Chapter 68
Effect of Information Sharing on Supply Chain Management: A Case Study

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Abstract The present work is concerned with the study of the impact of information sharing (IS) and consumer demand patterns on supply chain performance through a simulation approach. To remain competitive and sustainable globally due to rapid changes in technology and management tools, IS can act as an enabler. The small- and medium-scale industries producing consumer durables lack implementation of information-sharing strategies (ISS) and utilization of demand patterns in their supply chain system. A basic framework model for the supply chain is developed in the ARENA simulation package consisting of a retailer, distributor, manufacturer, and supplier. The demand patterns selected are stationary, volatile, and unknown which do occur in the case of such products. The main purpose of this work has been to improve the performance of the supply chain in terms of inventory-level reduction and cost-benefit under different information-sharing strategies. These strategies are: no information sharing, partial information sharing, and full information sharing. Experimental results show that the value of IS is highly dependent on demand patterns, supply chain echelons, and performance indicators.

Keywords Supply chain management · Information-sharing strategies · Simulation · Demand pattern

Introduction

Globalization of business has been increasing since the last three decades due to the rapid development of technology in manufacturing innovation, increasing cost pressure, and even aggressive demands from customers for innovation and flexibility

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[1]. New partnership relationships among suppliers, manufacturers, and retailers, and other parties have been replaced by innovative free market structures. Although the supply chain is frequently referred to as the logistic network in the literature, supply chain management emphasizes the overall and longtime benefits of all parties on the chain through optimum coordination and information sharing [2]. By coordinating different parties along with the logistic network or establishing business partnerships, supply chain management creates a win-win situation for all members. Information sharing on a supply chain brings about a great advance in business connections, such as vendor-managed inventory (VMI), cross-docking (CD), and quick response (QR). Information sharing is a vital aspect of coordination among parties in a supply chain [3]. Based on a two-stage decentralized supply chain comprising a retailer and a manufacturer, performance improvement is found in terms of inventory level and cost with an increasing level of information [4]. Information sharing is significant which accelerates information flow in the supply chain improving the efficiency and effectiveness of the supply chain and responds to end-users' needs quicker. Thus, information sharing can make an organization competitive in the long run [5].

Information sharing improves supply chain performance in terms of both total cost and service level [6]. The higher the degree of information sharing, the higher will be the order fulfillment rate and shorter will be the order cycle time [7]. The impact of information sharing on supply chain management depends on what information is shared, when it is shared, and how it is shared [8]; the study further explores the adjustment of information-sharing strategies on supply chain performance. The strategies considered are (1) order ISS, (2) demand ISS, (3) shipment ISS, and (4) forecast ISS.

Methodology

Profile of ABC Limited

The lock industry which has been used for the study is the largest lock manufacturer of city and the second biggest in India in terms of annual turnover. It has warehouses in all the states of India, and the distributors, sales personal, accountants are maintained everywhere. Some bigger states have even two warehouses in different cities. However, the working of the warehouses and distributors is on an autonomous basis; i.e., they work as decentralized units. The supply chain of ABC Limited is shown in Fig. 68.1, where W, D, R, and F represent warehouse, distributor, retailer, and factory, respectively, whereas subscript p, m, d, and r symbolize production unit, manufacturing unit, distribution unit, and retailer unit, respectively.

The type of supply chain in different lock companies is as follows:

- Producers-warehouses-retailers
- Producers-distributors (warehouses)
- Suppliers-manufacture-distributors-retailers
- Supplier-manufacture-distributors-retailers-consumers.

