reports to support the evaluation results.

Evaluation of Supplier-Provided Information

A purchaser sometimes directly requests specific information from potential suppliers, such as preliminary surveys from suppliers. This information is used by the purchaser to screen all the suppliers and to decide whether the purchaser's requirements seem to match the capabilities of each supplier.

A purchaser can directly request any specific information from the supplier, including information on process technology, quality performance, cost structure, market share data or any other information that is important for the purchase decision.

Before promising (large time) to evaluate a new supplier further, suppliers should firstly satisfy certain entry qualifiers. What are *Entry qualifiers*? Actually, entry qualifiers are the elementary or primary components which suppliers must fulfil before they proceed to the next phase of supplier selection and evaluation process. Usually there are many initial qualifiers that suppliers should satisfy, but major entry qualifiers are given below:

- Appropriate business strategy
- Proven capabilities of manufacturing
- Strong and supportive management
- Strong financial history
- Design capabilities

The cost and time associated with the process of supplier selection and evaluation make it essential to restrict suppliers in the selection pool that can fulfil these initial qualifiers.

Evaluation of Supplier Performance

A potential supplier may have a record of performance with different buyers. A buyer may have used a supplier for a previous requirement of purchase. A supplier may also have offered other sorts of services or commodities to the buyer than those under consideration. Due to the previous experience, a buyer may consider that supplier for distinctive sorts of service or commodity.

3.6.6 Determine Method of Supplier Selection and Evaluation

After the initial elimination cut of suppliers that are not capable, the purchasers need to determine how to evaluate and check remaining suppliers, which can appear to be qualified equally. The next elimination step requires a level of evaluation greater in depth and detail than that used in the first stage or initial stage. There are many methods of selecting and evaluating the remaining suppliers in the pool. These cover conducting supplier visits, using preferred lists of suppliers and evaluating supplier-provided information.

Supplier Visits
A cross-functional team may frequently visit potential suppliers. While there are many sources available to obtain the latest information regarding a potential supplier, visiting the supplier gives the most relevant and complete approach to ensure an accurate assessment. But site visits are usually expensive, requiring the buyer to spend much time and money. The buyer needs to gather all important and necessary information while being sensitive to the limitations of suppliers on restricted information. Table 3.5 illustrates a complete checklist of the key criteria of evaluation that should be well noted during the site visit to the supplier. Key staff contact in management, marketing and operations may be very useful resources in the further phases of supplier selection.

Despite it is not sure that if the supplier is an existing or potential supplier, the buyer should collect its information and data into a report that is maintained on file for quick and easy retrieval. In the next section, the criteria of evaluation will be discussed in more detail.

Evaluation from Supplier-Provided Information
Purchasers usually evaluate information directly from suppliers (potential) for awarding a purchase contract. This information can be taken from requests for proposals or requests for quotes. By the way, purchasers make almost all decisions of purchase by using this approach. In recent years, some companies have adopted a more direct approach to evaluating their suppliers. Increasingly, firms are also requesting that suppliers provide a complete cost breakdown of their price (quoted price) in response to a request for quote, as well as details on overhead, labour, material and profit margin.

Preferred List of Suppliers
Buyers always reward their good suppliers by creating a preferred list of those suppliers, which can simplify the process of supplier selection and evaluation. Generally, *preferred supplier* means, one who fulfils all criteria of performance. If there are current suppliers that can fulfil the new requirement of purchase, the buyer gives preference to those suppliers because the purchaser wants to save time and money, which would otherwise be spent on the evaluation and selection process.

Table 3.5 Major financial ratios

Ratios	Interpretation
Current Ratio = Current Assets/Current Liabilities	Should be over 1.0, but look at industry average; high-- may mean poor asset management
Quick Ratio = (Cash + Receivables)/Current Liabilities	At least 0.8 if supplier sells on credit; low--may mean problem of cash flow; high-- means poor asset management
Note: Calculation includes marketable securities	
Inventory Turnover = Inventory/Cost of Goods Sold	Compare industry average; low--means problem with slow inventory turnover, which can hurt cash flow.
Fixed Asset Turnover = Sales/Fixed Assets	Compare industry average; too low means supplier is not using assets (fixed) effectively and efficiently.
Total Asset Turnover = Sales/Total Assets	Compare industry average; too low means supplier is not using its TA (total assets) effectively and efficiently.
Days Sales Outstanding = (Receivables X 365)/Sales	Compare industry average, / a value of 45 to 50 if firm sells on net 30; too high hurts cash flow; too low may mean credit policies to customers are too restrictive.
Net Profit Margin = Profit after Taxes/Sales	Shows after-tax return; compare industry average
ROA (Return on Assets) = Profit after Taxes/Total Assets	Compare industry average; shows the return the firm earns on everything it owns.
Return on Equity = Profit after Taxes/Equity	The higher the better; the return on the shareholders' investment in the business.
Debt to Equity = Total Liabilities/Equity	Compare industry average; over 3 means highly leveraged.
Current Debt to Equity= Current Liabilities/Equity	Over one is risky unless industry average is over 1; when ratio is high, supplier may be unable to pay lenders.
Interest Coverage = (Pre-tax Inc. + Int. Exp.)/Int. Exp	Should be over 3; higher is better; how high means supplier is having difficulty paying creditors.

3.6.7 Select Supplier and Reach Contract

The last phase of the supplier selection and evaluation process is to select the supplier (s) and reach an agreement. The activities related to this phase may vary broadly depending on the purchased product/component under consideration. For normal and routine products/components, this can simply involve notifying and giving a basic purchase contract to a selected supplier. For a major and crucial purchase, the whole process can become lengthier and more complex. The seller and purchaser may have to follow long and detailed negotiations procedure to agree over the particular details of a purchase agreement.

3.7 Key Supplier Evaluation Criteria

Buyers usually assess potential suppliers through several or multiple categories using their own criteria of selection with assigned weights. Buyers that require consistent performance of delivery with short lead-time to support a JIT system might emphasize a supplier's technological and process capabilities, commitment towards research and development (R&D). The process of selection for a third party (3PL) or distributor will emphasize a different set of criteria.

Most suppliers rate evaluation on three basic and key criteria:

1. Quality
2. Price or Cost
3. Delivery

These basic performance elements are commonly the most critical areas that influence the buyer. For critical products/components requiring a detailed and in-depth capabilities analysis of suppliers, a more in-depth and thorough evaluation of supplier is needed. The following shows the broad range of criteria that a buyer usually considers in the evaluation and selection process of suppliers.

3.7.1 Management Capability

It is significant for a purchaser to assess a supplier's management capability. After all, management operates the business and makes the decisions which impact the supplier's competitiveness. A purchaser needs to ask several questions during assessing a supplier's management:

- Has management committed the supplier to continuous improvement (CI) and total quality management (TQM)?
- Does management practice long-term planning?

- What are the educational background and professional experience of the managers?
- Is turnover higher among managers or supervisors?
- Is there a visualization/vision regarding the future direction of the firm?
- Is management customer-focused?
- What is the history of the relation between labour and management?
- Is management making significant investments that are necessary to develop the business?
- Has management prepared the firm to face upcoming competitive challenges, as well as to provide training and development to employees?
- Does management understand the significance and criticality of strategic sourcing?

It can be a big challenge to recognize the correct state of affairs using a questionnaire or during a brief visit. On the other hand, asking all these questions can be very supportive and helpful for managers of purchasing to build a feeling for professional capabilities the managers should have in the supplying company. When interviewing with managers, it is significantly crucial to attempt to meet with as many people as possible so that a real picture can be drawn.

3.7.2 Capabilities of Employees

The evaluation process part needs a thorough assessment of non-management staff. Never underestimate the advantage that a well-trained, motivated and stable workforce shows, specifically during the period of employee shortages. A buyer should carefully think about the following points.

- The abilities and overall skills of the staff/employees
- The degree to which employees are well committed towards continuous improvement and quality
- Employee-management relations
- Worker flexibility
- Morale of employees
- Employee turnover
- Willingness of staff to participate to improve operations

A purchaser should also collect information about labour disputes and labour relations with management. This may give a common idea of how dedicated the employees of suppliers are to manufacturing goods and services that will exceed or fulfil the purchaser's expectations.

3.7.3 Cost Structure

An evaluation of the suppliers cost structure requires a detailed and thorough understanding of total costs, including indirect and direct labour costs, manufacturing costs, process operating costs, material costs and general overhead costs. Understanding the cost structure of a supplier helps a purchaser evaluate the efficiency of the supplier manufacturing a product/component. An analysis of costs also helps identify potential areas of cost improvement. There is no doubt that collecting and gathering a supplier's cost information can be a very big challenge. Suppliers may not understand their costs in detail. In fact, many suppliers do not have a sophisticated system of cost accounting and are unable to assign costs of overhead to processes/products. Additionally, suppliers think cost data as highly proprietary. Suppliers are afraid of leakage of their cost information, fearing such leakage will undermine pricing strategy and fearing competitors will gain access to their cost data, which could give insight into a supplier competitive edge. In this situation, during the beginning phase of evaluation the purchaser will usually develop reverse pricing models that estimate cost structure of the supplier.

3.7.4 TQM Philosophy

A main part of the evaluation of the supplier addresses quality philosophy, processes and management. Purchasers assess the apparent topics related with supplier quality (statistical process control, management commitment, defects) and also evaluate training, maintenance of equipment, facilities and safety.

3.7.5 Process Capability and Technological Capability

The buyer's evaluation team usually includes a member from the technical staff or engineering staff to assess process and technological capabilities of a supplier. Process consists of the design, technology, equipment and method used to produce a product and/or deliver a service. A supplier location of a manufacturing process supports and helps define its required human resource skills, requirement of capital equipment and technology.

The process of evaluation should contain both the future and current process of a supplier as well as technological capabilities. Evaluating a future process of supplier and technological capability involves reviewing capital equipment strategy and plans. Additionally, the buyer should assess the resources which a supplier is committing to research and development (R&D).

A buyer can also evaluate design capability of the supplier. One method to minimize the time that is needed to build new items/products is using qualified suppliers which have the ability to support product design activities.

3.7.6 Environmental Regulation

Buyers usually don't want to be in connection with known polluters from a public relations/potential liability viewpoint.

The most common criteria of environmental performance used during the evaluation of a supplier's overall performance are as follows:

- Toxic and hazardous waste management
- Disclosure of environmental infractions
- Recycling management
- ISO 14000 certification

According to researcher Herman Miller, DuPont's sustainability program has cut emissions (greenhouse gases) at its factories by 72% since 1990s, an advantage that has saved three billion US dollars in energy costs. Today's DuPont views the sustainability or environmental movement as a significant key to increasing revenue.

3.7.7 Financial Stability

An evaluation of a potential supplier's financial condition should be done during the screening or first evaluation process. Many big risks come after selecting a supplier in poor financial condition. The first and basic risk is that the supplier will go out of business. The second risk is that the supplier does not have many resources to invest in latest technology and process/equipment. The third risk is that the supplier would become too dependent on the buyer.

If the supplier is traded publicly, specific financial data can be acquired from a variety of websites. Some general ratios are needed to evaluate financial health of the supplier. See Table 3.5 providing detailed financial ratios and industry averages to do comparison among these ratios.

The procurement officer or buyer should be well familiar with financial ratios. With the benefit of financial analysis the purchaser can see valuable and quick insights into a supplier's financial condition. Moreover, procurement managers should check such ratios on a weekly or monthly basis to evaluate and monitor supplier financial condition.

3.7.8 Supplier Selection

There are some significant issues to be considered during the process of evaluation and selection of a supplier. Every issue is probably to affect the final decision of the purchaser.

Size Relationship
A buyer can decide to select a supplier over which it has a relative size benefit. A purchaser may simply have stronger influence when it has a relative size benefit over the supplier/represents a larger share of total business of the supplier.

Use of Foreign Suppliers
The selection decision of a foreign supplier may have significant and critical implication during the process of supplier's evaluation and selection. Usually global sourcing is much more complex and difficult than domestic buying. As a result, the process of supplier's evaluation and selection may take on added complexity. In addition, it can be much more complex to implement Just-in-Time system with international suppliers, as longer lead-times are required as compared to domestic suppliers.

Competitors as Suppliers
One critical matter is the degree to which a purchaser is willing to buy directly from a competitor. Purchasing goods, material or components from competitors can limit sharing of information among parties. The transaction is normally straightforward; the seller and purchaser cannot build a close and friendly working relationship characterized by confidential information sharing and mutual commitment.

Countertrade Requirements
Countertrade requirements may also affect the decision of supplier selection. The term *countertrade* means all trade in which seller and buyer have at least a half exchange of products/goods for goods.

Boeing, a manufacturer of commercial aircraft, purchases a part of its manufacturing requirements in markets where it plans to do business. A company involved in extensive global marketing has to deal with requirements of countertrade before it is able to sell to customers (international), which has a direct effect on the process of supplier evaluation and selection.

Social Objectives
Many buyers are trying to develop their own business with traditionally disadvantaged suppliers, such as suppliers with minority or female ownership. Purchasers may also want to conduct their business transactions with those suppliers that are well committed towards environmental protection.

3.8 Overview of Supplier QM (Quality Management)

3.8.1 What Is the Supplier Quality?

One well-known quality expert, Mr. Armand Feigenbaum, defines *quality* as the total composite of service and product characteristics of engineering, marketing, maintenance and manufacturing through which the service or product in use will meet the expectations of the consumer/customer. This definition differs from remaining definitions of quality that view quality as base and primarily conforming to consumer requirements. According to Joseph Juran (leading expert on quality) quality is conformance to requirements. Over just a couple of years, the concept of quality has been changed radically and completely with satisfying customer requirements.

There is no doubt that consumer/customer expectations are dynamic and continuously changing. Various actions taken by a company's competitors can change customers' quality expectations. For instance, a consumer may be well satisfied with 3-day delivery service until a competitor offers 2-day delivery service with guaranteed delivery of goods at competitive cost. Changes because of the competition can dramatically and quickly redefine the requirements that consumers accept as their standard of performance. The situation in reality happened as United Parcel Service (UPS) Co. announced it was minimizing delivery time by 1 day, adapting their processes and delivery systems to offer competitive services, a promise that went fulfilled. The challenge and hurdle during handling consumer expectations are the firm's capability to specifically define those expectations and then translate them upstream throughout the SC.

From the perspective of quality, we can define what we mean by supplier quality. Actually, supplier quality shows the ability to exceed or meet current consumer/customer requirements and expectations within critical performance areas on a continuous basis.

There are mainly three categories to this definition:

1. Ability to exceed or meet. In simple terms, this means that supplier exceeds buyer expectations or supplier meets buyer requirements every time. Inconsistent performance of supplier, whether in product, on time delivery or any defects or quality problem, is not a true representation of a quality supplier.
2. Future expectations and current requirements. Supplier must meet and fulfil today's demanding requirements as well as possess the ability to satisfy future demand and requirement of customers. Supplier must have the capability to demonstrate continuous improvement. However, a supplier that can fulfil today's requirement of a customer but is unable to meet and fulfil future requirements of the customer is not a true quality supplier.
3. Within critical performance areas on a continuous or regular basis. Supplier quality does not apply only over the product's physical attributes. Rather, quality suppliers fulfil a purchaser's requirements from many aspects, covering service/product delivery, conformance, technology and features, total cost management, and after-sale service/support.

Within SC (supply chain), supply management does not just purchase services or parts from suppliers—it buys supplier capabilities that lead to quality services or products. Purchasers should not only emphasize supplier materials, components or physical output, but they also focus on the processes and supporting systems that build that output. And capabilities and expertise of supplier in engineering, logistics and managing its own supply chain are included.

In supply quality management (SQM), supply management partly is being a good customer to its suppliers. It is usually difficult to maintain a collaborative and trusting relationship and receive quality services/goods all the time when suppliers really do not like to do business with the purchasing firm. Under this situation, quality performance of supplier requires that a purchaser learn how to be a good/preferred customer (for supplier) by understanding what suppliers appreciate in a relationship between purchaser and seller.

Generally, some of the supplier's expectations for buyers include minimizing product design changes once manufacturing starts, providing future purchase volume requirements as specific as possible, and real-time information sharing of present and future product requirements. Suppliers also value adequate lead-time of manufacturing and timely payment.

A purchaser cannot anticipate significant and high-level supplier performance when the supplier must respond to the changes of lead-time. Stable orders and lead-time allows a supplier to plan effectively and reduce its costs based on consistent purchaser information. Numerous and quick changes in order volume restrict a supplier's capability to fulfil the purchaser's expectations successfully.

3.9 Factors Affecting Supply Management's Role

Supply management should undertake primary organizational leadership for quality management with its suppliers (external). Several elements influence how much attention supply management should give to supplier quality management:

1. The supplier's ability to influence a purchaser's total quality. Certain suppliers will provide products/items that are very important to a company's success. Management of supply must manage the suppliers of these significant and critical items more intently compared to standardized or commodity items.
2. The resources available to support supplier improvement towards quality management. Companies with scarcity of resources in supplier improvement and quality management must carefully decide where to allocate their resources. The availability of resources will significantly affect the overall scope of the company's efforts towards quality management. These resources include budget, information technology (IT), time and employees.
3. The buying firm's ability to realize world-class quality. A purchasing company can help its suppliers to understand the application and use of quality tools, techniques and concepts only after the purchasing company itself correctly and thoroughly understands these tools and concepts internally.
4. A supplier's desire to work jointly to improve quality. Not all suppliers are willing to work collaboratively and closely with the purchasing company. Instead, some suppliers may more like traditional purchase arrangements characterized by limited involvement of the purchaser and a more hand's-off faire manage-partnership.
5. A supplier's performance level influences the type and amount of attention needed from a purchasing company.

3.9.1 Costs Associated with International Purchasing

Buyers must calculate the extra cost in connection with international purchasing. Whether the purchase transaction is with a foreign manufacturer or domestic manufacturer, usually there are certain shared costs. However, the major difference between foreign purchasing and domestic purchasing is that foreign buying always includes extra cost that is associated with overseas transactions. If price is a main element, then a purchaser must do comparison between the TC (total cost) of the domestic with of TC foreign purchase. The following table explains and summarizes the several charges often connected/associated with international logistics and purchasing (see Table 3.6).

3.9.2 Common Costs

Certain costs are shared between foreign purchasing and domestic purchasing. These cover the unit purchase price quoted, transportation and tooling charges from the supplier. Unit price assessment must reflect the influence of quantity discounts, the effect on price due to expedited shipment, minimum purchases necessary for efficiency of shipping and any supplier-specified extra charges/surcharges.

Costs of transportation also need critical assessment. For instance, what is the effect on cost of transportation if the buyer controls a consignment directly from supplier instead of having the supplier arrange consignment? What is the impact on costs of transportation because of time-consuming distances? International transportation usually requires assistance from staff with special skills and expertise. A group of transportation specialists can evaluate shipping alternatives, review carrier quotations, and recommend the most efficient course of action, which can cover combining international consignment with those of other buyers to acquire favourable rates of freight.

Purchasing around the world generates extra costs that are not part of domestic purchasing. Failure to add and estimate these costs in a total cost analysis may result in an inaccuracy/blunder of the TC.

For a first-time purchase, the seller can request a LC (letter of credit). An LC is issued by the buyer's bank together with an affiliate bank in the country of the seller. It guarantees the seller that the money is in the bank account. The supplier can draw against the LC upon presentation of the needed documents. There are two fundamental types of LC:

- Revocable
- Irrevocable

The revocable LC can be cancelled or/and changed (any time) by the purchaser without the seller's consent; that's why it's seldom used. The irrevocable LC can only be cancelled and/or changed upon acceptance of all parties.

Table 3.6 Factors of total cost for global sourcing

Base price	Ascertain quantity breaks, minimum purchase for efficiency of shipping, and any extra fees
	Determine price for urgent consignment of smaller-than-planned quantities
Tooling	Consider shipping tooling from local source if transferable
	Ideally, the buyer should own the tooling as well as pay for it only once
Escalation	Determine components of escalation
	Determine for how long the quoted price is firm
Packaging	Consult a supplier of packaging for methods to reduce cost on international consignment
	Packaging is a hidden cost (can be very expensive for multiple handlings and long distances)
Customs duty	Duties paid any time a consignment crosses international lines
	Items may fall into more than one category/classification
Transportation	Consider consolidation of consignment with other corporations from the same geographical location
	Obtain assistance from logistics staff who have skills and expertise in international transportation
Insurance premiums	Not included in an ocean consignment price
Additional commissions and fees	Ask customs broker, supplier and transportation staff if other costs may be incurred, and who is responsible for these costs
Payment terms	Suppliers (foreign) usually grant longer payment terms like net 60
	If dealing with middle intermediaries, the payment may be requested upon consignment
Customs broker fees	Flat charge per transaction
Port handling and terminal fees	Port and handling fees (administrative services of staff, use of port, unloading cargo, etc.)
Taxes	Consider any extra taxes that may be paid
Payment and currency fees	Bills of exchange, bank transfers, hedging and forward contracts
Communication costs	Travel, telex, e-mail, fax and phone charges
Inventory carrying costs	High levels of inventory will have to be held due to longer distances/lead-times
	Costs include the interest rate forgone by insurance, investing funds, property taxes, obsolescence and storage

Usually packaging requirements are higher with foreign purchases due to the longer lead-times as well as increased handling of consignment. Every item/component entering a country is also subject to a tariff or customs duty. Customs duty rates depend on seemingly small and minor distinctions between items/components. A knowledgeable customs broker can lower duty costs and expedite the shipment through customs. Total cost (TC) analysis must cover broker fees and duty.

Other costs include costs such as insurance, handling and terminal fees. Depending on the exact terms of the purchase contract, a buyer may expect charges for unloading of cargo, administrative services of port authority staff and common use (these all are United States port handling and terminal charges).

During international purchasing, a critical factor is keeping to a minimum the surprises which may affect customer service and total cost (TC). For instance, if a consignment arrives at port without appropriate and proper documentation, customs will place the consignment in WH (warehouse) storage waiting for proper and complete documentation. Whether the seller or purchaser pays the charges of storage should be clear in the event this problem arises.

3.9.3 International Costs of Transportation

3.9.3.1 Currency Risk

A main concern with global purchasing or international purchasing is handling the risk in connection with fluctuation of currency. Due to this risk, firms often take actions to minimize the unpredictability or uncertainty attached with currencies' fluctuations.

The following example shows the fundamentals of risk and currency fluctuation. Suppose a United States firm bought a machine from Australia in the year of 2015, July. The purchase is denominated in Australian dollars at $200,000 paid upon delivery in 2015, December. For simplicity, assume the rate of exchange in the month of July was US$1 equals $1 Australian. By December, however, the Australian dollar has increased to the point where US$1 equals $0.90 Australian. Now, US$100,000 only equals (200,000 × 0.90) = $180,000 Australian.

Organizations use several measures to solve risk of currency fluctuation. These range from primary methods to the sophisticated management of international currencies involving the corporate finance department.

3.9.3.2 Sharing Risk of Currency Fluctuation

Equal risk sharing allows a seller to price its items/products regardless of the acceptance of risk costs. Risk sharing involves equal division of the effects of a change in an agreed-upon price because of currency fluctuation.

3.9.4 Currency Hedging

Hedging technique involves the simultaneous sale and purchase of currency contracts in two markets. The result (expected) is that a gain obtained on one contract will be offset by a loss on the other contract. Indeed, hedging is a form of risk insurance for protecting buyer and seller from problem and risk of currency fluctuations. It is risk aversion, not monetary benefit that is the motivation for using hedging. If the purpose of purchasing currency contracts is to realize a net benefit, then the buyer is speculating and not hedging.

Sellers and buyers trade futures exchange contracts on commodity exchanges open to anyone requiring to hedge with speculative risk capital. By the way, the exchanges motivate speculation since speculators help build markets for sellers and buyers of futures/expected contracts. Traders sell their futures contracts in fixed currency with fixed contract period/length.

Forward exchange contracts have a distinctive emphasis other than that of futures exchange contracts. Issued by main banks, these contracts are agreements through which a buyer pays a pre-established currency rate in the future. Members of trading include multinational firms, brokers and banks. The uses of forward exchange contracts do not encourage speculation. The forward exchange contracts fulfil the requirement of an individual buyer in terms of time limit and dollar amount.

3.9.5 Treasury Department Expertise

Firms with extensive experience of global purchasing usually have a treasury department that can support and fulfil international currency requirements. Finance can identify the currency a company should use for payment on the basis of forecasts/estimations of currency fluctuations. The treasury department may also give suggestions regarding currency forecast and hedging and/or renegotiate current contracts (due to fluctuations in exchange rates), and find new contracts; it may also play the role of a clearing house for overseas money to make payment for overseas purchases.

3.9.6 Currency Adjustment Contract Clauses

With clauses of currency adjustment, both parties (buyer and seller) agree that payment occurs and exchange rates do not fluctuate outside an agreed-upon range. If rates move outside the agreed-upon range, the buyer and seller can look into the contract before final settlement or payment. This gives a mutual degree of safety and security to companies not knowing with certainty in which direction exchange rates will move or fluctuate.

3.9.7 Tracking Currency Movements

The buying manager should track currency fluctuation against the dollar over time to recognize long-term sourcing opportunities and changes. In the year of 2006, the weakening of the United States dollar made exports more attractive for companies in European countries. In the 1990s, the buys from Japan became very expensive to United States purchasers, as the Japanese currency increased in value (100 yen to 200 yen per dollar). As an outcome, there was an incentive to purchase locally or from countries where currency exchange rates were more favourable. In the year of 2007, the yen stayed in the range of 110–120 yen per US dollar and did not depreciate to the high (100s or the 200s) of the 1990s.

3.10 Developing from International Purchasing to Global Sourcing

Several organizations determined that moving beyond primary international buying might yield untapped advantages. Table 3.7 shows international purchasing and global sourcing as a series of growing stages along a continuum. A process of internationalization on sourcing is realized as companies evolve first from local buying to international buying, and then go to global integration and coordination of processes, items, components, technologies, design and suppliers across global locations.

Referring to Table 3.7, Level II shows primary international buying that is usually reactive and uncoordinated between purchasing units or purchasing locations. Advancing to Level III, approaches and strategies start to recognize that an appropriately implemented strategy of global sourcing may result in fundamental and significant improvements.

At this level, however, strategies are not very well coordinated across global purchasing operating centres, locations, business units or functional groups.

Level IV is a sophisticated level of strategy advancement that shows the coordination and integration of sourcing strategies across global purchasing locations. Operating at this level requires the following:

- Staff, personnel with sophisticated skills and knowledge
- Global information systems
- Extensive communication and coordination mechanisms
- Leadership that endorses an approach of global sourcing
- An organizational structure that endorses central coordination of worldwide activities

While global integration arises in Level IV, which is not the situation at Level III, the integration is basically cross-locational rather than cross-functional.

Companies which operate at Level V have realized the cross-locational integration which companies operating at the Level IV have achieved. The basic difference is that Level V participants coordinate and integrate common processes, items/components, technologies and design, suppliers across global buying centres, and other business units, mainly engineering. This integration arises during development of new products including the sourcing of services and/or items to meet aftermarket requirements and continuous demand.

Table 3.7 Global sourcing and international purchasing levels

	Level I	Local/Domestic purchasing only
International Purchasing or Buying	Level II	International buying as needed
	Level III	International buying, part of strategic sourcing
Worldwide Sourcing	Level IV	Coordination and integration of worldwide sourcing strategies across globe business units
	Level V	Coordination and integration of worldwide sourcing strategies with other business units.

3.11 Elements Separating Successful from Less-Successful Worldwide Sourcing Struggles

A main research project on worldwide sourcing, with almost 167 firms, identified a set of elements that influence worldwide performance. These factors were:

1. Defined process to support worldwide sourcing
2. Centrally led and centrally coordinated decision-making
3. Site-based control of operational activities
4. Communication (real-time) tools
5. Sharing of information with suppliers
6. Availability of critical and important resources
7. Contracting and sourcing systems
8. International purchasing office (IPO) support

In Table 3.7 these success elements are well explained more formally and in detail in the next sections

3.12 Defined Process to Support Worldwide Sourcing

The development of a well-defined process is critically important to worldwide sourcing success. Some companies have taken their regional or commodity strategy process and modified it for worldwide sourcing.

A defined process supports and helps minimize many of the differences inherent in worldwide sourcing. Social laws, abilities and skills of staff, and business culture are three areas where differences are the biggest across different geographic units. The processes of worldwide sourcing align different practices and participants around the world (Table 3.8).

3.12.1 Centrally Coordinated and Centrally Led Decision-Making

Maintaining central control over activities that are strategic in nature increases the chances of obtaining a range of improved sourcing process outcomes. The following advantages are realized:

- Early involvement of supplier
- Building supplier relationship
- Improved consistency/standardization of the sourcing process
- Stakeholder, senior management and client satisfaction with sourcing and sourcing process

3.12.2 Decentralized Control of Operational Activities

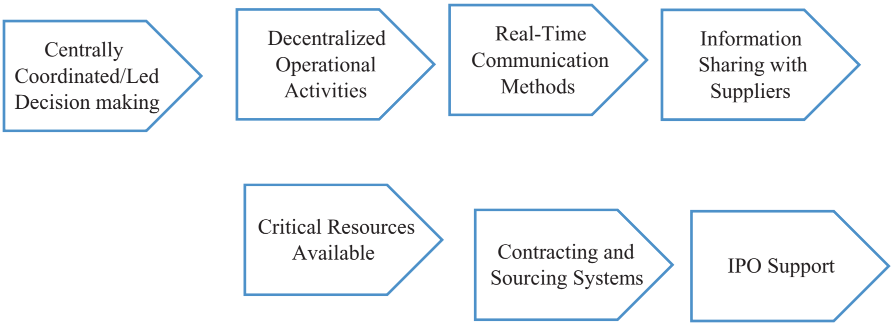
During worldwide purchasing, companies that decentralize operational activities are likely to achieve improved and better inventory management, lower total cost of ownership (TCO) and improved performance to customers (external)/consumers. At a decentralized level, operational activities include:

- Expediting orders when compulsory
- Planning inventory levels
- Issuing materials/components releases to suppliers
- Developing plan of logistics
- Resolving problems of performance

3.12.3 Communication Tools

Communication barriers and difficulties make worldwide sourcing more and more complex as compared to regional or local/domestic sourcing. The participants of worldwide sourcing are usually located around the globe, making face-to-face and real-time communication difficult. In addition, participants or members may speak many languages while adhering to different social cultures, different laws and business practices. Many approaches of coordination and communication support

Table 3.8 Global sourcing success elements



worldwide sourcing efforts. For instance, joint training sessions involving foreign participants/members, frequent review meetings, real-time reports and project-related updates via internet. A general approach for well-coordinated work is to use audio/video conferencing with a scheduled time, usually twice a week or a minimum of once a week. Members need to make full use of developing web-based tools of communication, including Centra, NetMeeting, etc.

One result is very clear: successful worldwide sourcing efforts feature well-established methods of communication to help in minimizing/overcoming the inherent hurdles, barriers and complexities of the process.

It is difficult to imagine successful worldwide efforts without access to timely and reliable information. For instance, such information should contain a listing of existing suppliers and contracts, report on supplier performance and capabilities, compilation of global sourcing volume by buying location and type, and information about new suppliers. The development of worldwide data warehouses and information technology are necessary for the ability to provide the information and data that worldwide sourcing requires demands.

While access to a common system of coding and real-time data is a main facilitator, the reality is that several companies lack IT capabilities. Most organizations have historically grouped their engineering and procurement centres by region, whereas other firms that are the result of acquisitions and mergers usually feature distinctive processes, legacy systems and part numbers across locations. This forces companies to spend money and time to standardize their coding and systems schemes. Commodity coding and part number schemes have the second lowest level of similarity from a top 20 items list compiled from all companywide locations.

3.12.4 Information Sharing with Suppliers

Successful worldwide sourcing requires both critical information and willingness to share information with essential suppliers on a global basis. Companies that share information of performance with their essential suppliers see lower purchase cost.

Shared information of performance cover: detail about supplier delivery, quality, flexibility and cycle time. A second type of information sharing relates to broader output. This covers assessment of the supplier's future capital plans, technological sophistication and product data.

3.12.5 Availability of Resources

Those resources that influence worldwide success include access to qualified staff, budget support for travel, availability of required data and information, and also time for personnel to build worldwide strategies. The availability of time is associated significantly with team effectiveness. Teams that have the time to pursue their agenda are more effective than those that have no time. This is essential, given the point that many companies use teams to coordinate their efforts globally.

3.12.6 Contracting and Sourcing Systems

The very significant way to ensure information access is to build technology systems that make critical information available on regular and global bases. Companies that have systems that provide access to related information are more likely to report low level total cost of ownership (TCO) costs and also better sourcing process output from worldwide sourcing. For instance, the information and the features they provide cover a global database of purchased services and goods; common part coding schemes; systems for measuring compliance of contract, contract management modules, global services and goods usage by location, and also purchase price paid by location.

3.12.7 IPO Support

As discussed before, international purchase offices support a higher level of global sourcing through wider access to process and product technology, minimize cycle times, and also increase responsiveness. More importantly, international purchase offices have the capability to provide all operational support from beginning negotiations through the final contract management stage of the supplier selection cycle. The increasing trend of "international purchasing offices" over the last couple of years has resulted in increasing movement to global sourcing.

3.13 Advantages of Global Sourcing

Perhaps one of the significant and interesting differences between global sourcing and international purchasing is that the perception held has regarding the advantages they realize from their worldwide efforts.

The basic advantages from international buying are price focused and are usually available from primary activities of international purchasing. However, companies realize several advantages (non-price) only after they have started to source. Mostly, non-price benefits include greater access to process and product technology, an output that is particularly critical given the more dynamic changes in technology that global sourcing companies face. Better management of supply chain (SC) inventory is also a big advantage that global sourcing companies have a higher position in the market. This is significant and critical given the focus that several companies place on inventory investment and managing costs across the whole supply chain. Remaining significant advantages more readily available from global sourcing cover high-level responsiveness, improved supplier relationships, greater sourcing process consistency and well-improved information sharing with suppliers. The advantages realized between the two groups help explain why several companies that pursue international purchasing want to progress into global sourcing.

3.14 Future Trend of Global Sourcing

Undeniably, globalization is a continuous process of improvement and development. Foremost in this journey is a requirement to advance, obtain and develop skills of supply management that encourage the evaluation of the supply network from a global perspective. Other developments cover the need to agree on global performance measures and to establish integrated systems between suppliers and with worldwide units. Doing this requires the continued refinement and development of coordinated and integrated global sourcing strategies across the functional organization. More extensive integration between engineering, sourcing groups and marketing should arise as companies evolve into globalization (higher level).

We also expect a trend towards doing transactions/business with suppliers that have worldwide competences and capabilities. In addition, the emphasis of global sourcing will shift from part/component sourcing to systems, services and subsystems. Pressures of cost minimization will also result in continued sourcing in low cost emerging supply markets, such as Eastern Europe, India and China. Although very attractive from a price perspective, in these markets there are some unseen/hidden costs that should be identified. The ability to cope with these changes will do help to separating leading firms from average companies.

Discussion Questions

1. What is the difference between international purchasing and global sourcing?
2. Do you think the differences between global sourcing and international purchasing are meaningful? If yes, why?
3. What are the major significant reasons for pursuing global sourcing today?
4. What are the main benefits of establishing an IPO?
5. What services do these IPOs provide?
6. How is the international part-sourcing process distinctive from the local sourcing process?
7. What are the major elements that separate successful from less-successful global sourcing efforts?
8. Why should a purchaser be concerned with supplier quality performance?
9. Why do companies commit the time and resources to evaluate suppliers before making a decision of supplier selection?
10. Discuss the sources of information available to a purchaser when finding information about potential sources of supply?
11. When do you think it is suitable to use different sources?
12. What are different methods for evaluating and selecting suppliers?
13. What purchasing issues need to be addressed during the process of evaluation?

References

Agerfalk, P. J., & Fitzgerald, B. (2008). Outsourcing to an unknown workforce: exploring open-sourcing as a global sourcing strategy. *MIS Quarterly, 32*(2), 385–409.

Ahmad Alinejad, E., Pishvaee, M. S., & Bonyadi Naeini, A. (2018). Key success factors for logistics provider enterprises: an empirical investigation in Iran. *Kybernetes, 47*(3), 426–440. https://doi.org/10.1108/K-10-2015-0269.

Akinboade, O. A., & Braimoh, L. A. (2010). International tourism and economic development in South Africa: a Granger causality test. *International Journal of Tourism Research, 12*(2), 149–163.

Anstine, J. (2000). Consumers' willingness to pay for recycled content in plastic kitchen garbage bags: a hedonic price approach. *Applied Economics Letters, 7*(1), 35–39.

Antras, P., & Helpman, E. (2004). Global sourcing. *Journal of Political Economy, 112*(3), 552–580.

Cohen, M. A., & Huchzermeier, A. (1999). Global supply chain management: A survey of research and applications. In S. Tayur, R. Ganeshan, & M. Magazine (Eds.), *Quantitative models for supply chain management* (pp. 669–702). New York: Springer.

Cohen, M. A., & Mallik, S. (1997). Global supply chains: Research and applications. *Production and Operations Management, 6*(3), 193–210.

Gronwald, K. (2012). Global sourcing: shifting the focus from cost saving to a strategic set-up. In U. Baeumer, P. Kreutter, & W. Messner (Eds.), *Globalization of Professional Services*. Berlin: Springer.

Khan, S. A. R. (2015a). Role of global sourcing in the modern supply chain of "FMCG" industries. *China marketing international conference—CMIC 2015 proceedings*.

Khan, S. A. R. (2015b). Challenges and benefits: Global sourcing vs. local sourcing in the manufacturing industry. *China marketing international conference—CMIC 2015, proceedings*.

Khan, S. A. R. (2015c). Barriers and drivers: Information technology in manufacturing firms of Australia. *China marketing international conference—CMIC 2015, proceedings*.

Khan, S.A.R., Dong, Q., SongBo, W., Zaman, K., and Zhang, Y. (2017a). Environmental logistics performance indicators affecting per capita income and sectoral growth: evidence from a panel of selected global ranked logistics countries. Environmental Science and Pollution Research, 24(2), 1518-1531.

Khan, S.A.R., Dong, Q., SongBo, W., Zaman, K., and Zhang, Y. (2017b). Travel and tourism competitiveness index: The impact of air transportation, railways transportation, travel and transport services on international inbound and outbound tourism. Journal of Air Transport Management, 58(1), 125-134.

Khan, S. A. R. (2019). The nexus between carbon emissions, poverty, economic growth, and logistics operations-empirical evidence from Southeast Asian countries. *Environmental Science and Pollution Research*. https://doi.org/10.1007/s11356-019-04829-4.

Locke, D. (1996). *Global supply management*. Boston: McGraw-Hill.

Peeters C, Lewin A, Manning S, Massini S. (2010). Shifting firm boundaries in global services sourcing: transaction costs, emerging capabilities and experience-based learning. In *Summer conference 2010 on opening up innovation: Strategy, organization and technology*, , 16–18 June 2010. Imperial College London Business School.

World Bank. (2018). Imports of goods and services. https://data.worldbank.org/indicator/ne.imp.gnfs.zs?end=2016&start=2013. Accessed Jan 12, 2019.

Chapter 4
Warehousing and Storage Equipment

Warehousing plays an important role in the perspective of supply chain management (SCM). In term of facilities, staff and equipment required, warehousing is somehow costly, whose performance will significantly and directly impact overall performance of SCM. Inadequate design of warehouse systems or poor management of warehouse systems will threaten the overall success of SCM. During the last couple of decades, some of the pressures on logistics—minimizing inventory, increasing customer service level and reducing cost and time—have inevitably changed supply chain structure and the position and role of warehousing within SCM.

Definitely, the traditional idea of warehouses as places to store material, components or finished goods has been outdated. Warehouses are possibly better improved to be distribution centres (DCs) to promote the movement of products. There are some exceptions like strategic stock holding, but commonly effective movement of products to the consumer/customer is the vital objective. In fact, as little inventory as possible has to be held to achieve this.

Warehouses come in different sizes and shapes, from facilities of some hundred square metres handling modest throughputs, to—regardless of the previous comments—large and continual throughputs (hundreds of pallets per hour).

On the other hand, the idea of throughput rather than storage, reduction of inventory and increased customer service has also seen the development of distribution centres that do not holding inventory—the minimum inventory/stockless depot, such like cross-docking operations and transhipment depots.

Another big problem troubling minds in recent years has been the technology level being use in the operations of warehouse. The range spans from conventional warehousing—shelving and racking with manual operations or forklift—to automated systems with AGVs, conveyors and on to robotic applications. It is not always clear-cut for the major reason of choosing a specific level of technology; reasons run from scope, marketing, financial and/or other factors, from firm's flexibility or image for future change to personal perception of the suitability of a specific information technology to a particular business.

S. A. Rehman Khan, Z. Yu, *Strategic Supply Chain Management*, EAI/Springer Innovations in Communication and Computing,
https://doi.org/10.1007/978-3-030-15058-7_4

4.1 Strategic Issues

Warehouses, distribution centres and stores should operate as integral component factors within whole end-to-end supply chain management. Main decisions when establishing such facilities must be made through the overall strategies of logistics for cost and service. The following elements should be taken into account:

Market/Product Base Stability
The market expectations (long term) for growth and for item range will affect decisions on the location and size of a warehouse. These considerations also will significantly impact the perceived requirement for flexibility, which in turn may affect decision-making on the level of technology and type of warehouse.

Type of Products to Be Handled
Products handled may cover spare parts, raw material, finished goods, packaging material, or work in progress in a span of material types, weights, sizes, and other characteristics. The units to be controlled/handled can range from individual small products to packages, drums, sacks, palletized loads and on up to container of ISO. Special necessities for humidity and temperature may also have to be met, and these all will influence the level of technology and type of warehouse.

Type of Facility, Location and Size
As is not determined directly, the type of operation, size of a warehouse, the design capacity and its location will be influenced by its particular position and role in the SC. Customer base, need for inventory minimization, amount of inventory, time compression in the SC and the service levels should all be taken into account carefully before deciding the location, size and type of warehouse.

Inventory Location
In the perspective of SC, there is not only the issue of what products/goods to hold and how many, but also of the locations. Options may cover distribution centres (DCs) dedicated to particular parts of the product range or serving specific geographic areas, or regional level DCs that hold, for instance, the fast moving consumer goods (FMCG) product lines, with the slower lines held in a national distribution centre only. The choice is dependent on some elements as product range, customer base and service levels.

Level of Technology
The decision of level of technology can be affected by firm-wide strategic marketing policies, budget and financial considerations and the required levels of customer service. Other elements may cover requirements for flexible operation to fulfil crucial demand fluctuations, for example, perceived future stability, market growth and seasonal variations. The technology level implemented in any specific application should be achieved to most closely match the given objectives and requirements. It cannot be realized that similar technologies and automation can be right

in every situation/case. But it is possibly true that computer-based information and communication system is crucial in every application, irrespective of the level of technology.

Choice of Unit Load

The choice of load or unit loads—cage pallets, tote bins—will be made by the characteristics and nature of the goods moving along the chain of supply, and this very clearly covers an extremely broad range of goods, pack types, sizes and unit quantities. This can appear as a very ordinary/mundane element more subject to operations than to strategies. On the other hand, in the warehouse, it may influence the sizing and choice of storage systems, and choice of handling equipment systems. In simple words, it will influence transport operations in the order of vehicle unloading, loading and utilization.

4.1.1 Costs

In the early 1980s, the Institute of Logistics and Transport commissioned and published an annual survey of the distribution costs incurred by industry, analysed by the cost of transport, inventory, handling of the inventory and storage. Warehousing cost, as a percentage of sales turnover, appears to settle out at a figure of almost 2%. As a percentage of the complete cost of distribution, the warehousing factor ranges between almost 30% and 40%. By any measure, this shows a large expense to industry.

The operating costs of the single components in the warehousing visibly depend on such elements as the nature of the industry and warehousing operation.

The freight transport association (FTA) publishes broad guidelines on early basis, in which it focuses on the large variability of such costs, but suggests the dominant costs are employees, accounting for almost 50% of the total, with building costs being a further quarter.

Further detailed cost surveys for operations of a "conventional warehouse"—reach pallet racking and trucks with case picking at ground level—have indicated average annual costs of:

- Employees/Staff—more than 50% almost half of which is accounted for by the labour of order picking
- Building—25%
- Building services—15%
- Equipment—10–15%

From a cost perspective, the two main elements that emerge from these figures, on which managers should put specific focus, are design or management of order picking and space (building) utilization.

4.2 The Role of Warehouses

The primary and basic value of DCs and warehouses lies in facilitating the movement of products/goods from upstream (suppliers) out to downstream (customers). In terms of achieving this objective effectively, warehouses and DCs may have to hold inventory, but that is not their most important function. Some warehouses/DCs have a specific objective of storing/stocking products and raw materials against particular contingencies, which it is hoped will not occur, for instance, spare parts and disaster relief supplies.

The adoption of JIT systems and other related approaches to material supply, allied to computer-based information systems that give real-time information on stock locations and availability, has definitely challenged the requirement for holding stock and having warehouses at all.

There is no doubt that inventory levels have significantly come down over time. However, even with closer integration of logistics planning and manufacturing and new techniques of demand forecasting, in many ways within SCM there will remain a level of mismatches and also conflicts between demand and supply optimization.

There will also be the need to consolidate products/goods from different sources, for operations of break-bulk, for activities of value addition including postponement.

Hence, there are authentic and valid reasons for continuing to have DCS and warehouses for holding stock in the supply chain including:

- To facilitate economies of long production runs in manufacturing
- To give a buffer inventory between production runs in manufacturing
- To provide a buffer inventory to smooth variations between demand and supply
- To facilitate procurement savings through large buying
- To cover seasonal peaks and fluctuations, e.g. the EID-ul-fitar and Christmas
- To cover for breakdowns in production or planned production shutdowns

Remaining important reasons for operations of warehouses have included more operational tasks such as:

- Packaging/repackaging
- Order picking and assembly
- Postponement
- Kit marshalling for manufacturing and assembly

Latest developments in JIT systems and other related approaches to inventory and time minimization will continue to decrease inventory levels and also will change the "centre of gravity" of where stock/inventory is held, pushing it back up the SC. This, however, will not minimize/remove completely the need for stock and the facilities in which to hold it. The importance of DCs and warehouses has been shifted more towards improvement and focused on the following objectives:

- Fulfil the need of customer service standards
- Facilitate the flow of products to the consumer/customer

- Incorporate value-added activities, e.g. postponement as a means of minimizing the SKUs (stock keeping units), and also increasing the flexibility to fulfil customer needs and wants

4.3 Types of Distribution Centre and Warehouse

DCs and warehouses may operate at regional or national levels, determined by the structure of supply chain and customer service, and strategic decisions on levels of inventory. National or regional distribution centres can use traditional storage and handling systems or can be designed to be well equipped and automated. On a domestic level there can be "stockrooms" that serve a small number of retail shops within a close territory. These are stock holding facilities.

A basic difference exists between stockless depots and stockholding warehouses, and the latter have been receiving more attention in current years as making fast stock movement and inventory minimization. Usually there are two fundamental norms for a stockless depot: cross-docking and transhipment depots.

Cross-Docking
This is the trend to operate out of an empty building. Goods ordered by SKU from suppliers in quantities sufficient to fulfil the next day's total customer orders are delivered to the site and unloaded. Goods then directly go to a sorting system which distributes the required quantities of each item/product to an allocated location of orders so that the orders build up, item by item, until the orders are fulfilled/completed. Completed orders are then loaded to outbound delivery vehicles parked along the dispatch face of the building. Dispatch vehicles leave to meet specified departure times to reach customer locations by given deadlines. The term "picked by line" is usually used to explain this type of operation.

Transhipment Depots
This is the trend to be located in such a way as to fulfil the specific areas of customer concentration. Customer orders are picked at a stock-holding depot—typically national distribution centre—loaded to road trailers in reverse drop sequence and dispatched to the transhipment depot overnight, where the trailer is dropped. The overnight tractor returns to the national distribution centres with the previous day's empty trailer. In the morning, a local tractor unit picks up the overnight trailer, delivers the customer orders and returns the empty trailer to the transhipment depot. This system's implication is that all order picking, down to individual customer level, is carried out at the national distribution centre, and there is no stock held at the transhipment depot, which need be only a small secure site without employees/personnel.

4.4 Operations of Warehouses

Among warehousing operations, there are many types of equipment and methods that can be used for handling and storing material and for order assembly, from which a system should be designed to fulfil the requirements of the SC within which it functions. However, there is a primary material flow that is general to most warehouse operations, while this can be modified in specific situations such as operations of cross-docking. Figure 4.1 shows the primary flow of material and the functions of a warehouse.

Figure 4.1 reflects the separation of reverse storage from order picking. The objective is to limit the distance that order picking personnel would otherwise have to travel to access the full range of stock items, particularly, in warehouses holding high stock volumes.

By limiting the stock held in the area of picking, travel distances for picking are minimized. Separation helps to minimize the interferences between building material movements and order picking. However, the risk is that due to concentrating all the picking activity into a small geographical location, congestion will ultimately occur. Hence there is a quid pro quo (balance/trade-off) between reducing distance of travel and avoiding congestion in the area of picking. Clearly, if the total inventory for a stock product is small, it will not be suitable to hold it in a separate place.

The functions of warehouse are the following:

Fig. 4.1 Warehouse functions and flow of material

Goods Inwards

This covers the physical unloading of incoming goods, recording of receipts, checking and making decisions on where these goods should to be put away. It also can cover such activities as repackaging, temporary quarantine storage of goods (awaiting clearance, due to quality reasons) and checks of quality control.

Reverse Storage

Reverse storage is the biggest space user in warehouses; this space holds the build-up of warehouse inventory in recognizable locations. Products are moved to storage (reverse) from goods inwards, and the locations/place communicated to the warehouse information system (WIS).

Replenishment

Replenishment is the movement of products/goods in greater than order quantities, for instance, a full pallet at a time, from reverse storage to order picking, to ensure that locations of order picking do not become empty. Keeping stock availability for order picking is crucial for attaining higher levels of order fill.

Secondary Sortation

For small order sizes, it is usually more suitable to batch a number of orders together and also treat them as "one" to pick. In this situation, the picked batch will have to be sorted down as single/individual orders, i.e. secondary sortation before shipping goods.

Sortation

In some situations the usage of IT means that the ultimate destinations of an important and crucial proportion of the products/goods coming into a warehouse are known. Latest developments have therefore used this facility to make goods coming into a warehouse to be sorted into particular order of customer immediately on arrival, often using high-speed sortation conveyors. The products then directly go to collation of order. This method has been used for a couple of years in operations of cross-docking for grocery items by key super markets.

Order Picking

Products are selected from stock of order picking in the required quantities and at the required time to fulfil the orders of customers. Usually picking involves operations of break-bulk, when products are received from suppliers in say, whole pallet quantities, but there are orders by customers in less than quantities of a pallet. On the other hand, if specific goods are required in sufficiently larger quantities, for instance, a whole pallet load, the order is directly picked from reverse storage. The picking order is crucial for achieving higher customer service; it also conventionally takes a high proportion of the total warehouse personnel complement and is costly. The picking systems and operations, good design and management are consequently important and critical to effective performance of warehouse.

Collate

This involves packing into dispatch outer cartons, operations of labelling and shrink and stretch wrapping for load stability and protection.

Dispatch
Collated, picked and packaged products are assembled for loading to outbound trucks, and onward dispatched to the next node in the SC—intermediate DCs, then to the next transport leg such as air, sea or dispatched directly to the customer/consumer.

The above-mentioned functions show the basic activities found in the operations of warehouse. Additionally, there may be a broad range of subsidiary activities like sub assembly, packaging material stores, packing areas, equipment maintenance shop, amenities and offices and truck battery charging area, and in some circumstances services to support particular product environments, such as frozen products stores.

4.5 Objectives of Good Warehouse Design and Management

There is an oft-quoted definition which used to be quoted to compress the final point of material handling, covering the goals of all SC operations in different ways, including warehousing:

"Getting the right products in the right quantities, at the right time and right place, in the right form, safely and at the minimum overall cost of system". From a couple of facets, this "old hat", has been around for decades, while it is hard to fault that as a statement of what goal distribution is trying to achieve.

Setting out a statement of best practices for the system design and management of warehouse, however, is more open; different authorities have expressed this in distinctive ways. A couple of decades ago, one researcher created a list of almost 30 principles. In an overall context of minifying overall cost of system, a briefer summary of the major and fundamental principle, providing the essential quality of customer service in order of accuracy, completeness of order fulfilment, timeliness, is displayed in the sections given below:

4.5.1 Use of Building Space

Warehouse space is a crucial proportion of total warehouse space, and costs should be utilized properly and effectively. For making full use of warehouse space, the following should be considerations:

- Eliminating obsolete stock and reducing total stock holding
- Careful selection of appropriate handling and storage systems
- Effective usage of space—building height, mezzanine floors
- Using random location systems for stock

However, it is crucial that there should be clear access to stocked products, and in warehouse design, one of the important "trade-offs" is to achieve maximum utilization of space while maintaining unrestricted stock access. With careful analysis of stock, where the emphasis should be put in any specific circumstances or for specific parts of the goods range will be suggested.

4.5.2 Choice of Unit Load

A unit load is an assembly of single/individual packages or products, often of a like kind, to make composite movement convenient, whether mechanized/manual. For instance, pallets in a range of goods, whether wooden pallets (still very common), post pallets, tote containers, roll cage pallets, steel or plastic cage pallets and ISO containers. The advantages of effective utilization cover moving maximum quantities of products every journey, and thus reducing the number of movements, the ability to use standard storage and handling equipment, protection and security of stock, best use of space for storage, and facilitating the interface between transport operations and warehousing, including the unloading and loading of trucks.

4.5.3 Utilization of Resources

The warehouse design and management should enable efficient and effective use of resources, covering the monitoring of equipment utilization and availability.

4.5.4 Minimum Movement

Movement of goods/products uses resources and, except in the case of an automated system, involves operating personnel time. The layout of warehouse and the positioning of the warehouse operations inside the building obviously influence the amount of goods movement, so does the location of stock within the systems of storage. Approaches to reduce goods movement are the following:

- To reduce travel time, locating FMCG/high turnover products close to dispatch area
- Providing handling equipment to reduce manual movement and effort;
- Computer-based planning of warehouse goods movement routes to shrink travel time
- Separation of reverse stock and order picking to concentrate picking activity into the smallest feasible area while avoiding bottleneck/congestion
- Movement planning to increase utilization of handling equipment and personnel and avoid travelling without payloads, for example, dual cycling, in which both return movements and outward movements of product handling equipment are utilized for carrying products

4.5.5 Control System and Information System

A fast, effective, flexible and accurate information and communication system should be established in the warehouse installation. The functionality should cover the capability of:

- Logging stock movements and maintaining balances
- Monitoring productivity, the availability and utilization of resources like storage and handling equipment
- Controlling stock location
- Tracking the goods movement through the effective system, ideally instantaneous communication between management system and operators
- Planning optimum goods movement routes, additionally order picking
- Sorting order requirements into suitable order picking tasks

4.5.6 Product Integrity

The systems of warehousing and handling should be so designed and managed that product can be maintained in an appropriate state for the consumers/customers. This involves systems in place to reduce loss and damage, and to satisfy stock rotation, and any legal constraints on storage environment like limits of temperature.

4.5.7 Working Safety and Conditions

Conventionally, the numbers of warehouse takes have made the function monotonous and arduous. In recent years, this becomes an area of growing importance. Some current innovations in trucks design (forklift), for instance, is particularly aimed at reducing risk of repetitive strain injury and improving operator environment. Lighting levels, humidity and hygiene also have an impact on operator environment and consequently on performance of operators in the long run.

There is no doubt that due to the lifting and manual handling of goods involved, safety has prime importance in warehousing operations. In fact, with the levels of automation and mechanization in some advanced installations, safety plays a vital role. This is further highlighted by the amount of related legislation.

4.5.8 Environmental Issues

The awareness of environmental issues is increasing day by day, and it is one major reason that more and more has to be taken into account in the system of warehouse design and management. Examples are the regulations affecting packaging, the additional responsibility and cost that have been forced/imposed on suppliers.

4.5.9 Information and Communication

In essence, warehousing is a simple operation, but it can go spectacularly wrong. The general reasons for performance failure are related with inadequate communication and information systems.

From the author's point of view, a good communication system, information and monitoring system inside the warehouse, and also communication out to the broader supply chain, are a sine qua non (essentials) of effective and efficient warehouse management. Without such an appropriate system, in fact, without experienced personnel and well-designed facilities, overall maximization of performance of the warehouse will not be accomplished.

4.5.10 Packaging and Unit Loads

4.5.10.1 Packaging

The definitions of packaging cover "the art, science and technology of preparing products for dispatch and sale". Safe delivery of goods is an integral part of a SC, and the use of packaging and design influence not just handling and storage, but also other functions like marketing, manufacturing and determination of the most suitable type of unit load to be in use. The following are the functions of packaging:

- To preserve an item from chemical, mechanical and physical deterioration, contamination or damage
- To contain the goods
- To communicate safety instructions, instructions for item use and other information
- To facilitate ease of unitizing, ease of handling, and, in some cases, to act as a dispenser and measure
- To act as a marketing aid through presentation and appearance

Packaging requires being compatible with the processes through which it will pass, such as packaging and filling machinery. The design must also take potential reuse and for the disposal of the package after use into account. Forms of packaging include the following:

- Primary package in direct contact with the product, to contain, protect and seal, e.g. tube, sachet or envelope
- Secondary package, considering one or many primary packages, to offer physical protection
- Transport pack or outer packaging

During moving and handling through the SC, packaging will be subject to potential deterioration, damage including the following:

- Environmental elements such as water, temperature changes, odours and other contamination
- Mechanical shock, vibration, compression, abrasion or impact
- Pilferage
- Other potential reasons of damage, including fungi, infestation, bacteria and vermin

4.5.10.2 Unit Loads

The concept or idea of unit loads puts goods onto suitable/appropriate standard modules for storage and handling, loading, unloading and movement. It facilitates the use of standard equipment irrespective of the goods being handled, meanwhile achieving goods security, economy and protection in the use of space, and minimization of the amount of handling needed for a given quantity of material.

Most physical distribution is structured round the concept of the unit load, and the choice of unit load is basically to facilitate the economies and effectiveness of a SC. The following are examples of unit loads:

- Wooden pallets made to standard sizes, although there are many and different standards, which can be the reason for some issues and problems with cross border movement. For instance, the dominant pallet in the United Kingdom is the ISO (1200 mm × 1000 mm), in Europe is the Europal (1200 mm × 800 mm). Except for the size of pallet, other variables cover pallet construction: 2-way or 4-way fork entry, non-reversible or reversible, closed boarded or open boarded. The pallet (wood) is possibly the most generally used type of unit load.
- Small containers like tote bins, made of galvanized plastic, and used for small parts handling and storage.
- The pallets (roll cage), which contain bases fitted with dolly cage sides and wheels. These have been widely used in wholesale grocery distribution systems.
- Box pallets and cage, usually of metal construction, fitted with corner posts to contain the items, and often stackable by means of bell ends fitted on the bottom of the corner posts.

- International standards organization freight containers are made in a range of standard external sizes that can stack and fit together for loading onto sea and land transport and for holding at container terminals. Standard handling, unloading or loading, and stowing can therefore be used, which support and help to minimize turn-around times of transport and offer secure transit. Different designs of containers, within the standard external dimensions, enable their use for bulk solids, refrigerated goods, general cargo and bulk liquids.
- Intermediate bulk containers (IBCs) show the link between unit load and bulk handling, and are designed for payloads of 1–2 tons. They are used for solid particulate goods like building products, chemicals, and some are specifically designed for liquid items. Usually these are rigid IBCs made of plastic, collapsible intermediate bulk containers made of canvas for ease of return, folding, and one-trip and low-cost intermediate bulk containers made of fireboard. IBCS are used inside of the plant transport and storage, and they cut out the need for conventionally sized sacks. Usually they are designed for bottom emptying, top filling and are handled by standard forklift. They can often be block stacked.

4.5.11 Storage Systems and Equipment

The function of storage in the warehouse design is a main consideration if for no other reason than that it frequently occupies more space than any other activity. Hence, it accounts for an important and significant part of the costs of building. Operational storage systems impact on product protection, integrity, access to stock, the discipline of correct stock rotation and location, the ease or otherwise of stock management.

The material type to warehouse differs enormously—different weights, sizes, brittleness, hazard characteristics and shapes. A main advantage of unit loads such as pallets is that they allow the use of handling equipment, and standard storage systems. On the other hand, variations in order picking and throughput patterns make it suitable to have types of storage systems with different operational characteristics, so that systems can be selected that the most nearly match the requirements of the broader system within which they are to operate.

Suggested clearances, horizontal and vertical, to enable safe access for items moved into and out of equipment of storage and other guidance for the use of storage and design equipment can be found in a series of codes of practice published by the storage equipment manufacturers association (SEMA).

The major elements affecting choosing a storage system are given below:

- The effective use of building volume—vertical and horizontal
- The characteristics and nature of the unit loads and items held
- Good access to stock
- Maintenance of stock integrity and condition
- Compatibility with requirements of information system
- Staff/personnel safety
- Overall system costs

Comparing the different storage systems' costs, it is not just the costs of storage equipment that must be considered. Other cost elements that can be mainly affected by the choice of system are:

- Fire protection
- Personnel
- Space—building, land and building services
- Handling equipment
- Information management systems

One method to categorizing storage systems could be:

- Loose product storage, e.g. fabrications, casting held loose on the floor
- Bulk storage for solids, such as bunkers, silos, and stockpiles
- Non-standard unit loads
- Small product storage for individual products or small unit loads

4.5.12 Stock Location

In stock management perspective, the location of stock within a warehouse is crucial. For instance, the overall position of stock within specific places/areas in the store can influence the total amount of movement needed to get goods into and out of stock. It also can significantly affect the efficiency with which order selection and picking operations can be done by influencing the distance that order pickers have to travel to get to required stock.

It is crucial to place certain stock products at lower levels for ease of handling and operator lifting. For instance, very large and heavy products should be near to the level of the picking trolley platform to reduce operator lifting. The product lines of fast moving stock have to be accessed frequently and should be placed at best possible operator arm movement levels.

4.5.13 Random and Fixed Stock Location

Whether single product lines are held in dedicated places or randomly in any available storage place would influence the effective storage capacity of a given installation.

In a fixed location system, any exact place can only be used for its labelled product line. Therefore, the installation should be designated with sufficient capacity to hold the maximum stock of every single item line.

With random location, when any empty place can be used for any item line as needed, the size of installation may be minimized, since the possibility of each item being in stock at maximum stock level at the same time is virtually nil. In this situation, the future capacity storage may be estimated according to the sum of the average level of stock for all item lines, inflated by a factor, say 10%, to account for variation above the average.

In any installation of storage, the usage of storage places will be less than 100% since the movement of goods builds empty places that can never be refilled immediately. This effect is also taken into account when estimating the storage locations required in a random place warehouse.

Random place is usually used for storage of reverse products, which tend to take up the biggest areas in a store, and fixed place for order picking stock, which allows the use of storage by specific classification, such as popularity—fast moving item lines placed to reduce the picker's moving distances.

As with other characteristics of warehouse management, the ability to record fast every place, and identify which places are empty and therefore available for use, is a vigorous requirement for the effective management of the storage installation. In this implication is a requirement for effective place identification systems for stock places.

4.6 Palletized Storage

4.6.1 Block Stacking

There is no use of any storage equipment in block stacking. Loaded pallets are directly located on the ground/floor and built up one pallet on top of another to a maximum stable height. Rows of stacked pallets are set out side by side (see Fig. 4.2). Usual clearance in a block stack is almost 100 mm between pallets in every single row. When stock is removed for use, the only free access is to pallets at the front and on top of each row.

The loads of pallets must be able to carry the placed over pallets, and the top of every load must be flat enough to offer a steady/stable base for the next layer. If these requirements cannot be met, post pallets and pallet converters may be used, which carry the placed over/superimposed load directly to the next pallet in the stack via corner posts, and no weight is placed directly onto the "payload".

Any one row should comprise only pallets of similar or same items, to avoid double handling, and must be fully deflated/emptied before being refilled in order to avoid trapping old stock at the backs of rows.

The front to back depth of any row must not exceed 6 pallets in from the truck access aisle, for safe driving, which means blocks of 12 deep, back to back. In fact, designs can well incorporate rows of distinctive depths to products' accommodation with distinctive levels of stock.

Block stacking is appropriate for that part of the range of products where there are few item lines, each with high level of stock, and where strict first-in-first-out movement of stock is not required. The benefits are efficient utilization of space, flexibility to change the design of the blocks, fast and timely access to inventory for rapid throughput.

Fig. 4.2 Block stacking

Remember that almost every working warehouse usually has some unoccupied places—for block stacking, where any row must be emptied before being refilled, usually some 30% of the single pallet positions. When planning and designing for random place block storage installation with capacity of "P" pallets, the capacity of holding for 1000 pallets is needed, then 1000/0.7 = 1429 approximate places should be provided.

4.6.2 Drive Through Racking and Drive-In

Although this is a racked storage system, it is operationally the same as block storage. In every row, there should be only one product line, and the effective usage of pallet positions is almost 70%. The weight of the pallets is supported the structure of racking, so this is suitable for very high inventory/stock product lines, where strictly first-in-first-out movement is not required, but where the pallet loads are not strong enough or of regular enough shape to carry over/superimposed loads.

Since the pallets are reinforced/sustained by the structure, the installation height is not limited by pallet stability or strength.

The rack is made up of vertical support frames, tied on the top, with cantilever pallet support beams at distinctive heights. The forklift enters the racking between the vertical supports to access the pallets sitting on the cantilever beams. If access is all from one end, the racking is called *drive-in*, and if pallets are fed in one end and removed from the other, it is called *drive-through*.

Access for the fork-lift within the racking is tight because the cantilever supports have to be narrower than the width-size of the pallets, which have to be moved out and in of the racking in a raised position. But this tends to limit the movement (out and in racking) of pallets in terms of speed, and driver strain can be one factor.

Since pallets are supported along each side, the condition of pallets is significantly important, and due to the narrow truck access, the floor and the racking have to be built with close-fitting tolerances to reduce the risk of the trucks colliding with the racking.

Fig. 4.3 Drive-in racking

The maximum height suggested is 10–11 m, with the front to back narrow depth of six pallets in from the forklift access aisle (Figs. 4.3).

This type of racking is a recent development. Similar to drive-in racking, it gives higher-density storage and can also be built to any height up to the maximum lift height of the lift trucks retrieving or accessing it. In the racking, the pallets can be stored very well up to almost four deep on both sides of the access aisle.

Each level in every vertical row of the racking is fixed with inclined rails along which trolleys may move, the incline sloping down to the front of the racking. The trolleys "nest" when vacant. The incoming pallets are lowered over to the trolleys, pushed up the incline and into the racking by fork truck till the lane is completely full. As a retiring/outgoing pallet is withdrawn, the pallet behind moves down to replace it, until the lane is completely vacant and can be refilled.

The primary operational differences between drive-in or block stacking and push back racking is the increased selectivity achieved (Fig. 4.4). There should be no mix of item lines in lanes, but mixed product can be among the lanes in any one row.

4.6.3 Adjustable Pallet Racking

It is probably that adjustable pallet racking is the type of pallet racking that is used the most frequently, which gives free and easy access to every pallet held. It can be created to match the height-lift of any fork truck.

This racking consists of horizontal beams and upright end frames on which the pallets are placed, and heights of beams are adjustable to suit the pallet height loads being stored. According to the academic theory to enhance the utilization of beam heights, vertical space can be altered if pallet load heights change. But, practically, this usually does not happen.

Other than on pallets, unit loads may be stored using "adjustable pallet racking" and there is a broad range of accessories like channel and drum supports for post pallets to facilitate this.

Fig. 4.4 Push back racking

The traditional method of laying out “adjustable pallet racking” is to have a deep single row on each end of the installation, with back-to-back rows in between. This offers each truck aisle access to two racking rows, reducing the number of aisles needed. Guidelines for the vertical and horizontal spacing of the racking component to make safe access to pallets are offered in “storage equipment manufacturers associations” code of practice.

The “adjustable pallet racking” is one versatile, flexible storage system, that offers excellent access to stocks. It is very simple in idea or concept, easily laid out, and damaged parts are easily changed. It may be appropriate for slow-moving stock and fast-moving stock, and for item lines with low levels or high levels of palletized stock holding. Typical utilizations for positions of pallets in random location “adjustable pallet racking” can lie in the range of 90–95%, depending partially on the effectiveness of the warehouse management system (WMS) handling the information of location.

On the other hand, “adjustable pallet racking” does not make good use of a building. In a typical installation using fork-reach, each aisle (say 2.8 m) is broader than the back-to-back pallets in the racking (2.1 m, with international standard organization pallets positioned 1000 mm deep into the racking). Therefore, before allowing for any other requirement of space, such as aisles of transverse, the space utilization

Fig. 4.5 Adjustable pallet racking

of the building is well below 50%, and this is significantly critical in the context of the costs of a building.

With high rack stacker trucks equipped with sliding pallet or rotating pallet handling mechanisms, there is no need to turn in an aisle to retrieve/access pallet places, and "adjustable pallet racking" stacker trucks may typically operate in aisles (1.8 m or less). High rack stacker trucks may also lift higher than reach trucks; these two effects maximize the use of space. On the other side, there are penalties of cost in providing the required floor flatness and strength for working in high but narrow aisles, and the trucks are more expensive than reach trucks (Fig. 4.5).

4.6.4 Double Deep Racking

Double deep racking may be used if little loss of totally free access to inventory may be accepted. While not nearly as severe as push back or drive-in storage, block utilization of space can be improved by using double deep racking. This supports pallets on pairs of beams as in "adjustable pallet racking", and also improves and enhances utilization of space by eliminating an alternate access aisle, using a double reach forklift that can access not only one but two pallets deep into the racking. The idea is shown in Fig. 4.6.

The price of this space saving is the requirement for double deep reach trucks to access the stock, more costly than ordinary reach trucks, and some loss of selectivity since pallets are now stacked two deep into the racking, i.e. loss of absolute first-in-first-out inventory rotation. The position of pallet expected to be of the order of 85%. A practical requirement is that the level of bottom of pallets in the racking has to be backing on a raised beam to permit the legs of a double reach truck to properly fit under the structure of racking when accessing the pallet furthest in from the aisle. In individual deep "adjustable pallet racking" the bottom pallet may directly sit on the floor.

Fig. 4.6 Double deep racking

4.6.5 Powered Mobile Racking

The powered mobile racking is significantly effective single deep "adjustable pallet racking", with the racking, excluding the outer rows or end rows, mounted on electrically powered base frames, which move on rails set into the floor as illustrated in Fig. 4.7. Commonly only one forklift access aisle is offered, and the rack sections are shifted to open up access as needed to any particular pallet place—floor loadings are high. Operationally it almost has the same characteristics as "adjustable pallet racking", but is somehow slower in use, and the position of pallet utilization is likely to be the same as "adjustable pallet racking" at 90–95%. Safety trips are fitted to both sides of every mobile base frame to cut power of any obstruction in the event of hazardous or other situations.

Usually, this kind of system takes up a big part in floor and equipment costs, and it tends to be slower in operation. But it offers dense storage, and is appropriate for the large number of item lines forming the "Pareto tail" of an item range, where single item lines have low stock and throughput. Also, it finds use in applications of cold-store where costs of space are significantly high, where variations of temperature are minimized by cutting the air space in the area of storage.

4.6.6 Pallet Live Storage

The systems of live storage are made up of inclined gravity roll conveyors, laid out side by side and on a number of vertical levels. The pallets are fed in at the high end and removed as required at the lower. Such a system imposes "first-in-first-out". The pallets (only accessible) are at the outfeed end, so any one lane only should hold pallets of the similar/same item line.

In these installations, the conveyor's incline is significantly critical, and is perhaps best obtained by trial and error, by testing the pallets that will be using the

Fig. 4.7 Powered mobile racking

system. The devices of braking and end stops are fitted to control the pallets' movements towards the discharge end.

The system of live pallet storage is appropriate for fast-moving item lines. They may offer effective order picking regimes, which automatically refill vacant places, as well as also offer physical separation between replenishment operations and picking.

The pallet live storage is significantly expensive, and utilization of pallet position is not always high—say 70%. The type of pallet and condition is significantly critical, and in some applications slave pallets may have to be used (Fig. 4.8).

4.6.7 High Bay and Other Storage Installations

High bay warehouses, with racking accessed through automated-control stacker cranes can be created with double deep racking or single deep racking. Typically stacker cranes require 1.5 m to 1.6 m aisles for installation and standard pallet handling can be 40–45 m high. They are, therefore, inclined to make good utilization of place.

Operationally, they are similar to "double deep installation" or "adjustable pallet racking", with almost similar pallet position utilization figures, but they may be designed for high rates of throughput, with operation of 24 h. Remaining computerized handling and storage systems cover block stacking accessed through computer controlled in the air/overhead cranes, and storage of racked with pallets accessed through robot trolleys.

Fig. 4.8 Pallet live storage

Table 4.1 Comparison of palletized systems of storage

Factors	Block	DD	APR	Live	VNA	Push-back	Mobile	Drive-in	High-bay
Use of floor area	5	3	1	5	3	5	5	5	4
Use of building	5–2	3	2	5	3	5	5+	5	5
Volume ability to go high[a]	1	4	4	4	5	4	4	4	5+
Speed of throughput	4	4	5	5	5	3	1	3	5
Access to stock	1	4	5	2	5	2	5	1	5
Suitability for picking	2	4	5	5	4	1	1	1	1
Stock rotation (FIFO)	1	4	5	5	5	3	5	1	5
Product damage	1	4	4	4	4	4	4	3	5
Easy to manage	3	4	5	5	5	3	5	3	5
Fire protection	5	3	4	3	3	2	1	3	2
Rack cost	5+	3	4	1	3	1	1	3	3

[a]Depends on height of building, *APR* adjustable pallet racking, *DD* double deep racking, *VNA* very narrow aisle racking, *FIFO* first in first out, Live = pallet live storage, Mobile = powered mobile racking

4.6.8 Palletized Storage

One method to compare systems of storage is the use of a matrix to "rank" the significance and importance of the different characteristics. This can be completed through grading on a scale of say 5 = Good to 1 = Poor. One researcher's example is shown as Table 4.1.

4.6.9 Small Product Storage Systems

With palletized storage systems, there is a different range and types of systems for holding small products. In some cases, operationally these are almost similar to their pallet holding "big brothers".

With storage of small product it usually occurs that many systems are integrated into one installation. For instance, cabinet and drawer units can be built into a shelving installation. As a result, the idea of modularity and standard size of equipment is significantly important for systems of small item storage.

4.6.10 Shelving: Long and Short Span

Generally, shelving consists of modular parts that allow installation of different heights, shelf depths and vertical shelf spacing. Typically the standard span width is almost 1 m; however, long span shelving is available that facilitates holding products of stock. Subdividers may be used to give more places but smaller where this is suitable for the stock being held.

Shelving can be accessed in many methods—from mezzanine levels, ground levels, free path or fixed path lifting equipment such as picking cranes and forklifts. A variant on this idea is cantilever shelving that is sustained/supported from sides and backs, and provides complete access from the front and flexibility for holding products of different sizes.

4.6.11 Tote Bins

Tote bins are created in a range of raw material such as polypropylene, fibreboard, wire mesh and galvanized steel. They are created in modular sizes that are submultiples of standard dimensions, and this facilitates stacking and nesting, and the use of many sizes of tote bins within one installation.

A very useful device of supporting tote bins—in place of static storage places—for ease of movement (e.g. movement from store to manufacturing assembly operation) is the Louvre panel. It gives easy removal and attachment of totes, and also gives other attachments like spigots for holding products such as belts, and gaskets.

4.6.12 Drawer Units

Drawer units may be incorporated or free-standing into shelving stores or modules counters. Sub-separators are used that enable specifically good use of drawer space, and there is a range of many other fittings suitable for such products as machined products and electronic components. The drawer offers good access to inventory/stock and gives a secure and clean environment.

4.6.13 Dynamic Systems: Live and Mobile Storage

For palletized inventory, there is very small item mobile storage with shelves mounted on moving platforms, which run along floor-mounted nails. Alternative palletized systems are not usually powered, but are moved manually by turning a large wheel at the end of every shelving section (Fig. 4.9).

Broad usage of this system is in insurance companies and banks for holding documents required not very frequently.

Small cartons and items may also be held in systems of live storage, sometimes referred to as flow racking, with the goods placed on inclined roller conveyors, fed in at the high end and taken out as needed at the lower end (Fig. 4.10).

4.6.14 Mechanized Systems: Carousels

On shelves carousels hold materials, moved and supported by chains, which are electric-motor-driven to bring particular item lines as needed to an operator. The aim is to reduce the movement of operator when accessing stock, so carousels find application in small products order picking. The carousel units may offer speedy rates of accession to inventory, and are secure.

Carousels have two different types, vertical and horizontal carousels.

In the horizontal carousel, inventory is held in shelved baskets suspended from a motor-driven overhead chain conveyor loop, and for every stock accession the chain is driven backwards or forwards to bring the needed materials/components to the operator through the shortest distance (Fig. 4.11).

Fig. 4.9 Mobile parts storage

Fig. 4.10 Small parts live storage

Fig. 4.11 Horizontal carousel

In the vertical carousel, inventory is held on shelves suspended between two motor-driven vertical chain loops. The shelves are moved down or up, taking the shortest distance/route to bring inventory products as needed to the operator. The one major benefit of the vertical carousel is "it can be built on the roof (roof height) of a building, and enjoy full use of building space" (Fig. 4.12).

For carousel units, usually it is not practical to replenish inventory at the same time as stock is being withdrawn, so a working pattern has to be established for these two aspects of the operation.

Another mechanized storage system of small products is the miniload. A computerized crane operates in a central aisle to retrieve products/materials and put them into the medium storage tote containers or shelving set out on either side of a central crane aisle (Fig. 4.13).

4.6.15 Other Types of Storage

Material like linoleum and carpets, and engineering material like rod, tube and bar are not appropriate for the standard types of storage system, which has been discussed before, and these items require special handling and storage.

Fig. 4.12 Vertical carousel

Fig. 4.13 Miniload

Cantilever racking—supporting bars set at many levels from back frames—is usually used in applications of engineering for long rigid products such as tube and bar stock. This kind of storage is usually accessed by four-directional reach trucks, overhead cranes or side loaders in order to reduce the aisle widths required for access. For products such as heavy sections of sheet or plate, vertical “toast-rack” storage type is very commonly used.

Other long loads that need some support along the length, such as carpet rolls, can be stocked in pigeonhole racking, accessed by forklift fitted with long carpet booms that are inserted into the centre of the roll to position and lift it.

Discussion Questions

1. Explain the strategic issues affecting warehousing.
2. What is the main role of warehouses?
3. Briefly explain the types of warehouses.
4. Discuss warehouse operations in detail with examples.
5. What are the principles and objectives of good warehouse design and management?

6. What is the difference between fixed stock and random stock location? Discuss with examples.
7. Explain and discuss the "palletized storage systems" with examples.

References

Chen, Z., & Haynes, K. E. (2015). Impact of high-speed rail on international tourism demand in China. *Applied Economics Letters, 22*(1), 57e60.

Chen, F. F., Mantel, R., Ioannou, G., Roos, H., van den Berg, J., & Wilhelm, M. R. (1996). Infrastructure and networking in material handling research and development. In R. J. Graves, L. F. McGinnis, D. J. Medeiros, R. E. Ward, & M. R. Wilhelm (Eds.), *Progress in material handling research* (pp. 25–28). Ann Arbor, MI: Braun-Brumfield.

Chuersuwan, N., Nimrat, S., Lekphet, S., & Kerdkumrai, T. (2008). Levels and major sources of PM2.5 and PM10 in Bangkok Metropolitan Region. *Environment International, 34*, 671–677.

Dunn, S. C., Seaker, R. F., & Waller, M. A. (1994). Latent variables in business logistics research: Scale development and validation. *Journal of Business Logistics, 15*(2), 145–172.

Herrmann, J. W., Ioannou, G., Minis, I., & Proth, J. M. (1999). Minimization of acquisition and operational costs in horizontal material handling system design. *IIE Transactions, 31*(7), 679–693.

Ioannou, G. (1996). Integrating shop layout and material handling system design decisions. In R. J. Graves, L. F. McGinnis, D. J. Medeiros, R. E. Ward, & M. R. Wilhelm (Eds.), *Progress in material handling research* (pp. 227–244). Ann Arbor, MI: Braun-Brumfield.

Khan, S.A.R., Dong, Q., SongBo, W., Zaman, K., and Zhang, Y. (2017b). Travel and tourism competitiveness index: The impact of air transportation, railways transportation, travel and transport services on international inbound and outbound tourism. Journal of Air Transport Management, 58(1), 125–134.

Khan, S. A. R., Dong, Q., & Zhang, Y. (2017). Role of ABC analysis in the process of efficient order fulfillment: Case study. *Advanced Engineering Forum, 23*(7), 114–121.

Khan, S. A. R., Zhang, Y., Anees, M., Golpîra, H., Lahmar, A., & Dong, Q. (2018). Green supply chain management, economic growth and environment: A GMM based evidence. *Journal of Cleaner Production, 185*(6), 588–599.

Skintzi, G., G. Ioannou and G.P. Prastacos. (2005). Flexible warehousing policies. EurOMA International Conference on Operations and Global Competitiveness, Budapest, Hungary, June 19–22.

Skintzi, G., G. Ioannou and G. Prastacos. (2008). Investigating warehousing policies. International Journal of Production Economics, 112(2), 955–970.

Chapter 5
Inventory Management

Inventory is the most expensive asset of a company. Usually inventory is more than 10–15% of total assets for some companies. Undeniably, manufacturing companies carry more inventory than service sector companies. But effective management of inventory is nonetheless significantly important for both service companies and manufacturing companies. Table 5.1 illustrates the amount of inventory, the ratio of inventory to total assets and total revenue, of some big well-recognized service multinational companies, such as casino hotels. The last two firms shown in Table 5.1 reflect relatively low ratios compared to most manufacturers. Management of inventory for service companies poses different challenges. For instance, casino hotels carry a broad range of food products to store the diverse restaurants functioning within their properties. Managing food-related inventory (perishable) presents a challenge to managers of operations.

The policy related to inventory management affects how efficiently a company deploys its assets in manufacturing services and goods. Developing effective inventory control systems to minimize stock-outs and waste in service companies and/or manufacturing companies is a very complex problem. The right quantity of inventory supports logistics, production and other functions. On the other hand, excessive inventory is a "killer and dangerous" for companies and it is a sign of poor management of inventory that builds unnecessary waste of scarce resources. However, excessive inventory adversely affects a company's financial performance. The need for good and better management of inventory continues to challenge operations supervisors/managers.

5.1 Dependent and Independent Demand

Generally, inventory management models are divided by the types and nature of the inventory that are taken into account and can be categorized as independent and dependent demand models.

S. A. Rehman Khan, Z. Yu, *Strategic Supply Chain Management*, EAI/Springer Innovations in Communication and Computing,
https://doi.org/10.1007/978-3-030-15058-7_5

Table 5.1 Inventory investments compared to total assets and revenue

Company	Financial Year End	Total Assets ($)	Total Revenue	Inventory/ Total Assets (%)	Inventory/ Total Revenue (%)	Year End Inventory ($)
Microsoft Corporation	Jun 30, 09	77,888	58,437	0.92	1.23	717
Ford Motor Company	Dec 31, 09	194,850	111,308	2.80	4.90	5,450
Toyota Motor Corporation	Mar 31, 09	295,857	208,995	5.02	7.11	14,857
Honda Motor Company	Mar 31, 09	121,735	103,116	10.53	12.43	12,813
Wal-Mart Stores, Inc.	Jan 31, 10	170,706	408,214	19.43	8.12	33,160
Target Corporation	Feb 3, 09	44,533	65,357	16.12	10.98	7,179
Pfizer, Inc.	Dec 31, 09	212,949	50,009	5.82	24.80	12,403
Intel Corporation	Dec 26, 09	53,095	35,127	5.53	8.36	2,935
Advanced Micro Devices, Inc.	Dec 26, 09	9,078	5,403	6.25	10.49	567
Las Vegas Sands Corp	Dec 31, 09	20,572	4,563	0.13	0.59	27
MGM Mirage	Dec 31, 09	22,518	5,979	0.45	1.71	102

Gray color shaded values reflect relatively low ratios when compared to other manufacturer

5.1.1 Dependent Demand

It is the internal demand on the basis of the demand of the finished goods in which the material/components are used. Raw materials, components and subassemblies are examples of dependent demand products. The dependent demand may have some dramatic fluctuations due to its dependency on the demand for finished goods, particularly if the final goods are manufactured in larger lot sizes. Dependent demand can be estimated or calculated once the demand for the finished goods is known. Hence, MRP (material requirement planning) software is usually used to calculate/compute exact requirements of material.

5.1.2 Independent Demand

It is the demand for a company's end goods and has a pattern of demand affected by seasonal patterns, trends and also conditions of market. For instance, the demand for an all-terrain vehicle is independent demand. Headlights, gaskets and batteries originally used in assembling the vehicles are dependent demands, while the replacement of headlights, gaskets, batteries and seals sold as service parts to the consumer/ repair shops are products of independent demand. In the same way, the battery (original) used in new car assembling is a dependent demand product for the automobile manufacturer, but the battery (new) that you bought to replace the original battery is demand of an independent item. Independent demand items cannot be derived using the MRP (material requirement planning) logic from the demand for other products, and must be forecasted on the basis of market conditions.

5.2 Tools of Inventory Management

Managers of operations are concerned with controlling inventories efficiently not only within their companies, but also throughout their end-to-end supply chains. An effective demand (independent) inventory system allows manufacturing companies to store up capacity of production in the form of finished products and WIP (work-in-process) inventories. However, few service companies are able to inventory their outcome; such companies may rely on labour scheduling, cross-training to balance demand and supply.

All service companies and manufacturing companies are concerned with effective inventory control and planning. Inventory requires storage and handling space, capital investment, and it is also subject to shrinkage and deterioration. Although a company's financial performance and operating cost performance can be enhanced through minimizing inventory, the risk of stock-outs may be disturbing to customer service.

5.3 The Basic Types of Inventories

Inventory includes all the goods and materials that are bought, partially completed components, materials and finished products produced. To buffer uncertainty in the marketplace or break dependencies between work phases in the chain of supply is the basic function of inventory. For instance, a suitable amount of inventory, known as buffer stock and safety stock, can be used to cushion uncertainties because of fluctuations in delivery lead-time, demand and supply. In the same way, the right quantity of inventory enables a work centre to smoothly operate/function without disruption when other work centres are off-line for repair or maintenance. Keeping the right quantity of inventory at every work centre allows a speedy work centre to run/function when it is constrained by slower upstream work centres.

In the global environment, it is not unfamiliar that companies use the concept of geographical specialization to produce their goods in developing regions and countries. In this situation, there is no doubt that developing countries specialize in abundant components/ raw materials and lower-wage labour, whereas producing companies offer the capital and technology to manufacture the products. The ability to geographically disperse and separate the consumption of the final products from manufacturing is a main function of inventory. For producers, inventories also act as stored capacity. For example, snowmobile producers can build up inventory by manufacturing snowmobiles year-round in anticipation of peak demand during the winter season.

There are usually five broad classifications of inventories: finished goods; raw materials; work in process; MRO (maintenance, repair and operating); and in-transit inventory.

- Finished products are completed items ready for dispatch. Finished product inventories are usually kept to buffer against unexpected changes in demand and in anticipation of manufacturing process downtime; to ensure production economies when the setup cost is high; or to stabilize manufacturing rates, especially for seasonal items.
- Raw materials are unprocessed purchased materials for producing the finished products. After the process of manufacturing, raw materials become a part of finished goods. There are several seasons for keeping inventories of raw material, including volume purchases to create transportation economies; stockpiling for anticipation of future price increases or avoiding a potential short supply; or keeping safety stock to protect delivery or quality problems from supplier side.
- Work in process (WIP) is partially processed goods not yet ready for sales. One main reason to keep inventories of work in process is to decouple processing phases/to break the dependencies between work centres.
- Maintenance, repair and operating (MRO) are supplies and materials used when manufacturing the items but are not part of the items. Solvents, lubricants and cutting tools for machines are examples of operating supplies and maintenance repair. The primary reasons for storing supplies of MRO are to gain purchase economies and to avoid material shortages that may shut down manufacturing.
- In-transit inventory is very critical and creates significant potential impact on a company's performance. Higher inventory in-transit means a higher risk factor, because in-transit inventory has been dispatched from its origin and still has not arrived at its destination.

5.3.1 Inventory Costs

The fundamental line of effective management of inventory, which is to minimize stock-out and effectively control the costs of inventory, can be classified in many ways: as indirect costs and direct costs; variable costs and fixed costs; order/setup costs and holding/carrying costs.

Direct costs are those that are traceable (directly) to the unit manufactured, including the amount of labour and materials used to manufacture a unit of the finished product. Indirect costs are those that cannot be traced directly to the unit manufactured, and they are synonymous with overhead of production. MRO, heating, building lighting, plant security and equipment are examples of indirect costs. Fixed costs are independent on the output quantity, but variable costs change in connection with the level of output. Equipment, lighting, building and heating are examples of fixed costs, whereas direct labour costs and direct material costs are variable costs. A main focus of inventory management is to somehow reduce and control variable costs since fixed costs are commonly considered sunk costs. In simple words, sunk costs are the costs that have already been incurred and cannot be reversed or recovered.

Order costs are the costs of direct variable connected with placing an order with the supplier, whereas carrying or holding costs are the costs incurred for holding inventory in storage. Order costs cover clerical and managerial costs for preparing the purchase, and also other incidental expenses that directly can be traced to the purchase, for instance, warehousing expenses, holding costs with charges of handling, pilferage, taxes, shrinkage, insurance and the cost of capital. In a context of manufacturing, setup costs are used in place of order costs to describe the costs related with equipment and setting up machines to manufacture goods. On the other hand, in inventory management discussions, order costs and setup costs are usually used interchangeably.

5.3.2 Inventory Investment

Unquestionably, inventory serves several critical functions for service and manufacturing companies; however, excessive inventory is damaging to a company's financial competitive edge and health. Whether inventory is an asset that contributes to company goals or a liability depends on its management.

Inventory is very expensive, and it ties up a company's working capital. Furthermore, inventory incurs carrying/holding costs and also requires space for storage. Some items such as hazardous or food items require special storage and handling that add additional cost.

Investment of inventory can be measured in many ways. Typically, annual physical stock counts to determine the total dollars invested in inventory offer an absolute measure of inventory investment. The value of inventory is then reported in the balance sheet of the company. This value may be used to compare past inventory investment and budget. On the other hand, the absolute invested dollars in inventory does not provide enough evidence about whether the firm is using its inventory wisely. A broadly used measure to determine whether a company is making full use of its inventory to generate income is inventory turnovers or ratio of inventory turnover. This ratio represents how many times a firm turns over its inventory in an accounting period. Generally, quick turnovers are viewed as a positive sign because it shows the firm is able to generate more and more revenue per dollar in inventory investment. Furthermore, faster and quicker turnovers allow the firm to minimize carrying costs and warehousing costs and also increase cash flow. Conversely, a low inventory turnover is a sign of deficiencies in the efforts of marketing personnel or of overstocking in the item line.

Formula of inventory turnover ratio is given below:

$$\text{Inventory turnover ratio} = \frac{\text{Cost of Revenue}}{\text{Avg. Inventory}}$$

Inventory turnover ratio may be calculated for any accounting period—annually, quarterly or monthly. *Cost of revenue* is also the cost of goods sold that is readily available from a company's statement of income. *Avg. inventory* is the mean of the starting and ending inventory. On the other hand, a company inventory can fluctuate

Table 5.2 Inventory turnover ratio

Company	Year end inventory ($) millions	Total revenue ($) millions	Inventory turnover ratio	Cost of revenue ($) millions	Financial year end
Microsoft Corporation	740	62,484	16.75	12,395	June 30, 10
Ford Motor Company	5450	118,308	18.35	100,016	Dec 31, 09
Toyota Motor Corporation	15,220	202,814	11.73	178,551	Mar 31, 10
Honda Motor Company	10,010	91,815	6.86	68,651	Mar 31, 10
Wal-Mart Stores, Inc.	33,160	408,214	9.19	304,657	Jan 31, 10
Target Corporation	7180	65,357	6.14	45,583	Jan 30, 10
Pfizer, Inc.	12,403	50,009	0.72	8888	Dec 31, 09
Intel Corporation	2935	35,127	5.30	15,566	Dec 26, 09
Advanced Micro Devices, Inc.	567	5403	5.52	3131	Dec 26, 09
Las Vegas Sands Corp	27	4563	107.67	2907	Dec 31, 09
MGM Mirage	102	5979	34.70	3539	Dec 31, 09

broadly in a financial year; thus, the average of the ending and beginning inventory may be not a good indicator of the company's average inventory for the year. In this situation, the average of the twelve monthly ending inventories can be used as the average inventory when calculating the turnover ratio (annually). Table 5.2 illustrates the inventory turnover (annual) for the companies in Table 5.1. Since the average monthly inventories were not available in the annual reports, companies such as LVS Corp. (Las Vegas Sands Corporation) turned over its inventory a staggering 107 times. While the nature of LVS's business suggests that a main position of its revenue came from gaming sales and hotel rooms, the inventory can consist of many goods for the related restaurants. Therefore, the revenue generated by gaming sales and hotel room could be excluded from the computation of the ratio.

5.4 ABC Inventory Control System

A general problem with systems of inventory management is the challenge to maintain accurate records of inventory. Several companies use "cycle counting" to resolve problems and discrepancies between their inventory records and physical inventory counts on a quarterly or monthly basis. Physically counting or cycle counting inventory on a specific period basis also helps to recognize inventory problems and obsolete stocks so that remedial/corrective action can be taken in a reasonable amount of time. On the other hand, cycle counting may be very time-consuming, costly and also can disrupt some activities of operations.

Table 5.3 ABC inventory classification

Classifications	% of Total inventory products/items	% of Total annual dollar usage
A Products	20	80
B Products	40	15
C Products	40	5

The ABC system of inventory control is a helpful approach for determining which inventories should be managed and counted more frequently and which should not. The analysis is usually combined with the rule of 80/20 or Pareto rule. The rule of 80/20 suggests that 80% of the targets can be achieved by doing sonly 20% of the tasks, but the rest of the 20% of the objective will take 80% of the tasks. The rule recommends that tasks fall into the two categories, the first category to be assigned the priority tasks and closely managed.

The ABC system of inventory control prioritizes inventory products into groups A, B and C. On the other side, it is common that some companies choose to use more than three broad categories. The "A" products are given the higher priority, while "B and C" are low and lower, respectively. Greater attention to resources and safety stocks is devoted to the "A" products. Usually priority is most determined by usage (annual dollar). However, priority can also be determined by shelf life of goods, critical material and strategic material, sales volume, or any other criteria.

Whenever prioritizing/arranging inventory by annual dollar usage, the ABC system recommends that almost 20% of the products make up about 80% of the annual dollar usage, and these products are well classified as the "A" products. The "B and C" products make up about 40% of the products and account for almost 15% of the total annual dollar usage; however, the category "C" products are the remaining 40% of the products, making up almost 5% usage of inventory (total annual dollars).

Table 5.3 provides the summary of the classification. Since the "A" products are the highest usage products, they should be well monitored. The "C" products would then be counted less frequently as stock-outs can be somehow allowed to save carrying/holding costs and space in the warehouse. The "B" products lie somewhere between A and C products.

The classification of inventory can be done annually, quarterly and monthly. As a result, inventory classification based on annual dollar usage would not be very significantly helpful to management. Example 5.1 shows the inventory classification (ABC) using annual dollar usage.

Example 5.1 Inventory classification based on annual usage ($)

Inventory item number	Classification by annual dollar usage	Item cost ($)	Annual usage ($) (millions)	Annual usage (units)	% of Total annual dollar usage
A 246	A	1.00	22,000	22,000	35.2
N 376	A	0.50	20,000	40,000	32.0
C 024	B	4.25	6239	1468	10.0
R 221	B	12.00	4920	410	7.8

Inventory item number	Classification by annual dollar usage	Item cost ($)	Annual usage ($) (millions)	Annual usage (units)	% of Total annual dollar usage
P 112	B	2.25	3600	1600	5.8
R 116	B	0.12	3000	25,000	4.8
T 049	C	8.50	1054	124	1.7
B 615	C	0.25	875	3500	1.4
L 227	C	1.25	550	440	0.9
T 519	C	26.00	260	10	0.4
Total annual dollar usage			$62,498		100%

Note that in this example, the "A" products only account for about 67% of the total annual dollar volume; however, the "B" products account for almost 28%. This shows that judgment must also be applied when using the classification method of ABC analysis and the rule of 80/20 should only be used as a general guideline.

Example 5.2 Inventory classification based on current value of inventory

Inventory item number	Total inventory value	Current inventory ($) (millions)	Current inventory (units)	Annual dollar usage	Item cost ($)	% of Total inventory value ($)
T 519	A	7800	300.00	C	26.00	40.5
A 246	A	5600	5600.00	A	1.00	29.1
L 227	B	1500	1200.00	C	1.25	7.8
C 024	B	1479	348.00	B	4.25	7.7
R 221	B	960	80.00	B	12.00	5.0
P 112	B	792	352.00	B	2.25	4.1
T 049	C	425	50.00	C	8.50	2.2
N 376	C	400	800.00	A	0.50	2.1
R 116	C	252	2100.00	B	0.12	1.3
B 615	C	30	120.00	C	0.25	0.2
Total physical inventory ($)	100%	$19,238				

5.5 The Matrix of ABC Inventory

The analysis of ABC inventory can be expanded to assist in recognizing expired/obsolete inventory and to analyse whether a firm is stocking the right inventory by comparing two ABC analyses. Firstly, an ABC inventory analysis is done based on annual inventory dollar usage (as represented in Example 5.1) to categorize inventories into C, B and A clusters. Lastly, the two ABC analyses are consolidated to form an inventory matrix of ABC as illustrated in Fig. 5.1. The products "A" based on current inventory value should match the "A" products based on annual

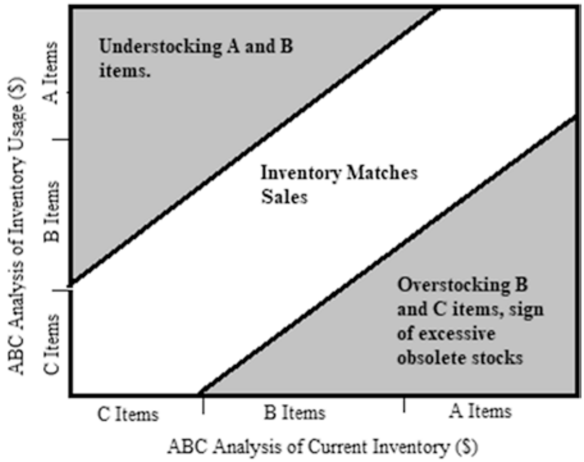


Fig. 5.1 Generic ABC inventory matrix

inventory dollar usage, falling within the unshaded diagonal region of the figure. In the same way, the “C and B” items should match when comparing the two ABC analyses. Otherwise, the firm is stocking the wrong products. The inventory matrix of ABC also recommends that some overlaps are expected between two borderline groupings (as shown by the broad diagonal region). For example, some marginal “B” products based on annual inventory dollar usage may appear as products “C” based on the current inventory value categorization and vice versa.

According to Fig. 5.1, plots in the upper-left shaded triangle of the inventory matrix of ABC show that some “A” products based on annual inventory dollar usage are presenting up as “C or B” products based on the current inventory value categorization and that some items of “B” similarly have been categorized as items “C”. This demonstrates that the firm has their higher dollar usage products. On the other hand, plots in the lower-right shaded triangle present products based on current inventory value, and some items of “B” are similarly presenting up as “A” products, thus indicating that the firm has current inventories for its “C and B” products and indicating the presence of excessive obsolete/expired stock if the turnover ratio of inventory is very low. Obsolete stocks should be decreased so that valuable investment of inventory and space of warehouse may be used for productive inventory. When used in conjunction with turnover of inventory, the inventory matrix of ABC is a powerful tool for managing inventory investment. For instance, Fig. 5.2 shows the categorization based on current inventory value for the same ten products illustrated in Example 5.1, and it also presents the annual dollar usage categorizations.

The two ABC analyses from Examples 5.1 and 5.2 are consolidated and plotted on the inventory matrix of ABC illustrated in Fig. 5.2. Each inventory product is plotted on the matrix using the “% of total current inventory” on the horizontal axis and the “% of total annual dollar usage” on the vertical axis. For example, the coordinate

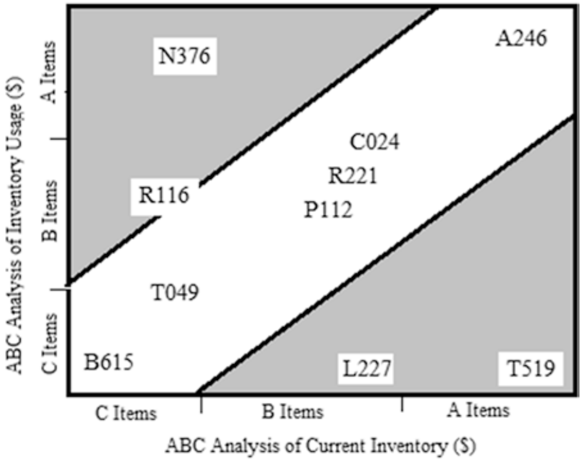


Fig. 5.2 ABC inventory matrix (for Example 5.2)

of the product "T519" would be (40.5, 0.4). The axis of vertical ranges from 0.4% to 35.2%, and the axis of horizontal ranges from 0.2% to 40.5%, thus "T519" falls on the extreme lower-right corner of the matrix. In Fig. 5.2, the plots present that six of the inventory products fell along the diagonal, suggesting the suitable stocking levels. The firm has probably overstocked products "T519 and L227" and under stocked "N376" and possibly "R116". It is significantly important, however, that the turnover ratio of inventory for each product be used in conjunction with the inventory matrix of ABC to get a sense of how slow or fast inventories are turning over.

5.6 Radio Frequency Identification Device

The barcode has been used to recognize the content of a carton for decades. However, it cannot save enough or store enough information to differentiate products at the item level. There is a need for direct line of sight to read a barcode and to store the information on it, which is not updatable. Radio Frequency Identification Device (RFID) has been used as an eventual successor to the barcode for tracking a single unit of products. Direct line of sight is not necessary in the technology of RFID to update information or read a tag. In the last couple of decades, the technology of RFID has been used in passport identification, medical discipline, libraries, etc.

Basically there are two main standards of RFID: the EPC (electronic product code) standard managed by EPCglobal, Inc., a subsidiary of GSI that built the UPC barcode; and second, the 18000 standard of the ISO (International Standards Organization). The DOD (Department of Defence) and Wal-Mart are the two largest adopters of RFID technology. In the year of 2005, both organizations issued man-

Table 5.4 EPCglobal's tag classes

EPC class type	Features	Type of tag
Class O	Read only	Passive (64 bits)
Class 1	Read many, write once	Passive (minimum 96 bits)
Class 2	Write/read	Passive (minimum 96 bits)
Class 3	Write/read with battery power to increase range	Semi-active
Class 4	Write/read active transmitter	Active
Class 5	Write/read active transmitter	Active tag that can communicate with another five tags

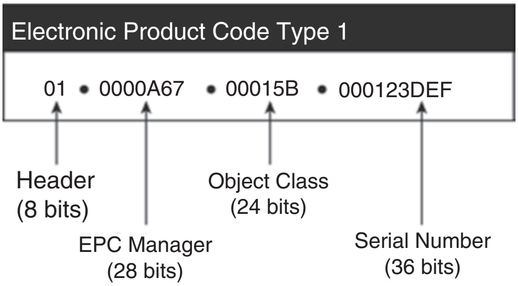


Fig. 5.3 Structure of the EPC

dates for their major suppliers to use and implement RFID to recognize their goods. The stores of Wal-Mart adopted the standard of EPC, whereas the DOD selected the EPC standard for general purpose applications and the ISO standard for air interface communications between the tags and the readers. The standard of EPC is more broadly adopted, especially in the commercial sector (Table 5.4 and Fig. 5.3).

5.6.1 Components of an RFID System

A Radio Frequency Identification Device solution consists of four parts: the reader, tag, RFID software and communication network. The tag contains an antenna for wireless communication and computer chip with the fixed position RFID reader, and the network of communication connects the readers to transmit inventory information to the enterprise information system. The software of RFID manages the synchronization, collection and communication of data with ERP, warehouse management, SC (supply chain) planning systems and stores the information in a databank. Figure 5.4 presents a generic system of RFID.

Though Radio Frequency Identification Device (RFID) was designed for use at the item level to recognize individual items, current execution emphasis is at the aggregate level where tags are located on crates, cases, containers or pallets due to the high cost of the tags. A tag of RFID costs almost 10 cents today compared to $2 in 1999, but it is still not financially possible to tag individual low value products. Thus, the existing focus is at the aggregate level, emphasizing pallets or cases of

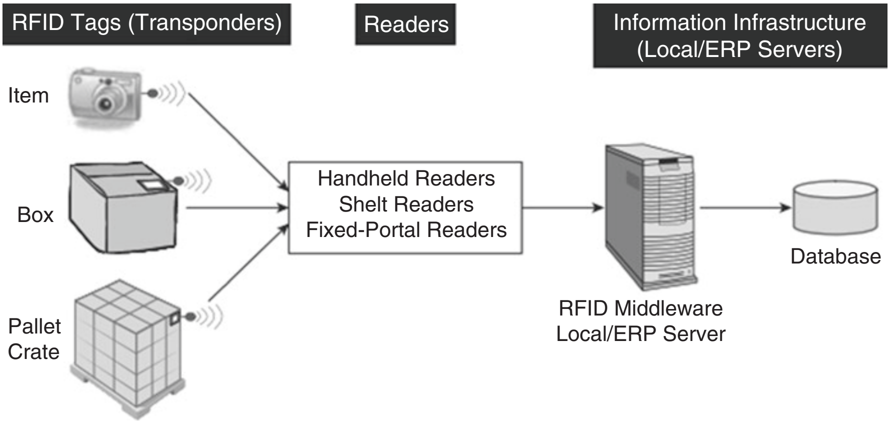


Fig. 5.4 Radio frequency identification device system

items, although some retailers have started to locate RFID tags on individual high value products, such as electronic products, to prevent theft.

5.6.2 How RFID Automates the Supply Chain

In the perspective of supply chain, the technology of RFID is valuable for tracking inventory. It can synchronize information and physical flow of products across the SC (supply chain) from producers to retailer and to the final customers at the right time and place. Similarly, RFID can trace and track returned products throughout the supply chain. Also, it helps to minimize out-of-stock products. It is true that RFID is an invaluable tool for improving management of inventory and efficiencies of supply chain. The steps by which RFID can automate the SC follow.

- *Manufacturing*: A RFID tag may be located on the unit being manufactured so that particular customer configurations can be incorporated during the manufacturing process. This is invaluable in a MTO (make-to-order) environment.
- *Material Management*: As a vehicle of supply enters the store/warehouse, the fixed portal RFID reader positioned at the entrance reads the tags on the individual products/pallets to provide routing, handling and storage information of the incoming products. However, status of inventory can be updated automatically.
- *Distribution Centre*: As the vehicle of logistics arrives at the loading dock, the fixed portal reader of RFID communicates with the tag on the vehicle to confirm that it is approved to pick up goods. When the loaded vehicle leaves the crosses and docks the portal, the reader picks up the signals from the tags to alert the ERP systems and RFID software to update the inventory and initiate an ASN (advance shipping notice).
- *Retail Store*: As a delivery truck enters the unloading dock, the fixed portal reader picks up the signals from the tags, and the RFID software application processes the signals to give particular instruction of handling and to initiate automatic

routing of the products. The RFID reader can also be located on the store shelf to trigger replenishments when products reach their reorder point. On the other hand, status of inventory can be updated in real time automatically at any stage.

5.7 Inventory Models

In this section, a variety of inventory models for independent demand products are reviewed by classifying the models into two wide-ranging categories. First of all, deterministic models of inventory are discussed that assume delivery time, demand and other parameters. These models use fixed parameters to derive the optimum order quantity to reduce cost of total inventory. Thus, these models are also known as fixed order quantity models. The economic order quantity, economic manufacturing quantity and quantity discount models, the three models are the most broadly used fixed order quantity models. In the following section(s), the statistical reorder point is discussed, where lead-time or/and demand are not constant but can be estimated through means of a normal distribution. Lastly, the periodic review system and continuous review system are briefly discussed.

5.7.1 The EOQ Model

The EOQ model (economic order quantity model) helps make many useful ordering decisions, which is a classic independent demand inventory system. The primary order decision is to determine the size of optimal order that reduces costs of total annual inventory—that is, the sum of the annual inventory carrying/handling costs and the annual setup cost/order cost. The problem revolves around the trade-off between annual order cost and annual inventory carrying cost. When the size of order for an item is small, orders have to be located on a frequent basis, causing high annual setup costs/order costs. On the other hand, in the company, then this item's average inventory level is low, leading to low annual costs of carrying inventory. When the size of order for an item is larger, orders are placed less frequently, resulting in lower annual order costs. Unluckily, this also causes the average inventory level for this item to be high, resulting in higher annual cost to carry the inventory. The model of EOQ thus seeks to find an optimal size of order that reduces the sum of the two annual costs.

5.7.1.1 Assumptions of the EOQ Model

Users should carefully think about the assumptions given below when determining the EOQ:

1. *The demand is constant and known*. For instance, if there are 365 days per year, the annual demand is known to be 730 units, and then daily use level must be two units throughout the whole year.

