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# Assessing the Impact of Information Technology on Supply Chain Management

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**Abstract:** Companies attempt to companies are attempting to find ways to improve their flexibility and responsiveness and in turn competitiveness by changing their operations strategy, methods and technologies that include the implementation of Supply Chain Management (SCM) paradigm. Hence, Information Technology (IT) can enhance the agility of SCM. The aspects, however, which IT impact on SCM are not equal. In this paper, we specify the areas that IT affects on supply chain and evaluate it. Since the judgments of Iranians automobile industry are qualitative, the evaluation has been done by fuzzy ranking method.

**Key words:** Information Technology • Supply Chain Management • Fuzzy Ranking ICT Project

## INTRODUCTION

The use of IT is considered as a prerequisite for the effective control of today's complex supply chains. Indeed, a recent study conducted by Forrester Research indicates that U.S. manufacturers are increasingly dependent on the benefits brought about by IT to: improve supply chain agility, reduce cycle time, achieve higher efficiency and deliver products to customers in a timely manner [1].

However, IT investment in the supply chain process does not guarantee a stronger organizational performance [2]. In fact, the adoption of a particular technology is easily duplicated by other firms and it often does not provide a sustained competitive advantage for the adopting firms [3]. The implementation of IT in the SCM can enable a firm to develop and accumulate knowledge stores about its customers, suppliers and market demands, which in turn influences firm performance [4].

The main objective of this paper is to provide a framework that illustrates the impacts of IT on SCM and evaluate this impact for some Iranians automobile industry supplier with their qualitative judgments. It is hard to explain the IT impact on SCM in quantitative values as the interaction of IT and SCM is not clear; thus, the Lee and Li fuzzy ranking method have been used for evaluating the impact of IT on SCM.

The rest of this paper is organized as follows. Definitions for IT and supply chain management (SCM) –as key subjects in this paper- are ambiguous. Therefore we begin with a brief review of the IT and supply chain. Then, impact of IT on SCM is argued and its framework is represented. The utilized fuzzy ranking method, afterwards, have been presented. Finally, experimental results for supplier of automobile industry in Iran have been presented. This is ended by conclusion.

**It systems:** As for IT systems, when discussing the use of IT in SCM, we refer to the use of interorganizational systems that are used for information sharing and/or processing across organizational boundaries. Thus, besides internal IT systems such as Enterprise Resource Planning systems we also consider identification technologies such as RFID from the scope of this study [5].

**Supply chain management:** A business network is defined as a set of two or more connected business relationships in which exchange in one relationship is contingent on (non-) exchange in another [6]. Stevens [7] defines SCM as 'a series of interconnected activities which are concerned with planning, coordinating and controlling materials, parts and finished goods from supplier to customer. A supply chain typically consists of the geographically distributed facilities and transportation links connecting these facilities. In services such as retail stores or a delivery service like UPS or Federal Express, the supply chain reduces to problem if distribution

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logistics, where the start point is the finished product that has to be delivered to the client in a timely, manner. As long as a pure service operation, such as a financial services firm or a consulting operation, the supply chain is principally the information flow [8].

**IT and SCM:** Recently with development of IT, the concepts of supply chain design and management have become a popular operations paradigm. The complexity of SCM has also forced companies to go for online communication systems. For example, the Internet increases the richness of communications through greater interactivity between the firm and the customer [9]. This illustrates an evolution in supply chain towards online business communities [10].

Supply chain management emphasizes the long-term benefit of all parties on the chain through cooperation and information sharing. This confirms the importance of IT in SCM which is largely caused by variability of ordering [11].

There have been an increasing number of studies of IT's effect on supply chain and interorganizational relationships [12]. In this paper, IT appears to be an important factor for collaborative relationships. A popular belief is that IT can increases the information processing capabilities of suppliers, thereby enabling or supporting greater relationship in addition to reducing uncertainty [13]. IT decreases transaction costs between buyers and suppliers and creates a more relational/cooperative governance structure, leads to closer buyer-supplier relationships [14], may decrease trust-based interorganizational partnerships and removes a human element in buyer-supplier interaction, while trust is built on human interaction [15].