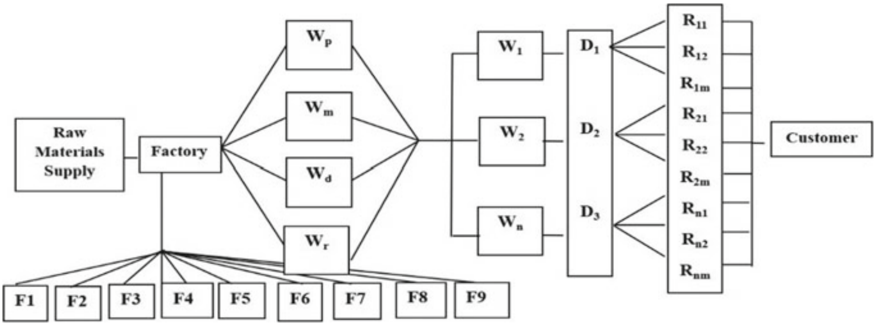

Fig. 68.1 Schematic diagram of supply chain of ABC Limited

Supply Chain of ABC Limited

The material suppliers of ABC Limited, India, are Jamnagar in Gujarat for brass, Tata Steel for steel, Hindustan Zinc for zinc, etc. The manufacturing unit is in the city at not more than 5 km from the main plant in the industrial estate of the city. Warehouses are located in almost all states, and there are various retailers in different cities on which customers' orders are placed. The problems found in the industry are evaluated with the help of the strengths, weaknesses, opportunities, and threats (SWOT) analysis and cause and effect diagram.

SWOT Analysis and Cause and Effect Diagram

Strengths

- Nationwide repute in quality, precision, and security of lock markets.
- Second position in Indian lock market
- Reasonably strong social, political, and economic background.
- Fast-growing demand of company goods.
- Improvement in the economy of the country and the very marginal effect of the global recession on the Indian economy.
- Growth of construction industries which requires growth of furniture, doors, cycles, and motorbikes even in rural areas.

Weaknesses

- Trust and commitment among top managers only.
- Lack of information sharing from top managers to middle-level managers and supervisors.
- Inflexible chain of command.

- Skilled workers are poorly paid.
- Non-ergonomic job design.
- Ever-changing business strategy due to innovative management techniques.
- The company does not want to change from family business to private limited company.

Opportunities

- There is a rapid increase in agricultural productivity due to good monsoon and infrastructure developed by the government like roads, water, and electricity, thus, naturally economic condition of the rural population would improve, and their purchasing power will also increase resulting in expansion of construction, furniture, and motorbike industries. This will require a higher demand for padlocks, furniture locks like door fittings and motorbike locks.
- Due to an increase in innovative new technologies, they are being adopted like the mechatronic locks, lever locks with pin cylinder, three-row pin.

Threats

- Due to globalization, international brands particularly from the people republic of china may compete with established domestic locks.
- Larger productivity of engineers and managers resulting into increase in unemployment into the growth of entrepreneurs, and some are attracted to establish their own lock manufacturing units.

From SWOT analysis, it can be concluded that the first two weaknesses of the company leading to poor information sharing at downstream levels of the supply chain result into bullwhip effect, and consequently, retailers and distributors are reluctant to share their information upstream. This is the reason that manufacturer maintains a high level of inventory to overcome volatility in demand or sometimes unknown demand when it arises. In order to find out the existing situation of the supply chain in the company, cause and effect diagram of the supply chain has also been done which further supports the findings of the SWOT analysis. Thus, information sharing has been considered as an enabler for improving the performance of supply chain (Fig. 68.2).

Supply Chain Simulation Model

In the model, a four-stage supply chain system consisting of a retailer, distributor, manufacturer, and supplier has been considered. The working of the model is such that the demand from the market is generated at the retailer node, and the retailer checks its inventory level whether it can meet the demand or not. If yes, it immediately dispatches the items, otherwise, the backorders are built up and after that, the signal is