2. *Lead-time of order is constant or known*. For instance, if the lead-time of delivery is known to be 10 days, every delivery will arrive 10 days after the order is placed.
3. *Replenishment is instantaneous*. It takes one time to deliver the complete order, and half shipments are not permitted.
4. *Price is constant*. Price or quantity discounts are not permitted.
5. *The carrying cost is constant and known*. The rate or cost to carry inventory must be constant or known.
6. *Cost of order is constant and known*. The cost of placing an order must be constant for all orders.
7. *Stock-outs are not allowed*. Inventory should be available.

5.7.1.2 Deriving the EOQ

The EOQ can be derived from the formula of total annual inventory cost using basic calculus. The sum of the annual cost of purchase, the annual cost of holding and the annual order cost comprise the total annual inventory cost. The formula is given below:

$$\text{TAIC} = \text{Annual purchase cost} + \text{Annual order cost} + \text{Annual holding cost}$$

$$\text{TAIC} = \text{AHC} + \text{APC} + \text{AOC} = (R \times C) + (Q/2) \times (k \times C) + (R/Q) \times S$$

where

TAIC = Total annual inventory cost
AHC = Annual holding cost
APC = Annual purchase cost
AOC = Annual order cost
R = Annual demand or requirement
C = Purchase cost per unit
S = Cost of placing an order
K = Holding rate, where annual cost of holding per unit = $k \times C$
Q = Order quantity

Since k, C, R and S are deterministic (assumed to be constant), Q is the only unknown variable in the equation of TAIC. The optimum Q (the economic order quantity) can be obtained by taking the first derivative of the TAIC with respect to Q and setting it equal to zero. The second derivative of TAIC can also be taken with respect to Q to prove that the TAIC is a concave function, and thus, $C - \mathrm{d}Q = 0$ is at the lowest point of the total annual inventory cost curve. Thus:

$$\frac{\mathrm{dTAIC}}{\mathrm{d}Q} = 0 + (½ \times k \times C) + (-1 \times R \times S \times 1/Q^2)$$

$$= \frac{KC}{2} - \frac{RS}{Q^2}.$$

Then setting $\frac{\mathrm{dTAIC}}{\mathrm{d}Q}$ equal to zero,

$$\frac{kC}{2} - \frac{RS}{Q^2} = 0$$

$$\Rightarrow \frac{kC}{2} = \frac{RS}{Q^2}$$

$$\Rightarrow Q^2 = \frac{2RS}{kC}$$

$$\Rightarrow \mathrm{EOQ} = \sqrt{\frac{2RS}{kC}}.$$

The second derivative of TAIC is

$$\frac{\mathrm{d}^2\mathrm{TAIC}}{\mathrm{d}Q^2} = 0 - \left(-2 \times \frac{RS}{Q^3}\right) = \left(\frac{2RS}{Q^3}\right) \geq 0,$$

implying that the TAIC is at its minimum when $\frac{\mathrm{dTAIC}}{\mathrm{d}Q} = 0$.

The annual cost of purchase decreases after the first derivative is taken. The implication here is that cost of purchase will not influence the decision of order if there is no quantity discount (the annual cost of purchase remains constant regardless of the size of order, as long as the annual quantity (same) is purchased). Thus, the annual cost of purchase is ignored in the classic "economic order quantity model". Example 5.3 provides an illustration of EOQ calculation. It should be well noted that all demand must be converted to the annual requirement, and carrying cost is the item of carrying rate and unit cost of the item. For example, if the annual carrying/holding rate (k) is 12% and the cost of item (C) is \$10 per unit, the carrying/holding cost (kC) is \$1.20 per unit per annum.

Figure 5.5 illustrates the relationship between total annual holding plus order cost and annual order and annual holding costs. In Example 5.3, using the data, at the EOQ (600 units), annual cost of holding (\$1200) equals annual cost of order (\$1200). Close to the EOQ, the annual total cost curve is rather flat, showing that it is not very sensitive to small variations in the economic order quantity. Consequently, the class model of EOQ is said to be very robust to minor errors in calculating cost parameters, like order cost or annual usage, rate of holding. Table 5.5, for example, compares the annual total cost at an EOQ (economic order quantity) of 600 units and at 10% below and above the EOQ. The analysis shows that the range of cost variations is only 0.01–0.56% above the minimum total cost.

Table 5.5 and Fig. 5.5 present that if the size of order is smaller than the EOQ (economic order quantity), the annual carrying cost is slightly lower, whereas the annual cost of order is slightly higher. The net effect is a slightly higher annual total cost. In the same way, if the order quantity is little larger than the EOQ (economic order quantity), the annual carrying cost is a little higher, whereas the annual order cost is little lower. The net effect is a slightly higher annual total cost.

Table 5.5 % Variation in total annual cost

Q (Units)	AOC ($)	ATC ($)	AHC ($)	Variation (%)
540	1333.33	2413.33	1080.00	0.56
550	1309.09	2409.09	1100.00	0.38
560	1285.71	2405.71	1120.00	0.24
570	1263.16	2403.16	1140.00	0.13
580	1241.38	2401.38	1160.00	0.06
590	1220.34	2400.34	1180.00	0.01
EOQ = 600	1200.00	2400.00[a]	1200.00	0.00
610	1180.33	2400.33	1220.00	0.01
620	1161.29	2401.29	1240.00	0.05
630	1142.86	2402.86	1260.00	0.12
640	1125.00	2405.00	1280.00	0.21
650	1107.69	2407.69	1300.00	0.32
660	1090.91	2410.91	1320.00	0.45

[a]Shows minimum total cost at the Economic Order Quantity (EOQ)

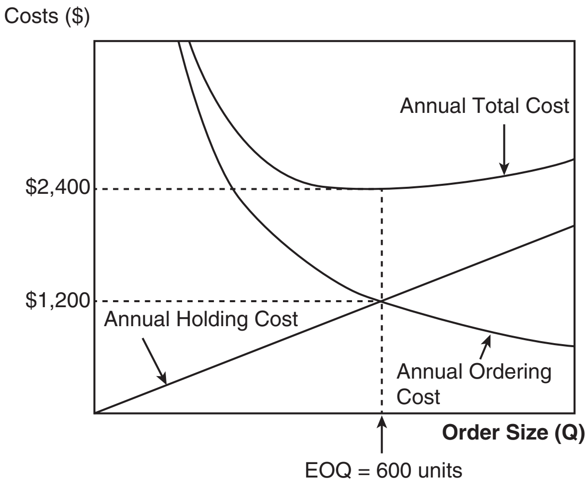


Fig. 5.5 The EOQ and total costs

Example 5.3 Calculating the Economic Order Quantity

Las Vegas firm purchases a component (critical) from one of its main suppliers. The manager of operations wants to determine the EOQ, along with when to reorder, to ensure the cost of annual inventory is reduced. The information given below was obtained from firm historical data.

Annual requirements (R) = 7200 units
Setup cost (S) = $100 per order
Holding rate (k) = 20% per annum
Unit cost (C) = $20 per unit
Order lead-time (LT) = 6 days
Number of days per year = 360

Thus,

$$\text{EOQ} = \sqrt{\frac{2RS}{kC}} = \sqrt{\frac{2 \times 7200\ \text{units} \times \$100}{0.20 \times \$20}} = 600\ \text{units}$$

1. The cost of annual purchase = $R \times C$ = 7200 units × \$20 = \$144,000.
2. The annual carrying cost = $(Q/2) \times k \times C$ = (600/2) × 0.20 × \$20 = \$1200.
3. The annual setup cost/order cost = $(R/Q) \times S$ = (7200/600) × \$100 = \$1200.

   (Note that when using the EOQ, the annual carrying cost equals the annual setup/order cost.)
4. The total annual cost of inventory = \$144,000 + \$1200 + \$1200 = \$146,400.
5. For lead-time of an order of 6 days, the reorder point would be:

   ROP = (7200/360) × 6 = 120 units.

   Thus, the purchasing supervisor or manager should reorder the component from the supplier whenever the on-hand stock is down to 120 units, and 600 units should be ordered each time. The cycle of order also can be calculated as given below:
6. Number of orders placed per year = 7200/600 = 12 orders.
7. Time between orders = 360/12 = 30 days.

Figure 5.6 presents the movement of physical inventory and the relationships of Economic Order Quantity–EOQ, reorder point, lead-time and the order cycle. Continuing with the use of the data in Example 5.3, at time 0, the company is assumed to begin with a complete order of 600 units. The inventory is consumed at a steady rate of 20 units per day. On the 24th day, the ROP (reorder point) of 120 is reached and the company places its first order of 600 units, which arrive 6 days later (on the 30th day). The inventory of 120 units vertical line on the 30th day presents that all 600 units are received (this is the instantaneous replenishment assumption of the economic order quantity model). A total of 12 orders (including the initial 600 units) will be placed during the year to fulfil and satisfy the yearly requirements of 7200 units.

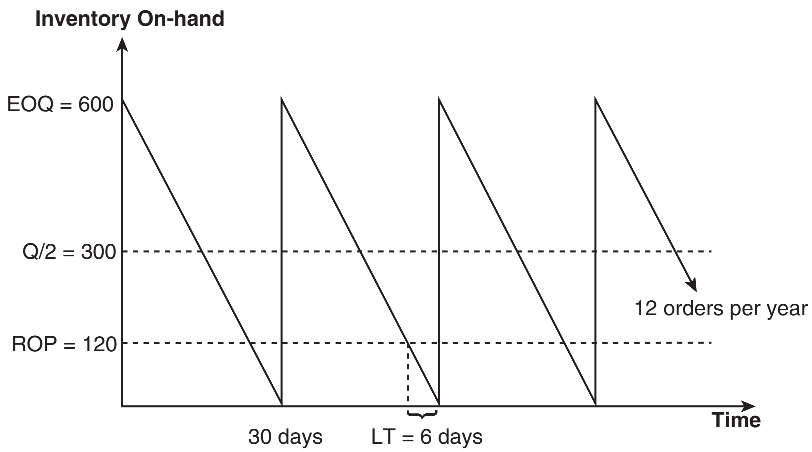


Fig. 5.6 Physical inventory with the economic order quantity model

5.7.2 The Quantity Discount Model

The price-break model or quantity discount model is one variation of the classic economic order quantity model. It relaxes the constant price assumption by allowing purchase quantity discounts. In this situation, the unit price of a product is allowed to vary with the size of order. For instance, a supplier can offer a $5 per unit price for orders of more than 500 units. This offer generates an incentive for the purchaser to buy in larger quantities to take benefit of the quantity discount, provided the savings is bigger than the extra cost of carrying larger inventory levels. Unlike the economic order quantity model, the annual cost of purchase now becomes an important factor in determining the optimal size of order and the corresponding total annual inventory cost. The quantity discount model must consider the trade-off between purchasing in larger quantities to take benefit from the discount (while also minimizing the number of orders required per annum) and the higher cost of carrying inventory. With the QDM (quantity discount model), there are thus two variables in the equation of TAIC (the C and Q; purchase price and order quantity, respectively). Hence, in order to find the optimal order quantity, a new approach is needed.

The price of purchase per unit, C, is no longer fixed, as assumed in the classical economic order quantity (EOQ) model derivations. So, the total annual inventory cost must include the annual cost of purchase, which varies depending on the quantity of order. The new total annual inventory cost formula can now be stated as:

$$\begin{aligned}\text{Total Annual Inventory Cost} = \text{Annual purchase cost} + \text{Annual carrying cost} \\ + \text{Annual order cost},\end{aligned}$$

or

$$\text{TAIC} = \text{AHC} + \text{APC} + \text{AOC} = (R \times C) + (Q/2) \times (k \times C) + (R/Q) \times S$$

The DQM (quantity discount model) yields a total annual inventory cost curve for each price level; hence, no single curve is relevant to all quantities of purchases. The relevant total cost of annual inventory curve is a combination of the cost curves for each price level, beginning with the top curve where the price is the highest, and dropping down curve by curve at the price break point, which is the minimum quantity needed to get a discount over price. There is an economic order quantity (EOQ) associated with each price level; however, the economic order quantity (EOQ) might not be feasible at that specific price level because the order quantity may not fall in the given range of quantity for that unit price. Because of the stepwise shape of the total inventory cost curve, the optimal order quantity falls at either a feasible price break point or economic order quantity (EOQ).

A properly straightforward two-step procedure may be used to solve the problem of quantity discount. Concisely, the two steps may be stated as follows:

1. Starting with a lowest price of purchase, calculate the EOQ (economic order quantity) for each price level until a feasible economic order quantity is found. If

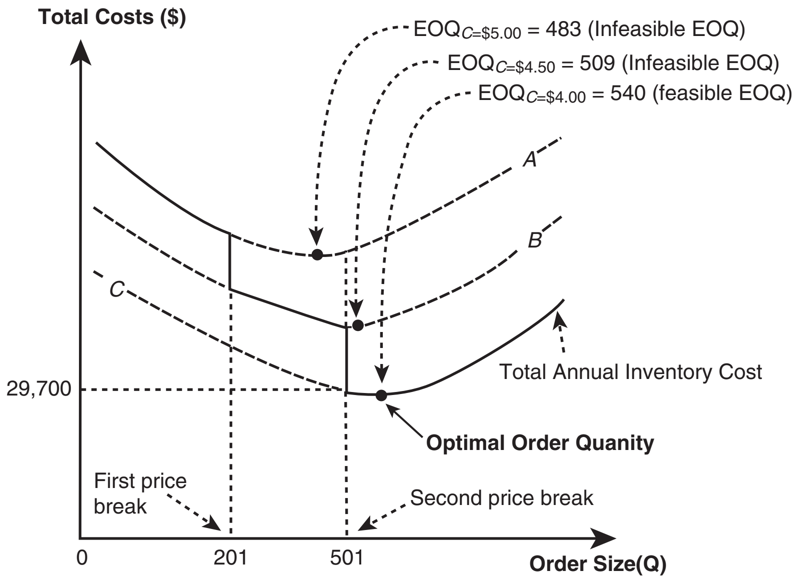


Fig. 5.7 Total annual inventory cost where the EOQ at the lowest price level is the optimal quantity of order

the feasible EOQ (economic order quantity) found is for the lowest purchase price, this is the optimal order quantity. The reason is that the economic order quantity (EOQ) for the lowest price level is the lowest point on the total annual inventory cost curve (see Fig. 5.5). If the feasible economic order quantity (EOQ) is not associated with the lowest price level, proceed to step 2.

2. Calculate the total annual inventory cost for the feasible economic order quantity found in step 1, and for all the price break points at each lower price level. The price break points above the feasible economic order quantity will result in higher total annual inventory cost, and thus need not be evaluated. The quantity of order that yields the lowest total annual inventory cost is the optimal quantity of order (Fig. 5.7).

5.7.3 *The EMQ Model*

The EMQ (economic manufacturing quantity) model, or POQ (production order quantity) model, is another variation of the classic EOQ (economic order quantity) model. It relaxes the instantaneous replenishment assumption by allowing partial delivery during manufacturing. The economic manufacturing quantity model is especially suitable for a production environment where products are being consumed and manufactured simultaneously, hence the name EMQ. Inventory is built up gradually during the period of manufacturing rather than at once, as in the economic order quantity model.

For example, let us assume that the manufacturing lot size for a produced item is 600 units; the producer's manufacturing rate is 100 units per day, and its demand is 40 units/day. The producer thus needs 6 days (600/100) to manufacture a batch of 600 units. While being manufactured, the products are also consumed simultaneously; hence, inventory builds up at the rate of 60 units (100 – 40)/day for 6 days. The maximum inventory is 360 units (60 × 6 days), which is less than the lot size of 600 units, as would have been in the case of the classic economic order quantity model. The lower inventory level implies that the carrying cost/holding cost of the EMQ model is less than the economic order quantity model given the same parameters of cost. It is also true that the manufacturing rate must be greater than the demand rate; otherwise, there would not be any inventory build-ups. On the 7th day, the manufacturing of the first batch stops and the inventory begins to deplete at the demand rate of 40 units for the next 9 days (360/40). The first manufacturing lot and the subsequent usage of the inventory takes 15 days (6 + 9) to complete, and then the second cycle repeats.

Figure 5.8 depicts the inventory versus time for the economic manufacturing quantity model. The product is manufactured in lot size of Q, at the manufacturing rate of P and consumed at the demand rate of D; hence, inventory builds up at the rate of $(P - D)$ during the manufacturing period.

At the end of the manufacturing period (T_p), inventory starts to deplete at the rate of demand D until it is exhausted at the end of the inventory cycle T_c.

The manufacturing rate, P, which can be expressed as Q/Tp, is the manufacturing lot size divided by the time needed to manufacture the lot. The maximum inventory, Q_M, may be obtained by multiplying the inventory build-up rate by the period of manufacturing, and can be expressed as $(P - D) \times T_p$. These relationships may be stated as:

$$P = Q - T_p \text{ and } Q_M = \left(P - D\right) \times T_p$$

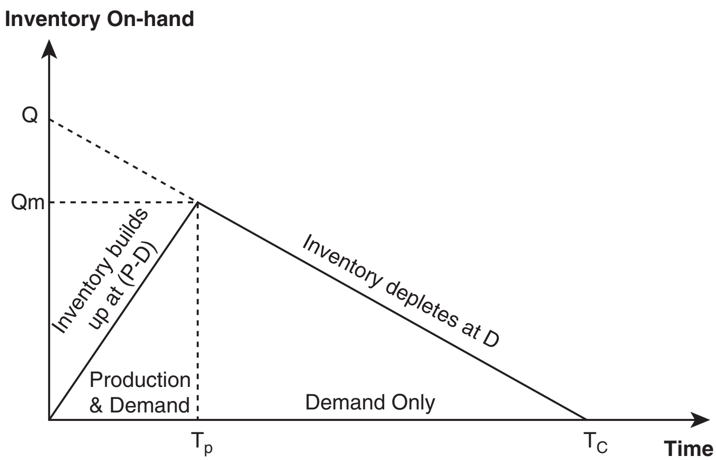


Fig. 5.8 Physical inventory with the EMQ model

Therefore, $T_p = Q/P$, and substituting Q/p for T_p in Q_M gives,

$$Q_M = (P - D) \times \frac{Q}{P}$$
$$= \frac{PQ}{P} - \frac{DQ}{P}$$
$$= Q\left(1 - \frac{D}{P}\right)$$

Hence, the average inventory, $\frac{Q_M}{2} = \frac{Q}{2}\left(1 - \frac{D}{P}\right)$

The total annual inventory cost may be stated as:

$$\text{Total Annual Inventory Cost} = \text{Annual holding cost} + \text{Annual product cost} \\ + \text{Annual Setup cost},$$

or

$$\text{TAIC} = \text{APC} + \text{AHC} + \text{ASC} = (R \times C) + \left[\frac{Q}{2}\left(1 - \frac{D}{P}\right) \times k \times C\right] + \left[(R/Q) \times s\right]$$

where

TAIC = total annual inventory cost
APC = annual product cost
AHC = annual carrying/holding cost
ASC = annual setup cost
R = annual demand or requirement
C = total cost of one unit of the finished goods
S = cost of setting up the equipment to process 1 batch of the item/product.
K = holding rate, where annual holding cost per unit = $k \times C$
Q = order quantity

Like the economic order quantity (EOQ) model where Q is the only known variable in the TAIC equation, the optimum production quantity, Q (the economic manufacturing quantity) can be acquired by taking the first derivative of TAIC with respect to Q and then setting it equal to 0. A second derivative of TAIC can also be taken with respect to Q to prove that the TAIC is a concave function, and thus $\frac{\text{dTAIC}}{\text{d}Q} = 0$ is at the lowest point of the cost curve.

Thus:

$$\frac{\text{dTAIC}}{\text{d}Q} = 0 + \left[½\left(1 - \frac{D}{P}\right) \times k \times C\right] + \left[-1 \times R \times S \times 1/Q^2\right]$$
$$= \left[\frac{kC}{2}\left(1 - \frac{D}{P}\right)\right] - \frac{RS}{Q^2}.$$

Then setting $\frac{\mathrm{dTAIC}}{\mathrm{d}Q}$ equal to zero and solving for the EMQ,

$$\left[\frac{kC}{2}\left(1-\frac{D}{P}\right)\right]=\frac{RS}{Q^2}=0$$

$$\Rightarrow\left[\frac{kC}{2}\left(1-\frac{D}{P}\right)\right]=\frac{RS}{Q^2}$$

$$\Rightarrow Q_2=\frac{2RS}{kC\left(1-\frac{D}{P}\right)}=\frac{2RS}{kC\left(\frac{P-D}{P}\right)}=\frac{2RS}{kC}\left(\frac{P}{P-D}\right)$$

And the

$$\mathrm{EMQ}=\sqrt{\left(\frac{2RS}{kC}\right)\left(\frac{P}{P-D}\right)}$$

The second derivative of the TAIC is:

$$\frac{\mathrm{d}^2\mathrm{TAIC}}{\mathrm{d}Q^2}=0-\left(-2\times\frac{RS}{Q^3}\right)=\left(\frac{2RS}{Q^3}\right)\geq 0,$$

Implying that the TAIC is at its minimum when $\frac{\mathrm{dTAIC}}{\mathrm{d}Q}=0$.

As in the economic order quantity model, after the first derivative is taken, the annual cost of product decreases, showing that cost of product does not affect the order decision if the unit cost of each product manufactured is constant; thus, the annual cost of product is also ignored in the economic order quantity model.

5.8 The Statistical Reorder Point

There are the two main inventory management decisions need to be made:

1. The right lot size or order quantity.
2. When to release an order.

Three primary independent demand lot-sizing techniques have been discussed, but as of yet, the question of when to order has not been fully discussed. The ROP (reorder point) is the lowest inventory level at which a new order must be placed to avoid a stock-out. In a deterministic setting where both the lead-time of delivery and demand are constant and known, Example 5.3 presented that the reorder point was equal to the demand during the order delivery lead-time. In reality, the lead-times of delivery and demand tend to vary. Lead-time or uncertain demand raises the possibility of stock-outs, thus requiring safety stock to be held to safeguard against variations in lead-time or demand.

5.8.1 *The Statistical Reorder Point with Constant Lead-Time and Probabilistic Demand*

This model assumes the lead-time of an item is constant while the demand during the lead-time of delivery is unknown but can be specified using a normal distribution. Since the statistical reorder point is to determine the lowest inventory level at which a new order should be placed, demand prior to a purchase order (PO) does not directly affect the reorder point (ROP). Figure 5.9 shows the relationship between probability of a stock-out and safety stock. If the average demand during the lead-time is shown by μ and the reorder point (ROP) is shown by x, then the safety stock is $(x - \mu)$, which can be derived from the formula of standard deviation $(Z = ,- \mu - \sigma)$. Then, if the probability of stock-out is shown by α, the probability that inventory is sufficient to fulfil/cover demand or the in-stock probability is $(1 - \alpha)$. The probability of in-stock is generally referred to as the service level. Next, the *Z*-value can be determined from the standardized normal curve and a desire to achieve a particular service level. For instance, one 97.5% service level ($\alpha = 2.5\%$) corresponds to the *Z*-value of 1.96. Note that at the middle of the normal distribution curve, where the ROP equals the average demand, the required safety stock is 0 and the probability of stock-out would be 50%.

The statistical ROP (x) can be computed as the average demand during the order delivery lead-time plus the desired safety stock, or:

$$\mathrm{ROP} = \bar{d}_{\mathrm{LT}} + Z\sigma_{\mathrm{dLT}}$$

The safety stock $Z\sigma_{\mathrm{dLT}}$ or $(x - \mu)$ can be derived from the formula of standard deviation of the normal distribution curve as illustrated earlier, and σ_{dLT} is the standard deviation of demand during the delivery lead-time.

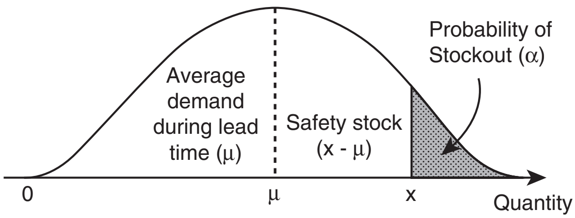


Fig. 5.9 The relationship of safety stock to the possibility/probability of a stock-out

Example 5.4 presents the safety stock calculation needed to be modified if the standard deviation is available for demand and not for lead-time demand. In this case, if the lead-time of delivery is greater than 1 day, the standard deviation of daily demand (σ_{d}) must be transformed to the standard deviation of lead-time demand (σ_{dLT}). If the daily demand is identically distributed, the statistical premise can be used that the variance of a series of independent occurrences is the sum of the variances of all the identical daily demands that shield or cover the lead-time period.

$$\sigma_{\mathrm{dLT}}^2 = \sigma_{\mathrm{d}}^2 + \sigma_{\mathrm{d}}^2 + \sigma_{\mathrm{d}}^2 + \cdots = \sigma_{\mathrm{d}}^2(\mathrm{LT}),$$

where

σ_{dLT}^2 = variance of demand during the lead-time
σ_{d}^2 = variance of the independently and identically distributed daily demand
LT = lead-time in days

Thus, the standard deviation of demand during the lead-time is $\sigma_{\mathrm{dLT}} = \sigma_{\mathrm{d}}\sqrt{\mathrm{LT}}$
Hence the statistical ROP and safety stock also can be stated as:

$$\text{Safety stock} = Z\sigma_{\mathrm{d}}\sqrt{\mathrm{LT}}$$

and

$$\mathrm{ROP} = \bar{d}_{\mathrm{LT}} + Z\sigma_{\mathrm{d}}\sqrt{\mathrm{LT}}.$$

Example 5.4 Calculating the Statistical ROP using Probabilistic Demand and Constant Delivery Lead-Times at London, Inc.

London, Inc. stocks a crucial part that obeys a normally distributed pattern of demand during the ROP. Previous demand presents that the average demand during lead-time (μ) for the part is 550 units, and the standard deviation of demand during lead-time (σ_{dLT}) is 40 units. The manager of supply chain wants to determine the statistical ROP and safety stock that result in 5% stock-outs. Alternately, the supply chain manager wants to know the additional safety stock needed to attain a 99% service level.

Solution
The normal distribution Z-table presents that a 95% service level corresponds to a Z-value of 1.65 standard deviation above the mean.

The required safety stock is

$$(x-\mu) = Z\sigma_{\mathrm{dLT}} = 1.65 \times 40 = 60 \text{ units}$$

$$\text{The reorder point} = \bar{d}_{\mathrm{LT}} + Z\sigma_{\mathrm{dLT}} = 550 + 66 \text{ units} = 616 \text{ units}.$$

This means the manager of supply chain must reorder the part from their supplier when their current stock level reaches 616 units.

Alternately, the needed safety stock at a 99% service level = $Z\sigma_{\mathrm{dLT}} = 2.33 \times 40 =$ 93 units.

Additionally, safety stock compared to the 95% service level is 27 units.

5.8.2 The Statistical ROP with Constant Demand and Probabilistic Lead-Time

When the product demand is constant and the lead-time is not clear but can be specified by means of a normal distribution, the safety stock is used to buffer against variations in the lead-time instead of demand. The safety stock is then (daily demand × $Z\sigma_{\mathrm{LT}}$), and the ROP is:

$$\mathrm{ROP} = (\text{avg. lead times in days} \times \text{daily demand}) + \text{daily demand} \times Z\sigma_{\mathrm{LT}},$$

where

σ_{LT} is the standard deviation of lead-time in days.

Example 5.5 Computing the Statistical ROP at the Harpert Store Using Probabilistic Lead-Time and Constant Demand.

The store of Harpert has an exclusive contract with Brussums Company to sell their most famous MP3. The demand of this player is stable at 120 units per day. On the other hand, the lead-time of delivery varies and can be specified by a normal distribution with a mean lead-time of 8 days and a standard deviation of 2 days. The manager of supply chain at Brussums desires to compute the ROP and safety stock for a 95% service level (in-stock probability).

Solution

Daily demand (d) = 120 units.

Mean lead-time $(\overline{\mathrm{LT}})$ = 8 days.

Standard deviation of lead time (σ_{LT}) = 2 days

A service level of 05% yields a Z = 1.65 from the Z-table.

$$\text{Needed safety stock} = (d \times \mathrm{Z}\sigma_{\mathrm{LT}}) = 120 \text{ units} \times 1.65 \times 2 = 396 \text{ units.}$$

$$\text{Reorder point} = (d \times \overline{\mathrm{LT}}) + (d \times Z\sigma_{\mathrm{LT}}) = (120 \times 8) + 396 = 1356 \text{ units.}$$

Brussums Co. must order more MP3 players from Harpert when their present inventory reaches 1356 units.

5.8.3 *The Statistical ROP with Probabilistic Demand and Lead-Time*

When both the lead-time and demand of goods are not known but can be specified by means of a normal distribution, safety stock should be held to cover the variation in both lead-time and demand, resulting in safety stocks (higher) compared to variations of the lead-time or demand only. The ROP can be calculated as follows:

$$\text{ROP} = \left(\bar{d} \times \overline{\text{LT}}\right) + Z\sigma_{\text{dLT}}$$

where

$$\sigma_{\text{dLT}} = \text{Standard deviation of demand during the lead time}$$
$$= \sqrt{\sigma_{\text{LT}}^2 \left(\bar{d}\right)^2 + \sigma_{\text{d}}^2 \left(\overline{\text{LT}}\right)}$$

And where

σ_{LT} = Standard deviation of lead-times (days)
σ_{d} = Standard deviation of demand (daily)

Note that this formula of standard deviation (σ_{dLT}) can be applied to all the previous ROP examples by observing the following fact: "no variation" means zero standard deviation. Therefore:

1. When the demand and lead-time are constant, then σ_{LT} and σ_{d} are zero, and the avg. lead-time and daily demand would be the deterministic lead-time and demand. Thus, the ROP is the demand during the period of lead-time.
2. When the daily demand is probabilistic and lead-time is constant, then σ_{LT} is zero and the avg. lead-time would be the deterministic lead-time.
3. When the lead-time is probabilistic and daily demand is constant, then σ_{d} is zero and the avg. daily demand would be the deterministic daily demand. Using this instruction, the ROP in Example 5.5 can also be calculated as:

$$\text{ROP} = (150 \times 6) + 1.96\sqrt{0^2 (150)^2 + 30^3 (6)} = 900 + 1.96 \times 30\sqrt{6} = 1044 \text{ cases.}$$

5.9 The Periodic Review and the Continuous Review Inventory Systems

The ROP (reorder point) inventory and order quantity models discussed thus far assume that the physical inventory levels are concisely known at every time point. This indicates that movements of stock should be updated in real time, and there should be assurance that there are no discrepancies or inconsistencies of the inventory (physical) to make sure that orders are originated when physical inventories reach their ROP. Practically, a continuous review system can be hard to achieve and not cheap to implement. Inventory review costs can be lowered by using a system of periodic review instead, where inventory (physical) is reviewed at normal/regular intervals, such as monthly or weekly. On the other hand, more safety stock would be needed for the period review system to buffer the added variations due to the longer period of review.

When analysing the period review system and continuous review system, the following symbols are used:

S = order point
Q = order quantity
S = maximum inventory level
R = periodic review
N = 1, 2, 3…

5.9.1 The Continuous Review System

The system of continuous review implies that inventory (physical) is known at all times, so it is very expensive to administer. On the other side, the only uncertainty is the magnitude of demand during the lead-time of delivery; thus, the only safety stock required is for potential stock-outs during this period of time. There are two continuous review systems, described below:

1. *(s, Q) continuous review policy:* This policy orders the same quantity Q when inventory (physical) reaches the ROP. The quantity Q can be determined by one of the fixed order quantity methods (EOQ). This policy properly works only if the quantity demanded is 1 unit at a time. Otherwise, the level of inventory may fall below the ROP.
2. *(s, S) continuous review policy:* When current inventory falls below the ROP, ordering sufficient units is to bring the inventory up to a pre-determined level S. As the quantity demanded is 1 unit at a time, this system is almost the same as the (s, Q) policy. On the other side, if the size of demand is larger than 1 unit, when inventory (physical) falls below the ROP, then the order size is larger than Q. For example, suppose, $s = 10$, $S = 120$, and current inventory is 11 units. If the next demand is three units, then on-hand inventory will be minimized to eight units. Therefore an order size of 112 units would be released.

5.9.2 The Periodic Review System

The periodic review system reviews inventory (physical) at specific intervals of time. Although this system is not expensive to administer, a higher level of safety stock is required to buffer against uncertainty in demand over a planning horizon (longer). There are three periodic review systems, described below:

1. (nQ, s, R) *policy of periodic review:* If at the time of inventory review, the inventory (physical) is equal to the ROP or less than the ROP, the quantity nQ is ordered to make the inventory up to the level between ($s + Q$) and s. Recall that $n = 1, 2, 3, \ldots$, and the size of order is then some multiple of Q. No order is placed if the present inventory is more than the ROP. For instance, let $s = 100$ and $Q = 50$. If the current inventory is 20 units at the time of the review, then 2Q quantities ($2 \times 50 = 100$) are ordered so that the inventory level can be brought up to units of 120.
2. (S, R) *policy of periodic review:* At each time of review, ordering enough quantity is to bring the inventory up to a predetermined maximum inventory level S. This policy locates a variable sized order as long as the inventory (physical) is less than the level of maximum inventory S. If cost of order is high, this is noticeably not a preferred system. However, it can work well if a large variety of products are ordered from the same supplier.
3. (s, S, R) *policy:* If at the time of inventory review, the inventory (physical) is equal to the ROP or less than the ROP, ordering enough quantity is to bring/raise the inventory level up to the maximum level of inventory S. On the other side, if the inventory (physical) is more than the ROP, no order is placed. This policy addresses the main deficiency of the (S, R) policy.

Discussion Questions

1. What is the difference between dependent and independent demand?
2. Describe the five basic types of inventory.
3. What is the ABC analysis, and how it is used to manage inventory?
4. What is the ABC matrix?
5. What is the EPC?
6. Why is management of inventory significantly important for efficient SCM?
7. How is inventory turnover ratio calculated?
8. What are the basic assumptions of the EOQ model?
9. How is the EOQ model related to the quantity discount model?
10. How is the EOQ model related to the EMQ model?
11. What is the purpose of the ROP and EOQ? How can they be used together?

Problems

1. The revenue for a company is \$250,000. Its cost of revenue is \$85,000, and its avg. inventory for the year is \$6200. What is their inventory turnover?
2. Given the following information, calculate the EOQ, annual order cost, annual total inventory cost and annual holding cost.

   Annual requirement (R) = 50,000 units
   Order cost (S) = \$150 per order
   Holding rate (k) = 15%
   Unit cost (C) = \$100 per unit

3. The annual requirement of a part is 360,000 units. The cost of order is \$120 per order, the rate of holding is 12%; and the part cost is \$2500 per unit. Calculate the following.

   (a) Economic order quantity (EOQ)
   (b) Annual holding cost
   (c) Annual order cost
   (d) Annual total inventory cost

4. Given the information below calculate the annual inventory turnover ratio.

   Revenue = \$22,000,000
   Cost of Revenue = \$1,250,000
   Quarter 1 Ending Inventory = \$85,000
   Quarter 2 Ending Inventory = \$98,000
   Quarter 3 Ending Inventory = \$125,000
   Quarter 4 Ending Inventory = \$68,000

5. The monthly demand for a component is 1500 units. The cost of order is \$285 per order; the cost of holding is \$56 per unit per year; and the component cost is \$850 per unit. The company operates 12 months/year. Calculate the following:

   (a) Economic Order Quantity
   (b) Annual holding cost
   (c) Annual order cost
   (d) Annual total inventory cost

References

Ioannou, G., G. Prastacos and G. Skintzi. (2001). Inventory positioning in single product supply chains. Proceeding of the 3rd International Conference on the Analysis and Design of Manufacturing Systems, Tinos, Greece, May, 49–58.

Ioannou, G., G.P. Prastacos and G. Skintzi. (2001). Inventory positioning in single product supply chains. Les Cahiers du Management Technologique, 11(2), 33–40.

Khan, S.A.R. (2019). The nexus between carbon emissions, poverty, economic growth, and logistics operations-empirical evidence from Southeast Asian countries. Environmental Science and Pollution Research, https://doi.org/10.1007/s11356-019-04829-4.

Khan, S.A.R., Dong, Q., SongBo, W., Zaman, K., and Zhang, Y. (2017). Environmental logistics performance indicators affecting per capita income and sectoral growth: evidence from a panel of selected global ranked logistics countries. Environmental Science and Pollution Research, 24(2), 1518–1531.

Khan, S.A.R., Dong, Q., SongBo, W., Zaman, K., and Zhang, Y. (2017b). Travel and tourism competitiveness index: The impact of air transportation, railways transportation, travel and transport services on international inbound and outbound tourism. Journal of Air Transport Management, 58(1), 125–134.

Khan, S.A.R., Dong, Q., and Zhang, Y. (2017). Role of ABC Analysis in the process of efficient order fulfillment: Case study. Advanced Engineering Forum, 23(7), 114–121.

Khan, S.A.R., Dong, Q., Zhang, Y., Khan, S.S. (2017). The impact of green supply chain on enterprise performance: In the perspective of China. Journal of Advanced Manufacturing Systems, 16(3), 263–273.

Sainanthuni B, Parikh PJ, Zhang X, Kong N. (2014). The warehouse-inventory-transportation problem for supply chains. Eur J Oper Res 237(2), 690–700.

Skintzi, G., G. Ioannou and G. Prastacos. (2004). Multi-node serial supply chains: Investigation of inventory management policies", Proceedings of the EURO-INFORMS: EURO XX Managing Electronic Services (Rhodes, Greece).

Skintzi, G., G. Ioannou and G. Prastacos. (2004). Inventory Positioning in Multiple Product Supply Chains EUMOptiFin 3 (EU-Workshop). The drivers of performance of large Financial Institutions, Bergamo, Italy, 16–21 May.

Wagner HM, Whitin TM. (1958). Dynamic version of the economic lot-size model. Manage Sci, 5(1), 89–96.

Wolsey LA. (2006). Lot-sizing with production and delivery time windows. Math Program, 107(3), 471–489.

Chapter 6
Warehouse Design and Management

The warehouse and system of handling design is not the manufacturing of a simple drafting including the size and position of racking or other storage areas, and the handling areas, aisle runs, and truck charging points. It is that, but it is also the specification, *inter alia,* of the unit loads (e.g. pallets), operating systems, equipment quantities and types, including service and ancillary activities, communication and information systems, organizational structure and staff levels, and the related operating and capital costs. It should also show the external layout and requirement of space for vehicle access, parking and manoeuvre, and for site security, car parking, and any other activities.

A principle of excellent warehouse design is to recognize the overall requirements of the system, and by analysing the relevant data to do design, incorporating equipment and methods that match all those requirements the most closely. One implication in that is it is not advisable to claim that one level/type of automation and mechanization is always the proper solution to warehouse design. "Horses of courses", this old adage applies, and the excellent design is the design that closely matches the initially specified constraints and requirements of the system. However, there is an overriding prerequisite: whatever design or technology is adopted for a given project, an accurate, effective, and fast information system to monitor and drive the operation is a *sine qua non*.

6.1 Warehouse Design Procedure

The warehouse and handling system design covers many stages, beginning with the definition of system constraints, and requirements, and ending with a preferred design after evaluated. While listed sequentially below, the design process involves an iterative checking back against the requirements of the system as the design is developed, and evaluating the interactions that necessarily happen during the course

S. A. Rehman Khan, Z. Yu, *Strategic Supply Chain Management*, EAI/Springer Innovations in Communication and Computing,
https://doi.org/10.1007/978-3-030-15058-7_6

of the process. A series of disciplines and skills will be used in any process of design. In addition to warehouse design expertise, it is suitable to draw on the operational experience of personnel and managers to integrate their perspectives and help to develop a draft that is financially, operationally and technically feasible.

The process of design covers the following steps:

- Define design constraints and requirements of systems.
- Define and obtain data.
- Analyse data.
- Postulate basic methods and operations.
- Consider possible equipment types for handling and storage.
- Establish what unit loads will be used.
- Calculate staffing levels.
- Calculate equipment quantities.
- Prepare possible building and site layouts.
- Evaluate the design against constraints and system requirements.
- Identify the preferred design.

6.2 Define Design Constraints and System Requirements

The requirements of design for a distribution depot or warehouse operation, taking future growth forecasts and other possible commercial developments into account, are likely to consist of:

- The capacities needed, both throughput and storage
- Service level that needs to be achieved
- Specified facilities such as quality control, packaging or others

Relevant constraints can cover:

- Time, e.g. facility to be up and running by a specified date
- Financial, e.g. limit on capital expenditure or on cost per unit of throughput
- Technical, e.g. compatibility with existing firm technology, to allow flexible throughput to fulfil and meet high seasonal variations, or technology level to present "leading-edge" firm image

Any design must also comply with legal requirements, which among other aspects can include building height constraints, limitations on working times, and legislation of safety including, specifically, non-automatic handling and fork truck codes of practice. Insurers also are likely to require measures relating particularly to fire control and prevention. The local fire officer will need to be satisfied regarding the measures for staff evacuation and safety in the event of fire. Ideally, the authority of local planning, local insurer and fire officer should be involved as early as possible in any design project.

The impact of environmental legislation and codes of practice is likely to grow with time, affecting such issues as package disposal, reuse and packaging.

6.2.1 Define and Obtain Data

The completeness and accuracy of the data on which any design is based will affect how well the design (final) fulfils the specified requirements. It is most unlikely that any design will depend on existing levels of business, and it is significantly important to establish anticipated growth and other important changes to the business that the warehouse is to be designed to satisfy. While, sometimes there are gaps in the available data, and on such occasion assumptions have to be made on the basis of experience and informed opinion, the assumptions should be clearly justified and highlighted in the document of final design. Depending on situations, it may be suitable to draw up a data report covering any assumptions, for all interested parties to agree and see before the full design is carried out.

The data required for warehouse designs includes:

1. Goods handled
   - Handling and other characteristics, weight, temperature, size or any other constraints
   - Inventory levels by SKU (stock keeping units)—maxima, minima, average and seasonal variations
   - Packaging and unit load(s)
   - Forecast growth trends
   - Throughput levels by SKU (stock keeping units)—minima, maxima, average and seasonal variations;
2. Order characteristics—influence system of order picking
   - Service levels for completeness, and for time of order fill
   - Order frequency
   - Priority or special order requirements
   - Size distribution as SKUs (stock keeping units) per order
   - Package and unit load complete details
3. Goods arrival and dispatch patterns
   - Vehicle types (end- or side-load), size, times and frequencies
   - Consignment sizes
   - Unit loads to be handled
   - Third-party vehicles or own vehicles
4. Warehouse operations
   - Ancillary activities, e.g. packaging store, quality control, packing, returns, offices and battery charging
   - Basic operations to be carried out
5. Site and building details
   - Size, gradients, location, access

- Activities of adjacent and scope for expansion, obstructions or constraints
- Services available

6. Any existing equipment or facilities that may be used

- Condition, size, numbers

Data is not always readily available and collection of data almost invariably takes considerable time. Potential sources cover existing operational records, computer records, customers, market forecasts, drawings for site and buildings, equipment suppliers and equipment records, and input from other relevant staff.

6.2.2 Analyse Data

The purpose of data analysis is to give the foundation for the designer's proposals for suitable operating systems and methods, layouts, equipment, staffing levels and costs.

Data may be presented and analysed in many different ways, including charts, drawings, graphs, statistical analyses, tables, drawings and networks.

One very useful analytical tool is to present sales quantities and picking accessions, inventory levels in descending order of magnitude across the whole range of SKUs (stock keeping units). This practice is known as Pareto analysis or it's also called ABC analysis or 80/20 rule. The results of 80/20 analysis more often than not show that roughly 20% of the stock range accounts for roughly 80% of the total inventory, 80% of the picking efforts and 80% of the sales. This allows the designer to classify and identify the significantly important stock keeping units in the range of products, and also to identify different characteristics for different sections of the item range and so devise solutions suitable to the material being stored and handled. One example of Pareto analysis is illustrated in Table 6.1.

In practice, other elements, such as throughput, would also have to be superimposed on Pareto analysis in determining the storage systems to be adopted for different components or parts of the item range.

Table 6.1 Pareto analyses

Product group	% of Product range	% of total stock	Suitable storage methods
A	20	80	Block stack, push back, drive-in, live, very narrow aisle VNA, double deep
B	30	15	APR, VNA
C	50	5	Mobile, APR

6.2.3 Establish What Unit Loads Will Be Used

Examples of unit loads cover stillages, skid sheets, pallets, roll cage pallets, tote boxes and hanging garment rails.

As is to be stored and handled in a warehouse, the unit loads that may be changed as material moves through the warehouse, will influence choosing equipment needed and the ability to make full use of space, and thus should be set early in the design process. Suppliers can impose the unit loads when material arrives at a warehouse and customers can specify dispatch unit loads, but the designer of the warehouse should use any freedom of choice that exists to ensure the most suitable unit loads for the processes the unit loads will go through.

The advantages of unit loads cover equipment standardization, material security, minimization of movement, and minimizing and facilitating the time for unloading and loading vehicles. For instance, roll cage pallets for picking grocery items make cases of different sizes handled and accumulated in a common unit. The roll cages can be moved by standard handling equipment, and if they are used for stores deliveries, it is not necessary to transfer picked products into another unit load before vehicle loading.

The most common unit load is the wooden pallet, and there are many designs, double-sided, four-way or two-way fork entry, single-sided and other variations.

In the United Kingdom, the common size is the ISO pallet, 1200 mm by 1000 mm, although in Europe most common is the Europal at 800 mm by 1200 mm. The dimensions of pallets determine how pallets can be loaded onto vehicles and such details as dimensions of storage racking, so the point must be focused that the choice of unit load is important. The difference between the dominant United Kingdom and European sizes pallets will eventually have to be solved.

6.2.4 Postulate Basic Methods and Operations

In a warehouse, the basic operations, and how they will be carried out, must be decided before choosing the equipment, and suitable staffing levels for them. These specifications will cover goods receipt, vehicle unloading, picking operations, storage, order packing and collation, vehicle loading for shipment and all related handling.

The communication and information requirements for the operations must also be determined, and this will help to build a specification for the WMS (warehouse management system) to operate and monitor the operations. This will cover considerations of whether paperless systems or paper-based systems will be used and which operations can include picking by lights, radio data communication and barcodes use.

Except for these basic considerations, while, the ancillary activities are required to backup or support the basic operations, which will need space and resources in their own right. Sometimes these are tagged onto a design almost as an afterthought, but really they are an essential and integral part of the whole design and should be treated accordingly. They can cover the following:

- Empty store and pallet repair
- Waste disposal
- Packing operations and related packaging material storage
- Returned goods area
- Battery-charging area
- Cleaning equipment and warehouse cleaning
- Offices
- Services-lighting, fire prevention, lighting, heating
- Stand-by generator
- Separate amenities for visiting drivers
- Lorry parking, car parking and manoeuvre areas
- Security facilities including gatehouse
- Fuel supply for lorries and vehicle wash

6.3 Consider Possible Types of Equipment for Handling and Storage

The equipment types used in warehouses have been outlined in Chap. 4. To be able to specify the suitable equipment for a particular application clearly requires an awareness of what is available and an in-depth understanding of the elementary operating characteristics of the different types of equipment.

To illustrate this point, consider a requirement for pallet storage of 1000 different product lines, stock keeping units, with only a small amount of stock related with each SKU (stock keeping unit), say not more than two pallets, and fairly low throughput rates. Clearly drive-in racking, block stacking, or even push back racking would not be suitable or appropriate since it is not practical to mix different stock keeping units in any one storage row, and the use of any of these methods would result in either very poor use of space or unacceptable levels of double handling. On the other side, adjustable pallet racking or mobile racking could be considered. Mobile racking is not inexpensive, but the good and maximum utilization of space might minimize building costs. It gives random access to all pallets, and the inherently slow operation would not be a drawback with low throughput items/products. However, adjustable pallet racking would not give such good use of space, but is really very inexpensive, and provides random access to all pallets. It is also inherently more flexible in the event of future changes to stock or throughput profiles. This sort of argument should be used, choosing equipment with characteristics that very closely match the system requirements for all warehouse operations.

After the completion of warehouse design comes the stage of procurement, identifying potential suppliers of equipment, going out to tender, assessing suppliers on equipment performance, service backup, spares, and the experience of other clients, before placing orders to suppliers.

6.3.1 Calculate Equipment Quantities

The amount of equipment required is estimated from the equipment operational characteristics and basic warehouse design data. Usually how much storage capacity to incorporate into a design is dependent on the requirements of stock-holding, and the storage type will also affect the final amount.

Requirements of handling equipment depend on movements of material in the warehouse, such as short-term peak loads, seasonal variations, and operational data on equipment capacities, typically producers' technical data plus operating experience. These estimations will be influenced by Shift working patterns, which also decide whether spare batteries will be needed for trucks (battery-powered). The number of trucks (order picking trucks) is based on total warehouse throughput, and also on the basis of the order frequencies and sizes.

Data on the received products, consisting of times required for vehicle unloading and delivery window, will dictate receiving dock facilities, like dock levellers and access doors, and the handling equipment for truck unloading. Similar considerations apply to shipping. The level docks provided or raised docks will be based on the types of vehicle accessing the warehouse—side loading or end loading. Requirements of space for order assembly and collation should contain the working patterns of order arrival at dispatch, and the way in which vehicle schedules integrate with these internal work patterns.

Using stock and equipment operating characteristics, the computation of basic equipment requirements is commonly straightforward when taking operation by operation. Nevertheless, what is difficult to compute are the effects of all the operating staff and mobile equipment, working together, and interfacing and interacting, sometimes getting in the way of one another and delaying and causing queues. This dynamic circumstance is nearer to the real operational situation than is one on the basis of merely computing each operation in separation. Hence, dynamic simulation techniques (computer-based) are used in order to validate the "static" computation and to take potential interference into account among activities when running concurrently.

6.3.2 Calculate Staffing Levels

The requirements for operating staff are closely connected to the mobile equipment requirements, and in several situations will "fall out" of the calculation of equipment. Obviously, as part of the design, staffing levels have to be established to allow a full costing of the warehouse to be built.

6.4 Prepare Site Layouts

The site layout brings together all the components of the warehouse operations inside the building, and also the external site features.

6.4.1 Internal Layout Issues

The basic principles for internal layout covers:

- Good access to stock
- Reduction in the amount of movement needed and people for handling equipment
- Logical flow patterns with backtracking or cross-flows of material or people, on the basis of material and personnel movements analysis, commonly in a rectilinear layout
- Making the best use of place volume
- Safe systems of work, consisting of the provision, where possible, of separate movement access doors and aisles for people and for mobile equipment, elimination of dead areas where operators could be trapped, e.g. no aisles with closed ends

A basic decision is whether to adopt a "U" or "through flow" configuration. With "through flow", products are input at one end of the warehouse and go out from the opposite end of the warehouse, and all material flows across the full length of the building. This is suitable when separate products dispatch and products receipt operations are needed, perhaps for control and security reasons, or because product dispatch vehicles and product inward vehicles are very different (nature of unit load, platform height), or when incoming products arrive from an immediately adjacent manufacturing facility. A "through flow" configuration has product dispatch and product receipt along the same face of the building, making better use of dock space and possibly of unloading and loading staff and also handling equipment, and allowing popularity storage to reduce movement of total products.

Other issues of layout include:

- The floor flatness tolerances and type of floor
- Battery-charging facilities
- The use of level docks for vehicle unloading and loading
- Location of ancillary functions including packaging store
- Provision of separate facilities for collection drivers and delivery drivers

Lastly, the likelihood of further expansion must be considered, with an internal layout that reduces disruption if expansion has to be executed.

6.4.2 External Layout

The most relevant external factors that affect the layout include:

- Vehicle/truck access to the site
- Access for fire appliances
- Car parking
- Security, including gatehouses, barriers and separate access for commercial vehicles and cars
- Locating new buildings with expected future expansion
- Internal roads and directions of turning, two-way circuits or one-way circuits
- Waiting areas and manoeuvre for vehicles waiting to be called forward for unloading and loading

6.5 Evaluate the Design Against System Constraints and Requirements

The design constraints and objectives will have defined commercial, technical and financial requirements to be met by the new warehouse, and these form the basic criteria for assessing the proposed warehouse design. The primary requirements for building size and position, storage capacity, site layout and staffing levels can all be readily validated. Costs of capital (building, systems, land and equipment, etc.) and operating costs (equipment operating, building insurance, depreciation and maintenance) can also be obtained. As recommended earlier in this chapter, however, it is not very easy to assess how effectively a warehouse will run when all the components are working and interacting with one another, and the use of simulation is an influential final arbiter of the feasibility of a warehouse.

6.5.1 Identify the Preferred Design

With design advancements, there will inevitably be a process of iteration, process of checking back to the requirements of design and partial evaluation of ideas to assist the process of honing in on the final preferred design. The preferred design should then present the proposed operating methods and processes, and equipment requirements and specifications, operating and capital costs, staffing levels, layout drawings and service requirements.

6.6 Warehouse Management and Information

A broad range of statement of responsibilities of DCs (distribution centres) or warehouse management would include effective control and planning, also the optimum use of resources to accomplish the aim of the operation.

More specifically, the aim for an effective operation would cover:

- Cost-effective operation
- Safe operation
- Fulfilment of required customer service levels
- Meeting and fulfilling local and legal requirements for work safety and environment
- Maintaining stock integrity
- Efficient and effective use of resources

6.6.1 Performance Monitoring

Obviously, performance monitoring is important to the effective control and management of any firm, and this definitely applies in warehousing. Although basically a simple process, usually warehousing is the last connection or link before the final customer or consumer, and it has to run within tight service and cost standards. Failing to meet these standards means the gap between an unsuccessful business and successful business. Effective monitoring requires an effective information system.

Obviously the performance indicators suitable to a particular operation will be peculiar to that operation, but typical measures will cover those detailed in the next sections.

6.6.2 Service Levels

Measures can cover:

- Order lead-time
- Stock availability in the DC or warehouse
- % of completeness of order fill
- % of orders completed on time
- Accuracy of order fill
- Damaged stock
- Number of outstanding backorders
- Customer complaints/returned orders

6.6.3 Cost-Effectiveness

Cost-effectiveness covers monitoring the costs of the following:

- Building and site
- Maintenance
- Packaging materials
- Pallets and pallet repairs
- Equipment and other resources
- Personnel, including overtime

It can be helpful to separate the costs of particular operations, such as packing or picking, and monitor these as a percentage of total warehouse costs. It also may be useful to express some of these measures as ratios such as the cost per pallet stores, the cost per unit of throughput or the cost per item picked.

6.6.4 Resource Utilization

Resource utilization is concerned with how effectively the warehouse facilities are being used. It may include utilization of storage facilities—percentage fill—and also the availability and utilization of handling equipment, and how much availability is lost through breakdown and maintenance.

6.6.5 Stock Integrity

Stock integrity is concerned with the security and condition of stock, covering damage, deterioration and reducing loss. Relevant elements can include the control of stock rotation on the basis of FIFO (first-in-first-out), and the meeting of "sell by" shelf life and date constraints.

A significant important control parameter is the measurement of stock turn, which shows the rate at which products move through the system in relation to the average stock level. Stock turn is:

$$\frac{\text{Annual throughput}}{\text{Avg.stock level}}$$

For example, if one item sells 1000 units per annum and the average stock level is 100 units, the stock turn will be 10. It means, the average stock is "turned over" almost 10 times yearly.

6.6.6 Legal Regulations and Requirements

This specifically applies to working safety and environment. There is wide-ranging legislation that impacts warehouse operations, which covers safety and health at work, self-propelled industrial trucks and manual handling regulations, and even the offices, shops, and railway premises as well as additional mundane requirements for a working environment. It also ought to be remembered that there are codes of practice providing guidance on a wide range of operational issues (warehouses and distribution), for example, the SEMA codes (Storage Equipment Manufacturer's Association) of practice for racking.

Increasing regulations of safety require formal risk assessment to be carried out within companies to motivate preventative measures and identify potential hazards.

6.6.7 Information Technology

In the last couple of decades, the dominant development in operation and warehouse management has been the use of electronic data transfer and computer technology, characterized by accurate, comprehensive collection, fast analysis and use of data. It has allowed stepwise enhancement in service levels; use of people; inventory minimization; maximum utilization of resources; elimination of clerical effort, paperwork and stock losses; management and stock location; and the facility for tracking products through a SC (supply chain).

Computer-based management packages are well designed to handle information on stock balances, order picking replenishment, products receipt, stock location, pick sizes and picking routes, order collation, and vehicle loading and order dispatch. They are also used to monitor and work out total performance measures to assist management control, and to log the output of individual operators as a basis for recognizing training requirements, and for calculating performance-related pay.

An increasingly significant and critical advantage of such a system is the ability to track individual batches and products as they progress through a system, to give accurate and quick information on progress and also to facilitate quality backchecks in the event of quality failures.

6.7 Warehouse Management

The most common characteristics of computer-based warehouse management packages cover the following:

- Accuracy through minimizing the errors inherent in manual clerical recording, and by eliminating or reducing altogether the need for human data transfer or input
- Facility for work allocation and planning of equipment and personnel

- The ability to present information
- The ability to track products as they move through a system
- Information visibility
- Speed of data processing, collection and communication, including immediacy of information recall and immediacy of updating computer files (particularly) valuable in providing real-time information on such aspects as status of customer orders and the stock levels
- Elimination or reduction of clerical effort
- The ability to work out and also present overall performance-monitoring information

Specific advantages of such systems for warehouse operations include:

- Accurate stock records
- Improved customer service level
- Fewer stock-outs
- Stock replenishment
- Accurate stock location records
- More effective use of workers, including poor picking accuracy or identification of low productivity
- Equipment utilization
- Information to operators and the facility for them to interrogate the system in the event of problems
- Verification of picking quantities and stock location
- Stock rotation and maintenance of "sell by" dates
- Routine status or performance reports

The information also provides data for location of picking stock, optimization stock zoning, picking routes and order picking batch sizes.

6.8 Data Transmission and Capture

An important part of exploiting the advantages of computer management packages is the communication and data capture systems to which they are connected.

Data transfer and capture can be achieved by several techniques. The most commonly and widely used in warehousing is barcoding, which represents letters and numbers in printed bar form, and is machine-readable by suitable scanning equipment. It is accurate and fast technology, and fairly robust. There are many different types of "symbologies" or barcodes, the most commonly encountered in warehousing being "code39". Barcoding is used in warehousing to identify products and also verify stock locations. It enables products to be routed and sorted through the handling system, and allows them to be tracked as they move through the system. It simplifies stock checking and a range of other data input and captures requirements. The barcode labels are inexpensive although they can be smashed/damaged by scuffing; the technology is established, fast and reliable.

OCR technology (Optimal Character Recognition) uses labels that are both human and machine-readable. It is suitable in applications such as text scanning, interrogation and handling of documents.

Voice data identification is one system of data capture in which the sounds of an operator's voice are interpreted and recognized by the system. The system shows what it thinks it has heard on a display screen for the operator to verify, before moving on to the next entry or transaction.

RF (Radio Frequency) uses small transmitter-receivers set into tags attached to the products to be tracked or identified. The tags can communicate and can be interrogated with a host computer. More complex tags can be reprogrammed during use.

An interesting set of experimental data derived by the United States DOD (Department of Defence) gave the below results for error rates when capturing data.

Techniques	Error rate (characters)
Transponders (RF tags)	1 in 30 million
Barcode (Code 39)	1 in 3 million
OCR	100 in 3 million
Keyboard entry	10,000 in 3 million
Written entry	25,000 in 3 million

Although experimental, this data shows the levels of accuracy achievable using IT. The use of a suitable computer-based communication and information system is a *sine qua non* for the achievement of operational objectives and effective warehouse management. However, without such a system, leading-edge or high-tech engineering technology, the operation will not function to the limit of its capability.

6.8.1 Radio Data Communication

Increasingly a technique of communication found in warehouse information application is the use of radio data communication. Usually, this is connected to the warehouse management computer system and enables radio communication between computer and required workstation (any), which can be mobile or static. Now it is common to see forklifts fitted with remote radio data terminals (See Fig. 6.1, and sometimes with a label printer mounted with the terminal. The operator is online to the computer, takes instructions from the computer, confirms work carried out, and interrogates the computer for further information if needed. This type of technology facilitates key enhancement or improvement in communication between the operator and warehouse management computer, leading towards much higher response speed within warehouse systems, and more productive and efficient use of equipment and staff.

Fig. 6.1 Radio data in warehouse

Discussion Questions

Q.1. What are the steps included in the process of design?
Q.2. What is the ABC analysis and how does it work?
Q.3. What are the internal layout and external layout issues?
Q.4. How is stock turnover calculated?
Q.5. Discuss related legal regulations and requirements.
Q.6. How can data transfer and capture be accomplished? Discuss the techniques.

References

Cunningham, C., Song, I.-Y., Jung, J. T., & Chen, P. (2003). Design and research implications of customer relationship management on data warehousing and CRM decisions. In *Proceedings of the 2003 Information Resources Management Association International Conference (IRMA 2003)* (pp. 82–85).

Garver, M. S., & Mentzer, J. T. (1999). Logistics research methods: employing structural equation modeling to test for construct validity. *Journal of Business Logistics, 20*(1), 33–57.

Green, K. W. J., Zelbst, P. J., Meacham, J., & Bhadauria, V. S. (2012). Green supply chain management practices: impact on performance. *An International Journal, 17*(3), 290–305. https://doi.org/10.1108/13598541211227126.

Herrmann, J.W., G. Ioannou, I. Minis and J.M. Proth. (1994). *Design for control of material handling systems*. ORSA/TIMS Joint National Meeting, Detroit, MI, October 23–26.

Ioannou, G. (1996). Integrating shop layout and material handling system design decisions. In Progress in material handling research 1996, R.J. Graves, L.F. McGinnis, D.J. Medeiros, R.E. Ward and M.R. Wilhelm (Editors), Braun-Brumfield, Inc., Ann Arbor, MI, pp. 227-244.

Khan, S. A. R., & Dong, Q. (2017a). Impact of green supply chain management practices on firms' performance: an empirical study from the perspective of Pakistan. *Environmental Science and Pollution Research, 24*(20), 16829–16844.

Khan, S. A. R., & Dong, Q. (2017b). Does national scale economic and environmental indicators spur logistics performance? Evidence from UK. *Environmental Science and Pollution Research, 24*(34), 26692–26705.

Khan, S. A. R., Dong, Q., & Zhang, Y. (2016). Research on the measuring performance of green supply chain management: In the perspective of China. *International Journal of Engineering Research in Africa, 27*(12), 167–178.

Khan, S. A. R., Dong, Q., & Zhang, Y. (2017). Role of ABC Analysis in the process of efficient order fulfillment: Case study. *Advanced Engineering Forum, 23*(7), 114–121.

Khan, S. A. R., Dong, Q., & Zhang, Y. (2018). The impact of green supply chain practices in business performance: Evidence from Pakistani FMCG firms. *Journal of Advanced Manufacturing Systems, 17*(2), 267–275.

Khan, S. A. R., Dong, Q., Zhang, Y., & Khan, S. S. (2017). The impact of green supply chain on enterprise performance: In the perspective of China. *Journal of Advanced Manufacturing Systems, 16*(3), 263–273.

Khan, S.A.R., Zaman, K., and Zhang. (2016). The relationship between energy-resource depletion, climate change, health resources and the environmental Kuznets curve: Evidence from the panel of selected developed countries. Renewable and Sustainable Energy Reviews, 62(9), 468-477.

Kimball, R., & Ross, M. (2002). *The data warehouse toolkit* (2nd ed.). New York: Wiley Computer.

Skintzi, G., Ioannou, G., & Prastacos, G. (2008). Investigating warehousing policies. *International Journal of Production Economics, 112*(2), 955–970.

Tarantilis, C., Kiranoudis, C., & Ioannou, G. (2004). *Distribution and service operations management in Greek enterprises—Methods, systems and case studies*. Athens, Greece: Sideris. Forthcoming (in Greek).

Winer, R. S. (2001). A framework for customer relationship management. *California Management Review, 43*(4), 89–108.

Chapter 7
Domestic and Global Logistics

Logistics plays a significant role in supply chain management. Logistics is mandatory for moving materials from upstream (suppliers) to downstream (customers), recycling products or returning products and also storing these products along the way in the SC (supply chain). Effective systems are required for commerce to exist in any industrialized society. Goods have no value to consumers until they are delivered to end-customer usage areas, at a point in time when they are needed. Logistics accordingly explain what are called time and place utility. The utility of time occurs when "customers receive their required products, materials or components at the right time, not later and not earlier". The utility of place occurs when "customers receive their required products at their desired place".

According to the CSCMP (Council of Supply Chain Management Professionals), the definition of logistics is "that part of SCM that plans, executes and controls the effective, efficient reverse flow and forward flow and storage of services, goods and relevant information between the origin and the point of consumption in terms to fulfil customers' requirements".

7.1 The Fundamentals of Transportation

This section reviews a number of important factors of transportation within function of logistics, including the objective of transportation, transportation modes, legal forms of transportation, transportation pricing, regulation of transportation, security of transportation and deregulation in the United States. This offers a foundation for discussion of the remaining sections, as well as an appreciation for the complicated nature of issues and problems of transportation issues in logistics.

S. A. Rehman Khan, Z. Yu, *Strategic Supply Chain Management*, EAI/Springer Innovations in Communication and Computing,
https://doi.org/10.1007/978-3-030-15058-7_7

7.2 The Objective of Transportation

While you can think the overriding transportation objective is obvious—that is, moving things and people from one location to another—for-hire company transportation services may go broke doing this inefficiently. For instance, over the last two decades, many passenger airlines of the United States have sought bankruptcy protection and also asked for concessions from labour unions to keep operating. Some of these include Continental Airlines, US Airways, United Airlines, America West and Northwest Airlines. The period of the 2008–2010 economic downturn, combined with high prices of fuel, made things more troublesome for transportation firms. The airline industry lost around 30 billion dollars in 2008 and 2009.

Managers of logistics have found that to maximize value their staff must correctly communicate the company's service needs to transportation providers while negotiating prices and negotiating services such that the transportation provider's delivery costs are covered and allow sufficient profit contribution and then make sure the desired services are completed effectively.

In the industry of transportation, competitive prices may be low for a number of trucking companies and airlines as mentioned above. Generally, objectives of transportation should be to fulfil customer requirements and satisfy customers. For managers of logistics, this also means deciding upon which mode or form of transportation, material storage and handling with suitable vehicle routing and scheduling.

7.3 Legal Forms of Transportation

For-hire transportation firms are categorized legally as contract, common, and private carriers. The different characteristics of each of these categorizations are given below.

7.3.1 Common Carriers

Common carriers provide services of transportation to all shippers at published prices, between designated locations. Common carriers must provide their services of transportation to the general public without any discrimination. In simple words, they charge the same price to all customers. In the United States, a common carrier is legally bound to carry all freight or passengers as long as there is enough space, the charge/fee is paid and there are no reasonable grounds to refuse service. A common carrier refusing to carry a cargo or people may be sued for damages. Because the objective of common carriers is to serve the general public, they are the most heavily regulated of all carrier categorizations. For example, in the United States, common carriers are Greyhound, Southwest Air, Carnival Cruise Lines and Amtrak.

7.3.2 Contract Carriers

Contract carriers may be common carriers. On the other hand, they are not bound to serve the general public. Instead, contract carriers service only particular customers under agreements/contracts. Typical contracts are for goods movement of a specified cargo for a negotiated price. Some contract carriers offer lower prices than common carriers for the same services because they (contract carriers) have specific capabilities. For example, Southwest Air and Dallas Cowboys football team entered into a contractual agreement under which terms Southwest Air provided transportation for the team's out-of-town games. Carriers and shippers are free to bargain and negotiate contractual agreements for price, liability, commodity carried, types of service and delivery timing.

7.3.3 Exempt Carriers

Exempt carriers are also for-hire carriers, but they are exempted from regulation of services and rates. Carriers are categorized as exempt if they transport certain exempt items such as newspapers, coal and school buses. The status of exempt was initially established to allow farmers to transport agricultural items on roads. But today exempt status has been expanded to include various products. Rail carriers hauling coal between particular places/locations are exempt from economic regulation. Almost all carriers may also act as exempt carriers for particular routes and products and commodities.

7.3.4 Private Carrier

Private carriers are not subject to economic regulation and typically transport products and commodities for the firm owning the carrier. These companies transport their items, commodities and operate fleets large enough to make the transportation cost lower. Control of items and flexibility of items movement also play basic roles in the ownership of a private carrier. For example, Wal-Mart, with its private fleet of trucks, was able to respond even more quickly than the government of the United States and relief workers after Hurricane Katrina struck the Louisiana Gulf Coast in the year of 2005.

7.4 Modes of Transportation

There are basically five modes of transportation:

1. Motor
2. Rail
3. Air
4. Water
5. Pipeline

These transportation modes and the amount of freight they hauled every year between the years of 1980 to 2007 in the United States are presented in Table 7.1. Each of these modes offers distinct benefits to customers, and their selection is dependent on many elements, such as the products to be transported, how quickly the products are required, the price and location of shippers and customers. Further we will discuss each transportation mode below.

7.4.1 Motor Carriers

There is no doubt that motor carriers represent the most flexible transportation and, as presented in Table 7.1, account for almost 1/3 of all United States for-hire transportation expenditures. The motor carriage gives door-to-door service, delivery, local pickup, and large and small shipment hauling. It has low VC (variable cost) and FC (fixed cost) and can compete favourably with air carriers and rail carriers for

Table 7.1 Total United States for-hire logistics services contribution to gross domestic product (Current $ billions)

	1980	1985	1990	1995	2000	2005	2006	2007
Total United States GDP	2790	4220	5803	7398	9817	12,422	13,178	13,808
For-hire logistics services GDP (% United States GDP)	102.3 (3.7)	136.3 (3.2)	169.4 (2.9)	226.3 (3.1)	301.6 (3.1)	364.7 (2.9)	387.4 (2.9)	407.2 (2.9)
Truck GDP (% for-hire GDP)	28.1 (27.5)	39.0 (28.6)	52.6 (31.1)	70.1 (31.0)	92.8 (30.8)	118.4 (32.5)	122.5 (31.6)	127.6 (31.3)
Pipeline GDP (% for-hire GDP)	6.1 (6.0)	8.7 (6.4)	7.2 (4.3)	8.1 (3.6)	8.7 (2.9)	9.5 (2.6)	11.4 (3.1)	12.0 (3.3)
Air GDP (% for-hire GDP)	12.8 (12.5)	19.0 (13.9)	26.8 (15.8)	41.0 (18.1)	57.7 (19.1)	48.3 (13.2)	50.3 (13.8)	55.2 (15.1)
Water GDP (% for-hire GDP)	3.3 (3.2)	3.7 (2.7)	4.6 (2.7)	5.8 (2.6)	7.2 (2.4)	10.0 (2.7)	10.8 (3.0)	10.7 (2.6)
Rail GDP (% for-hire GDP)	22.4 (21.9)	23.1 (16.9)	20.6 (12.2)	25.0 (11.0)	25.5 (8.5)	33.5 (9.2)	39.0 (10.1)	40.5 (9.9)
Warehouse GDP (% for-hire GDP)	5.6 (5.5)	8.4 (6.2)	11.8 (7.0)	16.8 (7.4)	25.0 (8.3)	35.6 (9.8)	37.3 (10.2)	40.3 (11.1)
Other GDP (% for-hire GDP)[a]	24.1 (23.6)	34.3 (25.2)	45.7 (27.0)	59.5 (26.3)	84.7 (28.1)	109.5 (30.0)	116.1 (31.8)	120.8 (33.1)

Source: United States DOC (Department of Commerce), Bureau of Transportation Statistics
aIncludes transit, ground passenger and other transportation and support activities.

short to medium hauls and is still competitive with other forms of transportation for long cross-country consignments, specifically if there are several delivery destinations. The motor carriers can provide a variety of specialized services from livestock, to automobile and refrigerated hauling.

The basic drawbacks for motor carriers are traffic congestion and weather problems. The motor carriers are usually categorized as LTL (less-than-truckload) or TL (truckload) carriers. Less-than-truckload carriers deliver small shipments or packages that take up less than one truckload, and the fees of shipping are higher per hundred weights (cwt) than truck load fees, since the carrier need to consolidate many small packages or shipments into one TL, and then separate the TL back into individual packages or shipments at the destination. On the other hand, for limited product shippers, using less-than-truckload carriers is still a much less expensive alternative than using a truck load carrier. The less-than-truckload industry in the United States is made up of a small number of national less-than-truckload carriers such as FedEx Freight and UPS (United Parcel Services) and a larger number of regional less-than-truckload carriers. Many regional carriers are small, privately owned firms that specialize in 2-day and overnight deliveries.

The motor carriers may also be categorized on the basis of the types of items and commodities they haul. General freight carriers carry the majority of items dispatched in the United States, common carriers included, whereas specialized carriers deliver household goods, liquid petroleum, building materials, agricultural commodities and other specialized products.

7.4.2 Rail Carriers

Rail carriers compete the most favourably when the consignments are bulky or heavy and the distance is long. In the United States, at one time rail carriers transported the majority of products dispatched; however, since WWII (World War II), their share of the transportation market has steadily fallen. Recently, United States railroads account for only around 10% of total for-hire transportation expenditure as presented in Table 7.1.

Rail service is relatively inflexible and slow, while rail carriers are lowest cost compared with motor carriers and air carriers and may compete fairly well on long hauls. To better compete, railroads have begun buying motor carrier firms and can thus offer delivery and pickup service (point-to-point) using flatcars and motor carriers that carry truck trailers. Nonetheless, railroads have drawbacks compared to motor carriers with respect to equipment availability, service frequency and shipment damage.

Since rail firms use each other's rail cars, keeping track of rail cars and getting them where they are needed could be tricky. However, with advances in scheduling software, and railroads routing and identification systems of rail cars, this has become less of a problem for rail carriers. RTLS (real-time location system) on rail cars uses active, WiFi-enabled RFID tags to allow tracking and tracing of rail cars and their goods in real time. The RFID tag is programmed to broadcast a signal detecting its place at regular time intervals. Sensors also can be added to the "Real-time location system" tags to monitor the temperature inside of refrigerated cars, for instance, and transmit a signal if the temperature inside of a refrigerated car goes out of a defined range. In the United States, infrastructure of railroad and ageing equipment have also been issues and problems for railroads; however, there has been a spending resurgence since the 1980s to replace rail cars and worn track segments, to upgrade terminals and to consolidate through acquisitions and mergers.

One of the trends in the transportation by rail is the use of high-speed trains. In the United States, they are operated by Amtrak along the northeast corridor (Boston–New York–Washington). These trains may make the Washington-to-Boston trip in almost 6.5 h (lack of straight-line track have tended to minimize the speed of trains).

7.4.3 Air Carriers

Transportation by air is very expensive relative to competing modes. On the other hand, it is very fast and reliable for long distances. In Table 7.1 it can be seen that carriers of air account for around 15% of total annual United States for-hire transportation expenditures. The amount of freight hauled is quite small, however, since airlines cannot carry much bulky and heavy cargo. For high value, light and small commodities that need to be moved for long distances quickly, transportation modes by air are the best of the modal alternatives.

For movement over water, the only other modal alternative is water carriage, where the decision of transportation is based on cost, weight of shipment and timing. Though the incidence of consignment damage is relatively low and schedule frequency is good, transportation by air is limited in orders of geographic coverage. In the United States, most small cities do not have airports; therefore air service transportation must combine with motor carriage service for these places.

7.4.4 Water Carriers

Water carrier is cheap but inflexible and slow. There are many types of water transportation including lake, inland waterway, coastal, global deep-sea and ocean carriers. Much of the inland waterway transportation is used to haul bulky, low-value and heavy goods such as grain, sand and coal and competes basically with rail and pipeline carriers. Transport by inland water services is obviously limited to areas accessible by water; hence, growth in this area of transportation is also limited. Based on information from Table 7.1, transportation by water as a % of total for-hire logistics services has remained fairly steady at about 3% for the past 30 years. Like transportation by rail and air, water carriers are typically paired with motor carriers to enable door-to-door delivery and pickup service.

In the United Kingdom, efforts are underway to increase the usage of inland waterway carriers, as this is somewhat environment friendly compared to motor freight carriers. The British Waterways, the association responsible for managing waterways in the United Kingdom, is investing to minimize highway pollution and congestion by increasing trade and business along their inland waterways. For instance, a single river barge can carry almost the equivalent of 24 truckloads of freight. Freight on inland waterways also generates less noise and lower emissions and is visually unobtrusive. At present, approximately 3.5 million tons of non-time-sensitive freight is moved every year via 2000 miles of United Kingdom inland waterways.

There have also been developments in deep-sea transportation that have made transportation more desirable and cheaper, even with the slow transportation times. The use of containerships, super-tankers has added a new dimension to transportation by water. Today's many super-tankers are more than 1200 feet in length; oil super-tankers are the *seawise giants*, measuring 1500 feet in length and are able to carry approximately four million barrels of oil. Now the oil-producing countries can ship larger quantities of oil at lower cost. However, small shippers also can dispatch their products at lower cost, because of the ability to combine or consolidate small consignments in containers that are placed on board containerships.

7.4.5 Pipeline Carriers

Pipeline carriers are very specialized with respect to the goods they can carry; additionally, fixed cost of the initial investment is very high. Once the initial cost is recovered, there is very small additional cost of maintenance. Limitation of the pipeline carrier is "pipeline mode can only be used for gas or liquid items". Today, pipelines are being constructed to haul larger quantities of oil and gas from desolate areas to existing processing facilities hundreds of miles away. There is no doubt that, day by day, the need for pipeline transportation is increasing, because pipeline carrier VC (variable cost) is very low and also secure as compared to other modes of carriers.

7.4.6 Intermodal Transportation

The combination of many transportation modes or intermodal transportation is becoming a very popular arrangement of transportation and makes the movement of products much more efficient and convenient. Most intermodal transportation firms today, such as United States firms FedEx and J.B. Hunt, offer one stop, door-to-door shipping capabilities. They transport goods of shippers for a price, then determine the best warehousing and intermodal transportation to fulfil their customer requirements at as low price as possible.

Here is an example of shipping using intermodal transportation:

A firm packs a standard 8-foot container for consignment to an overseas client. The container is connected and sealed to a motor carrier trailer for transport to a nearby rail terminal. The container is then loaded onto a double stacked and flat car with another container, where it is then transported to a seaport on the United States West Coast. Upon arrival, the container is placed aboard and transported on a container ship to Japan. In Japan, the container is moved and off-loaded through customs, where it is then loaded onto another carrier (motor carrier trailer) for transport to its last destination, where it finally is unpacked.

In this above example, products were only unpacked and packed one time. The container was used in three modes of transportation and remained sealed until it arrived at its last destination when custom authorities unsealed, examined and accepted the products/goods.

The above example mentioned a number of intermodal combinations. The most common are COFC (container on flatcar) and TOFC (trailer on flatcar), also called piggyback service.

The same containers can be located and boarded on container ships and freight airliners. These combinations of intermodal transportation attempt to combine the flexibility of motor carriers with the economy of rail and/or water carriers.

7.5 Transportation Pricing

The two primary strategies of pricing used by LSP (logistics service providers) are value-of-service pricing and cost-of-service pricing. Further, when the consignments are large enough, shippers and carriers enter into negotiated pricing. Obviously, carriers want higher profits and shippers want lower prices, and these desires are usually at odds with one another. Not many years ago, carriers such as UPS (United Parcel Service) simply distributed their costs evenly and charged a uniform rate to all clients. As pricing models (computer) improved, logistics firms were able to identify more closely their cost for various types of clients, and differential pricing become more the norm, with infrequent users and residential customers clearly seeing significant price increases. More recently, as economic conditions have worsened causing extra capacity because of lower shipping demand, pricing has once again been varied to stay competitive and shippers have been able to negotiate better terms. These topics are discussed below.

7.5.1 Value of Service Pricing

In this situation, the prices of carrier services are at the highest levels the market will bear. Prices, accordingly, depend on the current volume of demand for each service and the level of competition. This approach is called profit-maximizing approach. If a carrier has a service that is in little competition with high demand, prices will tend to be slightly high. As other carriers notice the high profit potential of this service, competition will ultimately increase and prices will decrease. As the level of competition rises, carriers will seek techniques and ways to minimize costs to maintain their profitability.

In the competitive airline industry, which was hit hard through 2009 by lower demand for travel, Southwest Airlines has been able to keep their costs low by using only one type of airplane, flying short distances among stops, using strategies of fuel price hedging, and keeping their airplanes in the air, which measures have enabled them to remain profitable through the year 2009, their 37th consecutive annual profit. The system of online booking for airlines, combined with revenue management software to control prices as demand fluctuates have allowed airlines to use value-of-service pricing to increase their revenues.

7.5.2 Cost-of-Service Pricing

In this case, carriers establish their prices based on variable and fixed costs of transportation. To achieve this, carriers must have ability to identify the relevant costs and then accurately allocate these to each consignment. This strategy (cost-of-service pricing) varies on the basis of distance and volume. As the volume of shipping goes up, the portions of FC (fixed costs) that are allocated to every consignment reduce, allowing the carrier to reduce their prices. The volume of large consignments also allows carriers to charge truckload rates/carload instead of LTL (less-than-truckload) rates. As the distance of shipping increases, prices will also tend to increase, but not proportionally with distance, because FC are essentially constant regardless of distance. The cost-of-service pricing shows the lowest shipping price for carriers, and in a highly competitive market, carriers will price just near or above these levels to maintain some profit. As we have seen in the last economic downturn in the year of 2008, many carrier companies were unable to maintain their prices at even these lowest levels, resulting in several companies filing bankruptcies.

7.5.3 Negotiated Pricing

In the United States, since the deregulation of transportation, negotiating prices of transportation has become very common among business logistics providers and shippers. Additionally, today's shippers are inclined to build alliances with logistics firms because of the main role they play in allowing companies and their SC (supply chain) to be more responsive to changing demand. This also has inclined to increase the use of negotiated prices. Shippers want carriers to use cost-of-service pricing; however, carriers want to use value-of-service pricing. To manage and maintain an equitable partnership, prices are negotiated such that they fall somewhere between the two levels, allowing shippers to receive the logistics services they want at a sensible price, and also allowing carriers to cover their VC (variable costs) and FC (fixed costs) and make a sensible profit.

7.5.4 Terms of Sale

In many situations, suppliers' terms of sale affect costs of transportation. When goods are bought from a supplier, the supplier can quote a price that covers transportation to the location of the buyer. This is known as FOB (free-on-board) destination pricing to the destination of the buyer. This also means that the supplier will be the legal owner of the goods until the shipment safely reaches its destination. For consignments of high value, small consignments, or when the purchaser has little expertise of transportation, FOB (free-on-board destination) is typically preferred. Otherwise, the purchaser can decide to buy products and supply its own transportation to the shipping destination; in this scenario, the supplier quotes the lower FOB (free-on-board) origination pricing. The goods or products then become the legal responsibility of the purchaser at the location of consignment pickup.

7.5.5 Rate Categories

Rates or prices of carriers can be classified in many different ways. Line haul rates are the charges for transferring products/goods to a nonlocal destination, and these can be further categorized as exception rates, class rates, commodities rates and miscellaneous rates.

In the United States, class rates are published on an annual basis by NMFTA (National Motor Freight Traffic Association) a non-profit group comprised of almost 1000 motor carrier firms. The class rate standards, called the NMFC (National Motor Freight Classification), are based on the value of the type of freight, its weight and dimensions, its ease of handling. There are 18 classes numbered from fifty to the five hundreds—the higher the class rating, the higher the price.

Exception rates are lower than NMFC class rates for particular origins and destinations and volumes and are commonly established on an account-by-account basis. Commodity rates apply to minimum quantities of goods that are dispatched between two specified places. Miscellaneous rates apply to agreement rates that are negotiated between two parties and to shipments covering a variety of goods (in this situation, the price is on the basis of the overall weight of the consignment). Nowadays, several of the rates charged by carriers are classified as miscellaneous, since negotiated rates tend to be used mainly for larger consignments.

7.6 Transportation Security

In the United States, security of transportation, specifically airline security, has become a very important issue since 9/11. Congress passed the Aviation and Transportation Security Act in November 2011, creating a large organization (the TSA or Transportation Security Administration) to oversee security of transportation, while giving high hopes to the many government security contractors. Today, the Transportation Security Administration oversees more than four hundred United States air ports. In addition, the DHS (Department of Homeland Security) was established in 2003 with a first year budget of more than 41 billion dollars to provide overall United States security leadership.

In the United States, several actions and problems have resulted from this heightened emphasis on security. The TSA (Transportation Security Administration) has had many agency chiefs since November 11, 2011, and has spent more than 12 billion dollars to improve security in airports and on airplanes. In 2010, the DHS initiative outfitted AIT (Advanced Imaging Technology) units in hundreds of United States airports. Travellers need to go through these full-body scanners, which can identify any harmful devices hidden beneath clothing. The Advanced Imaging Technology uses harmless millimetre technology of waves to produce images reflected from the bodies being scanned.

Other forms of United States transportation have taken a backseat to the airlines when it comes to funding and security concerns. In fact, the Transportation Security Administration 2011 budget allocated 68% of its resources to aviation security and only 2% to all other modes of transportation. Currently, the DHS (Department of Homeland Security) scans 98% of imported cargo for radiation and United States Border Protection and Customs screen United States bound containers at 58 ports around the globe. In addition, the United States Congress passed a law which called for 100% scanning of all United States bound cargo by 2012.

With respect to the other transportation modes, the Transportation Security Administration has been working with railroads to minimize the number of hours that hazardous chemicals can spend in transit, resulting in a 54% reduction since 2006 in the overall risk of a rail tanker exploding and exposing people to hazardous and toxic gases. The Transportation Security Administration also has a Pipeline Security Division, which basically mandates all pipeline operators to execute a program of pipeline security. For various truckers and other transportation workers such as United States deepwater port workers, one of the latest initiatives of transportation security is the use of Safe Port Act of 2006 and the Maritime Transportation Security Act of 2002. In 2009, the TWIC (Transportation Worker Identification Credential) became compulsory for port workers, and the TSA is currently trying to upgrade the technology to allow use of a device that would read a biometric card without it being swiped, greatly reducing congestion at port entry location and also minimizing the card reader time. Another type of system (smart card) is the use of Prepass, which allows prequalified United States motor carriers to bypass weigh stations and state inspections, saving several thousands of lost gallons of fuel and work hours for truckers.

7.7 Transportation Regulation and Deregulation

In the United States, the transportation industry has gone through periods of both government deregulation and regulation. However, the regulation of transportation is argued by many to be good because it tends to assure adequate transportation service throughout the country when protecting final customers in order of safety and liability and monopoly pricing. On the other side, deregulation of transportation is also argued to be good in that it encourages competition and also allows prices to be adjusted as supply, demand and negotiations dictate. Additionally, laws of anti-trust already in existence tend to protect transportation consumers. In 1994, this debate was the subject of a study to determine the impact deregulation had on the United States motor carrier industry. The study concluded that deregulation of transportation has resulted in larger use of cost-of-service pricing, rising freight prices/rates for LTL consignments and more safety issues and problems as operators have tended to let fleets age and to reduce the level of maintenance. In the United States, today's transportation industry remains essentially deregulated; however, carriers must adhere to a number of regulations that still exist. Some of the history of transportation deregulation and regulation in the United States is reviewed next.

7.7.1 Transportation Regulation

Table 7.2 summarizes the main regulation of transportation in the United States, starting with the Granger Law of the 1870s, which led to the Interstate Commerce Act of 1887. Before that time, in the United States the railroads were charging higher rates and discriminating against small shippers. So many Midwestern states passed laws to broadly regulate the railroads to establish maximum rates, prohibit local discrimination, forbid rail mergers (to encourage competition) and prohibit free passes to public officials. Though the United States Supreme Court later struck down these laws, the Granger movement made Congress realize the impacts of railroad monopolies. This led to the passage of the Interstate Commerce Act of 1887.

In the act of 1887, the ICC (Interstate Commerce Commission) required rail carriers to charge sensible or reasonable rates; to publish rates, file them with the ICC and make them available to the public; and prohibited practices of discrimination (charging lower prices than other shippers). The act of 1887 also prohibited agreements between railroads as to revenues or pool traffic. During 1887 to 1910, several amendments made to the 1887 act increased ICC enforcement power and control. All these amendments restricted railroads from offering service and rates that were not in the interest of the public, created penalties for failure to follow published rates or for accepting and offering rebates, set maximum rates and prevented railroads from owning water carriers or pipelines, unless approved by the ICC.

In the year 1917, increased competition combined with the restrictions of rates had built a rail system unable to offer the efficient service that the United States government needed in its war efforts, and thus the federal government seized the

Table 7.2 The United States transportation regulations

Date	Regulation	Summary
1870s	Granger Laws	Midwestern states passed laws to establish maximum rates, prohibit discrimination and forbid mergers for railroads
1887	Interstate Commerce Act	States cannot regulate transportation; established Interstate Commerce Commission; regulated and published rates, outlawed discriminatory pricing, prohibited pooling agreements to encourage competition
1920	Transportation Act	Instructed the ICC to establish rates that allowed RRs to earn a fair return; established minimum rates; gave control to ICC to set intrastate rates; allowed pooling agreements if they were in the public's best interest
1935	Motor Carrier Act	Extended the ICA of 1887 to include motor carriers and brought them under ICC control; established five classes of operators; common, contract, private, exempt and broker; mergers must be OK'd by ICC
1938	Civil Aeronautics Act	Established the Civil Aeronautics Board to regulate air carriers; new entrants had to get CAB approval; CAB controlled rates; Civil Aeronautics Administration control air safety
1940	Transportation Act	Extended the ICA of 1887 to include ICC control over domestic water transportation; ICC controlled entry, rates and services
1942	Freight Forwarders Act	Extended the ICA of 1887 to include ICC control over freight forwarders; ICC controlled entry, rates and services
1948	Reed-Bulwinkle Act	Amendment to the ICA of 1887 legalizing rate bureaus or conferences
1958	Transportation Act	Amended the rule of rate making by stating that rates couldn't be held up to protect the traffic of any other mode
1958	Federal Aviation Act	Created the Federal Aviation agency to assume the mission of the CAA; FAA empowered to manage and develop US airspace and plan the US airport system
1966	Dept. of Transportation Act	Assumed mission of FAA and a number of other agencies for research, promotion, safety and administration of transportation; organized into nine operating and six administrative divisions; also established the National Transportation Safety Board
1970	Railway Passenger Service Act	Created the National Railroad Passenger Corp. to preserve and upgrade intercity rail passenger service; resulted in the creation of Amtrak

railroads. Railroad companies were guaranteed a profit while the government poured large sums of money into advancing the rail system. By the end of WWII (World War II), Congress had come to realize that all of the negative controls imposed on railroads were unhealthy for the industry. They wanted to return the railroads to private ownership. This brought about the first of a number of regulations aimed at positive control, namely the Transportation Act of 1920.

The Act of 1920 instructed the ICC to ensure that rates were high enough to give a fair return for the railroads on a yearly basis (initially Congress set this at 6% return per annum). When firms made more than the agreed 6%, half of the excess was taken to fund low-interest loans to the weaker operators to increase their efficiency and update their systems. This act also permitted the ICC to set minimum rates, allowed joint use of terminal facilities, allowed railroads to enter into pooling contracts and allowed rail firm consolidations and acquisitions. Lastly, to keep the railroads from becoming overcapitalized, the act prohibited railroads from issuing securities without approval of the ICC. The rail system accordingly became a regulated monopoly.

During 1935 to 1942, regulations were passed that applied to other transportation modes and these were almost the same in nature to the Act of 1920. A great deal of money was spent during the 1920s and during the period of depression building the United States highway system. The time became ripe, then, for the emergence of for-hire motor carriers. Many small trucking firms grew tremendously during 1935 to 1942, creating competition for the railroads, as shippers opted to use the low-priced for-hire motor carriers.

The Motor Carrier Act of 1935 brought motor carriers under ICC control, thus controlling entry into the market, establishing motor carrier classes of operation, setting sensible rates, mandating ICC approval for any acquisitions or mergers and controlling the securities issuance.

In 1938, the federal government enacted another extension of the ICC by including regulation of air carriers in the CAA–Civil Aeronautics Act of 1938. This act fostered the development of air safety and the system of air transportation and airline efficiency through establishing the Civil Aeronautics Board to oversee market entry, establish routes with suitable levels of competition, develop regional feeder airlines and set sensible/reasonable rates. The CAA (Civil Aeronautics Administration) was also established to regulate air safety.

A transportation act in 1940 further extended the Act of Interstate Commerce of 1887 by establishing ICC control over domestic water transportation. The provisions for domestic water carriers were similar to those imposed on motor and rail carriers. In 1942, the act of 1887 was once again extended to cover freight forwarders, with the usual entry, service and rate controls of the ICC. Freight forwarders were also prohibited from owning any carriers.

Many other Congressional enactments occurred up through 1970, further refining and strengthening control of the market of transportation. In 1948, the Act of Reed-Bulwinkle enabled groups of carriers to form rate conferences where they could suggest rate changes to the ICC. The act of 1958 established temporary loan guarantees to railroads, liberalized control over intrastate rail rates and amended the rule of rate-making to clarify the difference between for-hire motor carriers and private carriers. The Act of Federal Aviation 1958 replaced the Civil Aeronautics Administration with the FAA (Federal Aviation Administration) and gave the FAA authority to prescribe rules of air traffic, make safety regulations and plan the system of national airports. In the year of 1966, the Department of Transportation Act created the DOT (Department of Transportation) to coordinate the executive functions of all government entities dealing in matters related with transportation. It was hoped that centralized coordination of all the agencies of transportation would lead to more effective transportation planning and promotion. Lastly, to improve the ability of the rail system to service passengers, in the 1970s, the Act of Railway Passenger Service was passed, thus creating Amtrak.

7.7.2 Transportation Deregulation

In 1976, Congress enacted many laws to eliminate and reduce transportation regulations. These are summarized in Table 7.3. This starts the movement towards less regulation by permitting market forces to determine prices, services and entry. In the United States, at this point in the history of transportation, politicians and consumers had the opinion that regulation of transportation was administered more for the profit of the carriers than the public. Additionally, with the bankruptcy filing of many railroads in the 1970s, combined with the Arab oil embargo of the same period of time, regulation was receiving much of the blame for an inefficient system of transportation.

The Railroad Revitalization and Regulatory Reform Act, generally known as the 4-R Act, was passed in 1976 and made several regulatory changes to assist the railroads. First, railroads were allowed to change rates without approval of the ICC, limited by *threshold costs* on one end and *market dominance* on the other. The costs of threshold were defined as the company's VC (variable costs) and the ICC determined whether the company was in a market dominant position (lack of market competition). Several procedures of the ICC were also sped up to aid decision making of transportation managers. These same ideas appeared again in later deregulation efforts.

In 1977 air freight was deregulated. No longer were there any barriers to entry provided the companies were deemed fit by the Civil Aeronautics Board. Size

Table 7.3 United States transportation deregulation

Date	Deregulation	Summary
1976	Railroad Revitalization and Regulatory Reform Act	The "4-R Act". Railroads were allowed to change rates without ICC approval, within limits; ICC procedures were sped up
1977	Air Cargo Deregulation Act	Freed all air cargo carriers from CAB regulations
1978	Air Passenger Deregulation Act	Airlines freed to expand routes, change fares within limits; small community routes were subsidized; CAB ceases to exist in 1985
1980	Motor Carrier Act	Fewer restrictions on entry, routes, rates and private carriers
1980	Staggers Rail Act	Freed railroads to establish rates within limits; legalized contract rates; shortened ICC procedure turnaround
1982	Bus Regulatory Reform Act	Amended the 1980 MCA to include buses
1984	Shipping Act	Partial deregulation of ocean transportation
1994	Trucking Industry Regulatory Reform Act	Motor carriers freed from filing rates with the ICC
1994	FAA Authorization Act	Freed intermodal air carriers from economic regulation by the states
1995	ICC Termination Act	Eliminated the ICC and moved regulatory duties to Dept. of Transportation
1998	Ocean Shipping Reform Act	Deregulated ocean liner shipping; allowed contract shipping; rate filing not required

restrictions were also lifted and carriers were free to charge any rate offered provided there was no discrimination. Lastly, carriers did not have to file freight rates with the CAB. This was followed soon after by deregulation of air passenger service in 1978. The targeted beneficiary of passenger airline deregulation was the traveller. In introducing the bill to the Senate, Senator Ted Kennedy, one of the bill's principal sponsors, proclaimed, "This bill, while preserving the authority of government to regulate safety and health, frees airlines to do what business is supposed to do serve clients/consumers better for less". This was a staged-in approach, wherein carriers could slowly add routes to their systems while protecting other routes from competition. Fares could be adjusted within limits without approval of the CAB. To protect small communities from losing service, all cities with service in 1977 were guaranteed service for ten additional years. In the era of 1981, all restrictions of routes were to be released, allowing any carrier to operate any route. In 1983, airline mergers and rates were to be released from regulation. Finally in 1985, the CAB was to shut down.

The impacts of regulation on the United States airline industry were enormous—in 1977, there were 34 air passenger carriers and by 1982 the number had dropped to nine. Some fares dropped substantially, while other fares went up, and routes to low-demand areas were reduced substantially. By 1981, among the main airlines of the United States, TWA and Delta were making revenue. Several notable airline failures also occurred in the year following deregulation. For example, after deregulation Braniff expanded speedily in the United States, purchased a larger number of planes, loaded up on debt and then declared bankruptcy in the period of 1982. They emerged from bankruptcy as a small airline, then seven years later declared bankruptcy again, after failing to obtain financing. A short period later, Braniff ceased their operation completely. People Express, a new low-fare, no-frills airline that began right after deregulation followed the Braniff model of large-expansion-high-debt, similarly had trouble operating in the era of 1986, eventually selling out to rival Texas Air, which filed for bankruptcy as well in 1990. In all, some 150 airline companies came and went during this era.

In 1980 motor carriers were deregulated. The objectives of this act were to promote competitive as well as efficient and safe motor transportation. Entry regulations were relaxed to make it easier to enter the market—companies had only to present that a "useful public purpose" would be served. Route restrictions were eliminated, and restrictions deemed to be wasteful of fuel, contrary or inefficient to the interest of the public were also removed. As with the Act of 4-R, a zone of rate freedom was also used. And, as with air passenger deregulation, a large number of new motor carriers began service. By 1981, in the United States, more than 2400 new motor carriers had begun business.

Railroads were further deregulated with the Act of 1980 (Staggers Rail Act). The financial situation of railroads was worsening, and this act was aimed at enhancing finances for the rail industry. With this act, rail carriers were free to change rates within a zone of rate freedom, but the market dominance or ceiling rate was set more definitively as 160% of VC (variable costs) and varied up to 180%, dependent on ICC cost formulas. After the era of 1984, rate increases were to be tied to the rate of inflation. Agreement rates were also allowed between shippers and railroads.

The Act of 1984 (Shipping Act) marked the end of the initial push by Congress to deregulate the entire United States industry of transportation. This act allowed ocean carriers to share or pool consignments, publish rates, assign ports and enter into agreements with shippers. More recently, with the passenger of the Ocean Shipping Reform Act of 1998 and Interstate Commerce Commission Termination Act of 1995, the ICC was eliminated and the requirements for ocean carriers to file rates with the Federal Maritime Commission also came to an end.

Therefore, many changes in the United States industry of transportation have occurred over the past century. Economic regulation of transportation occurred for various reasons. Primary transportation regulations were instituted to establish the ground rules as new forms of transportation developed and to control service, routes and prices when monopoly power existed in the transportation industry. Later, regulations were eased to increase safety and efficiency and encourage competition. In the future, as conditions of economic change and as political, social and technological changes occur, regulations of transportation will also continue to change, as we have seen since 2001 with regulation of transportation security.

7.8 Warehousing and Distribution

There is no doubt that warehouses offer a strategic SC (supply chain) service, in that warehousing enables companies to store their materials, finished goods, WIP (work-in-process); and warehouses are also used for value-added services including consolidation, postponement, assembly and break-bulk activities. Warehouses allow firms to make more frequent, smaller and faster deliveries to customers, which in turn result in higher customer service when the systems are designed and managed properly. For further in-depth discussion about warehousing see Chaps. 4 and 5. Here we will describe some roles of warehousing and distribution in the perspective of the United States.

In the United States, systems of freight distribution move products/commodities or goods from producers to consumers in an efficient manner; the growth in demand for warehouse space has outpaced this improved efficiency. Not only is the number of DCs (distribution centres) and warehouses growing, but they are also getting larger. Almost ten years ago in the United States, the average size of a warehouse was almost 250,000 square feet. But today, average warehouse size is 400,000 square feet. Denver-based ProLogis, a real estate builder, calculates that the available square footage of commercial warehouses in the United States is greater than 5 billion square feet (excluding private warehouses).

Now in many situations, warehouses are not only used for storing goods, but also used for value-added services, including consolidation, break-bulk, repackaging of various products into outgoing orders and then dispatching these orders to a retail centre or location of manufacturing. All these activities are referred to as cross-docking. In this situation, the warehouse is more accurately described as a DC. In other situations, companies are moving warehouses near customer/centralized locations, near suppliers, depending on the requirement of customer service and storage objectives. This section discusses the types of warehouses, risk pooling, lean warehousing and warehouse location.

7.9 The Types and Importance of Warehouses

Companies hold inventories for many reasons as explained in Chap. 5; warehouses are used to support production, distribution and purchasing activities. Companies place orders for parts, assemblies, components or raw materials, which are usually dispatched to a warehouse located close to the buyer's location, and then are finally transferred to the purchaser's various operations as needed. In a retail system, the warehouse may be located regionally, with the retailer receiving bulk orders from many suppliers, breaking these orders into small sizes (break-bulk) and reassembling outgoing orders for delivery to every retail location, and then using for-hire transportation providers or private fleet trucks to move orders to the locations of retail. Similar DCs are used when producers deliver bulk consignments to regional market areas and then break these orders (break-bulk) and dispatch LTL (less-than-truckload) quantities to customers.

On the other hand, companies may operate consolidation warehouses to collect large numbers of less-than-truckloads consignments from nearby regional sources of supply, where these are then consolidated and transported in CL (container load) or TL (truck load) to a user facility placed at some distance from the consolidation warehouse. The use of consolidation DCs and warehouses allows companies to realize both transportation economies and purchase economies. Companies may purchase products/goods in bulk at lower unit costs and then dispatch these products/goods at CL (container load) or TL (truck load) rates either directly to a production centre or to a DC. They can also buy and move small quantity purchases at less-than-truck rates to nearby warehouses (consolidation).

7.9.1 *Private Warehouses*

Just as with the private forms of transportation, *private warehouses* refers to the warehouses that are owned by the company for storing their products. For companies with large volumes of products to transfer or store, private warehouses show an opportunity to minimize the warehousing costs. Presently, UPS, Sears Holding Corp and Wal-Mart are the three largest private warehouse operations in North America. Besides the long-term benefit of costs private warehouses can provide, another consideration is the level of control provided by private warehouses. Companies can decide what to store and process, type of equipment and security system to use, among other operational aspects within the warehouses. This warehousing can also allow the company to maximize use of its workforce and expertise in orders of transportation, DC and warehousing activities. Also, as SC becomes more global to benefit from low-priced sources of labour and supply, the use of private warehouses is inclined to increase. Lastly, these warehouses can generate tax benefits and income through leasing of extra capacity. For these causes, in the United States, private warehousing accounts for the vast majority of overall warehouse space.

Private warehouses, though, can also show an important and critical loss of flexibility and financial risk to the companies. The costs to build, equipment and then run a warehouse can be very expensive, and usually small-size or medium-size companies cannot afford their own warehouse. Private warehouses bind companies to places that may not prove optimal as time passes. At least in the short term, capacity or size of warehouse is also somewhat inflexible. Another issue can be insurance. Firms' insurance coverage, in many situations, is non-existent or meagre, creating significant concerns about robberies, theft or fires resulting in the loss of products.

7.9.2 Public Warehouses

Public warehouses are for-profit organizations that lease or contract a broad range of light production, distribution and warehousing services to other firms. These warehouses offer several specialized services that companies may use to create customized services for many goods and consignments. Usually these services are the following:

- *Repackaging*—after break-bulk products are repackaged for particular customer orders. Warehouses can also do individual item labelling and packaging.
- *Break-bulk*—large consignments are broken down into smaller ones, so that products can be consolidated into specific customer orders and then dispatched out.
- *Assembly*—some warehouses offer final assembly operations to fulfil requests of customers and to create customized final goods.
- *Quality inspections*—warehouse staff can perform outgoing and incoming quality inspections.
- *Material handling, documentation services and equipment maintenance.*
- *Short-term storage* and *long-term storage*.

Besides the services mentioned here, these warehouses offer the flexibility (short-term) and investment cost savings that private warehouses cannot provide. If product changes or demand changes, the short-term commitments needed at warehouses (public warehouses) allow companies to quickly change locations of the warehouses. Public warehouses enable companies to test marketplace and withdraw quickly if demand does not materialize as expected. The cost for companies to use a public warehouse may also be very small if the requirements of capacity are minimal. For example, Nabisco spends millions of dollars every year to outsource to ten main warehouse providers and about 200 carriers for its delivery business and warehousing, which deliver to large food chains, drugstores and grocery wholesalers.

One of the primary drawbacks associated with public warehouses is the lack of control offered to the owner of products. Other issues include lack of specialized services or capacity on the desired locations, communication issues with warehouse staff/workers and the lack of security and care that might be given to goods.

Currently, public warehouses are finding new methods and techniques to add value for their customers, including the offering of specialized services such as customs clearance, freight consolidation, refrigerated warehouses, claims processing, reverse logistics, direct store deliveries and real-time information control. During the last economic recession period in the United States, use of public warehousing services grew tremendously as shippers sought to minimize supply chain costs. New Jersey-based Ultra Logistics grew meaningfully during the recession for exactly this reason. It now handles more than 40,000 just-in-time truckloads each year for customers such as Con-Agra, L'Oreal, Kraft Foods and Anheuser-Busch.

7.10 Risk Pooling and Warehouse Location

One of the critical decisions about private warehouses is where to place them. This decision will affect the number of warehouses and capacities required, customer service level, costs of warehousing system and system inventory levels. For a given market place, as the number of warehouses grows, the system becomes more and more decentralized. In a decentralized system of warehousing, delivery service levels and responsiveness will increase since products can be delivered more speedily to consumers or final customers; however, inventory costs and warehousing system operating costs will also rise. Other costs that come into play here are outbound transportation costs to consumers and the associated transportation costs with the inbound deliveries of products to every warehouse. Thus, the trade-off between customer service and costs must be carefully considered as the company makes its decision regarding warehouse location. This brings up the significantly important matter of risk pooling, which is discussed further below.

7.10.1 Risk Pooling

Risk pooling defines the correlation between the system inventories, the number of warehouses and customer service, and it can be described as follows:

"As market demand is random, it is likely that higher-than-average demand from few customers will be offset by lower-than-average demand from other customers." As the number of customers served through a single warehouse rises, these demand variability will incline to offset each other more frequently, thus minimizing overall demand variance and the likelihood of stock-outs; therefore, the amount of safety stock in a system of warehouse required to guard against stock-outs fall. Thus, the more centralized a system of warehousing is, the lower the safety stock needed to accomplish a given system-wide customer service level (recall that in inventory jargon the level of customer service has negative relationship with the number of stock-outs per period).

As described above, risk pooling assumes that demand of the markets served through a warehouse system is negatively correlated. In smaller market places served through warehouses, this cannot hold true and warehouses would then need higher levels of safety stock. This is why a smaller number of centralized warehouses serving a large market place requires lower overall inventories in a system, compared to a larger number of warehouses (decentralized) serving the same markets.

A good illustration of this principle occurred in Europe after the formation of the EU (European Union) in 1993. Prior to that period, logistics systems of Europe were formed along national lines. In simple words, every country's distribution system operated autonomously of the others, with warehouses placed in each country. In 1993, with the arrival of a single European market, these distribution systems no longer made economic sense. For example, Becton Dickinon (a producer of diagnostics equipment in the United States) was burdened in Europe in the 1990s with a costly and inefficient system of distribution. Their stock write-offs and inventory carrying costs were high; however, their stock-outs were numerous. After the formation of the EU, the firm closed their DCs in France, Belgium, Sweden and Germany and shifted all of their distribution operation to a single automated centre in Belgium. Within one year, average stock levels declined 45%, write-offs fell by 65% and stock-outs were decreased by almost 75%. Other firms in Europe had almost the same results.

The effect of risk pooling may be calculated numerically by the rule of square root, which holds that the system average inventory is equal to the original system inventory times the ratio of the square root of the new number of warehouses to the square root of the original number of warehouses. An example of risk pooling is presented in Example 7.1.

In this example, reducing the number of warehouses from 2 to 1 causes a decrease in average inventory of around 29%.

The differences between decentralized and centralized warehousing systems can be summarized as follows:

- *Avg. system inventory and safety stock*—as the company moves towards a more centralized warehousing system and fewer warehouses, safety stocks and thus average inventory levels across the system are reduced. The magnitude of the minimization depends on the correlations of demand in the several market areas/places.
- *Customer service*—as centralization increases, level of customer service offered by warehouse supplier is likely to rise, reducing the likelihood of stock-outs for a given level of average system warehouse inventory.

- *Responsiveness*—as warehouse centralization increases, there is an increase in the lead time of deliveries and/or risk of late deliveries, and a reduction in the ability of the company to respond speedily to changes in market demand. Service level to the customer may thus decrease because of problems such as weather delays and traffic congestion/problems.
- *Transportation costs*—as warehouse centralization increases, costs of outbound transportation increases, as LTL (less-than-truckload) consignments must travel farther to reach destinations. Costs of inbound transportation decrease, since producers and other suppliers are able to dispatch larger quantities at TL (truckload) rates to fewer warehouse locations. The overall impact on transportation costs thus depends on the particular warehouse locations, the products stored, the modes of transportation and the location of suppliers.
- *Warehouse system operating costs and capital costs*—as warehouse centralization increases, warehouse operating costs and capital costs decrease because there are fewer employees, less maintenance cost, fewer warehouses and less equipment.