As late description, in next section a main framework will represent to illustrate the impact of IT on SCM.

**The framework for impact of it on scm:** The research revealed that the most impact of IT on SCM is on procurement, logistic, firm, vendor relationship management and customer relationship management, which is described in follows.

**IT on Purchasing:** 1) The use of the IT in managing purchasing in the supply chains has developed rapidly over the last 10 years. The research demonstrates that the IT is utilized in a variety of procurement applications including the communication with vendors, checking vendor price quotes and making purchases from vendor catalogs. Vendor negotiation has also been streamlined through the use of the IT. Face-to-face negotiations are not used as frequently because the negotiations can conducted through the IT. This includes the bargaining, renegotiation, price and term agreements [16]. The receipt of queries from vendors, providing vendors with information and the processing of returns and damaged goods were all handled by the IT.

2) The other more popular use of the IT in supply chains is in order processing applications. The most frequent use of the IT here is in order placement and order status. Over half of the firms use the IT for this purpose. This has dramatically reduced the costs of order processing. The use of the IT in order processing has reduced the error rate involved in order processing. Errors now can be detected more easily and corrected more quickly.

**IT on Operation:** 1) One of the most costly aspects of supply chains is the management of inventory. The research has shown that the most popular use of the IT in this area is the communication of stock outs by customers to vendors, or the notification of stock outs by companies to their customers. The IT has enabled companies to more quickly institute EDI information programs with their customers. The IT has affected inventory management most dramatically in the ability of firms to be proactive in the management of inventory systems. This is demonstrated in the ability of firms to notify customers of order shipping delays and inventory emergencies, in order to decrease the delivery lead time and inventory.

2) Production scheduling has traditionally been the most difficult aspect of SCM. The IT has enabled firms to minimize the difficulty in their production scheduling by improving the communication between vendors, firms and customers. The research showed that some of the firms in the study use the IT to coordinate their JIT programs with vendors. In addition, some of the firms are beginning to use the IT to coordinate their production schedules with their vendors.

**IT on Logistic:** 1) The most popular use of the IT in supply chains is in the management of transport. Transportation typically is the highest cost component in a supply chain, according to literature review.

2) The research showed that the monitoring of pickups at regional distribution centers by carriers is the most popular application of the IT in this area. This is particularly important for a company, since tracking shipments to regional depots provides the firm with data on the reliability performance of the carriers it is using.

This enables transportation managers to make sure that the motor carriers they use are meeting their promised arrival times. It also provides managers with the information they need to inform carriers of shipment delays as they occur and to not have to wait for days before the information becomes available for corrective measures to be taken. Claims reporting, processing and settlement are more easily handled through the use of IT tracking system applications.

3) In production and logistics, many parties are involved in coordinating all the processes that are involved in fulfilling a customer's order: manufacturer, suppliers of parts and subassemblies, material managers, logistics managers, transportation carriers, customer service representatives, quality assurance staffs and others. The goals are to reduce the cycle time to fill a customer's order, reduce the inventory of parts, work in process and finished goods in the pipeline, increase the accuracy and completeness of filling a customer's order and of billing him for it and accelerate the payment for the delivered items to put cash in the bank as soon as possible. To achieve this degree of Order Cycle Integration, manufacturers, merchandisers and their trading partners are using IT.

**IT on Customer Relationships:** Many management experts argue that, by focusing on total customer satisfaction, a company can improve its processes to deliver better service at a lower cost. Customer-satisfaction driven is often described as the next step beyond TQM, total quality management: the objective is not simply to deliver some abstract definition of quality, but to deliver total satisfaction to the customer, of which the delivery of quality is only a part. Meanwhile, in the past, customer information could not be fully utilized in setting processes of firms' conditions. With recent increase in the speed of the IT, it has provided firms with the ability to offer their customers another way to contact the firm regarding service issues and integrate customer information and firm information to bring great benefits to both customer and firm. The research shows that some of the companies use the IT to receive customer complaints, while the others utilize it for emergency notifications.

