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

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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 back-checks 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.