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A Review of the Roles and Importance of Information and Communication Technologies (ICTs) in Supply Chain Management (SCM) of Organizations and Companies

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Abstract

In various service providing companies and organizations worldwide, Information and Communication Technologies (ICTs) play a role in the process of providing effectively efficient services, products and packages to better satisfy their customers. The increasing importance of ICT in Supply Chain Management (SCM) however, presents two main positive and negative alternatives for organizations: (i) to positively pursue the expensive and problematic procedures of becoming a value-added organization or company through an extensive use of ICT or (ii) to survive in the low-cost world of service providers. Our main objective for this research paper is to review literature and present related work on the roles ICT play in SCM and also outline the importance of adopting ICT in SCM, in order for companies and organisations to render and provide effective and efficient services.

Keywords: *Supply Chain Management (SCM), Organization(s), ICT, Companies, Customer(s)*

1. Introduction

In recent years, a growing number of companies and organizations such as manufacturers, retailers, shipping lines, telecommunication operators, mining companies, hospitals etc. have adopted the Supply Chain (SC) concept for the management of their businesses. The delivery system of these companies has become an integral part of the supplied product [1]. Supply Chain Management (SCM) has gained increasing prominence in recent years. SCM is an approach which is being viewed by companies in many sectors as a key source of competitive advantage [2]. The acceleration of physical and information flows along the multiple levels of the Supply Chain (SC) is making the whole logistical system more flexible, effective and efficient is responding to swift market changes [1].

The use of ICT by organizations and companies is considered as a prerequisite for the effective control of today's complex Supply Chains. ICT facilitates the management of interconnecting major information flows to good flows among all actors in the service production process of an organization or company [1]. A recent study conducted by Forrester Research indicates that U.S. manufacturers are increasingly dependent on the benefits brought about by IT/ICT to: improve supply chain agility, reduce cycle time, achieve higher efficiency and deliver products to customers in a timely manner [4] cited by Fasanghari et al., (2008) [3]. In order for organisations and companies to succeed in their service rendering efforts they have to develop Management Information Systems (MIS).

According to [3] the use of ICT in SCM can be referred to the integration of interorganizational ICT in SCM. According to Fasanghari et al., (2008) [3] the integration of interorganizational systems such as information sharing and/or processing are used across organizational boundaries for SCM. Thus, besides internal ICT systems such as Enterprise Resource Planning (ERP) systems, other identification technologies such as Radio Frequency Identification (RFID) can also be considered in SCM [3].

The main objective of this research paper is to review literature and related work on the roles ICT play in SCM and also outlines the importance of adopting ICT in SCM,

so that companies and organizations can provide effective and efficient services.

This paper is formulated and subdivided as follows: After the Introduction, Section 2 presents a Literature Review and Section 3 presents an outline of the importance of ICT in the SCM of companies and organisations. Section 4 elaborates on an Overview of the State-of-the-Art in the research areas of ICT in SCM. Discussions are elaborated in Section 5 and Section 6 concludes the paper with a recommendation.

2. Literature Review

2.1 Supply Chain Management (SCM)

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 [5]. Stevens (1989) [6] 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 United Parcel Service (UPS) or Federal Express, the supply chain reduces to a problem if distribution 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 [7].

The National Institute of Transport and Logistics (NITL)[1] cited by [2] define SCM in terms of its ***Four Fundamentals***.

Fundamental One (1)

Firstly, the objectives of SCM are to meet or exceed the required or demanded customer service level in targeted markets/segments and to optimise total Supply Chain (SC) investment and cost. Customer service requirements, dictated by the market place, "set the specification" for the Supply Chain (SC). Achieving this level of service at the optimal cost focuses attention on the elimination of "non value adding activities" (NVAs) throughout the Supply Chain (SC).

Fundamental Two (2)

Secondly, every product or service is delivered to the final consumer (the only source of "real" money in the chain) through a series of often complex movements between companies which comprise the complete chain. Inefficiency anywhere in the chain will result in the chain as a whole failing to achieve its true competitive potential. The phrase "Supply Chain (SC)" is used to indicate that the chain is only as strong as its weakest link.