**IT on Vendor Relationships:** 1) For IT in general, Bakos and Brynjyoolfsson [14] propose that IT deployment in supply chains leads to closer buyer-supplier relationships. Stump and Sriram [17] provide empirical evidence that the use of IT is associated with the overall closeness of buyer-supplier relationships. Subramani [13] reports a positive relationship between an IT-based supply chain and organizational benefits. Grover et al. [18] suggest that the decision to use IT within the dyad could encourage the commitment to establishing relational behavior. Their results show that IT decreases transaction costs between buyers and suppliers and creates a more relational/cooperative governance structure.

2) Trust plays a key role in any organizational relationship that IT facilitates it. Trust exists when a party believes that its partner is reliable and benevolent [18]. There has been a noticeable increase in the importance of trust in different forms of interorganizational relationships in management literature. The need for trust between partners has been identified as an essential element of buyer-supplier relationships.

3) Studies recognize long-term orientation commitment as a predictor for successful interorganizational relationships [19]. Long-term orientation refers to parties' willingness to exert effort in developing long-term relationships. Such willingness is frequently demonstrated by committing resources to the relationship, which may occur in the form of an organization's time, money, facilities, etc. Productivity gains in the supply chains are possible when firms are willing to make transaction or relation-specific investments, an important indication of commitment that was increased by IT.

4) Several studies suggest that successful buyer-supplier relationships are associated with high levels of information sharing. Information sharing (quality and quantity) refers to the extent to which critical and proprietary information is communicated to one's supply chain partner. IT caused to open and collaborative information sharing lead to positive effects on interfirm relationship.

**IT on Firm:** 1) To keep costs down, an organization must have a high level of discipline: each person knows what needs to be done, knows how to do it and does it quickly and efficiently. This argues for the organization to have a high degree of standardized procedures and for everyone to be trained in these procedures and to execute them without question. Yet, in an-ever-changing market place, it is important to also be able to innovate, to offer new service packages and new organizational linkages with the customer. To do this requires a discipline of change which encourages innovation and yet retains the stability of existing procedures until innovations are ready for wide-spread adoption. IT could overcome this problem.

2) IT usage was also explored in the context of the size of the firm with two measures-the number of employees and sales volume. As measured by the number of employees, larger firms were more likely to use the IT to communicate with customers on order status and to manage the outsourcing of customer service functions.

3) Each customer and each local situation will be different. If a company is serving a major multinational customer, then it will have to provide, or coordinate the provision of service, in a number of different countries and regions. In each situation, there are unique local characteristics, customs, business practices and ways of getting things done effectively. The same global procedures cannot be applied uniformly in every local situation. IT made a balance between the desired uniformity of global practices and the local variations.

4) The need for continued learning is acute in today's competitive environment. As new teams are formed, individuals must be able to learn rapidly what is needed to deal with a new set of issues. As new knowledge is developed, it must be made available to other members of the team and to individuals in other parts of the larger organization, that IT has the main impact on improving this process.

5) An organization must be "tight" at the same time that it is "loose". By light, we mean the need to have a lean, disciplined operation, in which there is a strong and ceaseless attention to keeping costs down and providing quality service at the same time. By loose, we mean the need to be innovative, to be responsive to customers' needs, to be flexible and adaptive to changing conditions and changing customer needs. This is the other area that IT has critical impact on firm in the SCM.