Example 7.1 Risk Pooling
Perkins Western Boot Emporium currently owns two warehouses in Houston and Seattle to store its boots before shipping them out to various retail customers across the western USA. Greg Perkins, the owner, is considering a change to one centralized warehouse in Denver to service all of their retail customers and is curious to know the impact this will have on their system inventory requirements. Their current average inventory level is approximately 6000 boots at each warehouse. He has found that this level of stock will result in warehouse stock-outs approximately 1% of the time. Using the square root rule, he calculates the new average inventory level needed at the central Denver warehouse to maintain the same low level of stock-outs:

$$S_2 = \frac{\sqrt{N_2}}{\sqrt{N_1}}\left(S_1\right) = \frac{1.0}{1.41}\left(12{,}000\right) = 8511\,\text{boots},$$

S_1 = Total system stock of boots for the N_1 warehouses
S_2 = Total system stock of boots for the N_2 warehouses
N_1 = Number of warehouses in the original system
N_2 = Number of warehouses in the proposed system

7.11 Warehouse Location

Many location theories and models have been proposed over the years to optimally locate warehouses and factories. Initially in the development of modern warehousing and transportation networks, several well-known economists posited theories regarding locations of warehouse that are discussed below:

German economist Johann Heinrich, who is usually regarded as the “father of location theory”, discussed in the 1820s that costs of transportation alone should be reduced when considering location of facilities. His model assumed that despite of the different warehouse location, manufacturing costs and market prices would be the same, so the optimum location would be the one that resulted in the minimum costs of transportation. Another German economist an era later, Alfred Weber, proposed an industrial location theory almost the same as Johann Heinrich's; he argued that the optimum location would be found when the sum of the incoming and outgoing transportation costs was reduced.

In the period of the 1940s, Edgar Hoover suggested three types of location strategies: product positioned, product intermediately positioned and market-positioned strategies. The product positioned strategy places warehouses near the sources of supply to allow the company to collect many products while reducing incoming transportation costs. This strategy works well when there are large numbers of products bought from various sources of assortments and supply of products ordered by customers. The market-positioned strategy locates warehouses near customers, to maximize the level of customer service. This strategy is suggested when high level of customer service and distribution flexibility is desirable. The intermediately positioned strategy locates warehouses midway between the customers and the sources of supply. This strategy is suggested when distribution service requirements are relatively high and customer order item assortments are purchased from numerous suppliers.

In the 1950s, Melvin Greenhut's location theory was dependent on profit rather than transportation costs. Greenhut argued that the optimum location would be the one that maximized revenue, which may not be in accordance with the minimum cost location, because prices and demand can potentially differ, based on location.

7.12 Lean Warehousing

As companies develop their SCM (supply chain management) capabilities, products will be moving more speedily through incoming and outgoing DCs (distribution centres) and warehouses. These DCs will thus have to create leaner capabilities. Examples of these capabilities are the following:

- *Reduced shipping quantities and lot sizes*—incoming and/or outgoing shipping quantities are likely to be smaller and more frequent, containing mixed quantities of products, and thus requiring more handling.
- *Greater emphasis on cross-docking*—warehouse employees must receive consignments and mix these quickly into outbound consignments. Far limited products will be stored for any appreciable time and average warehouse inventory levels will decline, while the number of stock-keeping units will grow.
- *Service quality*—warehouse employees must perform warehouse activities so as to fulfil the requirements of their incoming and outgoing customers and suppliers.

- *Increased automation*—to improve reliability and handling speed, more warehouse activities will become computerized/automated, from barcode and scanner computer tracking systems, to warehouse management software applications, to automated retrieval and storage systems.
- *Increased assembly operations*—as more companies execute mass customization and lean systems, warehouses will be called upon to perform final assembly operations to fulfil particular customer requirements. This will change the skill requirements of warehouse employees, along with equipment requirements.

Most DCs have adopted several concepts of lean warehousing. Indiana-based PDS (Prime Distribution Services) offers distribution services to suppliers in club-store grocery SCs (supply chain). They offer cross-docking, warehousing, freight consolidation and packaging to suppliers who are looking to reduce costs and increase speed to compete in the highly competitive low-profit-margin grocery industry. Consequently, Prime Distribution Services' capabilities have had to evolve to survive. They recently combined many DCs into a single 1.2 million square foot heavily automated facility that offers greater control over inventory, more speedy order management, and easier building of mixed SKU (stock keeping units) pallets. They have state-of-the-art systems of warehouse management to manage picking operations, routing and sorting capabilities to divert orders to packing stations and automated barcode scanning. They have seen enhancements in order accuracy and output since moving to the new facility. "Our leadership and our company are geared towards a lean warehousing operation", says Scott Zurawski, director of Prime Distribution Services. "We are trying to build quality and sustainability into each process".

7.13 The Impact of Logistics on SCM

For global SCs, the function of logistics is more critical and complex than for domestic SCs. Providing adequate storage and transportation, getting products through customs, delivering to foreign places in a timely fashion and logistics pricing may all impact the ability of a SC to serve a foreign market competitively. In many situations, companies are forced to use 3PLs to move products into foreign locations effectively.

Purchases from overseas suppliers are also similarly affected by logistics considerations. When companies start using and evaluating overseas suppliers, timing and costs of logistics become critical elements in the sourcing decision. For example, Chinese suppliers supplying products to purchasers along the United States East Coast are in various cases favouring an all-water route through the Panama Canal, rather than dealing with traffic and port congestion on the United States West Coast and then rail and trucking transportation within the United States. Purchasers get low freight rates and can plan on consignments arriving at a particular time when using an all-water route, whereas the possibility of domestic consignments of

United States being held up because of traffic and port congestion cause uncertainties. All-water consignments have grown almost 65% since the 1990s. Containerized cargo numbers are up in each port of Eastern United States. Basically, the growth has been the result of increased growth in worldwide trade in common and an increase particularly in Asia Pacific trade. For example, the port of Virginia has more than 50 DCs and has seen its business increase as retailers dispatch to the port and then feed products to their nearby East Coast DCs. In many situations, purchasers with limited experience of overseas purchasing must use a knowledgeable "Third-Party Logistics" service to purchase from overseas suppliers and make logistics decisions efficiently and effectively.

Consequently, the value created for SC by logistics can easily be seen. It is what effectively connects each partner of SC. Poor and ineffective logistics management can clearly bring a SC to its knees, regardless of the quality of the products or manufacturing cost. On the other hand, good and effective logistics management can be one of the factors creating competitive benefits for SCs. Many of these subject matters are discussed at greater length in sections that follow.

7.13.1 Third-Party Logistics Services

Usually logistics service firms provide both warehousing services and transportation services, enabling companies to make better use of distribution alternatives such as storage location, customs clearance and transportation mode. A number of third-party firms even offer complete supply chain management (end-to-end) services, including light manufacturing and network optimization. Several companies outsource part of or complete logistics to enable more attention to be focused on core competencies. In tough economic times, companies look to third-party firms to help minimize costs while maintaining levels of customer service. In the year 2009, 80% of United States firms used a third-party logistics service for at least one area of their SCs. In Europe, almost 66% of every logistics Euro spent was on outsourcing. Whatever the cause, demand for third-party logistics services is increasing quickly.

7.13.2 Outsourcing End-to-End SCM Activities

In some situations, companies may select to partner with third-party logistics for the provision of all or most activities of SCM. For small companies, it can be a big question of lack of expertise. The sheer scale of SC activities and cost can also attract larger companies that prefer to free up valuable resources for core activities. For instance, GM (General Motors) formed a joint venture with CNF, Inc. to manage the automaker's entire SC, specifically all of General Motors' existing 3PL providers for both outbound movements and inbound movements over a 3-year transition period. The joint venture firm, Vector supply chain management, termed a 4PL or a lead logistics provider, managed all of General Motors' worldwide third-party logistics providers. Vector also assumed responsibility for managing some 180 million pounds of components/material from General Motors' 12,000 global suppliers each day.

7.13.3 Third-Party Supply Base Reduction

Reducing the supply base may provide many benefits for the company. With third-party logistics suppliers, using a smaller number of third-party logistics allows the company to use and select only the best-performing third-party logistics providers as well as to give these third-party logistics a larger share of the company's logistics needs. This in turn results in improved levels of service and also lower prices. The bigger share of business given to every third-party logistics can be used as leverage when negotiating prices, shipping services and schedules. In the year 2005, for example, Hewlett-Packard halved the third-party logistics it was using to minimize this number. In the same way, other firms are seeking to achieve an "irreducible minimum" number of suppliers (third-party logistics). Consequently, third-party logistics supply base reduction should become an integral part of an effective logistics management strategy, specifically in markets considered by many third-party logistics choices.

7.13.4 Mode and Third-Party Logistics Selection

When attempting to reduce logistics costs and/or enhance customer service along the SC, companies must recognize the most desirable modes of transportation and third-party logistics services available for the several markets they serve as well as for their incoming purchased components/materials, and also for miscellaneous costs, warehousing costs, consignment damage costs and packaging costs. The second part of this text describes the subject matter of selection and evaluation suppliers. Companies use a mix of qualitative and quantitative elements to evaluate and also select third-part logistics services and there are many other comparative methods in existence to aid in the decision process. In many surveys conducted, significant and important factors of selection were found in transportation rates, transit-time reliability, damage-free delivery, total transit time, financial stability, willingness to expedite deliveries and use of electronic data interchange.

7.13.5 Building Strategic Logistics Alliances

Creating an effective SC very often includes the creation of strategic alliances with 3PLs. In fact, in many surveys of various industries and businesses, warehousing and transportation firms were included as SC partners by more than 50% of the survey respondents who were actively managing their SCs. In the recent business climate, partnering with a third-party logistics provider makes even more sense. “Now, many firms are moving from older and costly processes to outsourcing their logistics in favour of more concentration on their core business and competencies”, says Tony Zasimovich, VP of logistics services at APL logistics (California-based). These partnerships underscore the essential role played by logistics in SCM. A couple of examples are given below.

Automobile SCs are getting more difficult and complex as firms search for higher quality and lower cost suppliers. This has made collaborations with third-party logistics even more vital. A couple of years ago, in the United States, automakers focused on squeezing 3PLs for cost minimizations. “They considered logistics a commodity”, says Gregory Hines, President of NLM (National Logistics Management), a third-party logistics (Michigan-based). “The right cost is not always the lowest cost. One firm cannot do partnership alliances which are vital”, he adds. In the United States, partnerships between automakers and railroads means that seven out of ten vehicles manufactured are moved by rail to dealerships, along with a great percentage of the vehicle parts moving to assembly factories. Railroads have invested billions of dollars manufacturing special boxcars designed to the automakers’ requirements, auto-rack rail cars with premium cushioning, auto-carrier trucks, a network of vehicle DCs and information systems that enable railroad firms to function as an integral part of automaking companies.

7.14 Other Transportation Intermediaries

In some situations, firms utilize intermediaries of transportation that may not own any major logistics capital assets to find the most suitable mode of transportation or third-party logistics service. For several small size firms, where expertise of logistics may be limited, and in some situations for large size firms, where the scale of logistics needs is greater, use of these services (transportation) can make good economic logic. A couple of these intermediaries are discussed below.

7.14.1 Freight Forwarders

Freight forwarders consolidate many small consignments to fill rail cars or trucks to achieve truckload transportation rates. They also can offer consolidation services of air transportation. These firms pass some of the savings on to the small shippers and then keep the rest as fees. On the other hand, freight forwarders offer valuable services to both the carrier (higher equipment utilization and extra business) and the shipper (low shipping rates). The freight forwarders can specialize in global consignments or domestic consignments, as well as ground or air consignments. These firms can offer customs clearance, special freight handling and other documentation services.

7.14.2 Transportation Brokers

Transportation brokers, also referred to as load brokers, bring transportation and shipping firms together (primarily truckers). Load brokers are legally authorized to act on the carrier's or shipper's behalf, and typically these firms are recruited or hired because of their broad knowledge of the many transportation alternatives available. Transportation broker (Minnesota-based) C.H. Robinson Global provides an example of the way these middlemen can be profitable even in the down transportation industry. They purchase low-cost transport capacity on railcars, cargo ships, and trucks on the spot markets and then resell it to shippers at high price. According to Jon Fisher (fifth-ranking portfolio manager at Third Asset Management Inc.), the firm "does well in a world where there is more [transport] supply than there is demand for items to dispatch/ship".

Typical arrangements can find small firms using a load broker to handle many of their requirements of shipping, or trucking firms using brokers to find a back-haul job after a delivery is done. Many transportation broker or load broker directories exist, allowing carriers and shippers to find one fulfilling their requirements. For example, direct freight services and FreightQuote.com provide services such as matching up empty cargo space with shipper requirements for a monthly service charge.

7.14.3 Shippers' Associations

The AISA (American Institute for Shippers' Association) describes shippers' associations as "non-profit membership cooperatives which make international or local arrangements for the movements of members' cargo". Therefore, AISA's job is to consolidate only their members' consignments into full truckloads, container loads or carloads to accomplish discounts on volume for the members and to negotiate for improved terms of service. These associations also benefit the transportation firms, in that they help to maximize the utilization of their machines and equipment. Because associations of shippers do not recognize themselves as third-party logistics providers, or brokers, they are not required to adhere to or publish a number of United States transportation regulations and can keep service contracts confidential. A couple of drawbacks of membership include minimum volumes of consignment to achieve the benefits of low rates and a couple of ocean carriers' refusals to do business with these associations (shippers). Many of these cooperatives exist for diverse industries.

7.14.4 Intermodal Marketing Firms

IMCs (Intermodal Marketing Companies) are firms that act as intermediaries between shippers and intermodal railroad firms. Typically, they buy large blocks of flatcars for piggyback service and then find shippers to fill motor carriers with truckloads, to load the flatcars. Basically these are brokers of transportation for the rail industry. They get discounts on volume from the railroads and also pass small discounts to the shippers. These firms facilitate intermodal shipping and have become an essential service to railroads. Many intermodal marketing firms utilize cell phones, satellite transmission and the Internet to enable real-time communications among themselves, the shippers and the carriers.

7.15 Environmental Sustainability

To enhance environmental performance today, companies are facing increasing pressure from consumers as well as governments. In logistics, one of the large energy wastes comes from trailers coming back from their deliveries empty. Empty Miles, an internet subscriber service offered by "Voluntary Inter-industry Commerce Solutions Associations", seeks to reduce much of this issue. Members post regularly available trailer backhaul capabilities on their routes of delivery; hence, carriers obtain profit from an otherwise empty backhaul. For example, the retailer Macy's has seen its costs of delivery reduced significantly from use of the Empty Miles portal, while 3PL Schneider National has seen its backhaul profit increase by 25%. The potential economic and environmental advantages are huge—the NPTC (National Private Truck Council) calculates that 28% of the trucks on United States highways are presently running empty. Empty Miles is also better for SC relationships. According to Bill Connell, executive VP of logistics at Macy's, "It enables partnerships to evolve that would not naturally evolve".

Actually, many non-profit organizations have been formed to help companies in their efforts of sustainability. In the United States, the EPA (Environmental Protection Agency) launched SmartWay, a certification that represents a more fuel efficient transportation option. The SmartWay brand signifies a service or item that minimizes transportation-related emissions. The SmartWay website enables users to locate alternative fuel station locations, recognize greener vehicles to select and buy certified SmartWay transportation firms. The CRT (Coalition for Responsible Transportation) covers exporters, motor carriers, water carriers and importers who are taking roles of leadership in their industries to develop green transportation initiatives. In 2007 its inception, members such as Gap, Wal-Mart, Home Depot, Target have been instrumental in developing sustainable solutions to minimize truck pollution and emissions at United States deepwater ports without disturbing the flow of commerce.

Europe's third-party logistics and ports have been prominently the way towards sustainability by introducing many green management initiatives. The logistics arm of Denmark's AP Moller-Maersk Group has launched a system (graphical representation) called SC Carbon Dashboard that enables customers to track their SC carbon footprint. As per Erling Nielsen (head of Maersk SC), "It immediately enables you to identify carbon hotspots in your SC". Global freight management firm Geodis Wilson (based in The Netherlands) has tools that calculate and measure the environmental impact of its customers' transport solutions. For example, it might find that a consignment to the United States from Gothenburg, Sweden could decrease carbon emissions by 16% compared to one created in Rotterdam.

7.16 Global Logistics

For products and material movements, managers of logistics must be aware of many issues not impacting local logistics movements such as third-party logistics services and costs, regulatory requirements, port and warehousing issues, export or import limitations, and availability of transportation modes. In the United States, movement of freight to Asia or Europe involves either water transportation or air transportation and then most likely rail transportation and/or motor transportation to the final destination. Between most neighbouring countries, motor carrier consignments and rail carrier consignments tend to be the most common transportation modes. There are several differences in logistics infrastructure and problems found as goods are moved from one country to other country. In Europe, rail transportation tends to be much more reliable and prevalent than rail transportation in the United States, because European facilities and equipment and rail tracks are better maintained. This is partially because most modes of transportation in Europe are government maintained and owned. Water carriers may be the dominant transportation mode in countries with a great deal of developed and coastline inland waterways. In undeveloped and underdeveloped countries, ports may be poorly equipped; and the highway system may be more or less non-existent.

7.16.1 Global Logistics Intermediaries

These intermediaries offer global shipping, export/import services and consolidation for companies and offer expertise that may prove useful for most companies involved in global commerce. Many of these global logistics intermediaries are briefly discussed here.

7.16.2 Customs Brokers

Brokers of customs move global consignments through customs for firms as well as handle the essential documentation required to accompany the consignments. These specialists are usually used by firms requiring expertise in exporting goods; their knowledge of the many requirements of imports of various countries can reduce the document processing time.

7.16.3 International Freight Forwarders

The freight forwarders move products for firms from local/domestic manufacturing facilities to foreign destinations using surface and air warehousing and transportation. They consolidate small consignments into larger carloads, container consignments or truckload consignments, decide what modes of transportation to use, handle all requirements of documentation and then disperse the consignments at their final destination. They also determine the best overseas storage, requirements of repackaging and break-bulk and best route to use. Use of international freight forwarders may reduce costs of logistics, increase customer service and enable shippers to focus resources on core competencies or other activities. Many firms importing products or exporting products use the services of international forwarders because of their presence and expertise in international markets.

In recent times, many shippers were shipping and importing low-cost, high-quality products from “far-shore” operations (United States buyers purchasing products from Chinese producers). Today, some purchasers are utilizing a strategy called right-shoring. Right-shoring strategy combines far-shore, domestic opportunities and near-shore into a single, cost-driven and flexible approach to logistics and purchasing. As labour costs increase and prices of crude oil fluctuate and the value of the United States dollar decreases, global shippers find they must be much more flexible concerning where goods are purchased. This has built an even better and greater need for worldwide involved freight forwarders.

7.16.4 Trading Firms

Trading firms put sellers and buyers from different regions, countries together and handle all the import or export arrangements, transportation and documents for both services and products. Most trading firms are covered in exporting and they usually take title to the products until sold to international purchasers. They enjoy low price on economies of scale when exporting products as they dispatch larger quantities of consolidated consignments using established services of warehousing and transportation. In the United States, the 1982 act of export trading firms promotes United States exports and helps United States exporters enhance their competitiveness. Within the United States DOC (Department of Commerce), the ETCA (Export Trading Company Affairs) office helps promote the development of joint ventures between foreign firms and United States firms and the use of intermediaries (export trade).

7.16.5 NVCO: Non-vessel Operating Common Carriers

NVCO operates similarly to foreign freight forwarders, but normally uses only scheduled ocean liners. They consolidate small consignments from many shippers into FCL (full container loads) and then handle all of the transportation and documentation arrangements from the shipper's dock area. Non-vessel operating common carriers assume responsibility for cargo from origin to destination. On the other hand, they do not own any vessels. They enter into agreements/contracts with ocean liners, which can then subcontract with motor or rail carriers for land travel.

7.17 Foreign-Trade Zones

FTZs (Foreign-trade zones) are secure sites with the United States under the supervision of the United States Customer Service. These sites are well authorized by the FTZs board, chaired by the United States Secretary of Commerce, and are comparable to the so-called "free-trade zones" that are available in many countries today. FTZs are considered to be outside United States Customer territory, where domestic or foreign merchandise may enter without formal customs payment or entry of excise taxes or duties. Firms working in FTZs bring material, components and products into the site and might use assembly, repair, storage, packaging, testing and export services. No retail activities are enabled, however. If the finished goods are exported out of the United States, no local excise taxes or duties are levied. If the finished goods are imported into the United States from the FTZ, taxes and duties are paid only at the time the products leave the FTZ.

7.18 North American Free Trade Agreement

NAFTA (North American Free Trade Agreement) was primarily agreed upon in 1992, with the United States Congress passing it in 1993, and put into effect since 1994. It will finally eliminate many hurdles and barriers to investment and trade among Canada, Mexico and the United States. Many quotas and tariffs were removed immediately and many others were to be removed by 2008. NAFTA forms the world's second largest open market with a combined economy of more than 14 trillion dollars and a population exceeding 435 million people—somewhat smaller in size than the EU. The aims of NAFTA are to facilitate international trade among the three countries, increase opportunities of investment and promote fair trade.

NAFTA has not been without its detractors. Labour groups of the United States have argued that jobs are being lost as firms move to neighbour country (Mexico) to take benefit of low-cost labour, undermining labour union negotiating power. As mentioned before, free access to United States highways by Mexican truckers is not presently allowed by the United States. Environmental groups have been concerned that food safety, emission and pollution laws have become harder to enforce. Others argue that due to subsidies on agricultural items exported to Mexico, the small farmer (Mexican) is being run out of revenue. Some communities in the United States saw the "North American Free Trade Agreement" as a way to develop the economy of Mexico and control illegal immigration into the United States. On the other hand, migration into the United States, both illegal and legal, has risen since NAFTA started, majorly because of the Mexican peso crisis, enduring poverty in Southern Mexico and the influence of Chinese competition on Mexican industries. On account of these and other reasons, supplementary agreements continue to be added to NAFTA.

7.19 Reverse Logistics

Reverse logistics refers to the backward flow of products, components from consumer or final customer in the SC occurring when products are returned, either by the business customer or by an end-product consumer within the SC. In simple words, reverse logistics refers to the storage and movement of returned products. Today's returned products are increasing in part to the growth of online shopping, direct-to-home and direct-to-store consignments. Currently, the use of untested and low-price international suppliers has also caused relatively many goods recalls in the United States. During 2007, the world's largest toymaker (California-based Mattel) recalled around one million Chinese-made toys because they were covered with paint containing lead. The next couple of weeks later, Mattel again was forced to announce a big recall for toys containing small magnets that posed a choking hazard. In fact, eight of Mattel's nine toy recalls during 2004–2007 were for Chinese-made goods.

Customer (retailer) returns account for around 6% of sales and can sometimes be higher than 40%. The logistical cost to process these returned products can also be high-now running around one hundred billion dollars every year in the United States for handling of goods, repackaging, transportation, lost sales and disposal costs, refurbishment and remarketing. Besides the significant impact on costs, return goods also can have a direct inverse impact on customer service, reputation and profitability of firms, and also environment if not managed properly.

7.19.1 The Impact of Reverse Logistics

Returns can show big challenges to a SC. In many situations, reverse logistics is viewed as an unwanted activity of SCM. In these situations, reverse logistics is seen as a cost of regulatory compliance or doing business issues. Problems and issues cover the inability of information systems to monitor and handle reverse flow of product, lack of personnel training in reverse logistics procedures, inadequate or no identification on returned products/packages, the need for adequate testing and inspection of returns, and the placing of damaged returned goods, items into stocks of sales. A poor system of reverse logistics can affect the whole supply chain financially and can have a significant impact on how a final consumer views an item brand, potentially impacting future expected sales. According to recent research by GBCC (Global Business Consulting Company), Accenture found that reverse logistics costs are four to five times higher than forward logistics and on average requires 12 times as many processing stages. Their results, though, also suggest that reverse logistics illustrates a greater source of untapped value.

From a viewpoint of marketing, a good returns process may enhance customers' perceptions of purchase risk, product quality and also create goodwill. From a quality perspective, item failure and returns information may be used by quality staff in root cause analysis and by design staff to minimize future errors in products design (usually the reason for product return is a damaged or defective item). From a viewpoint of logistics, returned goods can still build value as original goods, repair components or refurbished goods. This also tends to minimize costs of disposal. Thus, while 46% of firms report losing money on goods returns, about 8% actually report making money. Wal-Mart recently stated in a meeting with government officials and 1000 suppliers in Beijing that they intend to do away entirely with defective item returns by 2012 using on-site audits, enforcement of social and environmental standards and the threat/risk of lost expected future business.

7.19.2 The Environment and Reverse Logistics

Reverse logistics can significantly and positively impact on the environment through activities such as reusing products and materials, recycling, refurbishing or remanufacturing used items. Environmental reverse logistics programs cover minimizing the environmental impact of certain transportation modes used for returned products, minimizing the amount of disposed product material and packaging by redesigning processes and products, and using reusable pallets and totes. According to Paul Vassallo (marketing director of United Parcel Service—UPS), “Sustainability is playing a key role in reverse logistics”. More and more firms are looking to minimize their impact on the environment and search for carbon-neutral methods and approaches to dispose of goods.

Traditionally, firms have used landfills for routine material and product disposal, but now, landfills have become more and more expensive to use. Federal and local governments are also imposing strict laws and higher costs regarding the use of landfills. These changes have led to new methods of dealing with used components, products or waste of products.

In the United States, Texas-based Advanced Micro Devices, Inc. works with their suppliers to find new methods to reduce handling activities and packaging waste. For example, the firm had traditionally used 55 gallon drums to store some of their bulk chemicals, but changed to 300 gallon totes and finally to bulk tankers to decrease packaging waste that would finally be disposed or delivered to a landfill.

Discussion Questions

1. Why are logistics issues significantly important for success of business?
2. What are the important factors or activities in logistics?
3. List the legal forms of transportation modes. Which mode is the lowest-cost? Which mode carries the most freight?
4. What are some alternatives within intermodal transportation?
5. What is the difference between value-of-service pricing and cost-of-service pricing?
6. Is US government regulation of transportation bad or good? Why?
7. What is a lead warehouse?
8. Discuss the types and importance of warehouse.
9. Is transportation in the United States regulated or deregulated today? Why?
10. What is the fundamental difference between a warehouse and a distribution centre?
11. What are International trade zones? What advantages do they provide?
12. How does reverse logistics impact supply chain management?
13. How can reverse logistics have a significant positive impact on the environment? On customer service? On repeat buying? On profits?
14. Describe several global logistics intermediaries and their roles.
15. Discuss the role of NAFTA in global and local logistics.

References

Agility. (2014). *Agility emerging markets logistics index 2014*. Transport Intelligence.

Arvis, J.-F., Saslavsky, D., Ojala, L., Shepherd, B., Busch, C., & Raj, A. (2014). *The logistics performance index and its indicators*. Washington, DC: The Word Bank.

Dong-Fang, D., Dong, Q., Peng, Z.-M., Khan, S. A. R., & Tarasov, A. (2018). The green logistics impact on international trade: Evidence from developed and developing countries. *Sustainability, 10*, 2235. https://doi.org/10.3390/su10072235.

Golpîra, H., & Khan, S. A. R. (2019). A multi-objective risk-based robust optimization approach to energy management in smart residential buildings under combined demand and supply uncertainty. *Energy, 170*(3), 1113–1129.

Golpîra, H., Khan, S. A. R., & Zhang, Y. (2018). Robust smart energy efficient production planning for a general job-shop manufacturing system under combined demand and supply uncertainty in the presence of grid-connected microgrid. *Journal of Cleaner Production, 202*(11), 649–665.

Khan, S. A. R. (2019). The nexus between carbon emissions, poverty, economic growth, and logistics operations-empirical evidence from Southeast Asian countries. *Environmental Science and Pollution Research*. https://doi.org/10.1007/s11356-019-04829-4.

Khan, S. A. R., Chen, J., Zhang, Y., Golpîra, H., Kumar, A., & Arshian, S. (2019). Environmental, social and economic growth indicators spur logistics performance: From the perspective of South Asian Association for Regional Cooperation countries. *Journal of Cleaner Production, 214*(3), 1011–1023.

Khan, S. A. R., Dong, Q., SongBo, W., Zaman, K., & Zhang, Y. (2017b). Travel and tourism competitiveness index: The impact of air transportation, railways transportation, travel and transport services on international inbound and outbound tourism. *Journal of Air Transport Management, 58*(1), 125–134.

Khan, S.A.R., Dong, Q., Zhang, Y., Khan, S.S. (2017). Research on decision-making of green reverse logistics in enterprises: A case study on electronic products manufacturers from the perspective of South Africa. *2nd International Conference on Advances in Management Engineering and Information Technology* in Shanghai, China during April 23-24, 2017 (AMEIT 2017), ISBN: 978-1-60595-457-8, pp. 11–18.

Khan, S. A. R., Zhang, Y., Golpîra, H., & Arshian, S. (2019). The nexus between corporate social responsibility and corporate performance. *An Empirical Evidence, 15*(2), 291–303.

Rykgm, E. A. (2014). *Connecting to compete 2014 "The logistics performance index and its indicators"*. Ankara: T.C. Gümrük Bakanlığı.

Schwab, K. (2014). *The global competitiveness report*. Cologny: World Economic Forum.

Zhang, Y., Golpîra, H., & Khan, S. A. R. (2018). The relationship between green supply chain performance, energy demand, economic growth and environmental sustainability: An empirical evidence from developed countries. *LogForum Scientific Journal of Logistics, 14*(4), 479–494. https://doi.org/10.17270/J.LOG.2018.304.

Zhang, Y., Golpîra, H., & Khan, S. A. R. (2018). The impact of GSCM on manufacturing enterprise's performance. *Journal of Advanced Manufacturing Systems, 17*(4), 445–459.

Chapter 8
Procurement

8.1 Definitions of Purchasing and Procurement

In a supply chain, every company purchases raw materials or components from upstream (suppliers), adds value, and sells finished goods to downstream customers. As each company, in turn, purchases and sells, the materials, components or goods move through the whole SC (supply chain). The trigger that initiates each move is a purchase. This is principally a message that a company sends to a supplier, saying, “We have agreed on terms, so send us components or materials, and we will pay you”.

In simple words, purchasing gives a complete mechanism for initiating and controlling the flow of components, materials or goods through an SC.

Purchasing is the function responsible for buying/acquiring all the components and materials needed by a company. A number of these transactions are not standard purchases, but include leasing, exchange, gifts, contracting, rental, borrowing and so on. This is why some people prefer to discuss “procurement”. Usually the terms *procurement* and *purchasing* are used interchangeably. Purchasing refers to the practical buying; however, procurement has a broader meaning. Procurement can include many types of acquisition (rental, purchasing, contracting, etc.) as well as the related work of negotiating, selecting suppliers, expediting, agreeing on terms, materials handling, transport, receiving products/components from suppliers and monitoring supplier performance.

In simple words, procurement is responsible for buying/acquiring all the components, materials or goods needed by a company. Procurement includes all the relevant activities required to get services, materials and components from suppliers to a company.

Usually procurement does not move materials itself, but procurement organizes the transfer. It sends the message that materials are required, and arranges the change of location and ownership. But it is another function, such as transport, that actually delivers them. So procurement is broadly concerned with the processing of information. Procurement collects data from different sources, analyses it, and then transfers information to the SC.

S. A. Rehman Khan, Z. Yu, *Strategic Supply Chain Management*, EAI/Springer Innovations in Communication and Computing,
https://doi.org/10.1007/978-3-030-15058-7_8

8.2 Importance of Procurement

It is very easy to understand why procurement is very important. If we take a broader view, procurement forms an important and essential link among companies in the SC, and it provides a mechanism for coordinating the flow of materials between suppliers and customers. At every stage in the SC, procurement delivers information backwards to describe what consumers or customers need, and it delivers information forward to explicate what suppliers have available. Then it negotiates conditions and terms for delivery.

If we take a more narrow view of procurement, it is simply a significantly important function within every company. It is known that every company requires a supply of components, materials or goods, and this is procurement's responsibility. If procurement is implemented badly, materials do not get delivered or wrong goods are delivered, at the wrong time, with high price and poor quality, low customer service, etc.

There is no doubt that procurement is very essential and plays a vital role in the organization. On the other hand, a lot of expenditure is generated because of procurement. Typically for a producer, 60% of its expense goes on components and materials, with firms like GM (General Motors) spending almost more than 50 billion dollars per year. Therefore, procurement is primarily responsible for a big part of a firm's expense, and a relatively small improvement can create significant advantages.

Given that a firm purchases raw materials for \$60, spends \$40 on operations and then sells the item for \$110, which simply makes a revenue of $110 - (60 + 40) = \$10$ per unit. Now given that procurement negotiates a 5% discount on components or raw materials. Components now spend $60 \times 0.95 = \$57$, and with the same selling price \$3 savings goes straight to revenue. Since the revenue per unit now jumps from \$10 to \$13, a 5% decrease in component costs increases revenue by 30%.

In the last couple of years procurement's job has been widely recognized as a critical function that can control most of a firm's expenditure. As a result, much more attention has been drawn to this function. It used to be regarded little more than a clerical job, purchasing components and materials when they were requested. Now it is recognized as a significantly important management function in its own right. The tendency has been encouraged through changing procurement patterns. SCs become shorter as more and more consumers or customers use the Internet; alliances are minimizing the number of suppliers used by each firm; amounts purchased are increasing as firms place emphasis on their core activities and outsource noncore activities; customers are more demanding of items and conditions of purchase. These factors and some other factors, turn a spotlight on the procurement function. With this perspective, there is no doubt that procurement is treated as a role of senior management.

8.3 Goal of Procurement

The overall goal of procurement is to guarantee that a company has a reliable supply of goods (raw material or components, etc.). With this overriding goal, we can build the below list of more immediate and specific objectives:

- Organizing a reliable and uninterrupted flow of materials into a company
- Finding good suppliers and developing beneficial relationships
- Working closely with customer services and the marketing department, understanding the requirement of customers
- Buying the right goods and making sure that they have acceptable quality, arrive at the place and time needed, and fulfil all requirements
- Moving materials quickly through the SC, expediting deliveries when necessary
- Keeping stocks low, considering policies of inventory, investment, standard and readily available materials, and so on
- Keeping abreast of conditions, covering pending price increases, new products, scarcities, etc.

8.3.1 Procurement Organization

The way that procurement is organized depends on the size and type of the company. In a small firm, a single buyer may be responsible for all administration and policies. An average size or medium size firm might have a department with buyers, store keepers, clerks and expeditors. MNCs (multinational companies) or large firms might have hundreds of staff coordinating huge amounts of purchases. Coordination efforts include the following:

- Consolidation of all orders for the same materials to get quantity discounts or for similar materials to get discounts on quantity
- Eliminating haphazard practices and duplicated efforts
- Improving procurement operations and developing specialized skills
- Having one single point of contact for suppliers and giving suppliers consistent service and information
- Enabling other staff to focus on their own task and work without diverting into purchasing
- Concentrating responsibility for procurement, and making senior management or manager control easier

8.4 Choosing Suppliers

8.4.1 Qualified Suppliers

Possibly and debatably, the most significant part of procurement is looking for not only a supplier but also the right one. It will be meaningless in having a well-designed item if the supplier cannot deliver it. Suppose that you are engaged in a project and plan to purchase some significant or strategic materials—perhaps one prefabricated bridge for construction. You will check two main factors. First of all, a design of products that fulfils or meets your requirements. Secondly, a supplier who can give surety to delivery of the product as designed. In simple words, the supplier should be able to do the work, provide excellent quality, work to a schedule, with minimum or reasonable costs, etc. An advertised time of five hours for a high-speed train journey might seem to be a good service; on the other hand, it has less value as the train operator cannot fulfil his promise or is unable to deliver this service.

Procurement begins, then, by finding a well-qualified supplier. Actually, this is one who can deliver the goods required. Commonly, companies look for suppliers who:

- Are financially strong
- Have the capability and ability to supply the required materials
- Deliver the requested goods on time
- Deliver on time with short lead-times
- Are flexible to customers' changes and needs
- Have a good reputation
- Use easy and convenient procurement systems
- Have full expertise in their products
- Deliver materials of guaranteed high quality

In different situations and conditions, many other factors can be more critical, such as ability to deal with variable demand, convenient location, etc.

Most companies list the approved suppliers who have given excellent service in the past, or who are otherwise known to be reliable. If there is not any previous acceptable supplier on file, the firm has to search for one. Suppliers for low value or non-strategic products can possibly be found in trade catalogues and journals. High-value products need a detailed search, and this may be time-consuming. A useful technique for selecting the best supplier for an item involves the steps below:

- Look for alternative suppliers.
- Make a detailed list of qualified suppliers who have capability to deliver the products.
- Compare companies on this detailed list and remove those who are less desirable for any reason.
- Continue removing companies until you have a shortlist of the most promising suppliers.
- Receive bids from the shortlisted suppliers.
- Prepare a request for quotation and send to the shortlisted suppliers.
- Do an elementary assessment of bids and also remove those with major disadvantages.
- Do a technical evaluation to see if the items fulfil all specifications.
- Do a commercial evaluation to compare the quality, costs, delivery and other factors.
- Arrange a pre-award meeting to discuss detailed bids with the remaining suppliers.
- Discuss condition bids, which are particular conditions that have to be agreed upon.

- Select the supplier who is the likeliest to win the order.
- Arrange a pre-commitment gathering to reform any last minute details.
- Finally award orders to the well-preferred supplier.

This is simply a time-consuming effort and procedure; on the other hand, a poor supplier can cause more problems and issues than poor materials. The whole procedure is only used for key or strategic purchases; usually, a firm will spend less time looking at alternative suppliers if:

- It is buying low-value goods
- There is one supplier
- There is already an agreement or arrangement with a supplier
- The firm has a policy of choosing a specific type of supplier
- There is not much time for extended negotiations

Particularly, sometimes with government work, procurement has to be visible, and all potential suppliers must be given an opportunity to submit their quotations. Rather than form a shortlist of suppliers (qualified suppliers), a firm will widely advertise that it's looking for particular materials or work. The company compares all the bids and chooses the one that best fulfils the prescribed standards or criteria. This is termed as "open tender". A variation minimizes the administrative effort by putting some qualifications on suppliers, perhaps based on size, financial status and experience. This gives "limited tender".

As we can see, we are discussing how customers choose suppliers—and assuming that suppliers are happy to fulfil the requirement of customers. Usually this is the situation, but sometimes suppliers have more power and effectively select their customers. This might happen when a supplier has a near monopoly or pure monopoly of some material. It might also happen when there is a temporary shortage of some material or commodity such as wheat, gas and oil. Suppliers may choose the customers they will supply, possibly giving preference to bigger customers, those who can pay more, or those who have a long-term relationship or agreements. In these situations the supplier has more power than the buyer, as illustrated in Fig. 8.1:

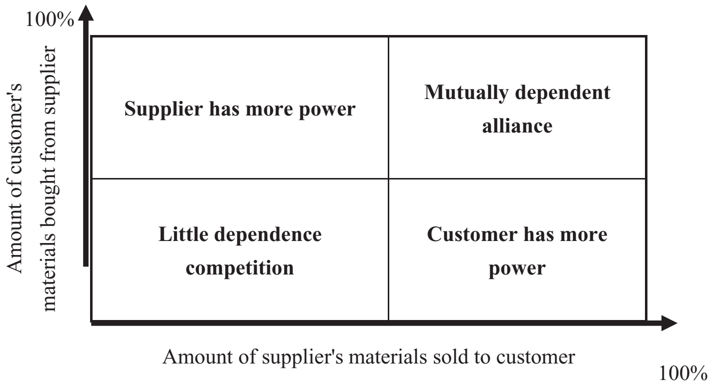


Fig. 8.1 Relative power of a supplier and customer

We have already mentioned the trend towards long-term partnerships and alliances. This inevitably moves companies towards single suppliers, either for every material or for specific types of materials. Some companies say that this "single sourcing" leaves them vulnerable to the performance of an individual firm, and they clearly have problems if something goes wrong. If the supplier (single supplier) of a key or strategic component hits bankruptcy or financial difficulties, a firm may, through no fault of its own, have to stop manufacturing. To avoid this, many companies have a policy of buying the same components or materials from more than one supplier. They might use rules of thumb such as "never let a producer account for more than 20% of total profit; never let a customer absorb more than 50% of total resources". The choice should depend on individual situations; on the other side, we can list identifiable benefits of policy:

- Benefits of single sourcing:
  - A stronger relationship between suppliers and customers, usually formalized into partnerships or alliances
  - Price discounts with larger orders or economies of scale
  - Less variation in materials, components and their supply
  - Easier communication, minimized administration, easier procedures for regular orders
  - Easier to keep requirements and conditions.
- Benefits of multi-sourcing:
  - Less chance of disruption in supplies (can easily switch suppliers)
  - Can deal more easily with volatile demand
  - Does not depend on one external company
  - Involving more companies can give access to wider information and knowledge
  - Is more and more likely to encourage improvement and innovation
  - Competition between suppliers can reduce material prices

Companies use many suppliers when they want to avoid potential problems. Another way of doing this uses "forward buying". In its easiest form, this happens when a firm orders more goods than it currently requires and keeps the excess in stock. Another form uses contracts to deliver goods at specific points in the future. Both of these bring two major advantages. Firstly, they guarantee supplies for some time period in the future and also reduce the effect of probable disruptions. Secondly, the price of goods is fixed, avoiding the effects of future price uncertainty or rises. Obviously, things can still go wrong. A firm that signs a long-term contract can still go out of business, but the probability of a problem is smaller. It is possibly safest for a company to hold spare stock itself. On the other hand, this has higher costs; entering a contract for future deliveries gives lowest possible costs, but does not reduce as much risk (and it is also a bad management decision when goods prices might fall).

8.5 Monitoring Supplier Performance

Many firms closely monitor their suppliers to make sure that they can continue and can fulfil the requirements and specifications of materials. This is called "vendor rating or supplier rating". Usually this is done informally through subjective review; most times there are very complex measures for every aspect of supplier performance. Many firms use a compromise that gives a reasonable view of performance and requires a reasonable amount of effort. One general approach or technique uses a checklist of critical factors and checks that the supplier fulfils an acceptable specification or standard in these. The checklist might ask whether the supplier delivers on time; whether the supplier is financially strong enough; whether there is technical support; whether quality of material is high enough; whether the price is competitive and so on. If the supplier does not fulfil any criterion, the customer has to look for new suppliers or sources. The objective is not really to replace an existing supplier, but to closely monitor performance of suppliers, identify areas that need improving and agree on the best way of achieving these improvements. Only as a last option should a company start searching for new suppliers.

8.6 Procurement Cycle

8.6.1 Steps in the Cycle

Once it has selected a supplier, a company has to follow some procedure for arranging purchases. Imagine that you want to purchase something at a price other than the cheapest, like a new car or laptop. You possibly approach this in several steps, listing the facilities you want, identifying suppliers, developing a shortlist of options, comparing these and selecting the best supplier. Your objective is to find the combination of suppliers and products that best satisfy and fulfil all your requirements. The function of procurement in a company does exactly the same and follows a specified procedure for every purchase. Usually this procedure is different in each firm and varies with the type of material, commodity or thing being purchased. You would not expect an organization such as the United States Army, which purchases millions of products a day, to work in the same way as the directors of Real Madrid football club when they acquire a new striker. And the army of the United States would not approach its decision to buy pencils in the same way as its decision to buy helicopters.

Despite these inevitable differences in detail, we can recommend a common approach to procurement. This has a series of general steps which begin with a user identifying a need for components, materials and end when the components or materials are delivered. Figure 8.2 presents an outline of these steps, while a more detailed view of a typical *procurement cycle* has the given steps (with key documents in bold).

1. A user department:

   (a) Identifies a requirement for purchased components or materials
   (b) Inspects components available and prepares *specifications*

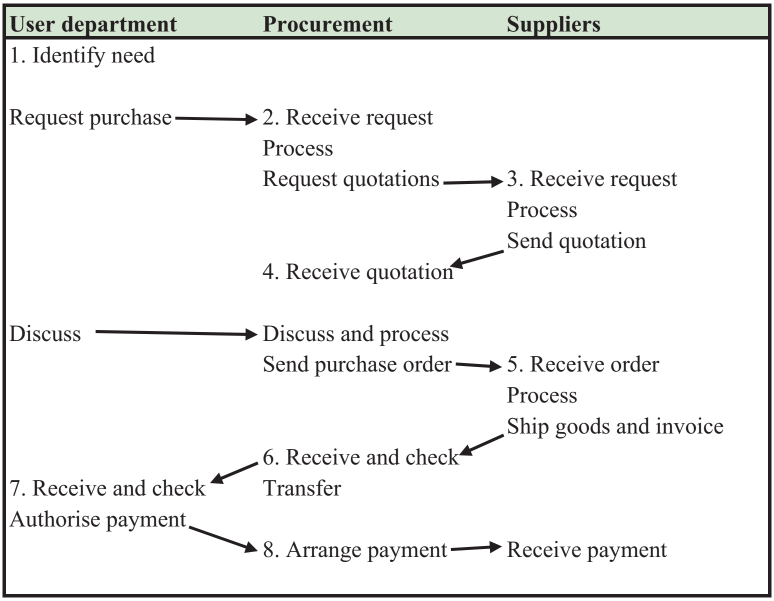


Fig. 8.2 Procurement cycle

   (c) Checks departmental budgets and gets clearance to buy
   (d) Sends a request of purchase to procurement

2. Then procurement:

   (a) Checks, verifies and receives the purchase request
   (b) Examines the component or material requested, looking at current stocks, alternative products, manufacturing options, etc.—and after discussion with the user department, confirms the final decision to purchase.

3. Then each supplier:

   (a) Examines the request for quotations
   (b) Checks the status, credit of customer and so on
   (c) Determines how it could best fulfil and satisfy the order
   (d) Sends a *quotation* back to the company giving details of items, conditions and prices

4. Then procurement:

   (a) Examines the quotations and performs commercial evaluations
   (b) Discusses technical characteristics with the marketing and customer department
   (c) Checks details of budget and obtains clearance to purchase
   (d) Selects the best supplier, based on the details supplied
   (e) Discusses and finalizes terms and conditions with the vendor or supplier
   (f) Issues a PO (purchase order) for the materials (with attachment of terms and conditions)

5. Then the chosen supplier:
   (a) Organizes all operations required to supply the materials or components
   (b) Receives, and processes the PO (purchase order)
   (c) Dispatches materials together with a shipping advice
   (d) Sends an invoice
6. Then procurement:
   (a) Acknowledges receipt
   (b) Does any necessary expediting and follow-up
   (c) Receives and accepts the materials after inspection
   (d) Notifies the relevant department of materials received
7. Then the user department:
   (a) Receives and also checks the materials or components
   (b) Authorizes transfer from budgets
   (c) Updates records of inventory
   (d) Uses the materials as required
8. Then procurement:
   (a) Arrange payment of the supplier bill or invoice.

The first three stages sort out the supplier and materials; then comes the critical point with the issue of a PO in stage four. At this step the company agrees to buy specified goods from a supplier, and the PO triggers the supply (along with necessary manufacturing planning, transport, finance and so on). The PO is part of a legal contract between the supplier and firm. The remaining stages finalize the details of delivery.

This procedure looks very complicated, and covers many documents and stages. If you are buying something expensive, this effort is certainly valuable—and you can actually follow a more detailed and complicated procedure to fix specifications of product, choose the right supplier and negotiate terms and conditions. But if you are making minor purchases, if there are existing relationships with suppliers, or there is only one qualified supplier, it is simply not worthwhile going through this lengthy procedure.

During the last couple of decades, many studies have been done to minimize both the time and cost for procurement. Some of these methods are simple. *Blanket orders*, for example, use a single order to cover regular deliveries of goods over some specified time period in the future. *Value analysis* uses a team of people from different functional areas to find substitute components or materials that are low cost but equally as good as original material quality and specifications.

None of these adjustments tackle one of the fundamental issues and problems with non-computerized procurement, which is its unreliability. Typically staff of purchasing departments spend a maximum of their time dealing with issues that occur when the process of procurement fails in some way. Some of these issues and problems with non-computerized procurement include:

- Taking a long time to go through the complete procedure
- Relying on a lot of paperwork and forms which move around different places
- Needing many people to complete, process, analyse, store and commonly deal with all the paper
- Having other people to manage, supervise and control the administrative procedures
- Inevitable errors with so many people and documents involved
- Not giving attention to related systems, such as stock control

A main stage in enhancing and improving procurement came with paperless procurement. Since the 1980s, EDI (electronic data interchange) has been used and this allows automated procurement. A company links its IS (information system) to a supplier's, and when it is time to place an order the system sends a message. This works for regular, small repeat orders and many firms have readily adopted the principles. There are many variations on automated procurement, all of which are considered under the common heading of e-procurement.

8.7 E-procurement

Many firms already use some form of electronic procurement. A survey suggests that over 60% of United Kingdom firms used electronic procurement by 2002, and 80% of European procurement managers soon expect to use it broadly. Some of the key benefits this brings are:

- Allowing instant access to suppliers
- Creating a transparent market where goods or items and terms are readily available
- Automating procurement with standard procedures
- Significantly minimizing the time required for transactions
- Outsourcing some activities of procurement to third parties or suppliers
- Integrating seamlessly with supplier IS (information systems)

Fundamentally, B2B (business to business) and B2C (business to consumer) are the two main types of electronic procurement. Many of us are more familiar with "business to consumer" transactions, where we buy music, books or tickets from websites. In the United Kingdom, during the period 1999–2002, the number of internet shoppers rose from two million to six million. Nonetheless, several of these websites have hit financial difficulties with the bursting of the "dot-com bubble", and there have been a number of widely publicized bankruptcies. In 1996, Anderson Consulting predicted that online shopping would soon account for 20% of United Kingdom groceries, but by 2002 the figure was still less than 1%. A retail research agency then predicted that online sales would grow to 6% for all grocery sales by 2006. Obviously, it is clearly difficult to anticipate reliable figures in this area, but there is a general feeling that "business to consumer" will continue to grow.

Of course, one problem or issue is that people do not necessarily like electronic procurement. If you want to buy a mobile, you can use many websites, fill in the forms for your purchase, and finally get the mobile delivered within a day. But if you go to your nearest mobile shop, you might pick up the mobile immediately and without any extra charges for delivery or any further risk. Business to consumer can hit difficulties because people actually like going to see things before they buy them. Some evidence for this comes from the United States, where only 1% of car purchases are made through the website, but before buying a vehicle, 75% of people do online searches to check and compare specifications and prices.

A significantly critical factor is that maximum electronic procurement is actually "business to business". The Gartner Group have produced the given estimates of business to business trade.

The attractions of electronic procurement are so great that several companies will continue to move in this direction. One main software firm estimated the following savings from electronic procurement (values are in € per transaction). The system gave a ROI (return on investment) of 400% per year.

There is no doubt that many people are excited and enthusiastic about the growth of electronic procurement, but they forget a critical point. If we organize electronic procurement very efficiently, it gives better communication—but it does not necessarily enhance the flow of physical materials. This only happens when companies in the SC use the communications to find better ways of moving goods. According to Doerflinger et al., "The real hurdles and barriers to business to business entry is the back-end—fulfilment—not the website itself". Perhaps the basic effects of electronic procurement are not the velocity or speed of purchasing but the effects it has on the SC. Now customers can purchase from a wide range of suppliers who might be geographically remote. They also have the option of buying directly from primary suppliers or producers, and can use the increasing number of specialized web retailers. Merrill Lynch suggests that the basic changes that this will bring are the following:

- Growing use of the website for procurement will change logistics patterns.
- E-commerce will change patterns of buying, but will possibly not generate much new business.
- Companies will have to enhance or improve customer service by arranging home deliveries, etc.

8.8 Types of Purchase

When we described an official procedure for procurement, we said that it may be somewhat timing consuming and complicated. It would be expensive and unnecessarily complicated to use this procedure for each and every purchase; nobody wants to spend eight months buying a box of papers. However, main purchases need much more analysis and information. This is why companies vary the details of their procedure of procurement, matching the techniques or methods to the material types. Commonly, the higher the cost of goods (components or materials) and the more complicated the requirements, the more effort and time procurement needs. Companies often set some rules for effort put into the process of procurement, perhaps using ad hoc procedures for non-strategic or low-value routine supplies; a non-complicated, automatic procedure for purchases up to £30,000; a more rigorous, detailed and sophisticated procedure for purchases up to £160,000; and special analysis for bigger purchases. Van de vliet explains a variation on this approach at 3 M Corporation, where the effort of procurement depends on the importance of goods.

- Non-critical items have low profits with low risk in supply, and need basic and simple procedures for purchasing.
- Bottleneck items have low profits but have high risk in supply, and need long-term contracts with substantial sources to avoid potential issues and problems.
- Strategic items with higher profits need more sophisticated relationships with suppliers over the long-term, probably developing into partnerships and alliances.

Once such rules are established, a MCS (management control system) can monitor purchases and ensure they are handled in the best way. MCS looks at how purchases have been made—if the output is good and satisfactory, if the effort is reasonable given the importance and costs, and if the procedure can be enhanced and improved for the future.

When vendor or supplier has given excellent service over some extended time, a company might avoid almost all the cycle of procurement and put little effort into administering expected future orders. Ordering becomes routine and the firm effectively sends a message to say "send the next order like the last one". With non-routine buying, a company has to put more effort into and be more careful with the choice of supplier, terms and conditions of purchase.

If an order is repeated often enough, a company might consider the "buy or make" decision. In simple words, it has to select those goods, materials that it can make itself, and those that are best fulfilled by outside suppliers. In its simplest form, this decision asks whether a company can receive goods more inexpensively from a supplier than it can make them. Economies of scale and efficient operations often mean that specialized suppliers can deliver goods at cheaper prices than other companies can manufacture them. There are, however, several other elements to consider. Internally making parts can be more reliable, give better control over supply, tailor items, have shorter lead-times, use spare resources, keep value-addition operations, protect designs, grow firm size and so on. But buying them from suppliers can get the advantages of specialization, get economies of scale, give access to better and more expertise, maintain flexibility, transfer some risk, minimize stock levels and so on.

The department of trade and industry suggests that three key criteria for such decisions are the following:

- Financial/Monetary factors (relating to costs)
- Operational factors (responsiveness, reliability, flexibility and so on)
- Strategic factors (long-term implications of the decision for the company)

In exercise, the perceived advantages of outsourcing are growing and more companies are happy to focus on their core competitive functions and use specialized suppliers for materials and components.

8.8.1 Terms and Conditions

Although we have discussed common terms covering "placing an order", there are many different order types. Typically companies discuss "placing an order" for materials, but "leasing" equipment and "signing a contract" for services. To a great extent, these are different ways of saying the same things, but there can be some legal differences. For instance, hire purchase goods remain the property of the supplier until they are fully paid for, while credit financing gives ownership to the company which becomes responsible for servicing a debt. Already we have pointed out some specific types of orders. Most common are those given below:

- POs (purchase orders) are used in the standard approach to procurement that we discussed above. It is significantly important a letter from one company to another give details of the goods it wants to purchase and its purchase conditions. Usually this is a response to a quotation from a well-qualified supplier, giving the goods it can supply and its conditions of trade.
- Blanket orders give a simple system for inexpensive, standard products, such as books and stationery. A company places a single order for all the goods that it will require over some period of time, such as 6 months. Then the supplier delivers batches of goods when requested during the six months.
- E-procurement uses internet or EDI (electronic data interchange) to simplify purchases by replacing non-computerized procedures with computerized ones. This gives an efficient and fast method for straightforward, or repeat, orders.
- Subcontracts: when a supplier enters an agreement with a company, it cannot do all the work itself, but prefers to pass on some work to another firm/subcontractor. Then, there are two agreements—the contract between the supplier and the firm, and the subcontract between subcontractor and supplier. For big projects, there can commonly be many layers of subcontracting.
- Contracts give very detailed descriptions of agreements between a supplier and a firm; they define exactly the responsibilities, services and work for each, together with all appropriate terms and conditions. Several firms use contracts instead of POs for extended services, so they sign a contract for a supply of electricity. Using the same approach, companies sign a contract for a specific piece of work such as a construction firm building a length of bridge.
- Retail and lease agreements again show the terms and conditions of acquiring goods. Generally, such agreements are used for equipment or buildings that are returned to the owner after some time of use. You can lease a car or you can rent a car, for example, and when you have finished, you return the car to the owner.

The different types of purchases suggest another issue with procurement. There can be several terms and conditions such that it is shockingly complex to compare them. Suppose that you are purchasing some commodity (standard commodity), such as electricity. A number of competitors offer the same item, so the best is the one that offers the inexpensive or lowest possible price. Usually, however, there are several conditions of purchase. If you want a telephone service, all suppliers give basically the same item, but the structure of pricing, offers, and discounts can make significant differences. Then it is the conditions of purchase that determine the best supplier.

In practice, there can be several factors other than cost to consider. Many researchers suggest that decisions about purchases are made in two steps. Firstly, available items are examined and those with "qualifying" factors get onto a shortlist. Then, "order-winning" factors identify the best products from the shortlist. Cost is likely to be one of the qualifying factors but is only likely to be an order-winning factor with commodities. Particularly, quality is very important, which is the reason why TQM (total quality management) holds that the lowest price does not necessarily give the best or ideal deal.

Pricing is a significantly complicated issue. It is certainly not in a firm's long-term interest to force suppliers to give unrealistically low prices, or they will go out of business and not be there next time they are needed. In parts of the European Union (EU), supermarkets have followed consumer pressure to minimize prices of food. However this advantages their customer—and presumably the broad population—it means paying less to farmers who grow the crops. If farmers go out of business, there is a key impact on rural communities, more reliance on imported food, an effect on the balance of trade and so on. Commonly, there are four ways of setting a price for goods:

1. Price lists—where suppliers quote fixed prices. For example, publishers of books quote a selling price that they expect retailers to use. They can give discounts for special purchases or large purchases, but one company essentially fixes the price.
2. Negotiation—when there is flexibility in conditions and price. A supplier might give a quote, but is willing to negotiate if it may get some advantages such as repeat orders. Similarly, customers can negotiate if they want special conditions, including fast delivery or overnight delivery.
3. Commodity pricing—for commodities such as coffee, wheat, oil and gold. Market forces set the going rate that is used by all suppliers. You may see many such figures in, say, financial futures markets.
4. Special quotation—where suppliers quote prices to every customer, specifically for non-standard goods. Customers submit a request for a quotation, and the supplier returns conditions and price that it is willing to offer.

Even when the basic price has been agreed there can be other complications and difficulties with conditions, for example, who pays for transportation to the final destination, and who accepts the risks for the in-transit goods. Many standard conditions are used (illustrated in Fig. 8.3), and for historical reasons they seem to be phrased in terms of shipping:

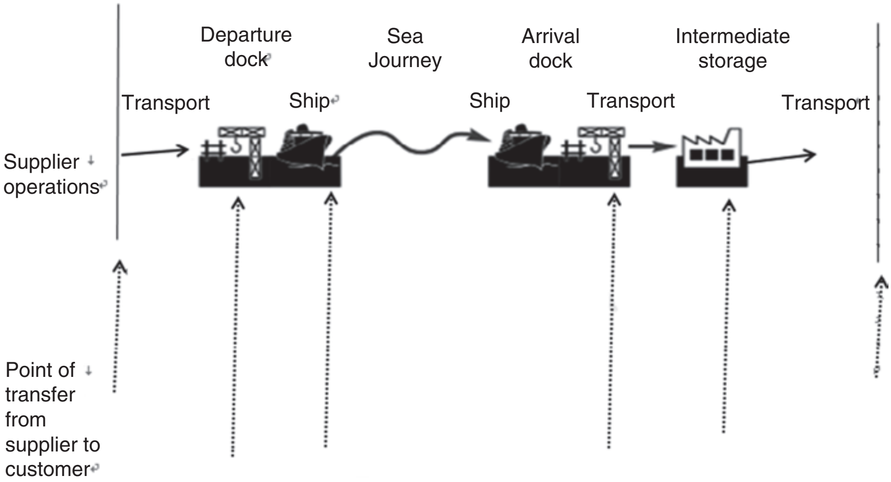


Fig. 8.3 Some arrangements for delivery of materials

- Ex-works: the purchaser accepts goods "at the factory gate" and takes over all responsibility for documentation, insurance, risk, customs clearance and transport. This type of contract is best when the supplier has little or no experience moving goods through the relevant area.
- FOB (free on board): this is variation of FAS, where the supplier also takes care of the loading onto the vessel, and then the customer is responsible for onward transport. This might seem like a small adjustment to FAS, but loading might cover risk of damage, heavy lifts, or use of lighters (small vessels used to move goods out to a larger vessel, in deep water).
- FAS (free alongside): here the supplier moves goods to a specified "port" and delivers them "alongside a ship". The customer takes over the loading onto a vessel and movement onward.
- Delivered ex-ship: where the materials are available on the ship but the customer has to arrange for duty, and customs clearance, etc.
- C&F (cost and freight): here the supplier arranges transport to an agreed point, but the customer arranges insurance for the journey and accepts all risk.
- CIF (cost, insurance and freight): where the supplier delivers to an agreed point, and also arranges insurance cost for the journey.
- Delivered: where the supplier is responsible for all aspects of the transport up to delivery to the customer gate.

Discussion Questions

1. What are procurement and purchasing?
2. Discuss the importance of procurement.
3. What is the goal of procurement?

4. What features would make an ideal supplier?
5. Describe the cycle of procurement.
6. What are the significant or major benefits of procurement?

References

Croom, S. R. (2000). The impact of web-based procurement on the management of operating resources supply. *The Journal of Supply Chain Management, 36*(1), 4–13.

Glas, A. H., & Kleemann, F. C. (2017). Performance-based contracting: contextual factors and the degree of buyer supplier integration. *Journal of Business & Industrial Marketing, 32*, 677–692.

Grant, S., Kline, J. J., & Quiggin, J. (2014). A matter of interpretation: ambiguous contracts and liquidated damages. *Games and Economic Behavior, 85*, 180–187.

Greenemeier, L. (2000). Buying power. *Information Week, 780*(3), 67–68.

Heywood, J. B. (2002). *E-procurement: Managing successful e-procurement implementation*. London: Financial Times/Prentice Hall.

Hungerford, N. J., & Blom, M. C. (2014). *Collective bargaining and the negotiation process: A primer for school board negotiators*. Alexandria, VA: National School Boards Association.

Khan, S. A. R., Dong, Q., & Zhang, Y. (2017). Role of ABC Analysis in the process of efficient order fulfillment: Case study. *Advanced Engineering Forum, 23*(7), 114–121.

Khan, S.A.R., Dong, Q., Zhang, Y., Khan, S.S. (2017). *Research on decision-making of green reverse logistics in enterprises: A case study on electronic products manufacturers from the perspective of South Africa*. 2nd International Conference on Advances in Management Engineering and Information Technology in Shanghai, (AMEIT 2017). ISBN: 978-1-60595-457-8, pp. 11–18.

Khan, S.A.R., Golpîra, H., and Zhang, Y. (2018). *The importance of advanced information technology and green vehicles in supply chain management*. International Conference on Computer, Communications, and Mechatronics Engineering (CCME-2018), July. doi: https://doi.org/10.12783/dtcse/ccme2018/28629.

Khan, S.A.R., and Zhang, Y. (2017). *The environmental supply chain management and the companies' sustainable development*. 3rd International Conference on Social Science and Higher Education, Sanya, September 2017 (ICSSHE-17). doi: https://doi.org/10.2991/icsshe-17.2017.32

Kollie, E. (2015). Today's purchasing practice. *School Planning and Management, 54*(7), 19–22.

Petersen, B., & Østergaard, K. (2018). Reconciling contracts and relational governance through strategic contracting. *Journal of Business & Industrial Marketing, 33*, 265–276.

Ramayah, T., Zbib, I., Jantan, M., & Koh, B. L. (2007). Type of procurement and operational performances: comparison of e-procurement and offline purchasing towards operational efficiency. *Advances in Global Business Research, 3*(1), 279–296.

Yeo, K. T., & Ning, J. (2006). Managing uncertainty in major equipment procurement in engineering projects. *European Journal of Operational Research, 171*(1), 123–134.

Zhang, Y., Ma, T., Khan, S.A.R., Arshian, S. (2018). *The study on efficient cold chain logistics*. 2nd International Conference on Economic Development and Education Management (ICEDEM-2018). Atlantis Press. doi: https://doi.org/10.2991/icedem-18.2018.117.

Chapter 9
Performance Measurement and Evaluation

The system for evaluating purchasing and SC (supply chain) performance represents a sophisticated, systematic technique to evaluate and monitor performance of purchasing. This looks easy, but usually it is very complex to develop measures that direct activity or behaviour exactly as planned. Some companies still depend on measures that could be causing harm, subject on performance goals, rather than supporting long-standing performance. For example, the capability to get discounts on price from a vendor is still a key objective for certain/cost/price performance measures. On the other hand, if short-term price bargains is continually squeezed from a vendor, will this vendor have the commitment or financial resources to invest in long-term performance enhancement?

Modern measurement and evaluation systems of purchasing and SC cover a range of measures. Many of these measures are divided into two main categories: efficiency measures and effectiveness measures.

The measures of effectiveness refer to the extent to which, by selecting a certain course of action, management can fulfil standard or goal. The efficiency measures refer to the correlation between actual and planned sacrifices made to realize an earlier agreed-upon goal. Usually the measures of efficiency relate some contribution to a performance productivity.

More or less all measures cover a target or standard against which to evaluate performance outcomes. It is not suitable and preferable to say, for instance, that a measure will track enhancement in quality of supplier. We will need to evaluate desire target against actual improvement. Fulfilling this target, which is probably on the basis of world-class performance benchmark, will contribute great value to a firm. Every performance measure needs to cover targeted performance levels and actual performance level.

S. A. Rehman Khan, Z. Yu, *Strategic Supply Chain Management*, EAI/Springer Innovations in Communication and Computing,
https://doi.org/10.1007/978-3-030-15058-7_9

9.1 Why Measure Performance?

There is no doubt that there are many reasons for measuring and evaluating activity and performance of purchasing and SC.

9.1.1 Support Healthier Decision-Making

Measurement may lead to good decisions by making performance and results more clear and visible. It is very complex to develop plans of performance improvement without in-depth understanding of the areas in which performance is not good. Measurement offers a track record of procurement and contracts performance over time and directly supports activity of policymaking through management.

9.1.2 Support Improved and Effective Communication

Performance measurement may lead to good communication from upstream to downstream of the SC, covering within supply departments, with senior management, and with suppliers. For instance, a buyer must transmit performance expectations to suppliers. Undeniably, performance of the supplier reflects a buyer's expectations.

9.1.3 Provide Performance Feedback

Measurement offers a chance for feedback and perfection of performance, which helps in the correction or prevention of glitches and difficulties identified during the process of performance measurement. Feedback also gives awareness into how well a purchaser, supplier or department is fulfilling its objectives of performance over time.

9.1.4 Motivate Behaviour

Measurement encourages behaviour towards desirable output. A system of measurement may perform this in many different methods techniques. First of all, the selection of objectives and performance categories shows purchasing staff those activities that a company consider significantly important. Second, management can influence behaviour through attaching achievement of performance goals to rewards, like promotion and cash rewards.

9.2 Problems of Measurement and Evaluation in Supply Chain

The measurement and evaluation of performance, covering procurement, logistics and overall firm performance, generally have had certain limitations, difficulties and problems. According to Mark Brown, many professionals and executives today are similar to a driver trying to drive a car with only half the tools needed and a number of additional tools and gadgets that measure unrelated data. Mark Brown suggests that, in practice, each and every firm has some sort of issues, difficulties and problems with its system of measurement.

9.2.1 Too Much Data

There are too much data for a company's measurement system to handle, which is a common problem for companies. And the data that supervisors, personnel or managers pay attention to are usually wrong, which is a significantly important problem. In reality, measures that supervisors, executives or personnel use may be encounter with the measures used in other functional areas. In general, workers should monitor simply a dozen measures, with half of those being significantly critical.

9.2.2 Measures That Are Not Long-Term Focused

Some medium and small companies are facing a problem of depending on data and measures that are not long-term focused. Normally the only data they gather are operating and financial data, including inventory and production related data. In purchasing, this would mean a not long-term focus on workload and SC activities (not long-term), while ignoring strategic or long-term measures.

9.2.3 Lack of Detail

Sometimes data are summarized and reported, resulting in making the information meaningless. A statistic that reports on a single measure of weekly supplier quality possibly lacks detail that a supervisor of supply will be interested to understand: which types of faults are experienced by supplier, what the faults cost the purchaser's firm, and the quality performance of supplier over time.

With the information the supervisor may be able to take necessary action to cope with the essential causes of the quality issues at his facility.

9.2.4 Wrong Performance

Unluckily, a number of measures drive behaviour that is not what was really needed or intended. If purchasers are measured on the basis of quantity of POs (purchase orders) printed, then they will ensure the distribution of orders between suppliers to produce as many POs as possible. Part of this is because of the fact that it is not an easy job to measure intellectual work. On the other hand, companies still want to look for factors or elements that can be reported and measured. But not always are these factors the right factors.

9.2.5 Behaviour vs. Accomplishments

The main problem with measuring behaviour is that the behaviour will lead to anticipated objectives has no guarantee. A behaviour measure that tracks the dollars of purchase volume enclosed by corporate wide agreements, for instance, is becoming increasingly common. However, a good measure is one that tracks the aggregate savings due to the use of corporate wide agreements.

9.3 Procurement and SCs Performance Measurement Classifications

As part of a firm-focused procurement and SC-measurement approach, companies should follow a systematic process to take full advantage of results and achieve horizontal and vertical alignment of purpose. As indicated in Fig. 9.1, firm aim drives specific firm strategies for example become the low-cost manufacturer. These firm strategies should then drive suitable and prioritized procurement and SC aims and specific strategies.

Alignment of measures, strategies and actions will bring together bottom-up targeting and top-down direction to produce positive contributions. In a single company, this could provide competitive benefit. Integrated procurement and SC may also produce competitive edge for the entire SC level, enhancing efficiency and minimizing overhead.

Undeniably, there are many procurement and SC measures. Perhaps the best approach to summarize the large number of separate measures is by developing performance measurement classification or grouping as identified in Fig. 9.1. Within each group, several separate measures relate to each common category. Many procuring and SC measures are covered in one of the given classifications:

- Cost-effectiveness
- Price performance
- Quality

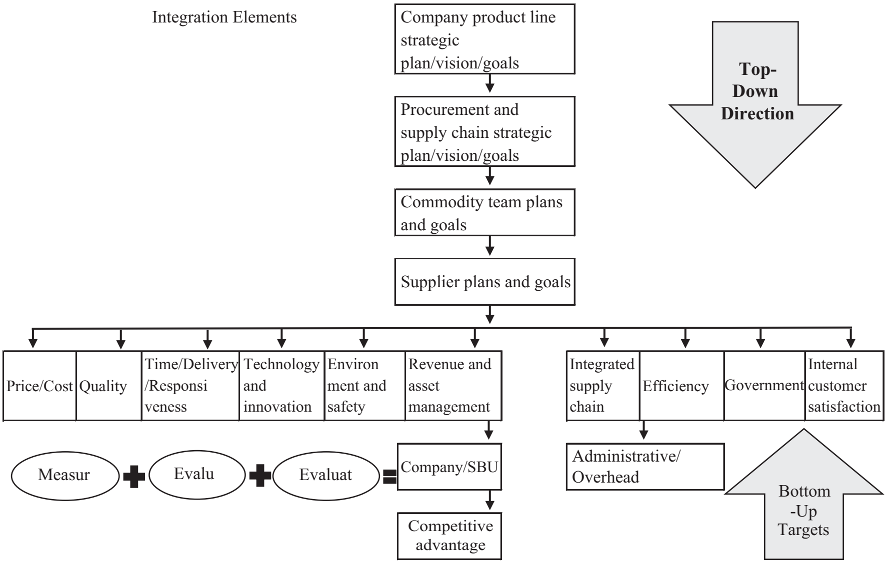


Fig. 9.1 Integrated firm/purchasing measurement process

- Revenue
- Innovation and technology
- Time/responsiveness/delivery
- Asset and integrated SCM (supply chain management)
- Physical environment and safety
- Administration and efficiency
- Internal customer satisfaction
- Government and social expectations
- Strategic performance
- Supplier performance

9.4 Price Performance Measures

Many indicators are used in purchasing to check price performance measures—in simple words, how effectively it spends purchase dollars. Planned purchase price versus actual purchase price comparisons, actual purchase price(s) compared to a market index, comparisons of actual to actual purchase prices for aggregated and individual products or divisions or factories within a company, and target prices achieved—these are all included in the very common price performance measures. Two measures of price performance which are important:

1. Price to market index comparison
2. Target prices achieved.

9.4.1 Actual Price Compared to Standard/Plan Price

Generally, the difference between planned purchase prices and actual purchase prices is reflected in measure of price performance. Measurement of planned purchase price difference can arise at different stages in organization.

For instance, procurement can calculate planned price versus actual price variances for every individual purchased product identified in Fig. 9.1. There are many approaches and techniques for computing purchase price variance.

9.5 Actual Price vs. Market Index

The price of purchase vs. market index measures give information about the relationship between published market prices and actual prices. These measures are the most suitable for market-based items where pricing is mainly a function of demand and supply. This also applies to readily and standard available items. The difference between a published index number over a designated period of time (such as month or quarter) and the change in the actual price paid is taken into account in index measures.

9.5.1 Price Comparison Between Operations

Actual prices for similar products are also compared between division, business units or factory. These comparisons give an opportunity to recognize purchase price differences within a company. This gives greater clarity as to which unit is securing the best purchase price. The activity of comparison may also help recognize commonly purchased products between units for purchase consolidation. Many companies also attempt actual-to-actual price comparisons between firms to determine true price advantage.

Companies are more and more emphasizing cost vs. price, but price performance measures are still used widely, mainly with companies that lack detailed data of cost. Price performance measures are also generally used when purchasing components, standard-type products, or other commodities, and raw materials.

9.5.2 Target Prices Achieved

Target pricing is the process of defining what the customer is eager to pay for service/item and then allocating specific cost targets to the assemblies, systems and components that make up the service or product. Target costing apply the given formula to define allowable costs:

Target Price – Project Target = Allowable Cost

Allowable cost is then assigned to several factors that constitute the finished goods.

9.6 Measures of Cost-Effectiveness

Cost-effectiveness measures fall into two broad categories:

1. Cost avoidance
2. Cost changes.

The use of measures of cost-effectiveness calls for a word of caution. The technique for attaining cost elimination is crucial. A cost minimization on the basis of mutual collaboration and cooperation is the same, on paper, as a cost minimization resulting from heavy-handed pressure on a vendor. Undeniably, cooperation and collaboration may reduce the cost but heavy-headed pressure lead vendor towards poor quality.

9.6.1 Cost Changes

A cost measure compares the actual cost of a product over a period. A cost change is the decrease of increase in cost resulting from a change in practice or purchasing strategy brought about by an individual or group.

The main measure of concern to firms is cost minimization accomplished, which is estimated by taking (Current Price – Previous Price) × Estimated Volume. For instance, if the current price was $10/unit and the previous price was $11/unit with an estimated volume of 20,000 units for the next budget, there would be forecasted cost minimization of $20,000. The final cost minimization achieved would depend on actual usage.

9.6.2 Cost Avoidance

The cost avoidance signifies the difference between a price paid and a potentially higher price (if purchasing had not achieved the lower price through a specific action or effort, this might have happened). For instance, given that purchasing paid $6.00 per unit for a product in the past, but the supplier has now quoted a price of $7 per unit. If the purchaser negotiates a price of $7 per unit, then she or he has obtained a cost avoidance of $1 per unit, even though the price was still $1 higher than the previous price. However, often finance believes that cost-avoidance savings hardly display on a company’s income line.

9.6.3 Revenue Measures

The effects of purchasing and supply actions and strategies on revenues of the company are shown in revenue measures. For instance, supply and purchasing may uncover new technologies of supplier before others in the industry do and gain exclusive access, leading to new item applications with volume growth and favourable pricing.

Revenue growth is also connected with meeting new-product launching dates with perfect supplier performance, and allowing a first-to-market position with premium pricing. Perfect-launch revenue is crucial at several companies and is affected by performance of supplier.

Revenue measures for supply and purchasing are significantly important since they connect supply and purchasing strategies to the revenue factors of economic value-added. However, relatively few measures of revenue are being used. Obviously, companies have not entirely identified the contribution to revenue generation that supply and purchasing can make. This is the situation for direct products, where the connection of supply and purchasing strategy to revenues is less recognizable.

9.6.4 Revenue Measure Examples

- Contribution of supplier as a reason for new business, e.g. new business development, flexibility in shifting output service or product mix to meet higher revenue or profit, creating customer demand
- Revenues of royalty generated from supplier- or buyer-developed technology and patents originated by sourcing or purchasing
- Return on licensing technology driven by sourcing or purchasing
- Number of invention disclosure forms filed
- Value of free samples from suppliers
- Number of patents granted

9.7 Quality Measures

9.7.1 Parts per Million

This measure shows a supreme level of defects allowable for any specific assembly, service or product. It can be expressed by using one of the given specific definitions or could be the mean time between failures for an equipment or factory item. When applied to components, systems, assemblies or products the traditional metric has been parts per million not to meet the specification. As quality control has been enhanced and the capability to produce to tighter tolerances has been increased, this metric can also be tightened. In determining the “Parts per Million” result, it is necessary to measure (by factual testing, statistically reliable sampling or inspection) the incidence of nonconforming or defective parts. The measure requires a reference point, like receipt, production, shipment or incoming inspection. Additionally, measures of quality are also being created and used for services.

9.7.2 Field Failure Rates by Purchase Product and by Supplier

In many industries, this measure use to calculate satisfaction of customers. As a measure, it shows failures rate after sale and companies will have a tendency to aim for a zero incidence of such failures.

9.8 Delivery/Time/Responsiveness Measures

9.8.1 New Services/Products, Time-to-Market Targets

This measure is the amount of time (in months or weeks) from idea to first provision or shipment of a service or product to the external customer. This aims at continuous reduction of the amount of time it takes to accomplish break-even of investment and also at being first to market with the service or product.

9.8.2 On-Time Delivery

These measures show the extent to which suppliers are capable of fulfilling the requirements of customers. Main factors for such measures cover the following:

- Delivery windows
- Scheduled due dates or promised
- Acceptable late or early arrivals to due dates

Typically the metrics are calculated as the percentage of services, shipments or indivisible products late or on time. These measures may be applied in manufacturing or service businesses. Procurement and supplier performance can be measured through indices on the basis of the above measures.

9.8.3 Achieving New Product Launching

These measures show whether SCM, procurement, supplier and strategic processes are achieving necessary available volume objectives at milestones and at market launching dates for the service or product.

9.8.4 Cycle Time Minimization: Order Entry, Operations/ Manufacturing, Logistics and Distribution

Total cycle time and its main components should be recognized by these measures. Measures emphasize minimization through elimination of delays and also delivering continuous enhancement to target times. Examples include supplier production cycle times, internal operations, order entry, and transportation.

9.8.5 Responsiveness to Schedule Changes, and Service or Design Changes, Mix Changes

These measures show how speedily suppliers may respond to changes or demand, for instance, the ability to adjust schedule by 50% within 2 weeks of scheduled delivery. Another measure could be time to accomplish changes of design to allowable targets. These measures identify the need for flexibility.

9.9 Innovation Measures

9.9.1 Manufacturing Outputs of Latest Supplier Technology

This measure would be typically in connection with a contractual agreement whereby for latest technologies, a company may get insight some period of time before latest technology developments are shared with other companies. This can be a significantly important focus in dealings with selected main technology suppliers to the company. A particular metric can be the number of such agreements with main suppliers for innovative and new technologies.

9.9.2 Standardization

These measures emphasize achieving standardization of systems, services, components and application of presently used purchased products or the use of industry standard vs. unique products. Particular measures cover reduction of different products used, percentage of new services or products made up of presently purchased products, and number of industry-unique products utilized in a new service or product. These measures then would be established in a company for service-specific goals or product-specific goals.

9.10 Safety and Physical Environment Measures

Firms are tracking the accomplishment of safety, environmental goals and cost connected with compliance, both voluntary compliance and where legislation enforces compliance. This aims at driving performance enhancement to achieve regulatory goals or self-imposed goals.

9.10.1 Integrated SCM Measures

As an asset for a single company, the measurement of inventory may contain a number of aggregate or unit inventory measures such as those mentioned below:

- Dollar value of inventory investment
- Inventory turnover
- Months/weeks/days of inventory supply

This aims at minimizing cost of inventory through increasing the speed of throughput or minimizing carrying cost of inventory. A unique set of this measure is its application across inventory throughout many steps within a company's SC and, more essentially, across companies in the aggregate SC (external to one's company) with specified future targets.

Generally, it is also common to have measures that track the velocity or speed of inventory as it moves through different factors of the SC. This covers work in process and raw material, final products and inventory turns. The amount of inventory maintained as safety stock is also a common measure. The accuracy of computer records that are part of the inventory location system is also closely tracked.

9.11 Transportation Cost Minimization

The measures of transportation cover tracking actual costs of transportation against some pre-established objective, premium transportation, detention and demurrage.

Cost minimization measures emphasize the total costs of transportation incurred per planning period to conduct business and those premium transportation costs incurred where a nonstandard method of transportation to fulfil external and internal requirements are required in expediting, for instance, using air consignments when trucking is the preferred mode of shipping.

9.11.1 Customer Orders

How well a company is satisfying its commitment to customers (downstream) can be evaluated by these measures. Many measures consist of the percentage of non-time delivery, returned orders, warranty claims and total time from customer order to delivery. We have focused basically on purchasing and activities of upstream SC, but materials and purchasing planners are increasingly accountable for managing inventory from a total SC perspective. This can also consist of activities of downstream.

9.11.2 E-Transactions (Percentage and Number of Dollars/ Orders and Suppliers)

These measures indicate some extent of cross-company linkage. The magnitude of use of web-based systems or EDI (electronic data interchange) that connect suppliers and purchasers can, for instance, be measured by the:

- Percentage of suppliers
- Percentage of ASN (advance shipping notices)
- Absolute number of suppliers
- EFT (electronic fund transfers)
- Percentage and dollar value of orders
- Inventory throughout the SC (supply chain)
- Meeting customer requirements
- Others

9.11.3 Shared Schedules/Pull Systems/SMI (Supplier Managed Inventory)

These measures establish the percentage or the number of suppliers that are sharing schedules and operating in pull systems. They can also measure percentages of suppliers that are sharing schedules against those that would be. Supplier Managed Inventory measures establish the magnitude of inventory and the number of suppliers being managed by suppliers for which they have financial responsibility.

9.11.4 Efficiency and Administration Measures

Efficiency and administration measures are used in management to plan the procurement annual administrative budget and to help control expenses of administration during a period of budget. Budgeted expense products usually cover travel, meetings, training expenses and other expenses. Conventionally, salaries take the largest portion of budget. The two common methods to establish the budget are following:

9.11.5 Present Budget Plus Adjustment

The very common method of establishing a budget uses the present administrative budget as a beginning point. Depending on expected conditions of business or other departmental requirements, management then adjusts the budget for the next year downward or upward.

9.11.6 Control Ratio Budget

With the approach of a control ratio, the purchasing administrative budget is a percentage of another measure that reflects workload of purchasing. Planned dollar expenditure for DM (Direct Material) is often the selected workload measure.

The old control ratio as well as negotiation between top management and purchasing often determines the control ratio percentage used during calculation of the administrative budget. The administrative budget then is influenced by a projection of DM requirements of purchase for the next period. Workload of purchasing is assumed to be proportional to planned dollar expenditures for DM. The budget of purchasing administration becomes the following:

Purchasing Budget = Estimated Expenditures for DMs × Control Ratio

Managers of purchasing use the total budget figure to assign resources among different departmental uses. Management must define how many purchasers are needed, the size of the clerical support personnel, and other budget-related problems and issues.

9.11.7 Other Approaches of Budgets

Existing budget plus adjustment and control ratios are not the only techniques used to arrive at a purchasing administration efficiency or budget. The efficiency can also be measured by using workload of purchasing such as POs processed, line products processed and headcount. Once more, we must warn against highlighting efficiency of purchasing over effectiveness of purchasing as a strict KPI (key performance indicator).

9.12 Social and Governmental Measures

9.12.1 Internal Customer Satisfaction Measures

Firms are also using measures that show the extent of satisfaction with buying's value-add contribution. Typically internal customers do this and they are asked to show their satisfaction with buying by responding to a series of open-ended questions. Satisfaction of suppliers' measures and surveys are also used.

9.12.2 Measures of Suppliers' Performance

Supplier performance measurement is an area where several companies have made great improvements. Supplier scorecards regularly cover several of the measures discussed before. Generally buyers track supplier cost, delivery and quality along with other performance areas. Moreover, companies are starting to quantify the cost connected with supplier non-performance. The resulting cost figure denotes the total cost of doing business with a supplier. Total cost measures of supplier allow direct comparison between suppliers.

9.12.3 Strategic Performance Measures

Procurement needs measures that show its capability to support overall functional and corporate goals, which means a minimized emphasis on pure efficiency measures and a larger emphasis on measures of effectiveness. Examples of the latter contain tracking early involvement of supplier in the design of product, performance gains because of valuable suggestions of suppliers.

9.13 Developing a System of Performance Measurement and Evaluation

The development of a system of measurement and evaluation requires the leadership, commitment and support of top management, who must commit the financial resources necessary for system development. Management must also require all purchasing locations to use the same structure of system, which can minimize duplication of effort and save training and development costs. This does not mean that every location must use the same performance criteria or objectives, but that the system's primary design should be similar. Top management support would also send a message about the monitoring, tracking and seriousness in improvement of performance.

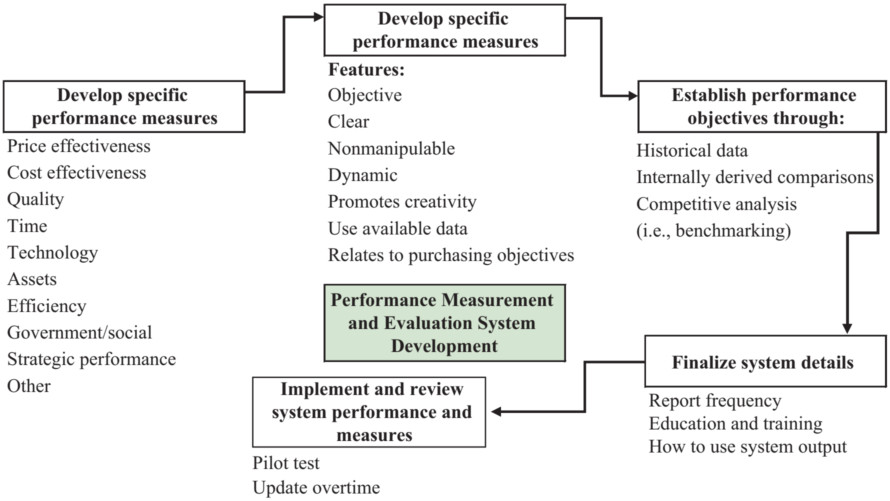


Fig. 9.2 Developing a purchasing and SC performance measurement and evaluation system

Development of an effective measurement and evaluation system follows a common sequence of activities. These cover defining which performance categories to measure, establishing performance standards for every measure, developing particular performance measures, finalizing details of the system, and reviewing and executing the system and every performance measure (see Fig. 9.2).

9.13.1 Determine which Performance Groups to Measure

The preceding section discussed many classes of performance measurement. The first stage of the development process requires recognizing measurement categories on which to focus. Also, a company can weigh its performance measures and classes differently.

During this period of system development, management does not concern itself with particular performance measures. The chosen performance classes must relate widely to organizational and SC and purchasing objectives and goals.

Choosing the performance measure classes is an important stage prior to developing particular performance measures.

9.13.2 Develop Particular Performance Measures

Developing particular performance measures starts once management recognizes the measurement classes it will emphasize. Certain features characterize successful SC and purchasing performance measures.

9.13.3 Objectivity

Every measure should be as objective as possible. Instead of qualitative assessments and feelings, the system of measurement should depend on quantitative data.

9.13.4 Clarity

Staff must understand a requirement of performance measure so as to direct performance towards the desirable outcome and remove misunderstanding and misconception. All members must be clear as to what every performance measure means, agree on the objectives of performance associated with the measure, and understand what it takes to achieve the measure. Well-understood measures are unambiguous and straightforward.

9.13.5 Use of Accurate Data

Well-defined measures use data that are accurate. If a measure requires data that are unreliable or difficult to generate, the probability of using the measure on a consistent basis declines. The cost of collecting and generating the required data should not outweigh the potential advantage of using the performance measure.

9.13.6 Creativity

A general misconception is that a system of performance evaluation should measure each possible activity. When this occurs, the measures can stifle individual creativity. The measures control behaviour so tightly that the system removes room for personal initiative. In a successful system, only what is significantly important will be measured while this system still promoting individual creativity and initiative, which can mean emphasizing five or six important, clearly explained measures instead of 25 vague measures.

9.13.7 Directly Associated to Organizational Goals

Figure 9.3 shows how corporate objectives/goals influence purchasing objectives/goals. Other functional objectives also may impact and influence purchasing. For example, goals of manufacturing can have a direct impact on purchasing because purchasing supports the process of manufacturing. To fulfil its objectives and goals, purchasing managers develop strategies and action plans. Finally, senior management develops measures that evaluate the performance or output from the activities needed to achieve purchasing's plans and strategies. The measures serve as indicators of purchasing's improvement.

9.13.8 Joint Participation

Joint participation means that the staffs responsible for every measure participate in establishing the measure's performance objective. Joint participation may go a long way towards getting the support of the staff responsible for achieving the measure.

9.13.9 Dynamic Over Time

A dynamic system is one that management reviews periodically to define whether existing measures still support objectives of purchasing and to determine whether performance objectives or standards require updating or whether there is a need for new measures.

9.13.10 Nonmanipulable

This measure is one of the results of which staff cannot inappropriately influence (i.e. the measure is cheat-proof). To be ideal, the individual(s) responsible for the measure should not be responsible for supplying the data to the reporting system, because it will be counted as an integrity and accountability problem. In fact, it should be a computerized system from receiving data till displaying performance.

9.13.11 Establish Performance Objectives

Establishing an objective for every performance measure is important. Objectives quantify the desired performance goal or target.

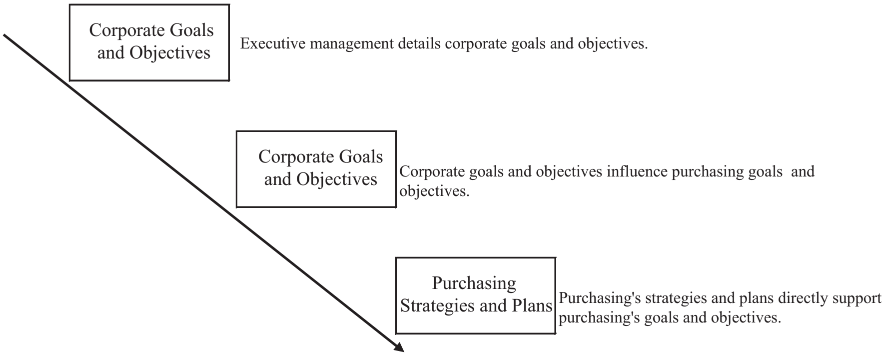


Fig. 9.3 Connecting purchasing measures and corporate objectives

Performance objectives or standards must be practical, which means the measure should be challenging yet achievable through a solid effort. Achieving a target should not be so easy that it needs small effort. While it should not be so difficult that it discourages staff from even attempting to achieve the goal. The actualities of a company's competitive environment must be reflected in the objective.

Usually companies use three methods when creating objectives:

1. Historical data
2. Internal comparison
3. External analysis

9.13.12 Historical Data

Past data about an activity are used as the basis in this technique for creating a performance objective. Usually historical performance is modified with a performance improvement element to arrive at a current objective. SC and purchasing management often use the historical approach with efficiency-related measures.

Some problems will occur due to relying on historical data. It is possible that past performance was less than optimal. By the establishment of an objective on the basis of suboptimal performance, even having an enhancement element, a company risks continuing suboptimal performance. Besides, historical data give no insight into the performance capabilities of rivals companies. Additionally, the company's strategies, and financial objectives will drive supply and purchasing goals. Without contributing to company success through objective accomplishment, purchasing cannot be a value contributor.

9.13.13 Internal Comparisons

A company can perform internal comparisons between business units. The best internal performance level can become the basis for a companywide performance objective. Companies with multiple business units often rank and compare performance internally across different performance classes.

This method, which provides some benefits over the historical approach, also has drawbacks. A company that emphasizes comparisons between internal units can lose sight of its external competition. Unhealthy competition can also develop between internal departments and business units. Moreover, it cannot be ensured that the best-performing internal unit matches the best-performing unit of a direct competitor.

9.13.14 External Analysis

This method involves examination of the performance objectives and practices of competitors or other leading companies. The benefit of this method is that it calls for an external evaluation at very specific levels of detail. The next part of this chapter discusses benchmarking as a competitive-analysis method for creating objectives of performance.

9.13.15 Finalize System Details

The management is required to consider issues in the next aspect of execution, such as the frequency of performance reporting, the training and education of system users, and the final determination of flow to use system outcome.

9.13.16 Performance-Reporting Frequency

A good system of measurement and evaluation gives regular reporting of performance outcomes. The actual reporting regularity may differ from measure to measure. What frequency supports the most effective use of every measure must be defined by management.

9.13.17 Training and Education

An organization must provide trainings to their suppliers and staff, how to use the system of measurement and evaluation. Every participant must know his or her responsibility and accountability.

9.13.18 Using System Output

Management uses the outcome of a performance measurement and evaluation system in many ways. Some supervisors comment on the output to directly evaluate the performance of purchasing suppliers and staff. Managers can use the system to trace the effectiveness of individual purchasers. System outcome can also recognize better-performing suppliers that deserve future contracts of purchase.

9.13.19 Execute and Review System Measures and System Performance

Every system has an execution stage, which may contain trial or pilot runs to ensure the system performs as planned. The system of measurement and evaluation, along with each performance measure, must be subject to periodic review. Having a system that includes inappropriate or obsolete measures can be more damaging than having no formal system at all.

9.14 Benchmarking of Performance: Comparing Against the Best

An ongoing method for establishing performance standards, measures, processes and objectives is benchmarking, a process that is not exclusively a SC or purchasing approach or practice *per se*. Rather, it is a method used by functional and corporate level managers and executives. Benchmarking has definite applications, however, when establishing SCM and purchasing performance objectives and action plans. Before discussing specific benchmarking applications, first an in-depth understanding of the process of benchmarking must be gained.

9.14.1 Benchmarking Overview

Benchmarking is the continuous measuring of services, activities, products, processes and practises against a company's best competitors. Formally, the process of activity or process of benchmarking requires measuring performance against that of best-in-class firms, determining how the best-in-class achieve their levels of performance, and using that information as the basis for establishing a firm's performance strategies, action plans and targets.

In benchmarking, comparisons against competitors are not always involved. Companies usually depend on comparisons with non-competitors as a source of information, especially when a process of benchmarking is common to companies across different industries such as SCM (supply chain management). Usually it is easier to obtain benchmarking information and data from a cooperative non-competitor.

9.14.2 Benchmarking Advantages

A firm hopes to gain advantage from actively pursuing performance benchmarking in many ways. The process of benchmarking helps recognize the best functional or business practices to include in a company's business plan, which can lead to performance enhancement. Benchmarking also can break down a reluctance to change. Senior managers start to see what it takes to maintain functional or corporate leadership by viewing the outside world. Benchmarking also can assist as a source of market intelligence. For instance, competitive benchmarking may find out a previously unidentified technological breakthrough. Eventually, valuable professional contacts between companies can result from the process of benchmarking.

9.15 The Benchmarking Process

Robert Camp noted that there are five different phases before a company fully receives advantages of the performance benchmarking process.

9.15.1 Planning

During this initial step of the benchmarking process, a company addresses issues such as which functions or products to benchmark, which firms to select as benchmarking targets (non-competitors, competitors), and how to recognize information. Benchmarking plans should emphasize methods and processes instead of simply quantitative performance results.

9.15.2 Analysis

Information and data collection and analysis occur during the second stage. A company must determine who and why the benchmarked company is better. A variety of questions should be asked:

- In what functional areas or product is the benchmarked firm better?
- Why is the benchmarked firm better?

- How large is the gap between the benchmarked firm's performance and our firm?
- Can we include the benchmarked firm's best practices directly in our plans of operating?
- Can we project future performance stages and rates of change?

This stage is important because it requires management to understand and interpret the benchmarked firm's methods, activities and processes.

9.15.3 Integration

Integration is the process of gaining and communicating acceptance of the benchmarking findings throughout a firm. During this stage, management starts to establish operational, functional and target goals based on the benchmark findings.

9.15.4 Action

The action stage requires translating the benchmark findings into detailed action plans. Clearly, actions during this stage include having staff directly responsible for carrying out the plans involved with formulation of the plans, developing a schedule for objectives over time and updating plans, and developing a reporting system to communicate progress towards benchmarking goals.

9.15.5 Maturity

A company reaches maturity when benchmarking becomes an accepted process for establishing performance objectives and plans. Another indicator of benchmarking maturity occurs when a company realizes continuous performance enhancement as a direct result of performance benchmarking.

9.15.6 Balanced Scorecard for Supply and Purchasing

The balanced scorecard was first presented by David P. Norton and Robert S. Kaplan in 1992. The original premise was that a total reliance on financial measures was leading companies to make poor decisions. Norton and Kaplan argued that companies must go beyond monetary (financial) measures, which are lagging indicators, and utilize measures that are leading indicators of performance.

They further recommended that the most suitable measures that would cause companies to do the right things would be those metrics that measure the strategy of the company, its processes, and functional activities.

According to Norton and Kaplan, the balanced scorecard covered four main connected performance measurement areas:

1. How do customers look at us? (customer satisfaction viewpoint)
2. What must we excel at? (operational excellence viewpoint)
3. Can we continue to enhance and create value? (innovation viewpoint)
4. How do we look to shareholders? (financial viewpoint)

Additionally, Norton and Kaplan stressed that measurement itself is not the objective. Measurement and particular metrics give clarity to general statements and strategy emphasis, around which to provide performance rewards and recognition.

The balanced scorecard and its related concepts have been adapted by numerous firms and applied to supply and purchasing.

Table 9.1 provides an example of balanced scorecard for supply and purchasing. Involved are measures related to the following questions:

1. How are we seen by shareholders?
2. How do our customers look at us?
3. What must we excel at?
4. What do we need to do to enhance business?

Table 9.1 Case example of strategic performance measures

Financial	Customer satisfaction
Revenue Revenue from suppliers based on process improvements Royalty revenue from patents *Cost* Cost for direct material, direct spend and capital spend Bill of material cost versus target Savings on direct materials used by contract manufacturers Administrative costs per headcount Maverick spend	*Internal* Number of plant shutdowns Single-source risk mitigation Internal stakeholder survey Factory quality incidents Supplier business continuity Tool performance On-time delivery Ramp-up readiness Percentage of spend with preferred suppliers *External* Customer quality incidents
Operational excellence	Innovation
Cost price enforcement Audit results and severity of errors Payment terms in contracts Most favoured customer clauses in contracts Not to exceed pricing in contracts Keeping pricing current in ERP database Strategic sourcing plans in place	*New-product development* Performance versus data milestones in the new-product innovation (NPI) process Current estimated cost against target in NPI process NPI process Cost savings initiated by purchasing/supply in the NPI process *People development* Training hours Leadership development pipeline Employee morale

Based on the firm's supply and purchasing strategies, the balanced scorecard would then be linked to a particular set of suitable performance measurements. The result would be a scorecard by people or department with specific KPI (key performance indicators).

9.16 Measurement and Evaluation Characteristics: A Summary

A review of supply chain and purchasing performance and systems of measurement supports many conclusions, which fall into two classes:

1. System characteristics
2. Human resource characteristics

9.16.1 System Characteristics

- Measurement is not free. A system of evaluation must compare the cost related with measurement against the advantages. Furthermore, increased measurement does not necessarily mean enhanced performance.
- Managers of supply chain and purchasing are better served by thoroughly understood and precisely defined measures.
- A system of effective management requires a database that gives reliable and consistent data. All staff must have access to the same data when reporting and calculating purchasing KPI (key performance indicators).
- Periodic review of the supply chain and purchasing measurement system should occur to remove unnecessary performance measures.
- It is very difficult to find a best way to measure performance. There is a difference between companies about performance measures and also between industries.
- Measurement-reporting requirements and content vary by level and position within the company. Careful planning helps to ensure effective use of the system at every organizational level.
- A single, overall productivity measure representing supply chain and purchasing performance is not feasible.
- Many industries are required to shift from operational measures to strategic measures evaluating a desirable end result (for instance, increase in participation by suppliers during new development of product).
- The plans and strategies used to create or produce a performance measure's results are possibly more important than the end performance result itself.
- An approach of balanced scorecard is an effective approach of evaluation and measurement of supply and purchasing.

9.16.2 HR Characteristics

- A system of measurement and evaluation is not an alternative for effective management. This system can be used to assist in the effective and efficient operation of the supply chain and purchasing function.
- An effective system is dependent on communication. Responsible staff must thoroughly understand its expectation of performance, the performance measure and the role of the measure during the process of performance assessment.
- Measures must strengthen positive behaviour and be positively connected to a company reward system. Dysfunctional, negative or beat-the-system behaviour may result if organization uses the measures exclusively as a means to recognize nonperforming individuals.

Discussion Questions

1. What are the types of benchmarking?
2. What are the safety and physical environment measures?
3. What is a purchasing performance measurement and evaluation system?
4. Why would a company want to measure performance of purchasing?
5. Which type of benchmarking is commonly used by the purchasing function?
6. Why would a company want to measure performance of suppliers?
7. What is the basic difference between efficiency and effectiveness measures?
8. When should a company focus on purchasing effectiveness and efficiency measures?
9. Discuss the basic difference between cost avoidance and cost-reduction measures.
10. What are the advantages of developing performance measures that focus on cost vs. purchase price?
11. Discuss the different use a manager has for supply chain and purchasing performance data.
12. What is required to establish a balanced scorecard to measure supply and purchasing performance?

References

Aramyan, L. H., Lansink, A. G. J. M. O., Vorst, J. G. A. J. V. D., & Kooten, O. V. (2007). Performance measurement in agri-food supply chains: A case study. *Supply Chain Management: An International Journal, 12*(4), 304–315.

Brettel, M., Strese, S., & Flatten, T. C. (2012). Improving the performance of business models with relationship marketing efforts—An entrepreneurial perspective. *European Management Journal, 30*(2), 85–98.

Chan, F. T. S. (2003). Performance measurement in a supply chain. *International Journal of Advanced Manufacturing Technology, 21*, 534–548.
Dickson, G. W. (1966). An analysis of vendor selection system and decisions. *Journal of Purchasing, 2*(1), 5–17.
Ellram, L. M. (1995). Total cost of ownership: an analysis approach for purchasing. *International Journal of Physical Distribution Logistics, 25*(8), 163–184.
Khan, S.A.R., Chen, J., Zhang, Y. (2018). Effect of green purchasing, green logistics, and ecological design on organizational performance: A path analysis using structural equation modeling. In L. C. Jain, X. Zhao, V. E. Balas, & F. Shi (Eds.), *Information Technology and Intelligent Transportation Systems: Vol. 314*. Frontiers in artificial intelligence and applications (pp. 183–190). Amsterdam, Netherlands. https://doi.org/10.3233/978-1-61499-939-3-183.
Khan, S. A. R., Chen, J., Zhang, Y., & Golpîra, H. (2019). Effect of green purchasing, green logistics, and ecological design on organizational performance: A path analysis using structural equation modeling. In L. C. Jain, X. Zhao, V. E. Balas, & F. Shi (Eds.), *Information Technology and Intelligent Transportation Systems* (Frontiers in artificial intelligence and applications) (Vol. 314, pp. 183–190). Amsterdam, Netherlands. https://doi.org/10.3233/978-1-61499-939-3-183.
Khan, S.A.R., Chen, J., Zhang, Y., and Golpîra, H. (2018). *Does ethical leadership really act as a positive role in sustainable supply chain management?* Proceedings of the 2018, 4th International Conference on Social Science and Higher Education (ICSSHE-2018), September-2018, ISBN: 978-94-6252-588-7, pp. 2352-5398. doi: https://doi.org/10.2991/icsshe-18.2018.133.
Khan, S.A.R., Golpîra, H., and Zhang, Y. (2018). *The importance of advanced information technology and green vehicles in supply chain management*. International Conference on Computer, Communications, and Mechatronics Engineering (CCME-2018), July. doi: https://doi.org/10.12783/dtcse/ccme2018/28629.
Khan, S. A. R., Jian, C., Yu, Z., Golpîra, H., & Kumar, A. (2019). Impact of green practices on Pakistani manufacturing firm performance: A path analysis using structural equation modeling. In H. Anandakumar, R. Arulmurugan, & C. Onn (Eds.), *Computational Intelligence and Sustainable Systems* (EAI/Springer innovations in communication and computing). Cham: Springer.
Khan, S. A. R., Yu, Z., & Qianli, D. (2019). Study on the supply chain integration: In the perspective of Pakistan. In H. Anandakumar, R. Arulmurugan, & C. Onn (Eds.), *Computational intelligence and sustainable systems* (EAI/Springer innovations in communication and computing). Cham: Springer.
Khan, S. A. R., Zhang, Y., Golpîra, H., & Arshian, S. (2019). The nexus between corporate social responsibility and corporate performance: An empirical evidence. *LogForum, 15*(2), 291–303.
Khan, S. A. R., & Yu, Z. (2019, March 25). Introductory chapter: Purchasing and supply management [Online First]. *IntechOpen*. https://doi.org/10.5772/intechopen.85380. Available from https://www.intechopen.com/online-first/introductory-chapter-purchasing-and-supply-management.
Neely, A., George, M., & Platts, K. (1995). Performance measurement system design. *International Journal of Operations & Production Management, 10*(5), 80–116.
Nydick, R. L., & Hill, R. P. (1992). Using the analytic hierarchy process to structure the supplier selection procedure. *International Journal of Purchasing and Materials Management, 28*(2), 31–36.
Patton, W. W. (1996). Use of human judgment models in industrial buyer's vendor selection decisions. *Industrial Marketing Management, 25*(2), 135–149.
Persson, F., & Olhager, J. (2002). Performance simulation of supply chain designs. *International Journal of Production Economics, 77*(3), 231–245.
Zhang, Y., Ma, T., Khan, S.A.R., Arshian, S. (2018). *The study on efficient cold chain logistics*. 2nd International Conference on Economic development and Education Management (ICEDEM-2018). doi: https://doi.org/10.2991/icedem-18.2018.117.

Chapter 10
Environmental and Ethical Issues in SCM

This chapter's basic purpose is to discover the relationship between the decisions of sourcing made within supply and purchasing and a number of impacts those decisions have on the earth, in the order of biophysical effects (for instance, water, soil and air pollution), economic effects (such as reduction in habitat) and ethical effects (such as the use of child labour). Conventionally speaking, within the office of purchasing, few considerations would have been given to such exotic and remote issues and problems. Unfortunately, today these problems more and more become real hurdles of the supply policymaker.

We will determine the reasons of that the professionals of purchasing should be concerned regarding the environmental part of SCM (supply chain management), describing such important concepts as sustainable development, environmental soundness and corporate social responsibility.

10.1 Purchasing Should Be Concerned

During 2000, as part of its investigative programme *Panorama,* an expose on SC in the industry of sports clothing was aired on the BBC. The programme televised scenes of children in a factory of Cambodia making goods for global brands, including The Gap and Nike. The episode was broadly discussed by many television anchors. Both firms' strategies of purchasing were immediately big news; both companies were immediately required to promises to remove such practices from their SCs so as to quell the adverse publicity with.

A couple of years later, Eric Schlosser (American journalist) published *Fast Food Nation* where Schlosser exposed abusive practices of labour in the factories processing potatoes and hamburgers working in United States restaurants. This book cites damage to US agriculture created by the massive commercial power of several large companies (seemingly in league with state and federal governments).

S. A. Rehman Khan, Z. Yu, *Strategic Supply Chain Management*, EAI/Springer Innovations in Communication and Computing,
https://doi.org/10.1007/978-3-030-15058-7_10

Additionally, various unsavoury and possibly dangerous ingredients in the food that people purchase were described in Schlosser's books.

Many large food firms criticized Schlosser, although they were not able to cite any particular fault in his damning book (Schlosser 2002: 276). This book was broadly studied/reviewed and conducted many TV shows on this books in the international media. The discussion of the relationship between fast food and obesity was fuelled by evidence given by Schlosser, driving a number of chains to minimize the offending menu items and also to introduce salads as substitutes to hamburgers.

In the United Kingdom, a program on child labour in the SC formulated by the retailer of High Street's Spencer and Marks has become a certain standard. In the industry of food, problems and matters such as the BSE (Bovine Spongiform Encephalopathy) crisis have led to strict laws and control of supply. It seems that the community have started to learn that their decisions of purchasing have a significant effect on the world.

Companies more and more measured their own environmental "footprints". A standard has emerged—first as BS7570 and then as ISO (International Organisation for Standardization) 14,000—as a reference for green and friendly environment practices. These standards of ISO have become broadly accepted by industry as a business "totem", much like the quality standard ISO 9000.

In several countries, companies face pressure from regulators and consumers for environment-friendly practices in their businesses. These pressures seem to appropriate a cyclical trend that is very closely associated with growth and economic prosperity. Even in the more *laissez-faire,* market-driven Anglo-Saxon economies, this trend is visible. According to Drumwright (1994), in the start of the 1990s in North America, 75% of consumers held that a firm's environmental practices would affect their decisions of purchasing; 80% would pay more for environment-friendly products. In 1994, a survey of public attitudes funded by the British Government, conducted by ENDS (Environmental Data Services Ltd), suggested the public deemed government should be addressing the concern for the environment that was the third on a list of the most critical problems, ranked just below unemployment and health but above crime, education and the economy in general. This survey also illustrated a dramatic shift of public opinion supporting a "Polluter Pays" principle, despite implementing such principle resulted in paying higher prices for services and products (62%). Further, 87% wanted more information from firms on the environmental impact of their goods, and 88% wanted better tagging to allow consumers to make more informed purchasing decisions. On the other hand, other studies have concluded that while during surveys, consumers claim these preferences, but on real fact and figure their buying behaviour/activities do not replicate these preferences. Ten years on, it is still very difficult to find any evidence that any consumers really will pay a "green premium". Nevertheless, it seems likely that choosing from two otherwise identical goods, final customers will purchase the more environmentally sound of the two.