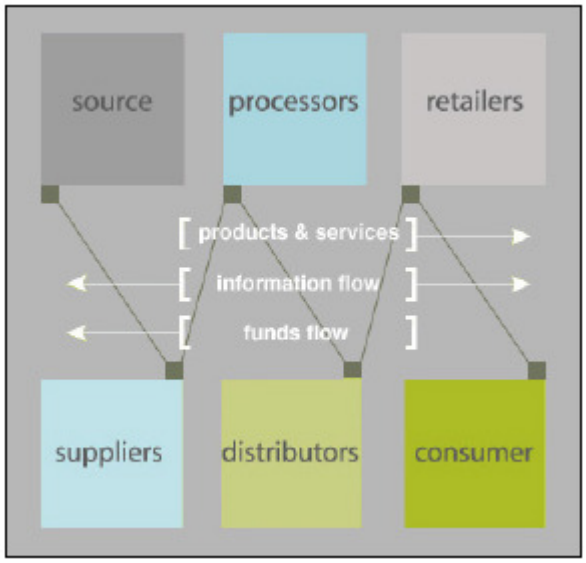

Fig.1 The External Supply Chain

The representation in Figure 1 (above) of a "macro" Supply Chain (SC) shows materials flowing from raw material source through the various stages in the chain to the final consumer. Money then flows back down the chain. The key point is that every link matters and that value is added, and profit generated, at each link along the way. Most businesses can be described in terms of the five functions buy, make, store, move and sell - known as the "micro" or internal supply chain as shown in Figure 2.

Fig 2. The Internal Supply Chain

Traditionally these functions have been managed in isolation (*functional silos*), often working at cross purposes. Supply Chain Management means thinking beyond the established boundaries, strengthening the linkages between the functions, and finding ways for them to pull together. A recognition that the whole is greater than the sum of the parts calls for more effective integration between purchasing and procurement (buy), production planning and control (make), warehouse management (store), transport management (move) and customer relationship management (sell), as illustrated in Figure 3.

Fig. 3 Integration in the Internal Supply Chain

Fundamental Three (3)

For a Supply Chain (SC) to achieve its maximum level of effectiveness and efficiency, material flows, money flows and information flows throughout the entire chain must be managed in an integrated and holistic manner, driven by the overall service and cost objectives. It can be argued that managing the information flows is considered the most critical of these activities. This is because the flow or movement of materials or money is usually triggered by an associated information movement. Effective management of material and financial flows is, therefore, predicated upon the effective management of the related information flows. For this reason, Information and Communication Technology (ICT) is becoming an increasingly important SCM enabler.

Fundamental Four (4)

Finally, this holistic approach requires a reappraisal of the way in which both internal and external customer/supplier relationships are created and managed. SCM is not a "zero-sum" game based on adversarial relationships. Rather, it needs to be a "win-win" game based on partnership approaches. This point is relevant to the interactions between the key "internal" supply chain functions of buy, make, store, move and sell, as well as to foster relationships between an organisation and its external customers and suppliers.

2.2 Definition of ICT

ICT (information and communications technology - or technologies) is an umbrella term that includes any communication device or application, encompassing: radio, television, cellular phones, computer and network hardware and software, satellite systems and so on, as well as the various services and applications associated with them, such as videoconferencing and distance learning [8]. ICTs are often spoken of in a particular context, such as ICTs in education, health care, or libraries. As pointed out earlier, Information and Communications Technology (ICT) has become a key enabler in the management of supply chains.

Recent years have seen the development of a plethora of Supply Chain ICT applications. In broad terms these can be classified into four areas as follows [8].

2.2.1 "Point" Solutions of SCM Through ICT

These are ICT applications which support the management of one link in the Supply Chain. At the "store" link in the supply chain Warehouse Management Systems (WMS) aim to support the efficient management of stored goods through, for example, the optimisation of warehouse space and the factoring in of rules which maximize the shelf life of products. Wireless networks can link warehouse staff (e.g. using handheld terminals) and forklifts with real-time picking systems. In this way, orders can be filled much faster and more accurately than with manual procedures.