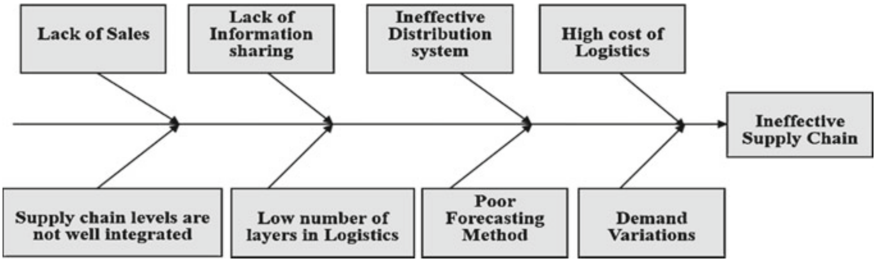

Fig. 68.2 Cause and effect diagram for ineffective supply chain of ABC Limited

sent to the distributor node for the replenishment of inventory, and the same procedure is followed at the other upstream nodes. The inventory of all nodes is managed according to (s, Q) policy; i.e., when an inventory level gets lower than a minimum specified level known as reorder point (s), an order for the product equal to order quantity (Q) is placed at the upstream node. The order quantity and the reorder point are decided. The same procedure is followed at the distributor and manufacturer node, and the manufacturer gets raw material from an outside supplier. It is assumed that the supplier has enough quantity of raw materials to supply to the manufacturer. When the retailer places an order, the distributor satisfies the full order immediately upon availability. If not enough stock is available, the excess order is fully backordered. All nodes have online information on the inventory status and demand activities of each other node and replenishment policy. Based on the above concept of supply chain network, a simulation model is developed in ARENA at all the four nodes and for different cases of order delay time, lead time uncertainty, and different ISS. The model is developed at various nodes of the supply chain by taking all the ISS and demand patterns. Demands are generated in the create module based on the time intervals and then the assign module is used for assigning the demands. These demands are entered in the record module and then checked with the inventory level of the retailer in the decision module. After being checked, the inventory of the retailer gets updated if it has sufficient inventory to satisfy the demand or backorders are generated in the assign module. The inventory updated is checked with the reorder point. If the inventory is less than the reorder point, then the signal is sent to the distributor node for order placement. The order information time is associated with the delay module. It allows the entity to remain for the duration equal to the order lead time. The holding cost, backorder costs, and ordering cost are all assigned and will be displayed in the variable box when the model is allowed to run. Inventory level of the retailer, its reorder point, and order quantity will be displayed. The order from the retailer nodes is being received at the distributor node. The route module at the retailer node transfers the order to the distributor through the station as shown in Fig. 68.3.

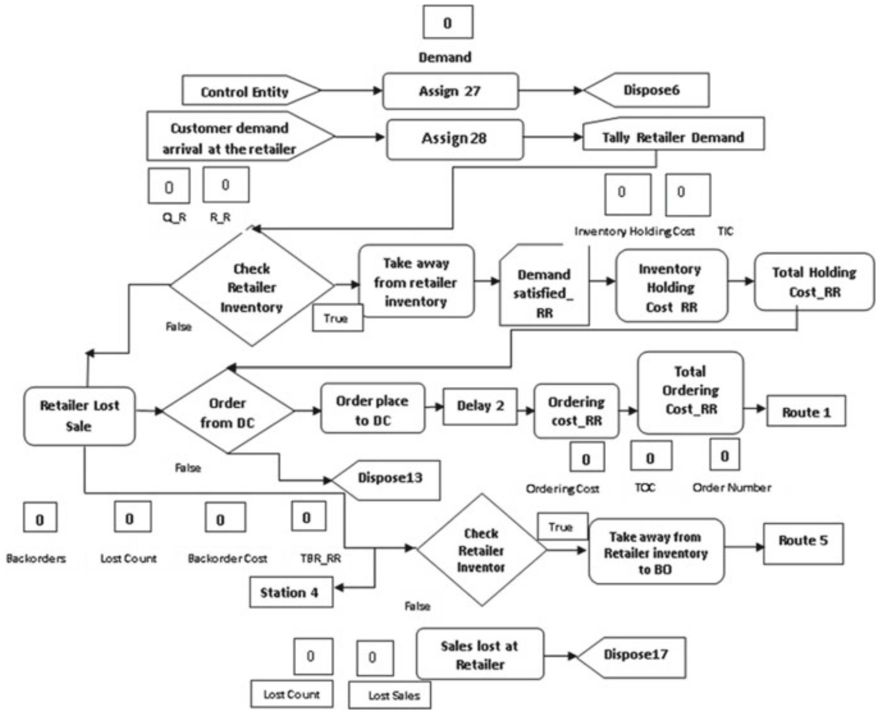

Fig. 68.3 Simulated model at retailer node

Simulation Experiment

The simulation lasts for 365 days in which the first 100 days served for the warm-up rounds of the experiment. Furthermore, the simulation is replicated for 25 times, and the averaged performance indicators are then used for evaluation.