Final consumers may not openly ask for ethically manufactured products, but Knight (1996: 65) holds that is their wish. When consumers unsure that products are not environmentally friendly, they would be dissatisfied/frustrated. As Knight says, disappointment is massively inferior to the goal of "customer satisfaction", not to mention "customer excitement or customer delight", which are the primary conditions to encourage repeat purchasing of services or goods.

Ethical and environmental issues are thus fundamentally connected to SCs. While these issues are manifested at one point in the supply chain—for instance, disposal of dangerous, toxic and hazardous chemicals—their root cause is usually located two or three tiers earlier in the supply chain. Therefore, a supervisor of supply's perspective must cover provision for potential issues or problems—and also opportunities—elsewhere in his organization's respective supply network. Strategies and policies must be formulated for that reason, to address many complicated problems. For instance, what do such terms mean as "environmentally sound", "green", "environmentally friendly", "corporate responsibility" and "sustainable development"? Even a brief encounter with the subject area discloses an amazing unclearness and significant vagueness/uncertainty.

10.2 Green, Sustainable and Environmental Soundness

The sustainability pressures that influence a business may come from the sources outside and inside the company. External sources contain requirements of industry (i.e. suppliers and customers), governmental bodies, local and internal NGOs and financial institutions (i.e. global, regional, national and local authorities and other organizations). While international pressures are significantly important, internal sources of pressure cover the marketing department's desires to green their respective company's image: the legal mandates of safety and health inspectors; the stewardship and fiduciary concerns of board of directors.

Developing green and environmentally friendly supply chain strategies and policies to address the connected market requirements, therefore, requires a clear understanding of each stakeholders' viewpoint. This should be fitted into a framework that may be used to guide the activities of the company. For the manager of supply and purchasing, the framework would act as the foundation for developing the company's green supply strategy.

Many MNCs (multinational firms) now publish reports on their "Corporate Social Responsibility" performance and also their policies—data that are taken into consideration by the investors. For determinations of focus, "Corporate Social Responsibility" can be seen as the endeavours of the company to accomplish green and ecological development. In defining sustainability as it applies to companies, "triple bottom line" is very common to speak of. This refers to a company's responsibilities in the areas of financial performance, social policy and environmental impact.

It may be noted that companies should not set goals for social policies development, since matters of policy are the responsibility of elected representatives in every region and country. On the other hand, buyers may have the expectation of

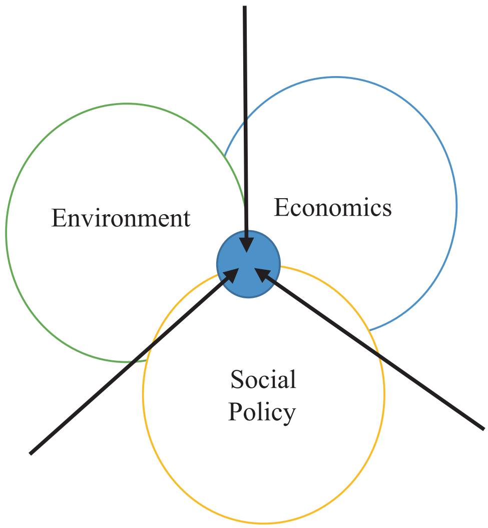


Fig. 10.1 The triple bottom line

political interference to prevent social impacts; it is compulsory to know the origins of components and raw materials and the impacts of their manufacturing and possibly take suitable strategic action.

For everyday decisions of sourcing materials or components, companies are required to develop strategies and policies for economic and environmental performance according to the agencies' and governments' definitions of what constitutes socially accepted performance and behaviour. As shown in Fig. 10.1 and according to Miller and Szekely (1995), the combination of the first two bottom lines (economics and environment) delivers a definition of "sustainability" that should be regarded as "a uninterrupted process with respect to refining performance of environment".

10.3 Supply Management's Environmental Contribution

For managers of supply and purchasing, "environmentally friendly" and "green" may be seen as the extent to which their activities comply with the requirement of framework their parent company has identified as its strategy and policy on the subject. This is an indirect point but one that should allow supervisors to create a suitable scope of responsibility. Using the framework of company, supply and purchasing strategists may express their own environmental and economic stances and plans to confirm they conform to company preferences and purposes.

A list of the supply manager's primary environmental considerations should include:

- An in-depth understanding of the pollution types linked with services and products being purchased

- A policy on environmental friendliness or soundness in supply and purchasing
- A strategy to remove the impact of sourcing decisions
- A complete plan for working with the threat connected with environmental performance

10.3.1 Understanding Pollution

The term pollution can be described as matter that is in the wrong location. Matter can neither be built nor destroyed—in simple words, it is covered from one form into another form. For instance, burning a paper does not destroy it; it turns it into billions of small atoms and particles. In the same way, using gas "scrubbers" to minimize sulphur dioxide from a smoke stack does not remove or reduce the problem; it only converts pollution in one form into air pollution, i.e. from gas form to liquid form. When the liquid is precipitated, it becomes an issue of solid waste. This is shown in Fig. 10.2. Of course, this is supply chain thinking—everything has an origin/source and endpoint. In economic orders, it is clear that pollution usually shows a form of waste (economic waste). According to Peter Jones (1996), it is estimated that in the United Kingdom, in orders of private consumption, companies pour six million tonnes of resources into the economy on a yearly basis and get 60 million tonnes output at the other end. It means, for every tonne used or consumed, there are nine tonnes of packing waste, and so on. According to the finding of Jones, 90% of everything a purchaser purchases is eventually likely to finish up as waste. Put this way, the extent of the issue or problem is clear. Khan and Dong (2017) highlighted that firms adopt green practices and renewable energy sources in their business operations due to some reasons, including regulatory authority and customers pressure, financial benefits and competitive advantage in terms of positive image and reputation. There is no doubt that environmental friendly practices and green design of products, green manufacturing, green purchasing and green transportation improve to the environmental sustainability and reduce to the harmful effects of industrialization. But on the other hand, governmental bodies also need to encourage these green projects through financial supports and subsidies.

10.4 Developing Policy on Environmental Soundness

It is very harsh to say that pollution is indicative of some business inefficiency representing that resources have been used ineffectively and inefficiently. It also requires additional cost, for instance, in dealing with dangerous and toxic materials, double handling of recycled goods, and conducting disposal activities, all of which add huge extra cost, but little value. Like defects, pollution usually reveals flaws in manufacturing processes and the design of products.

Traditional systems of costing have unnoticed these "external costs" as they cannot impact the activities of the company or business, and thus are not required to be attributed to the goods. As regulation changes (e.g. rights of consumers to return packaging to the producers, and landfill taxes), the external costs cease to be negligible and should be added into the products direct costs. In effect, the implications of supply chain of the goods must be well managed at the primary level of costing.

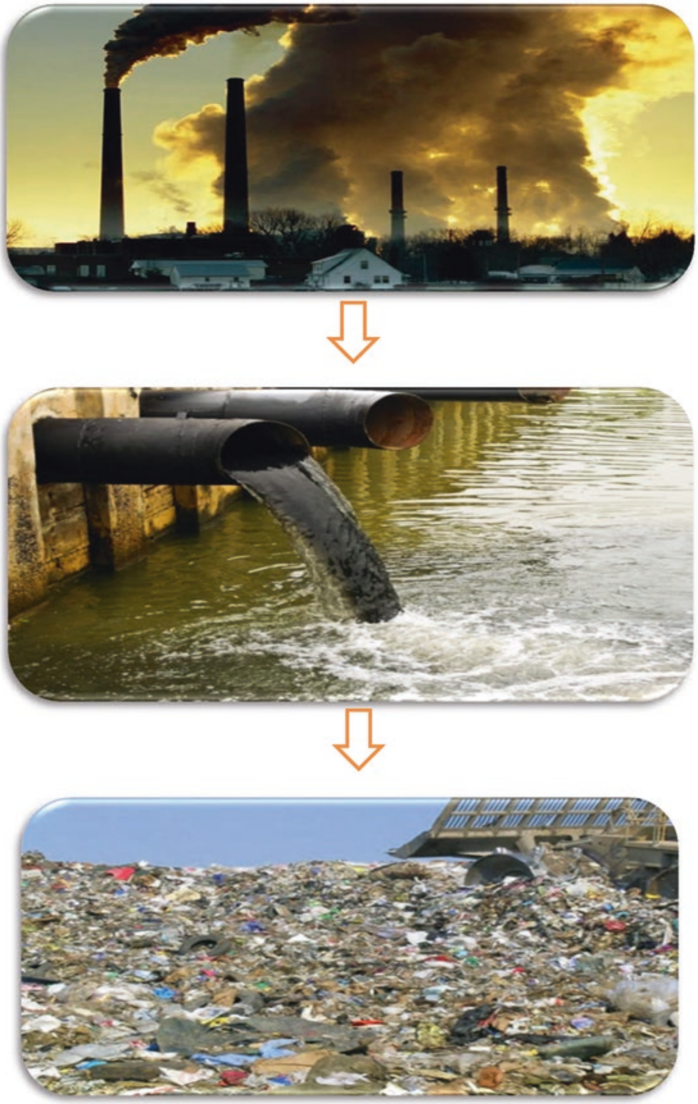


Fig. 10.2 Matter only converts in form

Khan and Dong (2017) shows another view on this problem. They highlight the huge costs related with executing sustainable technologies and the deficiency of any real monetary return. As an alternative they recommend that the company's objective should be to build a strategy that internalizes the external costs brought about by pressures of environmental regulations. To achieve this, supply chain managers should adopt a value approach, carrying out "trade-offs" between the costs of responding to environmental problems against the advantages. Khan et al. (2018) conducted an empirical study to explore the advantages of green practices and logistics operations. Their research results and evidence confirmed that green practices spur GDP per capita, industry and manufacturing value added, provide great opportunity of export to pro-environmental countries. In addition, renewable energy, biofuel is more economical than fossil fuel, which is a key factor of air and water pollution in the context of global supply chain.

Taking a view of process, and considering the network of supply (see Fig. 10.3), it may be argued that as a firm uses inputs from their suppliers to manufacture goods for its customers it pollutes the air, land and water. The management system is required to address every aspect of these phases, by translating requirements of customers towards suppliers, and by consolidating the many functions with other partners within the extended company (i.e. customers and vendors, where suitable) to well manage and control the inputs and outcomes. An environmental strategy of purchasing and supply might begin with putting information of the firms' situation onto such a map.

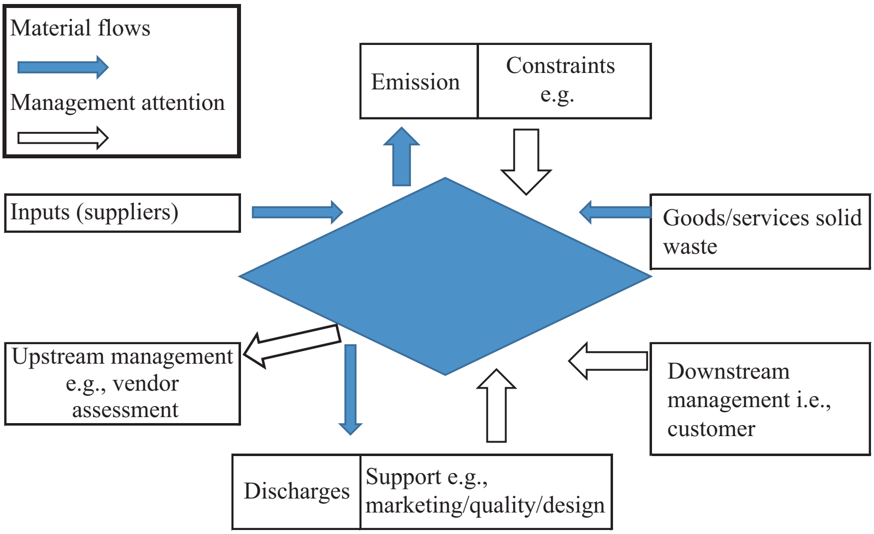


Fig. 10.3 A process view of business organizations. Source: Lamming and Hampson (1996)

This concept of environmental management fits well with the idea of "lean" if a company is seeking to manufacture products using lower levels of input (space, materials, time and labour) and avoid all procedures of waste. Under such circumstances, a company is likely to implement the ideologies or principles of environmentally sound supply easily: the removing of all costs incurred that do not increase value (competitive) to an item.

According to Warhurst (1994), secondary principles cover the utilization of space, minimization of waste, integration of quality control within the manufacturing process, and the reduction of inventories. Similarly (Lamming 1993a, b), principles can be applied to supply network and supply relationship in lean supply. If companies produce greater goods value from fewer or limited, then environmental management is an integral part of this—the use of limited natural resources should be a main objective of environmental strategies.

Instead of focusing on pollution control, hence, managers of purchasing and supply could encourage their suppliers to scrutinize the possibility for pollution avoidance, which is eventually related to enhanced productivity of resources, and also to an understanding of the opportunity costs of pollution. Recycling, in this situation, although commonly understood as a "sustainable/green" activity, deals with waste and pollution only after it has been manufactured. As one believes that all "waste" was once bought into the firm as an asset (or portion of one), it becomes advisable to try to reduce the amount of waste manufactured. Undeniably, it is very beneficial to deliberate a hierarchy of waste (Fig. 10.4), each of which gives opportunities to enhance product value and process efficiency:

- Increasing the life of that item.
- Minimizing total amount of resources used in the manufacturing.

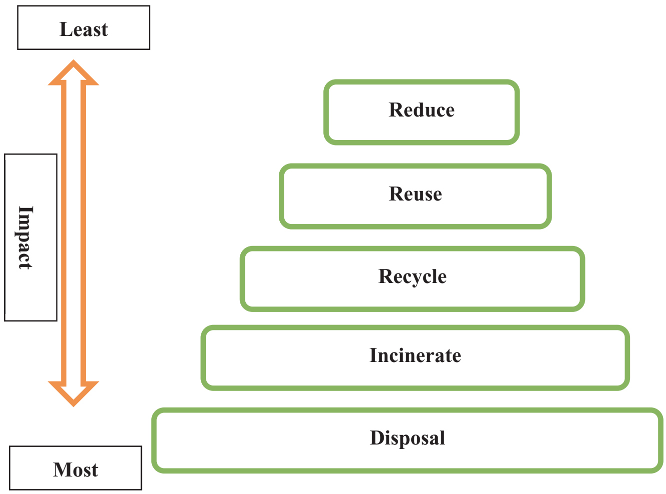


Fig. 10.4 The hierarchy of waste

- Minimizing unwanted side effects of the item throughout its life, including waste and pollution.
- Recycling, incineration with energy recovery at the end of a good's life cycle, instead of disposal to landfill. On this point it is very useful to make the distinction between open-loop and closed-loop SCs. The ideal closed-loop SC would be one in which all components and materials were recycled, or remanufactured without the addition of any new parts, components and materials. Even though whole closed-loops are hard to accomplish in practice, several firms are using reverse logistics to recover end-of-life goods, saving both environment and costs.

It is significantly crucial to retain a market concentration in dealing with environmental management. Conventionally, "environmentally friendly" goods or items have sold on the basis of what they do not comprise, as opposed to what they do. Commonly, this resulted in a loss of functionality of the product, i.e. "less from less approach". The approach of "more from less" can only be realized if the improved good or item sells in place of its less environmentally friendly/environmentally sound competitors. If it does not, the enhancement will have been made in ineffective/unsuccessful.

10.4.1 Strategy for Reducing Impacts

A primary objective of SC is to reduce the costs and also reduce the non-value-adding activities connected with each tier of the chain, however increasing the value added, with a basic focus on attaining revenue for the company from satisfying and fulfilling the requirements of consumers or end users. In environmental terms, there appears to be a clear connection between product stewardship and SCM (see Fig. 10.5). This idea shows that the extent of a firm's influence lies well beyond the traditional limitations of a company: it covers the environmental impacts of products downstream and upstream in the SC, from parts and components extraction to end-of-life disposal. For that reason, to understand the complete or whole impacts of goods throughout their life cycles, active firms need not only consider their own processes, but also those of their suppliers, distributors and all supply chain partners (Smart 1992).

Suppliers are required to be drawn into the environmental improvement process if a company is to make significant enhancements in the environmental performance of their processes and goods. Suppliers' own sourcing activities and decisions determine the nature of the inputs into a system and are also integral to the competitive survival of the company in the market.

In some respects, the "polluters pay" principle—a basic driver behind much legislation of environment—is a misnomer. According to Burt and Los (1995), if the polluter is not caught, then "society" pays, in terms of external costs. If the polluter is a contractor/vendor and is fined, then extra costs or additional costs may be passed along downstream to the consumer or end user, which is, in effect, paying for that

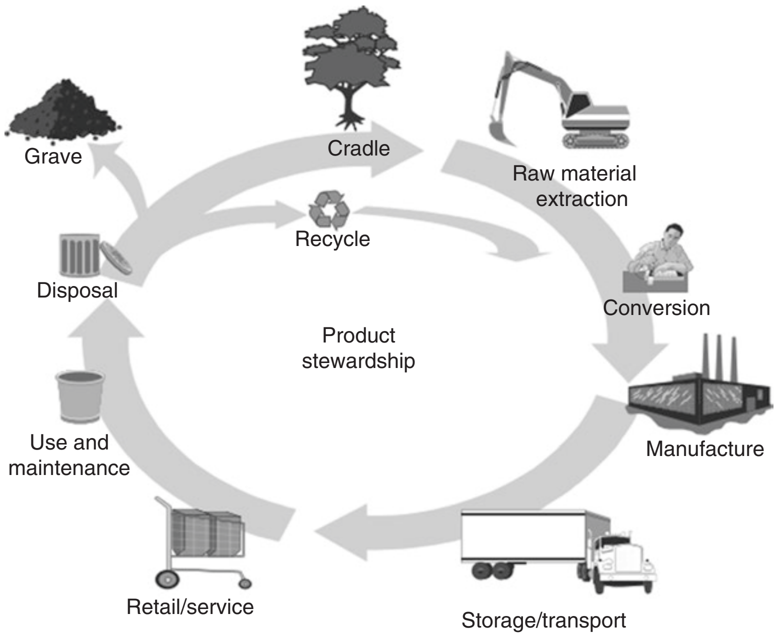


Fig. 10.5 The concept of product stewardship. Source: Lamming and Hampson (1996)

supplier's bad environmental management, i.e. purchasing at prices that reflect the cost of waste and manufacturing.

According to Burt and Los (1995), the significant challenge, then, is to urge suppliers to enhance their performance (environmental) at each tier of the SC, through executing the suitable features of the waste hierarchy at each tier. Some of the main areas to address in this process cover:

- Quality requirements
- Customer specification
- Interface waste due to long lead-time
- Post-consumption waste, not consumed through the consumer
- Progression to the next processing or production company in the value chain

With each of these, the objective should be to encourage a concept of non-stop improvement, without only pushing particular environmental issues back to the previous tier in the SC—therefore avoiding transference of the direct risk of financial punishments/fines, rather than pursuing an enhancement in the whole environmental performance of an item.

10.4.2 Risks for Supply Managers

Environmental problems pose many risks to supply managers. Understanding these risks, and working with them, is a critical challenge and/or assignment for the supervisor of supply and purchase who has to accomplish sustainable or environmental soundness. We outline many of the risks including:

- *Bought-in liability.* Consumers or users must be confident that the goods which they purchase into their own processes will not lead them to pollute once they are in use. This is associated to the duty of care principle, which states that any firm that manufactures a goods concerned with controlled waste (industrial or commercial) is responsible for its safe passage downstream through the SC.
- *Non-compliance with legislation.* Any non-compliance is likely to lead to firm financial punishment, penalties and fines, the risk of imprisonment for senior management, and potentially the loss of market place (goodwill). If suppliers are having issues with compliance, then it is likely that they are transferring these costs towards downstream.
- *Security of supply.* This is perhaps the main issue which the environment poses for supply and purchasing executives. Legislation will gradually restrict the availability of certain main items.
- *Loss of competitive positioning.* Main corporate and industrial customers are increasingly asking questions of their suppliers as regards environmental performance and, in some situations, how they assess environmental performance of their own suppliers. Those suppliers must answer these questions proactively and demonstrate improved cost effectiveness and resource efficiency.
- *Productivity.* Resources management, namely originating the optimum possible value from the minimum input, is becoming significantly important. Undeniably, with the growth in worldwide sourcing and the strength of competition, it is no longer sufficient to own or have access to resources—the important factor is how they are managed, to achieve the most out of them. The opportunity cost of not maximizing this objective, while competitors do so, can affect the cost performance of goods in their market place.

Developing a policy regarding environmental purchasing is therefore not about purchasing "green" products, with below average performance, to be socially responsible: it is about working to reduce a growing strategic business concern, simultaneously improving added value and minimizing costs.

10.5 Implementation Issues and Problems

There is a broad range of execution difficulties and issues that a Supply Strategist must study when thinking about ethical and environmental issues. We describe and discuss the main challenges to successful green supply management below.

10.5.1 Measuring Environmental Effectiveness

For green purchasing to be accomplished, it becomes compulsory to cultivate methods for measuring the function of purchasing on its performance in meeting these goals. As the nature of purchasing changes, that which constitutes good performance in purchasing must also be redefined.

A sustainable or green purchasing policy must be supported by credible measurements which reflect the objective of that policy; otherwise, it will become sidelined. There appear to be several firms that claim to have executed a green purchasing policy in their business activities, but on ground reality, it achieved little in terms of enhancements, because measurements have not been put in place against which purchasers may be assessed. For instance, it is meaningless to state that the firm will only purchase from vendors that can prove that they have made key steps towards addressing their environmental performance, if the usual measurement system simply assesses purchasing on the amount of savings made compared to the last period. In addressing these problems, the long-term competitive implications (such as quality improvements, continuity of supply, and total cost of ownership) with which improvements of the environment might be connected, need to be considered.

Firms may measure environmental performance on several stages such as the number of prosecutions or incidents faced by the firm over time, which many firms publish in their environmental performance reports. On the other hand, such measures can be deceptive; more sophisticated systems cover progress against corporate objectives, improvement and enhancement against waste tracking, environmental audit results, and develop an equilibrium between results-based measures and process.

10.5.2 Supplier Assessment

According to White (1996), life cycle inventory is potentially a tool which could allow buyer supervisors to build an "impact profile" for suppliers forming a baseline for assessing their future performance. A second technique, used by the British DIY retailer B&Q, is based on supplier management practices. The practices are translated and reviewed in purchaser appraisals and may ultimately affect their bonuses. Once a general profile of the main players in the supply base has been made, however, suitable actions need to be indicated for dealing with the information received: there is little point in investing time in setting up such an activity if plans for what to do with the facts, information do not exist.

A very useful exercise would be to analyse all of the supply sources, integrating environmental concerns with normal commercial analysis. An approach to this may be to create existing tools of supply chain to incorporate environmental considerations. For instance, Kraljic's supply positioning matrix accepts an approach of portfolio to the market, traditionally based on a categorization of items according to:

- The value added through product line, the percentage of bought products in total costs, and their impact on a firm's profitability
- The market complexity, depending on scarcity of supply, the pace of parts, components and materials replacement, technology, and oligopoly or monopoly conditions

This can be extended to add a "third dimension" for environmental costs in every industry (Fig. 10.6).

Using this matrix to consider an issue—with which most supply supervisors have been well familiar for many decades—would typically cover the capacity utilization and flexibility of supplier, the uniqueness of the goods, volumes bought and their expected future demand, quality history, organizational culture and levels of technology. The study of problems may well cause some suppliers to be positioned in distinctive areas of the grid, as per the strategic impact of the environmental issue.

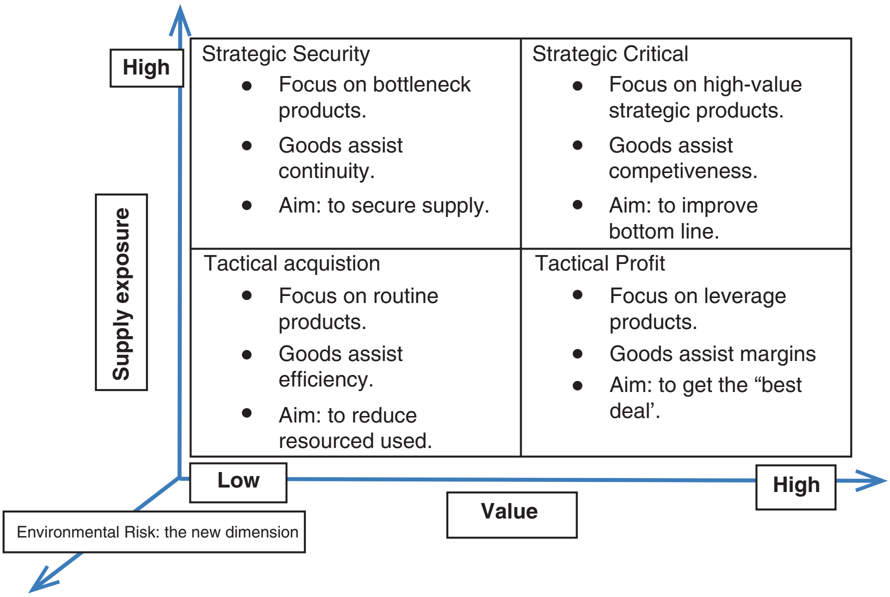


Fig. 10.6 Development of Kraljic's model to combine environmental concern

10.6 Senior Leadership Commitment

As with most initiatives of management, the need for a senior leadership figure—a "champion" to promote the cause, both within the company and to suppliers and customers, is significantly important and vital to the long-term success of pursuing green environment in SCs. According to ENDS (1995), it seems that this is not always the reason: in the 1990s, a study presented that although most United Kingdom environmental supervisors claim to have board-level approval for their work, 74% cite the lack of commitment of senior leadership as the main hurdle in their work. The problem also connects to the importance attached to those elements which are measured; the prominence of a top-level executive will support to convey the message that the initiative is significantly important to the firm, and worthy of senior leadership time.

Alignment between the environmental strategy of purchasing and supply and the overall environmental objectives of the firm is clearly important. Effective executives need the environmental objectives to be integrated with day-to-day activities, as part of overall performance of business, rather than as separate add-ons.

As with any project that introduces something new into working practices, it needs a change in attitudes; therefore it is critical for the manager of purchasing and supply to produce good results in a short period of time. In this way, credibility and general confidence in the project and the idea may be created. The way to do this is to recognize potentially successful pilot projects—small scale, with greater visibility, and well supported, to "harvest the low-hanging fruit". The practices of waste management offer several opportunities to eliminate costs simply through corrective action. As described above, poor and low product qualities that do not work are a waste of resources. In an early situation of this, enhancement processes applied by packaging engineers at Xerox to minimize the impact of product packaging and supplier allowed the firm to save 14 million dollars and avoid 10,000 tonnes of waste on a yearly basis (Smart 1992). One useful primary measure, as a portion of a waste audit, might be to compare the waste quantity produced by the firm with the buy-value of those wasted items (Biffa 1994). Not only would this highlight the cost savings potential of such initiatives internally, but also bring together disparate parts of the company, concentrating not just on the symptoms but also on the causes.

Once a suitable system of management and measurement has been developed and short-term enhancements have been realized, it is significantly important to use those results to communicate the performance to all supply chain partners or stakeholders, covering suppliers, based on their respective requirement for information (as opposed to what purchasing and supply managers think those supply chain partners or stakeholders want to know).

Discussion Questions

Q1. Why should purchasing be concerned about environmental soundness?
Q2. What is the concept of "triple bottom line"?
Q3. Describe a process view of the business organization.
Q4. Define the concept of product stewardship.
Q5. Explain and draw the waste hierarchy.
Q6. Discuss Kraljic's model and draw the figure.
Q7. Explain a couple of ways supply and purchasing management can make a contribution to environmental soundness.
Q8. Discuss many of the execution issues that are significantly important to "green supply".

References

Burt, D., & Los, R. (1995). A value chain approach to pollution avoidance. *Proceedings of the strategic supply management forum*, University of San Diego, September.

Drumwright, M. (1994). Socially responsible organizational buying: Environmental concern as a non-economic buying criterion. *Journal of Marking, 58*, 1–19.

ENDS. (1995). *Environmental managers call for greater support from the boardroom*. ENDS Report 241, Feb.

Jones, P. (1996). Producer responsibility and resource recovery from waste: The grave. In Lamming, R. C., Warhurst, A. C., & Hampson, J. P. (Eds.), *Purchasing and the environment: Problem or opportunity?*, Chartered Institute of Purchasing and Supply, Stamford, UK.

Khan, S. A. R., Chen, J., Zhang, Y., Golpîra, H., Kumar, A., & Arshian, S. (2019). Environmental, social and economic growth indicators spur logistics performance: From the perspective of South Asian Association for Regional Cooperation countries. *Journal of Cleaner Production, 214*(3), 1011–1023.

Khan, S. A. R., & Dong, Q. (2017). Impact of green supply chain management practices on firms' performance: An empirical study from the perspective of Pakistan. *Environmental Science and Pollution Research, 24*(20), 16829–16844.

Khan, S. A. R., Dong, Q., SongBo, W., Zaman, K., & Zhang, Y. (2017). Environmental logistics performance indicators affecting per capita income and sectoral growth: Evidence from a panel of selected global ranked logistics countries. *Environmental Science and Pollution Research, 24*(2), 1518–1531.

Khan, S. A. R., Dong, Q., Zhang, Y., & Khan, S. S. (2017). The impact of green supply chain on enterprise performance: In the perspective of China. *Journal of Advanced Manufacturing Systems, 16*(3), 263–273.

Khan, S. A. R., Yu, Z., & Qianli, D. (2019). Study on the supply chain integration: In the perspective of Pakistan. In H. Anandakumar, R. Arulmurugan, & C. Onn (Eds.), *Computational intelligence and sustainable systems* (EAI/Springer innovations in communication and computing). Cham: Springer.

Khan, S. A. R., Zaman, K., & Zhang, Y. (2016). The relationship between energy-resource depletion, climate change, health resources and the environmental Kuznets curve: Evidence from the panel of selected developed countries. *Renewable and Sustainable Energy Reviews, 62*(9), 468–477.

Khan, S. A. R., Zhang, Y., Anees, M., Golpîra, H., Lahmar, A., & Qianli, D. (2018). Green supply chain management, economic growth and environment: A GMM based evidence. *Journal of Cleaner Production, 185*, 588–599.
Khan, S. A. R., Zhang, Y., Golpîra, H., & Arshian, S. (2019). The nexus between corporate social responsibility and corporate performance: An empirical evidence. *LogForum, 15*(2), 291–303.
Khan, S. A. R. (2019). The nexus between carbon emissions, poverty, economic growth, and logistics operations-empirical evidence from Southeast Asian countries. *Environmental Science and Pollution Research*. https://doi.org/10.1007/s11356-019-04829-4.
Khan, S. A. R., & Yu, Z. (2019, March 25). Introductory chapter: Purchasing and supply management [Online First]. *IntechOpen*. https://doi.org/10.5772/intechopen.85380. Available from https://www.intechopen.com/online-first/introductory-chapter-purchasing-and-supply-management.
Knight, A. (1996). Driving continuous environmental improvement: The role of the retailer. In R. C. Lamming, A. C. Warhurst, & J. Hampson (Eds.), *The environment and purchasing: Problem or opportunity?* Stamford: Chartered Institute of Purchasing and Supply.
Lamming, R. (1993a). Beyond partnership: Strategies for innovation and lean supply. In *Hertfordshire*. Boston: Harvard University Press.
Lamming, R. C. (1993b). *Beyond partnership: Strategies for innovation and lean supply*. New York: Prentice Hall.
Lamming, R. C., & Hampson, J. P. (1996, March). The environment as a supply chain management issue. *British Journal of Management, 7*(Special Issue), 45–62.
Miller, J., & Szekely, F. (1995, September). What is green? *European Management Journal, 13*(3), 322–333.
Schlosser, E. (2002). *Fast food nation*. London: Penguin Books.
Smart, B. (1992). *Beyond compliance*. World Resource Institute, USA.
Warhurst, A. C. (1994). The limitations of environmental regulation in mining. In R. G. Eggert (Ed.), *Mining and the environment: Resources for the future* (pp. 133–172). Washington, DC.
White, P. (1996). Life cycle assessment: What can it tell the buyer? In R. C. Lamming, A. C. Warhurst, & J. Hampson (Eds.), *The environment and purchasing: Problem or opportunity?* Stamford: Chartered Institute of Purchasing and Supply.
Zhang, Y., Golpîra, H., & Khan, S. A. R. (2018). The impact of GSCM on manufacturing enterprise's performance. *Journal of Advanced Manufacturing Systems, 17*(4), 445–459.

Chapter 11
IT in Supply Chain Management

There is no doubt that information technology plays a vital role in businesses. Information technology allows quick and accurate handling and monitoring of vast amounts of data. In the last 50 years, technology has changed the way business is conducted. It has been referred to, with good cause, as the second industrial revolution. The ability to transfer real-time information between supply chain members or stakeholders via EDI (electronic data interchange) is being exploited by an increasing number of firms day by day. It is apparent that the beginning of mass access to the Internet has sparked off a boom in office-based or in-home shopping, to say nothing of the use of e-mail as a means of communication with business partners, colleagues and friends around the world.

In the SCM (supply chain management), the information system and connected hardware are used to fulfil different roles. They can help to monitor and control operations, decision-making, processes and to store data, create simulated systems, and aid communication among partners, firms and machines.

11.1 Basic Communication

11.1.1 EDI

Electronic data interchange has been described as system-to-system exchange of structured data for automatic processing. In the SCM, EDI is for exchanging significantly important information necessary for the effective operation of businesses. Usually, these structural links are setup among companies that have a long-term relationship of trading. For instance, a number of retailers will provide EPOS (electronic point of sale) data to suppliers, and it in turn triggers replenishment of the product sold. With this type of strong connection, suppliers will have the ability to build a historical pattern of sales that can support their own activities of demand

S. A. Rehman Khan, Z. Yu, *Strategic Supply Chain Management*, EAI/Springer Innovations in Communication and Computing,
https://doi.org/10.1007/978-3-030-15058-7_11

forecasting. Under this situation, electronic data interchange is advantageous. It is offering timely real-time information about its final customers' sales; it is very efficient and accurate because it does not require any human intervention to collect the information manually. Electronic data interchange is used to send standard information, like bills of lading, shipping details, invoices, confirmation of dispatch and any information that the connected companies agree to exchange.

UN/EDIFACT (United Nations / Electronic Data Interchange for Administration, Commerce and Transport) is the standard that ensures that information may be retrieved and sent in a suitable or appropriate format by trading companies.

The major benefits of using EDI are the following:

- Speed of transactions.
- Minimized error rate costs.
- Information is only required to enter the system (computer) once.

11.1.2 Barcodes

A barcode is the illustration of a code in a form appropriate for reading through computerized machines. The barcodes are broadly used through the SC to track and identify products at all tiers and stages in the process. Barcodes are a series of different width lines that can be presented in a vertical order, horizontal order, called ladder orientation, and called picket fence orientation.

For example, products received in DCs (distribution centres) or warehouses may be identified by the WMS (warehouse management system) and added to stock held in the warehouse. When stock is put away, the barcode is used to associate the location of storage with the barcoded stock, and on dispatch the stock record is adjusted/amended. The practice of utilizing barcodes can speed up operations. Problems and issues can occur if the label or tags of barcodes fall off during transit or barcodes are defaced.

11.1.3 Order Processing

Usually, customer order processing is not the primary or direct responsibility of a logistics staff. However, the results of order processing in terms of the construction of picking lists and the allocation of stock are significantly important.

Major developments have arisen in two particular areas. The first of these is the information now given by order takers. This covers the visibility of stock availability, which enables the order taker to recognize immediately whether or not stock can be supplied "off the shelf" to the customer. Also, the order taker is usually needed to provide the customer with an agreed date of delivery at the time the order is taken. It means that schedules of delivery must be reliable and clear. These developments help to enable a higher service to be offered to customers.

Second, there has been a rise in the ability to place orders directly by EDI (electronic data interchange). This has been extended in some cases to enable users/customers to have automatic access to status of their orders, so along with placing orders remotely through EDI they can then track their progress through the SC.

11.2 Supply Chain Planning

11.2.1 Company-Wide Information Systems

In the last couple of decades, a significantly important development for several firms has been the introduction of ERP (enterprise resource planning) systems. ERP systems are transaction-based information systems that are well integrated across the end-to-end business. Principally, ERP allows for data capture for the end-to-end business into a single computer package, which then offers a single source for all the main business information, including inventory and financials, customer orders.

Proprietary names, including Baan, Peoplesoft, SAP, and Edwards, feature strongly whenever these systems are discussed, and they are being used by a number of firms for benefit. It must be remembered that implementation or installation of some systems will entail widespread change within the firms and must not be entered into lightly. It will have implications in terms of organizational structure in addition to the way in which individuals work. It is not a question of simply computerizing a paper-based system but rather a matter of implementing a whole new system. This must take place while the rest of the company tries to keep the business operating. It must be thoroughly executed after being planned, which will require critically extra resources to accomplish a desirable output.

With these systems, many firms have benefited, while a number of firms have experienced issues and problems with their application. Commonly, these systems are not inexpensive to buy, need a lot of tailoring for each user firm, take a lot of expensive consultancy time to execute and a high extent of training for use at the operative level. It is a logical extension of the principles of SCM to have one overarching computerized system that enables the company and supports the planning of the end-to-end enterprise. Presently, systems of ERP do not do this. They require connection to suitable SCM and software of network strategy so that the relevant planning can be undertaken.

In the future these connected systems are likely to be commonplace. For today, apart from execution problems, it is compulsory to be aware that information technology is developing at such a speed that provision must be made for systems to be easily upgraded. Preferably, they should be "open" systems which are connected to customers and suppliers alike to ease the flow of information downstream and upstream within the SCs. Important provision must be made for recovery from disaster in the event of system failure because effectively all of a firm's eggs are placed in one basket.

11.2.2 Supply Chain Management

Very broadly, SCM systems are decision support and operational planning tools. They allow a firm to manage and plan its logistics operations by using an integrated system-wide package. With the help of some tools, the information including real-time forecasting and/or demand, connected to the capacities of manufacturing and run rates, inventory carrying levels and locations, supplier lead-times, etc., will be used to help determine the requirements of inventory and operational production.

These systems are dependent on the accuracy of data and real-time nature of the data that is fed into the system. They are usually transaction-based, similar to enterprise resource planning systems. They also depend on the suitable algorithms embedded in the system to arrive at useful solutions. Typical packages cover Numetrics, i2 and Manugistics. Such SCM software is now being associated much more directly with some of the main providers of ERP systems.

11.2.3 Network Strategy

A wide range of different strategic tools are included in the network strategy systems rather than operational decision-making tools. Common to this type of package is a depot location package, which is for optimizing the number of depots and location of depots within a firm's distribution network.

These systems enable data analysis using several algorithms to obtain an optimum solution for a particular case. For instance, the problem can be to establish the optimum location to make an item within a network of manufacturing sites which are spread across a wide geographic area. The systems will allow to analyse the costs of the sourcing components or raw materials, the availability of manufacturing capacity and costs, and costs of transport, to arrive at the optimum location.

11.3 Warehousing

11.3.1 WMS

WMS type computer systems monitor and control all the traditional activities of operations in the warehouse. The area usually covered are:

- Receipt of products
- Replenishment of picking locations
- Allocation of storage locations or recording of storage locations
- Order picking
- Manufacturing of picking lists or instructions
- Stock rotation
- Order assembly

A number of systems are used in conjunction with radio frequency communications equipment. This type of equipment can be fixed on forklifts. The WMS communicates through the radio frequency system, directing the activities of warehouse personnel.

For instance, when picking it will provide the tasks for the operative to carry out. Once the task is complete the operative updates the system and is directed to the next, which has the main benefit of updating stock-carrying in real time. There are also several sophisticated systems that control the operations of fully automated warehouses. This may include automated guided vehicles, automated retrieval and storage systems, and other devices that are relatively common in today's warehouse: carousels, sortation systems, conveyors, etc.

Nowadays many computer models have been generated to help with the planning of warehouse configuration and design. Generally, these are 3D simulation models that can provide a graphic, moving picture or image of the warehouse layout on the computer screen. They allow different configurations and configuration simulations, depending on varying requirements of demand, etc.

11.4 Inventory and Transport

11.4.1 Forecasting and Inventory Management Systems

The area of forecasting expected customer demand and the associated requirement of carrying inventory has been revolutionized by the use of customized computer packages. These packages comprise a number of different algorithms that enable the forecaster to use many techniques, including exponential smoothing, moving averages and regression analysis. These systems may be fed with information directly from inventory management systems and sales order processing to allow them to assess very quickly how customer demand is developing by individual SKU (stock keeping unit).

Systems of inventory management provide the ability to operate the day-to-day detailed management and control of stock within a firm. They are absolutely important for stock location and, in their ability, if used effectively, control of the stock levels within a system. These types of expertise enable companies to minimize inventory holding requirements, which enhances return on capital invested and improves stock turn. By the use of these systems, customer service is also maintained and the incidence of stock-outs is also minimized.

11.4.2 Vehicle Fleet Management

A vehicle fleet management system assists transport supervisors and managers in the task of monitoring the effectiveness of the companies' trucks, vehicle fleet. Information about vehicle activities will be collected, such as:

- Mileage travelled
- Vehicle details—type of body, age, axle configuration, gross vehicle weight and engine capacity

- Fuel used
- Idle time
- Maintenance details
- Details of deliveries made
- Driver details
- Tachograph detail and analysis

This information can be used to create KPIs (key performance indicators) for the vehicle fleet. These are probable to include:

- Truck utilization in terms of time in use and truck fill
- Miles per gallon
- Cost per mile
- Fuel costs
- Whole life cost of the vehicles
- Costs per tonne
- Maintenance costs
- Tyre costs
- Tonne per mile
- Average drop miles
- Average drop size

Latest heavy trucks, vehicles are well equipped with engines that are controlled through computerized engine management. This information can offer a great deal of detailed information regarding the activity of vehicles. Re-programming also can allow a number of these engine management systems to change the horsepower rating of the engine itself.

It is the plan of the EU (European Union) to introduce an electronic tachograph that will be fitted with a smart card rather than the existing system of recording drivers' activities on a wax-covered disk. One of the main benefits of this development is that it will enable the smart-card information to be downloaded into the fleet management system without any problems.

11.5 Other Applications

11.5.1 EPOS

Now, this technology has revolutionized the process of paying for products bought in most retail stores in the developed world. Equipment covers electronic scales readers, and electronic credit card readers. Products marked with a barcode are scanned through a reader, which the products' information will be obtained. It notes the product, records the transaction and also tallies the price of products. In some situations, EPOS (electronic point of sale) also triggers replenishment of the sold product.

That EPOS offers an instant record of transactions at the POS (point of sale) is its one main benefit. However, product replenishment can be coordinated in real time so as to ensure that stock-outs in the retail store are avoided. A second benefit of EPOS is that it has sped up the process of dealing with customers when many products are purchased. It also minimizes the chances of errors by being pre-programmed with the selling price.

11.5.2 General Application Packages

General application package development has given the business world applications at their fingertips that have enabled them to be far more flexible and self-sufficient. For instance, spreadsheets have enabled managers to use information in a way that is appropriate or suits their individual requirements. Packages of "word processing" enable personnel to produce documents and letters speedily. External and internal e-mail has facilitated fast communications among supply chain partners or companies around the world. Many of these applications, if not all, are virtually standard specifications for desktop computers.

These standard tools, along with electronic calculators and faxes, contribute to creating flexible, effective and efficient logistics operations.

11.5.3 Internet and E-Commerce

There is no doubt that, as companies and individuals become linked to the Internet, the possibilities for generating opportunities seem almost endless. On the other side, several challenges and hurdles have been created for the supply chain. For example, many consumers buy their products from home by using the Internet. Home shopping is also creating a need for small quantity deliveries. These products can have different types of characteristics, including ambient and frozen products. The shipment may very well be to a busy individual who is only at home before 8 o'clock a.m. or after 6 o'clock p.m. Consumers are likely to return unwanted products with a higher frequency rate. All of these issues and problems are not very new, as the domestic furniture delivery service knows. What is different is the scope and scale of home shopping that is being facilitated by use of the Internet. Specialist drivers with good interpersonal skills and vehicles will also need to be hired.

The recipe of small quantity deliveries, specialist small vehicles, limited time windows, poor vehicle utilization and returns adds up to an expensive mix. Systems of distribution are presently being developed to handle and manage this new phenomenon.

11.6 Integrating Supply Chain IT

How do all the factors of IT come together? SCM (supply chain management) is very complex, so it is very difficult to find a simple solution to the problems or issues we have raised. A number of firms do not believe it can be cost effective to introduce certain information technology innovations because they are not very sure of any visible ROI (Return on Investment). Trucking firms do not buy expensive technology for tracking systems because a couple of customers or clients actually want to receive such detailed information. And managers of warehouse do not invest in RF technology (radio frequency) because it is really not inexpensive.

The critical factor is to analyse what kind of contribution each component can make to the firm and then plan the investment as per the particular requirements of the organization and the industry demand. However, it should be noticed that the holistic or complete solution is normally greater than the arithmetic sum of the parts—that is, installation or implementation of a TMS (transportation management system) and a warehouse control system can do wonders for customer service performance.

Firms need to make decision on whether to agree to some industry conventions or to automate their firm's internal process—which sometimes takes place when investing in an ERP system from one of the main vendors (i.e. Baan, PeopleSoft, SAP). As more firms share information, including bills of material, requisition, order entry, and so forth and start joint planning, one can expect standard methods or approaches of sharing this information will decrease all SCM members' costs of doing business. In SCM, there has been no single standard emerged yet, as each Enterprise Resource Planning vendor continues to set its own de facto standards.

Because of the non-existence or lack of standards, it is expected that middleware in the shape of message brokers, the purpose of which is to mediate between different standards and systems, will be developed in the near future. Finally, standards of SC will become part of the basic systems that constitute the infrastructure.

In the upcoming sections, some significantly critical aspects of SC system integration will be reviewed. Firstly, we review Manugistics' Supply Chain Compass Model for evaluating a firm's phase of development in Information Technology for SCM. As a main vendor of SC systems, Manugistics helps customers/clients pinpoint their existing state of development and also points them towards goals for the future. In the second section, we will discuss execution of DSS and ERP.

11.6.1 Stages of Development

Manugistics has built a 5-stage business model called the SC Compass Model to evaluate a firm's development in the application of information technology for SCM. It is noticeable that at any point of time, different parts of a firm's business can be in different phases of development. The model describes the structure, IT and goals of a company in each phase. On the other hand, the Compass model is significantly useful in evaluating present development and identifying where other firms are heading and where future competitive benefits lie.

11.6.2 Phase 1: The Fundamentals: Emphasis on Quality

To produce dependable, quality, consistent goods at the lowest cost is the driving objective of the company in this phase. To achieve this objective, firms in phase 1 usually focus on automating current functions and tasks. The functioning of departments as independent units and systems reflects this structure. Tools of planning are chiefly spreadsheets.

11.6.3 Phase 2: Cross-Functional Teams: Assist Customers

Firms moving to Phase 2 focus on serving the customer, particularly emphasizing order fulfilment. In this phase, firms are starting to consolidate their SCs in some areas, including transportation and distribution into logistics, purchasing and manufacturing into operations, with the ultimate objective of better fulfilling customer demand. In this phase, IT is typically packages that offer functionality in certain areas. Planning is completed using point tools.

11.6.4 Phase 3: Integrated Enterprise: Drive Firm Efficiency

Firms in Phase 3 usually focus on efficiency. The driving goal for them is to be customer responsive, leveraging the ability to speedily deliver high quality services and products at the lowest cost. In this phase firms become highly responsive by investing in operational flexibility and also integrating their internal SCs, from the acquisition of components, raw materials to the delivery of goods to the customer. At this point, information technology is integrated with enterprise SC planning systems.

11.6.5 Phase 4: Extended SC: Create Market Value

As firms move towards Phase 4, creating market value becomes highly and significantly important. Firms execute a strategy of increasing market share by achieving “preferred partner” status with major customers. The driving objective is profitable growth, which they achieve through offering customer-tailored services, products and value-added information which create differentiation between firms and their competitors. Information technology is interoperable internally and with certain customers. Information of POS (point-of-sale) is employed in planning through tools of DSS (decision support system) and data warehouse.

11.6.6 Phase 5: Communities of Supply Chain: Be a Market Leader

This phase highlights market leadership. Firms consolidate into true SC communities whose partners share common objectives and goals across enterprises, using forward-looking technology such as the Internet. In Phase 5, firms are able to streamline business transactions with their members or partners to increase profit and growth. Information technology is fully networked with members outside the firm, which enables synchronized planning of SC.

Table 11.1 shows a comparison of the different phases of Information Technology development.

As we have discussed before, the ultimate objective is to standardize process across an industry so firms can cut, collaborate and also reduce their costs. The ability to interact with as varied business members as possible in e-commerce projects makes this objective attractive. On the other hand, many firms report that the success rate of an application like EDI (electronic data interchange) requires that a large number of customers and suppliers utilize the system, a "critical mass"; if not the expected cost savings cannot be accomplished and the whole system is not cost effective.

11.7 Implementation of DSS and ERP

Execution of a system that supports integration of SC includes DSS (decision support systems) and infrastructure. The system of ERP is usually part of the infrastructure and different in many aspects from the SC decision support systems. Table 11.2 compares DSS and ERP on the basis of various implementation issues.

Table 11.1 Manugistics supply chain compass

Phase	Name	Organization	Planning	IT	Goal/objective
1	Fundamentals	Independent departments	Spreadsheets	Automated -MRP and other applications	Cost and quality
2	Cross-functional teams	Consolidated operations	Point tools	Packaged -MRP 2	Customer service
3	Integrated enterprise	Integrated internal SC	Enterprise SC planning	Integrated ERP	Profitable customer responsiveness
4	Extended SC	Integrated external SC	POS SC planning	Interoperable customer management systems	Profitable growth
5	SC communities	Rapidly reconfigurable	Synchronized SC planning	Networked, network centric commerce	Market leadership

Table 11.2 DSS and ERP for supply chain management

Implementation issues	DSS	ERP
Length	6–12 months	18–48 months
Value	Strategic, tactical, operational	Operational
ROI (return on investment)	1 year payback	2–5 year payback
Users	Small group	All end users
Training	Complex	Simple

Table 11.3 Priorities when implementing decision support systems

Industry	Decision support systems (DSS)
Computer manufacturer	Demand and manufacturing
Apparel	Demand and distribution and capacity
Soft drink distributor	Network and transportation
Consumer products	Demand and distribution

It should be known what strategy a firm should use in the determination of what system to execute/install and when. The goals of information technology suggest that a firm first must implement an enterprise resource planning system so that the data will be complete and easily accessible. Only then can the firm begin analysis of its whole SC processing using many tools of DSS. This can be the idea, but in reality, the data are required to accomplish efficiencies of supply chain already existing—perhaps not in a single easy-to-access database—but it is worth the time it takes to assemble the database compared to the cost of waiting for implementation of the enterprise resource planning system.

These problems are shown in Table 11.2. The length of an enterprise resource planning execution compared to a typical decision support system is much longer. The ERP system's value to the firm covers the first two goals—single point of contact and visibility—and, while these can imply enhanced operations, decision support systems impact the ability to perform tactical planning and strategic planning as well. This means that decision support system projects have a much better return on investment (ROI). Lastly, installation of DSS is usually easier and less expensive to execute, and it affects a smaller number of highly trained clients compared with those of an enterprise resource planning system that has many users who need less extensive training.

The type of Decision Support Systems executed is dependent on the industry and the possible impact on the business. Table 11.3 covers some examples from many industries. In the industry of soft drinks, where distribution is a main cost element, priorities are different from those of a computer producer which has a complex process of manufacturing with many different components, materials or products and whose costs of distribution is only a fraction of item cost. On the other hand, in the latter situation, the producer can utilize expensive shipping solutions.

Discussion Questions

Q.1. How can information technology help to monitor and control operations?
Q.2. What is EDI? And what are the benefits?
Q.3. How can information technology play an effective role in warehousing?
Q.4. What is EPOS and how does it work?
Q.5. What is the role of IT in integrating Supply Chain?
Q.6. What is Manugistics' SC Compass Model?

References

Ambrose, E., Marshall, D., Fynes, B., & Lynch, D. (2008). Communication media selection in buyer-supplier relationships. *International Journal of Operations & Production Management, 28*(4), 360–379.

Attaran, M. (2007). RFID: An enabler of supply chain operations. *Supply Chain Management: An International Journal, 12*(4), 249–257.

Auramo, J., Kauremaa, J., & Tanskanen, K. (2005). Benefits of IT in supply chain management—An explorative study of progressive companies. *International Journal of Physical Distribution and Logistics Management, 35*(2), 82–100.

Auramo, J., Kauremaa, J., & Tanskanen, K. (2005). Benefits of IT in supply chain management—An explorative study of progressive companies. *International Journal of Physical Distribution and Logistics Management, 35*(2), 82–100.

Boyle, R. D. (2004, July/August). Achieving your supply chain goals: conquering the 'first mile' hurdle of data capture' APICS—The Performance Advantage, 14(7).

Brooks, F. D., & Davenport, T. H. (2004). Enterprise systems and the supply chain. *Journal of Enterprise Information Management, 17*(1), 8–19.

Chou, D. C., Tan, X., & Yen, D. C. (2004). Web technology and supply chain management. *Information Management & Computer Society, 12*(4), 338–349.

Jedermann, R., Ruiz-Garcia, L., & Lang, W. (2009). Spatial temperature profi ling by semi-passive RFID loggers for perishable food transportation. *Computers and Electronics in Agriculture, 65*, 145–154.

Khan, S. A. R., Dong, Q., & Zhang, Y. (2017). Role of ABC analysis in the process of efficient order fulfillment: Case study. *Advanced Engineering Forum, 23*(7), 114–121.

Khan, S.A.R., Golpîra, H., and Zhang, Y. (2018). *The importance of advanced information technology and green vehicles in supply chain management*. International Conference on Computer, Communications, and Mechatronics Engineering (CCME-2018), July. doi: https://doi.org/10.12783/dtcse/ccme2018/28629.

Laudon, K. C., & Laudon, J. P. (2000). *Management information systems: Organization and technology in the networked enterprises* (6th ed.). Upper Saddle River, NJ: Prentice-Hall.

Van De Vijver, E., Derudder, B., & Witlox, F. (2014). Exploring causality in trade and air passenger travel relationships: the case of Asia-Pacific, 1980–2010. *Journal of Transport Geography, 34*, 142–150.

Chapter 12
Future Trends in Supply Chain

In the comparatively short time that firms have been focusing on managing their end-to-end SC (supply chain), the world has changed dramatically. We have witnessed a key trend to globalized SCs, with activities that were once done in-house now outsourced, accompanied by a dramatic growth in volatility in the business environment, creating greater level of risk and disruption in supply and demand.

There can be some doubt that all these dramatic changes are only the precursor for the ever more seismic changes that possibly lie ahead. Because the SC development strategy has to be contingent on the circumstances prevailing in the global environment, it is more and more significantly important that managers of supply chain understand what the future landscape may look like. Usually, in the last couple of decades, companies have made decisions on their networks of SC based on the world as it then was. Those decisions, most times, led to a loss of flexibility and adaptability, which inhibited the ability of firms to change rapidly in response to changes in the business environment.

At the same time, we are unable to say with certainty what even the next couple of years will bring by way of change; there are few clear underlying trends which can give some sign of the backdrop to the future of SC.

12.1 Emerging Mega-Trends

There are several emerging trends that will affect the shape of SC in the upcoming future; perhaps the most important are those to do with changes in global consumer behaviours, spending patterns and demographics.

Several of these wealth and demographic redistribution changes are covered below:

- An expected increase in the population of the world from somewhere in the region of 7 billion today to 9 billion by the end of 2040. At the same time, age

S. A. Rehman Khan, Z. Yu, *Strategic Supply Chain Management*, EAI/Springer Innovations in Communication and Computing,
https://doi.org/10.1007/978-3-030-15058-7_12

profiles are also changing differently across regions and countries, and this, combined with cross-border migration, means that some countries' populations will increase while others will decrease such as China, since last two decades, Chinese population are continuously increasing by decreasing trend, e.g. during 2018, Chinese government issued two baby policy, but according to the survey, Chinese people are not willing to make second baby. As a consequence, consumers' behaviour and spending patterns are likely to change, because some markets are expected to decline and others to expand.

According to the report of the UN (United Nations), almost 50% of the world's population live in urban areas, and, by the end of 2050, almost 70% will be city dwellers. The increase in the number of megacities–defined as having a population of more than 10 million people—will continue as the move from rural areas to urban centres accelerates. The biggest challenge of serving these massive conurbations will be an increased focus on "logistics of city" with city-specific SC solutions.

- The trend of a redistribution of wealth from the Western and European region to the emerging economies will continue. For instance, it is calculated that over the next 20 years the United States' share of global wealth will decline by 23 to 27, but at the same time, the global market share of Asia will increase by more than 50% of the global economy by the end of 2040. The middle classes in the emerging economies are likely to increase from 400 million to over 1 billion by the end of 2040.

The combined impact of wealth and demographic distribution changes may well make current SC arrangements less than optimal. Businesses that have well-established supply and production arrangements designed to serve the "western-centric" demand patterns that prevailed in the past may be required to substantially reconfigure their networks of SC to benefit from the fast emerging markets of India, China, Pakistan and Brazil, for instance. To show the dramatic changes in worldwide spending power already apparent, it is also calculated that Asia accounts for around one-third of global retail sales, covering 40% and 45% of all cars and cell phones sales, respectively. Undeniably, China and India performance is outstanding in Asian region and have significant impact on global supply chain as both countries are fulfilling worldwide consumer needs. These both countries have billions of customers around the globe, particularly western, Asian and African regions. If supply disruption occurs in any one of these countries, rest of world will suffer badly.

During 2013, the Chinese chairman Mr. Xi Jinping paid a visit to Kazakhstan and Indonesia and proposed the "One-Belt-One-Road" project in his speech. The counterpart calls the initiative "a bid to improve economic growth and regional connectivity". The project will connect 64 European, Asian and African countries around the globe by road and maritime. Undeniably, the project will increase dominance position of China in the continents and enhance cooperation between countries, and trade and economic growth of associated countries. On the other hand, it will also increase the risk in global supply chain and it will be a challenge for associated countries, how to mitigate supply chain disruption. Additionally, the geographical location, distribution points of supply of several materials, components and goods/commodities could change as traditional distribution points and sources may no longer be much feasible. For instance, it may be possible that due to global warming, climate change and environmental degradation the patterns of worldwide food manufacturing will modify quite radically. In other situations, the relative manufacturing costs and extracting basic commodities and raw materials could change dramatically between regions and states, making some traditional sources uneconomic.

12.2 Shifting Centres of Gravity

All SCs have a "centre of gravity" determined by the pull of supply and demand elements. The availability of components, raw materials and relative costs and the costs of moving them to the demand destination will determine where the optimal locations for distribution warehouses, factories/plants, and other activities of value-adding should be.

Due to uncertainties that surround the pattern of future supply and demand and the possible changes in input costs like energy, water and also other primary or basic commodities, it becomes imperative that any decisions to redesign SCs reflect the requirement to maximize flexibility. In an ideal world, the SC of the future will be capable of adapting rapidly to any shifts that can occur on both sides of supply and demand of the business.

If the present situations of unpredictability and turbulence continue, it may be that the optimal solutions of SC which served well in the past will no longer be suitable for the purpose. As we have mentioned before, there is mounting evidence that due to key changes in demographics and reallocation of wealth around the world, the "centre of gravity" in many Western and European markets will shift—causing a rethink of existing structures of SC.

The growing urbanization of society and shifting "centre of gravity" are trends that forward-thinking SC planners will already be factoring into their strategy. The rise of megacities shows a specific logistical challenge. Usually, these megacities population is more than many small countries and are often characterized by insufficient logistical infrastructure. In a number of Asian emerging economies like China, Pakistan, Bangladesh and India, the challenge of fulfilling requirements of massive markets with a broad range of items to satisfy and cater to a consumer with greater discretionary spending power will demand innovative solutions of logistics and transport. Zhang et al. (2018) conducted an empirical research on developed countries and highlighted the importance of logistics industry for better economic growth and trade. They found that mostly developed countries' economy is healthy and strong due to improved and modern logistical and trade-related infrastructure, because high quality logistics and transport-related infrastructure provide opportunities to investors and businessmen. On the other hand, Khan et al. (2018) conducted an empirical research on emerging economies and found that mostly Asian developing countries' logistical infrastructure is very poor due to several reasons, including poor political instability, corruption, lack of good governance, and terrorist attacks and bombing, which not only creating troubles in terms of long delays due to traffic congestion but also a cause of car accidents.

The use of logistics “platforms” located on the edge of megacities is likely to increase to allow the consolidation of consignments for delivery into those cities. This will be accompanied by an increasing number of collaborative arrangements among firms that will share distribution and/or logistics assets like DCs and transport.

While centralized offshore and manufacturing will still make sense for some categories of products, there will be a requirement to reduce the gap between supply and demand. This change in thinking will be driven through the growing environmental concern over pollution (CO2, greenhouse gas emissions, nitrogen emissions and carbon footprint) and, on the other hand, by cost considerations as costs of transport continue to rise. At some point in the upcoming future, no doubt, new forms of energy (renewable energy and biofuels) will become available massively which could reverse this trend. But that is likely to be some years away. Khan et al. (2017) conducted a research to investigate the relationship between logistics performance, economic growth, energy demand and environmental degradations. The results revealed that logistics industry improve and lift to economic growth of countries, while also a primary cause of air and water pollution, climate change and global warming, because logistics activities heavily based on fossil fuel and energy consumption. Khan and Dong (2017) highlighted that companies should adopt biofuels and renewable energy in their logistical and business operations. Because usage of renewable energy in logistical operations will improve environmental sustainability including air and water quality, and build positive image of firm, without any negative influence on financial performance of firms. In simple word, renewable energy/biofuels will work like “kill two enemies with single stone”.

As well as these wealth distribution and demographic changes, other trends are changing or reshaping the SC landscape. One new trend in particular is the development of new routes to market and the adoption by several firms of what has come to be termed “multi-channel” distribution.

12.3 The Multi-Channel Revolution

Spurred on by the arrival of the Internet, there has been a dramatic increase in recent years of the use of alternative distribution channels. While the old routes to market can still be used, they have been augmented through these new channels, which more usually than not bypass traditional intermediaries and also allow direct contact between the consumer/customer and the supplier.

For instance, now several firms offer their customers/consumers a wide range of choices for ordering and for delivery. A retailer might offer the traditional “bricks and mortar” outlets but also a phone ordering, online shopping/internet shopping, and the possibility of directly collect from the outlet or home delivery service. The challenge for logistics is to ensure firstly that the customer experience is consistent across all the channels, and then that the channels may complement each other to allow, whenever possible, the most efficient use of resources, e.g. single inventories and shared DCs.

In markets of consumers there is evidence that the Internet is revolutionizing both SCM (supply chain management) and marketing. According to several researchers, people under 26 are doing 50% of their shopping online, whereas the over 60s are doing less than 6% of their shopping through internet, due to unfamiliarity with technology and limited knowledge of computer. Undeniably, the internet shopping/online shopping volume are continuously increasing, while traditional shopping trend is decreasing.

One of the main benefits of having direct contact with consumers or final customers through internet/phone ordering is the perfection in visibility of real demand that it provides. For example, Alibaba (founded in 1999 by Jack Ma, a Chinese businessman) can see what its real item/product availability is because it is able to capture real demand or actual demand as it happens and is therefore able to measure on-the-shelf availability accurately. But in the business of bricks and mortar, even with sophisticated EPOS data, the firm may not get the same accuracy level of information.

From a perspective of SCM, the multi-channel revolution has many implications. Ideally, all channels should be served through the same infrastructure of logistics, e.g. sharing distribution assets like DCs, inventories and vehicles. If this can be achieved, then a big advantage can be attained through gaining incremental revenue greater than the additional cost.

Usually multi-channel operations imply a growth in home delivery, as many of these emerging channels are basically aimed at end users who need delivery to a particular address rather than collect the product(s) themselves. While a retailer (bricks and mortar) has the "last 50 metre challenge", i.e. how to manage the major cost of getting the product from the vehicle of delivery onto the shelf in the most cost-effective way, the online business/online retailer is concerned with the "last mile" costs. Because most home deliveries are for a single case equivalent or less, the issue is how to ensure that the delivery cost does not erode profitability. With the advent of agreed times of delivery and the use of dynamic vehicle scheduling and routing, this problem should minimize.

12.4 The Need for Adaptability

Clearly markets and SCs are always in a constant state of dynamic adapting and change; the evidence is that the rate of change has accelerated to the point where the models of business that have served well in the past may no longer work at all tomorrow.

We have moved from a business environment where the supplier held the power—often through ownership of resources, brands and technology—to a situation where the customer/consumer is now in the driver's seat. Where once it was a seller's market, now it is a buyer's market. Simultaneously, the prevailing marketing philosophy has moved from the idea of mass markets serviced by mass manufacturing to the idea of "market-of-one" serviced by mass customization.

The traditional SC business model was based around increasing efficiency, specifically through the exploitation of the "economies of scale". So factories were designed to manufacture products in large quantities to use the full capacity. This business model worked well in the conditions for which it was designed, e.g. the manufacturing of standard items designed for mass markets.

The problem now is that the context has changed. We have seen a move from the "Mass production and supplier driven" to "Mass customization and market driven", and yet several firms have not identified the implications of this shift for SC design. What is now needed are SCs that are far better able and more agile to cope with rapid change and also higher levels of variety and even customization.

12.5 Structural Flexibility

It has long been identified that flexibility in SCM and operations is a desirable attribute. Commonly, flexibility in this context has usually been explained in terms of the ability to respond quickly to demand changes in volume for existing items. This capability may be defined as *dynamic flexibility* and it is connected to ideas like use of FMS (flexible manufacturing systems) and setup time minimization. On the other hand, in the world we have described characterized by change which is discontinuous rather than incremental, a different type of flexibility is needed.

In effect, what is required is something we can term *structural flexibility*. Structural flexibility reflects the ability of the SC to reconfigure or adapt its architecture in response to main changes on the supply side or the demand side. SCs with high levels of structural flexibility are well able to cope with the levels of volatility that are a feature of the twenty-first century business environment.

Equally, when basic shifts in the SCs centre of gravity occur, structural flexibility is capable of rapid adaptation to fulfil the changed conditions.

What are the main enablers of structural flexibility?

Perhaps the most important enabler, but the one most complicated to achieve, is a corporate culture that is open to change and is comfortable with frequent changes to working practices and processes. Also, due to the need for collaborative cooperation across boundaries of organizations, there is required a willingness to actively create "win-win" partnerships across the SC.

Given that this cooperative approach to working across the extended enterprises can be achieved, the key factors that underpin structural flexibility cover:

- *Information Sharing*

The greater visibility in the supply chain cannot be achieved without proper information sharing between stakeholders. It is significantly important to be able to see the changes that are on the horizon of both downstream (supplier side) and upstream (customer side). There is no doubt that sharing of information provides a powerful platform on which to develop strong win-win collaborative relationships across the stakeholders of SC.

- *Access to Capacity*

A significantly important facilitator of adaptive SCM is the facility to access additional capacity when needed. Capacity here refers not only to production but also to warehousing and transport. Furthermore, that capacity cannot be owned entirely by the company in question; it must also come from partners across the network, 3PL (third party) or even competitors.

- *Access to Knowledge*

Given the rapid rate of change in both technologies and markets, a main challenge to companies today is ensuring that they have complete/full access to knowledge to achieve the potential for process innovation. Similarly critical is access to people who are capable of abusing that information and/or knowledge. Technology sharing agreements and open innovations are ideas that are quickly gaining ground. Once more, firms are gradually turning to external sources rather than internal sources of knowledge to provide adaptive capabilities.

- *Network Orchestration*

Because the achievement of higher levels of adaptability commonly requires inputs from a variety of other entities in the broader demand network or supply network, the need for coordination across the network arises. As SCs become more "virtual/cybernetic" than traditional supply chain, which stands on "vertical integration", there is a growing requirement for orchestration. Whether that orchestration job is done by the company or by external 3PL / 4PL firms, the ability to build suitable networks and to harmonize activities across the links and nodes of those networks is paramount.

There are several schools of thought regarding "future trends in supply chain". Some thoughts we have discussed before in this chapter and some we will discuss in upcoming sections.

12.6 Trends in Future SCM

Tom Linton, the chief supply chain officer at Flextronics, discusses "future SC trends, their impacts" as follows:

- *"Non-zero" SCs (Supply Chains) Win:* SCs focused on greater strong cooperation, collaboration and partnership among everyone in the ecosystem will win. This will result in entire SC solutions that will generate new value for consumers/customers.
- *Corporate Social Responsibility:* It will not be an option anymore; global environmental friendly policies, ecological plans and projects will expand, developing

country laws will catch up, and big giants in the markets such as Procter & Gamble, Unilever, and Exxon Chemicals will follow global norms.
- *Predictable Unpredictability:* Predictability will become a competitive benefit as SC breaks through barriers and hurdles to become more cost efficient, safer and faster.
- *Emergence of Control Towers:* As SCs become more cybernetic (limited or no plants), SC winners will have a worldwide footmark and be trustworthy, flexible and transparent.
- *Regional Sourcing and Local Sourcing:* These will expand, and supply ecosystems will develop as economies raise; "Made in United Kingdom" and "locally-sourced" will drive sourcing.
- *Skill Specialization:* New skills of SC will emerge, such as managing virtual SCs, different core supply chain certifications including CSCP (certified supply chain professional), MBA, and undergraduate programs becoming more specialized.
- *Scarcity of Raw Material:* This is driving innovation in materials, with firms replacing gold with cooper, cooper with aluminium, and steel with resin in certain situations; firms will also need to better manage conflict over rare minerals and earth metals.
- *Global Labour Costs Equalize:* Labour arbitrage is in decline and cost of labour in Mexico is attractive; however, India, China, Indonesia and Ukraine are more cost competitive.
- *Business Process Convergence*: Instead of automating inefficient processes, firms will remove them–e.g. replace inter-firm business documents such as POs (purchase orders) with sense-and-response systems; firms will more seamlessly integrate functions of inter-firm.
- *Cloud Computing:* Reliable cloud solutions and low costs for global SCs are beginning to emerge; "apps" will transform SCs.

12.7 2030 Vision

In this period of uncertainty any attempt to develop a situation or scenario of the upcoming future is very challenging. Nevertheless because there are already some observable indicators and trends it is possible to draw a picture of the difficulties and hurdles that lie ahead for SCM and also to suggest possible ways of meeting those challenges and hurdles.

Eco-efficiency, corporate social responsibility and sustainable considerations will drive several decisions of SC, as firms seek to minimize both their costs and also their use of limited funds/resources. These pressures will fast-track move away from the classic extensive, in future SCs which use less resources yet are more flexible and also better able to fulfil needs of foreign and local markets.

Already, new technology and thinking are revolutionizing production in several industries. An excellent example is given by the steel production. Today, the technology of steel-making is more and more based on the concept of “mini-mills”, which are more flexible consuming electric arc furnaces and iron’s scrap as raw material. As a result, these innovative mills can manufacture steel both with greater flexibility and with eco-efficiency.

One more developing technology that has significant potential to allow more “local-for-local” production is what is frequently termed “rapid production or manufacturing”.

12.8 Rapid Manufacturing

One of the fast emerging technologies that has the full potential to convert SCs is RM (Rapid Manufacturing)—also sometimes called additive fabrication or digital manufacturing.

The basis for this technology is that items are built up layer by layer using laser-fused metal powders for polymers. Thus, rather than machining or casting an injection moulding or metal item, this item is created from a series of very thin layers of material.

Although this technology has been used for a couple of years to allow the manufacturing of prototypes, it is only now that these tools and ideas have been applied to the fabrication of end-use goods. For example, Boeing has used “Rapid Manufacturing” technology to manufacture parts for military aircraft and also for the F18.

The implications of rapid manufacturing for SCM and logistics operations are considerable: first of all, rapid manufacturing technology can permit local-for-local production to be accomplished more economically; second, a much advanced level of item customization will be possible; third, there is no as such requirement for inventory of finished goods to be detained; and fourth, the use of energy, water, components and raw material waste is significantly to be reduced.

Discussion Questions

Q.1. What are the emerging mega-trends in supply chain management?
Q.2. What is structural flexibility? Discuss in detail.
Q.3. From the perspective of Tom Linton, what are the future trends in supply chains?
Q.4. Discuss the 2030 vision of supply chains.

References

Ambrose, E., Marshall, D., Fynes, B., & Lynch, D. (2008). Communication media selection in buyer-supplier relationships. *International Journal of Operations & Production Management, 28*(4), 360–379.

Khan, S. A. R. (2019). The nexus between carbon emissions, poverty, economic growth, and logistics operations-empirical evidence from Southeast Asian countries. *Environmental Science and Pollution Research*. https://doi.org/10.1007/s11356-019-04829-4.

Khan, S. A. R., Jian, C., Yu, Z., Golpîra, H., & Kumar, A. (2019). Impact of green practices on Pakistani manufacturing firm performance: A path analysis using structural equation modeling. In H. Anandakumar, R. Arulmurugan, & C. Onn (Eds.), *Computational intelligence and sustainable systems* (EAI/Springer innovations in communication and computing). Cham: Springer.

Khan, S.A.R., and Dong, Q. (2017). Impact of green supply chain management practices on firms' performance: an empirical study from the perspective of Pakistan. Environmental Science and Pollution Research, 24(20), 16829-16844.

Khan, S. A. R., Zhang, Y., Anees, M., Golpîra, H., Lahmar, A., & Dong, Q. (2018). Green supply chain management, economic growth and environment: A GMM based evidence. *Journal of Cleaner Production, 185*(6), 588–599.

Khan, S. A. R. (2018, November 5). Introductory Chapter: Introduction of Green Supply Chain Management [Online First]. *IntechOpen*. https://doi.org/10.5772/intechopen.81088. Available from https://www.intechopen.com/online-first/introductory-chapter-introduction-of-green-supply-chain-management.

Khan, S. A. R., & Yu, Z. (2019, March 25). Introductory chapter: Purchasing and supply management [Online First]. *IntechOpen*. https://doi.org/10.5772/intechopen.85380. Available from https://www.intechopen.com/online-first/introductory-chapter-purchasing-and-supply-management.

Nair, P. R. (2013). E-Supply chain management using software agents. *CSI Communications, 37*(4), 13–16.

Zhang, Y., Golpîra, H., & Khan, S. A. R. (2018). The relationship between green supply chain performance, energy demand, economic growth and environmental sustainability: An empirical evidence from developed countries. *LogForum Scientific Journal of Logistics, 14*(4), 479–494.

Chapter 13
Case Studies

13.1 Case 1: The Global Sourcing Wire Harness Decision

Sheila Austin, a buyer at Autolink, a Detroit-based producer of subassemblies for the automotive market, has sent out requests for quotations for a wiring harness to four prospective suppliers. Only two of the four suppliers indicated an interest in quoting the business: Original Wire (Auburn Hills, MI) and Happy Lucky Assemblies (HLA) of Guangdong Province, China. The estimated demand for the harnesses is 5000 units a month. Both suppliers will incur some costs to retool for this particular harness. The harnesses will be pre-packaged in 24 × 24 × 6-inch cartons. Each packaged unit weighs approximately 10 pounds.

13.1.1 Quote 1

The first quote received is from Original Wire. Auburn Hills is about 20 miles from Autolink's corporate headquarters, so the quote was delivered in person. When Sheila went down to the lobby, she was greeted by the sales agent and an engineering representative. After the quote was handed over, the sales agent noted that engineering would be happy to work closely with Autolink in developing the unit and would also be interested in future business that might involve finding ways to reduce costs. The sales agent also noted that they were hungry for business, as they were losing a lot of customers to companies from China. The quote included unit price, tooling and packaging. The quoted unit price does not include shipping costs. Original Wire requires no special warehousing of inventory, and daily deliveries from its manufacturing site directly to Autolink's assembly operations are possible.

S. A. Rehman Khan, Z. Yu, *Strategic Supply Chain Management*, EAI/Springer Innovations in Communication and Computing,
https://doi.org/10.1007/978-3-030-15058-7_13

Original Wire Quote:

- Unit price = $30
- Packing costs = $0.75 per unit
- Tooling = $,6000 one-time fixed charge
- Freight cost = $5.20 per hundred pounds

13.1.2 Quote 2

The second quote received is from Happy Lucky Assemblies of Guangdong Province, China. The supplier must pack the harnesses in a container and ship via inland transportation to the port of Shanghai in China, have the shipment transferred to a container ship, ship material to Seattle, and then have material transported inland to Detroit. The quoted unit price does not include international shipping costs, which the buyer will assume.

HLA Quote:

- Unit price = $19.50
- Shipping lead-time = 8 weeks
- Tooling = $3000

In addition to the supplier's quote, Sheila must consider additional costs and information before preparing a comparison of the Chinese supplier's quotation:

- Each monthly shipment requires three 40-foot containers.
- Packing costs for containerization = $2 per unit.
- Cost of inland transportation to port of export = $200 per container.
- Freight forward's fee = $100 per shipment (letter of credit, documentation, etc.).
- Cost of ocean transport = $4000 per container. This has risen significantly in recent years due to a shortage of ocean freight capacity.
- Marine insurance = $0.50 per $100 of shipment.
- US port handling charges = $1200 per container. This fee has also risen considerably this year, due to increased security. Ports have also been complaining that the charges may increase in the future.
- Customs duty = 5% of unit cost.
- Customs broker fees per shipment = $300.
- Transportation from Seattle to Detroit = $18.60 per hundred pounds.
- Need to warehouse at lead 4 weeks of inventory in Detroit at a warehousing cost of $1.00 per cubic foot per month, to compensate for lead-time uncertainty.

Sheila must also figure the costs associated with committing corporate capital for holding inventory. She has spoken to some accountants, who typically use a corporate cost of capital rate of 15%.

- Cost of hedging currency—Broker fees = $400 per shipment

- Additional administrative time due to international shipping = 4 hours per shipment X $25 per hour (estimated)
- At least two 5-day visits per year to travel to China to meet with supplier and provide updates on performance and shipping = $20,000 per year (estimated)

The additional costs associated with international purchasing are estimated but are nevertheless present. If Sheila does not assume these costs directly, then both suppliers have agreed to either pay them and invoice Sheila later, or build the costs into a revised unit price. Sheila feels that the US supplier is probably less expensive, even though it quoted a higher price. Sheila also knows that this is a standard technology that is unlikely to change during the next 3 years, but which could be a contract that extends multiple years out. There is also a lot of "hall talk" among the engineers on her floor about next-generation automotive electronics, which will completely eliminate the need for wire harnesses, which will be replaced by electronic components that are smaller, lighter and more reliable. She is unsure about how to calculate the total costs for each option, and she is even more unsure about how to factor these other variables into the decision.

13.1.3 Assignment

1. Calculate the total cost per unit of purchasing from Original Wire.
2. Calculate the total cost per unit of purchasing from Happy Lucky Assemblies.
3. Based on the total cost per unit, which supplier should Sheila recommend?
4. Are there any other issues besides cost that Sheila should evaluate?
5. Based on this case, do you think international purchasing is more or less complex than domestic purchasing? Why? Is it worth the additional effort?

13.2 Case 2: Negotiation—Porto

Due to competitive pressures, firms in the computer industry are constantly looking to reduce costs. Computer manufacturers compete fiercely for contracts based on meeting the technology, quality and price requirements of customers. Profit margins and return-on-investment targets are almost always under pressure. Dell computer recently saw its operation margins slip to a slim 7%.

Most computer manufacturers have programs designed to improve quality and reduce the costs associated with their products. One strategy that many producers use is to contract only with high-quality suppliers and develop longer-term buyer-seller relationships. One major computer company, Porto, also initiated a program requesting suppliers to continually improve productivity, which should lead to cost reductions.

The objective of the program was to reduce purchase costs over the foreseeable future. Porto also expects its suppliers to contribute cost-saving ideas whenever possible.

The high-technology industry features high fixed costs due to large investments in plant and equipment. These companies also commit large expenditures to research and development.

Porto currently has a requirement for an electronic component termed “New Prod”, which is part of a recently designed product. The estimated volume requirement of New Prod is 200,000 units with additional follow-on orders likely. For the New Prod component, Porto felt there were five to eight highly competitive suppliers capable of producing the item. These suppliers are located primarily along the East and West Coasts of the United States. After a request for quote and preliminary analysis, the buyer for Porto decided to pursue further discussions with Technotronics.

13.2.1 Negotiation Session Requirements

Each negotiator must plan and prepare before conducting the negotiation. The group leader has information packages for the buyer and the seller that provide additional information and assignments required for conducting the negotiation. Buyers and sellers can share as little or as much of the information with each other as they desire during the actual negotiation.

Your negotiation strategy should be developed prior to the negotiation session. If working in groups, all group members should participate in the research planning as well as the actual negotiation. Remember, price is not the only variable subject to negotiation. In highly volatile industries like the computer industry, for example, capacity guarantees from suppliers are often critical. Be creative when crafting your purchase agreement.

13.3 Case 3: Purchasing Ethics

13.3.1 Scenario 1

Bryan Janz was just arriving back from lunch when his office phone rang. It was his wife, Nina, calling from home. Nina told Bryan that FedEx had just delivered a package addressed to her. The package contained a beautiful clock, now sitting over the fireplace. In fact, Nina said, “The clock looks absolutely beautiful on our living room fireplace”. Thinking the clock was from a family member, Bryan asked who sent the present. She said she did not recognize the name—the clock was from Mr. James McEnroe. Bryan immediately told Nina that she had to repack the clock because it was from a supplier who had been trying to win business from Bryan’s company. They definitely could not accept the clock. Nina was very upset and responded that the clock was perfect for the room and, besides, the clock came to their home, not to Bryan's office. Because of Nina's attachment to the clock, Bryan was unsure about what to do.

13.3.2 Assignment

1. What should Bryan do about the clock?
2. What does the Institute of Supply Management (ISM) code of ethics say about accepting supplier favours and gifts?
3. Why do you think the supplier sent the clock to Bryan's home and addressed it to his wife?
4. Does the mere act of sending the clock to Bryan mean that Mr. McEnroe is an unethical salesperson?

13.3.3 Scenario 2

Lisa Jennings thought that at long last, her company, Assurance Technologies, was about to win a major contract from Sealgood Instruments. Sealgood, a maker of precision measuring instruments, was sourcing a large contract for component subassemblies. The contract that Assurance Technologies was bidding on was worth at least $2.4 million annually, a significant amount given Assurance's annual sales of $30 million. Her team had spent hundreds of hours preparing the quotation and felt they could meet Sealgood's requirements in quality, cost, delivery, part standardization and simplification. In fact, Lisa had never been more confident about a quote meeting the demanding requirements of a potential customer.

Troy Smyrna, the buyer at Sealgood Instruments responsible for awarding this contract, called Lisa and asked to meet with her at his office to discuss the specifics of the contract. When she arrived, Lisa soon realized that the conversation was not going exactly as she had expected. Troy informed Lisa that Assurance Technologies had indeed prepared a solid quotation for the contract. However, when he visited Assurance's facility earlier on a prequalifying visit, he was disturbed to see a significant amount of a competitor's product being used by Assurance. Troy explained his uneasiness with releasing part plans and designs to a company that clearly had involvement with a competitor. When Lisa asked what Assurance could do to minimize his uneasiness, Troy replied that he would be more comfortable if Assurance no longer used the competitor's equipment and used Sealgood's equipment instead. Lisa responded that this would mean replacing several hundred thousand dollars worth of equipment. Unfazed, Troy simply asked her whether or not she wanted the business. Lisa responded that she needed some time to think and that she would get back to Troy in a day or so.

13.3.4 Assignment

1. Do you think the buyer at Sealgood Instruments, Troy Smyrna, is practicing unethical behaviour? First, what is the term for this behaviour, and defend why you think it is ethical or unethical behaviour.
2. What should Lisa do in this situation? Formulate a response.

13.3.5 Scenario 3

Sharon Gillespie, a new buyer at Visionex, Inc., was reviewing quotations for a tooling contract submitted by four suppliers. She was evaluating the quotes based on price, target quality levels and delivery lead-time promises. As she was working, her manager, Dave Cox, entered her office. He asked how everything was progressing and if she needed any help. She mentioned she was reviewing quotations from suppliers for a tooling contract. Dave asked who the interested suppliers were and if she had made a decision. Sharon indicated that one supplier, Apex, appeared to fit exactly the requirements Visionex had specified in the proposal. Dave told her to keep up the good work.

Later that day Dave again visited Sharon's office. He stated that he had done some research on the suppliers and felt that another supplier, Micron, appeared to have the best track record with Visionex. He pointed out that Sharon's first choice was a new supplier to Visionex and there was some risk involved with that choice. Dave indicated that it would please him greatly if she selected Micron for the contract.

The next day Sharon was having lunch with another buyer, Mark Smith. She mentioned the conversation with Dave and said she honestly felt that Apex was best choice. When Mark asked Sharon who Dave preferred, she answered, "Micron". At that point Mark rolled his eyes and shook his head. Sharon asked what the body language was all about. Mark replied, "Look, I know you're new but you should know this. I heard last week that Dave's brother-in-law is a new owner of Micron. I was wondering how soon it would be before he started steering business to that company. He is not the straightest character". Sharon was shocked. After a few moments, she announced that her original choice was still the best selection. At that point Mark reminded Sharon that she was replacing a terminated buyer who had not gone along with one of Dave's previous preferred suppliers.

13.3.6 Assignment

1. What does the Institute of Supply Management code of ethics say about financial conflicts of interest?

2. Ethical decisions that affect a buyer's ethical perspective usually involve the organizational environment, cultural environment, personal environment and industry environment. Analyse this scenario using these four variables.
3. What should Sharon do in this situation?

13.4 Case 4: Insourcing/Outsourcing: The FlexCon Piston Decision

This case addresses many issues that affect insourcing/outsourcing decisions. A complex and important topic facing businesses today is whether to produce a component, assembly or service internally (insourcing) or purchase that same component, assembly or service from an external supplier (outsourcing).

Because of the important relationship between insourcing/outsourcing and competitiveness, organizations must consider many variables when considering an insourcing/outsourcing decision. This may include a detailed examination of a firm's competency and costs, along with quality, delivery, technology, responsiveness and continuous improvement requirements. Because of the critical nature of many insourcing/outsourcing decisions, cross-functional teams often assume responsibility for managing the decision-making process. A single functional group usually does not have the data, insight or knowledge required to make effective strategic insourcing/outsourcing decisions.

13.4.1 FlexCon's Insourcing/Outsourcing of Pistons

FlexCon, a $3 billion maker of small industrial engines, is undergoing a major internal review to decide where the company should focus its product development efforts and strategic investment. Executive management is arguing that too much capacity and talent are being committed to producing simple, commodity-type items that provide small differentiation within the marketplace. FlexCon concluded that in its attempts to preserve jobs, it has insourced parts that are easy to manufacture, while outsourcing those that are complex or challenging. Producing commodity-like components with mature technologies is adding little to what FlexCon's customers consider important. The company has become increasingly dependent on suppliers for critical components and subassemblies that make a major difference in the performance and cost of finished products.

Part of FlexCon's effort at redefining itself involves creating an understanding of insourcing/outsourcing among managers and employees. The company has sponsored workshops and presentations to convey executive management's vision and goals, including educating those who are directly involved in making detailed insourcing/outsourcing recommendations.

One presentation given by an expert in strategic sourcing focused on the changes in the marketplace that are encouraging outsourcing. The expert noted six key trends and changes that influence insourcing/outsourcing decisions:

1. *The pressure for cost reduction is served and will continue to increase.* Cost reduction pressures are forcing organizations to use their production resources more efficiently. A recent study found that over 70% of firms surveyed expect stable or increasing purchased material costs through 2010. As a result, executive management will increasingly rely on insourcing/outsourcing decisions as a way to manage costs.
2. *Firms are continuing to become more highly specialized in product and process technology,* which contributes to greater cost differentials between firms.
3. *Firms will be increasing focus on what they excel at while outsourcing areas of nonexpertise.* Some organizations are formally defining their core competencies to help guide the insourcing/outsourcing effort. This has affected decisions concerning what businesses a firm should engage in.
4. *The need for responsiveness in the marketplace is increasingly affecting insourcing/outsourcing decisions.* Shorter cycle times, for example, encourage greater outsourcing with less vertical integration. The time to develop a production capability or capacity may exceed the window available to enter a new market.
5. *Wall Street recognizes and rewards firms with higher ROI/ROA.* Because insourcing usually requires an assumption of fixed assets (and increased human capital), financial pressures are causing managers to closely examine sourcing decisions. Avoidance of fixed costs and assets is motivating many firms to rely on supplier assets.
6. *Improved computer simulation tools and forecasting software enable firms to perform insourcing/outsourcing comparisons with greater precision.* These tools allow the user to perform sensitivity analysis (what-if analysis) that permits comparison of different sourcing possibilities.

One topic that interested FlexCon managers was a discussion of how core competencies relate to outsourcing decisions. Flexcon management commonly accepted that a core competency was something the company "was good at". This view, however, is not correct. A core competency refers to skills, processes, or resources *that distinguish a company,* are hard to duplicate, and make that firm unique compared to other firms. Core competencies begin to define a firm's long run, strategic ability to build a dominant set of technologies or skills that enable it to adapt quickly to changing market opportunities. The presenter argued three key points related to the idea of core competence and its relationship to insourcing/outsourcing decisions:

1. A firm should concentrate internally on those components, assemblies, systems or services that are critical to the finished product and where the firm possesses a distinctive (i.e. unique) advantage valued by the customer.
2. Consider outsourcing components, assemblies, systems or services when suppliers have an advantage. Supplier advantages may occur because of economies of

scale, process-specific investment, high quality, familiarity with a technology or a favourable cost structure.

3. Recognize that once a firm outsources an item or service, it usually loses the ability to bring that production capability or technology in-house without committing a significant investment.

The manager or team responsible for making an insourcing/outsourcing decision must develop a true sense of what the core competency of the organization is and whether the product or service under consideration is an integral part of that core competency.

The workshops and presentations have given most participants a greater appreciation of the need to consider factors besides cost when assessing insourcing/outsourcing opportunities. One breakout work session focused exclusively on developing a list of the key factors that may affect the insourcing/outsourcing analysis at FlexCon, which appears in Table 13.4.1.

Table 13.4.1 Key factors supporting insourcing/outsourcing decisions

Factors support insourcing	Factors support outsourcing
1. Cost considerations favour the buyer. 2. A need or desire exists to integrate internal plant operations. 3. Excess plant capacity is available that can absorb fixed overhead. 4. A need exists to exert direct control over production and quality. 5. Product design secrecy is an important issue. 6. A lack of reliable suppliers characterizes the supply market. 7. Firm desires to maintain a stable workforce in a declining market. 8. Item or service is directly part of a firm's core competency, or links directly to the strategic plans of the organization. 9. Item or technology behind making the item is strategic to the firm. The item adds to the qualities customers consider important. 10. Union or other restrictions discourage or even prohibit outsourcing. 11. Outsourcing may create or encourage a new competitor.	1. Cost considerations favour the supplier. 2. Supplier has specialized research and know-how, which creates differentials in cost and quality. 3. Buying firm lacks the technical ability to build an item. 4. Buyer has small volume requirements. 5. Buying firm has capacity constrains while the seller does not. 6. Buyer does not want to add permanent workers. 7. Future volume requirements are uncertain—Buyer wants to transfer risk to the supplier. 8. Item or service is routine and available from many competitive sources. 9. Short cycle time requirements discourage new investment by the buyer—Using existing supplier assets is logical. 10. Adding capacity at the buyer requires high capital start-up costs. 11. Process technology is mature with minimal likelihood of providing a future competitive advantage to the purchaser.

13.4.2 The Piston Insourcing/Outsourcing Decision

FlexCon is considering outsourcing production of all pistons that are part of the company's "R" series of engines. FlexCon has machined various versions of these pistons for as long as anyone at the company can remember. In fact, the company started 50 years ago as a producer of high-quality pistons. The company grew as customers requested that FlexCon produce a broader line of products. This outsourcing analysis has generated a great deal of interest and emotion among FlexCon engineers, managers and employees.

FlexCon produces pistons in three separate work cells, which differ according to the type of piston produced. Each cell has six numerically controlled machines in a U-shape layout, with a supervisor, a process engineer, a material handler and 12 employees assigned across the three cells. Employees, who are cross-trained to perform each job within their cell, work in teams of four. FlexCon experienced a 30% gain in quality and a 20% gain in productivity after shifting from a process layout, where equipment was grouped by similar capabilities, to work cells, where equipment was grouped to support a specific family of products. If FlexCon decides to outsource the pistons, the company will likely dedicate the floor space currently occupied by the work cells to a new product or expansion of an existing product. FlexCon will apply the work cell equipment for other applications, so the outsourcing analysis will not consider equipment write-offs beyond normal depreciation.

Although there are different opinions regarding outsourcing the pistons, FlexCon engineers agreed that the process technology used to produce this family of components is mature. Gaining future competitive advantages from new technology was probably not as great as other process applications within FlexCon's production process. This did not mean, however, that FlexCon could avoid making new investments in process technology if the pistons remained in-house, or that some level of process innovation is not possible.

Differences over outsourcing a component that is critical to the performance of FlexCon's final product threatens to affect the insourcing/outsourcing decision. One engineer threatened to quit if FlexCon outsourced a component that could "bring down" the entire engine in case of quality failure. He also maintained, "Our pistons are known in the industry as first-rate". Another engineer suggested that FlexCon's supply management group, if given support from the engineers, could adequately manage any risk of poor supplier quality. However, a third engineer noted, "Opportunistic suppliers will exploit FlexCon if given the chance—we've seen it before!" This engineer warned the group about suppliers "buying in" to the piston business only to coercively raise prices. Several experienced engineers voiced the opinion that they could not imagine FlexCon outsourcing a component that was responsible for making FlexCon the company it is today. Several newer members of the engineering group suggested they should wait until the outsourcing cost analysis was complete before rendering final judgment.

Management has created a cross-functional team composed of a process engineer, a cost analyst, a quality engineer, a procurement specialist, a supervisor and a machine cell employee to conduct the outsourcing analysis. A major issue confronting this team involves determining which internal costs to apply to the analysis. Including total variable costs is straightforward because these costs are readily identifiable and vary directly with production levels. Example of variable costs includes materials, direct labour and transportation.

The team is struggling with whether (or at what level) to include total factory and administrative costs (i.e. fixed costs and the fixed portion of semi-variable costs). Factory and administrative costs include utilities, indirect labour, process engineering support, depreciation, corporate office administration, maintenance and product design charges. Proper allocation of overhead is a difficult, and sometimes subjective, task. The assumptions the team makes about how to allocate total factory and operating costs can dramatically alter the results of analysis.

The aggregated volume for pistons over the next several years is critical to this analysis. Table 13.4.2 provides a monthly forecast of expected piston volumes over the next 2 years. Total forecasted volume is 300,000 units in Year 1 and 345,000 units in Year 2. The team arrived at the forecast by determining the forecast for FlexCon "R" series engines, which is an independent demand item. Pistons are a dependent demand item (i.e. dependent on the demand for the final product).

Although this is a long-term decision likely to extend beyond 10 years, the team has confidence in its projections (including supplier pricing) only through 2 years. Although maintaining piston production internally would require some level of process investment in Years 3 through 10, the team believes any projections past Year 2 contain too much uncertainty. (Conducting a net present value for expected savings from outsourcing, if they exist, is beyond the scope of this assignment).

Table 13.4.2 Aggregated 2-year piston demand

	Year 1 expected demand	Year 2 expected demand
January	30,000	34,000
February	30,000	34,000
March	30,000	34,000
April	27,000	31,000
May	25,000	28,000
June	25,000	28,000
July	23,000	27,000
August	21,000	25,000
September	22,000	25,000
October	23,000	27,000
November	23,000	27,000
December	21,000	25,000
Total	*300,000*	*345,000*

13.4.3 Insourcing Costs

The team has decided that a comprehensive total cost analysis should include all direct and indirect costs incurred to support piston production. FlexCon tracks its materials and labour by completing production worksheets for each job. The team collected data for the previous year, which revealed that the three work cells produced 288,369 pistons.

FlexCon machines the pistons from a semi-finished steel alloy purchased directly from a steel foundry. The foundry ships the alloy to FlexCon in 50 lb. blocks, which costs $195 per block. Each piston requires, on average, 1.1 lb. of semi-finished raw material for each finished piston. This figure includes scrap and waste.

The team expects the semi-finished raw material price to remain constant over the next 2 years. Although FlexCon expects greater piston volumes in Years 1 and 2 compared with current demand, the team does not believe additional material economies are available.

FlexCon spent $225,000 last year on other miscellaneous direct materials required to produce the pistons. The team expects to use this figure as a basis for calculating expected Year 1 and 2 costs for miscellaneous direct material requirements.

13.4.4 Direct Work Cell Labour

The direct labour staff in the three work cells worked a total of 27,000 hours last year. Total payroll for direct labour was $472,500, which includes overtime pay. The average direct labour rate is $17.50 per hour ($472,500/27,000 total hours = $17.50 per hour). As a rule of thumb, the team expects to add 40% to direct labour costs to account for benefits (health, dental, pension, etc.). The team also expects direct labour rates to increase 3% a year for the next 2 years. The team does not expect per-hour production rates to change significantly. The process is well established, and FlexCon has already captured any learning curve benefits.

Work cell employees are responsible for machine setup, so the team decided not to include machine setup as a separate cost category.

13.4.5 Indirect Work Cell Labour

FlexCon assigns a supervisor, material handler and engineer full-time to the three work cells. Last year, the supervisor earned $52,000, the material handler earned $37,000 and the engineer earned $63,000 in salary. Again, the team expects to apply an additional 40% to these figures to reflect fringe benefits. The team expects these salaries to increase 3% each year.

13.4.6 Factory Overhead and Administrative Costs

This category of costs is, without doubt, the most difficult category of costs to allocate. For example, should the team prorate part of the plant manager's salary to the piston work cells? One team member argued that these costs are present with or without piston production and, therefore, should not be part of the insourcing calculation. Another member maintained that factory overhead supports the factory, and the three work cells are a major part of the factory. Not including these costs would distort the insourcing calculation. She noted that the supplier is most assuredly considering these costs when quoting the piston contract. Another member suggested performing two analyses of insourcing costs. One would include factory overhead and administrative costs, and the other would exclude these costs.

The team divided the factory into six "zones" based on the functions performed throughout the plant. The piston work cells account for 25% of the factory's floor space, 28% of total direct labour hours, and 23% of plant volume. From this analysis, the team has decided to allocate 25% of the factory's overhead and administrative costs to piston work cells for the analysis that includes these costs. Table 13.4.3 presents relevant cost data for the previous year. The team expects these costs to increase 3% each year.

13.4.7 Preventive Maintenance Costs

FlexCon spent $40,250 on preventive maintenance activities on the 18 machines in the three cells last year and expects this to increase by 10% in each of the next 2 years (due to the increasing age of the equipment).

Table 13.4.3 Total factory overhead and administrative costs

Cost category	Previous year expense/costs
Administrative staff	$1,200,000
Staff engineering	$900,000
Taxes	$120,000
Utilities	$1,500,000
Insurance	$500,000
Plant maintenance	$800,000
Total	*$5,020,000*

13.4.8 Machine Repair Costs

An examination of maintenance work orders reveals that the 18 work cell machines, which are each 5 to 7 years old, required total unplanned repair expenses of $37,000 last year. The maintenance supervisor expects this figure to increase by 8% in Year 1 and 12% in Year 2 due to increasing age and volumes.

13.4.9 Ordering Costs

Although FlexCon produces pistons in-house, the company still incurs ordering costs for direct materials. The team estimates that each monthly order to the foundry and other suppliers costs FlexCon $1500 in direct and transaction-related costs.

13.4.10 Semi-finished Raw Material Inventory Carrying Costs

FlexCon typically materials 1 month of semi-finished raw material inventory as safety and buffer stock. The carrying charge assigned to this inventory is 18% annually.

13.4.11 Inbound Transportation

FlexCon receives a monthly shipment of semi-finished alloy that the work cells use to machine the pistons. Total transportation costs for the previous year amounted to $31,500 (which resulted in 288,369 pistons produced).

The team expects transportation charges for other direct materials used in production to be $0.01 per unit in Years 1 and 2 of the analysis.

13.4.12 Consumable Tooling Costs

The machines in the work cell are notorious for “going through tooling”. Given the consumable tooling costs incurred during the previous year, the team estimates additional tooling expenses of $56,000 in Year 1, and $65,000 in Year 2.

13.4.13 Depreciation

The team has decided to include in its cost calculation normal depreciation expenses for the 18 work cell machines. The depreciation expense for the equipment is $150,000 per year.

13.4.14 Finished Piston Carrying Costs

Because FlexCon coordinates the production of pistons with the production of “R” series engines, any inventory carrying charges for finished pistons are part of the cost of the finished engine and are not considered relevant to this calculation.

13.4.15 Opportunity Costs

The team recognizes that opportunities may exist for achieving a better return on the space and equipment committed to piston production. Unfortunately, the team does not know with any certainty what management’s plans may be for the floor space or equipment if FlexCon outsources piston production. The team is confident, however, that management will find a use for the space. If the facility no longer engages in piston production, then FlexCon must allocate fixed factory and overhead costs across a lower base of production. This will increase the average costs of the remaining items produced in the plant, possibly making them uncompetitive compared with external suppliers.

13.4.16 Outsourcing Costs

The following provides relevant information collected by the team as it relates to outsourcing the family of pistons to an external supplier. Although it is beyond the scope of this case, the team has already performed a rigorous assessment of the supply market and has reached consensus on the external supplier in the event the team recommends outsourcing. This was necessary to obtain reliable outsourcing cost data.

13.4.17 Unit Price

The most obvious cost in an outsourcing analysis is the unit price quoted by the supplier. In many respects, outsourcing is an exercise in supplier evaluation and selection. Insourcing/outsourcing requires the evaluation of several suppliers in depth—the internal supplier (FlexCon) and external suppliers (in the marketplace). The supplier that the team favours if FlexCon outsources the pistons quoted an average unit price of $12.20 per piston (recall that this outsourcing decision involves different piston part numbers). The team believes that negotiation will occur if FlexCon elects to outsource, perhaps resulting in a lower quoted price. Because the team does not yet know the final negotiated price, some members argued that several outsourcing analyses are required to reflect different possible unit prices. Quoted terms are 2/10, net 30. The supplier says it will maintain the negotiated price over the next 2 years.

13.4.18 Safety Stock Requirements

If the team decides to outsource, FlexCon will hold physical stock from the supplier equivalent to 1 month's average demand. This results in an inventory carrying charge, which the team must calculate and include in the total cost analysis. Although FlexCon likely will rely on or draw down safety stock levels during the next 2 years, for purposes of costing the inventory the team has decided not to estimate when this might occur. Inventory carrying charges include working capital committed to financing the inventory, plus charges for material handling, warehousing insurance and taxes, and risk of obsolescence and damage. FlexCon's inventory carrying charge is 18% annually.

13.4.19 Administrative Support Costs

FlexCon expects to commit the equivalent of one-third of a buyer's total time to supporting the commercial issues related to the outsourced family of pistons. The team estimated the buyer's salary at $54,000, with 40% for fringe benefits. The team expects the buyer's compensation to increase by 3% each year.

13.4.20 Ordering Costs

The team expects that FlexCon will order monthly, or 12 material releases a year. Unfortunately, suppliers in this industry have not been responsive to shipping on a just-in-time basis or using electronic data interchange. Although FlexCon would like to pursue a JIT purchasing model, the team feels that assuming lower volume shipments on a frequently scheduled basis is not appropriate. The company expects the supplier to deliver 1 month of inventory at the beginning of each month. The team estimates the cost to release and receive an order to be $1500 per order.

13.4.21 Quality-Related Costs

The team has decided to include quality-related costs in its outsourcing calculations. During the investigation of the supplier, a team member collected data on the process that would likely produce FlexCon's pistons. The team estimates that the supplier's defect level, based on process measurement data, will be 1500 ppm. FlexCon's quality assurance department estimates that each supplier defect will cost the company an average of $250 in non-conformance costs.

13.4.22 Inventory Carrying Charges

FlexCon must assume inventory carrying charges for pistons received at the start of each month and then consumed at a steady rate during the month. For purposes of calculating inventory-carrying costs for finished pistons provided by the supplier, the team expects to use the average inventory method. The formula for determining the average number of units in inventory each month is the following:

{(Beginning Inventory at the Start of Each Month + Ending Inventory at the End of Each Month)/2} × Carrying Cost per Month

For calculation purposes, the team assumes that ending inventory each month is zero units (excluding safety stock, which requires a separate calculation). The team expects production to use all the pistons received at the beginning of each month. The carrying charge applied to inventory on an annual basis is 14% of the unit value of the inventory. Appendixes 1 and 2 will help in the calculation of monthly carrying charges associated with holding supplier-provided piston inventory.

13.4.23 Transportation Charges

Although it is FlexCon's policy to have suppliers ship goods F.O.B. shipping point, the company does not accept title or ownership of goods until receipt at the buyer's dock. However, the company assumes all transportation-related charges. The team estimates that transportation charges for pistons will average $2100 per truckload, with 14 truckloads expected in Year 1 and 16 truckloads expected in Year 2. The outsourcing supplier is in the United States, which means the team does not have to consider additional costs related to international purchasing.

13.4.24 Tooling Charges

The supplier said that new tooling charges to satisfy FlexCon's production requirements would be $300,000. The team has decided to depreciate tooling charges over 2 years, or $150,000 per year.

Appendix 1: Year 1 Inventory Carrying Charges Outsourcing Option

	Beginning inventory	Ending inventory	Average inventory	Inventory carrying costs
January	30,000	0		$
February	30,000	0		$
March	30,000	0		$
April	27,000	0		$
May	25,000	0		$
June	25,000	0		$
July	23,000	0		$
August	21,000	0		$
September	22,000	0		$
October	23,000	0		$
November	23,000	0		$
December	21,000	0		$
			Total inventory carrying costs	

Appendix 2: Year 2 Inventory Carrying Charges Outsourcing Option

	Beginning inventory	Ending inventory	Average inventory	Inventory carrying costs
January	34,000	0		$
February	34,000	0		$
March	34,000	0		$
April	31,000	0		$
May	28,000	0		$

	Beginning inventory	Ending inventory	Average inventory	Inventory carrying costs
June	28,000	0		$
July	27,000	0		$
August	25,000	0		$
September	25,000	0		$
October	27,000	0		$
November	27,000	0		$
December	25,000	0		$
			Total inventory carrying costs	

Supplier Capacity The team has concluded that the supplier has available capacity to satisfy FlexCon's total piston requirements.

Appendix 3 provides a worksheet to help in the insourcing/outsourcing cost analysis.

Appendix 3: Insourcing/Outsourcing Cost Factors Worksheet

Insourcing cost per unit	Year 1	Year 2	Outsourcing cost per unit	Year 1	Year 2
Direct materials Semi-finished Other			Purchase cost		
Direct labour			Transportation		
Indirect labour			New tooling		
Factory overhead and administrative			Administrative support		
Preventive maintenance			Inventory carrying		
Machine repair			Safety stock		
Ordering			Quality-related costs		
Depreciation			Ordering		
Inventory carrying			Other costs		
Inbound transportation			*Total outsourcing costs per unit*		
Consumable tooling			Total savings (1)		
Other costs			Less: Taxes on savings (40%)		
Total insourcing cost per unit			*Net outsourcing savings*		

Total Savings = (Total Insourcing Costs − Total Outsourcing Costs) × (Total volume)
Note that the total savings could be negative if the analysis shows that outsourcing costs are greater than insourcing costs

Assignment

1. Perform a quantitative insourcing/outsourcing analysis using the data provided. What qualitative issues might affect your final decision? Identify any costs or issues that are not part of your analysis that might affect your decision. What is your recommendation regarding what FlexCon should do with its family of pistons? Support your arguments with evidence gathered during your analysis.
2. Assume your group decided to outsource the pistons to the external supplier. Identify a plan that would enable FlexCon to carry out this recommendation. Be as thorough as possible.
3. Discuss the primary reasons when and why insourcing/outsourcing decisions occur.
4. A major challenge with an insourcing/outsourcing analysis involves gathering reliable data. Discuss the various groups that should be involved when conducting an insourcing/outsourcing analysis such as the one presented in this case. What information can each of these groups provide?
5. Discuss the major issues associated with an insourcing/outsourcing analysis and decision.

Endnotes

The 14$ figure is less than the 18% figure applied to safety stock carrying charges. The supplier does not receive payment until at least 4 weeks after FlexCon receives the pistons. This makes FlexCon's working capital committed to financing production inventory somewhat less than the capital committed to financing safety stock.

Supply Chain Management Dictionary

These definitions are compiled by authors from different books, research papers, magazines, websites and authors' own experiences. The objective of these definitions is to make it easier for students to understand supply-chain-related terminologies.

S. A. Rehman Khan, Z. Yu, *Strategic Supply Chain Management*, EAI/Springer Innovations in Communication and Computing,
https://doi.org/10.1007/978-3-030-15058-7

A

Abandonment The decision of a carrier to give up or to discontinue service over a route. Railroads must seek ICC permission to abandon routes.

ABB *See Activity-Based Budgeting*

ABC *See Activity-Based Costing*

ABC Classification Classification of a group of items in decreasing order of annual dollar volume or other criteria. This array is then split into three classes called A, B and C. The A group represents 10–20% by number of items, and 50–70% by projected dollar volume. The next grouping, B, represents about 20% of the items and about 20% of the dollar volume. The C class contains 60–70% of the items, and represents about 10–30% of the dollar volume.