2.2.2 "Best of Breed" Solutions of SCM Through ICT

This approach aims to integrate the best of a company's existing point solutions. The main weakness of point solutions is that the various systems in use may not communicate well, may use different databases and may not have high levels of connectivity. This can result in "islands of automations" – the situation where many different applications simply do not work well together (*poor interfacing*). "Middleware" companies have developed data translation technology that has enabled organisations to adopt a more integrated "best of breed" approach. In essence, this technology is software that connects two otherwise separate applications.

2.2.3 "Enterprise" Solutions of SCM Through ICT

This approach, based on Enterprise Resource Planning (ERP), came about in the 1990s because of an organisational shift away from the traditional function-based structures towards more process-based approaches (in line with *Fundamental 2* of SCM). The phrase ERP was first coined by the Gartner Group to describe the change in computer systems from the inventory focused, transition-centric and reactive nature of ERP's predecessors – Materials Requirements Planning (MRP) and Manufacturing Resource Planning (MRP II) – two systems focused on customer service. ERP attempts to integrate all departments and functions across a company into a single computer system that can serve all those different departments' particular needs. Traditionally, each department from finance to human resource management to the warehouse had its own computer system, each optimised for the particular ways that the department does its work. But ERP combines them all together into a single, integrated software program that runs off a single database so that the various departments can more easily share information and communicate with each other.

3. Importance of ICT in SCM

Supply Chain Management (SCM) as defined by Tom McGuffog is "Maximizing Added Value and Reducing Total Cost across the Entire Trading Process through Focusing on Speed and Certainty of Response to the Market" [2]. Due to globalization and ICT, SCM has become a tool for companies to compete effectively either at a local level or at a global scale[2]. SCM has become a necessity especially for manufacturing industry when it comes to deliver products at a competitive cost and at a higher quality than their competitors[2].

With the rapid development of ICT, the concepts of supply chain design and management have become a popular operations paradigm. The complexity of SCM has also forced companies to go in for online communication systems such as Electronic Procurement (E-Procurement). For example, the Internet increases the richness of communications through greater interactivity between the firm and the customer [9] cited by Fasanghari et al., (2008) [3]. This illustrates an evolution in the Supply Chain towards online business communities [10]. SCM emphasizes the long-term benefits of all parties on the chain through cooperation and information sharing. This confirms the importance of ICT in SCM which is largely caused by variability of ordering [11]. There have been an increasing number of studies of ICT effects on SCM and interorganizational relationships [1, 2, 3, 12, 17, 18, 19, 20, 21. 22]. ICT appears to be an important factor for collaborative relationships. A popular belief in ICT can increase the information and communication processing of suppliers, thereby enabling or supporting greater relationship in addition to reducing uncertainty [13]. ICT decreases transaction costs between buyers and suppliers and creates a more relational/cooperative governance structure that leads to closer buyer-supplier relationships [14] cited by Fasanghari et al., (2008) [3], which may decrease trust-based interorganisational partnerships and remove a human element in buyer-supply interaction, while trust is built on human interaction [15] cited by Fasanghari et al., (2008) [3]. Table 1 below illustrates through factors and frameworks, what makes ICT important in SCM. Various factors and frameworks such as purchasing, logistics, operations, vendor relationships, customer relationships are all elaborated with reason in table 1.

Table 1. Why is ICT Important in SCM of Organisations
Source: Fasanghari et al., (2008) [3]

Factor/Framework	Reason
Purchasing and Electronic Procurement (E-Procurement)	The use of the ICT in managing purchasing in the supply chains has developed rapidly over the last 10 years. Current research demonstrates that ICT is utilized in a variety of procurement applications including the communication with vendors, checking vendor price quotes and making purchases from vendor catalogues. Vendor negotiation has also been streamlined through the use of the ICT. Face-to-face negotiations are not used as frequently because the negotiations can be conducted through ICT. 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 can all be handled by ICT. Supply chain procedures such as order process applications done by most organisation use ICT. The most frequent use of ICT in this scenario is order placement and order status. More than half of organisations and firms use ICT for this SCM purposes and operations. This has drastically reduced the costs of order processing involved in