## FUZZY RANKING METHOD

Fuzzy set theory provides a framework for handling the uncertainties. Zadeh initiated the fuzzy set theory [20]. Bellman presented some applications of fuzzy theories to the various decision-making processes in a fuzzy environment [21]. In non-fuzzy set every object is either a member of the set or it is not a member of the set but in fuzzy sets every object is to some extent member of a set and to some extent it is member of another set. Thus, unlike the crisp sets membership is a continuous concept in fuzzy sets. Fuzzy is used in support of linguistic variables and there is uncertainness in the problem. Fuzzy theory is widely applicable in information gathering, modeling, analysis, optimization, control, decision making and supervision.

A fuzzy number is a fuzzy set Ã on R which possesses as the following three properties:

Ã is a normal fuzzy set;

Special cases of fuzzy numbers include crisp real number and intervals of real numbers. Although there are many shapes of fuzzy numbers, the triangular and trapezoidal shapes are used most often for representing fuzzy numbers. The following describes and definitions show that membership function of triangular and trapezoidal fuzzy number and its operations.

A triangular fuzzy number can be defined by a quadruplet $\tilde{A} = (a_1,a_2,a_3)$, where $a_1 \le a_2 \le a_3$, its member function represented as follows.

$$\mu_{\tilde{A}} = \begin{cases} 0 & x < a_1 \\ (x-a_1)/(a_2-a_1) & a_1 \le x \le a_2 \\ (x-a_3)/(a_2-a_3) & a_2 \le x \le a_3 \\ 0 & x > a_3 \end{cases} \quad (1)$$

Let Ã and $\tilde{B}$ be two fuzzy numbers parameterized by the quadruplet $(a_1,a_2,a_3)$ and $(b_1,b_2,b_3)$, respectively. Then the operations of triangular fuzzy numbers are expressed as [22]:

$$\begin{aligned} &\tilde{A}(+)\tilde{B} = (a_1,a_2,a_3)+(b_1,b_2,b_3) = (a_1+b_1,a_2+b_2,a_3+b_3) \\ &\tilde{A}(-)\tilde{B} = (a_1,a_2,a_3)-(b_1,b_2,b_3) = (a_1-b_1,a_2-b_2,a_3-b_3) \\ &\tilde{A}(\times)\tilde{B} = (a_1,a_2,a_3)\times(b_1,b_2,b_3) = (a_1\times b_1,a_2\times b_2,a_3\times b_3) \\ &\tilde{A}(\div)\tilde{B} = (a_1,a_2,a_3)\div(b_1,b_2,b_3) = (a_1\div b_3,a_2\div b_2,a_3\div b_1) \end{aligned} \quad (2)$$

Triangular fuzzy numbers are appropriate for quantifying the vague information about most decision problems [23,26]. And the primary reason for using triangular fuzzy numbers can be stated as their intuitive and computational-efficient representation.

In this paper, the triangular fuzzy number is used for measuring Intellectual Capitals. More details about arithmetic operations laws of trapezoidal fuzzy number can be seen in [24,27].

Considering experts $E_i$ provide the possible realization rating of a certain Intellectual Capital. The evaluation value given by each expert $E_i$ are presented in the form of a triangular fuzzy number

$$\tilde{A}^{(i)} = (a_1^{(i)},a_2^{(i)},a_3^{(i)}), where \quad i = 1,2,...,n \quad (3)$$