ABC Costing *See Activity-Based Costing*

ABC Inventory Control An inventory control approach based on the ABC volume or sales revenue classification of products (A items are highest volume or revenue, C—or perhaps D—are lowest-volume SKUs).

ABC Model In cost management, a representation of resource costs during a time period that are consumed through activities and traced to products, services, and customers or to any other object that creates a demand for the activity to be performed.

ABC System In cost management, a system that maintains financial and operating data on an organization's resources, activities, drivers, objects and measures. ABC models are created and maintained within this system.

ABI *See Automated Broker Interface.*

ABM *See Activity-Based Management*

Abnormal Demand Demand in any period that is outside the limits established by management policy. This demand may come from a new customer or from existing customers whose own demand is increasing or decreasing. Care must be taken in evaluating the nature of the demand: is it a volume change, is it a change in product mix, or is it related to the timing of the order? *Also see: Outlier*

ABP *See Activity-Based Planning*

Absorption Costing In cost management, an approach to inventory valuation in which variable costs and a portion of fixed costs are assigned to each unit of production. The fixed costs are usually allocated to units of output on the basis of direct labour hours, machine hours or material costs.

Acceptable Quality Level (AQL) In quality management, when a continuing series of lots is considered, AQL represents a quality level that, for the purposes of sampling inspection, is the limit of a satisfactory process average. *Also see: Acceptance Sampling*

Acceptable Sampling Plan In quality management, a specific plan that indicates the sampling sizes and the associated acceptance or non-acceptance criteria to be used. Also see: *Acceptance Sampling.*

Acceptance Number In quality management, (1) A number used in acceptance sampling as a cut-off at which the lot will be accepted or rejected. For example, if x or more units are bad within the sample, the lot will be rejected. (2) The value of the test statistic that divides all possible values into acceptance and rejection regions. *Also see: Acceptance Sampling*

Acceptance Sampling (1) The process of sampling a portion of goods for inspection rather than examining the entire lot. The entire lot may be accepted or rejected based on the sample even though the specific units in the lot are better or worse than the sample. There are two types: attributes sampling and variables sampling. In attributes sampling, the presence or absence of a characteristic is noted in each of the units inspected. In variables sampling, the numerical magnitude of a characteristic is measured and recorded for each inspected unit; this type of sampling involves reference to a continuous scale of some kind. (2) A method of measuring random samples of lots or batches of products against predetermined standards.

Accessibility The ability of a carrier to provide service between an origin and a destination.

Accessory A choice or feature added to the good or service offered to the customer for customizing the end product. An accessory enhances the capabilities of the product but is not necessary for the basic function of the product. In many companies, an accessory means that the choice does not have to be specified before shipment but can be added at a later date. In other companies, this choice must be made before shipment.

Accessorial charges A charge for services over and above transportation charges, such as inside delivery, heading, sorting and segregating, heating and storage. *See also: Upcharges*

Accountability Being answerable for, but not necessarily personally charged with, doing specific work. Accountability cannot be delegated, but it can be shared. For example, managers and executives are accountable for business performance even though they may not actually perform the work.

Accounts Payable (A/P) The value of goods and services acquired for which payment has not yet been made.

Accounts receivable (A/R) The value of goods shipped or services rendered to a customer on whom payment has not yet been received. Usually includes an allowance for bad debts.

Accreditation Certification by a recognized body of the facilities, capability, objectivity, competence and integrity of an agency, service, operational group or individual to provide the specific service or operation needed. For example, the Registrar Accreditation Board accredits those organizations that register companies to the ISO 9000 Series Standards.

Accredited Standards Committee (ASC) A committee of the ANSI chartered in 1979 to develop uniform standards for the electronic interchange of business documents. The committee develops and maintains US generic standards (X12) for Electronic Data Interchange.

Accumulation bin A place, usually a physical location, used to accumulate all components that go into an assembly before the assembly is sent out to the assembly floor. *Syn: assembly bin*

Accuracy In quality management, the degree of freedom from error or the degree of conformity to a standard. Accuracy is different from precision. For example, four-significant-digit numbers are less precise than six-significant-digit numbers; however, a properly computed four-significant-digit number might be more accurate than an improperly computed six-significant-digit number.

ACD *See Automated Call Distribution*

ACE *See Automated Commercial Environment*

ACH *See Automated Clearinghouse*

Acknowledgment A communication by a supplier to advise a purchaser that a purchase order has been received. It usually implies acceptance of the order by the supplier.

Acquisition Cost In cost accounting, the cost required to obtain one or more units of an item. It is order quantity times unit cost.

Action Message An output of a system that identifies the need for and the type of action to be taken to correct a current or potential problem. Examples of action messages in an MRP system include release order, reschedule in, reschedule out and cancel. Synonym: exception message, action report.

Action Plan A specific method or process to achieve the results called for by one or more objectives. An action plan may be a simpler version of a project plan.

Action Report *See Action Message*

Activation In constraint management, the use of non-constraint resources to make parts or products above the level needed to support the system constraint(s). The result is excessive work-in-process inventories or finished goods inventories, or both. In contrast, the term utilization is used to describe the situation in which non-constraint resource(s) usage is synchronized to support the needs of the constraint.

Active Inventory The raw materials, work in process and finished goods that will be used or sold within a given period.

Active Stock Goods in active pick locations and ready for order filling.

Activity Work performed by people, equipment, technologies or facilities. Activities are usually described by the "action-verb-adjective-noun" grammar convention. Activities may occur in a linked sequence and activity-to-activity assignments may exist. (1) In activity-based cost accounting, a task or activity, performed by or at a resource, required in producing the organization's output of goods and services. A resource may be a person, machine or facility. Activities are grouped into pools by type of activity and allocated to products. (2) In project management, an element of work on a project. It usually has an anticipated duration, anticipated cost and expected resource requirements. Sometimes "major activity" is used for larger bodies of work.

Activity Analysis The process of identifying and cataloguing activities for detailed understanding and documentation of their characteristics. An activity analysis is accomplished by means of interviews, group sessions, questionnaires, observations and reviews of physical records of work.

Activity-Based Budgeting (ABB) An approach to budgeting where a company uses an understanding of its activities and driver relationships to quantitatively estimate workload and resource requirements as part of an ongoing business plan. Budgets show the types, number of and cost of resources that activities are expected to consume based on forecasted workloads. The budget is part of an organization's activity-based planning process and can be used in evaluating its success in setting and pursuing strategic goals.

Activity-Based Costing (ABC) A methodology that measures the cost and performance of cost objects, activities and resources. Cost objects consume activities and activities consume resources. Resource costs are assigned to activities based on their use of those resources, and activity costs are reassigned to cost objects (outputs) based on the cost objects, proportional use of those activities. Activity-based costing incorporates causal relationships between cost objects and activities and between activities and resources.

Activity-Based Costing Model In activity-based cost accounting, a model, by time period, of resource costs created because of activities related to products or services or other items causing the activity to be carried out.

Activity-Based Costing System A set of activity-based cost accounting models that collectively define data on an organization's resources, activities, drivers, objects and measurements.

Activity-Based Management (ABM) A discipline focusing on the management of activities within business processes as the route to continuously improve both the value received by customers and the profit earned in providing that value. ABM uses activity-based cost information and performance measurements to influence management action. *See also Activity-Based Costing*

Activity-Based Planning (ABP) Activity-based planning (ABP) is an ongoing process to determine activity and resource requirements (both financial and operational) based on the ongoing demand of products or services by specific customer needs. Resource requirements are compared to resources available and capacity issues are identified and managed. Activity-based budgeting (ABB) is based on the outputs of activity-based planning.

Activity Dictionary A listing and description of activities that provides a common/standard definition of activities across the organization. An activity dictionary can include information about an activity and/or its relationships, such as activity description, business process, function source, whether value-added, inputs, outputs, supplier, customer, output measures, cost drivers, attributes, tasks and other information as desired to describe the activity.

Activity Driver The best single quantitative measure of the frequency and intensity of the demands placed on an activity by cost objects or other activities. It is used to assign activity costs to cost objects or to other activities.

Activity Level A description of types of activities dependent on the functional area. Product-related activity levels may include unit, batch and product levels. Customer-related activity levels may include customer, market, channel and project levels.

Activity Network Diagram An arrow diagram used in planning and managing processes and projects.

Activity Ratio A financial ratio used to determine how an organization's resources perform relative to the revenue the resources produce. Activity ratios include inventory turnover, receivables conversion period, fixed-asset turnover and return on assets.

Actual Cost System A cost system that collects costs historically as they are applied to production and allocates indirect costs to products based on the specific costs and achieved volume of the products.

Actual Costs The labour, material and associated overhead costs that are charged against a job as it moves through the production process.

Actual Demand Actual demand is composed of customer orders (and often allocations of items, ingredients, or raw materials to production or distribution). Actual demand nets against or "consumes" the forecast, depending upon the rules chosen over a time horizon. For example, actual demand will totally replace forecast inside the sold-out customer order backlog horizon (often called the demand time fence), but will net against the forecast outside this horizon based on the chosen forecast consumption rule.

Actual to Theoretical Cycle Time The ratio of the measured time required to produce a given output divided by the sum of the time required to produce a given output based on the rated efficiency of the machinery and labour operations.

Adaptive Control (1) The ability of a control system to change its own parameters in response to a measured change in operating conditions. (2) Machine control units in which feeds and/or speeds are not fixed. The control unit, working from feedback sensors, is able to optimize favourable situations by automatically increasing or decreasing the machining parameters. This process ensures optimum tool life or surface finish and/or machining costs or production rates.

Adaptive Smoothing In forecasting, a form of exponential smoothing in which the smoothing constant is automatically adjusted as a function of one or many items, for example, forecast error measurement, calendar characteristics (launch, replenishment, end of life) or demand volume.

Advance Material Request Ordering materials before the release of the formal product design. This early release is required because of long lead times.

Advanced Planning and Scheduling (APS) Techniques that deal with analysis and planning of logistics and manufacturing over the short, intermediate and long-term time periods. APS describes any computer program that uses advanced mathematical algorithms or logic to perform optimization or simulation on finite capacity scheduling, sourcing, capital planning, resource planning, forecasting, demand management and others. These techniques simultaneously consider a range of constraints and business rules to provide real-time planning and scheduling, decision support, available-to-promise, and capable-to-promise capabilities. APS often generates and evaluates multiple scenarios. Management then selects one scenario to use as the "official plan". The five main components of APS systems are demand planning, production planning, production scheduling, distribution planning and transportation planning.

Advanced Shipping Notice (ASN) Detailed shipment information transmitted to a customer or consignee in advance of delivery, designating the contents (individual products and quantities of each) and nature of the shipment. May also include carrier and shipment specifics including time of shipment and expected time of arrival. *See also: Assumed Receipt*

After-Sale Service Services provided to the customer after products have been delivered. This can include repairs, maintenance and/or telephone support. *Synonym: Field Service*

Agency Tariff A publication of a rate bureau that contains rates for many carriers.

Agent An enterprise authorized to transact business for, or in the name of, another enterprise.

Agile Manufacturing Tools, techniques and initiatives that enable a plant or company to thrive under conditions of unpredictable change. Agile manufacturing not only enables a plant to achieve rapid response to customer needs, but also includes the ability to quickly reconfigure operations—and strategic alliances—to respond rapidly to unforeseen shifts in the marketplace. In some instances, it also incorporates "mass customization" concepts to satisfy unique customer requirements. In broad terms, it includes the ability to react quickly to technical or environmental surprises.

Agglomeration A net advantage gained by a common location with other companies.

Aggregate Forecast An estimate of sales, often time phased, for a grouping of products or product families produced by a facility or firm. Stated in terms of units, dollars, or both, the aggregate forecast is used for sales and production planning (or for sales and operations planning) purposes.

Aggregate Inventory The inventory for any grouping of items or products involving multiple stock-keeping units. *Also see: Base Inventory Level*

Aggregate Inventory Management Establishing the overall level (dollar value) of inventory desired and implementing controls to achieve this goal.

Aggregate Plan A plan that includes budgeted levels of finished goods, inventory, production backlogs and changes in the workforce to support the production strategy. Aggregated information (e.g. product line, family) rather than product information is used, hence the name aggregate plan.

Aggregate Planning A process to develop tactical plans to support the organization's business plan. Aggregate planning usually includes the development, analysis and maintenance of plans for total sales, total production, targeted inventory and targeted customer backlog for families of products. The production plan is the result of the aggregate planning process. Two approaches to aggregate planning exist—production planning and sales and operations planning.

Aggregate Tender Rate A reduced rate offered to a shipper who tenders two or more class-rated shipments at one time and one place.

Agility The ability to successfully manufacture and market a broad range of low-cost, high-quality products and services with short lead times and varying volumes that provides enhanced value to customers through customization. Agility merges the four distinctive competencies of cost, quality, dependability and flexibility.

AGVS *See Automated Guided Vehicle System*

Air Cargo Freight that is moved by air transportation.

Air Cargo Containers Containers designed to conform to the inside of an aircraft. There are many shapes and sizes of containers. Air cargo containers fall into three categories: (1) air cargo pallets (2) lower deck containers (3) box type containers.

Airport and Airway Trust Fund A federal fund that collects passenger ticket taxes and disburses those funds for airport facilities.

Air Taxi An exempt for-hire air carrier that will fly anywhere on demand: air taxis are restricted to a maximum payload and passenger capacity per plane.

Air Transport Association of America A US airline industry association.

Air Waybill (AWB) A bill of lading for air transport that serves as a receipt for the shipper, indicates that the carrier has accepted the goods listed, obligates the carrier to carry the consignment to the airport of destination according to specified conditions.

Alaskan carrier A for-hire air carrier that operates within the state of Alaska.

Alert *See Action Message*

Algorithm A clearly specified mathematical process for computation; a set of rules, which, if followed, give a prescribed result.

All-cargo Carrier An air carrier that transports cargo only.

Allocated Item In an MRP system, an item for which a picking order has been released to the stockroom but not yet sent from the stockroom.

Allocation (1) In cost accounting, a distribution of costs using calculations that may be unrelated to physical observations or direct or repeatable cause-and-effect relationships. Because of the arbitrary nature of allocations, costs based on cost causal assignment are viewed as more relevant for management decision-making. (2) In order management, allocation of available inventory to customer and production orders.

Allocation Costing *See Absorption Costing*

Alpha Release A very early release of a product to get preliminary feedback about the feature set and usability.

Alternate Routing A routing, usually less preferred than the primary routing, but resulting in an identical item. Alternate routings may be maintained in the computer or off-line via manual methods, but the computer software must be able to accept alternate routings for specific jobs.

American Customer Satisfaction Index (ACSI) Released for the first time in October 1994, an economic indicator and cross-industry measure of the satisfaction of US household customers with the quality of the goods and services available to them—both those goods and services produced within the United States and those provided as imports from foreign firms that have substantial market shares or dollar sales. The ACSI is co-sponsored by the University of Michigan Business School, ASQ and the CFI Group.

American National Standards Institute (ANSI) A non-profit organization chartered to develop, maintain and promulgate voluntary US national standards in a number of areas, especially with regards to setting EDI standards. ANSI is the US representative to the International Standards Organization (ISO).

American Society for Quality (ASQ) Founded in 1946, a not-for-profit educational organization consisting of 144,000 members who are interested in quality improvement.

American Society for Testing and Materials (ASTM) Not-for-profit organization that provides a forum for the development and publication of voluntary consensus standards for materials, products, systems and services.

American Society for Training and Development (ASTD) A membership organization providing materials, education and support related to workplace learning and performance.

American Society of Transportation and Logistics A professional organization in the field of logistics.

American Standard Code for Information Interchange (ASCII) ASCII format—simple text-based data with no formatting. The standard code for information exchange among data processing systems. Uses a coded character set consisting of 7-bit coded characters (8 bits including parity check).

American Trucking Association, Inc. A motor carrier industry association that is made up of subconferences representing various sectors of the motor carrier industry.

American Waterway Operators A domestic water carrier industry association representing barge operators on the inland waterways.

AMS *See Automated Manifest System*

Amtrak The National Railroad Passenger Corporation, a federally created corporation that operates most of the United States' intercity passenger rail service.

Animated GIF A file containing a series of GIF (Graphics Interchange Format) images that are displayed in rapid sequence by some Web browsers, giving an animated effect. *Also see: GIF*

ANSI *See American National Standards Institute*

ANSI ASC X12 American National Standards Institute Accredited Standards Committee X12. The committee of ANSI that is charted with setting EDI standards.

ANSI Standard A published transaction set approved by ANSI. The standards are reviewed every 6 months.

Anticipated Delay Report A report, normally issued by both manufacturing and purchasing to the material planning function, regarding jobs or purchase orders that will not be completed on time and explaining why the jobs or purchases are delayed and when they will be completed. This report is an essential ingredient of the closed-loop MRP system. It is normally a handwritten report. *Synonym: delay report*

Anticipation Inventories Additional inventory above basic pipeline stock to cover projected trends of increasing sales, planned sales promotion programs, seasonal fluctuations, plant shutdowns and vacations.

Anti-Dumping Duty An additional import duty imposed in instances where imported goods are priced at less than the normal price charged in the exporter's domestic market and cause material injury to domestic industry in the importing country.

Any-Quantity Rate (AQ) The same rate applies to any size shipment tendered to a carrier; no discount rate is available for large shipments.

A/P *See Accounts Payable*

Applicability Statement 2 (AS2) A specification for Electronic Data Interchange between businesses using the Internet's Web page protocol, the Hypertext Transfer Protocol (HTTP). The specification is an extension of the earlier version, Applicability Statement 1 (AS1). Both specifications were created by EDI over the Internet (EDIINT), a working group of the Internet Engineering Task Force (IETF) that develops secure and reliable business communications standards.

Application Service Provider (ASP) A company that offers access over the Internet to application (examples of applications include word processors, database programs, Web browsers, development tools, communication programs) and related services that would otherwise have to be located in their own computers. Sometimes referred to as "apps-on-tap", ASP services are expected to become an important alternative, especially for smaller companies with low budgets for information technology. The purpose is to try to reduce a company's burden by installing, managing and maintaining software.

Application-to-Application The direct interchange of data between computers, without re-keying.

Appraisal Costs Those costs associated with the formal evaluation and audit of quality in the firm. Typical costs include inspection, quality audits, testing, calibration and checking time.

Approved Vendor List (AVL) List of the suppliers approved for doing business. The AVL is usually created by procurement or sourcing and engineering personnel using a variety of criteria such as technology, functional fit of the product, financial stability and past performance of the supplier.

APS *See Advanced Planning and Scheduling*

AQ *See Any-quantity rate*

AQL *See Acceptable Quality Level*

A/R *See Accounts Receivable*

Army Corps of Engineers A federal agency responsible for the construction and maintenance of waterways.

Arrival Notice A notice from the delivering carrier to the Notify Party indicating the shipment's arrival date at a specific location (normally the destination).

Arrow diagram A planning tool to diagram a sequence of events or activities (nodes) and the interconnectivity of such nodes. It is used for scheduling and especially for determining the critical path through nodes.

Artificial Intelligence Understanding and computerizing the human thought process.

ASC *See Accredited Standards Committee of ANSI*

ASC X12 Accredited Standards Committee X12. A committee of ANSI chartered in 1979 to develop uniform standards for the electronic interchange of business documents.

ASCII *See American Standard Code for Information Interchange*

ASN *See Advanced Shipping Notice.*

ASP *See Application Service Provider*

ASQ *See American Society for Quality*

AS/RS *See Automated Storage and Retrieval System*

Association of American Railroads A railroad industry association that represents the larger US railroads.

ASTM *See American Society for Testing and Materials*

ASTD *See American Society for Training and Development*

AS2 *See Applicability Statement 2*

Assemble-to-order A production environment where a good or service can be assembled after receipt of a customer's order. The key components (bulk, semi-finished, intermediate, sub-assembly, fabricated, purchased, packing and so on) used in the assembly or finishing process are planned and usually stocked in anticipation of a customer order. Receipt of an order initiates assembly of the customized product. This strategy is useful where a large number of end products (based on the selection of options and accessories) can be assembled from common components. *Synonym: Finish to Order. Also see: Make to Order, Make to Stock*

Assembly A group of subassemblies and/or parts that are put together and that constitute a major subdivision for the final product. An assembly may be an end item or a component of a higher level assembly.

Assembly Line An assembly process in which equipment and work centres are laid out to follow the sequence in which raw materials and parts are assembled.

Assignment A distribution of costs using causal relationships. Because cost causal relationships are viewed as more relevant for management decision-making, assignment of costs is generally preferable to allocation techniques. *Syn: Tracing. Contrast with Allocation*

Assumed Receipt The principle of assuming that the contents of a shipment are the same as those presented on a shipping or delivery note. Shipping and receiving personnel do not check the delivery quantity. This practice is used in conjunction with barcodes and an EDI-delivered ASN to eliminate invoices and facilitate rapid receiving.

ATP *See Available to Promise*

ATS *See Available to Sell*

Attachment An accessory that has to be physically attached to the product.

Attributes A label used to provide additional classification or information about a resource, activity or cost object. Used for focusing attention and may be subjective. Examples are a characteristic, a score or grade of product or activity, or groupings of these items, and performance measures.

Audit The inspection and examination of a process or quality system to ensure compliance to requirements. An audit can apply to an entire organization or may be specific to a function, process or production step.

Audit Trail Manual or computerized tracing of the transactions affecting the contents or origin of a record.

Auditing Determining the correct transportation charges due the carrier: auditing involves checking the accuracy of the freight bill for errors, correct rate and weight.

Auditability A characteristic of modern information systems, gauged by the ease with which data can be substantiated by tracing it to source documents and the extent to which auditors can rely on pre-verified and monitored control processes.

Authentication (1) The process of verifying the eligibility of a device, originator or individual to access specific categories of information or to enter specific areas of a facility. This process involves matching machine-readable code with a predetermined list of authorized end users. (2) A practice of establishing the validity of a transmission, message, device or originator, which was designed to provide protection against fraudulent transmissions.

Authentication Key A short string of characters used to authenticate transactions between trading partners.

Autodiscrimination The functionality of a barcode reader to recognize the barcode symbology being scanned thus allowing a reader to read several different symbologies consecutively.

AutoID Referring to an automated identification system. This includes technology such as barcoding and radio frequency tagging (RFID).

Automated Broker Interface (ABI) The U.S. Customs program to automate the flow of customs-related information among customs brokers, importers and carriers.

Automated Call Distribution (ACD) A feature of large call centre or "Customer Interaction Center" telephone switches that routes calls by rules such as next available employee and skill-set.

Automated Clearinghouse (ACH) A nationwide electronic payments system, which more than 15,000 financial institutions use, on behalf of 100,000 corporations and millions of consumers in the USA. The funds transfer system of choice among businesses that make electronic payments to vendors, it is economical and can carry remittance information in standardized, computer processable data formats.

Automated Commercial Environment (ACE) Update of outmoded Automated Commercial System (ACS). It is intended to provide automated information system to enable the collection, processing and analysis of commercial import and export data, allowing for moving goods through the ports faster and at lower cost, as well as detection of terrorist threats.

Automated Guided Vehicle System (AGVS) A transportation network that automatically routes one or more material handling devices, such as carts or pallet trucks, and positions them at predetermined destinations without operator intervention.

Automated Manifest System (AMS) A multi-modular cargo inventory control and release notification system through which carriers submit their electronic cargo declaration 24 h before loading. *See 24-h Rule*

Automated Storage/Retrieval System (AS/RS) A high-density rack inventory storage system with un-manned vehicles automatically loading and unloading products to/from the racks.

Automatic Relief A set of inventory bookkeeping methods that automatically adjusts computerized inventory records based on a production transaction. Examples of automatic relief methods are backflushing, direct-deduct, pre-deduct and post-deduct processing.

Automatic Rescheduling Rescheduling done by the computer to automatically change due dates on scheduled receipts when it detects that due dates and need dates are out of phase. *Ant: manual rescheduling*

Available Inventory The on-hand inventory balance minus allocations, reservations, backorders and (usually) quantities held for quality problems. Often called "beginning available balance".

Available to Promise (ATP) The uncommitted portion of a company's inventory and planned production maintained in the master schedule to support customer-order promising. The ATP quantity is the uncommitted inventory balance in the first period and is normally calculated for each period in which an MPS receipt is scheduled. In the first period, ATP includes on-hand inventory less customer orders that are due and overdue. Three methods of calculation are used: discrete ATP, cumulative ATP with lookahead and cumulative ATP without lookahead.

Available to Sell (ATS) Total quantity of goods committed to the pipeline for a ship to or selling location. This includes the current inventory at a location and any open purchase orders.

Average Annual Production Materials Related A/P (Accounts Payable) The value of direct materials acquired in that year for which payment has not yet been made. Production-related materials are those items classified as material purchases and included in the Cost of Goods Sold (COGS) as raw material purchases. Calculate using the 5-Point Annual Average.

Average Cost per Unit The estimated total cost, including allocated overhead, to produce a batch of goods divided by the total number of units produced.

Average Inventory The average inventory level over a period of time. Implicit in this definition is a "sampling period" which is the amount of time between inventory measurements. For example, daily inventory levels over a 2-week period of time, hourly inventory levels over 1 day, etc. The average inventory for the same total period of time can fluctuate widely depending upon the sampling period used.

Average Payment Period (for materials) The average time from receipt of production-related materials and payment for those materials. Production-related materials are those items classified as material purchases and included in the Cost of Goods Sold (COGS) as raw material purchases. (An element of Cash-to-Cash Cycle Time).*Calculation:*[Five point annual average production-related material accounts payable]/[Annual production-related material receipts/365]

AVL *See Approved Vendor List*

Avoidable Cost A cost associated with an activity that would not be incurred if the activity was not performed (e.g. telephone cost associated with vendor support).

AWB *See Air Waybill*

B

B2B *See Business to Business*

B2C *See Business to Consumer*

Back Order Product ordered but out of stock and promised to ship when the product becomes available.

Back Scheduling A technique for calculating operation start dates and due dates. The schedule is computed starting with the due date for the order and working backward to determine the required start date and/or due dates for each operation.

Backflush A method of inventory bookkeeping where the book (computer) inventory of components is automatically reduced by the computer after completion of activity on the component's upper-level parent item based on what should have been used as specified on the bill of material and allocation records. This approach has the disadvantage of a built-in differential between the book record and what is physically in stock. Synonym: explode-to-deduct. *Also see: Prededuct Inventory Transaction Processing*

Backhaul The process of a transportation vehicle returning from the original destination point to the point of origin. The 1980 Motor Carrier Act deregulated interstate commercial trucking and thereby allowed carriers to contract for the return trip. The backhaul can be with a full, partial or empty load. An empty backhaul is called deadheading. *Also see: Deadhead*

Backlog Customer Customer orders received but not yet shipped; also includes backorders and future orders.

Backorder (1) The act of retaining a quantity to ship against an order when other order lines have already been shipped. Backorders are usually caused by stock shortages. (2) The quantity remaining to be shipped if an initial shipment(s) has been processed. Note: In some cases backorders are not allowed; this results in a lost sale when sufficient quantities are not available to completely ship and order or order line. *Also see: Balance to Ship*

Backsourcing The process of recapturing and taking responsibility internally for processes that were previously outsourced to a contract manufacturer, fulfilment or other service provider. Backsourcing typically involves the cancellation or expiration of an outsourcing contract and can be nearly as complex as the original outsourcing process.

Back Order Product ordered but out of stock and promised to ship when the product becomes available.

Balance-of-Stores Record A double-entry record system that shows the balance of inventory items on hand and the balances of items on order and available for future orders. Where a reserve system of materials control is used, the balance of material on reserve is also shown.

Balance of Trade The surplus or deficit which results from comparing a country's exports and imports of merchandise only.

Balance to Ship (BTS) Balance or remaining quantity of a promotion or order that has yet to ship.*Also see: Backorder*

Balanced Scorecard A structured measurement system developed by David Norton and Robert Kaplan of the Harvard Business School. It is based on a mix of financial and non-financial measures of business performance. A list of financial and operational measurements is used to evaluate organizational or supply chain performance. The dimensions of the balanced scorecard might include customer perspective, business process perspective, financial perspective, and innovation and learning perspectives. It formally connects overall objectives, strategies and measurements. Each dimension has goals and measurements. *Also see: Scorecard*

BAM *See Business Activity Monitoring*

Barcode A symbol consisting of a series of printed bars representing values. A system of optical character reading, scanning and tracking of units by reading a series of printed bars for translation into a numeric or alphanumeric identification code. A popular example is the UPC code used on retail packaging.

Barcode scanner A device to read barcodes and communicate data to computer systems.

Barge The cargo-carrying vehicle used primarily by inland water carriers. The basic barges have open tops, but there are covered barges for both dry and liquid cargoes.

Barrier to Entry Factors that prevent companies from entering into a particular market, such as high initial investment in equipment.

Base Demand The percentage of a company's demand that is derived from continuing contracts and/or existing customers. Because this demand is well known and recurring, it becomes the basis of management's plans. *Synonym: Baseload Demand*

Base Index *See Base Series*

Base Inventory Level The inventory level made up of aggregate lot-size inventory plus the aggregate safety stock inventory. It does not take into account the anticipation inventory that will result from the production plan. The base inventory level should be known before the production plan is made. *Also see: Aggregate Inventory.*

Base Series A standard succession of values of demand-over-time data used in forecasting seasonal items. This series of factors is usually based on the relative level of demand during the corresponding period of previous years. The average value of the base series over a seasonal cycle will be 1.0. A figure higher than 1.0 indicates that the demand for that period is more than the average; a figure less than 1.0 indicates less than the average. For forecasting purposes, the base series is superimposed upon the average demand and trend in demand for the item in question. *Synonym: Base Index. Also see: Seasonality*

Base Stock System A method of inventory control that includes as special cases most of the systems in practice. In this system, when an order is received for any item, it is used as a picking ticket, and duplicate copies, called replenishment orders, are sent back to all stages of production to initiate replenishment of stocks. Positive or negative orders (called base stock orders) are also used from time to time to adjust the level of the base stock of each item. In actual practice, replenishment orders are usually accumulated when they are issued and are released at regular intervals.

Baseload Demand *See Base Demand*

Basic Producer A manufacturer that uses natural resources to produce materials for other manufacturing. A typical example is a steel company that processes iron ore and produces steel ingots; others are those making wood pulp, glass and rubber.

Basing-Point Pricing A pricing system that includes a transportation cost from a particular city or town in a zone or region even though the shipment does not originate at the basing point.

Batch Control Totals The result of grouping transactions at the input stage and establishing control totals over them to ensure proper processing. These control totals can be based on document counts, record counts, quantity totals, dollar totals or hash (mixed data, such as customer AR numbers) totals.

Batch Number A sequence number associated with a specific batch or production run of products and used for tracking purposes. *Synonym: Lot Number*

Batch Picking A method of picking orders in which order requirements are aggregated by product across orders to reduce movement to and from product locations. The aggregated quantities of each product are then transported to a common area where the individual orders are constructed. *Also See*: *Discrete Order Picking, Order Picking, Zone Picking*

Batch Processing A computer term which refers to the processing of computer information after it has been accumulated in one group, or batch. This is the opposite of "real-time" processing where transactions are processed in their entirety as they occur.

Baud A computer term describing the rate of transmission over a channel or circuit. The baud rate is equal to the number of pulses that can be transmitted in 1 s, often the same as the number of bits per second. Common rates are now 1200, 2400, 4800, 9600 bits and 19.2 and 56 kilobytes (Kbs) for "dial-up" circuits, and may be much higher for broadband circuits.

BCP *See Business Continuity Plan*

Beginning Available Balance *See Available Inventory*

Benchmarking The process of comparing performance against the practices of other leading companies for the purpose of improving performance. Companies also benchmark internally by tracking and comparing current performance with past performance. Benchmarking seeks to improve any given business process by exploiting "best practices" rather than merely measuring the best performance. Best practices are the cause of best performance. Studying best practices provides the greatest opportunity for gaining a strategic, operational and financial advantage.

Benefit-cost ratio An analytical tool used in public planning; a ratio of total measurable benefits divided by the initial capital cost.

Bespoke An individual or custom-made product or service. Traditionally applied to custom-tailored clothing, the term has been extended to information technology, especially for custom-designed software as an alternative to commercial (COTS) software.

Best-in-Class An organization, usually within a specific industry, recognized for excellence in a specific process area.

Best Practice A specific process or group of processes which have been recognized as the best method for conducting an action. Best Practices may vary by industry or geography depending on the environment being used. Best practices methodology may be applied with respect to resources, activities, cost object or processes.

Beta Release A pre-released version of a product that is sent to customers for evaluation and feedback.

Bilateral Contract An agreement wherein each party makes a promise to the other party.

Bill of Activities A listing of activities required by a product, service, process output or other cost object. Bill of activity attributes could include volume and or cost of each activity in the listing.

Bill of Lading (BOL) A transportation document that is the contract of carriage containing the terms and conditions between the shipper and carrier.

Bill of Lading, Through A bill of lading to cover goods from point of origin to final destination when interchange or transfer from one carrier to another is necessary to complete the journey.

Bill of Material (BOM) A structured list of all the materials or parts and quantities needed to produce a particular finished product, assembly, sub-assembly, or manufactured part, whether purchased or not.

Bill of Material Accuracy Conformity of a list of specified items to administrative specifications, with all quantities correct.

Bill of Resources A listing of resources required by an activity. Resource attributes could include cost and volumes.

Bin (1) A storage device designed to hold small discrete parts. (2) A shelving unit with physical dividers separating the storage locations.

Binary A computer term referring to a system of numerical notation that assumes only two possible states or values, zero (0) and one (1). Computer systems use a binary technique where an individual bit or "Binary Digit" of data can be "on" or "off" (1 or 0). Multiple bits are combined into a "Byte" which represents a character or number.

Bisynchronous A computer term referring to a communication protocol whereby messages are sent as blocks of characters. The blocks of data are checked for completeness and accuracy by the receiving computer.

Bitmap Image (BMP) The standard image format on Windows-compatible computers. Bitmap images can be saved for Windows or OS/2 systems and support 24-bit colour.

Blanket Order *See Blanket Purchase Order*

Blanket Purchase Order A long-term commitment to a supplier for material against which short-term releases will be generated to satisfy requirements. Often blanket orders cover only one item with predetermined delivery dates. *Synonym: Blanket Order, Standing Order*

Blanket Release The authorization to ship and/or produce against a blanket agreement or contract.

Blanket Rate A rate that does not increase according to the distance the commodity is shipped.

Bleeding Edge An unproven process or technology so far ahead of its time that it may create a competitive disadvantage.

Block Diagram A diagram that shows the operation, interrelationships and interdependencies of components in a system. Boxes, or blocks (hence the name), represent the components; connecting lines between the blocks represent interfaces. There are two types of block diagrams: a functional block diagram, which shows a system's subsystems and lower level products and their interrelationships and which interfaces with other systems; and a reliability block diagram, which is similar to the functional block diagram except that it is modified to emphasize those aspects influencing reliability.

Blocking Bug A defect that prevents further or more detailed analysis or verification of a functional area or feature, or any issue that would prevent the product from shipping.

Blow Through An MRP process which uses a "phantom bill of material" and permits MRP logic to drive requirements straight through the phantom item to its components. The MRP system usually retains its ability to net against any occasional inventories of the item. *Also see: Phantom Bill of Material*

Body of Knowledge (BOK) The prescribed aggregation of knowledge in a particular area an individual is expected to have mastered to be considered or certified as a practitioner.

BOL *See Bill of Lading*

BOK *See Body of Knowledge*

BOM *See Bill of Materials*

Book Inventory An accounting definition of inventory units or value obtained from perpetual inventory records rather than by actual count.

Bookings The sum of the value of all orders received (but not necessarily shipped), net of all discounts, coupons, allowances and rebates.

Bundle A group of products that are shipped together as an unassembled unit.

Bonded Warehouse Warehouse approved by the Treasury Department and under bond/guarantee for observance of revenue laws. Used for storing goods until duty is paid or goods are released in some other proper manner.

Bottleneck A constraint, obstacle or planned control that limits throughput or the utilization of capacity.

Bottom-up Replanning In MRP, the process of using pegging data to solve material availability or other problems. This process is accomplished by the planner (not the computer system), who evaluates the effects of possible solutions. Potential solutions include compressing lead time, cutting order quantity, substituting material and changing the master schedule.

Box-Jenkins Model A forecasting method based on regression and moving average models. The model is based not on regression of independent variables, but on past observations of the item to be forecast at varying time lags and on previous error values from forecasting. *See also: Forecast*

Boxcar An enclosed rail car typically 40–50 feet long; used for packaged freight and some bulk commodities.

BMP *See Bitmap Imagine*

BPM *See Business Performance Measurement*

BPO *See Business Process Outsourcing*

BPR *See Business Process Reengineering*

Bracing Securing a shipment inside a carrier's vehicle to prevent damage.

Bracketed Recall Recall from customers of suspect lot numbers plus a specified number of lots produced before and after the suspect ones.

Branding The use of a name, term, symbol or design, or a combination of these, to identify a product.

Breadman A specific application of Kanban, used in coordinating vendor replenishment activities. In making bread or other route type deliveries, the deliveryman typically arrives at the customer's location and fills a designated container or storage location with product. The size of the order is not specified on an ongoing basis, nor does the customer even specify requirements for each individual delivery. Instead, the supplier assumes the responsibility for quantifying the need against a prearranged set of rules and delivers the requisite quantity.

Break-Bulk The separation of a single consolidated bulk load into smaller individual shipments for delivery to the ultimate consignees. This is preceded by a consolidation of orders at the time of shipment, where many individual orders which are destined for a specific geographic area are grouped into one shipment in order to reduce cost.

Break-Even Chart A graphical tool showing the total variable cost and fixed cost curve along with the total revenue curve. The point of intersection is defined as the break-even point, i.e. the point at which total revenues exactly equal total costs. *Also see: Total Cost Curve*

Break-Even Point The level of production or the volume of sales at which operations are neither profitable nor unprofitable. The break-even point is the intersection of the total revenue and total cost curves. *Also see: Total Cost Curve*

Bricks and Mortar The act of selling through a physical location. The flip side of clicks and mortar, where selling is conducted via the Internet. An informal term for representing the old economy versus new economy or the Industrial economy versus information economy.

Broadband A high-speed, high-capacity transmission channel. Broadband channels are carried on radio wave, coaxial or fibre-optic cables that have a wider bandwidth than conventional telephone lines, giving them the ability to carry video, voice and data simultaneously.

Broken Case An open case. The term is often used interchangeably with "repack" or "less-than-full-case" to name the area in which materials are picked in that form.

Broker An intermediary between the shipper and the carrier. The broker arranges transportation for shippers and represents carriers.

Brokered Systems Independent computer systems, owned by independent organizations or entities, linked in a manner to allow one system to retrieve information from another. For example, a customer's computer system is able to retrieve order status from a supplier's computer.

Browser A utility that allows an internet user to look through collections of things. For example, Netscape Navigator and Microsoft Explorer allow you to view contents on the World Wide Web.

BTS *See Balance to Ship*

Bulletin Board An electronic forum that hosts posted messages and articles related to a common subject.

Bucketed System An MRP, DRP or other time-phased system in which all time-phased data are accumulated into time periods, or buckets. If the period of accumulation is 1 week, then the system is said to have weekly buckets.

Bucketless System An MRP, DRP or other time-phased system in which all time-phased data are processed, stored and usually displayed using dated records rather than defined time periods, or buckets.

Buffer (1) A quantity of materials awaiting further processing. It can refer to raw materials, semi-finished stores or hold points, or a work backlog that is purposely maintained behind a work centre. (2) In the theory of constraints, buffers can be time or material and support throughput and/or due date performance. Buffers can be maintained at the constraint, convergent points (with a constraint part), divergent points and shipping points.

Buffer Management In the theory of constraints, a process in which all expediting in a shop is driven by what is scheduled to be in the buffers (constraint, shipping and assembly buffers). By expediting this material into the buffers, the system helps avoid idleness at the constraint and missed customer due dates. In addition, the causes of items missing from the buffer are identified, and the frequency of occurrence is used to prioritize improvement activities.

Buffer Stock *See Safety Stock*

Bulk Area A storage area for large items which at a minimum are most efficiently handled by the pallet load.

Bulk storage The process of housing or storing materials and packages in larger quantities, generally using the original packaging or shipping containers or boxes.

Bulk packing The process or act of placing numbers of small cartons or boxes into a larger single box to aid in the movement of product and to prevent damage or pilferage to the smaller cartons or boxes.

Bullwhip Effect An extreme change in the supply position upstream in a supply chain generated by a small change in demand downstream in the supply chain. Inventory can quickly move from being backordered to being excess. This is caused by the serial nature of communicating orders up the chain with the inherent transportation delays of moving product down the chain. The bullwhip effect can be eliminated by synchronizing the supply chain.

Bundle A group of products that are shipped together as an unassembled unit.

Bundling An occurrence where two or more products are combined into one transaction for a single price.

Burn Rate The rate of consumption of cash in a business. Burn rate is used to determine cash requirements on an ongoing basis. A burn rate of $50,000 would mean the company spends $50,000 a month above any incoming cash flow to sustain its business. Entrepreneurial companies will calculate their burn rate in order to understand how much time they have before they need to raise more money, or show a positive cash flow.

Business Activity Monitoring (BAM) A term which refers to capturing operational data in real-time or close to it, making it possible for an enterprise to react more quickly to events. This is typically done through software and includes features to provide alerts/notifications when specific events occur. *See also: Supply Chain Event Management*

Business Application Any computer program, set of programs or package of programs created to solve a particular business problem or function.

Business Continuity Plan (BCP) A contingency plan for sustained operations during periods of high risk, such as during labour unrest or natural disaster. CSCMP provides suggestions for helping companies do continuity planning in their Securing the Supply Chain Research. A copy of the research is available on the CSCMP website.

Business Logistics The systematic and coordinated set of activities required to provide the physical movement and storage of goods (raw materials, parts, finished goods) from vendor/supply services through company facilities to the customer (market) and the associated activities—packaging, order processing, etc.—in an efficient manner necessary to enable the organization to contribute to the explicit goals of the company.

Business Plan (1) A statement of long-range strategy and revenue, cost, and profit objectives usually accompanied by budgets, a projected balance sheet, and a cash flow (source and application of funds) statement. A business plan is usually stated in terms of dollars and grouped by product family. The business plan is then translated into synchronized tactical functional plans through the production planning process (or the sales and operations planning process). Although frequently stated in different terms (dollars versus units), these tactical plans should agree with each other and with the business plan. See: long-term planning, strategic plan. (2) A document consisting of the business details (organization, strategy and financing tactics) prepared by an entrepreneur to plan for a new business.

Business Performance Measurement (BPM) A technique which uses a system of goals and metrics to monitor performance. Analysis of these measurements can help businesses in periodically setting business goals, and then providing feedback to managers on progress towards those goals. A specific measure can be compared to itself over time, compared with a preset target or evaluated along with other measures.

Business Process Outsourcing (BPO) The practice of outsourcing non-core internal functions to third parties. Functions typically outsourced include logistics, accounts payable, accounts receivable, payroll and human resources. Other areas can include IT development or complete management of the IT functions of the enterprise.

Business Process Reengineering (BPR) The fundamental rethinking and oftentimes, radical redesign of business processes to achieve dramatic organizational improvements.

Business-to-Business (B2B) As opposed to business-to-consumer (B2C). Many companies are now focusing on this strategy, and their sites are aimed at businesses (think wholesale) and only other businesses can access or buy products on the site. Internet analysts predict this will be the biggest sector on the Web.

Business-to-Consumer (B2C) The hundreds of e-commerce Web sites that sell goods directly to consumers are considered B2C. This distinction is important when comparing Websites that are B2B as the entire business model, strategy, execution and fulfilment is different.

Business Unit A division or segment of an organization generally treated as a separate profit-and-loss centre.

Buyer Behaviour The way individuals or organizations behave in a purchasing situation. The customer-oriented concept finds out the wants, needs and desires of customers and adapts resources of the organization to deliver need-satisfying goods and services.

Byte A computer term used to define a string of 7 or 8 bits, or binary digits. The length of the string determines the amount of data that can be represented. The 8-bit byte can represent numerous special characters, 26 uppercase and lowercase alphabetic characters, and 10 numeric digits, totalling 256 possible combinations.

C

Cabotage A federal law that requires coastal and inter-coastal traffic to be carried in US-built and -registered ships.

CAE *See* Computer-*Aided Engineering*

Cage (1) A secure enclosed area for storing highly valuable items, (2) a pallet-sized platform with sides that can be secured to the tines of a forklift and in which a person may ride to inventory items stored well above the warehouse floor.

Caged Referring to the practice of placing high-value or sensitive products in a fenced off area within a warehouse.

Calendar Days The conversion of working days to calendar days is based on the number of regularly scheduled workdays per week in your manufacturing calendar.*Calculation:To convert from working days to calendar days: if work week = 4 days, multiply by 1.75 = 5 days, multiply by 1.4 = 6 days, multiply by 1.17*

Call Centre A facility housing personnel who respond to customer phone queries. These personnel may provide customer service or technical support. Call centres may be in-house or outsourced.

Can-order Point An ordering system used when multiple items are ordered from one vendor. The can-order point is a point higher than the original order point.

When any one of the items triggers an order by reaching the must-order point, all items below their can-order point are also ordered. The can-order point is set by considering the additional holding cost that would be incurred should the item be ordered early.

Cantilever rack Racking system that allows for storage of very long items.

Capable to Promise (CTP) A technique used to determine if product can be assembled and shipped by a specific date. Component availability *throughout the supply chain*, as well as available materials, is checked to determine if delivery of a particular product can be made. This process may involve multiple manufacturing or distribution sites. Capable-to-promise is used to determine when a new or unscheduled customer order can be delivered. Capable-to-promise employs a finite-scheduling model of the manufacturing system to determine when an item can be delivered. It includes any constraints that might restrict the production, such as availability of resources, lead times for raw materials or purchased parts, and requirements for lower-level components or subassemblies. The resulting delivery date takes into consideration production capacity, the current manufacturing environment and future order commitments. The objective is to reduce the time spent by production planners in expediting orders and adjusting plans because of inaccurate delivery-date promises.

Capability Maturity Model (CMM) A framework that describes the key elements of an effective software process. It's an evolutionary improvement path from an immature process to a mature, disciplined process. The CMM covers practices for planning, engineering and managing software development and maintenance. When followed, these key practices improve the ability of organizations to meet goals for cost, schedule, functionality and product quality.

Capacity The physical facilities, personnel and process available to meet the product or service needs of customers. Capacity generally refers to the maximum output or producing ability of a machine, a person, a process, a factory, a product or a service. *Also see: Capacity Management*

Capacity Management The concept that capacity should be understood, defined and measured for each level in the organization to include market segments, products, processes, activities and resources. In each of these applications, capacity is defined in a hierarchy of idle, non-productive, and productive views.

Capacity Planning Assuring that needed resources (e.g. manufacturing capacity, distribution centre capacity, transportation vehicles, etc.) will be available at the right time and place to meet logistics and supply chain needs.

CAPEX A term used to describe the monetary requirements (CAPital EXPenditure) of an initial investment in new machines or equipment.

Capital The resources, or money, available for investing in assets that produce output.

Car Supply Charge A railroad charge for a shipper's exclusive use of special equipment.

Cargo A product shipped in an aircraft, railroad car, ship, barge or truck.

Carload Lot A shipment that qualifies for a reduced freight rate because it is greater than a specified minimum weight. Since carload rates usually include minimum rates per unit of volume, the higher LCL (less than carload) rate may be less expensive for a heavy but relatively small shipment.

Carmack Amendment An Interstate Commerce Act amendment that delineates the liability of common carriers and the bill of lading provision.

Carousel Automated equipment generally used for picking of small, high-volume parts.

Carrier A firm which transports goods or people via land, sea or air.

Cartel A group of companies that agree to cooperate, rather than compete, in producing a product or service, thus limiting or regulating competition.

Case Code The UPC number for a case of product. The UPC case code is different from the UPC item code. This is sometimes referred to as the "Shipping Container Symbol" or ITF-14 code.

Cash-to-Cash Cycle Time The time it takes for cash to flow back into a company after it has been spent for raw materials. *Synonym: Cash Conversion CycleCalculation:Total Inventory Days of Supply + Days of Sales Outstanding – Average Payment Period for Material in days*

Cash Conversion Cycle (1) In retailing, the length of time between the sale of products and the cash payments for a company's resources. (2) In manufacturing, the length of time from the purchase of raw materials to the collection of accounts receivable from customers for the sale of products or services. *Also see: Cash-to-Cash Cycle Time*

Catalogue Channel A call centre or order processing facility that receives orders directly from the customer based on defined catalogue offerings and ships directly to the customer.

Categorical Plan A method of selecting and evaluating suppliers that considers input from many departments and functions within the buyer's organization and systematically categorizes that input. Engineering, production, quality assurance and other functional areas evaluate all suppliers for critical factors within their scope of responsibility. For example, engineering would develop a category evaluating suppliers' design flexibility. Rankings are developed across categories, and performance ratings are obtained and supplier selections are made. *Also see: Weighted-Point Plan*

Category Management The management of product categories as strategic business units. The practice empowers a category manager with full responsibility for the assortment decisions, inventory levels, shelf-space allocation, promotions and buying. With this authority and responsibility, the category manager is able to judge more accurately the consumer buying patterns, product sales and market trends of that category.

Cause and Effect Diagram In quality management, a structured process used to organize ideas into logical groupings. Used in brainstorming and problem solving exercises. *Also known as Ishikawa or fish bone diagram.*

Causal Forecast In forecasting, a type of forecasting that uses cause-and-effect associations to predict and explain relationships between the independent and dependent variables. An example of a causal model is an econometric model used to explain the demand for housing starts based on consumer base, interest rates, personal incomes and land availability.

CBP *See* Customs *and Border Protection, US*

CBT S*ee* Computer-*Based Training*

Cell A manufacturing or service unit consisting of a number of workstations, and the materials transport mechanisms and storage buffers that interconnect them.

Cellular Manufacturing A manufacturing approach in which equipment and workstations are arranged to facilitate small-lot, continuous-flow production. In a manufacturing "cell", all operations necessary to produce a component or sub-assembly are performed in close proximity, thus allowing for quick feedback between operators when quality problems and other issues arise. Workers in a manufacturing cell typically are cross-trained and, therefore, able to perform multiple tasks as needed.

Centre-of-Gravity Approach A supply chain planning methodology for locating distribution centres at approximately the location representing the minimum transportation costs between the plants, the distribution centres, and the markets.

Centralized Authority Management authority to make decisions is restricted to few managers.

Centralized Dispatching The organization of the dispatching function into one central location. This structure often involves the use of data collection devices for communication between the centralized dispatching function, which usually reports to the production control department, and the shop manufacturing departments.

Centralized Inventory Control Inventory decision-making (for all SKUs) exercised from one office or department for an entire company.

Certificate of Analysis (COA) A certification of conformance to quality standards or specifications for products or materials. It may include a list or reference of analysis results and process information. It is often required for transfer of the custody/ownership/title of materials.

Certificate of Compliance A supplier's certification that the supplies or services in question meet specified-requirements.

Certificate of origin An international business document that certifies the country of origin of the shipment.

Certificate of Public Convenience and Necessity The grant of operating authority that is given to common carriers. A carrier must prove that a public need exists and that the carrier is fit, willing and able to provide the needed service. The certificate may specify the commodities to be hauled, the area to be served and the routes to be used.

Certified Supplier A status awarded to a supplier who consistently meets predetermined quality, cost, delivery, financial and count objectives. Incoming inspection may not be required.

Certificated Carrier A for-hire air carrier that is subject to economic regulation and requires an operating certification to provide service.

CFD *See* Continuous *Flow Distribution*

CGMP *See* Current *Good Manufacturing Practice*

Chain of Customers The sequence of customers who in turn consume the output of each other, forming a chain. For example, individuals are customers of a department store, which in turn is the customer of a producer, who is the customer of a material supplier.

Chain Reaction A chain of events described by W. Edwards Deming: improve quality, decrease costs, improve productivity, increase market with better quality and lower price, stay in business, provide jobs and provide more jobs.

Challenge and Response A method of user authentication. The user enters an ID and password and, in return, is issued a challenge by the system. The system compares the user's response to the challenge to a computed response. If the responses match, the user is allowed access to the system. The system issues a different challenge each time. In effect, it requires a new password for each logon.

Champion A business leader or senior manager who ensures that resources are available for training and projects, and who is involved in project tollgate reviews; also an executive who supports and addresses Six Sigma organizational issues.

Change agent An individual from within or outside an organization who facilitates change within the organization. May or may not be the initiator of the change effort.

Change Management The business process that coordinates and monitors all changes to the business processes and applications operated by the business as well as to their internal equipment, resources, operating systems and procedures. The change management discipline is carried out in a way that minimizes the risk of problems that will affect the operating environment and service delivery to the users.

Change Order A formal notification that a purchase order or shop order must be modified in some way. This change can result from a revised quantity, date, or specification by the customer; an engineering change; a change in inventory requirement date; etc.

Changeover Process of making necessary adjustments to change or switchover the type of products produced on a manufacturing line. Changeovers usually lead to downtime and for the most part companies try to minimize changeover time to help reduce costs.

Channel (1) A method whereby a business dispenses its product, such as a retail or distribution channel, call centre or web-based electronic storefront. (2) A push technology that allows users to subscribe to a website to browse offline, automatically display updated pages on their screen savers, and download or receive notifications when pages in the website are modified. Channels are available only in browsers that support channel definitions, such as Microsoft Internet Explorer version 4.0 and above.

Channel Conflict This occurs when various sales channels within a company's supply chain compete with each other for the same business. An example is where a retail channel is in competition with a web-based channel set up by the company.

Channel Partners Members of a supply chain (i.e. suppliers, manufacturers, distributors, retailers, etc.) who work in conjunction with one another to manufacture, distribute and sell a specific product.

Channels of Distribution Any series of firms or individuals that participates in the flow of goods and services from the raw material supplier and producer to the final user or consumer. *Also see: Distribution Channel*

Charging Area A warehouse area where a company maintains battery chargers and extra batteries to support a fleet of electrically powered materials handling equipment. The company must maintain this area in accordance with government safety regulations.

Chock A wedge, usually made of hard rubber or steel, that is firmly placed under the wheel of a trailer, truck or boxcar to stop it from rolling.

CI *See* Continuous *Improvement*

CIF *See Cost, Insurance, Freight*

City driver A motor carrier driver who drives a local route as opposed to a long-distance, intercity route.

Civil Aeronautics Board A federal regulatory agency that implemented economic regulatory controls over air carriers.

CL Carload rail service requiring shipper to meet minimum weight.

Claim A charge made against a carrier for loss, damage, delay or overcharge.

Class I Carrier A classification of regulated carriers based upon annual operating revenues—motor carriers of property: > or = $5 million; railroads: > or = $50 million; motor carriers of passengers: > or = $3 million.

Class II Carrier A classification of regulated carriers based upon annual operating revenues—motor carriers of property: $1–$5 million; railroads: $10–$50 million; motor carriers of passengers: < or = $3 million.

Class III Carrier A classification of regulated carriers based upon annual operating revenues—motor carriers of property: < or = $1 million; railroads: < or = $10 million.

Classification An alphabetical listing of commodities, the class or rating into which each commodity is placed, and the minimum weight necessary for the rate discount; used in the class rate structure.

Classification yard A railroad terminal area where rail cars are grouped together to form train units.

Class Rate A rate constructed from a classification and a uniform distance system. A class rate is available for any product between any two points.

Clearinghouse A conventional or limited purpose entity generally restricted to providing specialized services, such as clearing funds or settling accounts.

Click-and-Mortar With reference to a traditional brick-and-mortar company that has expanded its presence online. Many brick-and-mortar stores are now trying to establish an online presence but often have a difficult time doing so for many reasons. Click-and-mortar is "the successful combination of online and real world experience".

Clip Art A collection of icons, buttons and other useful image files, along with sound and video files that can be inserted into documents/web pages.

Clipboard A temporary storage area on a computer for cut or copied items.

CLCA *See Closed-loop corrective action*

CLM *See Council of Supply Chain Management Professionals*

Closed-Loop Corrective Action (CLCA) A sophisticated engineering system designed to document, verify and diagnose failures, recommend and initiate corrective action, provide follow-up and maintain comprehensive statistical records.

Closed-Loop MRP A system built around material requirements planning that includes the additional planning processes of production planning (sales and operations planning), master production scheduling and capacity requirements planning. Once this planning phase is complete and the plans have been accepted as realistic and attainable, the execution processes come into play. These processes include the manufacturing control processes of input-output (capacity) measurement, detailed scheduling and dispatching, as well as anticipated delay reports from both the plant and suppliers, supplier scheduling and so on. The term closed loop implies not only that each of these processes is included in the overall system, but also that feedback is provided by the execution processes so that the planning can be kept valid at all times.

CMI *See Co-Managed Inventory*

CMM *See Capability Maturity Model*

COA *See Certificate of Analysis*

Coastal carriers Water carriers that provide service along coasts serving ports on the Atlantic or Pacific oceans or on the Gulf of Mexico

Co-destiny The evolution of a supply chain from intra-organizational management to inter-organizational management.

Co-Packer A contract co-packer produces goods and/or services for other companies, usually under the other company's label or name. Co-Packers are more frequently seen in CPG and Foods.

Co-Managed Inventory (CMI) A form of continuous replenishment in which the manufacturer is responsible for replenishment of standard merchandise, while the retailer manages the replenishment of promotional merchandise.

Code A numeric, or alphanumeric, representation of text for exchanging commonly used information. For example, commodity codes and carrier codes

Codifying The process of detailing a new standard.

COGS *See Cost of Goods Sold*

Collaboration Joint work and communication among people and systems—including business partners, suppliers and customers—to achieve a common business goal.

Collaborative Planning, Forecasting and Replenishment (CPFR) (1) A collaboration process whereby supply chain trading partners can jointly plan key supply chain activities from production and delivery of raw materials to production and delivery of final products to end customers. Collaboration encompasses business planning, sales forecasting and all operations required to replenish raw materials and finished goods. (2) A process philosophy for facilitating collaborative communications. CPFR is considered a standard, endorsed by the Voluntary Inter-industry Commerce Standards.

Collect Freight Freight payable to the carrier at the port of discharge or ultimate destination. The consignee does not pay the freight charge if the cargo does not arrive at the destination.

Combined Lead Time *See Cumulative Lead Time*

Commercial Invoice A document created by the seller. It is an official document which is used to indicate, among other things, the name and address of the buyer and seller, the product(s) being shipped, and their value for customs, insurance, or other purposes.

Commercial Off-the-Shelf (COTS) A computer software industry term which describes software which is offered for sale by commercial developers. This includes products from vendors such as SAP, Oracle and Microsoft and all of the smaller vendors.

Commercial Zone The area surrounding a city or town to which rates quoted for the city or town also apply; the area is defined by the ICC.

Committee of American Steamship Lines An industry association representing subsidized U.S. Flag steamship firms.

Committed Capability The portion of the production capability that is currently in use, or is scheduled for use.

Commodities clause A clause that prohibits railroads from hauling commodities that they produced, mined, owned or had an interest in.

Commodity An item that is traded in commerce. The term usually implies an undifferentiated product competing primarily on price and availability.

Commodity Buying Grouping like parts or materials under one buyer's control for the procurement of all requirements to support production.

Commodity Code A code describing a commodity or a group of commodities pertaining to goods classification. This code can be carrier tariff or regulating in nature.

Commodity Procurement Strategy The purchasing plan for a family of items. This would include the plan to manage the supplier base and solve problems.

Commodity rate A rate for a specific commodity and its origin-destination.

Common Carrier Transportation available to the public that does not provide special treatment to any one party and is regulated as to the rates charged, the liability assumed and the service provided. A common carrier must obtain a certificate of public convenience and necessity from the Federal Trade Commission for interstate traffic.

Common Carrier Duties Common carriers are required to serve, deliver, charge reasonable rates and not discriminate.

Common Cost A cost that cannot be directly assignable to particular segments of the business but that is incurred for the business as a whole.

Commuter An exempt for-hire air carrier that publishes a time schedule on specific routes; a special type of air taxi.

Communication Protocol The method by which two computers coordinate their communications. BISYNC and MNP are two examples.

Company Culture A system of values, beliefs and behaviours inherent in a company. To optimize business performance, top management must define and create the necessary culture.

Comparative Advantage A principle based on the assumption that an area will specialize in the production of goods for which it has the greatest advantage or least comparative disadvantage.

Competitive Advantage Value created by a company for its customers that clearly distinguishes it from the competition, and provides its customers a reason to remain loyal.

Competitive Benchmarking Benchmarking a product or service against competitors. *Also see: Benchmarking*

Competitive Bid A price/service offering by a supplier that must compete with offerings from other suppliers.

Complete and On-Time Delivery (COTD) A measure of customer service. All items on any given order must be delivered on time for the order to be considered as complete and on time.

Complete Manufacture to Ship Time Average time from when a unit is declared shippable by manufacturing until the unit actually ships to a customer.

Compliance Meaning that products, services, processes and/or documents comply with requirements.

Compliance Checking The function of EDI processing software that ensures that all transmissions contain the mandatory information demanded by the EDI standard. Compares information sent by an EDI user against EDI standards and reports exceptions. Does not ensure that documents are complete and fully accurate, but does reject transmissions with missing data elements or syntax errors.

Compliance Monitoring A check done by the VAN/third-party network or the translation software to ensure the data being exchanged is in the correct format for the standard being used.

Compliance Program A method by which two or more EDI trading partners periodically report conformity to agreed upon standards of control and audit. Management produces statements of compliance, which briefly note any exceptions, as well as corrective action planned or taken, in accordance with operating rules. Auditors produce an independent and objective statement of opinion on management statements.

Component Material that will contribute to a finished product but is not the finished product itself. Examples would include tyres for an automobile, power supply for a personal computer or a zipper for a ski parka. Note that what is a component to the manufacturer may be considered the finished product of their supplier.

Computer-Aided Design (CAD) Computer-based systems for product design that may incorporate analytical and “what if” capabilities to optimize product designs. Many CAD systems capture geometric and other product characteristics for engineering-data-management systems, producibility and cost analysis, and performance analysis. In many cases, CAD-generated data.

Computer-Aided Engineering (CAE) The use of computers to model design options to stimulate their performance.

Computer-Aided Manufacturing (CAM) Computerized systems in which manufacturing instructions are downloaded to automated equipment or to operator workstations.

Computer-Aided Process Planning (CAPP) Software-based systems that aid manufacturing engineers in creating a process plan to manufacture a product whose geometric, electronic and other characteristics have been captured in a CAD database. CAPP systems address such manufacturing criteria as target costs, target lead times, and anticipated production volumes.

Computer-Based Training (CBT) Training that is delivered via computer workstation and includes all training and testing materials.

Computer-Integrated Manufacturing (CIM) A variety of approaches in which computer systems communicate or interoperate over a local-area network. Typically, CIM systems link management functions with engineering, manufacturing and support operations. In the factory, CIM systems may control the sequencing of production operations, control operation of automated equipment and conveyor systems, transmit manufacturing instructions, capture data at various stages of the manufacturing or assembly process, facilitate tracking and analysis of test results and operating parameters, or a combination of these.

Computerized Maintenance Management Systems (CMMS) Software-based systems that analyse operating conditions of production equipment—vibration, oil analysis, heat, etc.—and equipment-failure data, and apply that data to the scheduling of maintenance and repair inventory orders and routine maintenance functions. A CMMS prevents unscheduled machine downtime and optimizes a plant's ability to process product at optimum volumes and quality levels.

Computerized Process Simulation Use of computer simulation to facilitate sequencing of production operations, analysis of production flows and layout of manufacturing facilities.

Computerized SPC *See Statistical process control*

Concurrent Engineering A cross-functional, team-based approach in which the product and the manufacturing process are designed and configured within the same time frame, rather than sequentially. Ease and cost of manufacturability, as well as customer needs, quality issues and product-life-cycle costs are taken into account earlier in the development cycle. Fully configured concurrent engineering teams include representation from marketing, design engineering, manufacturing engineering and purchasing, as well as supplier—and even customer—companies.

Configuration The arrangement of components as specified to produce an assembly.

Configure/Package-to-Order A process where the trigger to begin manufacture, final assembly or packaging of a product is an actual customer order or release, rather than a market forecast. In order to be considered a Configure-to-Order environment, less than 20% of the value-added takes place after the receipt of the order or release, and virtually all necessary design and process documentation is available at time of order receipt.

Confirmation With regards to EDI, a formal notice (by message or code) from a electronic mailbox system or EDI server indicating that a message sent to a trading partner has reached its intended mailbox or been retrieved by the addressee.

Confirming Order A purchase order issued to a supplier, listing the goods or services and terms of an order placed orally or otherwise before the usual purchase document.

Conformance An affirmative indication or judgment that a product or service has met the requirements of a relevant specification, contract or regulation. *Synonym: Compliance*

Conrail The Consolidated Rail Corporation established by the Regional Reorganization Act of 1973 to operate the bankrupt Penn Central Railroad and other bankrupt railroads in the Northeast; funding was provided by the 4-R Act of 1976.

Consensus A state in which all the members of a group support an action or decision, even if some of them don't fully agree with it.

Consignee The party to whom goods are shipped and delivered. The receiver of a freight shipment.

Consignment (1) A shipment that is handled by a common carrier. (2) The process of a supplier placing goods at a customer location without receiving payment until after the goods are used or sold.*Also see: Consignment Inventory*

Consignment Inventory (1) Goods or product that are paid for when they are sold by the reseller, not at the time they are shipped to the reseller. (2) Goods or products which are owned by the vendor until they are sold to the consumer.

Consignor The party who originates a shipment of goods (shipper). The sender of a freight shipment, usually the seller.

Consolidation Combining two or more shipments in order to realize lower transportation rates. Inbound consolidation from vendors is called make-bulk consolidation; outbound consolidation to customers is called break-bulk consolidation.

Consolidator An enterprise that provides services to group shipments, orders and/or goods to facilitate movement.

Consortium A group of companies that work together to jointly produce a product, service or project.

Constraint A bottleneck, obstacle or planned control that limits throughput or the utilization of capacity.

Consul A government official residing in a foreign country, charged with representing the interests of his or her country and its nationals.

Consular Declaration A formal statement made to the consul of a country describing merchandise to be shipped to that consul's country. Approval must be obtained prior to shipment.

Consular Documents Special forms signed by the consul of a country to which cargo is destined.

Consular Invoice A document, required by some foreign countries, describing a shipment of goods and showing information such as the consignor, consignee and value of the shipment. Certified by a consular official of the foreign country, it is used by the country's custom.

Consumer-Centric Database Database with information about a retailer's individual consumers, used primarily for marketing and promotion.

Consumer Packaged Goods (CPG) Consumable goods such as food and beverages, footwear and apparel, tobacco, and cleaning products. In general, CPGs are things that get used up and have to be replaced frequently, in contrast to items that people usually keep for a long time, such as cars and furniture.

Consuming the Forecast The process of reducing the forecast by customer orders or other types of actual demands as they are received. The adjustments yield the value of the remaining forecast for each period.

Consumption Entry An official Customs form used for declaration of reported goods, also showing the total duty due on such transaction.

Contactless Refers to the practice of using RFID, Smart Card or other forms of Near Field Communications technology to gather data electronically without the need to actually make contact physically with the item.

Container (1) A "box", typically 10–40 feet long, which is primarily used for ocean freight shipments. For travel to and from ports, containers are loaded onto truck chassis or on railroad flatcars. (2) The packaging, such as a carton, case, box, bucket, drum, bin, bottle, bundle or bag, that an item is packed and shipped in.

Container Security Initiative (CSI) U.S. Customs program to prevent global containerized cargo from being exploited by terrorists. Designed to enhance security of sea cargo container.

Containerization A shipment method in which commodities are placed in containers, and after initial loading, the commodities per se are not re-handled in shipment until they are unloaded at the destination.

Contingency Planning Preparing to deal with calamities (e.g. floods) and non-calamitous situations (e.g. strikes) before they occur.

Continuous Flow Distribution (CFD) The streamlined pull of products in response to customer requirements while minimizing the total costs of distribution.

Continuous-Flow, Fixed-Path Equipment Materials handling devices that include conveyors and drag lines.

Continuous Improvement (CI) A structured measurement driven process that continually reviews and improves performance.

Continuous Process Improvement (CPI) A never-ending effort to expose and eliminate root causes of problems; small-step improvement as opposed to big-step improvement. *Synonym: Continuous Improvement. Also see: Kaizen*

Continuous Replenishment Continuous Replenishment is the practice of partnering between distribution channel members that changes the traditional replenishment process from distributor-generated purchase orders, based on economic order quantities, to the replenishment of products based on actual and forecasted product demand.

Continuous Replenishment Planning (CRP) A program that triggers the manufacturing and movement of product through the supply chain when the identical product is purchased by an end user.

Contract An agreement between two or more competent persons or companies to perform or not to perform specific acts or services or to deliver merchandise. A contract may be oral or written. A purchase order, when accepted by a supplier, becomes a contract. Acceptance may be in writing or by performance, unless the purchase order requires acceptance in writing.

Contract Administration Managing all aspects of a contract to guarantee that the contractor fulfils his obligations.

Contract Carrier A carrier that does not serve the general public, but provides transportation for hire for one or a limited number of shippers under a specific contract.

Contribution The difference between sales price and variable costs. Contribution is used to cover fixed costs and profits.

Contribution Margin An amount equal to the difference between sales revenue and variable costs.

Controlled Access Referring to an area within a warehouse or yard that is fenced and gated. These areas are typically used to store high-value items and may be monitored by security cameras

Conveyor A materials handling device that moves freight from one area to another in a warehouse. Roller conveyors make use of gravity, whereas belt conveyors use motors.

Cookie A computer term. A piece of information from your computer that references what the user has clicked on, or references information that is stored in a text file on the user's hard drive (such as a username). Another way to describe cookies is to say they are tiny files containing information about individual computers that can be used by advertisers to track online interests and tastes. Cookies are also used in the process of purchasing items on the Web. It is because of the cookie that the "shopping cart" technology works. By saving in a text file, the name, and other important information about an item a user "clicks" on as they move through a shopping Website, a user can later go to an order form, and see all the items he selected, ready for quick and easy processing.

Cooperative Associations Groups of firms or individuals having common interests: agricultural cooperative associations may haul up to 25% of their total interstate tonnage in nonfarm, nonmenber goods in movements incidental and necessary to their primary business.

Co-opetition A combination of cooperation and competition that offers the counter intuitive possibility for rivals to benefit from each other's seemingly competitive activities. In short, there are circumstances where having more players to cut the pie means bigger pieces of pie for everyone. An example would be found in the group buying setting where its use refers to the activity of multiple, normally competitive buying group members leveraging each other's buying power to gain reduced pricing.

Coordinated Transportation Two or more carriers of different modes transporting a shipment.

Co-product The term co-product is used to describe multiple items that are produced simultaneously during a production run. Co-products are often used to increase yields in cutting operations such as die cutting or sawing when it is found that scrap can be reduced by combining multiple-sized products in a single production run. Co-products are also used to reduce the frequency of machine setups required in these same types of operations. Co-products, also known as by-products, are also common in process manufacturing such as in chemical plants. Although the concept of co-products is fairly simple, the programming logic required to provide for planning and processing of co-products is very complicated.

Core Competency Bundles of skills or knowledge sets that enable a firm to provide the greatest level of value to its customers in a way that is difficult for competitors to emulate and that provides for future growth. Core competencies are embodied in the skills of the workers and in the organization. They are developed through communication and commitment to work across levels and functions in the organization and with the customers and suppliers. For example, a core competency could be the capability of a firm to coordinate and harmonize diverse production skills and multiple technologies. To illustrate, advanced casting processes for making steel require the integration of machine design with sophisticated sensors to track temperature and speed, and the sensors require mathematical modelling of heat transfer. For rapid and effective development of such a process, materials scientists must work closely with machine designers, software engineers, process specialists and operating personnel. Core competencies are not directly related to the product or market.

Core Process That unique capability that is central to a company's competitive strategy.

Cost Accounting The branch of accounting that is concerned with recording and reporting business operating costs. It includes the reporting of costs by departments, activities and products.

Cost Allocation In accounting, the assignment of costs that cannot be directly related to production activities via more measurable means, e.g. assigning corporate expenses to different products via direct labour costs or hours.

Cost Centre In accounting, a sub-unit in an organization that is responsible for costs.

Cost Driver In accounting, any situation or event that causes a change in the consumption of a resource, or influences quality or cycle time. An activity may have multiple cost drivers. Cost drivers do not necessarily need to be quantified; however, they strongly influence the selection and magnitude of resource drivers and activity drivers.

Cost Driver Analysis In cost accounting, the examination, quantification and explanation of the effects of cost drivers. The results are often used for continuous improvement programs to reduce throughput times, improve quality and reduce cost.

Cost Element In cost accounting, the lowest level component of a resource, activity, or cost object.

Cost, Insurance, Freight (CIF) A freight term indicating that the seller is responsible for cost, the marine insurance and the freight charges on an ocean shipment of goods.

Cost Management The management and control of activities and drivers to calculate accurate product and service costs, improve business processes, eliminate waste, influence cost drivers and plan operations. The resulting information will have utility in setting and evaluating an organization's strategies.

Cost of Capital The cost to borrow or invest capital.

Cost of Goods Sold (COGS) The amount of direct materials, direct labour and allocated overhead associated with products sold during a given period of time, determined in accordance with Generally Accepted Accounting Principles (GAAP)

Cost of lost sales The forgone profit associated with a stockout.

Cost Trade-off The interrelationship among system variables indicates that a change in one variable has cost impact upon other variables. A cost reduction in one variable may be at the expense of increased cost for other variables, and vice versa.

Cost Variance In cost accounting, the difference between what has been budgeted for an activity and what it actually costs.

COTD *See Complete and On-Time Delivery*

COTS *See Commercial Off-the-Shelf*

Courier Service A fast, door-to-door service for high-valued goods and documents; firms usually limit service to shipments of 50 pounds or less.

Council of Logistics Management (CLM) *See Council of Supply Chain Management Professionals.*

Council of Supply Chain Management Professionals (CSCMP) The CSCMP is a not-for-profit professional business organization consisting of individuals throughout the world who have interests and/or responsibilities in logistics and supply chain management, and the related functions that make up these professions. Its purpose is to enhance the development of the logistics and supply chain management professions by providing these individuals with educational opportunities and relevant information through a variety of programs, services and activities.

CPFR *See Collaborative Planning Forecasting and Replenishment*

CPG *See Consumer Packaged Goods*

CPI *See Continuous Process Improvement*

Credit Level The amount of purchasing credit a customer has available. Usually defined by the internal credit department and reduced by any existing unpaid bills or open orders.

Critical Differentiators This is what makes an idea, product, service or business model unique.

Critical value analysis A modified ABC analysis in which a subjective value of criticalness is assigned to each item in the inventory.

Cross-Docking A distribution system in which merchandise received at the warehouse or distribution centre is not put away, but instead is readied for shipment to retail stores. Cross-docking requires close synchronization of all inbound and outbound shipment movements. By eliminating the put-away, storage and selection operations, it can significantly reduce distribution costs.

Cross-Functional A term used to describe a process or an activity that crosses the boundary between functions. A cross-functional team consists of individuals from more than one organizational unit or function.

Cross-Functional "Process" Metric A number resulting from an equation, showing the output of a process that spans departments. These types of measures are also known as process measures because they span across the breadth of a process, regardless of functional/departmental segregation within the process. Example: Perfect Order Index

Cross-Sell The practice of attempting to sell additional products to a customer during a sales call. For example, when the CSR presents a camera case and accessories to a customer that is ordering a camera.

Cross-Shipment Material flow activity where materials are shipped to customers from a secondary shipping point rather than from a preferred shipping point.

Cross-Subsidy In cost accounting, the inequitable assignment of costs to cost objects, which leads to over costing or under costing them relative to the amount of activities and resources actually consumed. This may result in poor management decisions that are inconsistent with the economic goals of the organization.

CRP *See Continuous Replenishment Program*

Critical Success Factor (CSF) Those activities and/or processes that must be completed and/or controlled to enable a company to reach its goals.

CRM *See Customer Relationship Management*

CSCMP *See Council of Supply Chain Management Professionals*

CSF *See Critical Success Factor*

CSI *See Container Security Initiative*

CSR *See Customer Service Representative*

CTP *See Capacity to Promise*

C-TPAT *See Customs-Trade Partnership against Terrorism*

Cube The volume of the shipment or package (the product of the length × width × depth).

Cubage Cubic volume of space being used or available for shipping or storage.

Cube Utilization In warehousing, a measurement of the utilization of the total storage capacity of a vehicle or warehouse.

Cubic Space In warehousing, a measurement of space available or required in transportation and warehousing.

Cumulative Available-to-Promise A calculation based on the available-to-promise (ATP) figure in the master schedule. Two methods of computing the cumulative available-to-promise are used, with and without lookahead calculation. The cumulative with lookahead ATP equals the ATP from the previous period plus the MPS of the period minus the backlog of the period minus the sum of the differences between the backlogs and MPSs of all future periods until, but not to include, the period where point production exceeds the backlogs. The cumulative without lookahead procedure equals the ATP in the previous period plus the MPS, minus the backlog in the period being considered. *Also see: Available-to-Promise*

Cumulative Lead Time The total time required to source components, build and ship a product.

Cumulative Source/Make Cycle Time The cumulative internal and external lead time to manufacture shippable product, assuming that there is no inventory on-hand, no materials or parts on order, and no prior forecasts existing with suppliers. (An element of Total Supply Chain Response Time)*Calculation:The critical path along the following elements: Total Sourcing Lead Time, Manufacturing Order Release to Start Manufacturing, Total Manufacture Cycle Time (Make-to-Order, Engineer-to-Order, Configure/Package-to-Order) or Manufacture Cycle*

*Time (Make-to-Stock), Complete Manufacture to Ship Time*Note: Determined separately for Make-to-Order, Configure/Package-to-Order, Engineer-to-Order and Make-to-Stock products

Currency Adjustment Factor (CAF) An added charge assessed by water carriers for currency value changes.

Current Good Manufacturing Practices (CGMP) Regulations enforced by the U.S. Food and Drug Administration for food and chemical manufacturers and packagers.

Customer (1) In distribution, the Trading Partner or reseller, i.e. Wal-Mart, Safeway, or CVS. (2) In Direct-to-Consumer, the end customer or user.

Customer Acquisition or Retention The rate by which new customers are acquired, or existing customers are retained. A key selling point to potential marquis partners. *Also see: Marquis Partner*

Customer Driven The end user, or customer, motivates what is produced or how it is delivered.

Customer Facing Those personnel whose jobs entail actual contact with the customer.

Customer Interaction Center *See Call Centre*

Customer Order An order from a customer for a particular product or a number of products. It is often referred to as an actual demand to distinguish it from a forecasted demand.

Customer/Order Fulfilment Process A series of customers' interactions with an organization through the order filling process, including product/service design, production and delivery, and order status reporting.

Customer Profitability The practice of placing a value on the profit generated by business done with a particular customer.

Customer Receipt of Order to Installation Complete Average lead-time from receipt of goods at the customer to the time when installation (if applicable) is complete, including the following sub-elements: time to get product up and running, and product acceptance by customer. (An element of Order Fulfilment Lead Time)Note: Determined separately for Make-to-Order, Configure/Package-to-Order, Engineer-to-Order and Make-to-Stock products.

Customer Relationship Management (CRM) This refers to information systems that help sales and marketing functions, as opposed to the ERP (Enterprise Resource Planning), which is for back-end integration.

Customer Segmentation Dividing customers into groups based on specific criteria, such as products purchased and customer geographic location.

Customer Service Activities between the buyer and seller that enhance or facilitate the sale or use of the seller's products or services.

Customer Service Ratio *See* Percent *of Fill*

Customer Service Representative (CSR) The individual who provides customer support via telephone in a call centre environment.

Customer Signature/Authorization to Order Receipt Average lead-time from when a customer authorizes an order to the time that that order is received and order entry can commence. (An element of Order Fulfilment Lead Time)

Note: Determined separately for Make-to-Order, Configure/Package-to-Order, Engineer-to-Order and Make-to-Stock products.

Customer-Supplier Partnership A long-term relationship between a buyer and a supplier characterized by teamwork and mutual confidence. The supplier is considered an extension of the buyer's organization. The partnership is based on several commitments. The buyer provides long-term contracts and uses fewer suppliers. The supplier implements quality assurance processes so that incoming inspection can be minimized. The supplier also helps the buyer reduce costs and improve product and process designs.

Customization Creating a product from existing components into an individual order. Synonym: Build to Order.

Customs and Border Protection, U.S. (CBP) Formed during the creation of the Department of Homeland Security in 2003, CBP consists primarily of the customs inspection function formerly performed by the U.S. Customs Service as part of the Department of Treasury, the immigration inspection function formerly performed by the Immigration and Naturalization Service (INS), and the Border Patrol, formerly part of the Department of Justice.

Customs House Broker A business firm that oversees the movement of international shipments through customs and ensures that the documentation accompanying a shipment is complete and accurate.

Customs-Trade Partnership against Terrorism (C-TPAT) A joint government/business initiative to build cooperative relationships that strengthen overall supply chain and border security. The voluntary program is designed to share information that will protect against terrorists' compromising the supply chain.

CWT *See* Hundredweight

Cycle Counting An inventory accuracy audit technique where inventory is counted on a cyclic schedule rather than once a year. A cycle inventory count is usually taken on a regular, defined basis (often more frequently for high-value or fast-moving items and less frequently for low-value or slow-moving items). Most effective cycle counting systems require the counting of a certain number of items every workday with each item counted at a prescribed frequency. The key purpose of cycle counting is to identify items in error, thus triggering research, identification and elimination of the cause of the errors.

Cycle Inventory An inventory system where counts are performed continuously, often eliminating the need for an annual overall inventory. It is usually set up so that A items are counted regularly (i.e. every month), B items are counted semi-regularly (every quarter or 6 months) and C items are counted perhaps only once a year.

Cycle Time The amount of time it takes to complete a business process.

Cycle Time to Process Excess Product Returns for Resale The total time to process goods returned as Excess by customer or distribution centres, in preparation for resale. This cycle time includes the time a Return Product Authorization (RPA) is created to the time the RPA is approved, from Product Available for Pick-up to Product Received and from Product Receipt to Product Available for use.

Cycle Time to Process Obsolete and End-of-Life Product Returns for Disposal The total time to process goods returned as Obsolete and End of Life to actual Disposal. This cycle time includes the time a Return Product Authorization (RPA) is created to the time the RPA is approved, from Product Available for Pick-up to Product Received and from Product Receipt to Product Disposal/Recycle.

Cycle Time to Repair or Refurbish Returns for Use The total time to process goods returned for repair or refurbishing. This cycle time includes the time a Return Product Authorization (RPA) is created to the time the RPA is approved, from Product Available for Pick-up to Product Received, from Product Receipt to Product Repair/Refurbish begin, and from Product Repair/Refurbish begin to Product Available for use.

Cyclical Demand A situation where demand patterns for a product run in cycles driven by seasonality or other predictable factors.

D

Dangerous Goods Articles or substances capable of posing significant health, safety or environmental risk, and that ordinarily require special attention including packaging and labelling when stored or transported. *Also referred to as Hazardous Goods or Hazardous Materials (HazMat).*

Dashboard A performance measurement tool used to capture a summary of the Key Performance Indicators (KPIs)/metrics of a company. Metrics dashboards/scorecards should be easy to read and usually have "red, yellow, green" indicators to flag when the company is not meeting its metrics targets. Ideally, a dashboard/scorecard should be cross-functional in nature and include both financial and non-financial measures. In addition, scorecards should be reviewed regularly—at least on a monthly basis and weekly in key functions such as manufacturing and distribution where activities are critical to the success of a company. The dashboard/scorecards philosophy can also be applied to external supply chain partners such as suppliers to ensure that supplier's objectives and practices align. *Synonym: Scorecard*

Data Communications The electronic transmission of data, usually in computer-readable form, using a variety of transmission vehicles and paths.

Data Dictionary Lists the data elements for which standards exist. The Joint Electronic Document Interchange (JEDI) committee developed a data dictionary that is employed by many EDI users.

Data Interchange Standards Association (DISA) The secretariat, which provides clerical and administrative support to the ASC X12 Committee.

Data Mining The process of studying data to search for previously unknown relationships. This knowledge is then applied to achieving specific business goals.

Data Warehouse A repository of data that has been specially prepared to support decision-making applications. *Synonym: Decision-Support Data*

Database Data stored in computer-readable form, usually indexed or sorted in a logical order by which users can find a particular item of data they need.

Date Code A label on products with the date of production. In food industries, it is often an integral part of the lot number.

Days of Supply Measure of quantity of inventory-on-hand, in relation to number of days for which usage which will be covered. For example, if a component is consumed in manufacturing at the rate of 100 per day, and there are 1585 units available on-hand, this represents 15.85 days' supply.

Days Sales Outstanding (DSO) Measurement of the average collection period (time from invoicing to cash receipt).*Calculation:[5 Point Annual Gross Accounts Receivables]/[Total Annual Sales/365]*

DBR See *Drum-Buffer-Rope*

DC See *Distribution Centre*

DD *See Direct Debit*

DDSN *See Demand-Driven Supply Network*

Dead on Arrival (DOA) A term used to describe products which are not functional when delivered. Synonym: Defective.

Deadhead The return of an empty transportation container to its point of origin. See: backhauling.

Deadweight The total lifting capacity of a ship expressed in tons of 2240 lbs. It is the difference between the displacement light (without cargo, passengers, fuel, etc.) and the displacement loaded.

Decentralized Authority A situation in which management decision-making authority is given to managers at many levels in the organizational hierarchy.

Decision Support System (DSS) Software that speeds access and simplifies data analysis, queries, etc. within a database management system.

Declaration of Dangerous Goods To comply with the US regulations, exporters are required to provide special notices to inland and ocean transport companies when goods are hazardous.

Declared Value The value of the goods, declared by the shipper on a bill of lading, for the purpose of determining a freight rate or the limit of the carrier's liability. Also used by customs as the basis for calculation of duties, etc.

Decomposition A method of forecasting where time series data are separated into up to three components: trend, seasonal and cyclical; where trend includes the general horizontal upward or downward movement over time; seasonal includes a recurring demand pattern such as day of the week, weekly, monthly or quarterly; and cyclical includes any repeating, non-seasonal pattern. A fourth component is random, that is, data with no pattern. The new forecast is made by projecting the patterns individually determined and then combining them.

Dedicated Contract Carriage A third-party service that dedicates equipment (vehicles) and drivers to a single customer for its exclusive use on a contractual basis.

Defective goods inventory (DGI) Those items that have been returned, have been delivered damaged and have a freight claim outstanding, or have been damaged in some way during warehouse handling.

Delimiters (1) ASCII, characters which are used to separate data elements within a data stream. (2) EDI, two levels of separators and a terminator that are integral parts of a transferred data stream. Delimiters are specified in the interchange header. From highest to lowest level, the separators and terminator are segment terminator, data element separator, and component element separator (used only in EDIFACT).

Delivery-Duty-Paid Supplier/manufacturer arrangement in which suppliers are responsible for the transport of the goods they have produced, which is being sent to a manufacturer. This responsibility includes tasks such as ensuring products get through Customs.

Delivery Appointment The time agreed upon between two enterprises for goods or transportation equipment to arrive at a selected location. Typically used to help plan warehouse and receiving/inspection operations and to manage backup of carriers at loading docks.

Delivery Performance to Commit Date The percentage of orders that are fulfilled on or before the internal Commit date, used as a measure of internal scheduling systems effectiveness. Delivery measurements are based on the date a complete order is shipped or the ship-to date of a complete order. A complete order has all items on the order delivered in the quantities requested. An order must be complete to be considered fulfilled. Multiple line items on a single order with different planned delivery dates constitute multiple orders, and multiple planned delivery dates on a single line item also constitute multiple orders.*Calculation:[Total number of orders delivered in full and on time to the scheduled commit date]/[Total number of orders delivered]*

Delivery Performance to Request Date The percentage of orders that are fulfilled on or before the customer's requested date used as a measure of responsiveness to market demand. Delivery measurements are based on the date a complete order is shipped or the ship-to date of a complete order. A complete order has all items on the order delivered in the quantities requested. An order must be complete to be considered fulfilled. Multiple line items on a single order with different planned delivery dates constitute multiple orders, and multiple planned delivery dates on a single line item also constitute multiple orders.*Calculation:[Total number of orders delivered in full and on time to the customer's request date]/[Total number of orders delivered]*

Delphi Method A qualitative forecasting technique where the opinions of experts are combined in a series of iterations. The results of each iteration are used to develop the next, so that convergence of the experts' opinions is obtained.

Delta Nu Alpha A professional association of transportation and traffic practitioners.

Demand Chain Another name for the supply chain, with emphasis on customer or end-user demand pulling materials and product through the chain.

Demand Chain Management Same as supply chain management, but with emphasis on consumer pull versus supplier push.

Demand-Driven Supply Network (DDSN) A system of technologies and processes that sense and react to real-time demand across a network of customers, suppliers and employees. In other words, a consumer purchase triggers real-time information movement throughout the supply network, which then initiates movement of product through the network.

Demand Management The proactive compilation of requirements information regarding demand (i.e. customers, sales, marketing, finance) and the firm's capabilities from the supply side (i.e. supply, operations and logistics management); the development of a consensus regarding the ability to match the requirements and capabilities; and the agreement upon a synthesized plan that can most effectively meet the customer requirements within the constraints imposed by supply chain capabilities.

Demand Planning The process of identifying, aggregating and prioritizing, all sources of demand for the integrated supply chain of a product or service at the appropriate level, horizon and interval.The sales forecast is comprised of the following concepts:1. The *sales forecasting level* is the focal point in the corporate hierarchy where the forecast is needed at the most generic level, i.e. Corporate forecast, Divisional forecast, Product Line forecast, SKU, SKU by Location.2. The *sales forecasting time horizon* generally coincides with the time frame of the plan for which it was developed, i.e. Annual, 1–5 years, 1–6 months, Daily, Weekly, Monthly.3. The *sales forecasting time interval* generally coincides with how often the plan is updated, i.e. Daily, Weekly, Monthly and Quarterly.

Demand Planning Systems The systems that assist in the process of identifying, aggregating and prioritizing, all sources of demand for the integrated supply chain of a product or service at the appropriate level, horizon and interval.

Demand Pull The triggering of material movement to a work centre only when that work centre is ready to begin the next job. It in effect eliminates the queue from in front of a work centre, but it can cause a queue at the end of a previous work centre.

Demand-Side Analysis Techniques such as market research, surveys, focus groups and Performance/cost modelling used to identify emerging technologies.

Demand Signal A signal from a consumer, customer or using operation that triggers the issue of product or raw material. The demand signal is most efficiently an electronic data transmission, but could be a physical document, Kanban or telephone call.

Demand Supply Balancing The process of identifying and measuring the gaps and imbalances between demand and resources in order to determine how to best resolve the variances through marketing, pricing, packaging, warehousing, outsource plans or some other action that will optimize service, flexibility, costs, assets (or other supply chain inconsistencies) in an iterative and collaborative environment.

Demand Time Fence (DTF) (1) That point in time inside of which the forecast is no longer included in total demand and projected available inventory calculations; inside this point, only customer orders are considered. Beyond this point, total demand is a combination of actual orders and forecasts, depending on the forecast consumption technique chosen. (2) In some contexts, the demand time fence may correspond to that point in the future inside which changes to the master schedule must be approved by an authority higher than the master scheduler. Note, however, that customer orders may still be promised inside the demand time fence without higher authority approval if there are quantities available-to-promise (ATP). Beyond the demand time fence, the master scheduler may change the MPS within the limits of established rescheduling rules, without the approval of higher authority. See: planning time fence, time fence.

De-Manufacturing Refers to the process of going in and taking back assets and harvesting the components and parts. After the components are tested, they may be sold into the secondary market or may be upgraded to "as new" and used in production again.

Deming Circle The concept of a continuously rotating wheel of plan-do-check-action (PDCA) used to show the need for interaction among market research, design, production and sales to improve quality. *Also see: Plan-Do-Check-Action*

Demographic Segmentation In marketing, dividing potential markets by characteristics of potential customers, such as age, sex, income and education.

Demurrage The carrier charges and fees applied when rail freight cars and ships are retained beyond a specified loading or unloading time. *Also see: Detention, Express*

Denied Party List (DPL) A list of organizations that are unauthorized to submit a bid for an activity or to receive a specific product. For example, some countries have bans for certain products such as weapons or sensitive technology.

Density A physical characteristic of a commodity measuring its mass per unit volume or pounds per cubic foot; an important factor in rate making, since density affects the utilization of a carrier's vehicle.

Density Rate A rate based upon the density and shipment weight.

Deregulation Revisions or complete elimination of economic regulations controlling transportation. The Motor Carrier Act of 1980 and the Staggers Act of 1980 revised the economic controls over motor carriers and railroads, and the Airline Deregulation Act of 1978 eliminated economic controls over air carriers.

Derived Demand Demand for component products that arises from the demand for final design products. For example, the demand for steel is derived from the demand for automobiles.

Design for Manufacture/Assembly (DFMA) A product design methodology that provides a quantitative evaluation of product designs.

Design of Experiments (DoE) A branch of applied statistics dealing with planning, conducting, analysing and interpreting controlled tests to evaluate the factors that control the value of a parameter or group of parameters.

Destination-Enhanced Consolidation Ganging of smaller shipments to cut cost, often as directed by a system or via pooling with a third party.

Detention The carrier charges and fees applied when rail freight cars and ships are retained beyond a specified loading or unloading time. *Also see: Demurrage, Express*

Deterministic Models Models where no uncertainty is included, e.g. inventory models without safety stock considerations.

DFMA *See Design for Manufacture/Assembly*

DFZ *See Duty-Free Zone*

DGI *See Defective Goods Inventory*

Dial Up Access a network by dialling a phone number or initiating a computer to dial the number. The dial-up line connects to the network access point via a node or a PAD.

Differential A discount offered by a carrier that faces a service time disadvantage over a route.

Digital Signature Electronically generated, digitized (as opposed to graphically created) authorization that is uniquely linkable and traceable to an empowered officer.

Direct Channel Your own sales force sells to the customer. Your entity may ship to the customer, or a third party may handle shipment, but in either case your entity owns the sales contract and retains rights to the receivable from the customer. Your end customer may be a retail outlet. The movement to the customer may be direct from the factory, or the product may move through a distribution network owned by your company. Order information in this channel may be transmitted by electronic means.

Direct Cost A cost that can be directly traced to a cost object since a direct or repeatable cause-and-effect relationship exists. A direct cost uses a direct assignment or cost causal relationship to transfer costs. *Also see: Indirect Cost, Tracing*

Direct Debit (DD) A method of ACH collection used where the debtor gives authorization to debit his or her account upon the receipt of an entry issued by a creditor. *See also automated clearinghouse*

Direct Product Profitability (DPP) Calculation of the net profit contribution attributable to a specific product or product line.

Direct Production Material Material that is used in the manufacturing/content of a product (example: Purchased parts, solder, SMT glues, adhesives, mechanical parts etc. Bill-of-Materials parts, etc.)

Direct Retail Locations A retail location that purchases products directly from your organization or responding entity.

Direct Store Delivery (DSD) Process of shipping direct from a manufacturer's plant or distribution centre to the customer's retail store, thus bypassing the customer's distribution centre. Also called Direct-to-Store Delivery

Direct Transmission A transmission whereby data is exchanged directly between sender and receiver computers, without an intervening third-party service. *Also called a point-to-point transmission*

Direct-to-Store (DTS) Delivery Same as Direct Store Delivery.

Directed tasks Tasks that can be completed based upon detailed information provided by the computer system. An order picking task where the computer details the specific item, location and quantity to pick is an example of a directed task. If the computer could not specify the location and quantity forcing the worker to choose locations or change quantities, it would not be a directed task. Directed tasks set up the opportunity for confirmation transactions.

DISA *See Data Interchange Standards Association.*

Disaster Recovery Planning Contingency planning, specifically software (e.g. data centres, application software, operations, information system outages).

Discontinuous Demand A demand pattern that is characterized by large demands interrupted by periods with no demand, as opposed to a continuous or steady (e.g. daily) demand. Synonym: Lumpy Demand.

Discrete Available-to-Promise A calculation based on the available-to-promise figure in the master schedule. For the first period, the ATP is the sum of the beginning inventory plus the MPS quantity minus backlog for all periods until the item is master scheduled again. For all other periods, if a quantity has been scheduled for that time period then the ATP is this quantity minus all customer commitments for this and other periods, until another quantity is scheduled in the MPS. For those periods where the quantity scheduled is zero, the ATP is zero (even if deliveries have been promised). The promised customer commitments are accumulated and shown in the period where the item was most recently scheduled. *Also see: Available-to-Promise*

Discrete Manufacturing Discrete manufacturing processes create products by assembling unconnected distinct parts as in the production of distinct items such as automobiles, appliances or computers.

Discrete Order Picking A method of picking orders in which the items on one order are picked before the next order is picked. *Also see: Batch Picking, Order Picking, Zone Picking*

Discrete Order Quantity An order quantity that represents an integer number of periods of demand. Most MRP systems employ discrete order quantities. *Also see: Fixed-period Requirements, Least Total Cost, Least Unit Cost, Lot-for-Lot, Part Period Balancing, Period Order Quantity, Wagner-Whitin Algorithm*

Disintermediation When the traditional sales channels are disassembled and the middleman gets cut out of the deal, such as when the manufacturer ships direct to a retailer, bypassing the distributor.

Dispatching The carrier activities involved with controlling equipment; involves arranging for fuel, drivers, crews, equipment and terminal space.

Distributed Inventory Inventory that is geographically dispersed. For example, where a company maintains inventory in multiple distribution centres to provide a higher level of customer service.

Distribution Outbound logistics, from the end of the production line to the end user. (1) The activities associated with the movement of material, usually finished goods or service parts, from the manufacturer to the customer. These activities encompass the functions of transportation, warehousing, inventory control, material handling, order administration, site and location analysis, industrial packaging, data processing and the communications network necessary for effective management. It includes all activities related to physical distribution, as well as the return of goods to the manufacturer. In many cases, this movement is made through one or more levels of field warehouses. *Synonym: Physical Distribution.* (2) The systematic division of a whole into discrete parts having distinctive characteristics.

Distribution Centre (DC) The warehouse facility which holds inventory from manufacturing pending distribution to the appropriate stores.

Distribution Channel One or more companies or individuals who participate in the flow of goods and services from the manufacturer to the final user or consumer.

Distribution Channel Management The organizational and pipeline strategy for getting products to customers. Direct channels involve company sales forces, facilities and/or direct shipments to customers. Indirect channels involve the use of wholesalers, distributors and/or other parties to supply the products to customers. Many companies use both strategies, depending on markets and effectiveness.

Distribution on Demand (DOD) The order fulfilment state a distribution operation achieves when it can respond, closest to real time, to changes in demand while shipping 100% customer compliant orders at the least cost.

Distribution Planning The planning activities associated with transportation, warehousing, inventory levels, materials handling, order administration, site and location planning, industrial packaging, data processing and communications networks to support distribution.

Distribution Requirements Planning (DRP) A system of determining demands for inventory at distribution centres and consolidating demand information in reverse as input to the production and materials system.

Distribution Resource Planning (DRP II) The extension of distribution requirements planning into the planning of the key resources contained in a distribution system: warehouse space, workforce, money, trucks, freight cars, etc.

Distribution Warehouse A warehouse that stores finished goods and from which customer orders are assembled.

Distributor A business that does not manufacture its own products, but purchases and resells these products. Such a business usually maintains a finished goods inventory. *Synonym: Wholesaler*

Diversion The practice of selling goods to a competitor that the vendor assumes would be used to service that Customer's store. Example; Grocery Store Chain A buys orange juice from Minute Maid. Grocery Store Chain A, because of their sales volume or because of promotion, can buy product for $12.50 per case. Grocery Store Chain B, because of a lower sales volume, buys the same orange juice for $14.50 per case. Grocery Store Chain A and Grocery Store Chain B get together and make a deal. Grocery Store Chain A resells that product to Grocery Store Chain B for $13.50 per case. Grocery Store Chain A makes $1.00 per case and Grocery Store Chain B gets product for $1.00 less per case than it can buy from Minute Maid.

Dock-to-Stock A program by which specific quality and packaging requirements are met before the product is released. Pre-qualified product is shipped directly into the customer's inventory. Dock-to-stock eliminates the costly handling of components, specifically in receiving and inspection and enables product to move directly into production.

Document In EDI, a form, such as an invoice or a purchase order, that trading partners have agreed to exchange and that the EDI software handles within its compliance-checking logic.

DOA *See Dead on Arrival*

Dock Receipt A receipt that indicates an export shipment has been delivered to a steamship company by a domestic carrier.

Documentation The papers attached or pertaining to goods requiring transportation and/or transfer of ownership. These may include the packing list, hazardous materials declarations, export/customs documents, etc.

DOD *See Distribution on Demand*

DOE *See Design of Experiments*

Domain A computer term for the following: (1) highest subdivision of the Internet, for the most part by country (except in the USA, where it's by type of organization, such as educational, commercial and government). Usually the last part of a host name; for example, the domain part of ibm.com is .com, which represents the domain of commercial sites in the USA and (2) in corporate data networks, a group of client computers controlled by a server system.

Domestic Trunk Line Carrier An air carrier classification for carriers that operate between major population centres. These carriers are now classified as major carriers.

Dormant route A route over which a carrier failed to provide service 5 days a week for 13 weeks out of a 26-week period.

Double Bottoms A motor carrier operation involving two trailers being pulled by one tractor.

Double Order Point System A distribution inventory management system that has two order points. The smallest equals the original order point, which covers demand during replenishment lead time. The second order point is the sum of the first order point plus normal usage during manufacturing lead time. It enables warehouses to forewarn manufacturing of future replenishment orders.

Double-pallet jack A mechanized device for transporting two standard pallets simultaneously.

Double Stack Two containers, one on top of the other, loaded on a railroad flatcar; an intermodal service.

Download To merge temporary files containing a day's or week's worth of information with the main data base in order to update it.

Downstream Referring to the demand side of the supply chain. One or more companies or individuals who participate in the flow of goods and services moving from the manufacturer to the final user or consumer. Opposite of Upstream.

DPC *See Dynamic Process Control*

DPL *See Denied Party List*

DPP *See Direct product profitability*

Drayage Transportation of materials and freight on a local basis, but intermodal freight carriage may also be referred to as drayage.

Driving Time Regulations Rules administered by the U.S. Department of Transportation that limit the maximum time a driver may drive in interstate commerce; both daily and weekly maximums are prescribed.

Drop A situation in which an equipment operator deposits a trailer or boxcar at a facility at which it is to be loaded or unloaded.

Drop Ship To take the title of the product but not actually handle, stock or deliver it, e.g. to have one supplier ship directly to another or to have a supplier ship directly to the buyer's customer.

DRP *See Disaster Recovery Planning*

DRP *See Distribution Requirements Planning*

DRPII *See Distribution Resources Planning*

Drum-Buffer-Rope (DBR) In the theory of constraints, the generalized process used to manage resources to maximize throughput. The drum is the rate or pace of production set by the system's constraint. The buffers establish the protection against uncertainty so that the system can maximize throughput. The rope is a communication process from the constraint to the gating operation that checks or limits material released into the system to support the constraint. *Also see: Finite Scheduling*

DSD *See Direct Store Delivery*

DSO *See Days Sales Outstanding*

DSS *See Decision Support System*

DTF *See Demand Time Fence*

DTS *See Direct Store Delivery*

Dual Operation A motor carrier that has both common and contract carrier operating authority.

Dual Rate System An international water carrier pricing system where a shipper signing an exclusive use agreement with the conference pays a lower rate (10–15%) than non-signing shippers for an identical shipment.

Dumping Selling goods below costs in selected markets.

Dunnage The packing material used to protect a product from damage during transport.

DUNS Number A unique nine-digit number assigned by Dun and Bradstreet to identify a company. DUNS stands for Data Universal Numbering System.

DUNS Data Universal Numbering System.

Durable Goods Generally, any goods whose continuous serviceability is likely to exceed 3 years (e.g. trucks, furniture).

Duty-Free Zone (DFZ) An area where goods or cargo can be stored without paying import customs duties while awaiting manufacturing or future transport.

Dynamic Lot Sizing Any lot-sizing technique that creates an order quantity subject to continuous recomputation. *See: Least total cost, least unit cost, Part period balancing, Period order quantity, Wagner-Whitin algorithm*

Dynamic Process Control (DPC) Continuous monitoring of process performance and adjustment of control parameters to optimize process output.

E

EAI *See Enterprise Application Integration*

EAN.UCC European Article Numbering/Uniform Code Council (now the European office of GS1). The EAN.UCC System provides identification standards to uniquely identify trade items, logistics units, locations, assets and service relations worldwide. The identification standards define the construction of globally unique and unambiguous numbers.

Early Supplier Involvement (ESI) The process of involving suppliers early in the product design activity and drawing on their expertise, insights and knowledge to generate better designs in less time and designs that are easier to manufacture with high quality.

Earnings Before Interest and Taxes (EBIT) A measure of a company's earning power from ongoing operations, equal to earnings (revenues minus cost of sales, operating expenses and taxes) before deduction of interest payments and income taxes. *Also called operating profit*

EBIT *See Earnings Before Interest and Taxes*

EC *See Electronic Commerce*

ECO *See Engineering Change Order*

E-Commerce *See Electronic Commerce*

Economic Order Quantity (EOQ) An inventory model that determines how much to order by determining the amount that will meet customer service levels while minimizing total ordering and holding costs.

Economic Value Added (EVA) A measurement of shareholder value as a company's operating profits after tax, less an appropriate charge for the capital used in creating the profits.

Economy of Scale A phenomenon whereby larger volumes of production reduce unit cost by distributing fixed costs over a larger quantity.

ECR *See Efficient Consumer Response*

EDI *See Electronic Data Interchange*

EDIA *See Electronic Data Interchange Association*

EDIFACT Electronic Data Interchange for Administration, Commerce, and Transport. The United Nations EDI standard.

EDI Standards Criteria that define the data content and format requirements for specific business transactions (e.g. purchase orders). Using standard formats allows companies to exchange transactions with multiple trading partners easily. *Also see: American National Standards Institute, GS1 Group*

EDI Transmission A functional group of one or more EDI transactions that are sent to the same location, in the same transmission, and are identified by a functional group header and trailer.

Efficient Consumer Response (ECR) A demand-driven replenishment system designed to link all parties in the logistics channel to create a massive flow-through distribution network. Replenishment is based upon consumer demand and point of sale information.

EFT *See Electronic Funds Transfer*

EH&S *See Environmental Health and Safety*

EIN *See Exporter Identification Number*

Electronic Commerce (EC) Also written as e-commerce. Conducting business electronically via traditional EDI technologies, or online via the Internet. In the traditional sense of selling goods, it is possible to do this electronically because of certain software programs that run the main functions of an e-commerce website, such as product display, online ordering and inventory management. The definition of e-commerce includes business activity that is business-to-business (B2B), business-to-consumer (B2C).

Electronic Data Interchange (EDI) Intercompany, computer-to-computer transmission of business information in a standard format. For EDI purists, "computer-to-computer" means direct transmission from the originating application program to the receiving, or processing, application program. An EDI transmission consists only of business data, not any accompanying verbiage or free-form messages. Purists might also contend that a standard format is one that is approved by a national or international standards organization, as opposed to formats developed by industry groups or companies.

Electronic Data Interchange Association A national body that propagates and controls the use of EDI in a given country. All EDIAs are non-profit organizations dedicated to encouraging EDI growth. The EDIA in the United States was formerly TDCC and administered the development of standards in transportation and other industries.

Electronic Funds Transfer (EFT) A computerized system that processes financial transactions and information about these transactions or performs the exchange of value. Sending payment instructions across a computer network, or the company-to-company, company-to-bank or bank-to-bank electronic exchange of value.

Electronic Mail (E-Mail) The computer-to-computer exchange of messages. E-mail is usually unstructured (free-form) rather than in a structured format. X.400 has become the standard for e-mail exchange.

Electronic Product Code (EPC or ePC) An electronically coded tag that is intended as an improvement to the UPC barcode system. The EPC is a 96-bit tag which contains a number called the Global Trade Identification Number (GTIN). Unlike a UPC number, which only provides information specific to a group of products, the GTIN gives each product its own specific identifying number, giving greater accuracy in tracking. EPC standards are managed by the Global Standards organization known as GS1.

Electronic Signature A form of authentication that provides identification and validation of a transaction by means of an authorization code identifying the individual or organization.

Elkins Act An amendment to the IC Act that prohibits giving rebates.

E-mail *See Electronic Mail*

Embargo A prohibition upon exports or imports, either with specific products or specific countries.

Empirical Pertaining to a statement or formula based upon experience or observation rather than on deduction or theory.

Empowerment A condition whereby employees have the authority to make decisions and take action in their work areas without prior approval. For example, an operator can stop a production process if he or she detects a problem, or a customer service representative can send out a replacement product if a customer calls with a problem.

Encryption The transformation of readable text into coded text for security purposes.

End item A product sold as a completed item or repair part; any item subject to a customer order or sales forecast. Synonym: Finished Goods Inventory.

End-of-Life Planning and execution at the end of the life of a product. The challenge is making just the right amount to avoid (A) ending up with excess, which have to be sold at great discounts or scrapped or (B) ending up with shortages before the next generation is available.

End-of-Life Inventory Inventory on hand that will satisfy future demand for products that are no longer in production at your entity.

Engineering Change A revision to a drawing or design released by engineering to modify or correct a part. The request for the change can be from a customer or from production, quality control, another department or a supplier. *Synonym: Engineering Change Order*

Engineering Change Order (ECO) A documented and approved revision to a product or process specification.

Engineer-to-Order A process in which the manufacturing organization must first prepare (engineer) significant product or process documentation before manufacture may begin.

Enroute A term used for goods in transit or on the way to a destination.