	purchasing. As a result of ICT and e-procurement, errors involved in procurement and purchasing processes can be detected more easily and corrected more quickly.
Logistics and Transport	ICT is used in SCM to manage logistics and transport. According to literature review and Evangelista (2002) [1], transportation is typically the highest cost component in a Supply Chain (SC). Research has shown that the monitoring of pick up vehicles at regional distribution centres of companies and organisations by carriers is the most popular application of ICT in the area of logistics and transport. This is important for companies or organisations such as shipping lines and ports since tracking shipments to regional depots provides them with data on the reliability performance of the carriers being used by the organisation or company.
Operations	One of the most costly aspects of SCM involves the management of the inventory of a company. Research has shown that the most popular use of ICT in the area of inventory in supply chains is the communication of stock outs by customers to vendor or the notification of stock outs by companies to their customers. ICT has enabled companies to quickly institute and implement Electronic Data Exchange (EDI) programs with their customers to help in communication and operations of an organization or company.
Vendor Relationships	Bakos and Brynjyoolfsson (1993) [14] proposed that the deployment of ICT in SCM leads to closer buyer-supplier relationships. Grover et al., (2002) [12] suggest that the decision to use ICT within the SCM could encourage the commitment of establishing relational behaviour. The results of Grover et al., (2002) [12] show that ICT decreases transaction cost between buyers and suppliers and creates a more relational/cooperative governance structure. Trust and privacy plays an important and key role in any orgnisational relationship that is facilitated by ICT. Trust exists when a party believes that its partner is reliable and benevolent (Grover et al., 2002) [12]. There has been a noticeable increase in the importance of trust in different forms of interorganisational relationships in management literature. The need for trust between partners has been identified as an essential element of buyer-supplier relationships in SCM and ICT has improved trust between organizational partnerships.
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 is often driven beyond the next step of Total Quality Management (TQM). The objective of an organisation is not to simply deliver some abstract definition of quality, but to deliver total satisfaction to the customer, of which the delivery of quality is only a part. In the past, customer information could not be fully utilized in setting processes of firms' conditions. The recent proliferation of ICT has provided companies and organisations the ability to offer their customers another way to contact the organisation or company regarding service issues. Through ICT there has been integration of customer information and organisation/company information which brings and introduces great benefits to both customer and the organisation/company. Research shows that some companies use ICT to receive customer complaints, while others utilize it for emergency notifications.

4. An Overview of the State-of-the Art: ICT In SCM

Research involving the relationship, roles and importance of ICT in SCM has been/is currently being conducted, by various researchers. Notable among these researchers ideas include how ICT can be used to enhance SCM operations in companies and organisations.

Due to the widespread adoption of supply chain view by shippers, transport providers, Evangelista (2002) [1] discusses the increase in requirements to offer global logistics service packages to better satisfy customer needs. Information and communication Technologies (ICTs) play a key role in this process, assuring the linkage between chain participants as well as a more effective control of time, cost and equality of the services rendered. Nevertheless, Evangelista (2002) [1] emphasizes that the introduction of ICT is not equally distributed in the industry. In case of maritime transport, shipping lines seem to be comparatively slow in implementing ICT in comparison with parcel delivery companies or large freight forwarders. The increasing importance of ICT for logistics as well as for Supply Chain Management (SCM)

presents ocean carriers with two alternatives presented by Evangelista, (2002) [1] and include: either to survive in a low-cost world of transport providers or to pursue the expensive and problematic path of becoming value-added providers through an extensive use of ICT. Apart from analyzing the impact of ICT on the container shipping industry, Evangelista, (2002) [1] also shows the way shipping trade is transformed from the conventional hardware-based into a know-how service industry.

Sweeney, (2005) [2] emphasizes on how Supply Chain Management (SCM) has gained increasing prominence in recent years. SCM is an approach which is being viewed by organisations and companies in many sectors as a key source of competitive advantage. Sweeney, (2005) [2] defines SCM and outlines the role of Information and Communication Technology (ICT) as a key enabler of the process.