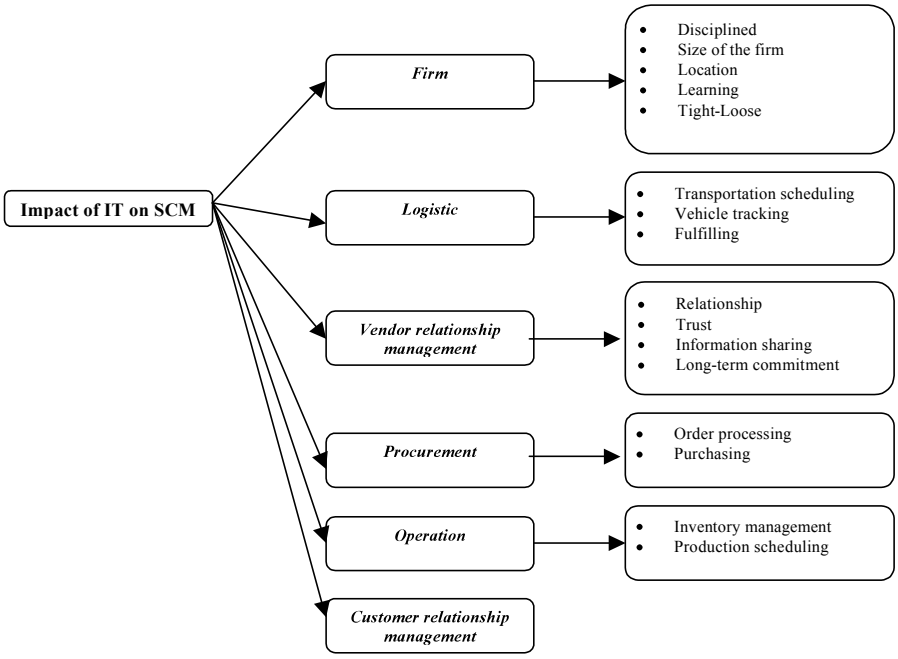


Fig. 1: Framework for impact of IT on SCM

The average $\tilde{A}_m$ of all $\tilde{A}^{(i)}$ is computed using average means

$$\tilde{A}_m = (a_{m1}, a_{m2}, a_{m3}) = (\frac{1}{n}\sum_{i=1}^{n} a_1^{(i)}, \frac{1}{n}\sum_{i=1}^{n} a_2^{(i)}, \frac{1}{n}\sum_{i=1}^{n} a_3^{(i)}) \quad (4)$$

A large variety of methods have been developed in an attempt to order fuzzy numbers [25]. Lee and Li ranked the fuzzy numbers based on the probability measure consider the mean and variance of the fuzzy numbers. According to the uniform probability distribution, they proposed the following fuzzy numbers ranking.

1) Calculate the mean of the fuzzy numbers $\tilde{A}(M_u(\tilde{A}))$ and compare them. The biggest fuzzy number has the biggest mean.

$$M_u(\tilde{A}) = \frac{\int_A x\mu_A(x)dx}{\int_A \mu_A(x)dx} \quad (5)$$

Where $\mu_A(x)$ is the membership function of $\tilde{A}$. If $\tilde{A}$ is a triangular fuzzy number, the following formula should be used.

$$M_u(\tilde{A}) = \frac{1}{3}(a^1 + a^2 + a^3) \quad (6)$$

2) If more than one fuzzy number has the same mean, calculate its variance.

$$G_u^2(\tilde{A}) = \frac{\int_A x^2\mu_A(x)dx}{\int_A \mu_A(x)dx} - M_u^2(\tilde{A}) \quad (7)$$

The fuzzy number with lowest value is the biggest fuzzy number.

Use the following fuzzy number providing that $\tilde{A}$ is a triangular fuzzy number.

$$G_u^2(\tilde{A}) = \frac{1}{18}((a^1)^2 + (a^2)^2 + (a^3)^2 - a^1a^2 - a^1a^3 - a^2a^3) \quad (8)$$

## EXPERIMENTAL RESULTS

The impacts of IT on SCM have been delivered to some experts of automobile industry of Iran who were the supplier of this industry. Obtained results have been illustrated in table 1. The averages of responding have been calculated according to relation (4).

The mean and variance of the total value of table 1, which are triangular fuzzy numbers, have been computed and illustrated in table 2.