Enterprise Application Integration (EAI) A computer term for the tools and techniques used in linking ERP and other enterprise systems together. Linking systems is key for e-business. Gartner says "firms implementing enterprise applications spend at least 30% on point-to-point interfaces".

Enterprise-Wide ABM A management information system that uses activity-based information to facilitate decision-making across an organization.

Enterprise Resource Planning (ERP) System A class of software for planning and managing "enterprise-wide" the resources needed to take customer orders, ship them, account for them and replenish all needed goods according to customer orders and forecasts. Often includes electronic commerce with suppliers. Examples of ERP systems are the application suites from SAP, Oracle, PeopleSoft and others.

Enveloping An EDI management software function that groups all documents of the same type, or functional group, and bound for the same destination into an electronic envelope. Enveloping is useful where there are multiple documents such as orders or invoices issued to a single trading partner that need to be sent as a packet.

Environmental Health and Safety (EH&S) The category of processes, procedures and regulations related to addressing the needs of maintaining environmental quality standards for health and safety. Includes the RoHS (Restriction of Hazardous Substances) and WEEE (Waste Electrical and Electronic) standards.

Environmentally Sensitive Engineering Designing features in a product and its packaging that improve recycling, etc. It can include elimination of compounds that are hazardous to the environment.

E&O *See Excess and Obsolescence*

EOL *See End-of-Life*

EOQ *See Economic Order Quantity*

EPC or ePC *See: Electronic Product Code*

EPS A computer term. Encapsulated Postscript. An extension of the PostScript graphics file format developed by Adobe Systems. EPS lets PostScript graphics files be incorporated into other documents.

Equipment The rolling stock carriers use to facilitate the transportation services that they provide, including containers, trucks, chassis, vessels and airplanes, among others.

Equipment I.D. An identifier assigned by the carrier to a piece of equipment. *See also Container ID*

Equipment Positioning The process of placing equipment at a selected location.

Ergonomic The science of creating workspaces and products which are human friendly to use.

ERP *See Enterprise Resources Planning System*

ERS *See Evaluated Receipts Settlement*

ESI *See Early Supplier Involvement*

ETA The Estimated Time of Arrival

ETD The Estimated Time of Departure

Ethernet A computer term for the most commonly used type of local area network (LAN) communication protocol using coaxial or twisted pair wiring.

Ethical Standards A set of guidelines for proper conduct by business professionals.

European Article Number (EAN) A defined numbering mechanism used in Europe to uniquely identify every retail product and packaging option. The EAN is similar in concept and design to the UPC code and is usually what the barcode represents on goods. *Also see: Uniform Product Code*

EVA *See Economic Value Added*

Evaluated Receipts Settlement (ERS) A process for authorizing payment for goods based on actual receipts with purchase order data, when price has already been negotiated. The basic premise behind ERS is that all of the information in the invoice is already transmitted in the shipping documentation. Therefore, the invoice is eliminated and the shipping documentation is used to pay the vendor.

Exception-Based Processing A computer term for applications that automatically highlight particular events or results which fall outside predetermined parameters. This saves considerable effort by automatically finding problems and alerting the right persons. An example would be where a shorted item on a purchase order receipt would automatically notify a purchasing agent for follow-up.

Exception Message *See Action Message*

Exception Rate A deviation from the class rate; changes (exceptions) made to the classification.

Excess and Obsolescence (E&O) The accounting value assigned to the cost associated with inventory that is disposed of as being excess or obsolete.

Exclusive Patronage Agreements A shipper agrees to use only member liner firms of a conference in return for a 10–15% rate reduction.

Exclusive Use Carrier vehicles that are assigned to a specific shipper for its exclusive use.

Executive Dashboard A series of cross-functional metrics that span the performance of the entire company and indicate the overall health of the company. Usually an Executive Dashboard includes the top KPIs for the company—and when possible is limited to the "vital few" that fit on a one page summary.

Exempt Carrier A for-hire carrier that is free from economic regulation. Trucks hauling certain commodities are exempt from Interstate Commerce Commission economic regulation. By far the largest portion of exempt carriers transports agricultural commodities or seafood.

Expediting (1) Moving shipments through regular channels at an accelerated rate. (2) To take extraordinary action because of an increase in relative priority. *Synonym: Stockchase*

Expert System A computer program that mimics a human expert.

Explode-to-Deduct *See Backflush*

Exponential Smoothing Forecast In forecasting, a type of weighted moving average forecasting technique in which past observations are geometrically discounted according to their age. The heaviest weight is assigned to the most recent data. The smoothing is termed exponential because data points are weighted in accordance with an exponential function of their age. The technique makes use of a smoothing constant to apply to the difference between the most recent forecast and the critical sales data, thus avoiding the necessity of carrying historical sales data. The approach can be used for data that exhibit no trend or seasonal patterns. Higher order exponential smoothing models can be used for data with either (or both) trend and seasonality

Export (1) In logistics, the movement of products from one country to another. For example, significant volumes of cut flowers are exported from The Netherlands to other countries of the world. (2) A computer term referring to the transfer of information from a source (system or database) to a target.

Export Broker An enterprise that brings together buyer and seller for a fee, then eventually withdraws from the transaction.

Export Compliance Complying with rules for exporting products, including packaging, labelling and documentation.

Export Declaration A document required by the Department of commerce that provides information as to the nature, value, etc., of export activity.

Export Licence A document secured from a government authorizing an exporter to export a specific quantity of a controlled commodity to a certain country. An export licence is often required if a government has placed embargoes or other restrictions upon exports.

Export sales contract The initial document in any international transaction; it details the specifics of the sales agreement between the buyer and seller.

Exporter Identification Number (EIN) A number required for the exporter on the Shipper's Export Declaration. A corporation may use their Federal Employer Identification Number as issued by the IRS; individuals can use their Social Security Numbers.

Exports A term used to describe products produced in one country and sold in another. *Also see: Export*

Express (1) Carrier payment to its customers when ships, rail cars or trailers are unloaded or loaded in less than the time allowed by contract and returned to the carrier for use. See: demurrage, detention. (2) The use of priority package delivery to achieve overnight or second-day delivery.

Extended Enterprise The notion that supply chain partners form a larger entity which works together as though it were a single unit.

Extensible Markup Language (XML) A computer term for a language that facilitates direct communication among computers on the Internet. Unlike the older hypertext markup language (HTML), which provides data tags giving instructions to a web browser about how to display information, XML tags give instructions to a browser or to application software which help to define the specifics about the category of information.

External Factory A situation where suppliers are viewed as an extension of the firm's manufacturing capabilities and capacities. The same practices and concerns that are commonly applied to the management of the firm's manufacturing system should also be applied to the management of the external factory.

Extranet A computer term describing a private network (or a secured link on the public internet) that links separate organizations and that uses the same software and protocols as the Internet. Used for improving supply chain management. For example, extranets are used to provide access to a supply chain partner's internal inventory data which is not available to unrelated parties. *Antonym: Intranet*

Extrinsic Forecast In forecasting, a forecast based on a correlated leading indicator, such as estimating furniture sales based on housing starts. Extrinsic forecasts tend to be more useful for large aggregations, such as total company sales, than for individual product sales. *Ant: intrinsic forecast method*

EXW *See Ex Works*

Ex Works (EXW) An international trade term (Incoterms, International Chamber of Commerce) requiring the seller to deliver goods at his or her own place of business. All other transportation costs and risks are assumed by the buyer.

F

FA *See Functional Acknowledgment*

Fabricator A manufacturer that turns the product of a raw materials supplier into a larger variety of products. A fabricator may turn steel rods into nuts, bolts and twist drills, or may turn paper into bags and boxes.

Facilities The physical plant, distribution centres, service centres and related equipment.

Factory Gate Pricing Like DSD in reverse, factory gate pricing (FGP) is a supply chain initiative that has been gaining popularity among retailers in England. With FGP, retailers buy goods at the suppliers' "gate" and take care of getting it to their stores or distribution centres, either with their own trucks or those of their contracted carriers.

Failure Modes Effects Analysis (FMEA) A pro-active method of predicting faults and failures so that preventive action can be taken.

Fair Return A level of profit that enables a carrier to realize a rate of return on investment or property value that the regulatory agencies deem acceptable for that level of risk.

Fair-share Quantity Logic In inventory management, the process of equitably allocating available stock among field distribution centres. Fair-share quantity logic is normally used when stock available from a central inventory location is less than the cumulative requirements of the field stocking locations. The use of fair-share quantity logic involves procedures that "push" stock out to the field, instead of allowing the field to "pull" in what is needed. The objective is to maximize customer service from the limited available inventory.

Fair value The value of the carrier's property; the basis of calculation has included original cost minus depreciation, replacement cost and market value.

FAK *See Freight all kinds*

FAS *See Final Assembly Schedule*

FAS *See Free Alongside Ship*

FAST *See Fast and Secure Trade*

Fast and Secure Trade (FAST) U.S. Customs program that allows importers on the US/Canada border to obtain expedited release for qualifying commercial shipments.

Fast-Moving Consumer Goods (FMCG) Fast-Moving Consumer Goods are packaged commercial products that are consumed through use. They include pre-packaged food and drinks, alcohol, health and beauty items, tobacco products, paper products, household cleansers and chemicals, animal care items, anything that we need, can buy right off the shelf, and use up through daily living.

FCL *See Full Container Load*

Feature A distinctive characteristic of a good or service. The characteristic is provided by an option, accessory or attachment. For example, in ordering a new car, the customer must specify an engine type and size (option), but need not necessarily select an air conditioner (attachment).

Federal Aviation Administration The federal agency charged with administering federal safety regulations governing air transportation.

Federal Maritime Commission A regulatory agency that controls services, practices and agreements of international water common carriers and noncontiguous domestic water carriers.

Feeder Railroad Development Program A Federal program which allows any financially responsible person (except Class I and Class II carriers) with ICC approval to acquire a rail line having a density of less than 3 million gross ton-miles per year, in order to avert the line being abandoned.

FEU *See Forty-foot Equivalent Unit*

FG *See Finished Goods Inventory*

FGI *See Finished Goods Inventory*

Field Finished Goods Inventory which is kept at locations outside the four walls of the manufacturing plant (i.e. distribution centre or warehouse).

Field Service *See After-Sale Service*

Field Service Parts Parts inventory kept at locations outside the four walls of the manufacturing plant (i.e. distribution centre or warehouse).

Field warehouse A warehouse on the property of the owner of the goods that stores goods that are under the custody of a bona fide public warehouse manager. The public warehouse receipt is used as collateral for a loan.

FIFO *See First In, First Out*

File Transfer Protocol (FTP) The Internet service that transfers files from one computer to another, over standard phone lines.

Filed rate doctrine The legal rate the common carrier may charge; the rate published in the carrier's tariff on file with the ICC.

Fill Rate The percentage of order items that the picking operation actually fills within a given period of time.

Fill Rates by Order Whether orders are received and released consistently, or released from a blanket purchase order, this metric measures the percentage of ship-from-stock orders shipped within 24 h of order "release". Make-to-Stock schedules attempt to time the availability of finished goods to match forecasted customer orders or releases. Orders that were not shipped within 24 h due to consolidation but were available for shipment within 24 h are reported separately. In calculating elapsed time for order fill rates, the interval begins at ship release and ends when material is consigned for shipment.*Calculation:[Number of orders filled from stock shipped within 24 h of order release]/[Total number of stock orders]*Note: The same concept of fill rates can be applied to order lines and individual products to provide statistics on percentage of lines shipped completely and percentage of products shipped completely.

Final Assembly The highest level assembled product, as it is shipped to customers. This terminology is typically used when products consist of many possible features and options that may only be combined when an actual order is received. *Also see: End Item, Assemble to Order*

Final Assembly Schedule (FAS) A schedule of end items to finish the product for specific customers' orders in a make-to-order or assemble-to-order environment.

It is also referred to as the finishing schedule because it may involve operations other than just the final assembly; also, it may not involve assembly, but simply final mixing, cutting, packaging, etc. The FAS is prepared after receipt of a customer order as constrained by the availability of material and capacity, and it schedules the operations required to complete the product from the level where it is stocked (or master scheduled) to the end-item level.

Finance Lease An equipment-leasing arrangement that provides the lessee with a means of financing for the leased equipment; a common method for leasing motor carrier trailers.

Financial Responsibility Motor carriers are required to have body injury and property damage (not cargo) insurance of not less than $500,000 per incident per vehicle; higher financial responsibility limits apply for motor carriers transporting oil or hazardous materials.

Finished Goods Inventory (FG or FGI) Products completely manufactured, packaged, stored and ready for distribution. *Also see: End Item*

Finite Forward Scheduling An equipment scheduling technique that builds a schedule by proceeding sequentially from the initial period to the final period while observing capacity limits. A Gantt chart may be used with this technique. *Also see: Finite Scheduling*

Finite Scheduling A scheduling methodology where work is loaded into work centres such that no work centre capacity requirement exceeds the capacity available for that work centre. See: drum-buffer-rope, finite forward scheduling.

Firewall A computer term for a method of protecting the files and programs on one network from users on another network. A firewall blocks unwanted access to a protected network while giving the protected network access to networks outside of the firewall. A company will typically install a firewall to give users access to the Internet while protecting their internal information.

Firm Planned Order A planned order which has been committed to production. *Also see: Planned Order*

First In, First Out (FIFO) Warehouse term meaning first items stored are the first used. In accounting this term is associated with the valuing of inventory such that the latest purchases are reflected in book inventory. *Also see: Book Inventory*

First Mover Advantage Market innovator, putting the company in the leadership position.

First Pass Yield The ratio of usable, specification conforming output from a process to its input, achieved without rework or reprocessing.

Fixed Costs Costs, which do not fluctuate with business volume in the short run. Fixed costs include items such as depreciation on buildings and fixtures.

Fixed Interval Inventory Model A setup wherein each time an order is placed for an item, the same (fixed) quantity is ordered.

Fixed Interval Order System *See Fixed Reorder Cycle Inventory Model*

Fixed Order Quantity A lot-sizing technique in MRP or inventory management that will always cause planned or actual orders to be generated for a predetermined fixed quantity, or multiples thereof if net requirements for the period exceed the fixed order quantity.

Fixed Order Quantity System *See Fixed Reorder Cycle Inventory Model*

Fixed Overhead Traditionally, all manufacturing costs, other than direct labour and direct materials, that continue even if products are not produced. Although fixed overhead is necessary to produce the product, it cannot be directly traced to the final product. *Also see: Indirect Cost*

Fixed-Period Requirements A lot-sizing technique that sets the order quantity to the demand for a given number of periods. *Also see: Discrete Order Quantity*

Fixed Quantity Inventory Model A setup wherein a company orders the same (fixed) quantity each time it places an order for an item.

Fixed Reorder Cycle Inventory Model A form of independent demand management model in which an order is placed every "n" time units. The order quantity is variable and essentially replaces the items consumed during the current time period. Let "M" be the maximum inventory desired at any time, and let x be the quantity on hand at the time the order is placed. Then, in the simplest model, the order quantity will be $M - x$. The quantity M must be large enough to cover the maximum expected demand during the lead time plus a review interval. The order quantity model becomes more complicated whenever the replenishment lead time exceeds the review interval, because outstanding orders then have to be factored into the equation. These reorder systems are sometimes called fixed-interval order systems, order level systems, or periodic review systems. *Synonyms: Fixed-Interval Order System, Fixed-Order Quantity System, Order Level System, Periodic Review System, Time-Based Order System. Also see: Fixed Reorder Quantity Inventory Model, Hybrid Inventory System, Independent Demand Item Management Models, Optional Replenishment Model*

Fixed Reorder Quantity Inventory Model A form of independent demand item management model in which an order for a fixed quantity is placed whenever stock on hand plus on order reaches a predetermined reorder level. The fixed order quantity may be determined by the economic order quantity, by a fixed order quantity (such as a carton or a truckload), or by another model yielding a fixed result. The reorder point may be deterministic or stochastic, and in either instance is large enough to cover the maximum expected demand during the replenishment lead time. Fixed reorder quantity models assume the existence of some form of a perpetual inventory record or some form of physical tracking, e.g. a two-bin system that is able to determine when the reorder point is reached.*Synonym: Fixed Order Quantity System, Lot Size System, Order Point-Order Quantity System, Quantity-Based Order System. Also see: Fixed Reorder Cycle Inventory Model, Hybrid Inventory System, Independent Demand Item Management Models, Optional Replenishment Model, Order Point—Order Management System*

Fixed-Location Storage A method of storage in which a relatively permanent location is assigned for the storage of each item in a storeroom or warehouse. Although more space is needed to store parts than in a random-location storage system, fixed locations become familiar, and therefore a locator file may not be needed. *Also see: Random-Location Storage*

Flag of Convenience A shipowner registers a ship in a nation that offers conveniences in the areas of taxes, manning and safety requirements; Liberia and Panama are two nations known for flags of convenience.

Flat A loadable platform having no superstructure whatever but having the same length and width as the base of a container and equipped with top and bottom corner fittings. This is an alternative term used for certain types of specific purpose containers—namely platform containers and platform-based containers with incomplete structures

Flatbed A flatbed is a type of truck trailer that consists of a floor and no enclosure. A flatbed may be used with "sideboards" or "tie downs" which keep loose cargo from falling off.

Flatcar A rail car without sides; used for hauling machinery.

Flat File A computer term which refers to any file having fixed-record length, or in EDI, the file produced by EDI translation software to serve as input to the interface. Usually includes the same fields as the original file, but each field is expanded to its maximum length. Does not have delimiters.

Flexibility Ability to respond quickly and efficiently to changing customer and consumer demands.

Flexible-Path Equipment Materials handling devices that include hand trucks and forklifts.

Flexible Specialization A strategy based on multi-use equipment, skilled workers and innovative senior management to accommodate the continuous change that occurs in the marketplace.

Float The time required for documents, payments, etc. to get from one trading partner to another.

Floor-Ready Merchandise (FRM) Goods shipped by suppliers to retailers with all necessary tags, prices, security devices, etc. already attached, so goods can be cross-docked rapidly through retail DCs, or received directly at stores.

Flow Rack Storage rack that utilizes shelves (metal) that are equipped with rollers or wheels. Such an arrangement allows product and materials to "flow" from the back of the rack to the front and therein making the product more accessible for small-quantity order-picking.

Flow-Through Distribution A process in a distribution centre in which products from multiple locations are brought in to the D.C. and are re-sorted by delivery destination and shipped in the same day. Also known as a "cross-dock" process in the transportation business. *See Cross-Docking.*

FMCG *See Fast-Moving Consumer Goods*

FMEA *See Failure Modes Effects Analysis*

FOB *See Free on Board*

FOB Destination Title passes at destination, and seller has total responsibility until shipment is delivered.

FOB Origin Title passes at origin, and buyer has total responsibility over the goods while in shipment.

For-Hire Carrier A carrier that provides transportation service to the public on a fee basis.

Forecast An estimate of future demand. A forecast can be constructed using quantitative methods, qualitative methods, or a combination of methods, and it can be based on extrinsic (external) or intrinsic (internal) factors. Various forecasting techniques attempt to predict one or more of the four components of demand: cyclical, random, seasonal and trend. *Also see: Box-Jenkins Model, Exponential Smoothing Forecast, Extrinsic Forecasting Method, Intrinsic Forecasting Method, Qualitative Forecasting Method, Quantitative Forecasting Method*

Forecast Accuracy Measures how accurate your forecast is as a percent of actual units or dollars shipped, calculated as 1 minus the absolute value of the difference between forecasted demand and actual demand, as a percentage of actual demand.*Calculation:[1-(|Sum of Variances|/Sum of Actual)]*

Forecast Cycle Cycle time between forecast regenerations that reflect true changes in marketplace demand for shippable end products.

Forecasting Predictions of how much of a product will be purchased by customers. Relies upon both quantitative and qualitative methods. *Also see: Forecast*

Foreign Trade Zone (FTZ) An area or zone set aside at or near a port or airport, under the control of the U.S. Customs Service, for holding goods duty-free pending customs clearance.

Forklift truck A machine-powered device that is used to raise and lower freight and to move freight to different warehouse locations.

Form utility The value created in a good by changing its form, through the production process.

Four P's A set of marketing tools to direct the business offering to the customer. The four P's are product, price, place and promotion.

Fourier Series In forecasting, a form of analysis useful for forecasting. The model is based on fitting sine waves with increasing frequencies and phase angles to a time series.

Four Wall Inventory The stock which is contained within a single facility or building.

Fourth-Party Logistics (4PL) Differs from third-party logistics in the following ways; (1) 4PL organization is often a separate entity established as a joint venture or long-term contract between a primary client and one or more partners; (2) 4PL organization acts as a single interface between the client and multiple logistics service providers; (3) All aspects (ideally) of the client's supply chain are managed by the 4PL organization; and, (4) It is possible for a major third-party logistics provider to form a 4PL organization within its existing structure. The term was registered by Accenture as a trademark in 1996 and defined as "A supply chain integrator that assembles and manages the resources, capabilities, and technology of its own organization with those of complementary service providers to deliver a comprehensive supply chain solution", but is no longer registered. *Also see: Lead Logistics Provider*

Forty-foot Equivalent Unit (FEU) A standard size intermodal container.

Foxhole *See Silo*

Free Alongside Ship (FAS) A term of sale indicating the seller is liable for all changes and risks until the goods sold are delivered to the port on a dock that will be used by the vessel. Title passes to the buyer when the seller has secured a clean dock or ship's receipt of goods. The seller agrees to deliver the goods to the dock alongside the overseas vessel that is to carry the shipment. The seller pays the cost of getting the shipment to the dock; the buyer contracts the carrier, obtains documentation and assumes all responsibility from that point forward.

Free on Board (FOB) Contractual terms between a buyer and a seller, that define where title transfer takes place.

Free Time The period of time allowed for the removal or accumulation of cargo before charges become applicable.

Freezing Inventory Balances In most cycle counting programs the term "freezing" refers to copying the current on-hand inventory balance into the cycle count file. This may also be referred to as taking a snapshot of the inventory balance. It rarely means that the inventory is actually frozen in a way that prevents transactions from occurring.

Freight Goods being transported from one place to another.

Freight-all-kinds (FAK) An approach to rate making whereby the rate is based only upon the shipment weight and distance; widely used in TOFC service.

Freight Bill The carrier's invoice for transportation charges applicable to a freight shipment.

Freight Carriers Companies that haul freight, also called "for-hire" carriers. Methods of transportation include trucking, railroads, airlines and seaborne shipping.

Freight Charge The rate established for transporting freight.

Freight Collect The freight and charges to be paid by the consignee.

Freight Consolidation The grouping of shipments to obtain reduced costs or improved utilization of the transportation function. Consolidation can occur by market area grouping, grouping according to scheduled deliveries, or using third-party pooling services such as public warehouses and freight forwarders.

Freight Forwarder An organization which provides logistics services as an intermediary between the shipper and the carrier, typically on international shipments. Freight forwarders provide the ability to respond quickly and efficiently to changing customer and consumer demands and international shipping (import/export) requirements.

Freight Forwarders Institute The freight forwarder industry association.

Freight Prepaid The freight and charges to be paid by the consignor.

FRM *See Floor Ready Merchandise*

Fronthaul The first leg of the truck trip that involves hauling a load or several loads to targeted destinations.

Frozen Zone In forecasting, this is the period in which no changes can be made to scheduled work orders based on changes in demand. Use of a frozen zone provides stability in the manufacturing schedule.

FTE *See Full-Time Equivalents*

FTL *See Full Truckload*

FTP *See File Transfer Protocol*

FTZ *See Free Trade Zone*

Fulfilment The act of fulfilling a customer order. Fulfilment includes order management, picking, packaging and shipping.

Full Container load (FCL) A term used when goods occupy a whole container.

Full-Service Leasing An equipment-leasing arrangement that includes a variety of services to support leased equipment (i.e. motor carrier tractors).

Full-Time Equivalents (FTE) Frequently organizations making use of contract and temporary employees; convert contract, part-time and temporary employees to full-time equivalents. For example, two contract employees who worked for 6 months full-time and a half-time regular employee would constitute 1.5 full-time equivalents. 1 FTE = 2000 h per year.

Full Truckload (FTL) A term which defines a shipment which occupies at least one complete truck trailer, or allows for no other shipper's goods to be carried at the same time.

Fully allocated cost The variable cost associated with a particular unit of output plus an allocation of common cost.

Functional Acknowledgment (FA) A specific EDI Transaction Set (997) sent by the recipient of an EDI message to confirm the receipt of data but with no indication as to the recipient application's response to the message. The FA will confirm that the message contained the correct number of lines, etc. via control summaries, but does not report on the validity of the data.

Functional Group Part of the hierarchical structure of EDI transmissions, a Functional Group contains one or more related Transaction Sets preceded by a Functional Group header and followed by a Functional Group trailer

Functional Metric A number resulting from an equation, showing the impact of one or more parts of a functional/department process. This is also known as a results measure as the metric measures the results of one aspect of the business. Example: Distribution Centre Fill Rate.

Functional Silo A view of an organization where each department or functional group is operated independent of other groups within the organization. Each group is referred to as a "Silo". This is the opposite of an integrated structure.

Future Order An order entered for shipment at some future date. This may be related to new products which are not currently available for shipment, or scheduling of future needs by the customer.

G

Gain Sharing A method of incentive compensation where supply chain partners share collectively in savings from productivity improvements. The concept provides an incentive to both the buying and supplier organizations to focus on continually re-evaluating, re-energizing and enhancing their business relationship. All aspects of value delivery are scrutinized, including specification design, order processing, inbound transportation, inventory management, obsolescence programs, material yield, forecasting and inventory planning, product performance and reverse logistics. The focus is on driving out limited value cost while protecting profit margins.

Gateway The connection that permits messages to flow freely between two networks.

Gathering lines Oil pipelines that bring oil from the oil well to storage areas.

GATT *See General Agreement on Tariffs and Trade*

GDSN *See Global Data Synchronization Network*

General Agreement on Tariffs and Trade (GATT) The General Agreement on Tariffs and Trade started as an international trade organization in 1947, and has been superseded by the World Trade Organization (WTO). GATT (the agreement) covers international trade in goods. An updated General Agreement is now the WTO agreement governing trade in goods. The 1986–1994 "Uruguay Round" of GATT member discussions gave birth to the WTO and also created new rules for dealing with trade in services, relevant aspects of intellectual property, dispute settlement, and trade policy reviews. GATT 1947: The official legal term for the old (pre-1994) version of the GATT. GATT 1994: The official legal term for new version of the General Agreement, incorporated into the WTO, and including GATT 1947.

General Commodities Carrier A common motor carrier that has operating authority to transport general commodities, or all commodities not listed as special commodities.

General-Merchandise Warehouse A warehouse that is used to store goods that are readily handled, are packaged, and do not require a controlled environment.

General Order (GO) A customs term referring to a warehouse where merchandise not entered within five working days after the carrier's arrival is stored at the risk and expense of the importer.

GIF *See Graphics Interchange Format*

Global Data Synchronization Network (GDSN) The GDSN is an Internet-based, interconnected network of interoperable data pools and a Global Registry, the GS1 Global Registry, that enables companies around the world to exchange standardized and synchronized supply chain data with their trading partners.

Global Standards Management Process (GSMP) The Global Standards Management Process (GSMP) is the Global Process established in January 2002 by EAN International and the Uniform Code Council, Inc. (UCC) for the development and maintenance of Global Standards and Global Implementation Guidelines that are part of the EAN.UCC system.

Global Strategy A strategy that focuses on improving worldwide performance through the sales and marketing of common goods and services with minimum product variation by country. Its competitive advantage grows through selecting the best locations for operations in other countries.

Global Trade Item Number (GTIN) A unique number that comprises up to 14 digits and is used to identify an item (product or service) upon which there is a need to retrieve pre-defined information that may be priced, ordered or invoiced at any point in the supply chain. The definition covers raw materials through end user products and includes services, all of which have pre-defined characteristics. GTIN is the globally unique EAN.UCC System identification number, or key, used for trade items (products and services). It's used for uniquely identifying trade items (products and services) sold, delivered, warehoused and billed throughout the retail and commercial distribution channels. Unlike a UPC number, which only provides information specific to a group of products, the GTIN gives each product its own specific identifying number, giving greater accuracy in tracking. *See EPC*

Global Positioning System (GPS) A system which uses satellites to precisely locate an object on earth. Used by trucking companies to locate over-the-road equipment.

Globalization The process of making something worldwide in scope or application.

GO *See General Order*

Going-Concern Value The value that a firm has as an entity, as opposed to the sum of the values of each of its parts taken separately; particularly important in determining what constitutes a reasonable railroad rate.

Gondola A rail car with a flat platform and sides three to five feet high; used for top loading of items that are long and heavy.

Good Manufacturing Practices (GMP) or 21 CFR, parts 808, 812 and 820 Requirements governing the quality procedures of medical device manufacturers.

Goods A term associated with more than one definition: (1) Common term indicating movable property, merchandise or wares. (2) All materials which are used to satisfy demands. (3) Whole or part of the cargo received from the shipper, including any equipment supplied by the shipper.

Goods Received Note (GRN) Documentation raised by the recipient of materials or products.

GMP *See Good manufacturing practices*

GNP *See Gross National Product*

GPS *See Global Positioning System*

Grandfather Clause A provision that enabled motor carriers engaged in lawful trucking operations before the passage of the Motor Carrier Act of 1935 to secure common carrier authority without proving public convenience and necessity; a similar provision exists for other modes.

Granger Laws State laws passed before 1870 in Midwestern states to control rail transportation.

Graphics Interchange Format (GIF) A graphical file format commonly used to display indexed-colour images on the World Wide Web. GIF is a compressed format, designed to minimize file transfer time over standard phone lines.

GreenLane A concept that would give C-TPAT members that demonstrate the highest standard of secure practices additional benefits for exceeding the minimum requirements of the program. GreenLane benefits would include expedited movement of cargo, especially during an incident of national significance.

Grid technique A quantitative technique to determine the least-cost centre, given raw materials sources and markets, for locating a plant or warehouse.

GRN *See Goods Received Note*

GPS *See Global Positioning System*

Groupthink A situation in which critical information is withheld from the team because individual members censor or restrain themselves, either because they believe their concerns are not worth discussing or because they are afraid of confrontation.

Gross Inventory Value of inventory at standard cost before any reserves for excess and obsolete items are taken.

Gross Margin The difference between total revenue and the cost of goods sold. *Syn: gross profit margin*

Gross National Product (GNP) A measure of a nation's output; the total value of all final goods and services produced during a period of time.

Gross Weight The total weight of the vehicle and the payload of freight or passengers.

GS1 The new name of EAN International. The GS1 US is the new name of the Uniform Code Council, Inc.® (UCC®), the GS1 Member Organization for the U.S. The association that administrates UCS, WINS and VICS and provides UCS identification codes and UPCs. Also, a model set of legal rules governing commercial transmissions, such as sales, contracts, bank deposits and collections, commercial paper, and letters of credit. Individual states give legal power to the GS1 by adopting its articles of law.

GSMP *See Global Standards Management Process*

GTIN *See Global Trade Item Number*

Guaranteed Loans Loans made to railroads that are cosigned and guaranteed by the federal government.

H

Handling Costs The cost involved in moving, transferring, preparing and otherwise handling inventory.

Hard copy Computer output printed on paper.

Harmonized Code An international classification system that assigns identification numbers to specific products. The coding system ensures that all parties in international trade use a consistent classification for the purposes of documentation, statistical control and duty assessment.

Haulage The inland transport service which is offered by the carrier under the terms and conditions of the tariff and of the relative transport document.

Hawaiian carrier A for-hire air carrier that operates within the state of Hawaii

Hawthorne Effect From a study conducted at the Hawthorne Plant of Western Electric Company in 1927–1932 which found that the act of showing people that you are concerned usually results in better job performance. Studying and monitoring of activities are typically seen as being concerned and results in improved productivity.

Hazardous Goods *See: Hazardous Material*

Hazardous Material A substance or material, which the Department of Transportation has determined to be capable of posing a risk to health, safety and property when stored or transported in commerce. *Also see: Material Safety Data Sheet*

HazMat *See Hazardous Material*

Hedge Inventory A form of inventory buildup to buffer against some event that may not happen. Hedge inventory planning involves speculation related to potential labour strikes, price increases, unsettled governments and events that could severely impair a company's strategic initiatives. Risk and consequences are unusually high, and top management approval is often required.

Heijunka In the Just-in-Time philosophy, an approach to level production throughout the supply chain to match the planned rate of end product sales.

Hierarchy of Cost Assignability In cost accounting, an approach to group activity costs at the level of an organization where they are incurred, or can be directly related to. Examples are the level where individual units are identified (unit-level), where batches of units are organized or processed (batch-level), where a process is operated or supported (process-level), or where costs cannot be objectively assigned to lower level activities or processes (facility-level). This approach is used to better understand the nature of the costs, including the level in the organization at which they are incurred, the level to which they can be initially assigned (attached) and the degree to which they are assignable to other activity and/or cost object levels, i.e. activity or cost object cost, or sustaining costs.

Highway Trust Fund Federal highway use tax revenues are paid into this fund, and the federal government's share of highway construction is paid from the fund.

Highway Use Taxes Taxes assessed by federal and state governments against users of the highway (the fuel tax is an example). The use tax money is used to pay for the construction, maintenance and policing of highways.

Hi-low Usually refers to a forklift truck on which the operator must stand rather than sit.

Home Page The starting point for a website. It is the page that is retrieved and displayed by default when a user visits the website. The default home-page name for a server depends on the server's configuration. On many web servers, it is index.html or default.htm. Some web servers support multiple home pages.

Honeycombing (1) The practice of removing merchandise in pallet load quantities where the space is not exhausted in an orderly fashion. This results in inefficiencies due to the fact that the received merchandise may not be efficiently stored in the space which is created by the honey-combing. (2) The storing or withdrawal of supplies in a manner that results in vacant space that is not usable for storage of other items. (3) Creation of unoccupied space resulting from withdrawal of unit loads. This is one of the major hidden costs of warehousing.

Hopper Cars Rail cars that permit top loading and bottom unloading of bulk commodities; some hopper cars have permanent tops with hatches to provide protection against the elements.

Horizontal Play/Horizontal Hub This is a term for a function that cuts across many industries, usually defines a facility or organization that is providing a common service.

Hoshin Planning Breakthrough planning. A Japanese strategic planning process in which a company develops up to four vision statements that indicate where the company should be in the next 5 years. Company goals and work plans are developed based on the vision statements. Periodic audits are then conducted to monitor progress.

Hostler An individual employed to move trucks and trailers within a terminal or warehouse yard area.

Household Goods Warehouse A warehouse that is used to store household goods.

HR *See Human Resources*

HTML *See HyperText Markup Language*

HTTP *See HyperText Transport Protocol*

Hub (1) A large retailer or manufacturer having many trading partners. (2) A reference for a transportation network as in "hub and spoke" which is common in the airline and trucking industry. For example, a hub airport serves as the focal point for the origin and termination of long-distance flights where flights from outlying areas are fed into the hub airport for connecting flights. (3) A common connection point for devices in a network. (4) A Web "hub" is one of the initial names for what is now known as a "portal". It came from the creative idea of producing a website, which would contain many different "portal spots" (small boxes that looked like ads, with links to different yet related content). This content, combined with Internet technology, made this idea a milestone in the development and appearance of websites, primarily due to the ability to display a lot of useful content and store one's preferred information on a secured server. The web term "hub" was replaced with portal.

Hub Airport An airport that serves as the focal point for the origin and termination of long-distance flights; flights from outlying areas are fed into the hub airport for connecting flights.

Human-Machine Interface Any point where data is communicated from a worker to a computer or from a computer to a worker. Data entry programs, inquire programs, reports, documents, LED displays and voice commands are all examples of human-machine interfaces.

Human Resources (HR) The function broadly responsible for personnel policies and practices within an organization.

Hundredweight (cwt) A pricing unit used in transportation (equal to 100 pounds).

Hybrid Inventory System An inventory system combining features of the fixed reorder quantity inventory model and the fixed reorder cycle inventory model. Features of the fixed reorder cycle inventory model and the fixed reorder quantity inventory model can be combined in many different ways. For example, in the order point-periodic review combination system, an order is placed if the inventory level drops below a specified level before the review date; if not, the order quantity is determined at the next review date. Another hybrid inventory system is the optional replenishment model. *Also see: Fixed Reorder Cycle Inventory Model, Fixed Reorder Quantity Inventory Model, Optional Replenishment Model*

Hyperlink A computer term. Also referred to as "link". The text you find on a website which can be "clicked on" with a mouse which, in turn, will take you to another web page or a different area of the same web page. Hyperlinks are created or "coded" in HTML.

HyperText Markup Language (HTML) The standard language for describing the contents and appearance of pages on the World Wide Web.

HyperText Transport Protocol (HTTP) The Internet protocol that allows World Wide Web browsers to retrieve information from servers.

I

IATA *See International Air Transport Association*

ICAO *See International Civil Aeronautics Organization*

ICC *See Interstate Commerce Commission*

Igloos Pallets and containers used in air transportation; the igloo shape is designed to fit the internal wall contours of a narrow-body airplane.

Image Processing Allows a company to take electronic photographs of documents. The electronic photograph then can be stored in a computer and retrieved from computer storage to replicate the document on a printer. The thousands of bytes of data composing a single document are encoded in an optical disk. Many carriers now use image processing to provide proof-of-delivery documents to a shipper. The consignee signs an electronic pad that automatically digitizes a consignee's signature for downloading into a computer. A copy of that signature then can be produced to demonstrate that a delivery took place.

IMB *See International Maritime Bureau*

IMC *See Intermodal marketing company*

IMO *See International Maritime Organization*

Import Movement of products from one country into another. The import of automobiles from Germany to the USA is an example.

Importation Point The location (port, airport or border crossing) where goods will be cleared for importation into a country.

Import/Export Licence Official authorization issued by a government allowing the shipping or delivery of a product across national boundaries.

Impressions With regard to online advertising, it is the number of times an ad banner is downloaded and presumably seen by users. Guaranteed impressions refer to the minimum number of times an ad banner will be seen by users.

In Bond Goods are held or transported In-Bond under customs control either until import duties or other charges are paid, or to avoid paying the duties or charges until a later date.

Inbound Logistics The movement of materials from suppliers and vendors into production processes or storage facilities.

Incentive Rate A rate designed to induce the shipper to ship heavier volumes per shipment.

INCOTERMS International terms of sale developed by the International Chamber of Commerce to define sellers' and buyers' responsibilities.

Independent action A carrier that is a member of a rate bureau has the right to publish a rate that differs from the rate published by the rate bureau.

Independent Demand Item Management Models Models for the management of items whose demand is not strongly influenced by other items managed by the same company. These models can be characterized as follows: (1) stochastic or deterministic, depending on the variability of demand and other factors; (2) fixed quantity, fixed cycle or hybrid—(optional replenishment). *Also see: Fixed Reorder Cycle Inventory Model, Fixed Reorder Quantity Inventory Model, Optional Replenishment Model*

Independent Trading Exchange (ITE) Often used synonymously with B2B, e-marketplace or Virtual Commerce Network (VCN). ITE is a more precise term, connoting many-to-many transactions, whereas the others do not specify the transactions.

Indirect Cost A resource or activity cost that cannot be directly traced to a final cost object since no direct or repeatable cause-and-effect relationship exists. An indirect cost uses an assignment or allocation to transfer cost. *Also see: Direct Cost, Support Costs*

Indirect/Distributor Channel Your company sells and ships to the distributor. The distributor sells and ships to the end user. This may occur in multiple stages. Ultimately your products may pass through the Indirect/Distributor Channel and arrive at a retail outlet. Order information in this channel may be transmitted by electronic means. These means may include EDI, brokered systems or linked electronic systems.

Indirect Retail Locations A retail location that ultimately sells your product to consumers, but who purchases your products from an intermediary, like a distributor or wholesaler.

Infinite Loading Calculation of the capacity required at work centres in the time periods required regardless of the capacity available to perform this work.

Information Systems (IS) Managing the flow of data in an organization in a systematic, structured way to assist in planning, implementing and controlling.

Inherent Advantage The cost and service benefits of one mode compared with other modes.

Inland Bill of Lading The carriage contract used in transport from a shipping point overland to the exporter's international carrier location.

Inland Carrier An enterprise that offers overland service to or from a point of import or export.

Insourcing The opposite of outsourcing, that is, a service performed in-house.

Inspection Certificate A document certifying that merchandise (such as perishable goods) was in good condition immediately prior to shipment.

Integrated Carrier A company that offers a blend of transportation services such as land, sea and air carriage, freight forwarding, and ground handling.

Integrated Logistics A comprehensive, system-wide view of the entire supply chain as a single process, from raw materials supply through finished goods distribution. All functions that make up the supply chain are managed as a single entity, rather than managing individual functions separately.

Integrated Services Digital Network (ISDN) A computer term describing the networks and equipment for integrated broadband transmissions of data, voice and image, from rates of 144 Kbps to 2 Mbps. ISDN allows integration of data, voice and video over the same digital links.

Integrated Tow Barge A series of barges that are connected together to operate as one unit.

Intellectual Property (IP) Property of an enterprise or individual which is typically maintained in a digital form. This may include software program code or digital documents, music, videos, etc.

Interchange In EDI, the exchange of electronic information between companies. Also, the group of transaction sets transmitted from one sender to one receiver at one time. Delineated by interchange control segments.

Intercoastal Carriers Water carriers that transport freight between East and West Coast ports, usually by way of the Panama Canal.

Intercorporate Hauling A private carrier hauling the goods of a subsidiary and charging the subsidiary a fee: this is legal if the subsidiary is wholly owned (100%) or if the private carrier has common carrier authority.

Interleaving The practice of assigning an employee multiple tasks which are performed concurrently.

Interline Two or more motor carriers working together to haul the shipment to a destination. Carrier equipment may be interchanged from one carrier to the next, but usually the shipment is re-handled without the equipment.

Intermediately Positioned Warehouse A warehouse located between customers and manufacturing plants to provide increased customer service and reduced distribution cost.

Intermittent-flow, fixed-path equipment Materials handling devices that include cranes, monorails and stacker cranes.

Intermodal Container Transfer Facility A facility where cargo is transferred from one mode of transportation to another, usually from ship or truck to rail.

Intermodal Marketing Company (IMC) An intermediary that sells intermodal services to shippers.

Intermodal Transportation Transporting freight by using two or more transportation modes such as by truck and rail or truck and oceangoing vessel.

Intermodal transport unit (ITU) Container, swap body or semi-trailer/goods road motor vehicle suitable for intermodal transport.

Internal Customer The recipient (person or department) of another person's or department's output (good, service or information) within an organization. *Also see: Customer*

Internal Labour and Overhead The portion of COGS that is typically reported as labour and overhead, less any costs already classified as "outsourced".

Internal Water Carriers Water carriers that operate over internal, navigable rivers such as the Mississippi, Ohio and Missouri.

International Air Transport Association (IATA) An international air carrier rate bureau for passenger and freight movements.

International Civil Aeronautics Organization (ICAO) An international agency that is responsible for air safety and for standardizing air traffic control, airport design and safety features worldwide.

International Maritime Bureau (IMB) A special division of the International Chamber of Commerce.

International Maritime Organization (IMO) A United Nations-affiliated organization representing all maritime countries in matters affecting maritime transportation, including the movement of dangerous goods. The organization also is involved in deliberations on marine environmental pollution.

International Ship and Port Facility Security Code (ISPS) Adopted by the IMO and based on the U.S. MTSA, came into force on July 1, 2004. It is a comprehensive, mandatory security regime for international shipping and port facility operations agreed to by the members of the IMO. Ships must be certified by their flag states to ensure that mandated security measures have been implemented; port facilities must undergo security vulnerability assessments that form the basis of security plans approved by their government authorities.

International Standards Organization (ISO) An organization within the United Nations to which all national and other standard setting bodies (should) defer. Develops and monitors international standards, including OSI, EDIFACT and X.400

Internet A computer term which refers to an interconnected group of computer networks from all parts of the world, i.e. a network of networks. Accessed via a modem and an on-line service provider, it contains many information resources and acts as a giant electronic message routing system.

Interstate Commerce The transportation of persons or property between states; in the course of the movement, the shipment crosses a state boundary line.

Interstate Commerce Commission (ICC) An independent regulatory agency that implements federal economic regulations controlling railroads, motor carriers, pipelines, domestic water carriers, domestic surface freight forwarders, and brokers.

Interstate System The National System of Interstate and Defense Highways, 42,000 miles of four-lane, limited-access roads connecting major population centres.

Intra-Manufacturing Re-plan Cycle Average elapsed time, in calendar days, between the time a regenerated forecast is accepted by the end-product manufacturing/assembly location, and the time that the revised plan is reflected in the Master Production Schedule of all the affected internal sub-assembly/component producing plant(s). (An element of Total Supply Chain Response Time)

Intrastate Commerce The transportation of persons or property between points within a state. A shipment between two points within a state may be interstate if the shipment had a prior or subsequent move outside of the state and the intent of the shipper was an interstate shipment at the time of shipment.

In-transit Inventory Material moving between two or more locations, usually separated geographically; for example, finished goods being shipped from a plant to a distribution centre. In-transit inventory is an easily overlooked component of total supply chain availability.

Intrinsic Forecast Method In forecasting, a forecast based on internal factors, such as an average of past sales.

Inventory Raw materials, work in process, finished goods and supplies required for creation of a company's goods and services; The number of units and/or value of the stock of goods held by a company.

Inventory Accuracy When the on-hand quantity is equivalent to the perpetual balance (plus or minus the designated count tolerances). Often referred to as a percentage showing the variance between book inventory and actual count. This is a major performance metric for any organization which manages large inventories. Typical minimum and best practice averages would be 95% and 99%.

Inventory Balance Location Accuracy When the on-hand quantity in the specified locations is equivalent to the perpetual balance (plus or minus the designated count tolerances).

Inventory Carrying Cost One of the elements comprising a company's total supply-chain management costs. These costs consist of the following:1. Opportunity Cost: The opportunity cost of holding inventory. This should be based on your company's own cost of capital standards using the following formula. Calculation: Cost of Capital × Average Net Value of Inventory2. Shrinkage: The costs associated with breakage, pilferage and deterioration of inventories. Usually pertains to the loss of material through handling damage, theft or neglect.3. Insurance and Taxes: The cost of insuring inventories and taxes associated with the holding of inventory.4. Total Obsolescence for Raw Material, WIP, and Finished Goods Inventory: Inventory reserves taken due to obsolescence and scrap and includes products exceeding the shelf life, i.e. spoils and is no good for use in its original purpose (do not include reserves taken for Field Service Parts).5. Channel Obsolescence: Ageing allowances paid to channel partners, provisions for buy-back agreements, etc. Includes all material that goes obsolete while in a distribution channel. Usually, a distributor will demand a refund on material that goes bad (shelf life) or is no longer needed because of changing needs.6. Field Service Parts Obsolescence: Reserves taken due to obsolescence and scrap. Field Service Parts are those inventory kept at locations outside the four walls of the manufacturing plant, i.e. distribution centre or warehouse.

Inventory Days of Supply (for RM, WIP, PFG and FFG) Total gross value of inventory for the category (raw materials, work in process, partially finished goods or fully finished goods) at standard cost before reserves for excess and obsolescence. It includes only inventory that is on the books and currently owned by the business entity. Future liabilities such as consignments from suppliers are not included.*Calculation:*[*5 Point Annual Average Gross Inventory]/[Calendar Year Value of Transfers/365]*

Inventory Deployment A technique for strategically positioning inventory to meet customer service levels while minimizing inventory and storage levels. Excess inventory is replaced with information derived through monitoring supply, demand and inventory at rest as well as in motion.

Inventory Management The process of ensuring the availability of products through inventory administration.

Inventory Planning Systems The systems that help in strategically balancing the inventory policy and customer service levels throughout the supply chain. These systems calculate time-phased order quantities and safety stock, using selected inventory strategies. Some inventory planning systems conduct what-if analysis and that compares the current inventory policy with simulated inventory scenarios and improves the inventory ROI.

Inventory Turns The cost of goods sold divided by the average level of inventory on hand. This ratio measures how many times a company's inventory has been sold during a period of time. Operationally, inventory turns are measured as total throughput divided by average level of inventory for a given period; How many times a year the average inventory for a firm changes over, or is sold.

Inventory Turnover *See Inventory Turns*

Inventory Velocity The speed with which inventory moves through a defined cycle (i.e. from receiving to shipping).

Invoice A detailed statement showing goods sold and amounts for each. The invoice is prepared by the seller and acts as the document that the buyer will use to make payment.

IP *See Intellectual Property*

Irregular Route Carrier A motor carrier that is permitted to provide service utilizing any route.

IS *See Information Systems*

ISDN *See Integrated services digital network*

ISO *See International Standards Organization*

ISO 9000 A series of quality assurance standards compiled by the Geneva, Switzerland-based International Standardization Organization. In the United States, ISO is represented by the American National Standards Institute based in Washington, DC.

ISO 14000 Series Standards A series of generic environmental management standards under development by the International Organization of Standardization, which provide structure and systems for managing environmental compliance with legislative and regulatory requirements and affect every aspect of a company's environmental operations.

ISPS *See International Ship and Port Facility Security Code*

IT Information Technology.

ITL International Trade Logistics.

ITE *See Independent Trading Exchange*

ITU *See Intermodal Transport Unit*

Item Any unique manufactured or purchased part, material, intermediate, subassembly or product.

J

Java A computer term for a general-purpose programming language created by Sun Microsystems. Java can be used to create Java applets. A Java program is downloaded from the web server and interpreted by a program running on the computer running the Web browser.

Java Applet A computer term for a short program written in Java that is attached to a web page and executed by the computer on which the Web browser is installed.

Java Script A computer term for a cross-platform, World Wide Web scripting language developed by Netscape Communications. JavaScript code is inserted directly into an HTML page.

Jidoka The concept of adding an element of human judgment to automated equipment. In doing this, the equipment becomes capable of discriminating against unacceptable quality, and the automated process becomes more reliable. This concept, also known as autonomation, was pioneered by Sakichi Toyoda at the turn of the twentieth century when he invented automatic looms that stopped instantly when any thread broke. This permitted one operator to oversee many machines with no risk of producing large amounts of defective cloth. The term has since been extended beyond its original meaning to include any means of stopping production to prevent scrap (for example, the andon cord which allows assembly-plant workers to stop the line), even where this capability is not built-in to the production machine itself.

JIT *See Just-In-Time*

JIT II *See Just-In-Time II*

JIT/QC Just-In-Time/Quality Control.

Joint Cost A type of common cost where products are produced in fixed proportions, and the cost incurred to produce one product necessarily entails the production of another; the backhaul is an example.

Joint Photographic Expert Group (JPEG) A graphical file format used to display high-resolution colour images on the World Wide Web. JPEG images apply a user-specified compression scheme that can significantly reduce the large file size usually associated with photo-realistic colour images. A higher level of compression results in lower image quality, whereas a lower level of compression results in higher image quality.

Joint Rate A rate over a route that involves two or more carriers to transport the shipment.

Joint Supplier Agreement (JSA) Indicative of Stage 3 Sourcing Practices, the JSA includes terms and conditions, objectives, process flows, performance targets, flexibility, balancing and incentives.

JPEG *See Joint Photographic Expert Group*

JSA *See Joint Supplier Agreement*

Just-in-Time (JIT) An inventory control system that controls material flow into assembly and manufacturing plants by coordinating demand and supply to the point where desired materials arrive just in time for use. An inventory reduction strategy that feeds production lines with products delivered “just in time”. Developed by the auto industry, it refers to shipping goods in smaller, more frequent lots.

Just-in-Time II (JIT II) Vendor-managed operations taking place within a customer's facility. JIT II was popularized by the Bose Corporation. The supplier reps, called "inplants", place orders to their own companies, relieving the customer's buyers from this task. Many also become involved at a deeper level, such as participating in new product development projects, manufacturing planning (concurrent planning).

K

Kanban Japanese word for "visible record", loosely translated means card, billboard or sign. Popularized by Toyota Corporation, it uses standard containers or lot sizes to deliver needed parts to assembly line "just in time" for use.

Kaizen The Japanese term for improvement; continuing improvement involving everyone—managers and workers. In manufacturing, kaizen relates to finding and eliminating waste in machinery, labour or production methods. *Also see: Continuous Process Improvement*

Kaizen Blitz A rapid improvement of a limited process area, for example, a production cell. Part of the improvement team consists of workers in that area. The objectives are to use innovative thinking to eliminate non-value-added work and to immediately implement the changes within a week or less. Ownership of the improvement by the area work team and the development of the team's problem-solving skills are additional benefits.

KD *See Knock-Down*

Keiretsu A form of cooperative relationship among companies in Japan where the companies largely remain legally and economically independent, even though they work closely in various ways such as sole sourcing and financial backing. A member of a keiretsu generally owns a limited amount of stock in other member companies. A keiretsu generally forms around a bank and a trading company but "distribution" (supply chain) keiretsus exist linking companies from raw material suppliers to retailers.

Key Custodians The persons, assigned by the security administrators of trading partners, that send or receive a component of either the master key or exchange key used to encrypt data encryption keys. This control technique involves dual control, with split knowledge that requires two key custodians.

Key Performance Indicator (KPI) A measure which is of strategic importance to a company or department. For example, a supply chain flexibility metric is Supplier On-time Delivery Performance which indicates the percentage of orders that are fulfilled on or before the original requested date.*Also see: Scorecard*

Kitting Light assembly of components or parts into defined units. Kitting reduces the need to maintain an inventory of pre-built completed products, but increases the time and labour consumed at shipment. *Also see: Postponement*

Knock-Down (KD) A flat, unformed cardboard box or tray. Knock-downs, also known as KDs, are constructed and glued in the recoup or packaging areas and used for repacked product. Many KDs are provided by the customer for their recouped products.

KPI *See Key Performance Indicator*

L

Lading The cargo carried in a transportation vehicle.

Laid-Down Cost The sum of the product and transportation costs. The laid-down cost is useful in comparing the total cost of a product shipped from different supply sources to a customer's point of use.

LAN *See Local Area Network*

Land Bridge The movement of containers by ship-rail-ship on Japan-to-Europe moves; ships move containers to the U.S. Pacific Coast, rails move containers to an East Coast port and ships deliver containers to Europe.

Land Grants Grants of land given to railroads during their developmental stage to build tracks.

Landed Cost Cost of product plus relevant logistics costs such as transportation, warehousing and handling. *Also called Total Landed Cost or Net Landed Costs*

Lash Barges Covered barges that are loaded on board oceangoing ships for movement to foreign destinations.

Last In, First Out (LIFO) Accounting method of valuing inventory that assumes latest goods purchased are first goods used during accounting period.

LCL *See Less-Than-Carload or Less-Than-Container load*

LDI *See Logistics data interchange*

Lead Logistics Partner (LLP) An organization that organizes other third-party logistics partners for outsourcing of logistics functions. An LLP serves as the client's primary supply chain management provider, defining processes and managing the provision and integration of logistics services through its own organization and those of its subcontractors. *Also see: Fourth-Party Logistics*

Lead Time The total time that elapses between an order's placement and its receipt. It includes the time required for order transmittal, order processing, order preparation and transit.

Lead Time from Complete Manufacture to Customer Receipt Includes time from when an order is ready for shipment to customer receipt of order. Time from complete manufacture to customer receipt including the following elements: pick/pack time, prepare for shipment, total transit time (all components to consolidation point), consolidation, queue time and additional transit time to customer receipt.

Lead Time from Order Receipt to Complete Manufacture Includes times from order receipt to order entry complete, from order entry complete to start to build, and from start to build to ready for shipment. Time from order receipt to order entry complete includes the following elements: order revalidation, configuration check, credit check and scheduling. Time from order entry complete to start to build includes the following elements: customer wait time and engineering and design time. Time from start to build to ready for shipment includes the following elements: release to manufacturing or distribution, order configuration verification, production scheduling, and build or configure time.

Least Total Cost A dynamic lot-sizing technique that calculates the order quantity by comparing the setup (or ordering) costs and the carrying cost for various lot sizes and selects the lot size where these costs are most nearly equal. *Also see: Discrete Order Quantity, Dynamic Lot Sizing*

Least Unit Cost A dynamic lot-sizing technique that adds ordering cost and inventory carrying cost for each trial lot size and divides by the number of units in the lot size, picking the lot size with the lowest unit cost. *Also see: Discrete Order Quantity, Dynamic Lot Sizing*

Leg A portion of a complete trip which has an origin, destination and carrier and is composed of all consecutive segments of a route booked through the same carrier. *Also called Bookable Leg*

Less-Than-Carload (LCL) Shipment that is less than a complete rail car load (lot shipment).

Less-Than-Truckload (LTL) Carriers Trucking companies that consolidate and transport smaller (less than truckload) shipments of freight by utilizing a network of terminals and relay points.

Lessee A person or firm to whom a lease is granted.

Lessor A person or firm that grants a lease.

Letter of credit (LOC) An international business document that assures the seller that payment will be made by the bank issuing the letter of credit upon fulfilment of the sales agreement.

Leverage Taking something small and exploding it. Can be financial or technological.

Licence Plate A pallet tag; refers to a uniquely numbered barcode sticker placed on a pallet of product. Typically contains information about product on the pallet.

Life Cycle Cost In cost accounting, a product's life cycle is the period that starts with the initial product conceptualization and ends with the withdrawal of the product from the marketplace and final disposition. A product life cycle is characterized by certain defined stages, including research, development, introduction, maturity, decline and abandonment. Life cycle cost is the accumulated costs incurred by a product during these stages.

Lighter A flat-bottomed boat designed for cross-harbour or inland waterway freight transfer. While the terms barge and lighter are used interchangeably, a barge usually refers to a vessel used for a long haul, while a lighter is used for a short haul.

LIFO *See Last In, First Out*

Lift truck Vehicles used to lift, move, stack, rack or otherwise manipulate loads. Material handling people use a lot of terms to describe lift trucks; some terms describe specific types of vehicles, others are slang terms or trade names that people often mistakenly use to describe trucks. Terms include industrial truck, forklift, reach truck, motorized pallet trucks, turret trucks, counterbalanced forklift, walkie, rider, walkie rider, walkie stacker, straddle lift, side loader, order pickers, high lift, cherry picker, Jeep, Towmotor, Yale, Crown, Hyster, Raymond, Clark and Drexel.

Line (1) A specific physical space for the manufacture of a product that in a flow shop layout is represented by a straight line. In actuality, this may be a series of pieces of equipment connected by piping or conveyor systems. (2) A type of manufacturing process used to produce a narrow range of standard items with identical or highly similar designs. Production volumes are high, production and material handling equipment is specialized, and all products typically pass through the same sequence of operations. *Also see: Assembly Line*

Line Functions The decision-making areas associated with daily operations. Logistics line functions include traffic management, inventory control, order processing, warehousing and packaging.

Line-Haul Shipment A shipment that moves between cities and distances over 100–150 miles.

Line Scrap Value of raw materials and work-in-process inventory scrapped as a result of improper processing or assembly, as a percentage of total value of production at standard cost.

Liner Service International water carriers that ply fixed routes on published schedules.

Link The transportation method used to connect the nodes (plants, warehouses) in a logistics system.

Linked Distributed Systems Independent computer systems, owned by independent organizations, linked in a manner to allow direct updates to be made to one system by another. For example, a customer's computer system is linked to a supplier's system, and the customer can create orders or releases directly in the supplier's system.

Little Inch A federally built pipeline constructed during World War II that connected Corpus Christi and Houston, Texas.

Live A situation in which the equipment operator stays with the trailer or boxcar while it is being loaded or unloaded.

LLP *See Lead Logistics Partner*

Load Factor A measure of operating efficiency used by air carriers to determine the percentage of a plane's capacity that is utilized, or the number of passengers divided by the total number of seats.

Load Tender (Pick-Up Request) An offer of cargo for transport by a shipper. Load tender terminology is primarily used in the motor industry.

Load Tendering The practice of providing a carrier with detailed information and negotiated pricing (the tender) prior to scheduling pickup. This practice can help assure contract compliance and facilitate automated payments (self billing).

Loading allowance A reduced rate offered to shippers and/or consignees who load and/or unload LTL or AQ shipments.

Loading Port The port where the cargo is loaded onto the exporting vessel. This port must be reported on the Shipper's Export Declaration, Schedule D and is used by US companies to determine which tariff is used to freight rate the cargo for carriers with more than one tariff.

LOC *See Letter of credit*

Local Area Network (LAN) A data communications network spanning a limited geographical area, usually a few miles at most, providing communications between computers and peripheral devices.

Local Rate A rate published between two points served by one carrier.

Local Service Carriers An air carrier classification of carriers that operate between areas of lesser and major population centres. These carriers feed passengers into the major cities to major hubs.

Location Tag A barcoded sign that hangs above or on a warehouse location. The location number can be read from the tag or scanned with an RF gun.

Locational Determinant The factors that determine the location of a facility. For industrial facilities, the determinants include logistics.

Locator System Locator systems are inventory-tracking systems that allow you to assign specific physical locations to your inventory to facilitate greater tracking and the ability to store product randomly. Location functionality in software can range from a simple text field attached to an item that notes a single location, to systems that allow multiple locations per item and track inventory quantities by location. Warehouse management systems (WMS) take locator systems to the next level by adding functionality to direct the movement between locations.

Logbook A daily record of the hours an interstate driver spends driving, off duty, sleeping in the berth, or on duty but not driving.

Logistics The process of planning, implementing and controlling procedures for the efficient and effective transportation and storage of goods including services, and related information from the point of origin to the point of consumption for the purpose of conforming to customer requirements. This definition includes inbound, outbound, internal and external movements.

Logistics Channel The network of supply chain participants engaged in storage, handling, transfer, transportation and communications functions that contribute to the efficient flow of goods.

Logistics Data Interchange (LDI) A computerized system to electronically transmit logistics information.

Logistics Management As defined by the Council of Supply Chain Management Professionals (CSCMP)"Logistics management is that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customers' requirements. Logistics management activities typically include inbound and outbound transportation management, fleet management, warehousing, materials handling, order fulfilment, logistics network design, inventory management, supply/demand planning, and management of third party logistics services providers. To varying degrees, the logistics function also includes sourcing and procurement, production planning and scheduling, packaging and assembly, and customer service. It is involved in all levels of planning and execution—strategic, operational, and tactical. Logistics management is an integrating function which coordinates and optimizes all logistics activities, as well as integrates logistics activities with other functions, including marketing, sales, manufacturing, finance, and information technology".

Long Ton Equals 2240 pounds.

Lot Control A set of procedures (e.g. assigning unique batch numbers and tracking each batch) used to maintain lot integrity from raw materials, from the supplier through manufacturing to consumers.

Lot-for-Lot A lot-sizing technique that generates planned orders in quantities equal to the net requirements in each period. *Also see: Discrete Order Quantity*

Lot Number *See Batch Number*

Lot Size The quantity of goods purchased or produced in anticipation of use or sale in the future.

Lot Sized System *See Fixed Reorder Quantity Inventory Model*

LTL *See Less-than-truckload Carriers*

Lumping A term applied to a person who assists a motor carrier owner-operator in the loading and unloading of property: quite commonly used in the food industry.

Lumpy Demand *See Discontinuous Demand*

M

M2M *See Machine-to-Machine interface*

Machine Downtimes Time during which a machine cannot be utilized. Machine downtimes may occur during breakdowns, maintenance, changeovers, etc.

Machine-to-Machine interface (M2M) A term describing the process whereby machines are remotely monitored for status and problems reported and resolved automatically or maintenance scheduled by the monitoring systems.

Macro Environment The environment external to a business including technological, economic, natural and regulatory forces that marketing efforts cannot control.

Mainframe A term sometimes generically used to refer to an organization's central computer system. Specifically the largest class of computer systems manufactured.

Maintenance, Repair and Operating supplies (MRO) Items used in support of general operations and maintenance such as maintenance supplies, spare parts, and consumables used in the manufacturing process and supporting operations.

Major Carrier A for-hire certificated air carrier that has annual operating revenues of $1 billion or more: the carrier usually operates between major population centres.

Make-or-Buy Decision The act of deciding whether to produce an item internally or buy it from an outside supplier. Factors to consider in the decision include costs, capacity availability, proprietary and/or specialized knowledge, quality considerations, skill requirements, volume and timing.

Make-to-Order (Manufacture-to-order) (MTO) A manufacturing process strategy where the trigger to begin manufacture of a product is an actual customer order or release, rather than a market forecast. For Make-to-Order products, more than 20% of the value-added takes place after the receipt of the order or release, and all necessary design and process documentation is available at time of order receipt.

Make-to-Stock (Manufacture-to-stock) (MTS) A manufacturing process strategy where finished product is continually held in plant or warehouse inventory to fulfil expected incoming orders or releases based on a forecast.

Manifest A document which describes individual orders contained within a shipment.

Manufacturer's Representative One who sells goods for several firms but does not take title to them.

Manufacturing Calendar A calendar used in inventory and production planning functions that consecutively numbers only the working days so that the component and work order scheduling may be done based on the actual number of workdays available. Synonyms: M-Day Calendar, Planning Calendar, Production Calendar, Shop Calendar.

Manufacturing Capital Asset Value The asset value of the "Manufacturing fixed assets" after allowance for depreciation. Examples of equipment are SMT placement machines, conveyors, Auto guided vehicles, robot cells, testers, X-ray solder machines, Burn-in chambers, Logic testers, Auto packing equipment, PLC station controllers, Scanning equipment, PWB magazines.

Manufacturing Critical-Path Time (MCT) The typical amount of calendar time from when a manufacturing order is created through the critical-path until the first, single piece of that order is delivered to the customer.

Manufacture Cycle Time The average time between commencement and completion of a manufacturing process, as it applies to make-to-stock products.*Calculation*:*[Average # of units in WIP]/[Average daily output in units]*

Manufacturing Execution Systems (MES) Programs and systems that participate in shop floor control, including programmed logic controllers and process control computers for direct and supervisory control of manufacturing equipment; process information systems that gather historical performance information, then generate reports; graphical displays; and alarms that inform operations personnel what is going on in the plant currently and a very short history into the past. Quality control information is also gathered and a laboratory information management system may be part of this configuration to tie process conditions to the quality data that are generated. Thereby, cause-and-effect relationships can be determined. The quality data at times affect the control parameters that are used to meet product specifications either dynamically or off line.

Manufacturing Lead Time The total time required to manufacture an item, exclusive of lower level purchasing lead time. For make-to-order products, it is the length of time between the release of an order to the production process and shipment to the final customer. For make-to-stock products, it is the length of time between the release of an order to the production process and receipt into finished goods inventory. Included here are order preparation time, queue time, setup time, run time, move time, inspection time and put-away time. *Synonyms: Manufacturing Cycle Time. Also see: Lead Time*

Manufacturing Resource Planning (MRP II) A method for the effective planning of all resources of a manufacturing company. Ideally, it addresses operational planning in units, financial planning in dollars, and has a simulation capability to answer what-if questions. It is made up of a variety of processes, each linked together: business planning, production planning (sales and operations planning), master production scheduling, material requirements planning, capacity requirements planning, and the execution support systems for capacity and material. Output from these systems is integrated with financial reports such as the business plan, purchase commitment report, shipping budget and inventory projections in dollars. Manufacturing resource planning is a direct outgrowth and extension of closed-loop MRP.

Mapping A computer term referring to diagramming data that is to be exchanged electronically, including how it is to be used and what business management systems need it. Preliminary step for developing an applications link. Performed by the functional manager responsible for a business management system.

Marginal Cost The cost to produce one additional unit of output. The change in total variable cost resulting from a one-unit change in output.

Marine Insurance Insurance to protect against cargo loss and damage when shipping by water transportation.

Maritime Administration A federal agency that promotes the merchant marine, determines ocean ship routes and services, and awards maritime subsidies.

Maritime Transportation Security Act (MTSA) Law passed in 2002 to create a comprehensive national system of transportation security enhancements. The MTSA designated the U.S. Coast Guard as the lead federal agency for maritime homeland security and requires federal agencies, ports and vessel owners to take numerous steps to upgrade security. The MTSA requires the Coast Guard to develop national and regional area maritime transportation security plans and requires seaports, waterfront terminals and vessels to submit security and incident response plans to the Coast Guard for approval. The MTSA also requires the Coast Guard to conduct antiterrorism assessments of certain foreign ports.

Market Demand In marketing, the total demand that would exist within a defined customer group in a given geographical area during a particular time period given a known marketing program.

Market Dominance In transportation rating this refers to the absence of effective competition for railroads from other carriers and modes for the traffic to which the rate applies. The Staggers Act stated that market dominance does not exist if the rate is below the revenue-to-variable-cost ratio of 160% in 1981 and 170% in 1983

Market Segment A group of potential customers sharing some measurable characteristics based on demographics, psychographics, lifestyle, geography, benefits, etc.

Market Share The portion of the overall market demand for a specific product or service which is provided by any single provider.

Market-Positioned Warehouse Warehouse positioned to replenish customer inventory assortments and to afford maximum inbound transport consolidation economies from inventory origin points with relatively short-haul local delivery.

Marks and Numbers Identifying marks and numbers affixed to or placed on goods used to identify a shipment or parts of a shipment.

Marquis Partners Key strategic relationships. This has emerged as perhaps the key competitive advantage and barrier to entry of e-marketplaces. Get the big players in the fold first, offering equity if necessary.

Marshaller or Marshalling Agent This is a service unique to international trade and relates to an individual or firm that specializes in one or more of the activities preceding Main Carriage, such as consolidation, packing, marking, sorting of merchandise, inspection and storage. References state that Marshalling Agent, Consolidation Agent and Freight Forwarder all have the same meaning.

Mass Customization The creation of a high-volume product with large variety so that a customer may specify his or her exact model out of a large volume of possible end items while manufacturing cost is low because of the large volume. An example is a personal computer order in which the customer may specify processor speed, memory size, hard disk size and speed, removable storage device characteristics, and many other options when PCs are assembled on one line and at low cost.

Master Pack A large box that is used to pack a number of smaller boxes or containers. Aids in protecting the smaller cartons or packages and reduces the number of cartons to be handled during the material handling process.

Master Production Schedule (MPS) The master level or top level schedule used to set the production plan in a manufacturing facility.

Material Acquisition Costs One of the elements comprising a company's total supply-chain management costs. These costs consist of the following:1. Materials (Commodity) Management and Planning: All costs associated with supplier sourcing, contract negotiation and qualification, and the preparation, placement, and tracking of a purchase order, including all costs related to buyer/planners.2. Supplier Quality Engineering: The costs associated with the determination, development/certification and monitoring of suppliers' capabilities to fully satisfy the applicable quality and regulatory requirements.3. Inbound Freight and Duties: Freight costs associated with the movement of material from a vendor to the buyer and the associated administrative tasks. Duties are those fees and taxes levied by government for moving purchased material across international borders. Customs broker fees should also be considered in this category.4. Receiving and Put Away: All costs associated with taking possession of material and storing it.*Note that carrying costs are not a part of acquisition, and inspection is handled separately.*1. Incoming Inspection: All costs associated with the inspection and testing of received materials to verify compliance with specifications.2. Material Process and Component Engineering: Those tasks required to document and communicate component specifications, as well as reviews to improve the manufacturability of the purchased item.3. Tooling: Those costs associated with the design, development and depreciation of the tooling required to produce a purchased item. A tooling cost would be incurred by a company if they actually paid for equipment and/or maintenance for a contract manufacturer that makes their product. Sometimes, there isn't enough incentive for a contract manufacturer to upgrade plant equipment to a level of quality that a company requires, so the company will pay for the upgrades and maintenance to ensure high quality. May not be common in some industries such as Chemicals.

Material Index The ratio of the sum of the localized raw material weights to the weight of the finished product.

Material Safety Data Sheet (MSDS) A document that is part of the materials information system and accompanies the product. Prepared by the manufacturer, the MSDS provides information regarding the safety and chemical properties and (if necessary) the long-term storage, handling, and disposal of the product. Among other factors, the MSDS describes the hazardous components of a product; how to treat leaks, spills and fires; and how to treat improper human contact with the product. *Also see: Hazardous Materials*

Materials Handling The physical handling of products and materials between procurement and shipping.

Materials Management Inbound logistics from suppliers through the production process. The movement and management of materials and products from procurement through production.

Materials planning The materials management function that attempts to coordinate the supply of materials with the demand for materials.

Materials Requirements Planning (MRP) A decision-making methodology used to determine the timing and quantities of materials to purchase.

Matrix Organizational Structure An organizational structure in which two (or more) channels of command, budget responsibility and performance measurement exist simultaneously. For example, both product and functional forms of organization could be implemented simultaneously, that is, the product and functional managers have equal authority and employees report to both managers.

MAX The lowest inventory quantity that is desired at a ship to location or selling location. This quantity will over-ride the forecast number if the forecast climbs above the MAX. Maximum stock

Maximum Inventory The planned maximum allowable inventory for an item based on its planned lot size and target safety stock.

Maximum Order Quantity An order quantity modifier applied after the lot size has been calculated, that limits the order quantity to a pre-established maximum.

m-Commerce Mobile commerce applications involve using a mobile phone to carry out financial transactions. This usually means making a payment for goods or transferring funds electronically. Transferring money between accounts and paying for purchases are electronic commerce applications. An emerging application, electronic commerce has been facilitated by developments in other areas in the mobile world, such as dual slot phones and other smarter terminals and more standardized protocols, which allow greater interactivity and therefore more sophisticated services.

MCT *See Manufacturing critical-path time*

M-Day Calendar *See Manufacturing Calendar*

Mean The arithmetic average of a group of values. *Syn: arithmetic mean*

Measure A number used to quantify a metric, showing the result of part of a process often resulting from a simple count. Example: Number of units shipped.

Measurement Ton Equals 40 cubic feet; used in water transportation rate making.

Median The middle value in a set of measured values when the items are arranged in order of magnitude. If there is no single middle value, the median is the mean of the two middle values.

Merge In Transit The process of combining or "merging" shipments from multiple suppliers which are going directly to the buyer or to the store, bypassing the seller. Effectively a "drop shipment" from several vendors to one buyer, which is being combined at an intermediary point prior to delivery.

Merger The combination of two or more carriers into one company for the ownership, management and operation of the properties previously operated on a separate basis.

MES *See Manufacturing Execution Systems*

Message The EDIFACT term for a transaction set. A message is the collection of data, organized in segments, exchanged by trading partners engaged in EDI. Typically, a message is an electronic version of a document associated with a common business transaction, such as a purchase order or shipping notice. A message begins with a message header segment, which identifies the start of the message (e.g. the series of characters representing one purchase order). The message header segment also carries the message type code, which identifies the business transaction type. EDIFACT's message header segment is called UNH; in ANSI X12 protocol, the message header is called ST. A message ends with a message trailer segment, which signals the end of the message (e.g. the end of one purchase order). EDIFACT's message trailer is labelled UNT; the ANSI X12 message trailer is referred to as SE.

Meta Tag An optional HTML tag that is used to specify information about a web document. Some search engines use "spiders" to index web pages. These spiders read the information contained within a page's META tag. So in theory, an HTML or web page author has the ability to control how their site is indexed by search engines and how and when it will "come up" on a user's search. The META tag can also be used to specify an HTTP or URL address for the page to "jump" to after a certain amount of time. This is known as Client-Pull. What this means, is a web page author can control the amount of time a web page is up on the screen as well as where the browser will go next.

Metrics Specific areas of measurement. A metric must be quantitative and must support benchmarking, and it must be based on broad, statistically valid data. Therefore, it must exist in a format for which published data exists within the enterprise or industry. *See Performance Measures*

Micro-Land Bridge An intermodal movement in which the shipment is moved from a foreign country to the USA by water and then moved across the USA by railroad to an interior, nonport city, or vice versa for exports from a nonport city.

Mileage Allowance An allowance based upon distance and given by railroads to shippers using private rail cars.

Mileage Rate A rate based upon the number of miles the commodity is shipped.

Milk Run A regular route for pickup of mixed loads from several suppliers. For example, instead of each of five suppliers sending a truckload per week to meet the weekly needs of the customer, one truck visits each of the suppliers on a daily basis before delivering to the customer's plant. Five truckloads per week are still shipped, but each truckload contains the daily requirement from each supplier. *Also see: Consolidation*

Min–Max System A type of order point replenishment system where the "min" (minimum) is the order point, and the "max" (maximum) is the "order up to" inventory level. The order quantity is variable and is the result of the max minus the available and on-order inventory. An order is recommended when the sum of the available and on-order inventory is at or below the min.

Mini-Land Bridge An intermodal movement in which the shipment is moved from a foreign country to the USA by water and then moved across the USA by railroad to a destination that is a port city, or vice versa for exports from a US port city.

Minimum Weight The shipment weight specified by the carrier's tariff as the minimum weight required to use the TL or CL rate; the rate discount volume.

Misguided Capacity Plans Plans or forecasts for capacity utilization, which are based on inaccurate assumptions or input data.

Mixed loads The movement of both regulated and exempt commodities in the same vehicle at the same time.

Modal Split The relative use made of the modes of transportation; the statistics used include ton-miles, passenger-miles and revenue.

Mode *See Transportation Mode*

MOTE (as in reMOTE) A wireless receiver/transmitter that is typically combined with a sensor of some type to create a remote sensor. Motes are being used in ocean containers to look for evidence of tampering. They have huge application in food, pharma and other "cold chain" industries to closely monitor temperature, humidity and other factors.

Motor Carrier An enterprise that offers service via land motor carriage.

Move Ticket A document used to move inventory within a facility. Warehouse management systems use move tickets to direct and track material movements. In a paperless environment the electronic version of a move ticket is often called a task or a trip.

MPS *See Master Production Schedule*

MRO *See Maintenance, Repair and Operating Supplies*

MRP *See Material Requirements Planning*

MRP-II *See Manufacturing Resource Planning*

MSDS *See Material Safety Data Sheet*

MTO *See Make-to-Order*
MTS *See Make-to-Stock*
MTSA *See Maritime Transportation Security Act*
Multi-Currency The ability to process orders using a variety of currencies for pricing and billing.
Multinational Company A company that both produces and markets products in different countries.
Multiple-Car Rate A railroad rate that is lower for shipping more than one carload rather than just one carload at a time.
Multi-Skilled Pertaining to individuals who are certified to perform a variety of tasks.

N

NAFTA *See North American Free Trade Agreement*
National Carrier A for-hire certificated air carrier that has annual operating revenues of $75 million to $1 billion; the carrier usually operates between major population centres and areas of lesser population.
National Industrial Traffic League An association representing the interests of shippers and receivers in matters of transportation policy and regulation.
Nationalization Public ownership, financing and operation of a business entity.
National Motor Bus Operators Organization An industry association representing common and charter bus firms; now known as the American Bus Association.
National Motor Freight Classification (NMFC) A tariff, which contains descriptions and classifications of commodities and rules for domestic movement by motor carriers in the USA
National Railroad Corporation Also known as Amtrak, the corporation established by the Rail Passenger Service Act of 1970 to operate most of the United States' rail passenger service.
National Stock Number (NSN) The individual identification number assigned to an item to permit inventory management in the federal (US) supply system.
Net Asset Turns The number of times you replenish your net assets in your annual sales cycle. A measure of how quickly assets are used to generate sales.*Calculation:Total Product Revenue/Total Net Assets*
Net Assets Total Net assets are calculated as Total Assets—Total Liabilities; where: The total assets are made up of fixed assets (plant, machinery and equipment) and current assets which is the total of stock, debtors and cash (also includes A/R, inventory, prepaid assets, deferred assets, intangibles and goodwill). The total liabilities are made up in much the same way of long-term liabilities and current liabilities (includes A/P, accrued expenses, deferred liabilities).
Net Change MRP An approach in which the material requirements plan is continually retained in the computer. Whenever a change is needed in requirements, open order inventory status, or bill of material, a partial explosion and netting is made for only those parts affected by the change. Antonym: Regeneration MRP.

Net Requirements In MRP, the net requirements for a part or an assembly are derived as a result of applying gross requirements and allocations against inventory on hand, scheduled receipts, and safety stock. Net requirements, lot-sized and offset for lead time, become planned orders.

Net Weight The weight of the merchandise, unpacked, exclusive of any containers.

New Product Introduction (NPI) The process used to develop products that are new to the sales portfolio of a company.

NII *See Non-Intrusive Inspection Technology*

NES *See Not Otherwise Specified/Not Elsewhere Specified*

NMFC *See National Motor Freight Classification*

Node A fixed point in a firm's logistics system where goods come to rest; includes plants, warehouses, supply sources and markets.

No Location (No Loc) A received item for which the warehouse has no previously established storage slot.

Noncertified Carrier A for-hire air carrier that is exempt from economic regulation.

Nonconformity Failure to fulfil a specified requirement. *See: blemish, defect, imperfection*

Non-Conveyable Materials which cannot be moved on a conveyor belt.

Non-Durable goods Goods whose serviceability is generally limited to a period of less than 3 years (such as perishable goods and semidurable goods).

Non-Intrusive Inspection technology (NII) Originally developed to address the threat of smugglers using increasingly sophisticated techniques to conceal narcotics deep in commercial cargo and conveyances, NII systems, in many cases, give Customs inspectors the capability to perform thorough examinations of cargo without having to resort to the costly, time consuming process of unloading cargo for manual searches, or intrusive examinations of conveyances by methods such as drilling and dismantling.

Non-Vessel-Owning Common Carrier (NVOCC) A firm that offers the same services as an ocean carrier, but which does not own or operate a vessel. NVOCCs usually act as consolidators, accepting small shipments (LCL) and consolidating them into full container loads. They also consolidate and disperse international containers that originate at or are bound for inland ports. They then act as a shipper, tendering the containers to ocean common carriers. They are required to file tariffs with the Federal Maritime Commission and are subject to the same laws and statutes that apply to primary common carriers.

North American Free Trade Agreement (NAFTA) A free trade agreement, implemented January 1, 1994, between Canada, the United States and Mexico. It includes measures for the elimination of tariffs and non-tariff barriers to trade, as well as many more specific provisions concerning the conduct of trade and investment that reduce the scope for government intervention in managing trade.

NOS *See Not Otherwise Specified/Not Elsewhere Specified*

Not Otherwise Specified/Not Elsewhere Specified (NOS/NES) This term often appears in ocean or airfreight tariffs, respectively. If no rate for the specific commodity shipped appears in the tariff, then a general class rate (for example: printed matter NES) will apply. Such rates usually are higher than rates for specific commodities.

NPI *See New Product Introduction*
NSN *See National Stock Number*
NVOCC *See Non-vessel-owning common carrier*

O

Object Linking and Embedding (OLE) An object system created by Microsoft. OLE lets an author invoke different editor components to create a compound document.

Obsolete Inventory Inventory for which there is no forecast demand expected. A condition of being out of date. A loss of value occasioned by new developments that place the older property at a competitive disadvantage.

Ocean Bill of Lading The bill of lading issued by the ocean carrier to its customer.

OEE *See Overall Equipment Effectiveness*

OEM *See Original Equipment Manufacturer*

Offer *See Tender*

Offline A computer term which describes work done outside of the computer system or outside of a main process within the corporate system. In general usage this term describes any situation where equipment is not available for use, or individuals cannot be contacted.

Offshore Utilizing an outsourcing service provider (manufacturer or business process) located in a country other than where the purchasing enterprise is located.

Offshoring The practice of moving domestic operations such as manufacturing to another country.

OLE *See Object Linking and Embedding*

On-Demand Pertaining to work performed when demand is present. Typically used to describe products which are manufactured or assembled only when a customer order is placed.

On-Hand Balance The quantity shown in the inventory records as being physically in stock.

On-Line Receiving A system in which computer terminals are available at each receiving bay and operators enter items into the system as they are unloaded.

On Order The amount of goods that has yet to arrive at a location or retail store. This includes all open purchase orders including, but not limited to, orders in transit, orders being picked and orders being processed through customer service.

On Time In Full (OTIF) Sales order delivery performance measure which can be expressed as a target, say, of achieving 98% of orders delivered in full, no part shipments, on the requested date.

One Piece Flow Moving parts through a process in batches of one

One-Way Networks The advantages generally live with either the seller or buyer, but not both. B2C websites are one-way networks.

Online A computer term which describes activities performed using computer systems.

Open-to-Buy A control technique used in aggregate inventory management in which authorizations to purchase are made without being committed to specific suppliers. These authorizations are often reviewed by management using such measures as commodity in dollars and by time period.

Open-to-Receive Authorization to receive goods, such as a blanket release, firm purchase order item or supplier schedule. Open-to-receive represents near-term impact on inventory, and is often monitored as a control technique in aggregate inventory management. The total of open-to-receive, other longer term purchase commitments and open-to-buy represents the material and services cash exposure of the company.

Operational Performance Measurements (1) In traditional management, performance measurements related to machine, worker or department efficiency or utilization. These performance measurements are usually poorly correlated with organizational performance. (2) In theory of constraints, performance measurements that link causally to organizational performance measurements. Throughput, inventory and operating expense are examples. *Also see: Performance Measures*

Operating ratio A measure of operation efficiency defined as:*(Operating expenses/Operating revenues) × 100*

Optimization The process of making something as good or as effective as possible with given resources and constraints.

Option A choice that must be made by the customer or company when customizing the end product. In many companies, the term option means a mandatory choice from a limited selection.

Optional Replenishment Model A form of independent demand item management model in which a review of inventory on hand plus on order is made at fixed intervals. If the actual quantity is lower than some predetermined threshold, a reorder is placed for a quantity $M - x$, where M is the maximum allowable inventory and x is the current inventory quantity. The reorder point, R, may be deterministic or stochastic, and in either instance is large enough to cover the maximum expected demand during the review interval plus the replenishment lead time. The optional replenishment model is sometimes called a hybrid system because it combines certain aspects of the fixed reorder cycle inventory model and the fixed reorder quantity inventory model. *Also see: Fixed Reorder Cycle Inventory Model, Fixed Reorder Quantity Inventory Model, Hybrid Inventory System, Independent Demand Item Management Models*

Order A type of request for goods or services such as a purchase order, sales order and work order.

Order Batching Practice of compiling and collecting orders before they are sent in to the manufacturer.

Order Complete Manufacture to Customer Receipt of Order Average lead time from when an order is ready for shipment to customer receipt of order, including the following sub-elements: pick/pack time, preparation for shipment, total transit time for all components to consolidation point, consolidation, queue time, and additional transit time to customer receipt. (An element of Order Fulfilment

Lead-Time).Note: Determined separately for Make-to-Order, Configure/Package-to-Order, Engineer-to-Order and Make-to-Stock products.

Order Consolidation Profile The activities associated with filling a customer order by bringing together in one physical place all of the line items ordered by the customer. Some of these may come directly from the production line; others may be picked from stock.

Order Cycle The time and process involved from the placement of an order to the receipt of the shipment.

Order Entry and Scheduling The process of receiving orders from the customer and entering them into a company's order processing system. Orders can be received through phone, fax or electronic media. Activities may include "technically" examining orders to ensure an orderable configuration and provide accurate price, checking the customer's credit and accepting payment (optionally), identifying and reserving inventory (both on hand and scheduled), and committing and scheduling a delivery date.

Order Entry Complete to Start Manufacture Average lead-time from completion of customer order to the time manufacturing begins, including the following sub-elements: order wait time, engineering and design time. (An element of Order Fulfilment Lead-Time).Note: Determined separately for Make-to-Order, Configure/Package-to-Order and Engineer-to-Order products. Does not apply to Make-to-Stock products.

Order Fulfilment Lead Times Average, consistently achieved lead-time from customer order origination to customer order receipt, for a particular manufacturing process strategy (Make-to-Stock, Make-to-Order, Configure/Package-to-Order, Engineer-to-Order). Excess lead-time created by orders placed in advance of typical lead times (Blanket Orders, Annual Contracts, Volume Purchase Agreements, etc.), is excluded. (An element of Total Supply Chain Response Time)*Calculation:Total average lead time from: [Customer signature/authorization to order receipt] + [Order receipt to completion of order entry] + [Completion of order entry to start manufacture] + [Start manufacture to complete manufacture] + [Complete manufacture to customer receipt of order] + [Customer receipt of order to installation complete]*Note: The elements of order fulfilment lead time are additive. Not all elements apply to all manufacturing process strategies. For example, for Make-to-Stock products, the lead-time from Start manufacture to complete manufacture equals 0.

Order Interval The time period between the placement of orders.

Order Level System *See Fixed Reorder Cycle Inventory Model*

Order Management The planning, directing, monitoring and controlling of the processes related to customer orders, manufacturing orders and purchase orders. Regarding customer orders, order management includes order promising, order entry, order pick, pack and ship, billing, and reconciliation of the customer account. Regarding manufacturing orders, order management includes order release, routing, manufacture, monitoring, and receipt into stores or finished goods inventories. Regarding purchasing orders, order management includes order placement, monitoring, receiving, acceptance and payment of supplier.

Order Management Costs One of the elements comprising a company's total supply-chain management costs. These costs consist of the following:1. New Product Release Phase-In and Maintenance: This includes costs associated with releasing new products to the field, maintaining released products, assigning product ID, defining configurations and packaging, publishing availability schedules, release letters and updates, and maintaining product databases.2. Create Customer Order: This includes costs associated with creating and pricing configurations to order and preparing customer order documents.3. Order Entry and Maintenance: This includes costs associated with maintaining the customer database, credit check, accepting new orders, and adding them to the order system as well as later order modifications.4. Contract/Program and Channel Management: This includes costs related to contract negotiation, monitoring progress, and reporting against the customer's contract, including administration of performance or warranty-related issues.5. Installation Planning: This includes costs associated with installation engineering, scheduling and modification, handling cancellations, and planning the installation.6. Order Fulfilment: This includes costs associated with order processing, inventory allocation, ordering from internal or external suppliers, shipment scheduling, order status reporting and shipment initiation.7. Distribution: This includes costs associated with warehouse space and management, finished goods receiving and stocking, processing shipments, picking and consolidating, selecting carrier, and staging products/systems.8. Transportation, Outbound Freight and Duties: This includes costs associated with all company paid freight duties from point-of-manufacture to end customer or channel.9. Installation: This includes costs associated with verification of site preparation, installation, certification and authorization of billing.10. Customer Invoicing/Accounting: This includes costs associated with invoicing, processing customer payments and verification of customer receipt.

Order Picking Selecting or "picking" the required quantity of specific products for movement to a packaging area (usually in response to one or more shipping orders) and documenting that the material was moved from one location to shipping. *Also see: Batch Picking, Discrete Order Picking, Zone Picking*

Order Point—Order Quantity System The inventory method that places an order for a lot whenever the quantity on hand is reduced to a predetermined level known as the order point. *Also see: Fixed Reorder Quantity Inventory Model, Hybrid system*

Order Processing Activities associated with filling customer orders.

Order Promising The process of making a delivery commitment, i.e. answering the question, When can you ship? For make-to-order products, this usually involves a check of uncommitted material and availability of capacity, often as represented by the master schedule available-to-promise. *Also see: Available-to-Promise*

Order Receipt to Order Entry Complete Average lead-time from receipt of a customer order to the time that order entry is complete, including the following sub-elements: order revalidation, product configuration check, credit check and order scheduling.Note: Determined separately for Make-to-Order, Configure/Package-to-Order, Engineer-to-Order and Make-to-Stock products.

Origin The place where a shipment begins its movement.

Original Equipment Manufacturer (OEM) A manufacturer that buys and incorporates another supplier's products into its own products. Also, products supplied to the original equipment manufacturer or sold as part of an assembly. For example, an engine may be sold to an OEM for use as that company's power source for its generator units.

OS&D *See Over, Short and Damaged*

OTIF *See On Time In Full*

Out Of Stock The state of not having inventory at a location and available for distribution or for sell to the consumer (zero inventory).

Out of Stocks *See Stock Outs*

Outbound Consolidation Consolidation of a number of small shipments for various customers into a larger load. The large load is then shipped to a location near the customers where it is broken down and then the small shipments are distributed to the customers. This can reduce overall shipping charges where many small packet or parcel shipments are handled each day. *Also see: Break Bulk*

Outbound Logistics The process related to the movement and storage of products from the end of the production line to the end user.

Outlier A data point that differs significantly from other data for a similar phenomenon. For example, if the average sales for a product were 10 units per month, and 1 month the product had sales of 500 units, this sales point might be considered an outlier. *Also see: Abnormal Demand*

Outpartnering The process of involving the supplier in a close partnership with the firm and its operations management system. Outpartnering is characterized by close working relationships between buyers and suppliers, high levels of trust, mutual respect, and emphasis on joint problem solving and cooperation. With outpartnering, the supplier is viewed not as an alternative source of goods and services (as observed under outsourcing) but rather as a source of knowledge, expertise and complementary core competencies. Outpartnering is typically found during the early stages of the product life cycle when dealing with products that are viewed as critical to the strategic survival of the firm. *Also see: Customer-Supplier Partnership*

Outsource To utilize a third-party provider to perform services previously performed in-house. Examples include manufacturing of products and call centre/customer support.

Outsourced Cost of Goods Sold Operations performed on raw material outside of the responding entity's organization that would typically be considered internal to the entity's manufacturing cycle. Outsourced cost of goods sold captures the value of all outsourced activities that roll up as cost of goods sold. Some examples of commonly outsourced areas are assembly by subcontract houses, test, metal finishing or painting, and specialized assembly process.

Overpack The practice of using a large box or carton to contain multiple smaller packages which are all going to the same destination in order to achieve a reduced overall shipping cost vs. the individual packages.

Over, short and damaged (OS&D) This is typically a report issued at warehouse when goods are damaged. Used to file claim with carrier.

Over-the-road A motor carrier operation that reflects long-distance, intercity moves; the opposite of local operations.

Overall Equipment Effectiveness (OEE) A measure of overall equipment effectiveness that takes into account machine availability and performance as well as output quality.

Owner-Operator A trucking operation in which the opener of the truck is also the driver.

P

P2P *See Path to Profitability*

P2P *See Peer to Peer*

Pack Out In a fulfilment environment this refers to the operations involved in packaging and palletizing individual units of product for introduction into the warehouse distribution environment. For example, a contract 3PL may receive or assemble units of product which need to be placed into retail packaging, then overpacked with a carton and then palletized.

Package to Order A production environment in which a good or service can be packaged after receipt of a customer order. The item is common across many different customers; packaging determines the end product.

Packing and Marking The activities of packing for safe shipping and unitizing one or more items of an order, placing them into an appropriate container, and marking and labelling the container with customer shipping destination data, as well as other information that may be required.

Packing List List showing merchandise packed and all particulars. Normally prepared by shipper but not required by carriers. Copy is sent to consignee to help verify shipment received. The physical equivalent of the electronic Advanced Ship Notice (ASN).

Pallet The platform which cartons are stacked on and then used for shipment or movement as a group. Pallets may be made of wood or composite materials.

Pallet Jack Material handling equipment consisting of two broad parallel pallet forks on small wheels used in the warehouse to move pallets of product, but not having the lifting capability of a forklift. It may be a motorized unit guided by an operator who stands on a platform; or it may be a motorized or manual unit guided by an operator who is walking behind or beside it. Comes as a “single” (one pallet) or “double” (two pallets).

Pallet Rack A single or multi-level structural storage system that is utilized to support high stacking of single items or palletized loads.

Pallet Tag The barcoded sticker that is placed on a unit load or partial load, typically at receiving. The pallet tag can be scanned with an RF gun.

Pallet Ticket A label to track pallet-sized quantities of end items produced to identify the specific sub lot with specifications determined by periodic sampling and analysis during production.

Pallet Wrapping Machine A machine that wraps a pallet's contents in stretch-wrap to ensure safe shipment.

Parcel Shipment Parcels include small packages like those typically handled by providers such as UPS and FedEx.

Pareto A means of sorting data. For example, number of quality faults by frequency of occurrence. An analysis that compares cumulative percentages of the rank ordering of costs, cost drivers, profits or other attributes to determine whether a minority of elements have a disproportionate impact. Another example, identifying that 20% of a set of independent variables is responsible for 80% of the effect. *Also see: 80/20 Rule*

Part Period Balancing (PPB) In forecasting, a dynamic lot-sizing technique that uses the same logic as the least total cost method, but adds a routine called look ahead/look back. When the look ahead/look back feature is used, a lot quantity is calculated, and before it is firmed up, the next or the previous period's demands are evaluated to determine whether it would be economical to include them in the current lot. *Also see: Discrete Order Quantity, Dynamic lot sizing*

Part Standardization A program for planned elimination of superficial, accidental, and deliberate differences between similar parts in the interest of reducing part and supplier proliferation. A typical goal of part standardization is to reduce costs by reducing the number of parts that the company needs to manage.

Passenger-Mile A measure of output for passenger transportation; it reflects the number of passengers transported and the distance travelled; a multiplication of passengers hauled and distance travelled.

Password A private code required to gain access to a computer, an application program, or service.

Path to Profitability (P2P) The step-by-step model to generate earnings.

Pay-on-Use Pay-on-Use is a process where payment is initiated by product consumption, i.e. consignment stock based on withdrawal of product from inventory. This process is popular with many European companies.

Payment The transfer of money, or other agreed upon medium, for provision of goods or services.

Payroll Total of all fully burdened labour costs, including wage, fringe, benefits, overtime, bonus and profit sharing.

PBIT *See Profit Before Interest and Tax*

PBL *See Performance-Based Logistics*

P&D Pickup and delivery.

PDA *See Personal Digital Assistant*

PDCA *See Plan-Do-Check-Action*

Peak Demand The time period during which the quantity demanded is greater than during any other comparable time period.

Peer to Peer (P2P) A computer networking environment which allows individual computers to share resources and data without passing through an intermediate network server.

Pegged Requirement An MRP component requirement that shows the next-level parent item (or customer order) as the source of the demand.

Pegging A technique in which a ERP system traces demand for a product by date, quantity and warehouse location.

Percent of Fill Number of lines or quantity actually shipped as a percent of the original order. Synonym: Customer Service Ratio.

Per Diem (1) The rate of payment for use by one railroad of the cars of another. (2) A daily rate of reimbursement for expenses.

Perfect Order The definition of a perfect order is one which meets all of the following criteria:• Delivered complete, with all items on the order in the quantity requested• Delivered on time to customer's request date, using the customer's definition of on-time delivery• Delivered with complete and accurate documentation supporting the order, including packing slips, bills of lading and invoices• Delivered in perfect condition with the correct configuration, customer ready, without damage and faultlessly installed (as applicable)

Performance-Based Logistics (PBL) A U.S. Government program that describes the purchase of services and support as an integrated, affordable, performance package designed to optimize system readiness and meet performance goals for a weapon system through long-term support arrangements with clear lines of authority and responsibility.

Performance and Event Management Systems The systems that report on the key measurements in the supply chain—inventory days of supply, delivery performance, order cycle times, capacity use, etc. Using this information to identify causal relationships to suggest actions in line with the business goals.

Performance Measures Indicators of the work performed and the results achieved in an activity, process or organizational unit. Performance measures should be both non-financial and financial. Performance measures enable periodic comparisons and benchmarking. For example, a common performance measure for a distribution centre is % of order fill rate. *Also see: Performance Measurement Program*Attributes of good performance measurement include the following:1. Measures only what is important: The measure focuses on key aspects of process performance2. Can be collected economically: Processes and activities are designed to easily capture the relevant information3. Are visible: The measure and its causal effects are readily available to everyone who is measured4. Is easy to understand: The measure conveys at a glance what it is measuring and how it is derived5. Is process oriented: The measure makes the proper tradeoffs among utilization, productivity and performance6. Is defined and mutually understood. The measure has been defined and mutually understood by all key parties (internal and external)7. Facilitates trust: The measure validates the participation among various parties and discourages "game playing"8. Are usable: The measure is used to show progress and not just data that is "collected". Indicated performance vs. data

Performance Measurement Program A performance measurement program goes beyond just having performance metrics in place. Many companies do not realize the full benefit of their performance metrics because they often do not have all of the necessary elements in place that support their metrics. *Also see: Performance Measures, Dashboard, Scorecard, Key Performance Indicator*Typical characteristics of a good performance measurement program include the following:• Metrics that are aligned to strategy and linked to the "shop floor" or line level workers• A process and culture that drives performance and accountability to delivery performance against key performance indicators.• An incentive plan that is tied to performance goals, objectives and metrics• Tools/technology in place to support easy data collection and use. This often includes the use of a "dashboard" or "scorecard" to allow for ease of understanding and reporting against key performance indicators.

Period Order Quantity A lot-sizing technique under which the lot size is equal to the net requirements for a given number of periods, e.g. weeks into the future. The number of periods to order is variable, each order size equalizing the holding costs and the ordering costs for the interval.*Also see: Discrete Order Quantity, Dynamic Lot Sizing*

Periodic Review System *See Fixed Reorder Cycle Inventory Model*

Permit A grant of authority to operate as a contract carrier.

Perpetual Inventory An inventory record keeping system where each transaction in and out is recorded and a new balance is computed. Perpetual inventory records may be kept manually on paper logs or stock cards, or in a computer database.

Personal Digital Assistant (PDA) A computer term for a handheld device that combines computing, telephone/fax and networking features. PDA examples include the Palm and Pocket PC devices. A typical PDA can function as a cellular phone, fax sender and personal organizer. Unlike portable computers, most PDAs are pen-based, using a stylus rather than a keyboard for input. This means that they also incorporate handwriting recognition features. Some PDAs can also react to voice input by using voice recognition technologies. Some PDAs and networking software allow companies to use PDAs in their warehouses to support wireless transaction processing and inquiries.

Personal Discrimination Charging different rates to shippers with similar transportation characteristics, or vice versa.

Phantom Bill of Material A bill-of-material coding and structuring technique used primarily for transient (nonstocked) subassemblies. For the transient item, lead time is set to zero and the order quantity to lot-for-lot. A phantom bill of material represents an item that is physically built, but rarely stocked, before being used in the next step or level of manufacturing. This permits MRP logic to drive requirements straight through (blowthrough) the phantom item to its components, but the MRP system usually retains its ability to net against any occasional inventories of the item. This technique also facilitates the use of common bills of material for engineering and manufacturing. *Synonym: Pseudo Bill of Material. Also see: blowthrough*

Physical Distribution The movement and storage functions associated with finished goods from manufacturing plants to warehouses and to customers; also, used synonymously with business logistics.

Physical Supply The movement and storage functions associated with raw materials from supply sources to the manufacturing facility.

Pick-by-Light A laser identifies the bin for the next item in the rack; when the picker completes the pick, the barcode is scanned and the system then points the laser at the next bin.

Pick/Pack Picking of product from inventory and packing into shipment containers.

Pick List A list of items to be picked from stock in order to fill an order; the pick list generation and the picking method can be quite sophisticated.

Pick on Receipt Product is receipted and picked in one operation (movement); therefore the product never actually touches the ground within the warehouse. It is unloaded from one vehicle and re-loaded on an outbound vehicle. *Related to Cross-Docking*

Pick-to-Clear A method often used in warehouse management systems that directs picking to the locations with the smallest quantities on hand.

Pick-to-Carton Pick-to-carton logic uses item dimensions/weights to select the shipping carton prior to the order picking process. Items are then picked directly into the shipping carton.

Pick-to-Light Pick-to light systems consist of lights and LED displays for each pick location. The system uses software to light the next pick and display the quantity to pick.

Pick-to-Trailer Order-picking method where the order picker transports the materials directly from the pick location to the trailer without any interim checking or staging steps.

Pick-Up Order A document indicating the authority to pick up cargo or equipment from a specific location.

Picking The operations involved in pulling products from storage areas to complete a customer order.

Picking by Aisle A method by which pickers pick all needed items in an aisle regardless of the items' ultimate destination; the items must be sorted later.

Picking by Source A method in which pickers successively pick all items going to a particular destination regardless of the aisle in which each item is located.

Piggyback Terminology used to describe a truck trailer being transported on a railroad flatcar.

Pin Lock A hard piece of iron, formed to fit on a trailer's pin, that locks in place with a key to prevent an unauthorized person from moving the trailer.

Place Utility A value created in a product by changing its location. Transportation creates place utility.

Plaintext Data before it has been encrypted or after it has been decrypted, e.g. an ASCII text file.

Plan Deliver The development and establishment of courses of action over specified time periods that represent a projected appropriation of supply resources to meet delivery requirements.

Plan-Do-Check-Action (PDCA) In quality management, a four-step process for quality improvement. In the first step (plan), a plan to effect improvement is developed. In the second step (do), the plan is carried out, preferably on a small scale. In the third step (check), the effects of the plan are observed. In the last step (action), the results are studied to determine what was learned and what can be predicted. The plan-do-check-act cycle is sometimes referred to as the Shewhart cycle (because Walter A. Shewhart discussed the concept in his book Statistical Method from the Viewpoint of Quality Control) and as the Deming circle (because W. Edwards Deming introduced the concept in Japan; the Japanese subsequently called it the Deming circle). *Synonyms: Shewhart Cycle. Also see: Deming Circle*

Plan Make The development and establishment of courses of action over specified time periods that represent a projected appropriation of production resources to meet production requirements.

Plan Source The development and establishment of courses of action over specified time periods that represent a projected appropriation of material resources to meet supply chain requirements.

Plan Stability The difference between planned production and actual production, as a percentage of planned production.*Calculation:[(Sum of Monthly Production Plans) + (Sum of the absolute value of the difference between planned and actual)]/[Sum of Monthly Production Plans]*Note: Base Production Plan is the 3-month removed plan

Planned Date The date an operation, such as a receipt, shipment or delivery of an order, is planned to occur.

Planned Order A suggested order quantity, release date, and due date created by the planning system's logic when it encounters net requirements in processing MRP. In some cases, it can also be created by a master scheduling module. Planned orders are created by the computer, exist only within the computer, and may be changed or deleted by the computer during subsequent processing if conditions change. Planned orders at one level will be exploded into gross requirements for components at the next level. Planned orders, along with released orders, serve as input to capacity requirements planning to show the total capacity requirements by work centre in future time periods.*Also see: Planning Time Fence, Firm Planned Order*

Planned Receipt An anticipated receipt against an open purchase order or open production order.

Planning Bill *See Planning Bill of Material*

Planning Bill of Material An artificial grouping of items or events in bill-of-material format used to facilitate master scheduling and material planning. It may include the historical average of demand expressed as a percentage of total demand for all options within a feature or for a specific end item within a product family and is used as the quantity per in the planning bill of material. *Synonym: Planning Bill. Also see: Hedge Inventory, Production Forecast, Pseudo Bill of Material*

Planning Calendar *See Manufacturing Calendar*

Planning Fence *See Planning Time Fence*

Planning Horizon The amount of time a plan extends into the future. For a master schedule, this is normally set to cover a minimum of cumulative lead timesplus time for lot sizing low-level components and for capacity changes of primary work centres or of key suppliers. For longer term plans the planning horizon must be long enough to permit any needed additions to capacity. *Also see: Cumulative Lead Time, Planning Time Fence*

Planning Time Fence A point in time denoted in the planning horizon of the master scheduling process that marks a boundary inside of which changes to the schedule may adversely affect component schedules, capacity plans, customer deliveries and cost. Outside the planning time fence, customer orders may be booked and changes to the master schedule can be made within the constraints of the production plan. Changes inside the planning time fence must be made manually by the master scheduler. *Synonym: Planning Fence. Also see: Cumulative Lead Time, Demand Time Fence, Firm Planned Order, Planned Order, Planning Horizon, Time Fence.*

Planogram The end result of analysing the sales data of an item or group of items to determine the best arrangement of products on a store shelf. The process determines which shelf your top-selling product should be displayed on, the number of facings it gets, and what best to surround it with. It results in graphical picture or map of the allotted shelf space along with a specification of the facing and depth.

Plant Finished Goods Finished goods inventory held at the end manufacturing location.

PLU *See Price Look-Up*

PM *See Preventative Maintenance*

PO *See Purchase Order*

POD *See Proof of Delivery*

Point-of-Purchase (POP) A retail sales term referring to the area where a sale occurs, such as the checkout counter. POP is also used to refer to the displays and other sales promotion tools located at a checkout counter.

Point of Sale (POS) (1) The time and place at which a sale occurs, such as a cash register in a retail operation, or the order confirmation screen in an on-line session. Supply chain partners are interested in capturing data at the POS, because it is a true record of the sale rather than being derived from other information such as inventory movement. (2) Also a national network of merchant terminals, at which customers can use client cards and personal security codes to make purchases. Transactions are directed against client deposit accounts. POS terminals are sophisticated cryptographic devices, with complex key management processes. POS standards draw on ABM network experiences and possess extremely stringent security requirements.

Point of Sale Information Price and quantity data from retail locations as sales transactions occur.

Point-of-Use Inventory Material used in production processes that is physically stored where it is consumed.

Poka Yoke (mistake-proof) The application of simple techniques that prevent process quality failure. A mechanism that either prevents a mistake from being made or makes the mistake obvious at a glance.

Police Powers The United States constitutionally granted rights to the states to establish regulations to protect the health and welfare of its citizens; truck weight, speed, length and height laws are examples.

Pooling A shipping term for the practice of combining shipment from multiple shippers into a truckload in order to reduce shipping charges.

POP *See Point-of-Purchase*

Port A harbour where ships will anchor.

Port Authority A state or local government that owns, operates or otherwise provides wharf, dock and other terminal investments at ports.

Port of Discharge Port where vessel is off loaded.

Port of Entry A port at which foreign goods are admitted into the receiving country.

Port of Loading Port where cargo is loaded aboard the vessel.

Portal Websites that serve as starting points to other destinations or activities on the Internet. Initially thought of as a "home base" type of web page, portals attempt to provide all Internet needs in one location. Portals commonly provide services such as e-mail, online chat forums, shopping, searching, content and news feeds.

POS *See Point of Sale*

Possession Utility The value created by marketing's effort to increase the desire to possess a good or benefit from a service.

Post-Deduct Inventory Transaction Processing A method of inventory bookkeeping where the book (computer) inventory of components is reduced after issue. When compared to a real-time process, this approach has the disadvantage of a built-in differential between the book record and what is physically in stock. Consumption can be based on recorded actual use, or calculated using finished quantity received times the standard BOM quantity (backflush). *Also see: Backflush*

Postponement The delay of final activities (i.e. assembly, production, packaging, etc.) until the latest possible time. A strategy used to eliminate excess inventory in the form of finished goods which may be packaged in a variety of configurations.