The need for flexibility and adaptability to customer requirements requires a new face of supply chain strategy that will help create both efficiency and value along the length of the chain, from raw materials stage to finished products. As a results, many 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 Fasanghari et al. (2008) [3] specific areas that IT affects on supply chain are evaluated. Since the judgments of Iranians automobile industry are qualitative, the evaluation in Fasanghari et al. (2008) [3] was done by fuzzy ranking method.

Today, Supply Chain Management (SCM) is as a principle underlying the implementation of electronic business world. In fact, the need for ICT in the current business environment cannot be underestimated. As a result of this underlying principle, Biniazi et al. (2011) [17] reviewed supply chain management issues and after expressing its concepts, its relationship with e-commerce and its role in general Information Technology were studied. Biniazi et al. (2011) [17] try to clarify the main concepts of Supply Chain Management (SCM) position in the development of Information Technology (IT), especially electronic commerce (e-commerce).

Nowadays in complex business environment it is very difficult for an organization to act independently (*no organization is an island*) on the market. Organizations which are participating in one or more supply chains could outperform their competitors, which are not taking part in any supply chain. In fact research has shown that, in recent times, companies are not competing again companies, but rather their supply chains are competing against other supply chains (Christopher, M, 2005) [23]. Therefore membership in one or more supply chains has become one amongst most important prerequisites, in order to retain/gain competitive advantage in modern business environment. One amongst most important considerations in the problematic of supply chain is its organization and especially its management, known as supply chain management.

Advancement in modern Information and Communication Technology (ICT) and Internet coupled with heightened interest for virtuality and virtual design of organizations has a great impact on many business segments/areas. Therefore organization of supply chain could vary on a continuum from traditional to virtual organization. To corroborate the above statements and scenarios, Nedelko, (2008) [18] discuses two thesis: (1) Information and Communication Technology (ICT) is a base for virtual organization of supply chain and for linking dispersed supply chain participants; and (2) The role and importance of modern Information and Communication Technology (ICT) for/in supply chain is importantly dependent upon geographic dispersion of supply chain participants.

Shavazi et al. (2009) [19] discuss how ICT and supply chain management (SCM) are two notions, which have attracted much attention among both academicians and practitioners during the last decade. However, the discussion of the relationship between the two notions has been limited and fragmented. In (Shavazi et al., 2009) [19], a summary of the discussion of ICT components and SCM based on an extensive literature review are presented. Shavazi et al. (2009) [19] further discuss the interrelation between ICT and SCM from some major components and applications of ICT perspective. Furthermore, Shavazi et al. (2009) [19] introduce e-SCM concept, that has arisen recently in management literature, in order to cover the whole topic. Shavazi et al. (2009) [19] look at all of the major components of electronic supply chain management and demonstrate that the future holds tremendous opportunity for those firms that take advantage of all its possibilities.

Information and Communication Technology (ICT) developments have strongly affected Supply Chain Management (SCM) in recent years. ICT has had a great impact on all supply chain processes including planning, purchasing, production management, stock management, physical distribution and related integration management. Technology has become an important dimension of third

party logistics (3PL) service supply because competitive advantage increasingly depends on the ability to create value for customers through the effective application of ICT. Within this process, while large 3PLs are gaining substantial benefits from technology usage and implementation, the magnitude of changes spurred by ICT dissemination in small logistics service providers remains unclear. This is reflected by the existing gap in literature where the role and competitive developing processes of small 3PLs are seriously underestimated. This gives rise to the need to develop research and investigation in this particular area. As a result of the above deficiencies and problems Evangelista et al. (2005) [20] had and objective of narrowing the knowledge gap in the field of ICT adoption in small 3PLs through an empirical investigation. Evangelista et al. (2005) [20] presented the results of a survey on a sample of small Italian 3PLs.