Performance Measures

Input parameters

- Customers' demand
- Reorder point
- Quantity ordered to an upstream node
- Quantity shipped to a downstream node

In order to understand the characteristics of the supply chain, relevant performance measures should be identified.

- Order lead time
- Delivery lead time
- Initial inventory at each node
- Policy to be used
- Unit backorder cost, unit inventory cost, unit ordering cost

Output parameters.
The following performance indicators are selected for this modeling approach:

- Inventory level at each node.
- Backorders at each node.
- Inventory cost, ordering cost, backorder cost, and total cost at each node.
- Service level at each node.

Information-sharing Strategies and Parameters

The model allows many parameters to vary in the simulation experiment. In the set of experiments, the effect of order lead time and lead time uncertainty is studied along with the effect of ISS on the supply chain performance. Order lead time (OLT): It is defined as the time between placing an order and receiving the ordered item. Lead time uncertainty (SL): Lead time uncertainty is defined as the variability in lead time. The performance in terms of inventory level, backorders, ordering cost, backorder cost, total cost, and service level by varying order lead time and lead time uncertainty will be studied. With some real time and approximate data, different ISS have been considered, and the effect of all the ISS is studied under varying demand patterns of the lock industry. In these sets of experiments, the delivery and processing lead time are assumed to be grouped into one single parameter which is kept constant throughout the experiment. There are no fixed ordering or setup costs for all the levels of supply chain. The average cost for all the types of locks has been considered. A single unit of retailer, distributor, and manufacturer has been assumed, and the supplier has sufficient inventories to fulfill the manufacturer's demands. The models for different ISS are developed for different demand patterns. Four ISS and three demand patterns are considered as shown in Table 68.1.

Result and Discussion

In this paper, the impact of variation of different parameters is discussed, and the performance is measured in terms of inventory, backorders, inventory, ordering, and holding cost and service level. Also, the effects of ISS on all the levels of a supply chain are presented. The results show how all the nodes are affected by IS and which demand pattern is more sensitive to IS. First, the effect of order lead time and lead time uncertainty on supply chain performance has been studied.

Table 68.1 Levels of information sharing and demand pattern

Variable	No. of levels	Values and labels
Information-sharing strategies (ISS)	4	1. No information sharing (NIS) 2. Retailer-distributor information sharing (RDIS) 3. Distributor-manufacturer information sharing (DMIS) 4. Retailer-distributor-manufacturer information sharing/full information sharing (FIS)
Customers demand pattern	3	1. Stationary demand 2. Volatile demand 3. Unknown demand

Information-sharing Strategies and Parameters

As indicated in figures from Figs. 68.4 and 68.5, it is observed that sharing information among supply chain echelons is generally beneficial in terms of reducing inventory levels under all the three demand patterns with the largest benefit when all the nodes share information. Looking through Figs. 68.4 and 68.5 and moving from left-hand side to right-hand side, it can be observed that inventory improvements are in general similar in all the sharing modes. Percentage improvement under stationary and volatile demand environments is generally similar, although there is

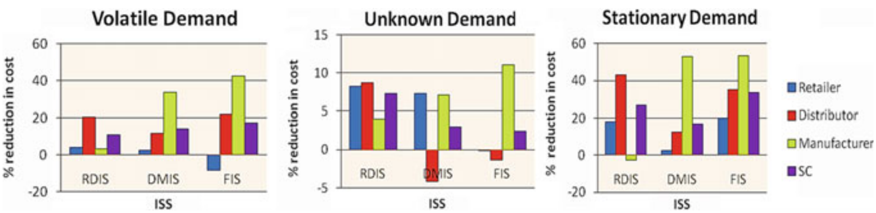

Fig. 68.4 Percentage reduction in inventory for volatile, unknown, and stationary demand after information sharing in supply chain in ABC Limited

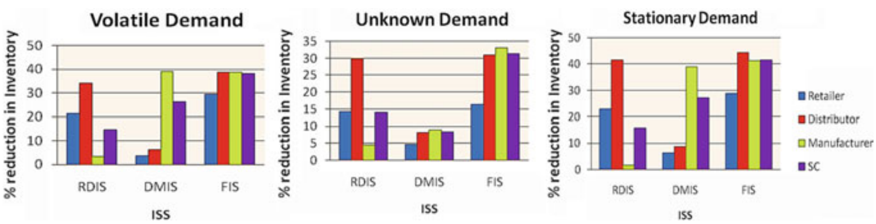

Fig. 68.5 Percentage reduction in cost for volatile, unknown, and stationary demand after information sharing in supply chain in ABC Limited