PPB *See Part Period Balancing*

Pre-Deduct Inventory Transaction Processing A method of inventory bookkeeping where the book (computer) inventory of components is reduced before issue, at the time a scheduled receipt for their parents or assemblies is created via a bill-of-material explosion. When compared to a real-time process, this approach has the disadvantage of a built-in differential between the book record and what is physically in stock.

Pre-Expediting The function of following up on open orders before the scheduled delivery date, to ensure the timely delivery of materials in the specified quantity.

Prepaid A freight term, which indicates that charges are to be paid by the shipper. Prepaid shipping charges may be added to the customer invoice, or the cost may be bundled into the pricing for the product.

Present Value Today's value of future cash flows, discounted at an appropriate rate.

Predictive Maintenance Practices that seek to prevent unscheduled machinery downtime by collecting and analysing data on equipment conditions. The analysis is then used to predict time-to-failure, plan maintenance and restore machinery to good operating condition. Predictive maintenance systems typically measure parameters on machine operations, such as vibration, heat, pressure, noise and lubricant condition. In conjunction with computerized maintenance management systems (CMMS), predictive maintenance enables repair-work orders to be released automatically, repair-parts inventories checked, or routine maintenance scheduled.

Preventative Maintenance (PM) Regularly scheduled maintenance activities performed in order to reduce or eliminate unscheduled equipment failures and downtime.

Price Erosion The decrease in price point and profit margin for a product or service, which occurs over time due to the effect of increased competition or commoditization.

Price Look-Up (PLU) Used for retail products sold loose, bunched or in bulk (to identify the different types of fruit, say). As opposed to UPC (Universal Product Codes) for packaged, fixed weight retail items. A PLU code contains 4–5 digits in total. The PLU is entered before an item is weighed to determine a price.

Primary-Business Test A test used by the ICC to determine if a trucking operation is bona fide private transportation; the private trucking operation must be incidental to and in the furtherance of the primary business of the firm.

Primary highways Highways that connect lesser populated cities with major cities.

Primary Manufacturing Strategy Your company's dominant manufacturing strategy. The Primary Manufacturing Strategy generally accounts for 80-plus % of a company's product volume. According to a study by Pittiglio Rabin Todd & McGrath (PRTM), approximately 73% of all companies use a make-to-stock strategy.

PRIME QR Product Replenishment and Inventory Management Edge for Quick Response.

Private carrier A carrier that provides transportation service to the firm and that owns or leases the vehicles and does not charge a fee. Private motor carriers may haul at a fee for wholly owned subsidiaries.

Private Label Products that are designed, produced, controlled by, and which carry the name of the store or a name owned by the store; also known as a store brand or dealer brand. An example would be Wal-Mart's "Sam's Choice" products.

Private Warehouse A warehouse that is owned by the company using it.

Pro Number Any progressive or serialized number applied for identification of freight bills, bills of lading, etc.

Proactive The strategy of understanding issues before they become apparent and presenting the solution as a benefit to the customer, etc.

Process A series of time-based activities that are linked to complete a specific output.

Process Benchmarking Benchmarking a process (such as the pick, pack and ship process) against organizations known to be the best in class in this process. Process benchmarking is usually conducted on firms outside of the organization's industry. *Also see Benchmarking, Best-in-Class, Competitive Benchmarking*

Process Improvement Designs or activities which improve quality or reduce costs, often through the elimination of waste or non-value-added tasks.

Process Manufacturing Production that adds value by mixing, separating, forming and/or performing chemical reactions. It may be done in a batch, continuous, or mixed batch/continuous mode. Products in this manufacturing group include: foods, petrochemicals, bottling, chemicals, etc. Process manufacturing frequently generates co-products and by-products as an outcome in addition to the primary product being manufactured. An example would be the manufacture of petroleum products, where multiple grades of lubricants and fuels are produced from a single run as well as non-usable by-products such as sludge.

Process Yield The resulting output from a process. An example would be a quantity of finished product output from manufacturing processes.

Procurement The business functions of procurement planning, purchasing, inventory control, traffic, receiving, incoming inspection and salvage operations. *Synonym: Purchasing*

Procurement Services Provider (PSP) A services firm that integrates procurement technologies with product, sourcing and supply management expertise, to provide outsourced procurement solutions. A PSP serves as an extension of an organization's existing procurement infrastructure, managing the processes and spending categories and procurement processes that the organization feels it has opportunities for improvement but lacks the internal expertise to manage effectively.

Product Something that has been or is being produced.

Product Characteristics All of the elements that define a product's character, such as size, shape and weight.

Product Configurator A system, generally rule-based, to be used in design-to-order, engineer-to-order or make-to-order environments where numerous product variations exist. Product configurators perform intelligent modelling of the part or product attributes and often create solid models, drawings, bills of material, and cost estimates that can be integrated into CAD/CAM and MRP II systems as well as sales order entry systems.

Product ID A method of identifying a product without using a full description. These can be different for each document type and must, therefore, be captured and related to the document in which they were used. They must then be related to each other in context (also known as SKU, Item Code or Number, or other such name).

Product Family A group of products with similar characteristics, often used in production planning (or sales and operations planning).

Production Calendar *See Manufacturing Calendar*

Production Capacity Measure of how much production volume may be experienced over a set period of time.

Production Forecast A projected level of customer demand for a feature (option, accessory, etc.) of a make-to-order or an assemble-to-order product. Used in two-level master scheduling, it is calculated by netting customer backlog against an overall family or product line master production schedule and then factoring this product's available-to-promise by the option percentage in a planning bill of material. *Also see: Assemble-to-Order, Planning Bill of Material, Two-Level Master Schedule*

Production Line A series of pieces of equipment dedicated to the manufacture of a specific number of products or families.

Production Planning and Scheduling The systems that enable creation of detailed optimized plans and schedules taking into account the resource, material and dependency constraints to meet the deadlines.

Production-Related Material Production-related materials are those items classified as material purchases and included in Cost of Goods Sold as raw material purchases.

Productivity A measure of efficiency of resource utilization; defined as the sum of the outputs divided by the sum of the inputs.

Profit Ratio The percentage of profit to sales—that is, profit divided by sales.

Profit Before Interest and Tax (PBIT) The financial profit generated prior to the deduction of taxes and interest due on loans. Also called operating profit.

Profitability Analysis The analysis of profit derived from cost objects with the view to improve or optimize profitability. Multiple views may be analysed, such as market segment, customer, distribution channel, product families, products, technologies, platforms, regions and manufacturing capacity.

Profitable to Promise This is effectively a promise to deliver a certain order on agreed terms, including price and delivery. Profitable-to-Promise (PTP) is the logical evolution of Available-to-Promise (ATP) and Capable-to-Promise (CTP). While the first two are necessary for profitability, they are not sufficient. For enterprises to survive in a competitive environment, profit optimization is a vital technology.

Pro-Forma A type of quotation or offer that may be used when first negotiating the sales of goods or services. If the pro-forma is accepted, then the terms and conditions of the pro-forma may become the request.

Pro Forma Invoice An invoice, forwarded by the seller of goods prior to shipment, that advises the buyer of the particulars and value of the goods. Usually required by the buyer in order to obtain an import permit or letter of credit.

Pro Number Any progressive or serialized number applied for identification of freight bills, bills of lading, etc.

Profitability Analysis The analysis of profit derived from cost objects with the view to improve or optimize profitability. Multiple views may be analysed, such as market segment, customer, distribution channel, product families, products, technologies, platforms, regions and manufacturing capacity.

Promotion The act of selling a product at a reduced price, or a buy one—get one free offer, for the purpose of increasing sales.

Proof of Delivery (POD) Information supplied by the carrier containing the name of the person who signed for the shipment, the time and date of delivery, and other shipment delivery-related information. POD is also sometimes used to refer to the process of printing materials just prior to shipment (Print on Demand).

Proportional Rate A rate lower than the regular rate for shipments that have prior or subsequent moves; used to overcome competitive disadvantages of combination rates.

Protocol Communication standards that determine message content and format, enabling uniformity of transmissions.

Pseudo Bill of Materials *See Phantom Bill of Materials*

PSP *See Procurement Services Provider*

Public Warehouse A business that provides short-or long-term storage to a variety of businesses usually on a month-to-month basis. A public warehouse will generally use their own equipment and staff; however, agreements may be made where the client either buys or subsidizes equipment. Public warehouse fees are usually a combination of storage fees (per pallet or actual square footage) and transaction fees (inbound and outbound). Public warehouses are most often used to supplement space requirements of a private warehouse. See also Contract warehouse and 3PL.

Public Warehouse Receipt The basic document issued by a public warehouse manager that is the receipt for the goods given to the warehouse manager. The receipt can be either negotiable or non-negotiable.

Pull Signal A signal from a using operation that triggers the issue of raw material.

Pull or Pull-through distribution Supply-chain action initiated by the customer. Traditionally, the supply chain was pushed; manufacturers produced goods and "pushed" them through the supply chain, and the customer had no control. In a pull environment, a customer's purchase sends replenishment information back through the supply chain from retailer to distributor to manufacturer, so goods are "pulled" through the supply chain.

Pull Ordering System A system in which each warehouse controls its own shipping requirements by placing individual orders for inventory with the central distribution centre. A replenishment system where inventory is "pulled" into the supply chain (or "demand chain" by POS systems, or ECR programs). Associated with "build to order" systems.

Purchase Order (PO) The purchaser's authorization used to formalize a purchase transaction with a supplier. The physical form or electronic transaction a buyer uses when placing order for merchandise.

Purchase Price Discount A pricing structure in which the seller offers a lower price if the buyer purchases a larger quantity.

Purchasing The functions associated with buying the goods and services required by the firm.

Pure Raw Material A raw material that does not lose weight in processing.

Push Back Rack Utilizing wheels in the rack structure, this rack system allows palletized goods and materials to be stored by being pushed up a gently graded ramp. Stored materials are allowed to flow down the ramp to the aisle. This rack configuration allows for deep storage on each rack level.

Push Distribution The process of building product and pushing it into the distribution channel without receiving any information regarding requirements. *Also see: Pull or Pull-Through Distribution*

Push Ordering System A situation in which a firm makes inventory deployment decisions at the central distribution centre and ships to its individual warehouses accordingly.

Push Technology Webcasting (push technology) is the prearranged updating of news, weather, or other selected information on a computer user's desktop interface through periodic and generally unobtrusive transmission over the World Wide Web (including the use of the Web protocol on Intranet). Webcasting uses so-called push technology in which the Web server ostensibly "pushes" information to the user rather than waiting until the user specifically requests it.

Put Away Removing the material from the dock (or other location of receipt), transporting the material to a storage area, placing that material in a staging area, and then moving it to a specific location and recording the movement and identification of the location where the material has been placed.

Put-to-Light A method that uses lights to direct the placement of materials. Most often used in batch picking to designate the tote into which picked items are placed.

Q

QC *See Quality Control*

QFD *See Quality Function Deployment*

QR *See Quick Response*

Qualifier A data element, which identifies or defines a related element, set of elements or a segment. The qualifier contains a code from a list of approved codes.

Qualitative Forecasting Techniques In forecasting, an approach that is based on intuitive or judgmental evaluation. It is used generally when data are scarce, not available, or no longer relevant. Common types of qualitative techniques include: personal insight, sales force estimates, panel consensus, market research, visionary forecasting and the Delphi method. Examples include developing long-range projections and new product introduction.

Quality Conformance to requirements or fitness for use. Quality can be defined through five principal approaches:1. Transcendent quality is an ideal, a condition of excellence2. Product-based quality is based on a product attribute3. User-based quality is fitness for use4. Manufacturing-based quality is conformance to requirements5. Value-based quality is the degree of excellence at an acceptable price. Also, quality has two major components:(a) quality of conformance—

quality is defined by the absence of defects(b) quality of design—quality is measured by the degree of customer satisfaction with a product's characteristics and features.

Quality Circle In quality management, a small group of people who normally work as a unit and meet frequently to uncover and solve problems concerning the quality of items produced, process capability or process control. *Also see: Small Group Improvement activity*

Quality Control (QC) The management function that attempts to ensure that the goods or services manufactured or purchased meet the product or service specifications

Quality Function Deployment (QFD) A structured method for translating user requirements into detailed design specifications using a continual stream of "what-how" matrices. QFD links the needs of the customer (end user) with design, development, engineering, manufacturing and service functions. It helps organizations seek out both spoken and unspoken needs, translate these into actions and designs, and focus various business functions towards achieving this common goal.

Quantitative Forecasting Techniques An approach to forecasting where historical demand data is used to project future demand. Extrinsic and intrinsic techniques are typically used. *Also see: Extrinsic Forecasting Method, Intrinsic Forecasting Method*

Quantity-Based Order System *See Fixed Reorder Quantity Inventory Model*

Quarantine In quality management, the setting aside of items from availability for use or sale until all required quality tests have been performed and conformance certified. In a best practice process, items in quarantine are tagged, logged and kept in a secure area pending disposition.

Quick Response (QR) A strategy widely adopted by general merchandise and soft lines retailers and manufacturers to reduce retail out-of-stocks, forced markdowns and operating expenses. These goals are accomplished through shipping accuracy and reduced response time. QR is a partnership strategy in which suppliers and retailers work together to respond more rapidly to the consumer by sharing point-of-sale scan data, enabling both to forecast replenishment needs.

R

Rack A storage device for handling material in pallets. A rack usually provides storage for pallets arranged in vertical sections with one or more pallets to a tier. Some racks accommodate more than one-pallet-deep storage. Some racks are static, meaning that the rack contents remain in a fixed position until physically moved. Some racks are designed with a sloped shelf to allow products to "flow" down as product in the front is removed. Replenishment of product on a flow rack may be from the rear, or the front in a "push back" manner.

Racking A function performed by a rack-jobber, a full-function intermediary who performs all regular warehousing functions and some retail functions, typically stocking a display rack. Also a definition that is applied to the hardware which is used to build racks.

Radio Frequency (RF) A form of wireless communications that lets users relay information via electromagnetic energy waves from a terminal to a base station, which is linked in turn to a host computer. The terminals can be place at a fixed station, mounted on a forklift truck or carried in the worker's hand. The base station contains a transmitter and receiver for communication with the terminals. RF systems use either narrow-band or spread-spectrum transmissions. Narrow-band data transmissions move along a single limited radio frequency, while spread-spectrum transmissions move across several different frequencies. When combined with a barcode system for identifying inventory items, a radio-frequency system can relay data instantly, thus updating inventory records in so-called "real time".

Radio Frequency Identification (RFID) The use of radio frequency technology including RFID tags and tag readers to identify objects. Objects may include virtually anything physical, such as equipment, pallets of stock or even individual units of product. RFID tags can be active or passive. Active tags contain a power source and emit a signal constantly. Passive tags receive power from the radio waves sent by the scanner/reader. The inherent advantages of RFID over barcode technology are: (1) the ability to be read over longer distances, (2) the elimination of requirement for "line of sight" reads, (3) added capacity to contain information and (4) RFID tag data can be updated/changed.

Ramp Rate A statement which quantifies how quickly you grow or expand an operation Growth trajectory. Can refer to sales, profits or margins.

Random-Location Storage A storage technique in which parts are placed in any space that is empty when they arrive at the storeroom. Although this random method requires the use of a locator file to identify part locations, it often requires less storage space than a fixed-location storage method.*Also see: Fixed-Location Storage*

Rate-Based Scheduling A method for scheduling and producing based on a periodic rate, e.g. daily, weekly or monthly. This method has traditionally been applied to high-volume and process industries. The concept has recently been applied within job shops using cellular layouts and mixed-model level schedules where the production rate is matched to the selling rate.

Rate Basis Number The distance between two rate basis points.

Rate Basis Point The major shipping point in a local area; all points in the local area are considered to be the rate basis point.

Rate Bureau A group of carriers that get together to establish joint rates, to divide joint revenues and claim liabilities, and to publish tariffs. Rate bureaus have published single line rates, which were prohibited in 1984.

Rationing The allocation of product among customers during periods of short supply. When price is used to allocate product, it is allocated to those willing to pay the most.

Raw Materials (RM) Crude or processed material that can be converted by manufacturing, processing, or combination into a new and useful product.

Real-Time The processing of data in a business application as it happens—as contrasted with storing data for input at a later time (batch processing).

Reasonable Rate A rate that is high enough to cover the carrier's cost but not too high to enable the carrier to realize monopolistic profits.

Recapture Clause A provision of the 1920 Transportation Act that provided for self-help financing for railroads. Railroads that earned more than the prescribed return contributed one-half of the excess to the fund from which the ICC made loans to less profitable railroads. The Recapture Clause was repealed in 1933.

Receiving The function encompassing the physical receipt of material, the inspection of the incoming shipment for conformance with the purchase order (quantity and damage), the identification and delivery to destination, and the preparation of receiving reports.

Receiving Dock Distribution centre location where the actual physical receipt of the purchased material from the carrier occurs.

Reconsignment A carrier service that permits changing the destination and/or consignee after the shipment has reached its originally billed destination and paying the through rate from origin to final destination.

Reed-Bulwinkle Act Legalized joint rate making by common carriers through rate bureaus; extended antitrust immunity to carriers participating in a rate bureau.

Refrigerated Carriers Truckload carriers designed to keep perishable goods refrigerated. The food industry typically uses this type of carrier.

Reefer A term used for refrigerated vehicles.

Reengineering (1) A fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in performance. (2) A term used to describe the process of making (usually) significant and major revisions or modifications to business processes. (3) Also called Business Process Reengineering.

Regeneration MRP An MRP processing approach where the master production schedule is totally reexploded down through all bills of material, to maintain valid priorities. New requirements and planned orders are completely recalculated or "regenerated" at that time.

Regional Carrier A for-hire air carrier, usually certificated, that has annual operating revenues of less than $74 million; the carrier usually operates within a particular region of the country.

Regular-Route Carrier A motor carrier that is authorized to provide service over designated routes.

Relay Terminal A motor carrier terminal designed to facilitate the substitution of one driver for another who has driven the maximum hours permitted.

Release-to-Start Manufacturing Average time from order release to manufacturing to the start of the production process. This cycle time may typically be required to support activities such as material movement and line changeovers.

Released-Value Rates Rates based upon the value of the shipment; the maximum carrier liability for damage is less than the full value, and in return the carrier offers a lower rate.

Reliability A carrier selection criterion that considers the variation in carrier transit time; the consistency of the transit time provided.

Reorder Point A predetermined inventory level that triggers the need to place an order. This minimum level provides inventory to meet anticipated demand during the time it takes to receive the order.

Reparation The ICC could require railroads to repay users the difference between the rate charged and the maximum rate permitted when the ICC found the rate to be unreasonable or too high.

Re-plan Cycle Time between the initial creation of a regenerated forecast and the time its impact is incorporated into the Master Production Schedule of the end-product manufacturing facility. (An element of Total Supply Chain Response Time)

Replenishment The process of moving or re-supplying inventory from a reserve (or upstream) storage location to a primary (or downstream) storage or picking location, or to another mode of storage in which picking is performed.

Request for Information (RFI) A document used to solicit information about vendors, products and services prior to a formal RFQ/RFP process.

Request for Proposal (RFP) A document, which provides information concerning needs and requirements for a manufacturer. This document is created in order to solicit proposals from potential suppliers. For, example, a computer manufacturer may use a RFP to solicit proposals from suppliers of third-party logistics services.

Request for Quote (RFQ) A document used to solicit vendor responses when a product has been selected and price quotations are needed from several vendors.

Resellers Organizations intermediate in the manufacturing and distribution process, such as wholesalers and retailers.

Resource Driver In cost accounting, the best single quantitative measure of the frequency and intensity of demands placed on a resource by other resources, activities or cost objects. It is used to assign resource costs to activities, and cost objects, or to other resources.

Resources Economic elements applied or used in the performance of activities or to directly support cost objects. They include people, materials, supplies, equipment, technologies and facilities. *Also see: Resource Driver, Capacity*

Retailer A business that takes title to products and resells them to final consumers. Examples include Wal-Mart, Best Buy and Safeway, but also include the many smaller independent stores.

Return Disposal Costs The costs associated with disposing or recycling products that have been returned due to End-of-Life or Obsolescence.

Return Goods Handling Processes involved with returning goods from the customer to the manufacturer. Products may be returned because of performance problems or simply because the customer doesn't like the product.

Return Material Authorization or Return Merchandise Authorization (RMA) A number usually produced to recognize and give authority for a faulty, perhaps, good to be returned to a distribution centre of manufacturer. A form generally required with a Warranty/Return, which helps the company identify the original product, and the reason for return. The RPA number often acts as an order form for the work required in repair situations, or as a reference for credit approval.

Return on Assets (ROA) Financial measure calculated by dividing profit by assets.

Return on Net Assets Financial measure calculated by dividing profit by assets net of depreciation.

Return on Sales Financial measure calculated by dividing profit by sales.

Return Product Authorization (RPA) Also called Return Material or Goods Authorization (RMA or RGA). A form generally required with a Warranty/Return, which helps the company identify the original product, and the reason for return. The RPA number often acts as an order form for the work required in repair situations, or as a reference for credit approval.

Return to Vendor (RTV) Material that has been rejected by the customer or the buyer's inspection department and is awaiting shipment back to the supplier for repair or replacement.

Returns Inventory Costs The costs associated with managing inventory returned for any of the following reasons: repair, refurbish, excess, obsolescence, End-of-Life, ecological conformance and demonstration. Includes all applicable elements of the Level 2 component Inventory Carrying Cost of Total Supply Chain Management Cost

Returns Material Acquisition, Finance, Planning and IT Costs The costs associated with acquiring the defective products and materials for repair or refurbishing items, plus any Finance, Planning and Information Technology cost to support Return Activity. Includes all applicable elements of the Level 2 components Material Acquisition Cost (acquiring materials for repairs), Supply-Chain-Related Finance and Planning Costs and Supply Chain IT Costs of Total Supply Chain Management Cost.

Returns Order Management Costs The costs associated with managing Return Product Authorizations (RPA). Includes all applicable elements of the Level 2 component Order Management Cost of Total Supply Chain Management Cost. *See Order Management Costs*

Returns Processing Cost The total cost to process repairs or refurbish, excess, obsolete, and End-of-Life products, including cost to diagnose problems and replace products. Includes the costs of logistics support, materials, centralized functions, troubleshooting service requests, on-site diagnosis and repair, external repair, and miscellaneous. These costs are broken into Returns Order Management, Returns Inventory Carrying, Returns Material Acquisition, Finance, Planning, IT, Disposal and Warranty Costs.

Returns To Scale A defining characteristic of B2B. Bigger is better. It's what creates the winner takes all quality of most B2B hubs. It also places a premium on being first to market and first to achieve critical mass.

Reverse Auction A type of auction where suppliers bid to sell products to a buyer (e.g. retailer). As bidding continues, the prices decline (opposite of a regular auction, where buyers are bidding to buy products).

Reverse Engineering A process whereby competitors' products are disassembled and analysed for evidence of the use of better processes, components and technologies

Reverse Logistics A specialized segment of logistics focusing on the movement and management of products and resources after the sale and after delivery to the customer. Includes product returns for repair and/or credit.

RF *See Radio Frequency*

RFI *See Request for Information*

RFID *See Radio Frequency Identification. Also see: Radio Frequency*

RFP *See Request for Proposal*

RFQ *See Request for Quote*

RGA Return Goods Authorization. *See: Return Material Authorization*

Rich Media An Internet advertising term for a Web page ad that uses advanced technology such as streaming video, downloaded applets (programs) that interact instantly with the user, and ads that change when the user's mouse passes over it.

Rich Text Format (RFT) A method of encoding text formatting and document structure using the ASCII character set. By convention, RTF files have an .rtf filename extension.

Right of Eminent Domain A concept that permits the purchase of land needed for transportation right-of-way in a court of law; used by railroads and pipelines.

RM *See Raw Materials*

RMA Return Material Authorization. *See Return Product Authorization*

ROA *See Return on Assets*

ROI Return on Investment.

Roll-On-Roll-Off (RO-RO) A type of ship designed to permit cargo to be driven on at origin and off at destination; used extensively for the movement of automobiles.

Root Cause Analysis Analytical methods to determine the core problem(s) of an organization, process, product, market, etc.

RosettaNet Consortium of major Information Technology, Electronic Components, Semiconductor Manufacturing, Telecommunications and Logistics companies working to create and implement industry-wide, open e-business process standards. These standards form a common e-business language, aligning processes between supply chain partners on a global basis. RosettaNet is a subsidiary of the GS1 Group.

Routing or Routing Guide (1) Process of determining how shipment will move between origin and destination. Routing information includes designation of carrier(s) involved, actual route of carrier and estimated time enroute. (2) Right of shipper to determine carriers, routes and points for transfer shipments. (3) In manufacturing this is the document which defines a process of steps used to manufacture and/or assemble a product.

Routing Accuracy When specified activities conform to administrative specifications, and specified resource consumptions (both man and machine) are detailed according to administrative specifications and are within ten percent of actual requirements.

RPA *See Return Product Authorization*
RTF *See Rich Text Format*
RTV *See Return to Vendor*
Rule of Eight Before the Motor Carrier Act of 1980, contract carriers requesting authority were restricted to eight shippers under contract. The number of shippers has been deleted as a consideration for granting a contract carrier permit.
Rule of Rate Making A regulatory provision directing the regulatory agencies to consider the earnings necessary for a carrier to provide adequate transportation.

S

S&OP *See Sales and Operations Planning*
SAE Society of Automotive Engineers.
Safety Stock The inventory a company holds above normal needs as a buffer against delays in receipt of supply or changes in customer demand.
Salable Goods A part or assembly authorized for sale to final customers through the marketing function.
Sales and Operations Planning (SOP) A strategic planning process that reconciles conflicting business objectives and plans future supply chain actions. S&OP Planning usually involves various business functions such as sales, operations and finance working together to agree on a single plan/forecast that can be used to drive the entire business.
Sales Mix The proportion of individual product-type sales volumes that make up the total sales volume.
Sales Plan A time-phased statement of expected customer orders anticipated to be received (incoming sales, not outgoing shipments) for each major product family or item. It represents sales and marketing management's commitment to take all reasonable steps necessary to achieve this level of actual customer orders. The sales plan is a necessary input to the production planning process (or sales and operations planning process). It is expressed in units identical to those used for the production plan (as well as in sales dollars). *Also see: Aggregate planning, Production Planning, Sales and Operations Planning*
Sales Planning The process of determining the overall sales plan to best support customer needs and operations capabilities while meeting general business objectives of profitability, productivity, competitive customer lead times and so on, as expressed in the overall business plan. *Also see: Production Planning, Sales and Operations Planning*
Salvage Material Unused material that has a market value and can be sold.
SaS *See Software as Services*
Saw-Tooth Diagram A quantity-versus-time graphic representation of the order point/order quantity inventory system showing inventory being received and then used up and reordered.
SBT *See Scan-Based Trading*

SCAC/SCAC Code *See Standard Carrier Alpha Code*

Scalability (1) How quickly and efficiently a company can ramp up to meet demand. See also uptime production flexibility. (2) How well a solution to some problem will work when the size of the problem increases? The economies to scale don't really kick in until you reach the critical mass, then revenues start to increase exponentially.

Scan A computer term referring to the action of scanning barcodes or RF tags.

Scan-Based Trading (SBT) Scan-based trading is a method of using Point of Sale data from scanners and retail checkout to initiate invoicing between a manufacturer and retailer (pay on use), as well as generate re-supply orders.

Scanlon Plan A system of group incentives on a companywide or plantwide basis that sets up one measure that reflects the results of all efforts. The Scanlon plan originated in the 1930s by Joe Scanlon and MIT. The universal standard is the ratio of labour costs to sales value added by production. If there is an increase in production sales value with no change in labour costs, productivity has increased while unit cost has decreased.

SCE *See Supply Chain Execution*

SCEM *See Supply Chain Event Management*

Scenario Planning A form of planning in which likely sets of relevant circumstances are identified in advance, and used to assess the impact of alternative actions.

SCI *See Supply Chain Integration*

SCM *See Supply Chain Management*

SCOR *See Supply Chain Operations Reference Model*

Scorecard A performance measurement tool used to capture a summary of the key performance indicators (KPIs)/metrics of a company. Metrics dashboards/scorecards should be easy to read and usually have "red, yellow, green" indicators to flag when the company is not meeting its targets for its metrics. Ideally, a dashboard/scorecard should be cross-functional in nature and include both financial and non-financial measures. In addition, scorecards should be reviewed regularly—at least on a monthly basis and weekly in key functions such as manufacturing and distribution where activities are critical to the success of a company. The dashboard/scorecards philosophy can also be applied to external supply chain partners such as suppliers to ensure that suppliers' objectives and practices align. *Synonym: Dashboard*

Scrap Material Unusable material that has no market value.

Seasonality A repetitive pattern of demand from year to year (or other repeating time interval) with some periods considerably higher than others. Seasonality explains the fluctuation in demand for various recreational products which are used during different seasons. *Also see: Base Series*

Secondary Highways Highways that serve primarily rural areas.

Secure Electronic Transaction (SET) In e-commerce, a system for guaranteeing the security of financial transactions conducted over the Internet.

Self Billing A transportation industry strategy which prescribes that a carrier will accept payment based on the tender document provided by the shipper.

Self Correcting A computer term for an online process that validates data and won't allow the data to enter the system unless all errors are corrected.

Sell In Units which are sold to retail stores by the manufacturer or distributor for resale to consumers. The period of time in a Product Life Cycle where the manufacturer works with its resellers to market and build inventory for sale. *Also see: Sell Through*

Sell Through Units sold from retail stores to customers. The point in a Product Life Cycle where initial consumption rates are developed and demand established. *Also See: Sell In*

Selling, General and Administrative (SG&A) Expenses Includes marketing, communication, customer service, sales salaries and commissions, occupancy expenses, unallocated overhead, etc. Excludes interest on debt, domestic or foreign income taxes, depreciation and amortization, extraordinary items, equity gains or losses, gain or loss from discontinued operations and extraordinary items.

Separable Cost A cost that can be directly assignable to a particular segment of the business.

Serial Number A unique number assigned for identification to a single piece that will never be repeated for similar pieces. Serial numbers are usually applied by the manufacturer but can be applied at other points, including by the distributor or wholesaler. Serial numbers can be used to support traceability and warranty programs.

Serpentine Picking A method used for picking warehouse orders wherein the pickers are directed to pick from racks on both sides of an aisle as they move from one end to the other. A different method would be to pick from one side (front to back) then from the opposite side (back to front). Where used, serpentine picking can halve travel time and improve traffic flow down the aisles.

Service Level A measure (usually expressed as a percentage) of satisfying demand through inventory or by the current production schedule in time to satisfy the customer's requested delivery dates and quantities.

Service Oriented Architecture (SOA) A computer system term which describes a software architectural concept that defines the use of services to support business requirements. In an SOA, resources are made available to other participants in the network as independent services that are accessed in a standardized way. Most definitions of SOA identify the use of web services (using SOAP and WSDL) in its implementation, however it is possible to implement SOA using any service-based technology.

Service Parts Revenue The sum of the value of sales made to external customers and the transfer price valuation of sales within the company of repair or replacement parts and supplies, net of all discounts, coupons, allowances, and rebates.

SET *See Secure Electronic Transaction*

Setup Costs The costs incurred in staging the production line to produce a different item.

SG&A *See Selling General and Administrative Expense*

Shared Services Consolidation of a company's back-office processes to form a spinout (or a separate "shared services" unit, to be run like a separate business), providing services to the parent company and, sometimes, to external customers. Shared services typically lower overall cost due to the consolidation, and may improve support as a result of focus.

Shareholder Value Combination of profitability (revenue and costs) and invested capital (working capital and fixed capital).

Shelf Life The amount of time an item may be held in inventory before it becomes unusable. Shelf life is a consideration for food and drugs which deteriorate over time, and for high tech products which become obsolete quickly.

Shewhart Cycle *See Plan-Do-Check-Action*

Shingo's Seven Wastes Shigeo Shingo, a pioneer in the Japanese Just-in-Time philosophy, identified seven barriers to improving manufacturing. They are (1) waste of overproduction, (2) waste of waiting, (3) waste of transportation, (4) waste of stocks, (5) waste of motion, (6) waste of making defects and (7) waste of the processing itself.

Ship Agent A liner company or tramp ship operator representative who facilitates ship arrival, clearance, loading and unloading, and fee payment while at a specific port.

Ship Broker A firm that serves as a go-between for the tramp ship owner and the chartering consignor or consignees.

Shipper The party that tenders goods for transportation.

Shipper-Carriers Shipper-carriers (also called private carriers) are companies with goods to be shipped that own or manage their own vehicle fleets. Many large retailers, particularly groceries and "big box" stores, are shipper-carriers.

Shipper's Agent A firm that acts primarily to match up small shipments, especially single-traffic piggyback loads to permit use of twin-trailer piggyback rates.

Shipper's Association A non-profit, cooperative consolidator and distributor of shipments owned or shipped by member firms; acts in much the same way as for-profit freight forwarders.

Shipping The function that performs tasks for the outgoing shipment of parts, components and products. It includes packaging, marking, weighing and loading for shipment.

Shipping Lane A predetermined, mapped route on the ocean that commercial vessels tend to follow between ports. This helps ships avoid hazardous areas. In general transportation, the logical route between the point of shipment and the point of delivery used to analyse the volume of shipment between two points.

Shipping Manifest A document that lists the pieces in a shipment. A manifest usually covers an entire load regardless of whether the load is to be delivered to a single destination or many destinations. Manifests usually list the items, piece count, total weight, and the destination name and address for each destination in the load.

Shop Calendar *See Manufacturing Calendar*

Shop Floor Production Control Systems The systems that assign priority to each shop order, maintaining work-in-process quantity information, providing actual output data for capacity control purposes and providing quantity by location by shop order for work-in-process inventory and accounting purposes.

Short-Haul Discrimination Charging more for a shorter haul than for a longer haul over the same route, in the same direction and for the same commodity.

Short Shipment Piece of freight missing from shipment as stipulated by documents on hand.

Shrinkage Reductions of actual quantities of items in stock, in process or in transit. The loss may be caused by scrap, theft, deterioration, evaporation, etc.

SIC *See Standard Industrial Classification*

Sigma A Greek letter commonly used to designate the standard deviation of a population. Sigma is a statistical term that measures how much a process varies from perfection, based on the number of defects per million units.One Sigma = 690,000 per million unitsTwo Sigma = 308,000 per million unitsThree Sigma = 66,800 per million unitsFour Sigma = 6210 per million unitsFive Sigma = 230 per million unitsSix Sigma = 3.4 per million units

Silo Also frequently called "Foxhole" or "Stovepipe", relates to a management/organization style where each functional unit operates independently, and with little or no collaboration between them on major business processes and issues.

Simulation A mathematical technique for testing the performance of a system due to uncertain inputs and/or uncertain system configuration options. Simulation produces probability distributions for the behaviour (outputs) of a system. A company may build a simulation model of its build plan process to evaluate the performance of the build plan under multiple scenarios on product demand.

Single-Period Inventory Models Inventory models used to define economical or profit maximizing lot-size quantities when an item is ordered or produced only once, e.g. newspapers, calendars, tax guides, greeting cards or periodicals, while facing uncertain demands.

Single Sourcing When an organization deliberately chooses to use one supplier to provide a product or service, even though there are other suppliers available.

Single Source Leasing Leasing both the truck and driver from one source.

Six-Sigma Quality A term used generally to indicate that a process is well controlled, i.e. tolerance limits are ±6 sigma {3.4 defects per million events) from the centreline in a control chart. Six Sigma's goal is to define processes and manage those processes to obtain the lowest possible level of error—thus it can be applied to virtually any process, not just manufacturing. The term is usually associated with Motorola, which named one of its key operational initiatives Six-Sigma Quality.

Skills Matrix A visible means of displaying people's skill levels in various tasks. Used in a team environment to identify the skills required by the team and which team members have those skills.

SKU *See Stock Keeping Unit*

Sleeper Team The use of two drivers to operate a truck equipped with a sleeper berth; while one driver sleeps in the berth to accumulate the mandatory off-duty time, the other driver operates the vehicle.

Slip Seat Operation A term used to describe a motor carrier relay terminal operation where one driver is substituted for another who has accumulated the maximum driving time hours.

Slip Sheet Similar to a pallet, the slip sheet, which is made of cardboard or plastic, is used to facilitate movement of unitized loads.

Slot-Based Production A lean manufacturing term used to describe a production system which has been level loaded (Heijunka) with a few slots held open for situations where demand must be met immediately.

Slotting Inventory slotting or profiling is the process of identifying the most efficient placement for each item in a distribution centre. Since each warehouse is different, proper slotting depends on a facility's unique product, movement and storage characteristics. An optimal profile allows workers to pick items more quickly and accurately and reduces the risk of injuries.

Slurry Dry commodities that are made into a liquid form by the addition of water or other fluids to permit movement by pipeline.

Small Group Improvement Activity An organizational technique for involving employees in continuous improvement activities. *Also see: Quality Circle*

SMART *See Specific, Measurable, Achievable, Realistic, Time-Based*

Smart and Secure Trade Lanes (SST) Private initiative of the Strategic Council on Security Technology, an assembly of executives from port operators, major logistics technology providers, transportation consultancies, and former generals and public officials. Aims to enhance the safety, security and efficiency of cargo containers and their contents moving through the global supply chain into US ports.

Smart Label A label that has an RFID tag integrated into it.

SOA *See Service Oriented Architecture*

Society of Logistics Engineers A professional association engaged in the advancement of logistics technology and management.

Software as Services (SaS) A term which describes the use of computer systems provided by a remote third party, similar to what has traditionally been called a "Service Bureau" or "Application Service Provider (ASP)". In this setting the service provider maintains all of the computer hardware and software at their location, while the user accesses the systems via an internet connection and is charged a rate based on access time. Sometimes also referred to as "On Demand" services.

SOP *See Sales and Operations Planning*

SOW *See Statement of Work*

Sole Sourcing When there is only one supplier for a product or service, and no alternate suppliers are available.

Sortation Separating items (parcels, boxes, cartons, parts, etc.) according to their intended destination within a plant or for transit.

Spam A computer industry term referring to the act of sending identical and irrelevant postings to many different newsgroups or mailing lists. Usually this posting is something that has nothing to do with the particular topic of a newsgroup or of no real interest to the person on the mailing list.

SPC *See Statistical Process Control*

Special-Commodities Carrier A common carrier trucking company that has authority to haul a special commodity; there are 16 special commodities, such as household goods, petroleum products and hazardous materials.

Special-Commodity Warehouses A warehouse that is used to store products that require unique types of facilities, such as grain (elevator), liquid (tank) and tobacco (barn).

Specific, Measurable, Achievable, Realistic, Time-Based (SMART) A shorthand description of a way of setting goals and targets for individuals and teams.

Splash Page A "first" or "front" page that you often see on some websites, usually containing a "click-through" logo or message, or a fancy Flash presentation, announcing that you have arrived. The main content and navigation on the site lie "behind" this page (a.k.a. the homepage or "welcome page").

Split Case Order Picking A process used to fill orders for quantities less than a full case thereby requiring ordered items to be picked from a case or some similar container.

Split Delivery A method by which a larger quantity is ordered on a purchase order to secure a lower price, but delivery is divided into smaller quantities and spread out over several dates to control inventory investment, save storage space, etc.

Spot To move a trailer or boxcar into place for loading or unloading.

Spot Demand Demand, having a short lead time that is difficult to estimate. Usually supply for this demand is provided at a premium price. An example of spot demand would be when there's a spiked demand for building materials as a result of a hurricane.

Spur Track A railroad track that connects a company's plant or warehouse with the railroad's track; the cost of the spur track and its maintenance is borne by the user.

SST *See Smart and Secure Trade Lanes*

Stable Demand Products for which demand does not fluctuate widely at specific points during the year.

Staff Functions The support activities of planning and analysis provided to assist line managers with daily operations. Logistics staff functions include location analysis, system design, cost analysis and planning.

Staging (1) Pulling material for an order from inventory before the material is required. Staging is a means to ensure that all required materials are and will be available for use at time of assembly. The downside to staging is that it creates additional WIP inventory and reduces flexibility. (2) Placing trailers. *Also see: Accumulation Bin*

Stakeholders People with a vested interest in a company or in a project, including managers, employees, stockholders, customers, suppliers and others.

Stand Up Fork Lift A forklift where the operator stands rather than sits. Most commonly used in case picking operations where the operator must get on and off the lift frequently.

Standard Carrier Alpha Code (SCAC/SCAC Code) A unique 2 to 4-letter code assigned to transportation companies for identification purposes. SCAC codes are required for EDI, and are printed on bills of lading and other transportation documents.

Standard Components Components (parts) of a product, for which there is an abundance of suppliers. Not difficult to produce. An example would be a power cord for a computer.

Standard Cost Accounting System A cost accounting system that uses cost units determined before production for estimating the cost of an order or product. For management control purposes, the standards are compared to actual costs, and variances are computed.

Standard Deviation/Variance Measures of dispersion for a probability distribution. The variance is the average squared difference of a distribution from the distribution's mean (average) value. The standard deviation is defined mathematically as the square root of the variance, and is thereby expressed in the same units as the random variable that's described by the probability distribution. A distribution that varies widely above its mean value will have a larger standard deviation/variance than a distribution with less variation above its mean value.

Standard Industrial Classification (SIC) Classification codes that are used to categorize companies into industry groupings.

Standing Order *See Blanket Purchase Order*

Start Manufacture to Order Complete Manufacture Average lead-time from the time manufacturing begins to the time end products are ready for shipment, including the following sub-elements: order configuration verification, production scheduling, time to release order to manufacturing or distribution, and build or configure time. (An element of Order Fulfilment Lead Time)Note: Determined separately for Make-to-Order, Configure/Package-to-Order and Engineer-to-Order products. Does not apply to Make-to-Stock products.

Statement of Work (SOW) (1) A description of products to be supplied under a contract. A good practice is for companies to have SOWs in place with their trading partners—especially for all top suppliers. (2) In projection management, the first project planning document that should be prepared. It describes the purpose, history, deliverables and measurable success indicators for a project. It captures the support required from the customer and identifies contingency plans for events that could throw the project off course. Because the project must be sold to management, staff and review groups, the statement of work should be a persuasive document.

Statistical Process Control (SPC) A visual means of measuring and plotting process and product variation. Results are used to adjust variables and maintain product quality.

Steamship Conferences Collective rate-making bodies for liner water carriers.

Stickering Placing customer-specific stickers on boxes of product. An example would be where Wal-Mart has a request for their own product codes to be applied to retail boxes prior to shipment.

Stochastic Models Models where uncertainty is explicitly considered in the analysis.

Stock Keeping Unit (SKU) A category of unit with unique combination of form, fit and function (i.e. unique components held in stock). To illustrate: If two items are indistinguishable to the customer, or if any distinguishing characteristics visible to the customer are not important to the customer so that the customer believes the two items to be the same, these two items are part of the same SKU. As a further illustration consider a computer company that allows customers to configure a product from standard catalogue components, choosing from three keyboards, three monitors and three CPUs. Customers may also individually buy keyboards, monitors and CPUs. If the stock were held at the configuration component level, the company would have nine SKUs. If the company stocks at the component level, as well as at the configured product level, the company would have 36 SKUs. (9 component SKUs +3*3*3 configured product SKUs. If as part of a promotional campaign the company also specially packaged the products, the company would have a total of 72 SKUs.

Stock Out A term used to refer to a situation where no stock was available to fill a request from a customer or production order during a pick operation. Stock outs can be costly, including the profit lost for not having the item available for sale, lost goodwill, substitutions. *Also referred to Out of Stock (OOS)*

Stockchase Moving shipments through regular channels at an accelerated rate; to take extraordinary action because of an increase in relative priority. *Synonym: Expediting*

Stockless Purchasing A practice whereby the buyer negotiates a price for the purchases of annual requirements of MRO items and the seller holds inventory until the buyer places an order for individual items.

Stockout Cost The opportunity cost associated with not having sufficient supply to meet demand.

Stovepipe *See Silo*

Straight Truck A truck which has the driver's cab and the trailer combined onto a single frame. Straight trucks do not have a separate tractor and trailer. The driving compartment, engine and trailer are one unit.

Strategic Alliance Business relationship in which two or more independent organizations cooperate and willingly modify their business objectives and practices to help achieve long-term goals and objectives. *Also see: Marquee Partners*

Strategic Planning Looking 1–5 years into the future and designing a logistical system (or systems) to meet the needs of the various businesses in which a company is involved.

Strategic Sourcing The process of determining long-term supply requirements, finding sources to fulfil those needs, selecting suppliers to provide the services, negotiating the purchase agreements and managing the suppliers' performance. Focuses on developing the most effective relationships with the right suppliers, to ensure that the right price is paid and that lifetime product costs are minimized. It also assesses whether services or processes would provide better value if they were outsourced to specialist organizations.

Strategic Variables The variables that effect change in the environment and logistics strategy. The major strategic variables include economics, population, energy and government.

Strategy A specific action to achieve an objective.

Stretch Wrap Clear plastic film that is wrapped around a unit load or partial load of product to secure it. The wrap is elastic.

Stores The function associated with the storage and issuing of items that are frequently used. Also frequently seen as an alternative term for warehouse.

Sub-Optimization Decisions or activities in a part made at the expense of the whole. An example of sub-optimization is where a manufacturing unit schedules production to benefit its cost structure without regard to customer requirements or the effect on other business units.

Subcontracting Sending production work outside to another manufacturer. This can involve specialized operations such as plating metals, or complete functional operations. *Also see: Outsource*

Substitutability The ability of a buyer to substitute the products of different sellers.

Sunk Cost (1) The unrecovered balance of an investment. It is a cost, already paid, that is not relevant to the decision concerning the future that is being made. Capital already invested that for some reason cannot be retrieved. (2) A past cost that has no relevance with respect to future receipts and disbursements of a facility undergoing an economic study. This concept implies that since a past outlay is the same regardless of the alternative selected, it should not influence the choice between alternatives.

Surrogate [item] Driver A substitute for the ideal driver, but is closely correlated to the ideal driver, where [item] is Resource, Activity, Cost Object. A surrogate driver is used to significantly reduce the cost of measurement while not significantly reducing accuracy. For example, the number of production runs is not descriptive of the material disbursing activity, but the number of production runs may be used as an activity driver if material disbursements correlate well with the number of production runs.

Supermarket Approach An inventory management and picking technique used in lean enterprises. This concept was conceived by Taiichi Ohno of Toyota after a visit to the US in 1956 where he was impressed by how consumers could pick whatever they needed from the shelf, and the store would simply replenish what was taken. This became the basis for the "pull system".

Supplier (1) A provider of goods or services. *Also see: Vendor* (2) A seller with whom the buyer does business, as opposed to vendor, which is a generic term referring to all sellers in the marketplace.

Supplier Certification Certification procedures verifying that a supplier operates, maintains, improves and documents effective procedures that relate to the customer's requirements. Such requirements can include cost, quality, delivery, flexibility, maintenance, safety, and ISO quality and environmental standards.

Supplier-Owned Inventory A variant of Vendor-Managed Inventory and Consignment Inventory. In this case, the supplier not only manages the inventory, but also owns the stock close to or at the customer location until the point of consumption or usage by the customer.

Supplemental Carrier A for-hire air carrier subject to economic regulations; the carrier has no time schedule or designated route; service is provided under a charter or contract per plane per trip.

Supply Chain (1) Starting with unprocessed raw materials and ending with the final customer using the finished goods, the supply chain links many companies together. (2) The material and informational interchanges in the logistical process stretching from acquisition of raw materials to delivery of finished products to the end user. All vendors, service providers and customers are links in the supply chain.

Supply Chain Council A non-profit organization dedicated to improving the supply chain efficiency of its members. The Supply-Chain Council's membership consists primarily practitioners representing a broad cross section of industries, including manufacturers, services, distributors and retailers. It is the organization responsible for the SCOR standards.

Supply Chain Design The determination of how to structure a supply chain. Design decisions include the selection of partners, the location and capacity of warehouse and production facilities, the products, the modes of transportation, and supporting information systems.

Supply Chain Execution (SCE) The ability to move the product out the warehouse door. This is a critical capacity and one that only brick-and-mortar firms bring to the B2B table. Dot-coms have the technology, but that's only part of the equation. The need for SCE is what is driving the Dot-coms to offer equity partnerships to the wholesale distributors.

Supply Chain Event Management (SCEM) SCEM is an application that supports control processes for managing events within and between companies. It consists of integrated software functionality that supports five business processes: monitor, notify, simulate, control and measure supply chain activities.

Supply Chain Integration (SCI) Likely to become a key competitive advantage of selected e-marketplaces. Similar concept to the Back-End Integration, but with greater emphasis on the moving of goods and services.

Supply Chain Inventory Visibility Software applications that permit monitoring events across a supply chain. These systems track and trace inventory globally on a line-item level and notify the user of significant deviations from plans. Companies are provided with realistic estimates of when material will arrive.Supply Chain Management (SCM) as defined by the Council of Supply Chain Management Professionals (CSCMP)"Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers and customers.

In essence, supply chain management integrates supply and demand management within and across companies. Supply Chain Management is an integrating function with primary responsibility for linking major business functions and business processes within and across companies into a cohesive and high-performing business model. It includes all of the logistics management activities noted above, as well as manufacturing operations, and it drives coordination of processes and activities with and across marketing, sales, product design, finance and information technology".

Supply Chain Network Design Systems The systems employed in optimizing the relationships among the various elements of the supply chain manufacturing plants, distribution centres, points-of-sale, as well as raw materials, relationships among product families, and other factors to synchronize supply chains at a strategic level.

Supply Chain Operations Reference Model (SCOR) This is the model developed by the Supply-Chain Council SCC and is built around six major processes: plan, source, make, deliver, return and enable. The aim of the SCOR is to provide a standardized method of measuring supply chain performance and to use a common set of metrics to benchmark against other organizations.

Supply Chain-Related Finance and Planning Cost Element One of the elements comprising a company's total supply-chain management costs. These costs consist of the following:1. Supply-Chain Finance Costs: Costs associated with paying invoices, auditing physical counts, performing inventory accounting and collecting accounts receivable. Does NOT include customer invoicing/accounting costs (see Order Management Costs).2. Demand/Supply Planning Costs: Costs associated with forecasting, developing finished goods, intermediate, sub-assembly or end item inventory plans, and coordinating Demand/Supply

Supply Chain-Related IT Costs Information Technology (IT) costs (in US dollars) associated with major supply-chain management processes as described below. These costs should include: Development costs (costs incurred in process reengineering, planning, software development, installation, implementation, and training associated with new and/or upgraded architecture, infrastructure, and systems to support the described supply-chain management processes), Execution costs (operating costs to support supply-chain process users, including computer and network operations, EDI and telecommunications services, and amortization/depreciation of hardware, Maintenance costs (costs incurred in problem resolution, troubleshooting, repair and routine maintenance associated with installed hardware and software for described supply-chain management processes. Includes costs associated with data base administration, systems configuration control, release planning and management. These costs are associated with the following processes:• PLAN1. Product Data Management—Product phase-in/phase-out and release; post introduction support and expansion; testing and evaluation; end-of-life inventory management. Item master definition and control.2. Forecasting and Demand/Supply Manage and Finished Goods—Forecasting; end-item inventory planning, DRP, production master scheduling for all products, all channels.• SOURCE1. Sourcing/Material Acquisition—Material requisitions, purchasing, supplier quality engineering, inbound freight management, receiving, incoming inspection, component engineering, tooling acquisition, accounts payable.2. Component and Supplier Management—Part number cross-references, supplier catalogues, approved vendor lists.3. Inventory Management—Perpetual and physical inventory controls and tools.• MAKE1. Manufacturing Planning—MRP, production scheduling, tracking, mfg. engineering, mfg. documentation management, inventory/obsolescence tracking.2. Inventory Management—Perpetual and physical inventory controls and tools.3. Manufacturing Execution—MES, detailed and finite interval scheduling, process controls and machine scheduling.• DELIVER1. Order Management—Order entry/maintenance, quotes, customer database, product/price database, accounts receivable, credits and collections, invoicing.2. Distribution and Transportation Management—DRP shipping, freight management, traffic management.3. Inventory Management—Perpetual and physical inventory controls and tools.4. Warehouse Management—Finished goods, receiving and stocking, pick/pack.5. Channel Management—Promotions, pricing and discounting, customer satisfaction surveys.6. Field Service/Support—Field service, customer and field support, technical service, service/call management, returns and warranty tracking.• External Electronic InterfacesPlan/Source/Make/Deliver—Interfaces, gateways and data repositories created and maintained to exchange supply-chain-related information with the outside world. E-Commerce initiatives. Includes development and implementation costs.Note: Accurate assignment of IT-related cost is challenging. It can be done using Activity-Based-Costing methods, or using other approaches such as allocation based on user counts, transaction counts or departmental headcounts. The emphasis should be on capturing all costs. Costs for any IT activities that are outsourced should be included.

Supply Chain Resiliency A term describing the level of hardening of the supply chain against disasters.

Supply Chain Strategy Planning The process of analysing, evaluating, defining supply chain strategies, including network design, manufacturing and transportation strategy and inventory policy.

Supply Chain Vulnerability Of equal importance to Variability, Velocity and Volume in the elements of the Supply Chain. The term evaluates the supply chain based on the level of acceptance of the five steps of disaster logistics: planning, detection, mitigation, response and recovery.

Supply Planning The process of identifying, prioritizing, and aggregating, as a whole with constituent parts, all sources of supply that are required and add value in the supply chain of a product or service at the appropriate level, horizon and interval.

Supply Planning Systems The process of identifying, prioritizing, and aggregating, as a whole with constituent parts, all sources of supply that are required and add value in the supply chain of a product or service at the appropriate level, horizon and interval.

Supply Warehouse A warehouse that stores raw materials. Goods from different suppliers are picked, sorted, staged or sequenced at the warehouse to assemble plant orders.

Support Costs Costs of activities not directly associated with producing or delivering products or services. Examples are the costs of information systems, process engineering and purchasing. *Also see: Indirect Cost*

Surcharge An add-on charge to the applicable charges; motor carriers have a fuel surcharge, and railroads can apply a surcharge to any joint rate that does not yield 110% of variable cost.

Sustaining Activity An activity that benefits an organizational unit as a whole, but not any specific cost object.

SWAS Store-Within-A-Store.

Switch Engine A railroad engine that is used to move rail cars short distances within a terminal and plant.

Switching Company A railroad that moves rail cars short distances; switching companies connect two mainline railroads to facilitate through movement of shipments.

SWOT *See SWOT Analysis*

SWOT Analysis An analysis of the strengths, weaknesses, opportunities and threats of and to an organization. SWOT analysis is useful in developing strategy.

Synchronization The concept that all supply chain functions are integrated and interact in real time; when changes are made to one area, the effect is automatically reflected throughout the supply chain.

Syntax The grammar or rules which define the structure of the EDI standard.

System A set of interacting elements, variables, parts or objects that are functionally related to each other and form a coherent group.

Systems concept A decision-making strategy that emphasizes overall system efficiency rather than the efficiency of the individual part of the system.

T

Tact Time *See Takt Time*

Tactical Planning The process of developing a set of tactical plans (e.g. production plan, sales plan, marketing plan and so on). Two approaches to tactical planning exist for linking tactical plans to strategic plans—production planning and sales and operations planning. *See: Sales and operational planning, strategic planning.*

Taguchi Method A concept of off-line quality control methods conducted at the product and process design stages in the product development cycle. This concept, expressed by Genichi Taguchi, encompasses three phases of product design: system design, parameter design and tolerance design. The goal is to reduce quality loss by reducing the variability of the product's characteristics during the parameter phase of product development.

Takt Time Sets the pace of production to match the rate of customer demand and becomes the heartbeat of any lean production system. It is computed as the available production time divided by the rate of customer demand. For example, assume demand is 10,000 units per month, or 500 units per day, and planned available capacity is 420 min per day. The takt time = 420 min per day/500 units per day = 0.84 min per unit. This takt time means that a unit should be planned to exit the production system on average every 0.84 min.

Tally Sheet A printed form on which companies record, by making an appropriate mark, the number of items they receive or ship. In many operations, tally sheets become a part of the permanent inventory records.

Tandem A truck that has two drive axles or a trailer that has two axles.

Tank Cars Rail cars that are designed to haul bulk liquids or gas commodities.

Tapering Rate A rate that increases with distance but not in direct proportion to the distance the commodity is shipped.

Tare Weight The weight of a substance, obtained by deducting the weight of the empty container from the gross weight of the full container.

Target Costing A target cost is calculated by subtracting a desired profit margin from an estimated or a market-based price to arrive at a desired production, engineering or marketing cost. This may not be the initial production cost, but one expected to be achieved during the mature production stage. Target costing is a method used in the analysis of product design that involves estimating a target cost and then designing the product/service to meet that cost. *Also see: Value Analysis*

Tariff A tax assessed by a government on goods entering or leaving a country. The term is also used in transportation in reference to the fees and rules applied by a carrier for its services.

Tasks The breakdown of the work in an activity into smaller elements.

Task Interleaving A method of combining warehouse picking and put away. Warehouse Management Systems (WMS) use logic to direct (typically with an RF terminal) a lift truck operator to put away a pallet en route to the next pick. The idea is to reduce “deadheading” or driving empty material handling equipment around the warehouse.

T’s and C’s *See Terms and Conditions*

TCO *See Total Cost of Ownership*

Technical Components Component (part) of a product for which there is a limited number of suppliers. These parts are hard to make, and require much more lead time and expertise on the part of the supplier to produce than standard components do.

Temporary authority The ICC may grant a temporary operating authority as a common carrier for up to 270 days.

Ten Principles A principle is a general rule, fundamental, or other statement of an observed truth. Over time certain fundamental truths of material handling have been found to exist. The “principles” of material handling are often useful in analysing, planning and managing material handling activities and systems. At the very least they form a basic foundation upon which one can begin building expertise in material handling.These principles serve as a starting point to identifying potential problems and assessing needs:1. Planning2. Standardization3. Work4. Ergonomics5. Unit Load6. Space Utilization7. System8. Automation 9. Environment10. Life Cycle Cost

Tender The document which describes a business transaction to be performed.

Terminal Delivery Allowance A reduced rate offered in return for the shipper of consignee tendering or picking up the freight at the carrier's terminal.

Terms and conditions (T's and C's) All the provisions and agreements of a contract.

TEU *See Twenty-foot Equivalent Unit*

Theoretical Cycle Time The back-to-back process time required for a single unit to complete all stages of a process without waiting, stoppage or time lost due to error.

Theory of Constraints (TOC) A production management theory which dictates that volume is controlled by a series of constraints related to work centre capacity, component availability, finance, etc. Total throughput cannot exceed the capacity of the smallest constraint, and any inventory buffers or excess capacity at non-related work centres is waste.

Third-Party Logistics (3PL) Outsourcing all or much of a company's logistics operations to a specialized company. The term "3PL" was first used in the early 1970s to identify intermodal marketing companies (IMCs) in transportation contracts. Up to that point, contracts for transportation had featured only two parties, the shipper and the carrier. When IMCs entered the picture—as intermediaries that accepted shipments from the shippers and tendered them to the rail carriers—they became the third party to the contract, the 3PL. But over the years, that definition has broadened to the point where these days, every company that offers some kind of logistics service for hire calls itself a 3PL

Third-Party Logistics Provider A firm which provides multiple logistics services for use by customers. Preferably, these services are integrated, or "bundled" together by the provider. These firms facilitate the movement of parts and materials from suppliers to manufacturers, and finished products from manufacturers to distributors and retailers. Among the services which they provide are transportation, warehousing, cross-docking, inventory management, packaging and freight forwarding.

Third-Party Warehousing The outsourcing of the warehousing function by the seller of the goods.

Three-layer Framework A basic structure and operational activity of a company; the three layers include operational systems, control and administrative management, and master planning.

Throughput A measure of volume through a process such as warehousing output volume (weight, number of units). Also, the total amount of units received plus the total amount of units shipped, divided by two.

Time-Based Order System *See Fixed Reorder Cycle Inventory Model*

Time Bucket A number of days of data summarized into a columnar display. A weekly time bucket would contain all of the relevant data for an entire week.

Weekly time buckets are considered to be the largest possible (at least in the near and medium term) to permit effective MRP.

Time Fence A policy or guideline established to note where various restrictions or changes in operating procedures take place. For example, changes to the master production schedule can be accomplished easily beyond the cumulative lead time, while changes inside the cumulative lead time become increasingly more difficult to a point where changes should be resisted. Time fences can be used to define these points.

Time-Definite Services Delivery is guaranteed on a specific day or at a certain time of the day.

Time/Service Rate A rail rate that is based upon transit time.

Time-to-Product The total time required to receive, fill and deliver an order for an existing product to a customer, timed from the moment that the customer places the order until the customer receives the product.

Time Utility A value created in a product by having the product available at the time desired. Transportation and warehousing create time utility.

Timetables Time schedules of departures and arrivals by origin and destination; typically used for passenger transportation by air, bus and rail.

TL *See Truckload Carrier*

TMS *See Transportation Management System*

TOC *See Theory of Constraints*

TOFC *See Trailer-on-Flat Car, Piggyback*

Ton-Mile A measure of output for freight transportation; it reflects the weight of the shipment and the distance it is hauled; a multiplication of tons hauled and distance travelled.

Total Annual Material Receipts The dollar amount associated with all direct materials received from Jan 1 to Dec 31.

Total Annual Sales Total Annual Sales are Total Product Revenue plus post-delivery revenues (e.g. maintenance and repair of equipment, system integration) royalties, sales of other services, spare parts revenue, and rental/lease revenues.

Total Average Inventory Average normal use stock, plus average lead stock, plus safety stock.

Total Cost Analysis A decision-making approach that considers minimization of total costs and recognizes the interrelationship among system variables such as transportation, warehousing, inventory and customer service.

Total Cost Curve (1) In cost-volume-profit (breakeven) analysis, the total cost curve is composed of total fixed and variable costs per unit multiplied by the number of units provided. Breakeven quantity occurs where the total cost curve and total sales revenue curve intersect. *See: Break-even chart, Break-even point*. (2) In inventory theory, the total cost curve for an inventory item is the sum of the costs of acquiring and carrying the item. *Also see: Economic Order Quantity*

Total Cost of Ownership (TCO) Total cost of a computer asset throughout its lifecycle, from acquisition to disposal. TCO is the combined hard and soft costs of owning networked information assets. “Hard” costs include items such as the purchase price of the asset, implementation fees, upgrades, maintenance contracts, support contracts, and disposal costs, licence fees that may or may not be upfront or charged annually. These costs are considered “hard costs” because they are tangible and easily accounted for.

Total Cumulative Manufacture Cycle Time The average time between commencement of upstream processing and completion of final packaging for shipment operations as well as release approval for shipment. Do not include WIP storage time.*Calculation:[Average # of units in WIP]/[Average daily output in units] – WIP days of supply*

Total Inventory Days of Supply Total gross value of inventory at standard cost before reserves for excess and obsolescence. Includes only inventory that is on the books and currently owned by the business entity. Future liabilities such as consignments from suppliers are not included.*Calculation:[5 Point Annual Average Gross Inventory]/[Cost of Good Sold/365]*

Total Make Cycle Time The average total processing time between commencement of upstream processing and completion of all manufacturing process steps up to, but NOT including, packaging and labelling operations (i.e. from start of manufacturing to final formulated product ready for primary packaging). Do not include hold or test and release times.*Calculation:[Average # of units in active manufacturing]/[Average daily output in units]*

Total Package and Label Cycle Time The average total processing time between the commencement of the primary packaging and labelling steps to completion of the final packaging steps for shipment.*Calculation:[Average # of units in packaging and labelling WIP]/[Average daily output in units]*

Total Product Revenue The total value of sales made to external customers plus the transfer price valuation of intra-company shipments, net of all discounts, coupons, allowances, and rebates. Includes only the intra-company revenue for product transferring out of an entity, installation services if these services are sold bundled with end products, and recognized leases to customers initiated during the same period as revenue shipments, with revenue credited at the average selling price.Note: Total Product Revenue excludes post-delivery revenues (maintenance and repair of equipment, system integration), royalties, sales of other services, spare parts revenue, and rental/lease revenues.

Total Productive Maintenance (TPM) Team-based maintenance process designed to maximize machine availability and performance and product quality.

Total quality management (TQM) A management approach in which managers constantly communicate with organizational stakeholders to emphasize the importance of continuous quality improvement.

Total Sourcing Lead Time (95% of Raw Material Dollar Value) Cumulative lead time (total average combined inside-plant planning, supplier lead time [external or internal], receiving, handling, etc., from demand identification at the factory until the materials are available in the production facility) required to source 95% of the dollar value (per unit) of raw materials from internal and external suppliers.

Total Supply-Chain Management Cost (5 elements) Total cost to manage order processing, acquire materials, manage inventory, and manage supply-chain finance, planning, and IT costs, as represented as a percent of revenue. Accurate assignment of IT-related cost is challenging. It can be done using Activity-Based-Costing methods, or based on more traditional approaches. Allocation based on user counts, transaction counts or departmental headcounts are reasonable approaches. The emphasis should be on capturing all costs, whether incurred in the entity completing the survey or incurred in a supporting organization on behalf of the entity. Reasonable estimates founded in data were accepted as a means to assess overall performance. All estimates reflected fully burdened actual inclusive of salary, benefits, space and facilities, and general and administrative allocations.*Calculation:[Order Management Costs + Material Acquisition Costs + Inventory Carrying Costs + Supply-Chain-Related Finance and Planning Costs + Total Supply-Chain-Related IT Costs]/[Total Product Revenue] (Please see individual component categories for component detail and calculations)*

Total Supply Chain Response Time The time it takes to rebalance the entire supply chain after determining a change in market demand. Also, a measure of a supply chain's ability to change rapidly in response to marketplace changes.*Calculation:[Forecast Cycle Time] + [Re-plan Cycle Time] + [Intra-Manufacturing Re-plan Cycle Time] + [Cumulative Source/Make Cycle Time] + [Order Fulfilment Lead Time]*

Total Test and Release Cycle Time The average total test and release time for all tests, documentation reviews, and batch approval processes performed from start of manufacturing to release of final packaged product for shipment.*Calculation:[Average # of units in test and release]/[Average daily output in units]*

Toto Authority A private motor carrier receiving operating authority as a common carrier to haul freight for the public over the private carrier's backhaul; this type of authority was granted to the Toto Company in 1978.

Touches The number of times a labour action is taken during a manufacturing or assembly process. Touches are typically used to measure efficiency or for costing and pricing purposes.

TPM *See Total Productive Maintenance*

TQM *See Total Quality Management*

Tracing Determining where a shipment is during the course of a move. The practice of relating resources, activities and cost objects using the drivers underlying their cost causal relationships. The purpose of tracing is to observe and understand how costs are arising in the normal course of business operations. *Synonym: Assignment*

Traceability (1) The attribute allowing the ongoing location of a shipment to be determined. (2) The registering and tracking of parts, processes and materials used in production, by lot or serial number.

Tracking and Tracing Monitoring and recording shipment movements from origin to destination.

Tracking Signal The ratio of the cumulative algebraic sum of the deviations between the forecasts and the actual values to the mean absolute deviation. Used to signal when the validity of the forecasting model might be in doubt.

Tractor The tractor is the driver compartment and engine of the truck. It has two or three axles.

Trading Partner Companies that do business with each other via EDI (e.g. send and receive business documents, such as purchase orders).

Trading Partner Agreement The written contract that spells out agreed upon terms between EDI trading partners.

Traffic A department or function charged with the responsibility for arranging the most economic classification and method of shipment for both incoming and outgoing materials and products.

Traffic Management The management and controlling of transportation modes, carriers and services.

Trailer The part of the truck that carries the goods.

Trailer Drops When a driver drops off a full truck at a warehouse and picks up an empty one.

Trailer on a Flatcar (TOFC) A specialized form of containerization in which motor and rail transport coordinate. *Synonym: Piggyback*

Tramp An international water carrier that has no fixed route or published schedule; a tramp ship is chartered for a particular voyage or a given time period.

Transaction A single completed transmission, e.g. transmission of an invoice over an EDI network. Analogous to usage of the term in data processing, in which a transaction can be an inquiry or a range of updates and trading transactions. The definition is important for EDI service operators, who must interpret invoices and other documents.

Transaction Set Commonly used business transactions (e.g. purchase order, invoice, etc.) organized in a formal, structured manner, consisting of a Transaction Set header control segment, one or more Data Segments and a Transaction Set trailer Control Data Segment.

Transaction Set ID A three digit numerical representation that identifies a transaction set.

Transactional Acknowledgement Specific Transaction Sets, such as the Purchase Order Acknowledgement (855), that both acknowledges receipt of an order and provides special status information such as reschedules, price changes and back order situation.

Transfer Pricing The pricing of goods or services transferred from one segment of a business to another. Transfer pricing generally includes the costs associated with performing the transfer and therefore item costs will be incrementally higher than when received through normal channels.

Transit Inventory Inventory in transit between manufacturing and stocking locations, or between warehouses in a distributed warehousing model. *Also see: In-transit Inventory*

Transit Privilege A carrier service that permits the shipper to stop the shipment in transit to perform a function that changes the commodity's physical characteristics but to pay the through rate.

Transit Time The total time that elapses between a shipment's pickup and delivery.

Translation Software Software that converts or "translates" business application data into EDI standard formats, and vice versa.

Transmission Acknowledgment Acknowledgment that a total transmission was received with no errors detected

Transparency The ability to gain access to information without regard to the systems landscape or architecture. An example would be where an online customer could access a vendor's web site to place an order and receive availability information supplied by a third-party outsourced manufacturer or shipment information from a third-party logistics provider. *See also: Visibility*

Transportation Association of America An association that represents the entire U.S. Transportation system, carriers, users and the public; now defunct.

Transportation Management System (TMS) A computer system designed to provide optimized transportation management in various modes along with associated activities, including managing shipping units, labour planning and building, shipment scheduling through inbound, outbound, intra-company shipments, documentation management (especially when international shipping is involved) and third-party logistics management.

Transportation Research Forum A professional association that provides a forum for the discussion of transportation ideas and research techniques.

Transportation Mode The method of transportation: land, sea or air shipment.

Transportation Planning The process of defining an integrated supply chain transportation plan and maintaining the information which characterizes total supply chain transportation requirements, and the management of transporters both inter and intra company.

Transportation Planning Systems The systems used in optimizing assignments from plants to distribution centres, and from distribution centres to stores. The systems combine "moves" to ensure the most economical means are employed.

Transportation Requirements Planning (TRP) Utilizing computer technology and information already available in MRP and DRP databases to plan transportation needs based on field demand.

Transportation Research Board A division of the National Academy of Sciences which pertains to transportation research.

Transportation Method A linear programming technique that determines the least-cost allocation of shipping goods from plants to warehouses or from warehouses to customers.

Transportation Security Administration (TSA) TSA was created in response to the attacks of September 11th and signed into law in November 2001. TSA was originally in the Department of Transportation but was moved to the Department of Homeland Security in March 2003. TSA's mission is to protect the nation's transportation systems by ensuring the freedom of movement for people and commerce.

Transshipment Problem A variation of the transportation method of linear programming that considers consolidating shipments to one destination and reshipping from that destination.

Travel Agent A firm that provides passenger travel information; air, rail and steamship ticketing; and hotel reservations. The travel agent is paid a commission by the carrier and hotel.

Trend General upward or downward movement of a variable over time such as demand for a product. Trends are used in forecasting to help anticipate changes in consumption over time.

Trend Forecasting Models Methods for forecasting sales data when a definite upward or downward pattern exists. Models include double exponential smoothing, regression and triple smoothing.

TRP *See Transportation Requirements Planning*

Truckload Carriers (TL) Trucking companies, which move full truckloads of freight directly from the point of origin to destination.

Truckload Lot A truck shipment that qualifies for a lower freight rate because it meets a minimum weight and/or volume.

Trunk Lines Oil pipelines that are used for the long-distance movement of crude oil, refined oil or other liquid products.

TSA *See Transportation Security Administration*

Turnover (1) Typically refers to Inventory Turnover. (2) In the United Kingdom and certain other countries, turnover refers to annual sales volume. *Also see: Inventory Turns*

Twenty-foot Equivalent Unit (TEU) Standard unit for counting containers of various capacities and for describing the capacities of container ships or terminals. One 20 Foot ISO container equals 1 TEU. One 40 Foot ISO container equals two TEU.

Two-Level Master Schedule A master scheduling approach in which a planning bill of material is used to master schedule an end product or family, along with selected key features (options and accessories). *Also see: Production Forecast*

Two-Bin System An inventory ordering system in which the time to place an order for an item is indicated when the first bin is empty. The second bin contains sufficient supply until the order is received.

U

Ubiquity Existence or apparent existence everywhere at the same time. A raw material that is found at all locations.

UCC *GS1*

UCS *See Uniform Communication Standard*

UI User Interface.

ULD *See Unit Load Device*

Umbrella Rate An ICC rate-making practice that held rates to a particular level to protect the traffic of another mode.

Unbundled Payment/Remittance The process where payment is delivered separately from its associated detail.

Uniform Code Council (UCC) *See GS1*

Uniform Communication Standard (UCS) A set of standard transaction sets for the grocery industry that allows computer-to-computer, paperless exchange of documents between trading partners. Using Electronic Data Interchange, UCS is a rapid, accurate and economical method of business communication; it can be used by companies of all sizes and with varying levels of technical sophistication.

Uniform Product Code (UPC) A standard product numbering and barcoding system used by the retail industry. UPC codes are administered by the Uniform Code Council; they identify the manufacturer as well as the item, and are included on virtually all retail packaging. *Also see: Uniform Code Council*

Uniform Resource Locator (URL) A string that supplies the Internet address of a website or resource on the World Wide Web, along with the protocol by which the site or resource is accessed. The most common URL type is http; //, which gives the Internet address of a web page. Some other URL types are gopher://, which gives the Internet address of a Gopher directory, and ftp: //, which gives the network location of an FTP resource.

Uniform Warehouse Receipts Act The act that sets forth the regulations governing public warehousing. The regulations define the legal responsibility of a warehouse manager and define the types of receipts issued.

Unit Cost The cost associated with a single unit of product. The total cost of producing a product or service divided by the total number of units. The cost associated with a single unit of measure underlying a resource, activity, product or service. It is calculated by dividing the total cost by the measured volume. Unit cost measurement must be used with caution as it may not always be practical or relevant in all aspects of cost management.

Unit of Driver Measure The common denominator between groupings of similar activities. Example: 20 h of process time is performed in an activity centre. This time equates to a number of common activities varying in process time duration. The unit of measure is a standard measure of time such as a minute or an hour.

Unit Load Device (ULD) Refers to air freight containers and pallets.

Unit of Measure (UOM) The unit in which the quantity of an item is managed, e.g. pounds, each, box of 12, package of 20 or case of 144. Various UOMs may exist for a single item. For example, a product may be purchased in cases, stocked in boxes and issued in single units.

Unit-of-Measure Conversion A conversion ratio used whenever multiple units-of-measure are used with the same item. For example, if you purchased an item in cases (meaning that your purchase order stated a number of cases rather than a number of pieces) and then stocked the item in pieces, you would require a conversion to allow your system to calculate how many pieces are represented by a quantity of cases. This way, when you received the cases, your system would automatically convert the case quantity into piece quantity.

Unit Train An entire, uninterrupted locomotive and caboose movement between an origin and destination.

United Nations Standard Product and Service Code (UN/SPSC) Developed jointly between the UN and Dun & Bradstreet (D&B). Has a five level coding structure (segment, family, class, commodity, business function) for nearly 9000 products.

United States Railway Association The planning and funding agency for Conrail; created by the 3-R Act of 1973.

Unitize To consolidate a number of packages into one unit; the several packages are strapped, banded or otherwise attached together.

Unitization In warehousing, the consolidation of several units into larger units for fewer handlings.

Unplanned Order Orders which are received that do not fit into the volumes prescribed by the plans developed from forecasts.

UN/SPSC *See United Nations Standard Product and Service Code*

UOM *See Unit of Measure*

UPC *See Uniform Product Code*

Upcharges Charges added to a bill, particularly a freight bill, to cover additional costs that were not envisioned when a contract was written. These might include costs related to rapidly increasing fuel charges or costs related to government mandates. *See also: Accessorial Charges*

Upsell The practice of attempting to sell a higher-value product to the customer.

Upside Production Flexibility The number of days required to complete manufacture and delivery of an unplanned sustainable 20% increase in end product supply of the predominant product line. The one constraint that is estimated to be the principal obstacle to a 20% increase in end product supply, as represented in days, is Upside Flexibility: Principal Constraint. Upside Flexibility could affect three possible areas: direct labour availability, internal manufacturing capacity, and key components or material availability.

Upstream Refers to the supply side of the supply chain. Upstream partners are the suppliers who provide goods and services to the organization needed to satisfy demands which originate at point of demand or use, as well as other flows such as return product movements and payments for purchases. Opposite of downstream.

Urban Mass Transportation Administration An agency of the U.S. Department of Transportation responsible for developing comprehensive mass transport systems for urban areas and for providing financial aid to transit systems.

URL *See Uniform Resource Locator*

Usage Rate Measure of demand for product per unit of time (e.g. units per month, etc.).

V

Validation To check whether a document is the correct type for a particular EDI system, as agreed upon by the trading partners, in order to determine whether the document is going to or coming from an authorized EDI user.

Value Added Increased or improved value, worth, functionality or usefulness.

Value-Added Network (VAN) A company that acts as a clearing-house for electronic transactions between trading partners. A third-party supplier that receives EDI transmissions from sending trading partners and holds them in a "mailbox" until retrieved by the receiving partners.

Value-Added Productivity Per Employee Contribution made by employees to total product revenue minus the material purchases divided by total employment. Total employment is total employment for the entity being surveyed. This is the average full-time equivalent employee in all functions, including sales and marketing, distribution, manufacturing, engineering, customer service, finance, general and administrative, and other. Total employment should include contract and temporary employees on a full-time equivalent (FTE) basis.*Calculation:Total Product Revenue-External Direct Material/[FTE's]*

Value-Adding/Nonvalue-Adding Assessing the relative value of activities according to how they contribute to customer value or to meeting an organization's needs. The degree of contribution reflects the influence of an activity's cost driver(s).

Value Analysis A method to determine how features of a product or service relate to cost, functionality, appeal and utility to a customer (i.e. engineering value analysis). *Also see: Target Costing*

Value-Based Return (VBR) A measure of the creation of value. It is the difference between economic profit and capital charge.

Value Chain A series of activities, which combined, define a business process; the series of activities from manufacturers to the retail stores that define the industry supply chain.

Value Chain Analysis A method to identify all the elements in the linkage of activities a firm relies on to secure the necessary materials and services, starting from their point of origin, to manufacture, and to distribute their products and services to an end user.

Value-of-Service Pricing Pricing according to the value of the product being transported; third-degree price discrimination; demand-oriented pricing; charging what the traffic will bear.

Value of Transfers The total dollar value (for the calendar year) associated with movement of inventory from one "bucket" into another, such as raw material to work-in-process, work-in-process to finished goods, plant finished goods to field finished goods or customers, and field finished goods to customers. Value of Transfers is based on the value of inventory withdrawn from a certain category and is often approached from a costing perspective, using cost accounts. For example, Raw Materials Value of Transfers is the value of transfers out of the raw material cost accounts (you may have cost centres associated with inventory locations, but all "raw ingredients" usually share common cost accounts or can be rolled up into one financial view). The same goes for WIP. Take the manufacturing cost centres and look at the total value of withdrawals from those cost centres. While Average Gross Inventory represents the value of the inventory in the cost centre at any given time, the Value of Transfers is the total value of inventory leaving the cost centre during the year. The value of transfers for Finished Goods is, in theory, equivalent to COGS.

Value Proposition What the supply chain member offers to other members. To be truly effective, the value proposition has to be two-sided; a benefit to both buyers and sellers.

Value stream All activities, both value added and nonvalue added, required to bring a product from raw material state into the hands of the customer, bring a customer requirement from order to delivery and bring a design from concept to launch.

Value Stream Mapping A pencil and paper tool used in two stages: (1) Follow a product's production path from beginning to end and draw a visual representation of every process in the material and information flows. (2) Then draw a future state map of how value should flow. The most important map is the future state map.

VAN *See Value-Added Network*

Variable Cost A cost that fluctuates with the volume or activity level of business.

VBR *See Value-Based Return*

Velocity Rate of product movement through a warehouse

Vendor The manufacturer or distributor of an item or product line. *Also see: Supplier*

Vendor Code A unique identifier, usually a number and sometimes the company's DUNS number, assigned by a Customer for the Vendor it buys from. Example; a Grocery Store Chain buys Oreo's from Nabisco. The Grocery Store Chain, for accounting purposes, identifies Nabisco as Vendor #76091. One company can have multiple vendor codes. Example; Welch's Foods sells many different products. Frozen grape juice concentrate, chilled grape juice, bottled grape juice and grape jelly. Because each of these items is a different type of product, frozen food, chilled food, beverages, dry food, it may have a different buyer at the Grocery Store Chain, requiring a different vendor code for each product line.

Vendor-Managed Inventory (VMI) The practice of retailers making suppliers responsible for determining order size and timing, usually based on receipt of retail POS and inventory data. Its goal is to increase retail inventory turns and reduce stock outs. It may or may not involve consignment of inventory (supplier ownership of the inventory located at the customer).

Vendor Owned Inventory (VOI) *See Consignment Inventory*

Vertical Hub/Vertical Portal Serving one specific industry. Vertical portal websites that cater to consumers within a particular industry. Similar to the term "vertical industry", these websites are industry specific, and like a portal, they make use of Internet technology by using the same kind of personalization technology. In addition to industry specific vertical portals that cater to consumers, another definition of a vertical portal is one that caters solely to other businesses.

Vertical Integration The degree to which a firm has decided to directly produce multiple value-adding stages from raw material to the sale of the product to the ultimate consumer. The more steps in the sequence, the greater the vertical integration. A manufacturer that decides to begin producing parts, components and materials that it normally purchases is said to be backward integrated. Likewise, a manufacturer that decides to take over distribution and perhaps sale to the ultimate consumer is said to be forward integrated.

Vessel A floating structure designed for transport.

VICS Voluntary Interindustry Commerce Standards. The retail industry standards body responsible for the CPFR standard, among other things.

Viral Marketing The concept of embedding advertising into web portals, pop-ups and as e-mail attachments to spread the word about products or services that the target audience may not otherwise have been interested in.

Virtual Corporation The logical extension of outpartnering. With the virtual corporation, the capabilities and systems of the firm are merged with those of the suppliers, resulting in a new type of corporation where the boundaries between the suppliers' systems and those of the firm seem to disappear. The virtual corporation is dynamic in that the relationships and structures formed change according to the changing needs of the customer.

Virtual Factory A changed transformation process most frequently found under the virtual corporation. It is a transformation process that involves merging the capabilities and capacities of the firm with those of its suppliers. Typically, the components provided by the suppliers are those that are not related to a core competency of the firm, while the components managed by the firm are related to core competencies. One advantage found in the virtual factory is that it can be restructured quickly in response to changing customer demands and needs.

Visibility The ability to access or view pertinent data or information as it relates to logistics and the supply chain, regardless of the point in the chain where the data exists.

Vision The shared perception of the organization's future—what the organization will achieve and a supporting philosophy. This shared vision must be supported by strategic objectives, strategies and action plans to move it in the desired direction. *Syn: vision statement*

VMI *See Vendor Managed Inventory*

VOI *See Vendor Owned Inventory*

Voice Activated or Voice Directed Systems which guide users such as warehouse personnel via voice commands

Voice of the Customer The expressed requirements and expectations of customers relative to products or services, as documented and disseminated to the members of the providing organization.

W

Wagner-Whitin Algorithm A mathematically complex, dynamic lot-sizing technique that evaluates all possible ways of ordering to cover net requirements in each period of the planning horizon to arrive at the theoretically optimum ordering strategy for the entire net requirements schedule. *Also see: Discrete Order Quantity, Dynamic Lot Sizing*

Wall-to-Wall Inventory An inventory management technique in which material enters a plant and is processed through the plant into finished goods without ever having entered a formal stock area.

WAN *See Wide Area Network*

Warehouse Storage place for products. Principal warehouse activities include receipt of product, storage, shipment and order picking.

Warehousing The storing (holding) of goods.

Warehouse Management System (WMS) The systems used in effectively managing warehouse business processes and direct warehouse activities, including receiving, put away, picking, shipping and inventory cycle counts. Also includes support of radio-frequency communications, allowing real-time data transfer between the system and warehouse personnel. They also maximize space and minimize material handling by automating put away processes.

Warranty Costs Includes materials, labour and problem diagnosis for products returned for repair or refurbishment.

Waste (1) In Lean and Just-in-Time, any activity that does not add value to the good or service in the eyes of the consumer. (2) A by-product of a process or task with unique characteristics requiring special management control. Waste production can usually be planned and controlled. Scrap is typically not planned and may result from the same production run as waste.

Waterway Use Tax A per-gallon tax assessed on barge carriers for use of the waterways.

Wave Picking A method of selecting and sequencing picking lists to improve the efficiency of picking and minimize the waiting time of the delivered material. Shipping orders may be picked in waves combined by a common product, common carrier or destination, and manufacturing orders in waves related to work centres. Picked materials would then be consolidated by ship location during the packaging/shipping process.

Waybill Document containing description of goods that are part of common carrier freight shipment. Shows origin, destination, consignee/consignor and amount charged. Copies travel with goods and are retained by originating/delivering agents. Used by carrier for internal record and control, especially during transit. Not a transportation contract.

Web A computer term used to describe the global Internet. *Synonym: World Wide Web*

Web Browser A client application that fetches and displays web pages and other World Wide Web resources to the user.

Web Services A computer term for information processing services that are delivered by third parties using internet portals. Standardized technology communications protocols; network services as collections of communication formats or endpoints capable of exchanging messages.

Web Site A location on the Internet.

Weight Break The shipment volume at which the LTL charges equal the TL charges at the minimum weight.

Weight Confirmation The practice of confirming or validating receipts or shipments based on the weight.

Weight-losing raw material A raw material that loses weight in processing

Weighted-Point Plan A supplier selection and rating approach that uses the input gathered in the categorical plan approach and assigns weights to each evaluation category. A weighted sum for each supplier is obtained and a comparison made. The weights used should sum to 100% for all categories.*Also see: Categorical Plan*

What You See Is What You Get (WYSIWYG) An editing interface in which a file created is displayed as it will appear to an end-user.

Wholesaler *See Distributor*

Wide Area Network (WAN) A public or private data communications system for linking computers distributed over a large geographic area.

Will Call The practice of taking orders that will be picked up at the selling facility by the buyer. An area where buyers can pick up an order at the selling facility. This practice is widely used in the service parts business.

Windows Meta File (WMF) A vector graphics format for Windows-compatible computers used mostly of word processing clip art.

WIP *See Work in Process*

WMS *See Warehouse Management System*

Work-in-Process (WIP) Parts and subassemblies in the process of becoming completed finished goods. Work in process generally includes all of the material, labour and overhead charged against a production order which has not been absorbed back into inventory through receipt of completed products.

World Trade Organization (WTO) An organization established on January 1, 1995 replacing the previous General Agreement on Tariffs and Trade (GATT) that forms the cornerstone of the world trading system.

World Wide Web (WWW) A “multimedia hyper linked database that spans the globe” and lets you browse through a myriad of interesting information. Unlike earlier Internet services, the “Web” combines text, pictures, sounds and even animations, and it lets you move around with a click of your computer mouse.

WTO *See World Trade Organization*

WWW *See World Wide Web*

WYSIWYG *See What You See Is What You Get*

X

X12 The ANSI standard for interindustry electronic interchange of business transactions.

XML *See Extensible Mark-up Language*

Y

Yard Management System (YMS) A system which is designed to facilitate and organize the coming, going and staging of trucks and trucks with trailers in the parking “yard” that serves a warehouse, distribution or manufacturing facility.

Yield The ratio of usable output from a process to its input.

YMS *See Yard Management System*

Z

Zone of Rate Flexibility Railroads are permitted to raise rates by a percentage increase in the railroad cost index determined by the ICC; rates may be raised by 6% per year through 1984 and 4% thereafter.

Zone of Rate Freedom Motor carriers are permitted to raise or lower rates by 10% in 1 year without ICC interference; if the rate change is within the zone of freedom, the rate is presumed to be reasonable.

Zone of Reasonableness A zone or limit within which air carriers are permitted to change rates without regulatory scrutiny; if the rate change is within the zone, the new rate is presumed to be reasonable.

Zone Picking A method of subdividing a picking list by areas within a storeroom for more efficient and rapid order picking. A zone-picked order must be grouped to a single location and the separate pieces combined before delivery or must be delivered to different locations, such as work centres. *Also see: Batch Picking*

Zone Price The constant price of a product at all geographic locations within the zone.

Zone Skipping For shipments via the US Postal Service, depositing mail at a facility one or more zones closer to the destination. This option would benefit customers operating in close proximity to a zone border or shipping sufficient volumes to offset additional transportation costs.

Numbers

14 Points W. Edwards Deming's 14 management practices to help companies increase their quality and productivity:1. Create constancy of purpose for improving products and services,2. Adopt the new philosophy,3. Cease dependence on inspection to achieve quality,4. End the practice of awarding business on price alone; instead, minimize total cost by working with a single supplier,5. Improve constantly and forever every process for planning, production and service,6. Institute training on the job,7. Adopt and institute leadership,8. Drive out fear,9. Break down barriers between staff areas,10. Eliminate slogans, exhortations and targets for the workforce,11. Eliminate numerical quotas for the workforce and numerical goals for management,12. Remove barriers that rob people of pride of workmanship, and eliminate the annual rating or merit system,13. Institute a vigorous program of education and self-improvement for everyone and14. Put everybody in the company to work to accomplish the transformation.

24-hour Manifest Rule (24-hour Rule) U.S. Customs rule requiring carriers to submit a cargo declaration 24 h before cargo is laden aboard a vessel at a foreign port.

24/7 Referring to operations that are conducted 24 h a day, 7 days a week

24/7/365 Referring to operations that are conducted 24 h a day, 7 days a week, 365 days per year, with no breaks for holidays, etc.

3D Loading 3D loading is a method of space optimizing designed to help quickly and easily plan the best compact arrangement of any 3D rectangular object set (boxes) within one or more larger rectangular enclosures (containers). It's based on three-dimensional, most-dense packing algorithms

3PL *See Third-Party Logistics*

4PL *See Fourth-Party Logistics*

5-Point Annual Average Method frequently used in PMG studies to establish a representative average for a 1 year period.*Calculation:[12/31/98 + 3/31/98 + 6/30/99 + 9/30/99 + 12/31/99]/5*

5-S Program A program for organizing work areas. Sometimes referred to as elements, each of the five components of the program begins with the letter "S". They include sort, systemize, shine or sweep, standardize, and sustain. In the UK, the concept is converted to the 5-C program comprising five comparable components: clear out, configure, clean and check, conformity, and custom and practice.• Sort—get rid of clutter; separate out what is needed for the operations.• Systemize/Set in Order—organize the work area; make it easy to find what is needed.• Shine—clean the work area; make it shine.• Standardize—establish schedules and methods of performing the cleaning and sorting.• Sustain—implement mechanisms to sustain the gains through involvement of people, integration into the performance measurement system, discipline and recognition.The 5-S program is frequently combined with precepts of the Lean Manufacturing Initiative. Even when used separately, however, the 5-S (or 5-C) program is said to yield excellent results. Implementation of the program involves introducing each of the five elements in order, which reportedly generates multiple benefits, including product diversification, higher quality, lower costs, reliable deliveries, improved safety and higher availability rate.

80-20 Rule A term referring to the Pareto principle. The principle suggests that most effects come from relatively few causes; that is, 80% of the effects (or sales or costs) come from 20% of the possible causes (or items). *Also see: ABC Classification, Pareto.*

Further Reading Materials

Acola. (2014). *The role of science, research and technology in lifting Australian productivity*. Australian Council of learned Academies, ISBN 978-0-9875798-3-6.

Adam, N. R., Dogramaci, O., Gangopadhyay, A., & Yesha, Y. (1999). *Electronic commerce: Technical, business, and legal issues*. Upper Saddle River, NJ: Prentice-Hall.

Agan, M. F. A., & Borodin, A. (2013). Drivers of environmental processes and their impact on performance: A study of Turkish SMEs. *Journal of Cleaner Production, 51*, 23–33.

Agarwal, A., Shankar, R., & Tiwari, M. (2007). Modeling agility of supply chain. *Industrial Marketing Management, 36*(4), 443–457.

Ahmadi, H. (2005). *Supply chain management and internet* (1st ed.). Iran Industrial Training and Research Center, Yas Print.

Ahsan, K. (2013). Trend analysis of car recalls: Evidence from the US market. *International Journal of Managing Value & Supply Chains*, *4*(4), 1–16. Retrieved February 12, 2015, from http://airccse.org/journal/mvsc/papers/4413ijmvsc01.pdf

Aitken, J., & Harrison, A. (2013). Supply governance structures for reverse logistics systems. *International Journal of Operations & Production Management*, *33*(6), 745–764. Retrieved February 12, 2015, from http://www.emeraldinsight.com/doi/abs/10.1108/IJOPM-10-2011-0362

Alguire, M. S., Frear, C. R., & Metcalf, L. E. (1994). An examination of the determinants of global sourcing. *Journal of Business and Industrial Marketing, 9*(2), 62–74.

Al-Mashari, M. (2000). Implementing ERP through SAP R/3: A process change management PCS perspective. *King Saud University Journal Computer & Information Sciences Division, 14*, 25–37.

Al-Mashari, M., Al Mudimigh, A., & Zairi, M. (2001). Realizing IT value: The case of enterprise resource planning. In *Proceedings of IRMA'2001*.

Alonso-Almedia, M. D. M., Rodriguez-Anton, J. M., & Rubio-Andrada, L. (2012). Reasons for implementing certified quality systems and impacts on performance: An analysis of the hotel industry. *The Service Industries Journal, 32*(6), 919–936.

Alvarado, U. Y., & Kotzab, H. (2001). Supply chain management: The integration of logistics in marketing. *Industrial Marketing Management, 30*(2), 183–198.

Alvarez Gil, M. J., Jimenez, J. B., & Lorente, J. C. (2001). An analysis of environmental management, organizational context and performance of Spanish hotels. *Omega, 29*(6), 457–471.

Anderson, M. G. (1998). Strategic sourcing. *International Journal of Logistics Management, 9*(1), 1–13.

Anderson, J. A. (2002). Organizational design: Two lessons to learn before reorganizing. *International Journal of Organization Theory and Behavior, 5*(3–4), 343.

S. A. Rehman Khan, Z. Yu, *Strategic Supply Chain Management*, EAI/Springer Innovations in Communication and Computing,
https://doi.org/10.1007/978-3-030-15058-7

Angel del Brio, J., & Junquera, B. (2003). A review of the literature on environmental innovation management in SMEs: Implications for public policies. *Technovation, 23*(12), 939–948.

Anthony, J., Leung, K., Knowles, G., & Gosh, S. (2002). Critical success factors of TQM implementation in Hong Kong industries. *International Journal of Quality & Reliability Management, 19*(5), 551–566.

Antonette, G., Sawchuk, C., & Giunipero, L. (2002). *E-purchasing plus* (2nd ed.). New York: JGC Enterprises.

Appolloni, A., Sun, H., Jia, F., & Li, X. (2014). Green procurement in the private sector: A state of the art review between 1996 and 2013. *Journal of Cleaner Production, 84*, 122–133.

Aramyan, L. H., Oude Lansink, A. G. M., & Van der Vorst, J. G. A. J. (2007). Performance measurement in agri-food supply chains: A case study. *Supply Chain Management: An International Journal, 12*(4), 304–315.

Arnold, U. (1989). Global sourcing—An indispensable element in worldwide competition. *Management International Review, 29*(4), 20.

ASUSTek Compute Inc., (ASUS). (2005). *Social environment responsibility report*. Taipei, Taiwan

Attarsadegh, S. (2007). Container shipping in supply chain. *The 2nd conference of logistics and supply chain, trade panel papers*, Trade Researches Institution.

Auger, P., & Devinney, T. M. (2007). Do what consumers say matter: The misalignment of preferences with unconstrained ethical intentions. *Journal of Business Ethics, 76*, 361–383.

Avery, S. (2006). *GM strives for consistent metrics*. Purchasing, October 5.

Ayers, J. (2006). *Handbook of supply chain management*. Boca Raton: Auerbach Publications.

Azfar, K. R. W. (2012). Finding common ground for alignment of supply chain paradigms. In *The 6th international days of statistics and economics*, September 13–15, Prague, Czech Republic.

Baenas, J. M. H., De Castro, R., Battistelle, R. A. G., & Junior, J. A. G. (2011). A study of reverse logistics flow management in vehicle battery industries in the midwest of the state of São Paulo (Brazil). *Journal of Cleaner Production*, *19*(2), 168–172. Retrieved February 12, 2015, from http://www.sciencedirect.com/science/article/pii/S095965261000346X

Bagur-Femenias, L., LIach, J., & del Mar Alonso-Almeida, M. (2013). Is the adoption of environmental practices a strategical decision for small service companies?: An empirical approach. *Management Decision, 51*(1), 41–62.

Bai, X. M., & Hidefumi, I. (2001). Towards sustainable urban water resource management: A case study in Tianjin, China. *Sustainable Development, 9*, 24–35.

Bai, C., & Sarkis, J. (2013). Flexibility in reverse logistics: A framework and evaluation, approach. *Journal of Cleaner Production*, *47*, 306–318. Retrieved February 12, 2015, from http://www.sciencedirect.com/science/article/pii/S0959652613000103

Bai, C., Sarkis, J., Wei, X., & Koh, L. (2012). Evaluating ecological sustainable performance measures for supply chain management. *Supply Chain Management: An International Journal, 17*(1), 78–92.

Baker, S. (2003). *New consumer marketing*. Chichester: Wiley.

Baker, P. (2004). Aligning distribution center operations to supply chain strategy. *International Journal of Logistics Management, 15*(1), 111–123.

Barney, J. (2001). Resource-based theories of competitive advantage: A ten year retrospective on the resource-based view. *Journal of Management, 27*, 643–650.

Barratt, M. A., & Oliveira, A. (2001). Exploring the experiences of collaborative planning initiatives. *International Journal of Physical Distribution and Logistics Management, 31*(4), 266–289.

Barroso, A. P., & Machado, V. H. (2005). Sistemas de Gestao Logistica de Residuos em Portugal. *Investigacao Operacional, 25*, 179–194.

Barve, A., & Muduli, K. (2011). Challenges to environmental management practices in Indian mining industries. In *International conference on innovation, management and service IPEDR* (Vol. 14). Singapore: IACSIT Press.

Bauknight, D. N. (2000). The supply chain future in the e-economy. *Supply Chain Management Reviews, 4*(1), 28–55.

Baumer, D. L., & Poindexter, J. C. (2002). *Cyber law and e-commerce*. New York: McGraw-Hill.

Baumer, D. L., & Poindexter, J. C. (2004). *Legal environment of business in the information age*. New York: McGraw-Hill.

Bayle, M. (2003). *Brand Killers*, Fortune, 11 August 2003, pp. 51–56.

Beamon, B. M. (1998). Supply chain design and analysis: Models and methods. *International Journal of Production Economics, 55*(3), 281–294.

Bendorf, R. (2002, May). *Supplier pricing models* (pp. 18–19). Inside Supply Management.

Benson, R. (1998). *Benchmarking lessons in the process industries*. Manufacturing Excellence, May, Haymarket Business Publications, London.

Bhateja, A. K., Babbar, R., Singh, S., & Sachdeva, A. (2012). Study of the critical factor findings regarding evaluation of green supply chain performance of Indian scenario for manufacturing sector. *International Journal of Computational Engineering & Management, 15*(1), 74–80.

Bhatt, G. D. (2000). An empirical examination of the effects of information systems integration on business process improvement. *International Journal of Operations & Production Management, 20*(11), 1331–1359.

Bhote, K. R. (1989). *Strategic supply management: A blueprint for revitalizing the manufacturing supplier partnership* (p. 13). New York: American Management Association.

Bibby, S. (2003). *Supply chain management and regional development in Europe. Virtual environment for innovation management (VERITE)*. Wales: University of Cardiff.

Biomni. (2011). *E-procurement implementation: Building a business case*. Retrieved from www.biomni.com

Bitran, G. R., & Ferrer, J. C. (2009). On pricing and composition of bundles. *Production and Operations Management, 16*(1), 93–108.

Bjorklund, M., Martinsen, U., & Abrahamson, M. (2012). Performance management in the greening of supply chains. *Supply Chain Management: An International Journal, 17*(1), 29–39.

Bogataj, M., Bogataj, L., & Vodopivec, R. (2005). Stability of perishable goods in cold logistics chains. *International Journal of Production Economics, 93–94*(8), 345–356.

Bolanos, R., Fontela, R. E., & Pastor, P. (2005). Using interpretive structural modeling in strategic decision-making groups. *Management Decision, 43*(5/6), 877–895.

Bolstorff, P., & Rosenbaum, R. (2007). *Supply chain excellence: A handbook for dramatic improvement using the SCOR Model* (2nd ed.). New York: AMACOM.

Booth-Sweeney, L., & Sterman, J. D. (2001). Bathtub dynamics: Initial results of a systems thinking inventory. *System Dynamics Review, 16*(4), 249–286.

Borchardt, M., Poltosi, L., Sellito, M., & Pereira, G. (2009). Adopting ecodesign practices: Case study of a midsized automotive supplier. *Environmental Quality Management, 19*, 7–22.

Borchardt, M., Wendt, M., Pereira, G., & Sellito, M. (2011). Redesign of a component based on eco-design practices: Environmental impact and cost reduction achievements. *Journal of Cleaner Production, 19*, 49–57.

Botte, H., Meyer, T., & Stuchtey, M. (2009). *An energy efficiency resolution in supply chains'*. McKinsey Quarterly, August 2009.

Bowen, F. E., Cousins, P. D., Lamming, R. C., & Faruk, A. C. (2001). The role of supply management capabilities in green supply. *Production and Operations Management, 10*(2), 174–190.

Bowen, F. E., Cousins, P. D., Lamming, R. C., & Faruk, A. C. (2002). Horses for courses: Explaining the gap between the theory and practice of green supply. *Greener Management (International Issue), 35*(Autumn), 41–60.

Bowersox, D. J. (1997). Integrated supply chain management: A strategic imperative, presented at the council of logistics management. In *1997 Annual conference*, 5–8, October, Chicago, IL.

Bozarth, C., Handfield, R., & Das, A. (1998). Stages of global sourcing evolution: An empirical study. *International Journal of Physical Distribution and Logistics Management, 27*(3–4), 244–259.

Brickmann, C., & Ungerman, D. (2008). *Climate change and supply chain management*. McKinsey Quarterly, July 2008.

Brock, D. L. (2001). *The compact electronic product code: A 64-bit Representation of the electronic product code*. Auto-id center, http://www.autoidlabs.org

Brody, B. (2001). High-Tech clusters span the globe. *Business facilities*, March 2001. Available at www.facilitycity.com/busfac/bf_01_03_global.asp

Brown, M. G. (1996). *Keeping score: Using the right metrics to drive world-class performance* (pp. 15–26). New York: American Management Association.

Brun, A., Salama, K. F., & Gerosa, M. (2009). Selecting performance measurement systems: Matching a supply chain's requirements. *European Journal of Industrial Engineering, 3*(3), 336–362.

BSR (Business for Social Responsibility). (2001). *Supplier's perspectives on greening the supply chain*. A report prepared by BSR education fund, San Francisco, CA 94105-3506. www.gtf.org/file/toolmanaer/O16F15429.pdf

Buehlmann, U., Bumgardner, M., & Fluharty, T. (2009). Ban on landfilling of wooden pallets in North Carolina: An assessment of recycling and industry capacity. *Journal of Cleaner Production, 17*(2), 271–275.

Burgess, K., Singh, P. J., & Koroglu, R. (2006). Supply chain management: A structured literature review and implications for future research. *International Journal of Operations & Production Management, 26*(7), 703–729.

Burt, D. N., & Pinkerton, R. L. (1996). *A purchasing manager's guide to strategic proactive procurement*. New York: AMACOM.

Butner, K., Geuder, D., & Hittner, J. (2008). *Measuring carbon management balancing trade-offs to optimize supply chain efficiencies*. IBM Gobal Services, 2008.

Butterfield, B. (2000). Mentoring for advantage. *Purchasing, Today, 11*(3), 14.

Cachon, G., & Fisher, M. (2000). Supply chain inventory management and the value of information shared. *Management Science, 46*(8), 1032–1048.

Camp, R. C. (1989). *Benchmarking: The search for industry best practices that lead to superior performance*. Milwaukee, WI: ASQC Quality Press.

Campbell, J. F. (1994). Integer programming formulations of discrete hub location problems. *European Journal of Operational Research, 72*(2), 387–405.

Campo, I. S., & Beghin, J. C. (2006). Dairy food consumption, supply, and policy in Japan. *Food Policy, 31*(3), 228–237.

Carbon Trust. (2006). *Carbon footprints in the supply chain*. Carbon Trust, London, 2006.

Carbone, J. (1999a). Evaluation programs determine top suppliers. *Purchasing, 127*(8), 31–35.

Carbone, J. (1999b). Reinventing purchasing wins the medal for big blue. *Purchasing, 127*(4), 38–41.

Carbone, J. (2003, April 17). Strategic sourcing. *Purchasing*, 32–36.

Carter, R. (1995). The seven C's of effective supplier evaluation. *Purchasing and Supply Management*, 44–46.

Carter, C. R. (2000). Ethical issues in international buyer-supplier relationships: A dyadic examination. *Journal of Operations Management, 18*(2), 191–208.

Carter, C. R., & Easton, P. L. (2011). Sustainable supply chain management: Evolution and future directions. *International Journal of Physical Distribution and Logistics Management, 41*(1), 46–62.

Carter, P. L., Monczka, R. M., & Mosconi, T. (2005). *Strategic performance measurement for purchasing and supply*. Tempe, AZ: CAPS Research.

Carter, J. R., & Narasimham, R. (1998). *Environmental supply chain management*. Tempe, AZ: CAPS.

Carter, C., & Rogers, D. (2008). A framework of sustainable supply chain management: Moving forward new theory. *International Journal of Physical Distribution and Logistics Management, 38*, 360–387.

Carton, T. J., & Jacoby, D. J. (1997). *A review of managing quality and a primer for the certified quality manager exam*. Milwaukee, WI: ASQ Quality Press.

Cavinato, J. L. (1992). A total cost/value model for supply chain competitiveness. *Journal of Business Logistics, 13*(2), 285–301.

Cecere, L. (2005). So you want to outsource manufacturing. *Supply Chain Management. Review, 9*(6), 13–14.
Center for Advanced Purchasing Studies. (1999). *ISO 14000: Assessing its impact on corporate effectiveness and efficiencies*. Tempe, AZ: National Association of Purchasing Management.
Center for Advanced Purchasing Studies. (2000a). *ISO 14000: Assessing its impact on corporate effectiveness and efficiency*. Tempe, AZ: CAPS.
Center for Advanced Purchasing Studies. (2000b). *Purchasing contribution to the socially responsible supply chain*. Tempe, AZ: CAPS.
Chan, F. (2003). Performance measurement in a supply chain. *The International Journal of Advanced Manufacturing Technology, 21*(7), 534–548.
Chan, W. W. (2005). Partial analysis of the environmental costs generated by hotels in Hong Kong. *Tourism Management, 24*, 517–531.
Chan, F. T., Chan, H. K., & Jain, V. (2012). A framework of reverse logistics for the automobile industry. *International Journal of Production Research*, *50*(5), 1318–1331. Retrieved February 12, 2015, from http://www.tandfonline.com/doi/abs/10.1080/00207543.2011.571929
Chan, W. W., & Lam, J. C. (2003). Energy-saving supporting tourism sustainability: A case study of hotel swimming pool heat pumps. *Journal of Sustainable Tourism, 11*(1), 74–83.
Chan, R. Y. K., & Lau, L. B. Y. (2001). Explaining green purchasing behavior: A cross-cultural study on American and Chinese consumers. *Journal of International Consumer Marketing, 14*(2/3), 9–41.
Chandra, C., & Grabis, J. (2007). *Supply chain configuration. Concepts solutions and applications*. New York: Springer.
Chandra, K., & Kumar, S. (2000). Supply chain management in theory and practice: A passing fad or a fundamental change? *Industrial Management & Data System, 100*(3), 100–113.
Chaneski, W. S. (2010). Planning your resources wisely. *Modern Machine Shop, 89*(09), 30–32.
Chang, I.-C., Hwang, H.-G., Liaw, H.-C., Huang, M.-C., Chen, S.-L., & Yen, D. C. (2008). A neural network evaluation model for ERP performance from SCM perspective to enhance enterprise competitive advantage, Expert Systems with Applications. *Supply Chain Management An International Journal, 35*(4), 1809–1816.
Chen, Y. (2008). The driver of green innovation and green image—Green core competence. *Journal of Business Ethics, 81*, 531–543.
Chen, F., Drezner, Z., Ryan, J. K., & Simchi-Levy, D. (1999). *Quantifying the bullwhip effect in a supply chain: The impact of forecasting, lead-times information*. Northwestern University.
Chen, C. F., & Kao, Y. L. (2010). Relationships between process quality, outcome quality, satisfaction and behavioural intentions for online travel agencies—Evidence from Taiwan. *The Service Industries Journal, 30*(12), 2081–2092.
Chen, I. J., & Paulraj, A. (2004). Towards a theory of supply chain management: The constructs and measurements. *Journal of Operations Management, 22*(2), 119–150.
Cheng, J. H., Yeh, C. H., & Tu, C. W. (2008). Trust and knowledge sharing in green supply chains-moderating by relational benefits and guanxi. *Transportation Research Part E: Logistics and Transportation Review, 47*(6), 837–849.
Cheung, K. I., & Lee, H. L. (2002). The inventory benefit of shipment coordination and stock rebalancing in a supply chain. *Management Science, 48*(2), 300–306.
Chien, M. K., & Shih, L. H. (2007). An empirical study of the implementation of green supply chain management practices in the electrical and electronic industry and their relation to organizational performance. *International Journal of Environmental Sciences, 4*(3), 383–394.
Childerhouse, P., & Towill, D. (2000). Engineering supply chains to match customer requirements. *Logistics Information Management, 13*(5), 337–345.
Childhouse, P., & Towill, D. R. (2003). Simplified material flow holds the key to supply chain integration. *Omega, 31*(1), 17–27.
Chin, W. W., Marcolin, B. L., & Newsted, P. R. (2003). A partial least squares latent variable modeling approach for measuring interaction effects. Results from a Monte Carlo simulation study and an electronic-mail emotion/adoption study. *Information Systems Research, 14*(2), 189–217.