As have been shown in table 2, customer relationship management is the first and has more impact on SCM as

Table 1: The average opinion of the automobile industry experts of Iran for impact of It on SCM

| First indexes | value | Second indexes | value | Total value |
|---|---|---|---|---|
| Firm | (5.2,8.1,8.9) | Disciplined | (6.2,7.1,7.9) | (32.2,57.570.3,) |
| | | Size of the firm | (3.1,4.5,4.9) | (16.1,36.5,43.6) |
| | | Location | (3.5,3.9,4.4) | (18.2,31.6,39.2) |
| | | Learning | (6.3,7.6,8.9) | (32.8,61.6,79.2) |
| | | Tight-Loose | (2.2,3,4.6) | (11.4,24.3,40.9) |
| Logistic | (3.5,4.2,6.1) | Transportation scheduling | (5.3,6.9,8.9) | (18.6,29,54.3) |
| | | Vehicle tracking | (6.2,7.2,8) | (21.7,30.2,48.8) |
| | | Fulfilling | (7.3,8.9,9.1) | (25.6,37.4,55.5) |
| Vendor relationship | (7.2,8.1,9.3) | Relationship | (6.3,7,8.1) | (45.4,56.7,75.3) |
| | | Trust | (2,3,3.7) | (14.4,23.3,34.4) |
| | | Information sharing | (8.5,8.9,9.9) | (61.2,72.1,92.1) |
| | | Long-term commitment | (4,6.4,7) | (28.8,51.8,65.1) |
| Procurement | (7.9,8.5,9.6) | Order processing | (7.8,9.2,9.9) | (61.6,78.2,95) |
| | | Purchasing | (7,7.9,8.8) | (55.3,67.2,84.5) |
| Operation | (6.3,7.8,8.6) | Inventory management | (7.8,8.4,9.6) | (49.1,65.5,82.6) |
| | | Production scheduling | (6,6.9,8.3) | (37.8,53.8,71.4) |
| Customer relationship management | (8.1,9.3,9.6) | | | (65.6,86.5,92.2) |

Table 2: The mean and variance of the scored indexes for impact of IT on SCM

| First indexes | Second indexes | Mean | Variance | Ranking |
|---|---|---|---|---|
| Firm | Disciplined | 53.4 | 62.5 | 9 |
| | Size of the firm | 32.1 | 33.9 | 14 |
| | Location | 29.7 | 18.8 | 15 |
| | Learning | 57.8 | 91.6 | 17 |
| | Tight-Loose | 25.6 | 36.5 | 16 |
| Logistic | Transportation scheduling | 33.9 | 56.3 | 12 |
| | Vehicle tracking | 33.6 | 32 | 13 |
| | Fulfilling | 39.5 | 38 | 11 |
| Vendor relationship | Relationship | 59.1 | 38.2 | 6 |
| | Trust | 24.4 | 16.7 | 17 |
| | Information sharing | 75.1 | 40.9 | 3 |
| | Long-term commitment | 48.6 | 56.2 | 10 |
| Procurement | Order processing | 78.3 | 46.5 | 2 |
| | Purchasing | 69 | 35.9 | 4 |
| Operation | Inventory management | 35.7 | 46.5 | 5 |
| | Production scheduling | 54.3 | 47 | 8 |
| Customer relationship management | | 81.4 | 32.6 | 1 |

a segment of IT. In addition, procurement and operation has more impact after customer relationship management on SCM. Most of the experts (7 of 8) were agree with outputs, which it shows the accuracy of the framework and computing method.

## CONCLUSION

In this article, at first was presented the definition of IT and SCM; afterward, the impact of IT on SCM was illustrated in a framework. It is important that, the impact of IT on SCM is much larger as it facilitates inter-organizational communication and in turn reduces cycle times and develops collaborative work. IT provides opportunities for an organization to expand their markets worldwide. Also, IT enhanced teamwork and customer relationship management. To evaluate the impact of IT on SCM of automobile industry of Iran, it was tested by 8 experts of Iranians automobile industry supply chains, which 90% were pleased with the obtained results.

The proposed framework support the huge area of IT based SCM and can be used as a controller to evaluate the SCM progress through use of IT.

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