An extensive amount of research has been done in the important domain of Supply Chain Management (SCM) and its Integration with Information and Communication Technology (ICT). However pragmatic insight to address the SCM-ICT integration challenges based upon real world contemporary case studies are scanty. Shamim, et al. (2009) [21] targets Fast Moving Consumer Good (FMCG) companies located in Pakistan. Shamim, et al. (2009) [21] examine data from the FMCG sector in Pakistan and proposes a model for Key Realization Concepts for Supply Chain Success (KRC-SCS). During the course of this study involved in (Shamim, et al., 2009) [21], it was discovered that those FMCG companies which integrated ICT with SCM in a sequentially structured approach, took shorter learning curves, had realistic Return on Investment (ROI) expectations, and where the top management demonstrated greater appreciation and commitment towards technology as a solution facilitator, proved to be more successful than those who did not have these characteristics. Shamim, et al. (2009) [21] concluded that successful integration of ICT and SCM requires strategic commitment by the stakeholders and the top management, well thought and methodical plans of integration, rational ROI potential, and up to date technical know-how.

Zhang et al. (2011) [22] finds that measurements and constructs in all three major variables (ICT, SCM, SC performance) are different and often incomparable, and contextual factors are not systematically considered. Surprisingly, despite these differences, the research papers reviewed in (Zhang et al., 2011) [22] show that generally, there is a positive direct or indirect effect of ICT on performance and SCM. Therefore the purpose of Zhang et al. (2011) [22] based upon a structured literature review of the major journals in the fields of operations management, logistics, and information systems was to review and classify survey-based research connecting Information and Communication Technology (ICT), supply chain management (SCM) and supply chain (SC) performance. The review evaluated in (Zhang et al. 2011) [22] presented empirical results and aims at detecting explanations for similarities and differences in reported findings in the current literature. The research findings in (Zhang et al. 2011) [22] showed the possible inconsistency in reported findings within this field of research. Zhang et al. (2011) [22] offers a systematic review that helps to further develop our understanding of the relationship of SCM, ICT, and SC performance.
Zhang et al. (2011) [22] aimed at reviewing the survey-based literature only. Findings from case studies and other types of studies were not considered. An implication of Zhang et al. (2011) [22] might be to reconsider how future survey studies should be designed and what constructs and issues need to be incorporated. Specifically, the relationships between single technologies, aspects of SCM and performance dimensions need specific attention in future research.

5. Research Discussions

The review of roles and relationship of ICT and SCM coupled with the importance of ICT in SCM in this paper shows the relevance of these terms in organisations and companies. Table 1 outlines using factors and frameworks, reasons why ICT is important for integration in SCM. Section 2 also presented different fundamental definitions of SCM in a sequence of four (4) different steps and the role ICT plays in SCM. There is however a great challenge on how organizations can recognize the potential of ICT in SCM to meet their goals of providing better services offerings and provisions. According to literature, notable companies and organizations to this effect include shipping lines, transports and logistics companies/organisations and ports.

6. Conclusion & Recommendation

6.1 Conclusion

In this paper, we presented a review of the roles and relationships of ICT and SCM coupled with the importance of ICT in SCM. The research revealed that a lot of research has been/is being conducted in the area of ICT integration in SCM and without integration of ICT, results of managing Supply Chains will lead to poor SCM

procedures and operations that are likely to collapse or become highly unreliable, unresponsive and inefficient. Factors such as purchasing, e-procurement, operations, customer relationships, vendor relationships, transport and logistics as elaborated are all improved through the use of ICT in the SCM. Lately businesses are most often performed on a global level. Organizations and companies organize themselves into complex networks, mostly across many countries in different geographical location in order to meet the high and ever changing demand of the consumers around the globe. The procuring and storing of supplies, sub-components, assembly of final products and their delivery to consumers can all take place in widely separated geographical locations but can easily be integrated through the use of ICT. This has indeed place ICT as the topmost or critical driver to the success of all current business operations.

From experience, it is obvious that the relationship between the SCM partners within the chain can be sour when they are at cross-purpose or disintegrated and this can be improved or harmonized/integrated through the use of ICT. It is therefore extremely important for companies and organizations to ensure that they do develop and implement policies and process frameworks that will allow the integration of ICT applications into their SCM to enable greater process alignment that will drive further value in service delivery to customers and cost efficiency to their operations.

6.2 Recommendation

This paper through its review recommends that all organsations and companies should enforce implementation of ICT in SCM so as to meet the required profit and Return of Investment (ROI) standards in order to deliver the services they render and offer.

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