Table 68.2 Performance parameters of supply chain with various order lead time (OLT)

OLT (days)	Inventory level	Backorders	Inventory cost	Backorder cost	Ordering cost	Total cost	Service level
Retailer							
7	1317	865	72,464	7916	72,246	152,626	0.871
14	1392	1422	80,311	11,108	76,517	167,936	0.781
21	1468	1989	86,523	16,825	88,303	191,651	0.694
Distributor							
7	3224	0	61,924	0	72,245	134,169	1
14	3480	1452	67,294	5728	95,449	168,471	0.816
21	4648	4787	84,838	46,169	109,457	240,464	0.711
Manufacturer							
7	12,320	0	111,887	0	102,254	214,141	1
14	15,803	1456	179,272	4367	131,372	315,011	0.916
21	20,347	2753	250,270	12,344	159,993	422,607	0.818

a slight decrease when we move from stationary to volatile and unknown demand conditions. Echelons are always benefited when their immediate downstream nodes share their demand information. This is so because it helps the upstream node to predict the market and accordingly manages its activities. Under stationary demands, distributors and manufacturers lower their inventory levels to more than 40% when there is full information sharing. In general, the retailer's performance is lower than the average performance of the supply chain. Here, the effect of information delays is studied; i.e., if the order information is not reached on time or there is delay in decision making, then how this will be going to affect different parameters of SC and these effect will be seen on every level. The delivery lead time is certain and constant for each level, i.e., lead times of retailer = 5, distributor = 10 days, manufacturer = 8 days. The variation of order delay time (OLT) is shown in Table 68.2.

For constant order delay time, uncertainty in delivery lead time is taken as a variable. The results when lead time is constant ($S_L = 0$) and when there is uncertainty ($S_L = 3$) are given for various performance measures in Table 68.3.

Discussion

By simulation experiments with some real time and approximate data, it was found that:

- With an increase in order lead time, the inventory level, backorders, and total cost increase, while the service level decreases.
- With lead time uncertainty, there is a decrease in inventories and service level, while backorders and the total cost increase.

Table 68.3 Performance parameters of supply chain with different service level (SL)

Retailer							
SL	Inventory level	Backorders	Inventory cost	Backorder cost	Ordering cost	Total cost	Service level
0	1392	1422	80,311	11,108	76,517	167,936	0.7812
3	2840	738	159,994	4908	85,258	250,185	0.9075
Distributor							
0	3480	1453	67,294	5728	95,449	168,471	0.8168
3	10,997	479	154,505	1597	131,146	287,249	0.9736
Manufacturer							
0	15,803	1456	179,272	4367	131,372	315,011	0.9167
3	81,063	384	302,342	1152	416,458	719,953	0.9367

- Sharing information among supply chain echelons is beneficial in terms of reducing inventory levels under all the three types of demand. Percentage improvement in reducing inventory level under stationary demand was found to be more as compared to unknown demand, so information sharing is more valuable under stationary demand patterns.
- The experiment has shown that the reduction in inventory level is more important than the generation of backorders as the problem of backorders seldom arises in case of items like a lock which has enough shelf life.
- It has been found that the value of information sharing is different for different echelons of supply chain. Retailers are not benefited from information sharing to the same extent as distributors and manufacturers. The manufacturer is most sensitive to information sharing especially when demand patterns are stationary and volatile.
- Although in the present study, both inventory level and inventory cost have been considered; inventory level seems to be more general as holding cost must consider the fluctuation in price depending on the nature of items. For computers or food items, the holding cost must include the decrease in the price of items or loss of products.

Conclusion

The paper is an attempt to measure the performance of each echelon and supply chain by different ISS under varying demand patterns. A template for supply chain simulation has been created. A simulation model at different nodes of the supply chain in ARENA for different ISS is developed. It has been analyzed that under which demand pattern information sharing is more valuable and beneficial to various levels and to the entire supply chain.

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