Chiou, T. Y., Chan, H. K., Lettice, F., & Chung, S. H. (2011). The influence of green the suppliers and green innovation on environmental performance and competitive advantage in Taiwan. *Transportation Research Part E, 47*, 822–836.

Cho, J., & Kang, B. (2001). Benefits and challenges of global sourcing: Perceptions of U.S. apparel retail firms. *International Marketing Review, 18*(5), 542–561.

Choi, T. Y., & Hartley, J. L. (1996). An exploration of supplier selection practices across the supply chain. *Journal of Operations Management, 14*, 333–343.

Choi, T. Y., & Hong, Y. (2002). Unveiling the structure of supply networks: Case studies in Honda, Acura and DaimlerChrysler. *Journal of Operations Management, 20*, 469–493.

Choi, T. Y., & Krause, D. R. (2006). The Supply base and its complexity: Implications for transaction costs, risks, responsiveness, and innovation. *Journal of Operations Management, 24*, 637–652.

Chopra, S., & Meindl, P. (2004). *Supply chain management: Strategy, planning and operation*. New Jersey: Prentice Hall.

Chopra, S., & Meindl, P. (2010). *Supply chain management: Strategy, planning, and operation* (4th ed.). Upper Saddle River, NJ: Pearson Education.

Chow, W., Madu, C., Kuei, C., Lu, M., Lin, C., & Tseng, H. (2006). Supply chain management in the U.S. and Taiwan: An empirical study. *Omega*. Available online May 05, 2006.

Christmann, P. (2000). Effects of best practices of environmental management on cost advantage: The role of complementary assets. *Academy of Management Journal, 43*(4), 663–680.

Christmann, P., & Taylor, G. (2001). Globalization and the environment: Determinants of firm self-regulation in China. *Journal of International Business Studies, 32*(3), 439–458.

Christopher, M. (2000). The agile supply chain: Competing in volatile markets. *Industrial Marketing Management, 29*, 37–44.

Christopher, M., Payne, A., & Ballantyne, D. (2002). *Relationship marketing: Creating stakeholder value*. Oxford: Butterworth-Heinemann.

Christopher, M., & Peck, H. (2003). *Marketing logistics* (2nd ed.). Oxford: Butterworth Heinemann.

Christopher, M., & Peck, H. (2004). Building the resilient supply chain. *The International Journal of Logistics Management, 13*(4), 283–295.

Christopher, M., & Towill, D. (2001). An integrated model for the design of agile supply chain. *International Journal of Physical Distribution and Logistics Management, 31*(4), 2001.

Churchill, G. A. (1979). A paradigm for developing better measures of marketing constructs. *Journal of Marketing Studies, 16*, 12–27.

Cigolini, R., Cozzi, M., & Perona, M. (2004). A new framework for supply chain management: Conceptual model and empirical test. *International Journal of Operations and Production Management, 24*(1), 7–14.

Clapp, D., McCandless, M. E., & Khan, K. (2001). The world's most competitive locations. *Business Facilities*. Available at www.facilitycity.com/busfac/bf_01_09_cover.asp

Clark, K. B., & Fujimoto, T. (1991). *Product development performance: Strategy, organization and management in the world of auto industry*. Boston: Harvard Business School.

Cochran, J. K., & Ramanujam, B. (2006). Carrier-mode logistics optimization of inbound supply chains for electronic manufacturing. *International Journal of Production Economics, 103*(2), 826–840.

Cognizant white paper. (2008). Creating a green supply chain-information technology as an enabler for a green supply chain. *Cognizant passion for building stronger business report*. www.cognizant .com/InsightsWhitepapers/GSM.pdf

Colby, E. (1995). The real green issue: Debunking the myths of environmental management. *The McKinsey Quarterly, 2*, 132–143.

Columbus, L. (2007). Quality partnerships with your customers. *Quality Digest, 27*(8), 44–48.

Cooke, J. A. (1996). The check in the computer. *Logistic Management, 32*(12), 49–52.

Cooper, R., & Kaplan, R. (1988, September–October). Measure costs right: Make the right decisions. *Harvard Business Review*, *66*, 23–28.

Cooper, M. C., Lambert, D. M., & Pagh, J. D. (1997). Supply chain management: More than a new name for logistics. *The International Journal of Logistics Management, 8*(1), 1–14.

Corbett, C. J., & Klassen, R. D. (2006). Extending the horizons: Environmental excellence as key to improving operations, manufacturing and service operations management. *Journal for Operations Management, 8*, 5–22.

Cordano, M., Marshall, R. S., & Silverman, M. (2010). How do small and medium enterprises go green? A study of environmental management programs in the U.S. wind industry. *Journal of Business Ethics, 92*, 463–478.

Corsten, D., & Gruen, T. (2004, May). Stock-outs cause walkouts'. *Harvard Business Review, 82*, 26–28.

Corsten, D., & Kumar, N. (2005). Do suppliers benefit from collaborative relationships with large retailers? An empirical investigation of efficient consumer response adoption. *Journal of Marketing, 69*(3), 80–94.

Coulomb, D. (2008). Refrigeration and cold chain serving the global food industry and creating a better future: Two key IIR challenges for improved health and environment. *Trend in Food Science and Technology, 19*(8), 413–417.

Council of Logistics Management. (2000). *What it's all about*. Oak Brook: CLM.

Cousins, P. D., Lawson, B., & Squire, B. (2006a). An empirical taxonomy of purchasing functions. *International Journal of Operations and Production Management, 26*(7), 775–794.

Cousins, P., Lawson, B., & Squire, B. (2006b). Supply chain management: The emergence of an academic discipline? *International Journal of Operations and Production Management, 26*(7), 697–702.

Cox, A., & Chicksand, D. (2005). The limits of lean management thinking: Multiple retailers and food and farming supply chain. *European Management Journal, 23*(6), 648–662.

Craighead, C. W., Blackhurst, J., Rungtusanatham, M. J., & Handfield, R. B. (2007). The severity of supply chain disruptions: Design characteristics and mitigation capabilities. *Decision Sciences, 38*(1), 131–156.

Cramer, J. (1996). Experiences with implementing integrated chain management in Dutch industry. *Business Strategy & the Environment, 5*, 38–47.

Croom, S. (2001). Restructuring supply chains through information channel innovation. *International Journal of Operations and Production Management, 21*(4), 504–515.

Croom, S. R., & Johnston, R. (2003). E-service: Enhancing internal customer service through e-procurement. *International Journal of Service Industry Management, 14*(5), 539–555.

Croom, S., Romano, P., & Giannakis, M. (2000). Supply chain management: An analytical framework for critical literature review. *European Journal of Purchasing and Supply Management, 6*(1), 67–83.

Croson, R., & Donohue, K. (2003). Impact of post data sharing on supply chain management: An experimental study. *Production and Operations Management, 12*(1), 1–11.

Cumbo, D., Kline, D., & Bumgardner, M. M. (2006). Benchmarking performance measurement and lean manufacturing in the rough mill. *Forest Products Journal, 56*(6), 25–30.

Curkovic, S. (2003). Environmentally responsible manufacturing: The development and validation of a measurement model. *European Journal of Operational Research, 146*, 130–155.

Curkovic, S., Vickery, S., & Droge, C. (2000). Quality-related action programs: Their impact on quality performance and firm performance. *Decision Sciences, 31*, 885–905.

Curry, A., & Moore, C. (2003). Assessing information culture—An exploratory model. *International Journal of Information Management, 23*, 91–110.

Curt, B. (2007). The ERP edge. *Multichannel Merchant, 3*(7), 60–54.

Cutler, F. (2005). *Marketing management, analysis, planning, implementation, and control*, translated by Foruzande, Bahamn (2nd ed.). Rangarang Publication.

D'Avanzo, R., et al. (2003). The link between supply chain and financial performance. *Supply Chain Management Review, 27*(6), 40–47.

Dasgupta, T. (2003). Using the six-sigma metric to improve the performance of a supply chain. *Total Quality Management and Business Excellence, 14*(3), 355–366.

Davenport, T. H., & Harris, J. G. (2007). *Competing on analytics: The new science of winning*. Boston: Harvard Business School Press.
Davis, K. (1998). Cash forwarding expands business for university medical products. *Business Credit, 100*(2), 10–12.
Dawes, J. (2008). Do data characteristics change according to the number of scale points used? An experiment using 5-point, 7-point and 10-point scales. *International Journal of Market Research, 50*(1), 61–77.
De Crombrugghe, A., & Le Coq, G. (2003). *Guide to supplier development: For programmes to be implemented by industrial subcontracting and partnership exchanges (SPXs)*. Vienna: United Nations Industrial Development Organization.
De Toni, A., & Nassimbeni, G. (2000). Just-in-time purchasing: An empirical study of operational practices, supplier development and performance. *Omega, 28*(6), 631–651.
Degreve, Z., & Roodhooft, F. (1999). Effectively selecting suppliers using total cost of ownership. *Journal of Supply Chain Management, 35*(1), 5.
Dejonckheere, J., Disney, S. M., Lambrecht, M. R., & Towill, D. R. (2004). The impact of information enrichment on the bullwhip effect in supply chains: A control engineering perspective. *European Journal of Operational Research, 153*(3), 727–746.
Delfmann, W., Albers, S., & Gehring, M. (2002). The impact of electronic commerce on logistics service providers. *International Journal of Physical Distribution and Logistics Management, 32*(3), 203–222.
Deloitte Consulting. (2000). *Success file*. Deloitte Consulting.
Demirel, E., Demirel, N., & Gökçen, H. (2014). A mixed integer linear programming model to optimize reverse logistics activities of end-of-life vehicles in Turkey. *Journal of Cleaner Production*. Retrieved February 12, 2015, from http://www.sciencedirect.com/science/article/pii/S0959652614011226
Denscombe, M. (2000). *The good research guide for small-scale social research projects*. Buckingham: Open University Press.
Department of Environment–DOE. (2010). *Department of environment annual report*. Number of waste pollution sources by manufacturing industry.
Department of Trade and Industry. (1991). *Environment: A challenge for business*. London: Department of Trade and Industry.
Desai, M. P. (1996). Implementing a supplier Scorecard program. *Quality Progress, 29*(2), 73–76.
Deutsch, N., Dravavolgyi, T., & Rideg, A. (2013). Note on the development of sustainable supply chain strategy. *Chemical Engineering Transactions, 35*, 655–660.
Devellis, R. F. (2003). *Scale development, theory and application* (2nd ed.). Thousand Oaks, CA: Sage.
Dey, A., Laguardia, P., & Srinivasan, M. (2011). Building sustainability in logistics operations: A research agenda. *Management Research Review, 34*(11), 1237–1259.
Diabat, A., & Govindan, K. (2011). An analysis of the drivers affecting the implementation of green supply chain management. *Resources, Conservation and Recycling, 55*(6), 659–667.
Digalwar, A. K., & Metri, B. A. (2004). Performance measurement framework for world class manufacturing. *International Journal of Applied Management and Technology, 3*(2), 83–101.
Dodgson, M. (2000). *Management of technology*. London: Routledge.
Dong Qian, L. (2000). Research into the third party logistics based on supply chain management. *China Soft Science, 10*, 34–37.
Downs, A. (1973). Up and down with ecology: The issue-attention cycle. In J. Bain (Ed.), *Environmental decay: Economic causes and remedies, little*. Boston, MA: Brown and Company.
Duarte, S, Cabrita, R., & Machado, V. C. (2011). Exploring lean and green supply chain performance using balanced scorecard perspective. *Proceedings of the 2011 international conference on industrial engineering and operations management* (pp. 520–526), Jan 22–24.
Duber-Smith, D. (2005). The green imperative. *Soap, Perfumery, and Cosmetics, 78*(8), 24–26.

Dubey, R., Bag, S., Ali, S. S., & Venkatesh, V. G. (2013). Green purchasing is key to superior performance: An empirical study. *International Journal of Procurement Management, 6*(2), 187–210.

Dubois, A. (2003). Strategic cost management across boundaries of firms. *Industrial Marketing Management*.

Duerden, J. (1995). Walking the walk on global ethics. *Directors and Boards, 19*(3), 42–45.

Duncan, W. L. (1995). *Total quality: Key terms and concepts*. New York: AMACOM.

Dunn, S. C., & Young, R. R. (2004). Supplier assistance within supplier development initiatives. *Journal of Supply Chain Management, 40*(3), 19–29.

Dutta, A., & Roy, R. (2012). *System dynamics*. OR/MS Today, June, The Institute for Operations Research and the Management Sciences.

Dwyer, R. F., Schurr, P. H., & Oh, S. (1987). Developing buyer-seller relationships. *Journal of Marketing, 51*, 11–25.

Dyllick, T., & Hockerts, K. (2002). Beyond the business case for corporate sustainability. *Business Strategy and the Environmental, 11*(2), 130–141.

Eadie, R., Perera, S., & Heaney, G. (2010). Identification of e-procurement drivers and barriers for UK construction organizations and ranking of these from the perspective of quantity surveyors. *Journal of Information Technology in Construction*, ITcom Vol. 15, ISSN 1874-4753.

Eccles, R. G. (1991). The performance measurement manifesto. *Harvard Business Review*, January–February, 131–137.

Eeloy, V., Ganesan, S., Fukuda, Y., Wu, J., & Pecht, M. G. (2005). Are you ready for lead-free electronics? *IEEE Transactions on Components and Packaging Technology, 99*, 1–11.

Elkington, J. (1997). *Cannibals with Forks: The triple bottom line for 21st century business*. Oxford: Capstone Publishing.

Ellram, L. M. (1991a). A managerial guideline for the development and implementation of purchasing partnerships. *International Journal of Purchasing and Materials Management, 27*(3), 2–9.

Ellram, L. M. (1991b). Supply chain management: The industrial organization perspective. *International Journal of Physical Distribution and Logistics Management, 21*, 13–22.

Ellram, L. (1993). *Total cost of ownership*. Tempe, AZ: Center for Advanced Purchasing Studies.

Ellram, L. (1996). A structured method for applying purchasing cost management tools. *International Journal of Purchasing and Materials Management, 32*(1), 11–19.

Ellram, L. (2002). Supply management's involvement in the target costing process. *European Journal of Purchasing and Supply Management, 8*(4), 235–244.

Ellram, L. M., & Carr, A. (1994). Strategic purchasing: A history and review of the literature. *International Journal of Purchasing and Materials Management, 30*(2), 10–20.

Ellram, L. M., & Cooper, M. C. (1990). Supply chain management, partnership, and the shipper—Third party relationship. *The International Journal of Logistic Management, 1*(2), 1–10.

Eltayeb, T. K., & Zailani, S. (2009). Going green through green supply chain initiatives towards environmental sustainability. *Operational Supply Chain Management, 2*, 93–110.

Eltayeb, T. K., & Zailani, S. H. M. (2011). Greening supply chain through supply chain initiatives towards environmental sustainability. *International Journal of Environmental Science and Technology, 2*(5), 506–516.

ENDS. (1994). *Public concern for the environment rides the recession*. ENDS Report 232, May.

Environmental Information Centre (EIC). (2005). Available at http://www.cleantechindia.com/. EPA. Indian.

EPA. United States Environmental Protection Agency. (2000). *The lean and green supply chain*. A practical guide for materials managers and supply chain managers to reduce costs and improve environmental performance (pp. 12–13), Washington, DC.

Evans, H., & Johnson, J. (2005). 10 steps towards RoHS directive compliance. *Circuits Assembly, 16*(2), 68–70.

Evans, J. R., & Lindsay, W. M. (2008). *Managing for quality and performance excellence* (7th ed.). Mason, OH: South-Western.

Eylon, D., & Allison, S. T. (2002). The paradox of ambiguous information in collaborative and competitive settings. *Group and Organization Management, 27*(2), 172–208.
Faith-El, C., Balfors, B., & Folkeson, L. (2006). The application of environmental requirements in Swedish road maintenance contracts. *Journal of Cleaner Production, 14*, 163–171.
Farmer, D. (1978). Developing purchasing strategies. *Journal of Purchasing and Materials Management, 14*, 6–11.
Farmer, D., & van Amstel, R. (1991). *Effective pipeline management*. Aldershot: Gower.
Farris, T., II, & Hutchison, P. P. (2002). Cash-to-cash: The new supply chain management metric. *International Journal of Physical Distribution & Logistics Management, 32*(3/4), 288–298.
Faruk, A. C., Lamming, R. C., Cousins, P. D., & Bowen, F. E. (2002). Analyzing, mapping and managing environmental impacts along the supply chain. *Journal of Industrial Ecology Review, 5*(2), 13–36.
Fawcett, S. E., & Fawcett, S. A. (1995). The firm as a value-added system: Integrating logistics, operations, and purchasing. *International Journal of Physical Distribution and Logistics Management, 25*(3), 24–42.
Fawcett, S. E., & Magnan, G. M. (2002). The rhetoric and reality of supply chain integration. *International Journal of Physical Distribution and Logistics Management, 32*(5), 339–361.
Fawcett, S. E., Osterhaus, P., Magnan, G., Brau, J. C., & Mc Carter, M. W. (2007). Information sharing and supply chain performance: The role of connectivity and willingness. *Journal of Supply Chain Management, 12*(5), 358–368.
Fearon, H. (1965). The purchasing function within 19th century railroad organization. *Journal of Purchasing*, 1–7.
Fearon, H., & Leenders, M. (1996). *Purchasing organizational roles and responsibilities*. Tempe, AZ: Center for Advanced Purchasing Studies.
Ferdows, K. (1997, March–April). Making the most of foreign factories. *Harvard Business Review*, 73–78.
Ferguson, M. E., & Toktay, L. B. (2006). The effect of competition on recovery strategies. *Production and Operations Management, 15*(3), 351–368.
Fernandez, R. R. (1995). *Total quality in purchasing and supplier management*. Delray Beach, FL: St. Lucie Press.
Fernie, J., & Staine, H. (2001). Towards an understanding of European grocery supply chains. *Journal of Retailing and Consumer Services, 8*(1), 29–36.
Ferretti, I., Zanoni, S., Zavanella, L., & Diana, A. (2007). Greening the aluminium supply chain. *International Journal of Production Economics, 108*, 236–245.
Ferrir, B., & Plank, R. E. (2002). Total cost of ownership models: An exploration study. *Journal of Supply Chain Management, 38*(3), 18–12.
Fiala, P. (2005). Information sharing in supply chains. *Omega, 33*, 419–423.
Field, A. M. (2007). Stretching the limits of ERP. *The Journal of Commerce, 8*, 76–78.
Field, J., & Sroufe, R. (2007). The use of recycled materials in manufacturing: Implications for supply chain management. *International Journal of Production Research, 45*(18–19), 4439–4463.
Fish, L. A., & Forrest, W. C. (2007). A world look at RFID. *Supply Chain Management Review, 11*(03), 48–55.
Fitzgerald, K. R. (1995). For superb supplier development, Honda wins! *Purchasing, 21*, 32.
Flammer, G. (2013). Corporate social responsibility and shareholder reaction: The environmental awareness of investors. *Academy of Management Journal, 56*(3), 758–781.
Fleischmann, H. R., Krikke, M., Dekker, R., & Flapper, S. D. P. (2000). A characterization of logistics policies in European bottling and packaging firms. *International Journal of Production Economics, 88*(1), 95–104.
Fleischmann, B., Meyr, H., & Wagner, M. (2002). Advanced planning. In H. Stadtler & C. Kilger (Eds.), *Supply chain management and advanced planning concepts, models, software and case studies* (pp. 71–96). Berlin: Springer.

Fleishmann, B., & Meyr, H. (2003). Planning hierarchy, modeling and advanced planning systems. In A. de Kok & S. Graves (Eds.), *Supply chain management: Design, coordination, operation. Handbooks in operations research and management science* (pp. 457–523).

Flint, D. J., Larsson, E., & Gammelgaard, B. (2008). Exploring processes for customer value insights, supply chain learning and innovation: An International Study. *Journal of Business Logistics, 29*(1), 257.

Florida, R., & Davison, D. (2001). Gaining from green management: Environmental management systems inside and outside the factory. *California Management Review, 43*(3), 63–68.

Fogarty, D. W., Blackstone, J. H., & Hoffmann, T. R. (1991). *Production and inventory management* (2nd ed.). Cincinnati: South-Western.

Font, X., Tapper, R., Schwartz, K., & Kornilaki, M. (2008). Sustainable supply chain management in tourism. *Business Strategy and the Environment, 17*(4), 260–271.

Forker, L. B., & Janson, R. L. (1990). Ethical practices in purchasing. *Journal of Purchasing and Materials Management, 26*(1), 19–26.

Forker, L. B., Ruch, W. A., & Hershauer, J. C. (1999). Examining supplier improvement efforts from both sides. *Journal of Supply Chain Management, 35*(3), 40–50.

Forrest, W. (2006). McDonald's applies SRM strategy to global technology buy. *Purchasing, 135*(12), 16–17.

Forrester, J. W. (1959). Advertising: A problem in industrial dynamics. *Harvard Business Review*, *37*(2).

Forsber, J., & Towers, N. (2007). Creating agile supply networks in the fashion industry; A pilot study of the European textile and clothing industry. *The Journal of the Textile Institute, 98*(4), 377–386.

Fortes, J. (2009). Green supply chain management: A literature review. *Otago Management Graduate Review, 7*(1), 51–62.

Foster, S. T. (2007). *Managing quality: Integrating the supply chain* (3rd ed.). Upper Saddle River, NJ: Pearson.

Fraering, M., & Prasad, S. (1999). International sourcing and logistics: An integrated model. *Logistics Information Management, 12*(6), 451.

Freires, F. G. M., & Guedes, A. P. S. (2008). Power and trust in reverse logistics systems for scrap-tires and its impact on performance. *Journal of Operations and Supply Chain Management, 1*(1), 57–65.

Friedman, T. (2005). *The world is flat*. Allen Lane, UK.

Friedman, T. L. (2006). *The world is flat: A brief history of the twenty first century*. London: Penguin Books.

Friedman, D. (2008). Inventory management that counts. *Electrical Wholesaling, 89*(09), 59–60.

Fritzsche, D. J., & Oz, E. (2007). Personal values' influence on the ethical dimension of decision making. *Journal of Business Ethics, 75*(4), 335–343.

Fuentes-Fuentes, M. M., Albacete-Saez, C. A., & Liorens-Montes, F. J. (2004). The impact of environmental characteristics on TQM principles and organizational performance. *International Journal of Management Science, 32*, 425–442.

Galt, M. J. D. A., & Dale, B. G. (1991). Supplier development: A British case study. *International Journal of Purchasing and Materials Management, 27*, 16–22.

Gao, Y., Li, J., & Song, Y. (2009). Performance evaluation of green supply chain management based on membership conversion algorithm. In *Proceeding: IEEE international colloquium on computing, communication, control and management*.

Garcia, V., Pongracz, E., Phillips, P., & Kiski, R. (2008). Factors affecting resource use optimization of the chemical industry in the Northern Ostrobothnia Region of Finland. *Journal of Cleaner Production, 16*(18), 1987–1994.

Gartner Group. (1999). C-commerce: The new arena for business applications. *Business Wire*, 16.

Garvin, D. A. (1988). *Managing quality: The strategic and competitive edge*. New York: Free Press.

Gavirneni, S. (2002). Information flow in capacitated supply chains with fixed ordering costs. *Management Science, 48*(5), 644–651.

Gavirneni, S., Kapuscinski, R., & Tayur, S. (1997). The bullwhip effect in supply chains. *Sloan Management Review, 38*(3), 93–102.
Geffen, C. A., & Rothenberg, S. (2000a). Suppliers and environmental innovation: The automotive paint process. *International Journal of Operations and Production Management, 20*(2), 166–186.
Geffen, C., & Rothenberg, S. (2000b). Sustainable development across firm boundaries: The critical role of suppliers in environmental innovation. *International Journal of Operations and Production Management, 20*(2), 166–186.
GEMI (Global Environmental Management Initiative). (2001). *New paths to business value*. Washington DC: GEMI.
GEMI (Global Environmental Management Initiative). (2004). *Environment: Value to the top line*. Available www.gemi.org
Geng, Y., & Cote, R. (2002). Scavengers and decomposers. *International Journal of Sustainable Development & World Ecology, 9*(4), 333–340.
Geng, Y., & Cote, R. (2003). Environmental management systems at the industrial park level in China. *Environmental Management, 31*(6), 784–794.
Geyer, R., & Jackson, T. (2004). Supply loops and their constraints: The industrial ecology of recycling and reuse. *California Management Review, 46*(2), 55–73.
Giannakis, M. (2007). Performance measurement of supplier's relationships. *Supply Chain Management an International Journal, 12*(6), 400–411.
Gil, L. A., Kwon, K. N., Good, L. K., & Johnson, L. W. (2012). Impact on self on attitudes toward luxury brands among teens. *Journal of Business Research, 65*, 1425–1433.
Gilbert, S. (2001). *Greening supply chain: Enhancing competitiveness through green productivity* (pp. 1–6). Tapei, Taiwan.
Gill, P., & Abend, J. (1997). Wal-Mart: The supply chain heavyweight champ. *Supply Chain Management Review, 1*(1), 8–16.
Gimenez, C., & Sierra, V. (2013). Sustainable supply chains: Government mechanisms to greening suppliers. *Journal of Business Ethics, 116*(1), 189–203.
Giovanni, P. (2011). Environmental collaboration in a closed-loop supply chain with a reverse revenue sharing contract? *International Journal of Operations and Production Management, 32*(3), 265–290.
Giunipero, L. C. (1990). Motivating and monitoring JIT supplier performance. *Journal of Purchasing and Materials Management, 26*, 19–24.
Giunipero, L., & Brand, R. R. (1996). Purchasing role in supply chain management. *The International Journal of Logistics Management, 7*(1), 29–38.
Giunipero, L., & Carter, C. R. (2006). International supply relationships and non-financial performance: A comparison of U.S. and Germany practices. *Journal of Operations Management, 24*, 653–675.
Giunipero, L., Handfield, R., Tantawy, E. I., & R. (2006). Supply management's evolution: Key skill set for the purchaser of the future. *International Journal of Production and Operations Management, 26*(7), 822–844.
Global Location Trends—Annual Report. (2009). *IBM Global Business Service*. ftp://public.dhe.ibm.com/common/ssi/sa/wh/n/gbl03009usen/GBL03009USEN.PDF
Gold, S., Hahn, R., & Seuring, S. (2013). Sustainable supply chain management in base of the pyramid food projects: A path to triple bottom line approaches for multinationals? *International Business Review, 22*, 784–799.
Goldsby, T., Griffis, S., & Roath, A. (2006). Modeling lean, agile and leagile supply chain strategies. *Journal of Business Logistics, 27*(1), 57–80.
Gonzalez, P., Sarkis, J., & Adenso-Diaz, B. (2008). Environmental management system certification and its influence on corporate practices: Evidence from the automotive industry. *International Journal of Operations and Production Management, 28*(11), 1021–1041.
Gonzalez-Benito, J. (2007). A theory of purchasing contribution to business performance. *Journal of Operations Management, 25*(4), 901–917.

Gopalakrishnan, K., Yusuf, Y., Musa, A., Abubakar, T., & Ambursa, H. (2012). Sustainable supply chain management: A case study of British Aerospace (BAe) systems. *International Journal of Production Economics, 140*, 193–203.

Gore, A. (2006). *An inconvenient truth*. London: Bloomsbury.

Gottberg, A., Morris, J., Pollard, S., Mark-Herbert, C., & Cook, M. (2006). Producer responsibility, waste minimization and the WEEE directive: Case studies in eco-design from the European lighting sector. *Science of the Total Environment, 359*(1/3), 38–56.

Gottfredson, M., Puryear, R., & Phillips, S. (2005). Strategic sourcing: From periphery to the core. *Harvard Business Review, 83*(2), 132–139.

Gould, R. A., Arter, D. R., Ball-Brown, P., Creinin, D., Howe Garriz, L., Schoenfelt, T. I., & Van Arsdale, T. (2006). Quality management. In J. L. Cavinato, A. E. Flynn, & R. G. Kauffman (Eds.), *The supply management handbook* (pp. 565–586). New York: McGraw-Hill.

Govindan, K., Kaliyan, M., Kannan, D., & Haq, A. (2014). Barriers analysis for green supply chain management implementation in Indian industries using analytic hierarchy process. *International Journal of Production Economics, 147*, 555–568.

Grabara, J., Man, M., & Kolcun, M. (2014). The benefits of reverse logistics. *International letters of social and humanistic sciences, 15*, 138–147.

Grant, R. (2002). *Contemporary strategy analysis: Concepts, techniques, applications*. Massachusetts: Blackwell.

Green Business Network. (2011). *Going green… Upstream—The promise of supplier environmental management*. Washington DC: The National Environmental Education and Training Foundation (NEETF).

Green Industry Project. (2014). *Green industry manual: The guideline for green industry promotion and development* (pp. 1–58). Thailand: Bangkok.

Green, K. W., Jr., & Inman, R. A. (2005). Using a just-in-time selling strategy to strengthen supply chain linkages. *International Journal of Production Research, 43*(16), 3437–3453.

Green, K. W., Jr., Medlin, B., & Whitten, D. (2004). Developing optimism to improve performance: An approach for the manufacturing sector. *Industrial Management and Data Systems, 104*(2), 106–114.

Green, K. W., Jr., Zelbst, P. J., Meacham, J., & Bhadauria, V. S. (2012). Green supply chain management practices: Impact on performance. *Supply Chain Management: An International Journal, 17*(3), 290–305.

Greenhalgh, C., & Rogers, M. (2010). *Innovation, intellectual property, and economic growth*. Princeton, NJ: Princeton University Press.

Greenwood, M. (2001). The importance of stakeholders according to business leaders. *Business and Society Review, 106*(1), 29–49.

Grier, P. (1999). An economic vision: Silicon states. *Christian Science Monitor, 91*(61), 1.

Grubisic, I. (2014). ERP in Clouds or Still Below. *Journal of Systems and Information Technology, 16*(1), 62–76. https://doi.org/10.1108/JSIT-05-2013-0016.

Gualandris, J., & Kalchschmidt, M. (2014). Customer pressure and innovativeness: Their role in sustainable supply chain management. *Journal of Purchasing & Supply Management, 20*, 92–103.

Gunasekaran, P., Patel, C., & Tirtiroglu, E. (2001). Performance measures and metrics in a supply chain environment. *International Journal of Operations & Production Management, 21*(1/2), 71–87.

Gunnasekaran, A., Patel, C., & McGaughey, R. (2004). Performance measures and metrics in a supply chain environment. *International Journal of Operations & Production Management, 21*(1/2), 71–87.

Guo, L., Ma, Y., Sun, D., & Wang, P. (2007). Effects of controlled freezing-point storage at 0°C on quality of green bean as compared with cold and room-temperature storages. *Journal of Food Engineering, 86*(1), 25–29.

Gupta, A. (2000). Enterprise resource planning: The emerging organizational value systems. *Industrial Management & Data System, 100*(3), 114–118.

Gupta, V., Abidi, N., Bansal, T., & Jain, R. K. (2013). Green supply chain management initiatives by IT companies in India. *The IUP Journal of Operations Management, XII*(2), 6–24.
Gurumurthy, A., & Kodali, R. (2009). Application of benchmarking for assessing the lean manufacturing implementation. *Benchmarking: An International Journal, 16*(2), 274–308.
Gustin, C. M., Daugherty, P. J., & Ellinger, A. E. (1997). Supplier selection decisions in systems/software purchases. *Journal of Supply Chain Management, 33*(4), 41–46.
Hahn, C. K., Watts, C. A., & Kim, K. Y. (1990). The supplier development program: A conceptual model. *International Journal of Purchasing and Materials Management, 26*, 2–7.
Haimes, Y. Y. (2006). On the definition of vulnerabilities in measuring risks to infrastructures. *Risk Analysis, 26*(2), 293–296.
Hair, J. F., Jr., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2007). *Multivariate data analysis* (6th ed.). New Delhi: Pearson Education.
Hair, J. F., Jr., Black, W. C., Babin, B., Anderson, R., & Tatham, R. (2005). *Multivariate data analysis*. Upper Saddle River, NJ: Prentice-Hall.
Hall, J. (2000). Environmental supply chain dynamics. *Journal of Cleaner Production, 8*, 455–471.
Hall, J. (2001). Environmental supply chain innovation. *Greener Management International, 35*, 105–119.
Hall, J., Matos, S., & Silvestre, B. (2012). Understanding why firms should invest in sustainable supply chains: A complexity approach. *International Journal of Production Research, 50*(5), 1332–1348.
Handfield, R. (2006a). *Best practices in the procure to pay cycle*. Practix.
Handfield, R. (2006b). *Supplier market intelligence*. Boca Raton, FL: Auerbach Publications.
Handfield, R., & Baumer, D. (2006). Conflict of interest in purchasing management. *Journal of Supply Chain Management, 42*(3), 41–50.
Handfield, R. B., & Bechtel, C. (2002). The role of trust and relationship structure in improving supply chain responsiveness. *Industrial Marketing Management, 3*(31), 367–382.
Handfield, R., & Edwards, S. (2006). Minority supplier development: We are not there yet. *Inside Supply Management, 17*(5), 20–21.
Handfield, R., Elkin, D., Blackhurst, J., & Craighead, C. (2005). 18 ways to guard against disruption. *Supply Chain Management Review, 9*(1), 46–53.
Handfield, R., & Krause, D. (1999). Think globally, source locally. *Supply Chain Management Review, 3*, 36–49.
Handfield, R. B., Krause, D. R., Scannell, R. V., & Monczka, R. M. (2000). Avoid the pitfalls in supplier development. *Sloan Management Review, 41*(2), 37–49.
Handfield, R., & McCormack, K. (2005). What you need to know about sourcing in China. *Supply Chain Management Review, 9*(5), 56–62.
Handfield, R., & Onitsuka, M. (1995). *Process and supply chain management evolution in the American cotton textile industry*. St. Andrew's University Economic and Business Review.
Handfield, R., Sroufe, R., & Walton, S. (2005). Integrating environmental management and supply chain strategies. *Business Strategy and the Environment, 14*(1), 1–19.
Handfield, R., Walton, S., & Sroufe, R. (2002). Applying environmental criteria to supplier assessment: A study of the application of the analytical hierarchy process. *European Journal of Operational Research, 141*, 70–87.
Hanna, M. D., Newman, W. R., & Johnson, P. (2000). Linking operational and environmental improvement through employee involvement. *International Journal of Operations & Production Management, 20*(2), 148–165.
Hansbeck, Hanns-Christian, Director Enterprise Applications. (2004). *Process management and RFID: Implications and considerations for process management*. GlobeRanger, White Paper.
Harland, C. M., Lamming, R. C., & Cousins, P. D. (1999). Developing the concept of supply strategy. *International Journal of Operations and Production Management, 19*(7), 650–673.
Harmon, H. A., Brown, G., Widing, R. E., II, & Hammond, K. L. (2002). Exploring the sales manager's feedback to a failed sales effort. *Journal of Business & Industrial Marketing, 17*, 43–55.

Harrison, K., quoted in Birchall, J. and Rigby, E. (2008). *Oil price forces LPG to rethink its distribution*. Financial Times, 27 June 2008.

Hartley, J., & Choi, T. (1996, July–August). Supplier development: Customers as a catalyst of process change. *Business Horizons*, *39*(4), 37–44.

Hartley, J., & Jones, G. (1997). Process oriented supplier development: Building the capability for change. *International Journal of Purchasing and Materials Management, 33*(3), 24–29.

Hasnelly, S. (2012). Factors determining green companies performance in Indonesia: A conceptual model. *Procedia-Social and Behavioral Sciences, 57*, 518–523.

Hassini, E., Surti, C., & Searcy, C. (2012). A literature review and a case study of sustainable supply chains with a focus on metrics. *International Journal of Production Economics, 140*(1), 69–82.

Healy, M., & Perry, C. (2000). Comprehensive criteria to judge validity and reliability of qualitative research within the realism paradigm. *Qualitative Market Research: An International Journal, 3*(3), 118–126.

Hedstorm, G., & McLean, R. (1993). *Six imperatives for excellence in environmental management*. New York: PRISM: Arthur D. Little.

Helmuth, C. A., Craighead, C. W., Connelly, B. L., Collier, D. Y., & Hanna, J. B. (2015). Supply chain management research: Key elements of study design and statistical testing. *Journal of Operations Management, 36*, 178–186.

Henderson, B. D. (1975). The coming revolution in purchasing. *Journal of Purchasing and Materials Management, 11*(2, Summer), 44–50.

Herani, A., Helms, M., & Sarkis, J. (2005). Performance measurement for green supply chain. *Benchmarking: An International Journal, 12*, 330–353.

Herbert, W. Davis & Company. (2005). *Survey of U.S. logistics costs*. www.establishinc.corn

Hervani, A. A., Helms, M. M., & Sarkis, J. (2005). Performance measurement for green supply chain management. *Benchmarking: An International Journal*, *12*(4), 330–353. http://www.kmu.unisg.ch/rencontres/band2002/F_09_Schaper.pdf

Hewitt, F. (1994). Supply chain redesign. *The International Journal of Logistics Management, 5*(2), 1–9.

Heyes, A. (2000). Implementing environmental regulation: Enforcement and compliance. *Journal of Regulatory Economics, 17*(2), 107–129.

Hill, J. A. (1975). The purchasing revolution. *Journal of Purchasing Management, 11*(Summer), 18–19.

Hill, C. A., & Scudder, G. D. (2002). The use of electronic data interchange for supply chain coordination in the food industry. *Journal of Operations Management, 20*(4), 375–387.

Hindle, E., White, P. R., & Minion, K. (1993). Achieving real environmental improvements value impact assessment. *Long Range Planning, 26*(3), 36–48.

Hoejmose, S. U., & Adrien-Kirby, A. J. (2012). Socially and environmentally responsible procurement: A literature review and future research agenda of a managerial issue in the 21st century. *Journal of Purchasing and Supply Chain Management, 18*(4), 232–242.

Hoffman, A. J. (2000). *Competitive environmental strategy a guide to the changing business landscape*. Washington, DC: Island Press.

Hoffman, W. (2007). Who's carbon-free? Wal-Mart takes on supply chains of products as expensive carbon measuring plan eyes distribution. *Traffic World, 271*(42), 15.

Hoffman, W. (2008). Wave of the future: Changes in technology. Industry consolidation, global standards begin to raise RFID's profile. *Journal of Commerce, 09*(35), 44.

Hoffman, M., Cheung, B., & Peterson, D. *A framework to measure and improve your virtual prototyping process*. MSC Software, at http://www.mscsoftware.com

Holliday, C. O., Schmidheing, S., & Watts, P. (2002). *Walking the talk: The business case for sustainable development*. San Francisco: Bennett-Koehler.

Hollos, D., Blome, C., & Foerstl, K. (2012). Does sustainable supplier cooperation affect performance? Examining implications for the triple bottom line. *International Journal of Production Research, 50*(11), 2968–2986.

Holmstrom, J., Framling, K., Kaipia, R., & Saranen, J. (2002). Collaborative planning forecasting and replenishment: New solutions needed for mass collaboration. *Supply Chain Management, 7*(3/4), 136–145.

Holt, D., & Ghobadian, A. (2009). An empirical study of green supply chain management practices amongst UK manufacturers. *Journal of Manufacturing Technology Management, 20*(7), 933–956.

Holweg, M. (2007). The genealogy of lean production. *Journal of Operations Management, 25*(3), 420–437.

Hong, P., Kwon, H., & Roh, J. (2009). Implementation of strategic green orientation in supply chain: An empirical study of manufacturing firm. *European Journal of Innovation Management, 12*(4), 512–532.

Hoover, W. E., Eloranta, E., Holmstrom, J., & Huttunen, K. (2001). *Managing the demand-supply chain-value innovations for customer satisfaction*. New York: Wiley.

Hosseini, A. (2007). Identification of green management of system's factors: A conceptualized model. *International Journal of Management Science and Engineering Management, 2*(3), 221–228.

Houlihan, J. B. (1985). International supply chain management. *International Journal of Physical Distribution and Materials Management, 15*, 22–38.

Hoyt, J., & Huq, F. (2000). From arms length to collaborative relationships in the supply chain: An evolutionary process. *International Journal of Physical Distribution and Logistics Management, 30*(9), 750–764.

Hsu, C. W., & Hu, A. H. (2008a). Green supply chain management in the electronic industry. *International Journal of Environmental Science and Technology, 5*(2), 205–216.

Hsu, C. W., & Hu, A. H. (2008b). Pro-environmental concern influencing green buying: A study on Indian consumers. *International Journal of Business and Management, 6*(6), 124–133.

Hu, A. H., & Hsu, C.-W. (2010). Critical factors for implementing green supply chain management practice. *Management Research Review, 33*(6), 586–608.

Huang, Z., & Gangopadhyay, A. (2004). A simulation study of supply chain management to measure the impact of information sharing. *Information Resources Management Journal, 17*(3), 20–31.

Hugo, A., & Pistikopoulos, E. (2005). Environmentally conscious long-range planning and design of supply chain networks. *Journal of Cleaner Production, 13*, 1471–1491.

Hui, I. K., Chan, A. H. S., & Pun, K. F. (2001). A study of the environmental management system implementation practices. *Journal of Cleaner Production, 9*, 269–276.

Humphreys, P. K., Li, W. L., & Chan, L. Y. (2004). The impact of supplier development on buyer-supplier performance. *Omega: The International Journal of Management Science, 32*(2), 131–143.

Irby, J. (2003). Supply chain challenges: Building relationships. *Harvard Business Review, 81*(07), 65–73.

Ireland, J. (1998). Purchasing policies and procedures. *Supply Management*, May 21.

Ishikawa, K. (translated by David J. Lu) (1985). *What is total quality control?* The Japanese Way, Englewood Cliffs, NJ: Prentice Hall.

iThink. High performance Systems Inc., Hanover, NH 03755, http://www.hps-inc.com

Jackson, W. (2004). *New tool demonstrates hacks against RFID tags*. Government Computer News, July 29.

Johnson, P. F., Klassen, R. D., Leenders, M. R., & Fearon, H. E. (2002). Determinants of purchasing team usage in the supply chain. *Journal of Operations Management, 20*(1), 77–89.

Johnson, P. F., Leenders, M., & Fearon, H. (2006). Supply's growing status and influence. *Journal of Supply Chain Management, 42*, 38–48.

Johnston, R. G., & Warner, J. S. (2005). *The Dr. Who Conundrum*. Security Management, ASIS International, September.

Jones, T. C., & Riley, D. W. (1985). Using inventory for competitive advantage through supply chain management. *International Journal of Physical Distribution and Materials Management, 15*, 16–26.
Jutras, C. (2006). *The ERP in manufacturing benchmark report*. Aberdeen Group, Inc., 1–31.
Kabachinski, J. (2005, March/April). An introduction to RFID. *Biomedical Instrumentation and Technology*, *39*(2), 131–134.
Kaplan, R. S., & Norton, D. P. (1992). The balanced scorecard—Measures that drive performance. *Harvard Business Review*, January–February, 71–79.
Kaplan, R. S., & Norton, D. P. (1996). *The balanced scorecard*. Cambridge, MA: Harvard Business School Press.
Karimi, A., & Rahim, K. A. (2015). Classification of external stakeholders pressures in green supply chain management. *Procedia Environmental Sciences, 30*, 27–32.
Kelly, C. (2010). *Analytics drives strategic sourcing*. APICS Best Practices, www.apics.org
Kerr, J. (2006). The changing complexion of supplier diversity. *Supply Chain Management Review, 10*(2), 38–45.
Khalil Kalantari, S. (2003). *Data processing and analysis social-economic researches in Tehran* (1st ed.).
Khan, S. A. R, Dong, Q., & Zhang, Y. (2015a, December). Classification of important and critical factors in enterprise resource planning. *Life Science Journal, Zhengzhou University*, *12*.
Khan, S. A. R, Dong, Q., & Zhang, Y. (2015b, December). Analysis and Usage: Cloud computing technology in the supply chain management. *Life Science Journal, Zhengzhou University*, *12*.
Khan, R. W. A., Khan, N., & Chaudhary, M. A. (2011). Green supply chain management-Global opportunities and challenges: A case study. *Business Innovation and Technology Management (APBITM), IEEE International Summer Conference of Asia Pacific*, 5–9.
Khan, S. A. R., Zaman, K., & Zhang, Y. (2016). The relationship between energy-resource depletion, climate change, health resources and the environmental Kuznets curve: Evidence from the panel of selected developed countries. *Renewable and Sustainable Energy Reviews, 62*, 468–477.
Khan, S. A. R., & Zhang, Y. (2016). Logistics forecasting method based on a hybrid quantum particle swarm optimization and RBF neural network model. *RISTI-Revista Iberica de Sistemas e Tecnologies de Informacao, 16*(18), 317–325.
Khiewnavawongsa. (2011). *Barriers to green supply chain implementation in the electronics industry*. Ph.D. dissertation, Faculty of the Graduate College, Purdue University, West Lafayette, Indiana.
Kim, S. (2010). *Implementation of green supply chain management: Impact on performance outcomes in small and medium-sized Electrical and Electronic firms*. Ph.D. Dissertation, Faculty of the Graduate College, University of Nebraska, Lincoln, Nebraska.
Kotabe, M. (1994). Global sourcing strategy: R&D, manufacturing, and marketing interfaces. *Journal of Global Marketing, 7*(3), 157.
Kotler, P., & Bloom, P. N. (1984). *Marketing professional services*. New Jersey: Prentice Hall.
Krause, D. R. (1997). Supplier development: Current practices and outcomes. *International Journal of Purchasing and Materials Management, 33*(2), 12–19.
Krause, D. R., & Ellram, L. M. (1997a). Critical elements of supplier development: The buying firm perspective. *European Journal of Purchasing and Supply Management, 3*(1), 21–31.
Krause, D. R., & Ellram, L. M. (1997b). Success factors in supplier development. *International Journal of Physical Distribution and Logistics Management, 27*(1), 39–52.
Krause, D. R., Handfield, R. B., & Tyler, B. B. (2007). The relationship between supplier development, commitment, social capital accumulation and performance improvement. *Journal of Operations Management, 25*(2), 528–545.
Krause, D. R., & Scannell, T. V. (2002). Supplier development practices: Product and service based industry comparisons. *Journal of Supply Chain Management, 38*(2), 13–22.
Kumar, D., & Rahman, Z. (2015). Sustainability adoption through buyer supplier relationship across supply chain: A literature review and conceptual framework. *International Strategic Review, 3*, 110–127.

LaLonde, B. J., & Zinszer, P. H. (1976). *Customer service: Managing and measurement*. National Councile of Physical Distribution Management, Chicago.

Lamm, D. V., & Vose, L. C. (1988). Seller pricing strategies: A buyer's perspective. *International Journal of Purchasing and Materials Management, 24*(3), 9–13.

Lamming, R. C., Cousins, P. D., & Notman, D. (1996). Beyond vendor assessment: Relationship assessment programme. *European Journal of Purchasing and Supply Management, 2*(4), 173–181.

Lamming, R. C., Faruk, A. C., & Cousins, P. D. (1999). Environmental soundness: A pragmatic alternative to expectations of sustainable development in business strategy. *Business Strategy and the Environment, 8*(3), 177–188.

Larson, P. D. (2002). What is SCM? And where is it? *Journal of Supply Chain Management, 38*(4), 36–44.

Law, A. M., & Kelton, W. D. (2001). *Simulation modeling and analysis* (3rd ed.). New York: McGraw-Hill International Editions.

Lee, S., & Klassen, R. D. (2008). Drivers and enablers that foster environmental management capabilities in small-and medium-sized suppliers in supply chains. *Production and Operations Management, 17*, 573–586.

Lee, V.-H., Ooi, K.-B., Chong, A. Y.-L., & Seow, C. (2014). Creating technological innovation via green supply chain management: An empirical analysis. *Expert Systems with Applications, 41*, 6983–6994.

Lee, H., & Whang, W. (1998). *Information sharing in a supply chain*. Research Paper No. 1549, Stanford University.

Leenders, M. R., & Johnson, P. F. (2000). *Major structural changes in supply organizations*. Tempe, AZ: Center for Advanced Purchasing Studies.

Leenders, M. R., & Johnson, P. F. (2002). *Major changes in supply chain responsibilities*. Tempe, AZ: Center for Advanced Purchasing Studies.

Li, Y. (2014). Environmental innovation practices and performance moderating effect of resource commitment. *Journal of Cleaner Production, 66*, 450–458.

Li, W.-L., Humphreys, P., Chan, L. Y., & Kumaraswamy, M. (2003). Predicting purchasing performance: The role of supplier development programs. *Journal of Materials Processing Technology, 38*(1–3), 243–249.

Liker, J. K., & Choi, T. Y. (2004). Building deep supplier relationships. *Harvard Business Review, 83*(1), 104–113.

Lin, C.-T., Chen, C.-B., & Ting, Y.-C. (2012). A green purchasing model by using ANP and LP methods. *Journal of Testing and Evaluation, 40*, 1049.

Lings, I. N. (2000). Internal marketing and supply chain management. *The Journal of Services Marketing, 14*(1), 27–29.

Lintukangas, K., Hallikas, J., & Kahkonen, A.-k. (2015). The role of Green supply management in the Development of sustainable supply chain. *Corporate Social Responsibility and Environmental Management, 22*(10), 321–333.

Lockamy, A., III, & Smith, W. I. (2000). Target costing for supply chain management: Criteria and selection. *Industrial Management and Data Systems, 100*(5), 210–218.

Lowe, D. (2005). *The transport manager's and operator's handbook*. London: Kogan Page.

Luthra, S., Garg, D., & Haleem, A. (2014). Greening supply chain management implementation and performance—A literature review and some issues. *Journal of Advances in Management Research, 11*(1), 20–46.

Luthra, S., Kumar, V., Kumar, S., & Haleem, A. (2011). Barriers to implement green supply chain management in automobile industry using interpretive structural modelling technique—an Indian perspective. *Journal of Industrial Engineering and Management, 4*(2), 231–257.

Luthra, S., Manju, K. S., & Haleem, A. (2010). Suggested implementation of the green supply chain management in automobile industry of India: A review. *Proceedings of National Conference on Advancements and Futuristic Trends of Mechanical and Industrial Engineering, GITM, Bilaspur (India), 12*(13), 114–125.

Lyle Ginsburg. (2003). *The impact of electronic product code (EPC)/Radio frequency identification (RFID) on chain pharmacy operations*. Pharmacy and Technology Conference, National Association of China Drug Stores, Philadelphia, Pennsylvania, August 23–27, 2003 at http://meetings.nacds.org/rxconference/2003/presentations/Tues_Impactof EPC_Ginsburg.Pdf

Maass, R., Brown, J. Q., & Bossert, J. L. (1999). *Supplier certification: A continuous improvement Strategy*. Milwaukee, WI: ASQ Quality Press.

Maignan, I. (2002). Managing socially-responsible buying: How to integrate non-economic criteria into the purchasing process. *European Management Journal, 20*(6), 641–648.

Malkin, E. (2002). *Manufacturing jobs are exiting Mexico*. New York Times, November 5, 2002, 1.

Mallot, J. (2002). Quality of life: How to know it when you see it. *Business Facilities*, November 2002. Available at www.facilitycity.com/busfac/bf_02_11_cover2.Asp

Martinson, B. (2002). The power of the P-card. *Strategic Finance, 83*(8), 30–36.

Maslennikova, I., & Foley, D. (2000). Xerox's approach to sustainability. *Interfaces, 30*(3), 2000.

Masoumik, S. M., Abdul-Rashid, S. H., Olugu, E. U., & Ghazilla, R. A. R. (2014). Sustainable supply chain design: A configurational approach. *The Scientific World Journal, 2014*, 1–16.

McDonough, E. F. (2000). An investigation of factors contributing to the success of cross-functional teams. *Journal of Product Innovation Management, 17*(3), 221.

McGinnis, M. A., & Lalonde, B. J. (1983, March/April). The physical distribution manager and strategic planning. *Managerial Planning*, *31*(5).

Mentzer, J. T. (2001). *Supply chain management* (pp. 306–319). Thousand Oaks, CA: Sage.

Merrill, P. (1997). *Do it right the second time: Benchmarking best practices in the quality change process*. Portland, OR: Productivity Press.

Minahan, T. (1998). Purchasing needs to do more than measure. *Purchasing, 124*(1), 59–61.

Mitra, S. (2005a). An algorithm for the generalized vehicle routing problem with backhauling. *Asia-Pacific Journal of Operational Research, 22*, 153–169.

Mitra, S. (2005b). The introduction of environmental requirements for trucks and construction vehicles used in road maintenance contracts in Sweden. *Corporate Social Responsibility and Environmental Management, 12*(10), 62–72.

Moden, Y. (1983). *The Toyota production*. Productivity Press.

Monczka, R., & Trecha, S. (1988). Cost-based supplier performance evaluation. *International Journal of Purchasing and Materials Management, 45*, 12–18.

Monczka, R., & Trent, R. J. (1991). Evolving sourcing strategies for the 1990s. *International Journal of Physical Distribution and Logistics Management, 21*(5), 4–12.

Monczka, R., & Trent, R. J. (1995). *Supply management and sourcing strategy: Trends and implications*. Tempe, AZ: Center for Advanced Supply Management Studies.

Moore, J. F., & Curry, S. R. (1996). The death of competition. *Fortune*, 15 April, pp. 144.

Murray, J. Y. (2001). Strategic alliance-based global sourcing strategy for competitive advantage: A conceptual framework and research propositions. *Journal of International Marketing, 9*(4), 30–58.

Murray, J. E. (2003). When you get what you bargained for—But do not. *Purchasing, 132*(4), 26–27.

Myerson, J. M. (2002). Enterprise project failures and solutions. In *Information management: Strategy, systems and technologies* (p. 2002). Boca Raton, FL: CRC.

Myerson, J. (2003). Web services: A supplement to enterprise application integration. In *Information management: Strategy, systems and technologies*. Boca Raton, FL: Auerbach.

Narsimhan, S., McLeavey, D. W., & Billington, P. (1995). *Production planning and inventory control* (2nd ed.). Saddle River, NJ: Prentice Hall.

National Association of Purchasing Management. (1995). *Ethics policy statements for purchasing, supply and material management: Examples of policies and procedures*. Tempe, AZ: National Association of Purchasing Management.

Neal, B. (1994, December). Springing the distribution credit trap. *Credit Management*, 31–35.

Neef, D. (2001). *E-procurement: From strategy to implementation*. Saddle River, NJ: Prentice Hall.

Nellore, R., & Motwani, J. (1999). Procurement commodity structures: Issues, lessons and contributions. *European Journal of Purchasing and Supply Management, 5*, 157–166.
Nelson, D., Mayo, R., & Moody, P. E. (1998). *Powered by Honda: Developing excellence in the global enterprise*. New York: Wiley.
Nelson, D., Moody, P. E., & Stegner, J. R. (2005). *The incredible payback: Innovation solutions that deliver extraordinary results*. New York: AMACOM.
New, S. J., & Westbrook, R. (Eds.). (2004). *Understanding supply chains: Concepts, critiques and futures*. Oxford: Oxford University Press.
Newman, R. G. (1988). Insuring quality: Purchasing role. *International Journal of Purchasing and Materials Management, 24*(3), 14–21.
Newman, R., & McKeller, J. R. (1995). Target pricing: A challenge for purchasing. *International Journal of Purchasing and Materials Management, 31*(3), 12–20.
Nix, N. W., Lusch, R. F., Zacharia, Z. G., & Bridges, W. (2007, October 27–28). The hand that feeds you: What makes some collaborations with suppliers succeed, when so many fail? *Wall Street Journal*, R8.
Normann, R. (2005). *Service management system* (3rd ed.). New York: Wiley.
North America Free Trade Agreement (NAFTA)—Office of the United States trade representative available www.ustr.gov/trade-agreements/free-trade-agreements/north-american-free-trade-agreement-nafta
O'Marah, K., & Hofman, D. (2009). Top 25 supply chains. *Supply Chain Management Review*, October 2009.
OECD. (2002). *Corporate social responsibility: Partners for progress*. Washington, DC: The Brookings Institute.
Oliver, R. K., & Webber, M. D. (1982). *Supply chain management: Logistics catches up with strategy*. Outlook, Booz, Allen & Hamilton; reprinted in Christopher, M., Logistics: The Strategic Issues, Chapman & Hall, 1992.
Orr, B. (1996). EDI: Banker's ticket to electronic commerce. *ABA Banking Journal, 88*(5), 64–70.
Palmer, R. J., Gupta, M., & Davila, A. (2003). Transforming the procure-to-pay process: How fortune 500 corporations use purchasing cards. *Management Accounting Quarterly, 4*(4), 14–22.
Pande, P. S., Neuman, R. P., & Cavanaugh, R. R. (2000). *The six sigma way: How GE, Motorola, and other top companies are honing their performance*. New York: McGraw-Hill.
Patterson, J. L., & Nelson, J. D. (1999). OEM cycle time reduction through supplier development. *Practix: Best Practices in Purchasing and Supply Chain Management, 2*(3), 1–5.
Perotti, S., Zorzini, M., Cagno, E., & Micheli, G. J. L. (2012). Green supply chain practices and company performance: The case of 3PLs in Italy. *International Journal of Physical Distribution & Logistics Management, 42*(7), 640–672.
Perumalla, K. S. (2007). Model execution. In P. A. Fishwick (Ed.), *Handbook of dynamic system modeling*. Boca Raton: Chapman and Hall/CRC.
Petersen, K. J., Frayer, D. J., & Scannel, T. V. (2006). An empirical investigation of global sourcing strategy effectiveness. *Journal of Supply Chain Management, 36*(2), 29–38.
Pidd, M. (2003). *Tools for thinking. Modeling in Management Science*. Chichester: Wiley.
Poirier, C. C. (1999). *Advanced supply chain management*. San Francisco: Berret-Koehler Publisher.
Poorpongsakorn, N. (2005). *An analysis study of marketing management system of freshed fruits and processed fruits in the East of Thailand*. Research Report, Thailand Development Research Institute.
Porter, M. E. (1980). *Competitive strategy*. New York: The Free Press.
Porter, M. E. (1985). *Competitive advantage: Creating and sustaining superior performance*. New York: Free Press.
Porter, M. (1998, November–December). Clusters and the new economics of competition. *Harvard Business Review*, 77–90.
Porter, M., & van der Linde, C. (1995, September–October). Green and competitive: Ending the stalemate. *Harvard Business Review*, 120–134.

Prokopets, L., & Tabibzadeh, R. (2006). *Supplier relationship management: Maximizing the value of your supply base*. Stamford, CT: Archstone Consulting.
Przirembel, J. L. (1997). *How to conduct supplier surveys and audits*. West Palm Beach, FL: PT Publications.
Quayle, M. (2002). Purchasing policy in Switzerland: An empirical study of sourcing decisions. *Thunderbird International Business Review, 44*(2), 205–236.
Quesada, G., Bailey, C., & Woodfin, B. (2011). An analysis of drivers and barriers to innovation in green supply chain. *Practices in Mexico*.
Quinn, J. B. (1999). Strategic outsourcing: Leveraging knowledge capabilities. *Sloan Management Review, 40*(4), 9–21.
Raghunathan, S. (1999). Interorganizational collaborative forecasting and replenishment systems and supply chain implications. *Decision Sciences, 30*(4), 1053–1071.
Rebitzer, G., Ekvall, T., Frischknecht, R., Hunkeler, D., Norris, G., Rydberg, T., Schmidt, W. P., Suh, S., Weidema, B. P., & Pennington, D. W. (2004). Life cycle assessment part 1: Framework, goal and scope definition, Inventory analysis, and applications. *Environment International, 30*(5), 701–720.
Reck, R. F., & Long, B. G. (1988). Purchasing: A competitive weapon. *Journal of Purchasing and Materials Management, 24*(3), 2–8.
Reichheld, F. A. (1994). Loyalty and the renaissance of marketing. *Marketing Management, 2*(4), 10–21.
Reid, D. R. (2002). Purchaser and supplier quality. *Quality Progress, 35*(8), 81–85.
Rexha, N., & Miyamoto, T. (2000). International Sourcing: An Australian perspective. *Journal of Supply Chain Management, 36*(1), 27–34.
Rice, J. B., & Hoppe, R. M. (2001). SC vs. SC: The hype and the reality. *Supply Chain Management Review, 5*(5), 46–54.
Roberto, M. (2007). ERP enters age of infrastructure. *Manufacturing Business Technology, 25*(7), 24–25.
Robitaille, D. (2007). *Managing supplier-related processes*. Chico, CA: Paton Professional.
Rogers, P. A. (2005). Optimising supplier management and why co-dependency equals mutual success. *Journal of Facilities Management, 4*(1), 40–50.
Rostamzadeh, R., Govindan, K., Esmaeili, A., & Sabaghi, M. (2015). Application of fuzzy VIKOR for evaluation of green supply chain management practices. *Ecological Indicators, 49*, 188–203.
Roy, R., & Wheelan, R. (1992). Successful recycling through value chain collaboration. *Long Range Planning, 25*(4), 62–71.
Rozemeijer, F. A., Van Weele, A., & Weggeman, M. (2003). Creating corporate advantage through purchasing: Toward a contingency model. *Journal of Supply Chain Management, 39*(1), 4–13.
Saaty, T. (1980). *The analytic hierarchy process: Planning, priority setting. Resource Allocation*. New York: McGraw-Hill.
SAB Miller and World Wildlife Fund. (2009). *Water footprinting: Identifying and addressing water risks in the value chain*. London: SAB Miller.
Sabri, E., Gupta, A., & Beitler, M. (2006). *Purchase order management best practices: Process, technology, and change management*. J. Ross Publishing.
Sabzehali, R. (2009). *Study of relation between organizational learning and financial performance by innovation process in industrial companies of Golpayegan*. MA thesis, Islamic Azad University, Arak Branch.
Safizadeh, H. M., Ritzman, L. P., Sharma, D., & Wood, C. (1996). An empirical analysis of the product-process mix. *Management Science, 42*(11), 1576–1591.
Sage, A. P. (1977). *Interpretive structural modeling: Methodology for large-sale systems* (pp. 91–164). New York: McGraw-Hill.
Sahin, F., & Robinson, E. P. (2002). Flow coordination and information sharing in supply chains: Review, implications and directions for future research. *Decision Sciences, 33*(4), 504–536.
Sain, F., & Robinson, E. P. (2005). Information sharing and coordination in make-to-order supply chains. *Journal of Operations Management, 23*, 579–598.

Sako, M. (2004). Supplier development at Honda, Nissan and Toyota: Comparative case studies of organizational capability enhancement. *Industrial and Corporate Change, 13*(2), 281–308.

Salman, A. Z., & Al-Karablieh, E. (2004). Measuring the willingness of farmers to pay for groundwater in the highland areas of Jordan. *Agricultural Water Management, 68*(1), 61–76.

Samaddar, S., & Kaul, T. (1995). Effects of setup and processing time reductions on WIP in the JIT production systems. *Management Science, 41*(7), 1263–1265.

Samson, D., & Terziovski, M. (1999). The relationship between total quality management practices and operational performance. *Journal of Operations Management, 17*, 393–409.

Sanchez-Rodriguez, C., Hemsworth, D., & Martinez-Lorente, A. R. (2005). The effect of supplier development initiatives on purchasing performance: A structural model. *Supply Chain Management, 10*(3–4), 289–301.

Sarkar, A., & Mohapatra, P. K. J. (2006). Evaluation of supplier capability and performance: A method for supply base reduction. *Journal of Purchasing and Supply Management, 12*, 148–163.

Sarkis, J. (1995a). Manufacturing strategy and environmental consciousness. *Technovation, z15*(2), 79–97.

Sarkis, J. (1995b). Supply chain management and environmentally conscious design and manufacturing. *International Journal of Environmentally Conscious Design an Manufacturing, 4*(2), 43–52.

Sarkis, J. (1998). Theory and methodology evaluating environmentally conscious business practices. *European Journal of Operational Research, 107*, 159–174.

Sarkis, J. (2001a). *Greening supply chain management*. GMI 35 Autumn, Greenleaf Publishing.

Sarkis, J. (2001b). Manufacturing's role in corporate environmental sustainability: Concerns for the new millennium. *International Journal of Operations & Production Management, 21*(5/6), 666–685.

Sarkis, J. (2002). A strategic decision framework for green supply chain management. *Journal of Cleaner Production, 11*, 397–409.

Sarkis, J. (2003). A strategic decision making framework for green supply chain management. *Journal of Cleaner Production, 11*(4), 397–409.

Sarkis, J. (2005). Performance measurement for green supply chain management. *Benchmarking: An International Journal, 12*(4), 330–353.

Sarkis, J. (2006). *Greening the supply chain*, Chapter 11. Springer, London, pp. 189–204.

Sarkis, J., & Kitazawa, S. (2000). The relationship between ISO 14001 and continuous source reduction programs. *International Journal of Operations and Production Economics, 140*, 116–128.

Sarkis, J., & Tamarkin, M. (2005). Real options analysis for green trading: The case of greenhouse gases. *The Engineering Economist, 50*, 273–294.

Sarkis, J., & Zhu, Q. (2004). Relationship between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises. *Journal of Operations Management, 22*(3), 265–289.

Sarode, A. D., & Bhaskarwar, V. S. (2011). Development and evaluation of performance measure for the environmental management in Indian industries. *Industrial Engineering Journal, 2*(26), 31–34.

Sarode, A. D., & Sunnapwar, V. K. (2010). Improving effectiveness of supply chain by selecting appropriate suppliers: An analytic hierarchy process approach. *Journal of Advanced Manufacturing Systems, 9*, 129–144.

Sason, D., & Terziovski, M. (1999). The relationship between total quality management practices and operational performance. *Journal of Operations Management, 17*(4), 393–409.

Scannel, T. V., Vickery, S. K., & Droge, C. L. (2000). Upstream supply chain management and competitive performance in the automotive supply industry. *Journal of Business Logistics, 21*, 23–48.

Schaltegger, S., & Burritt, R. L. (2000). *Contemporary environmental accounting: Issues, concepts and practice*. Sheffield: Greenleaf Publishing.

Schmidheiny, S. (1992). *Changing course: A global business perspective on development and the environment*. Cambridge, MA: MIT Press.
Schonberger, R. J. (1990). *Building a chain of customers*. The Free Press.
Schorr, J. (1998). *Purchasing in the 21st century*. New York: Wiley.
Schot, J., & Fischer, K. (1993). Introduction: The greening of the industrial firm. In K. Fischer & J. Schot (Eds.), *Environmental strategies for industry* (pp. 3–36). Washington, DC: Island Press.
Schroer, B. (2004). Simulation as a tool in understanding the concepts of lean manufacturing. *Simulation, 80*(3), 171–175.
Schuler, D. A., & Cording, M. (2006). A corporate social performance-Corporate financial performance behavioral model for consumers. *Academy of Management, 31*, 540–558.
Schulze, W. S. (1994). The two schools of thought in resource-based theory: Definitions and implications for research. In P. Shrivastava, A. S. Huff, & J. E. Dutton (Eds.), *Resource-based views of the firm*. Greenwich, CT: JAI Press.
Schumacker, R. E., & Lomax, R. G. (1996). *A beginner's guide to structural equation modelling*. New Jersey: Lawrence Erlbaum Associates.
Schwartz Ephraim. (2004). *Oracle unveils next round of RFID solutions*. Infoworld, March 29, 2004.
Scott, W. R. (1987). *Organization: Rational, natural and open systems* (2nd ed.). Englewood Cliffs, NJ: Prentice-Hall International.
Scott, J. E., & Vessey, I. (2002). Managing risks in enterprise system implementation. *Communications of the ACM, 45*(4), 77–81.
Scott, C., & Westbrook, R. (1991). New strategic tools for supply chain management. *International Journal of Physical Distribution and Logistics Management, 21*(1), 23–33.
Sellito, M., Borchardt, M., Pereira, G., & Gomes, L. (2012). Environmental performance assessment of a provider of logistical services in an industrial supply chain. *Theoretical Foundations of Chemical Engineering, 46*, 691–703.
Sellitto, M., Borchardt, M., & Pereira, G. (2010). Modeling for environmental performance in manufacture operations. *Gestao and Producao*, *17*, 1–14 (in Portuguese).
Sellitto, M., Borchardt, M., Pereira, G., & Gomes, L. (2011). Environmental performance assessment in transportation and warehousing operations by means of categorical indicators and multicriteria preference. *Chemical Engineering Transactions, 25*, 291–296.
Sellitto, M., Borchardt, M., Pereira, G., & Sauer, M. (2013). Perception of users on the environmental impact caused by public transport operation. *Chemical Engineering Transactions, 35*, 793–798.
Sellitto, M., Borchardt, M., Pereira, G., & Silva, R. (2013). Greening the supply chain: A model for green performance assessment. *Proceedings of the 22nd international conference on production research*, Foz do lgussu, Brazil.
Seman, N. A. A., Zakun, N., Jusoh, A., & Arif, M. A. (2012). Green supply chain management: A review and research direction. *International Journal of Managing Values and Supply Chain, 3*(1), 1–18.
Seuring, S. A. (2003). Outsourcing into service factories: An exploratory analysis of facility operators in the German chemical industry. *International Journal of Operations and Production Management, 23*(10), 1207–1223.
Seuring, S. (2004). Integrated chain management and supply chain management comparative analysis and illustrative cases. *Journal of Cleaner Production, 12*, 1059–1071.
Seuring, S., & Muller, M. (2008). From a literature review to a conceptual framework for sustainable supply chain management. *Journal of Cleaner Production, 16*(15), 1699–1710.
Shah, J. (2001). Fedex's hub of supply chain activity—At its own operation, the logistics company has made an art out of the science of supply chain management. *EBN*, April 30, 01.
Shah, R., Goldstein, S. M., & Ward, P. T. (2002). Aligning supply chain management characteristics and interorganizational information system types: An exploratory study. *IEEE Transactions on Engineering Management, 49*(3), 282–292.

Shah, R., & Ward, P. (2003). Lean manufacturing: Context, practice bundles and performance. *Journal of Operations Management, 21*, 129–149.

Shang, K. C., Lu, C. S., & Li, S. (2010). A taxonomy of green supply chain management capability among electronics-related manufacturing firms in Taiwan. *Journal of Environmental Management, 91*, 1218–1226.

Shank, J. K. (1999). Case study: Target costing as a strategic tool. *Sloan Management Review, 41*(1), 73–83.

Shank, J., & Govindarajan, V. (1993). *Strategic cost management: The new tool for competitive advantage*. New York: Free Press.

Shao, J., Taisch, M., & Ortega Mier, M. (2017). Influencing factors to facilitate sustainable consumption: From the experts' viewpoints. *Journal of Cleaner Production, 142*, 203–216.

Sharma, S., & Vredenburg, H. (1998). Proactive corporate environmental strategy and the development of competitively valuable organizational capabilities. *Strategic Management Journal, 19*(8), 729–753.

Sharman, P. (1995, May). How to implement performance measurement in your organization. *CMA Magazine*, pp. 33–38.

She, W., & Thuraisingham, B. (2007). Security for enterprise resource planning system. *Journal of Information Systems Security*, *16*(3). https://doi.org/10.1080/10658980701401959

Sheffi, Y., & Rice, J. B. (2005). A supply chain view of the resilient enterprise. *Sloan Management Review, 47*(1), 41–48.

Sheridan, J. H. (1998). The supply-chain paradox. *Industry Week, 247*(3), 20–29.

Sherman, R. J. (1998). Collaborative planning, forecasting and replenishment (CPFR): Realizing the promise of efficient consumer response through collaborative technology. *Journal of Marketing Theory and Practice, 6*(4), 6–9.

Sheth, J. N., & Sharma, A. (1997). Supplier relationships. *Industrial Marketing Management, 26*, 91–100.

Sheu, J. B., Chou, Y.-H., & Hu, C.-C. (2005). An integrated logistics operational model for green supply chain management. *Transportation Research Part E, 41*, 287–313.

Sheu, J. B., Chou, Y. H., & Hu, C. C. (2010). Critical factors for implementing green supply chain management practice. *Management Research Review, 33*(6), 586–608.

Shi, V., Koh, S., Baldwin, J., & Cucchiella, F. (2012). Natural resource based green supply chain management. *Supply Chain Management: An International Journal, 17*, 54–67.

Shih, L. H. (2001). Reverse logistics system planning for recycling electrical appliances and computers in Taiwan. *Resources, Conservation and Recycling, 32*(1), 55–72.

Shin, H., Collier, D. A., & Wilson, D. D. (2000). Supply management orientation and supplier/buyer performance. *Journal of Operations Management, 18*(3), 317–333.

Shore, B. (2001). Information sharing in global supply chain systems. *Journal of Global Information Technology Management, 4*(3), 27–50.

Shore, B., & Venkatachalam, A. R. (2003). Evaluating the information sharing capabilities of supply chain partners: A fuzzy logic model. *International Journal of Physical Distribution and Logistics Management, 33*(9/10), 804–824.

Shreckengost, R. C. (1985). Dynamics simulation models: How valid are they?. In *Self-report methods of estimating drug use: Meeting current challenges to validity*. Division of epidemiology and statistical analysis, National Institute on Drug Abuse, NIDA Research Monograph, 57. Washington: U.S. Government Printing Office.

Shrivastava, P. (1995a). Environmental technologies and competitive advantages. *Strategic Management Journal, 16*, 183–200.

Shrivastava, P. (1995b). The role of corporations in achieving ecological sustainability. *The Academy of Management Review, 20*(4), 936–960.

Shukla, A. C., Deshmukh, S. G., & Kanda, A. (2009). Environmentally responsive supply chains: Learning from the Indian auto sector. *Journal of Advances in Management Research, 6*(2), 154–171.

Shultz, C. J., II, & Holbrook, M. B. (1999). Marketing and tragedy of the common: A synthesis, commentary and analysis for action. *Journal of Public Policy and Marketing, 18*(2), 218–229.

Silva, L., Pereira, G., Borchardt, M., & Sellitto, M. (2013). How can the sales of green products in the Brazilian supply chain be increased? *Journal of Cleaner Production, 47*, 274–282.

Silver, A. (1990). Friendship in commercial society: Eighteenth-century social theory and modern sociology. *American Journal of Sociology, 95*(6), 1474–1504.

Silvestro, R. (1999). Positioning services along the volume-variety diagonal: The contingencies of service design, control and improvement. *International Journal of Operations and Production Management, 19*(4), 399–412.

Simmons, B. L., & White, M. A. (1999). The relationship between ISO 9000 and business performance. *Journal of Managerial Issues, 11*(3), 330.

Simposon, D. Y., Power, D. J., & Samson, D. (2007). Greening the automotive supply chain: A relationship perspective. *International Journal of Operations and Production Management, 27*(1), 28–48.

Simpson, D., & Samson, D. (2008). Developing strategies for green supply chain management. *Decision Line, 39*(4), 12–15.

Sinclair, D., & Zairi, M. (2000). Performance measurement: A critical analysis of the literature with respect to total quality management. *International Journal of Management Reviews, 2*(2), 145–168.

Singels, J., Ruel, G., & van de Water, H. (2001). ISO 9000 series certification and performance. *International Journal of Quality & Reliability Management, 18*, 62–75.

Singh, N., & Shah, J. (2001). Benchmarking internal supply chain performance: Development of a framework. *The Journal of Supply Chain Management, 37*, 37–47.

Skinner, W. (1985). The taming of the lions: How manufacturing leadership involved, 1780–1984. In K. B. Clark, R. Hayes, & C. Lorenz (Eds.), *The uneasy alliance: Managing the productivity-technology dilemma* (pp. 63–110). Boston, MA: The Harvard Business School Press.

Skjoett-larsen, T. (2000). European logistics beyond 2000. *International Journal of Physical Distribution and Logistics Management, 30*(5), 337–387.

Slack, N., Chambers, S., & Johnston, R. (2004). *Operations management* (4th ed.). Prentice Hall, ISBN-0273679066.

Smali, A. C., Browning, J. M., & Busbia, C. (1998). The status of global sourcing as a critical tool of strategic planning. *Journal of Business Research, 43*(3), 177–187.

SME Annual Report. (2011/2012). *Redefining the future*. SME Corporation Malaysia www.smecorp.ogv.my/vn2/node/177

Smeltzer, L. R., & Manship, J. A. (2003). How good are your cost reduction measures? *Supply Chain Management Review*, May–June, 3–7.

Smith, G. F. (1995). *Quality problem solving*. Milwaukee, WI: ASQ Quality Press.

Smith, B. (2003). Lean and six sigma—A one-two punch. *Quality Progress, 36*(1), 37–42.

Smith, L. (2006). Quality around the world. *Quality Digest*, June, 41–47.

Soh, C., Kien, S., & Tay-Yap, J. (2000). Cultural fits and misfits: Is ERP a universal solution? *Communications of the ACM, 43*(4), 47–51.

Sokol, P. (1995). *From EDI to electronic commerce*. New York: McGraw-Hill.

Soler, C., Bergstrom, K., & Shanahan, H. (2010). Green supply chains and the missing link between environmental information and practice. *Business Strategy and the Environment, 19*(1), 14–25.

Solvang, W. D., Deng, Z., & Solvang, B. (2007). A Closed-loop supply chain model for managing overall optimization of eco-efficiency. In *POMS 18th annual conference*, Dallas Texas, USA.

Songini, M. L. Procter & Gamble: Wal-Mart RFID effort effective. *Computerworld, 41*(09), 14.

Soosay, C. A. (2008). Supply chain collaboration: Capabilities for continuous innovation. *Supply Chain Management, 13*(2), 160–169.

Sousa, S., & Aspinwall, E. (2010). Development of a performance management framework for SMEs. *Total Quality Management, 21*(5), 475–501.

Spekman, R. E. (1989). A strategic approach to procurement planning. *Journal of Purchasing and Materials Management*, 25th Anniversary, 4–8.

Spekman, R. E., Kamauff, J. W., Jr., & Myhr, N. (1998). An empirical investigation into supply chain management: A perspective on partnerships. *Supply Chain Management, 3*(2), 53–67.

Sprague, L. G. (2007). Evolution of the field of operations management. *Journal of Operations Management, 25*(2), 219–238.

Srivastava, S. K. (2005). Profits driven reverse logistics. *International Journal of Business Research, 4*, 53–61.

Srivastava, K. S. (2007). Green supply-chain management: A state-of-the-art literature review. *International Journal of Management Reviews, 9*(1), 53–80.

Srivastava, S. K. (2008). Green supply chain management: A state-of-the-art literature review. *International Journal of Management Reviews, 9*(1), 53–80.

Srivastava, S. K., & Srivastava, R. K. (2006). Managing product returns for reverse logistics. *International Journal of Distribution and Logistics Management, 36*, 524–546.

Stalk, G. (1988). Time—The next source of competitive advantage. *Harvard Business Review, 66*(4), 41–51.

Stalk, G., Evans, P., & Schulman, E. (1992). Competing on capabilities: The new role of corporate strategy. *Harvard Business Review*, 57–69.

Stanley, L. L., & Wisner, J. D. (2001). Service quality along the supply chain: Implications for purchasing. *Journal of Operations Management, 16*(2), 22–28.

Starik, M., & Marcus, A. (2000). Introduction to the special research forum on the management of organizations in the natural environment: A field emerging from multiple paths, with many challenges ahead. *Academy of Management Journal, 43*, 539–546.

Starik, M., & Rands, G. (1995). Weaving an integrated web: Multilevel and multisystem perspectives of ecologically sustainable organizations. *Academy of Management Review, 20*(4), 908–935.

Stein, T., & Sweat, J. (1998). Killer supply chains. *Information Week, 708*(9), 37–56.

Sterman, J. (2000). *Business dynamics: Systems thinking and modeling for a complex world*. New York: McGraw-Hill.

Stern, L., & Reve, T. (1980). Distribution channels as political economies: A framework for competitive analysis. *Journal of Marketing, 44*, 52–64.

Stevens, G. C. (1989). Integrating the supply chain. *International Journal of Physical Distribution and Materials Management, 19*, 3–8.

Stock, J. (1998). *Development and implementation of reverse logistics programs*. Oak Brook IL, Council of Logistics Management.

Stock, G. N., Greis, N. P., & Kasarda, J. D. (2000). Enterprise logistics and supply chain structure: The role of fit. *Journal of Operations Management, 18*(5), 531–547.

Stonebraker, P. W., Goldhar, J., & Nassos, G. (2009). Weak links in the supply chain: Measuring fragility and sustainability. *Journal of Manufacturing Technology Management, 20*(2), 161–177.

Storer, M., & Hyland, P. (2009). Dynamic capabilities and innovation in supply chains. *Enhancing the innovation environment: Proceedings of the 10th international CINet conference*, Brisbane.

Stuart, F. I. (1993). Supplier partnerships: Influencing factors and strategic benefits. *International Journal of Purchasing and Materials Management, 29*(4), 22–28.

Stuart, F. I. (1997). Supply-chain strategy: Organizational influence through supplier alliances. *British Academy of Management, 8*(3), 223–236.

Stundza, T. (2000, March 2). Focus is on total cost of ownership. *Purchasing*, 34.

Stundza, T. (2007). Assured quality critical in global sourcing. *Purchasing*, *136*(11), 32, 927–939.

Subramani, M. (2004). How do suppliers benefit from information technology use in supply chain relationships? *MIS Quarterly, 28*(1), 45–73.

Sum, C., Yang, K., Ang, J., & Quek, S. (1995). An analysis of material requirements planning benefits using alternating conditional expectation. *An Journal of Operations Management, 13*(1), 35–48.

Sumter, S. R., Bokhorst, C. L., Steinberg, L., & Westenberg, P. M. (2009). The developmental pattern of resistance to peer influence in adolescence: Will the teenage ever be able to resist. *Journal of Adolescence, 32*(4), 1009–1021.

Sundarakani, B., Soua, R., Goh, M., Wagner, S., & Manikandan, S. (2010). Modeling carbon footprints across the supply chain. *International Journal of Production Economics, 128*, 43–50.
Suprina, D. (2005, May 16). Security risks with RFID. *RFID Journal*.
Sushil. (2005). Interpretive matrix: A tool to aid interpretation of management and social research. *Global Journal of Flexible Systems Management, 6*(2), 27–30.
Svensson, G. (2007). Aspects of sustainable supply chain management (SSCM): Conceptual framework and empirical example. *Supply Chain Management: An International Journal, 12*(4), 262–266.
Swafford, M., Ghosh, S., & Murthy, N. (2008). Achieving supply chain agility through IT integration and flexibility. *International Journal of Production Economics, 116*(2), 288–297.
Swamidass, P. M., & Kotabe, M. (1993). Component sourcing strategies of multinationals: An empirical study of European and Japanese multinationals. *Journal of International Business Studies, 24*(1), 81–100.
Swaminathan, J. M., & Tayur, S. R. (2003). Models for supply chains in E-business. *Management Science, 49*(10), 1387–1406.
Sykes, T. A., Venkatesh, V., & Gosain, S. (2009). Model of acceptance with peer support: A social network perspective to understand employees' system use. *MIS Quarterly, 33*(2), 371–393.
Szwejczewski, M., Lemke, F., & Goffin, K. (2005). Manufacturer supplier relationships: An empirical study of German manufacturing companies. *International Journal of Operations and Production Management, 25*(9), 875–897.
Szwilski, T. B. (2000). Using environmental management systems to systematically improve operational performance and environmental protection. *International Journal of Surface Mining, Reclamation and Environment, 14*(3), 183–191.
Taguchi, G., & Clausing, D. (1990, January–February). Robust quality. *Harvard Business Review*, *68*, 65–75.
Taiwan Semiconductor Manufacturing Company (TSMC). (2005). Environmental, safety and health annual report, Taipei, Taiwan.
Tan, K. C. (2002). Supply chain management: Practices, concerns, and performance issues. *Journal of Supply Chain Management, 38*(1), 42–53.
Tan, K. C., Kannan, V. R., & Handfield, R. B. (1998). Supply chain management: Supplier performance and firm performance. *International Journal of Purchasing and Materials Management, 34*(3), 2–9.
Tan, X. C., Liu, F., Cao, H. J., & Zhang, H. (2002). A decision-making framework model of cutting fluid selection for green manufacturing and a case study. *Journal of Materials Processing Technology, 129*(1–3), 467–470.
Tan, K. C., Lyman, S. B., & Wisner, J. D. (2002). Supply chain management: A strategic perspective. *International Journal of Operations and Production Management, 22*(6), 614–631.
Tang, C. (2006). Robust strategies for mitigating supply chain disruption. *International Journal of Logistics Research and Applications: A Leading Journal of Supply Chain Management, 9*(1), 33.
Tatikonda, M. V., & Montoya-Weiss, M. M. (2001). Integrating operations and marketing perspectives of product innovation. *Management Science, 47*(1), 151–172.
Tatikonda, M. V., & Rosenthal, S. R. (2000). Successful execution of product development project: Balancing firmness and flexibility in the innovation process. *Journal of Operations Management, 18*, 401–425.
Tatung Co. (2005). *Tatung environmental report*. Taipei, Taiwan.
Taylor, D. (1999). Parallel incremental transformation strategy: An approach to the development of lean supply chains. *International Journal of Logistics Research and Applications, 2*(3), 305–323.
Taylor-Coates, T., & McDermott, C. M. (2002). An exploratory analysis of new competencies: A resource based view perspective. *Journal of Operations Management, 20*, 435–450.
Teague, P. E. (2007). How to improve supplier performance. *Purchasing, 136*(4), 31–32.
TEDA (Tianjin Economic and Tecnological Development Area). (2003, February). *A report on integrated solid waste management in Tianjin Economic and Development Area* (in Chinese).

Tenaga, K., & dan Air, T. H. (2010). *National green technology policy*. Available http://www.greentechmalaysia.my/
Terlaak, A., & King, A. A. (2006). The effect of certification with the ISO 9000 quality management standard: A signaling approach. *Journal of Economic Behavior & Organization, 60*(4), 579–602.
Terziovski, M., Power, D., & Sohal, A. (2003). The longitudinal effects of the ISO 9000 certification process on business performance. *European Journal of Operational Research, 146*, 580–595.
Terziovski, M., Samson, S., & Dow, D. (1997). The business value of quality management systems certification. Evidence from Australia and New Zealand. *Journal of Operations Management, 15*(1), 17.
Testa, F., & Iraldo, F. (2010). Shadows and lights of GSCM (Green Supply Chain Management): Determinants and effects of these practices based on a multi-national study. *Journal of Cleaner Production, 18*, 953–962.
Testa, M. R., & Sipe, L. J. (2006). A systems approach to service quality tools for hospitality leaders. *Cornell Hotel and Restaurant Administration Quarterly, 47*(1), 36–48.
The European Union at a Glance, Member States of the EU. Available from http://europa.eu/abc/european _Countries/index_en.htm
Theodorakioglou, Y., Gotzamani, K., & Tsiolvas, G. (2006). Supplier management and its relationship to buyers' quality management. *Supply Chain Management, 11*(2), 148–159.
Theyel, G. (2001). Customer and supplier relations for environmental performance. *Greener Management International, 35*(Autumn), 61–69.
Thoo, A. C., Abdul Hamid, A. B., Rasli, A., & Zhang, D. (2014). The moderating effect of enviropreneurship on green supply chain management practices and sustainability performance. *Advanced Materials Research, Sustainable Development of Industry and Economy*, 869–870.
Timme, S., & Williams-Timme, W. (2000, August 22–24). What you do, start measuring. *Logistics Today*.
Tobias Schoenherr. (2012). The role of environmental management in sustainable business development: A multi-country investigation. *Journal of Production Economics, 140*, 116–128.
Tompkins, J., & Ang, D. (1999). What are your greatest challenges related to supply chain performance measurement? *IEE Solutions, 31*(6), 66.
Tooru, S. (2001). Certification and operational performance of ISO 14001. *Kamipa Gikyoshi, 55*(1), 52–58.
Torraco, R. J. (2005). Writing integrative literature reviews: Guidelines and examples. *Human Resource Development Review, 4*, 356–367.
Towers, N., & Chen, R. (2007). Employing the participative paradigm as a valid empirical approach to gaining a greater understanding of contemporary supply chain and distribution management issues. *The International Journal of Retail and Distribution Management, 36*(8), 627–637.
Towill, D. R., Naim, N. M., & Wikner, J. (1992). Industrial dynamics simulation models in the design of supply chains. *International Journal of Physical Distribution and Logistics Management, 22*(1), 3–13.
Tracey, M., Vonderembse, M. A., & Lim, J. S. (1999). Manufacturing technology and strategy formulation: Keys to enhancing competitiveness and improving performance. *Journal of Operations Management, 17*(4), 411–428.
Trent, R. J., & Kolchin, M. G. (1999). *Reducing the transaction costs of purchasing low-value goods and services*. Tempe, AZ: Center for Advanced Purchasing Studies.
Trent, R. J., & Monczka, R. M. (2007). Achieving excellence in global sourcing. *Sloan Management Review, 47*(Fall), 24–32.
Trowbridge, P. (2001). A case study of green supply-chain management at advanced micro devices. *Greener Management International, 35*, 121–135.
Tsai, W., & Hung, S. (2009). A fuzzy goal programming approach for green supply chain optimization. *International Journal of Production Research, 47*(18), 4991–5017.

Tsekouras, K., Dimara, E., & Skuras, D. (2002). Adoption of a quality assurance scheme and its effects on firm performance: A study of green firms implementing ISO 9000. *Total Quality Management, 13*, 827–841.

Tsoulfas, G. T., & Pappis, C. P. (2006). Environmental principles applicable to supply chains design and operation. *Journal of Cleaner Production, 14*, 1593–1602.

Tu, Q., Vonderembse, M. A., & Ragu-Nathan, T. S. (2001). The impact of time-based manufacturing practices on mass customization and value to customer. *Journal of Operations Management, 19*(2), 201–217.

Turner, J. R. (1993). Integrated supply chain management: What's wrong with this picture. *Industrial Engineering, 25*(12), 52–55.

Uchida, T., & Ferraro, P. J. (2007). Voluntary development of environmental management systems: Motivation and regulatory implication. *Journal of Regulatory Economics, 32*(1), 37–65.

United Microelectronics Corporation. (2005). *Corporate social responsibility report*, Taipei, Taiwan.

US-AEP. (1999). *Sector based public policy in the Asia-Pacific Region*.

Vachon, S. (1997). Green supply chain practices and the selection of environmental technologies. *International Journal of Production Research, 45*(18–19), 4357–4379.

Vachon, S., & Klassen, R. D. (2006a). Green project partnership in the supply chain: The case of the package printing industries. *Journal of Cleaner Production, 14*, 661–671.

Vachon, S., & Klassen, R. D. (2006b). Extending green practices across the supply chain: The impact of upstream and downstream integration. *International Journal of Operations and Production Management, 26*(7), 795–821.

Vachon, S., & Klassen, R. D. (2008). Environmental management and manufacturing performance: The role of collaboration in the supply chain. *International Journal of Production Economy, 111*, 299–315.

Vachon, G., Louka, P., Rosant, J.-M., Mestayer, P. G., & Sini, J.-F. (2001). Measurements of traffic-induced turbulence within a street canyon during the Nantes 99 experiment. *The Third international conference on urban air quality*, 19–23 March, Loutraki, Greece.

Van der Laan, E., & Salomon, M. (1997). Production planning and inventory control with remanufacturing and disposal. *European Journal of Operational Research, 102*, 264–278.

Van der Laan, E., Salomon, M., & Dekker, R. (1996). Production remanufacturing and disposal: A numerical comparison of alternative control strategies. *International Journal of Production Economies, 45*, 489–498.

Van der Zee, D. J., & Van der Vorst, J. G. A. J. (2005). A modeling framework for supply chain simulation: Opportunities for improved decision making. *Decision Sciences, 36*(1), 65–95.

Van Hock, R., & Erasmus, I. (2000). From reversed logistics to green supply chains. *Logistics Solutions Issue, 2*, 28–33.

Van Hoek, R. I. (1998). Measuring the unmeasurable—Measuring and improving performance in the supply chain. *Supply Chain Management, 3*(4), 187–192.

Van Hoek, R. I. (1999). From reversed logistics to green supply chain. *Supply Chain Management: An International Journal, 4*(3), 129–134.

Van Hoek, R. I., & Voss, R. I. (1999). Commandeur HR. Restructuring European supply chain by implementing postponement strategies. *Long Range Planning, 32*(5), 505–518.

Van Maanen, J. (1983). Epilogue: Qualitative methods reclaimed. In J. Van Maanen (Ed.), *Qualitative methodology*. Beverly Hills: Sage.

Van Weenen, J. C., & Eekels, J. (1989). Design and waste prevention. *The Environmental Professional, 11*(1), 23–25.

Venkat, K., & Wakeland, W. (2006). *Is lean necessarily green?* Proceedings of the 50th annual meeting of the ISSS Papers.

Venkatesan, R. (1992, November–December). Strategic sourcing: To make or not to make. *Harvard Business Review*, 98–107.

Venus Lun, Y. H. (2011). Green management practices and firm performance: A case of container terminal operations. *Resources, Conservation and Recycling, 55*, 559–566.

Vernon, R. (1966). International investment and international trade in the product cycle. *Quarterly Journal of Economics, 80*(2), 190–207.

Vesey, J. T. (1991). The new competitors: They think in terms of speed-to-market. *Academy of Management Executive, 5*(2), 23–33.

Vickery, S., Calantone, R., & Droge, C. (1999). Supply chain flexibility: An empirical study. *Journal of Supply Chain Management, 35*(3), 16–24.

Viehland, D., & Wong, A. (2007). The future of radio frequency identification. *Journal of Theoretical and Applied Electronic Commerce Research, 2*(2), 74–81.

Vijayasarathy, L., & Robey, D. (1997). The effect of EDI on market channel relationship in retailing. *Information and Management, 33*(2), 73–86.

Vitale, R., & Mavrinac, S. C. (1995, August). How effective is your performance measurement system? *Management Accounting*, 43–47.

Vokurka, R. J., & Lummas, P. R. (2000). The role of just-in-time in supply chain management. *International Journal of Logistics Management, 11*, 89–98.

Von Hippel, E. (1988). *The source of innovation*. Oxford: Oxford University Press.

Vonderembse, M. A., & Tracey, M. (1999). The impact of supplier selection criteria and supplier involvement on manufacturing performance. *Journal of Supply Chain Management, 35*(3), 33–39.

Vonderembse, M. A., Uppal, M., Huang, S. H., & Dismukes, J. P. (2006). Designing supply chains: Towards theory development. *International Journal of Production Economics, 100*(2), 223–238.

Wadhwa, S., & Saxena, A. (2005). Knowledge management based supply chain: An evolution perspective. *Global Journal of e-Business and Knowledge Management, 2*(2), 13–29.

Wagne, M., Schaltegger, S., & Wehrmeyer, W. (2001). The relationship between the environmental and economic performance of firms: What does theory propose and what does empirical evidence tell us? *Greener Management International, 34*, 95–108.

Wagner, S. M. (2006). Supplier development practices: An exploratory study. *European Journal of Marketing, 40*(50–6), 554–571.

Wahid, N. A., Rahbar, E., & Shyan, T. S. (2011). Factors influencing the green purchase behavior of Penang environment volunteers. *Journal of International Management, 5*(1), 38–49.

Walker, H., Di Sisto, L., & McBain, D. (2008). Drivers and barriers to environmental supply chain management practices: Lessons from the public and private sectors. *Journal of Purchasing and Supply Management, 14*(1), 69–85.

Waller, M. A., Dabholkar, P. A., & Gentry, J. J. (2000). Postponement, product customization, and market-oriented supply chain management. *Journal of Business Logistics, 21*(2), 133–159.

Waller, M., Johnson, M. E., & Davis, T. (1999). Vendor-managed inventory in the retail supply chain. *Journal of Business Logistics, 20*(1), 183–203.

Walley, N., & Whitehead, B. (1994). It's not easy being green. *Harvard Business Review, 72*(3), 46–52.

Walter, D., & Buchanan, J. (2001). The new economy, new opportunities, and new structures. *Management Decision, 39*(10), 818–834.

Walton, L. W. (1996). Partnership satisfaction: Using the underlying dimensions of supply chain partnership to measure current and expected levels of satisfaction. *Journal of Business Logistics, 17*(2), 57–75.

Walton, S., Handfield, R., & Melnyk, S. (1998). The green supply chain: Integrating suppliers into environmental management processes. *International Journal of Purchasing and Materials Management, 3*(2), 2–11.

Walton, L. W., & Miller, L. G. (1995). Moving toward LIS theory development: A framework of technology adoption within channels. *Journal of Business Logistics, 16*(2), 117–136.

Wang, G., Huang, S. H., & Dismukes, J. P. (2004). Product-driven supply chain selection using integrated multi-criteria decision-making methodology. *International Journal of Production Economics, 91*, 1–15.

Warfield, J. N. (1973). *An assault on complexity*. Columbus, OH: Battelle Memorial.

Warfield, J. W. (1974). Developing interconnected matrices in structural modeling. *IEEE Transactions on Systems, Man, and Cybernetics, 4*(1), 51–81.
Warner, H. W., & Aberg, L. (2006). Drivers' decision to speed: A study inspired by the theory of planned behavior. *Transportation Research Part F: Traffic Psychology and Behavior, 9*(6), 427–433.
Watts, C. A., & Hahn, C. K. (1993). Supplier development programs: An empirical analysis. *International Journal of Purchasing and Materials Management, 29*(2), 11–17.
Wayhan, V. B., Kirche, E. T., & Khumawala, B. M. (2002). ISO 9000 certification: The financial performance implications. *Total Quality Management, 13*(2), 217–231.
Wee, Y. S., & Quazi, H. A. (2005). Development and validation of critical factors of environmental management. *Industrial Management and Data Systems, 105*(1), 96–114.
Welford, R. (1995). *Environmental strategy and sustainable development: The corporate challenge for the 21st century*. London: Routledge.
Welford, R., & Goulson, A. (1993). *Environmental management and business strategy*. London: Pitman.
Welti, N. (1999). *Successful SAP R/3 implementation: Practical management of ERP projects*. Reading, MA: Addison Wesley.
Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic Management Journal, 5*, 171–180.
Wesner, J. W., Hiatt, J. M., & Trimble, D. C. (1995). *Winning with quality: Applying quality principles in product development*. Reading, MA: Addison-Wesley.
Whang, S. (1995). Coordination in operations: A taxonomy. *Journal of Operations Management, 12*, 413–422.
Whipple, J. M., Frankel, R., & Daugherty, P. J. (2002). Information support for alliances: Performance implications. *Journal of Business Logistics, 23*(2), 67–82.
White, P. R. (1995). Environmental management in an international consumer goods company. *Resources, Conservation and Recycling, 14*, 171–184.
White, R. E., Pearson, J. N., & Wilson, J. R. (1999). JIT manufacturing: A survey of implementations in small and large U.S. manufacturers. *Management Science, 45*, 1–15.
Whitelock, V. G. (2012). Alignment between green supply chain management strategy and business strategy. *International Journal of Procurement Management, 5*(4), 430–451.
Wieder, B., Booth, P., Matolcsy, Z. P., & Ossimitz, M. L. (2006). The impact of ERP systems on firm and business process performance. *Journal of Enterprise Resource Management, 19*(1), 13–29. https://doi.org/10.1108/17410390610636850.
Wikner, J., Towill, D. R., & Naim, N. M. (1991). Smoothing supply chain dynamics. *International Journal of Production Economics, 22*(3), 231–248.
Wilkinson, G., & Dale, B. (1999). Integrated management systems: An examination of the concept and theory. *The TQM Megazine, 11*, 95–104.
Williamson, O. (1975). *Markets and hierarchies: Analysis and antitrust implications*. New York: The Free Press.
Williamson, O. E. (1981). The electronics of organization: The transaction cost approach. *American Journal of Sociology, 87*(3), 548–577.
Williamson, O. E. (1985). *The economic institutions of capitalism*. New York: Free Press.
Wilson, O. E. (1998). *Consilience: The unity of knowledge*. New York: Knopf.
Wines, L. (1996). High order strategy for manufacturing. *The Journal of Business Strategy, 17*(4), 32–33.
Wisner, J. E. (2003). A structural equation model of supply chain management strategies and firm performance. *Journal of Business Logistics, 24*, 1–26.
Wold, H. (1989). *Introduction to the second generation of multivariate analysis. Theoretical Empiricism*. New York: Paragon House.
Womack, J. P., & Jones, D. T. (2003). *Lean thinking*. New York: The Free Press.
Womack, J. P., Jones, D. T., & Roos, D. (1990). *The machine that changed the world*. New York: Macmillan.

Womack, P., Jones, D., & Roos, D. (1991). *The machine that changed the world: The story of lean production*. Harper Perennial.

Wong, C. W. Y., Lai, K.-H., Shang, K.-C., Lu, C.-S., & Leung, T. K. P. (2012). Green operations and the moderating role of environmental management capability of suppliers on manufacturing firm performance. *International Journal of Production Economics, 140*, 283–294.

Woo, K.-S., & Ennew, C. T. (2005). Measuring business-to-business professional service quality and its consequences. *Journal of Business Research, 58*(09), 1178–1185.

Woodruff, D. L., Spearman, M. L., & Hopp, W. J. (1990). ConWiP: A pull alternative to Kanban. *International Journal of Production Research, 28*(5), 879–894.

Woods, J. A. (Ed.). (2000). *The purchasing and supply. Yearbook: 2000 edition*. New York: McGraw-Hill.

Wooi, G. C., & Zailani, S. (2010). Green supply chain initiatives: Investigation on the barriers in the context of SMEs in Malaysia. *International Business Management, 4*, 20–27.

Wooten, D. B. (2006). From labeling possessions to possessing labels: Ridicule and socialization among adolescents. *Journal of Consumer Research, 33*(2), 188–198.

World Commission on Environment and Development (WCED). (1987). *Our common future*. Oxford: Oxford University Press.

Worrell, D., Gilley, K. M., Davidson, W. D., EI-Jely, A. (1995). When green turns to red: Stock market reaction to announced greening activities. *Paper presented at the academy of management meeting*, Vancouver.

Wu, G.-C., Cheng, Y.-H., & Huang, S.-Y. (2010). The study of knowledge transfer and green management performance in green supply chain management. *African Journal of Business Management, 4*(1), 44–48.

Wu, H. J., & Dunn, S. C. (1995). Environmentally responsible logistics system. *International Journal of Physical Distribution and Logistics Management Systems, 25*, 20–39.

Wu, N., Tsai, H. H., Chang, Y. S., & Yu, H. C. (2010). The radio frequency identification industry development strategies of Asian countries. *Technology Analysis & Strategic Management*, *22*(4), 417–431. Accessed May 30, 2010, from http://en.wikipedia.org/wiki/image: EPC-RFID-TAG.jpg

Wu, C. Y., Zhu, Q. H., & Geng, Y. (2001). Green supply chain management and enterprises' sustainable development. *China Soft Science*, *16*(3), 67–70 (in Chinese).

Xie, Y., & Breen, L. (2012). Greening community pharmaceutical supply chain in UK: A cross boundary approach. *Supply Chain Management: An International Journal, 17*(1), 40–53.

Xinhua News Agency (China). (2001, August 21). What should China do to meet with the challenge of green barriers? *Economy Daily*, pp. A2 (in Chinese).

Yamin, S., Gunasekruan, A., & Mavondo, F. T. (1999). Relationship between generic strategy, competitive advantage and firm performance: An empirical analysis. *Technovation, 19*(8), 507–518.

Yang, C. L., & Sheu, C. (2011). The effects of environmental regulations on green supply chains. *African Journal of Business Management, 5*(26), 10601–10614.

Yang, W., & Zhang, Y. (2012). Research on factors on green purchasing practices on Chinese. *Journal of Business Management and Economics, 3*(5), 222–231.

Yee, R. W., Yeung, A. C., & Cheng, T. C. (2008). The impact of employee satisfaction on quality and profitability in high-contact service industries. *Journal of Operations Management, 26*(5), 651–668.

Yee, R. W., Yeung, A. C., & Edwin Cheng, T. C. (2010). An empirical study of employee loyalty, service quality and firm performance in the service industry. *International Journal of Production Economics, 124*(1), 109–120.

Yen, Y., & Yen, S. (2011). Top-management's role in green purchasing standards in high-tech industrial firms. *Journal of Business Research, 65*(7), 951–959.

Yin, R. (1989). *Case study research: Design and methods* (1st ed.). Thousand Oaks, CA: Sage.

Yin, R. (2003). *Case study research. Design and methods, Edisi Ke-3*. Beverly Hills, CA: Sage.

Yorks, L. (2008). What we know, what we don't know, what we need to know—Integrative literature reviews are research. *Human Resource Development Review, 7*, 139–141.
Yoshino, M., & Rangan, S. (1995). *Strategic alliances: An entrepreneurial approach to globalization*. Boston, MA: Harvard Business School Press.
Youna, S., Yangb, M., Honga, P., & Park, K. (2013). Strategic supply chains partnership, environmental supply chain management practices, and performance outcomes: An empirical study of Korean firms. *Journal of Cleaner Production, 56*, 121–130.
Yu, Z., Yan, H., & Cheng, T. C. E. (2000). Benefits of information sharing with supply chain partnerships. *Industrial Management and Data Systems, 101*(3), 114–119.
Yu, Z., Yan, H., & Cheng, T. C. E. (2001). Benefits of information sharing with supply chain partnerships. *Industrial Management & Data Systems, 101*(3), 114–121.
Yuang, A., & Kielkiewicz-Yuang, A. (2001). Sustainable supply network management. *Corporate Environmental Management, 8*(3), 260–268.
Zairi, M. (1994). *Competitive benchmarkting*. Cheltenham: Stanley Thorns.
Zaklad, A., McKnight, R., Kosansky, A., & Piermarini, J. (2004). The social side of the supply chain: Align three factors, and hitting the jackpot is a sure bet. *Industrial Engineer, 36*(2), 40–44.
Zeigler, B. P., Praehofer, H., & Kim, T. G. (2000). *Theory of modeling and simulation* (2nd ed.). New York: Academic Press.
Zhang, Q. Y. (2001). *Technology infusion enabled value chain flexibility: A learning and capability-based perspective*. Doctoral dissertation, University of Toledo, Toledo, OH.
Zhang, H. C., Kuo, T. C., Lu, H., & Huang, S. H. (1997). Environmentally conscious design and manufacturing: A state of the art survey. *Journal of Manufacturing Systems, 16*, 352–371.
Zhang, B., Wang, Z., Yin, J., & Su, L. (2012). CO2 emission reduction within Chinese iron & steel industry: Practices, determinants and performance. *Journal of Cleaner Production, 33*, 167–178.
Zhao, X., Lai, F., & Lee, T. (2001). Evaluation of safety stock methods in multi-level material requirements planning (MRP) systems. *Production Planning & Control, 12*(8), 794–803.
Zhou, F. (2009). Study on the implementation of green supply chain management in textile enterprises. *Journal of Sustainable Development*, *2*(1).
Zhu, Q. H., & Cote, R. (2002). Green supply chain management in China: How and Why? *The Fifth international eco-city conference*, August, 2002, Shenzhen, China.
Zhu, Q., & Cote, R. P. (2003). Green supply chain management in China: Why and How?. *Internet conference on ecocity development*.
Zhu, Q., & Cote, R. (2004). Integrating green supply chain management into an embryonic eco-industrial development: A case study of the Guitang Group. *Journal of Cleaner Production, 12*(8–10), 1025–1035.
Zhu, Q., & Geng, Y. (2001). Integrating environmental issues into supplier selection and management: A study of large and medium-sized state-owned enterprises in China. *Greener Management International, 35*, 27–40.
Zhu, Q. H., & Geng, Y. (2002). Analysis on current practices of green purchasing on the basis of international comparisons. *Science and Science Technology Management*, *3*, 71–74 (in Chinese).
Zhu, Q. H., Geng, Y. (2003). Eco-design model on the basis of EMS. *Science and Science Technology Management*, *24*(4), 19–23 (in Chinese).
Zhu, Q., Sarkis, J., Cordeiro, J. J., & Lai, K. (2008a). Firm-level correlates of emergent green supply chain management practices in the Chinese Context. *The International Journal of Management Science, 36*(4), 577–591.
Zhu, Q., Sarkis, J., Cordeiro, J. J., & Lai, K. H. (2008b). Firm-level correlates of emergent green supply chain management practices in the Chinese context. *Omega, 36*, 577–591.
Zhu, Q., Sarkis, J., Lai, K., & Geng, Y. (2008). The role of organizational size in the adoption of green supply chain management practices in China. *Corporate Social Responsibility and Environmental Management, 15*(6), 322–337.

Zhu, K., Zhang, R. Q., & Tsung, F. (2007). Pushing quality improvement along supply chain. *Management Science, 53*(3), 421–436.

Zhu, Q. H., & Zhao, Y. P. (2003, February). A report on integrated solid waste management. In *Tianjin Economic and Development Area*.

Zipkin, P. H. (1995). Performance analysis of a multi-item production-inventory system under alternative policies. *Management Science, 41*, 690–703.

Zirger, B. J., & Maidique, M. A. (1990). A model of new product development: An empirical test. *Management Science, 36*, 867–883.

Zsidisin, G. A., & Hendrick, T. E. (1998). Purchasing's involvement in environmental issues: A multi-country perspective. *Industrial Management & Data Systems, 7*, 313–320.

Index

S. A. Rehman Khan, Z. Yu, *Strategic Supply Chain Management*, EAI/Springer Innovations in Communication and Computing,
https://doi.org/10.1007/978-3-030-15058-7