Integration and Efficiency Enhancement of Supply Chain by using Information and Communication Technology Tools

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Abstract:- **Adoption of information and communications technology (ICT) tools is gaining greater significance in Supply Chain Management. Currently, various ICT tools are used to process, analyze, store, distribute and exchange information among the supply chain partners. The aspect of how ICT tools affects the level of control integration is one of key research areas in SCM. Literature review indicates that there are diverse ICT tools, aspects and benefits arising out of supply chain integration. In this paper, we have identified ten major factors based on literature review and four major dimensions' aids in enhancing efficiency of supply chain by using ICT tools. A framework to assess the interdependence among the criteria is also developed. The model is developed based on the existing literature by employing a theoretical conceptual approach and also a case study. Future scope of research can be in the field of development of theoretical models based on the new emerging tools and technologies that are applicable to integration of supply chain.**

Keywords:- Supply Chain Integration; Information and Communication Technology (ICT) Tools; Supply Chain Efficiency.

I. INTRODUCTION

The main objective of a supply chain is to maximize the profit by delivering the product or service to meet the customer requirements. The integration of supply chain helps to coordinate the main three components of supply chain, i.e. materials, funds and information. Inventory, information, sourcing, transportation and pricing are the major drivers of supply chain integration that affects the performance of supply chain. The partners in a supply chain can be connected by using ICT which is a complex and protracted task. [1, 2].

Internet helps in allowing the partners in a supply chain to get networked and also to work on a real time basis, which is the core area of supply chain integration. Thus real time collaboration between the suppliers, manufacturers, wholesalers, retailers and customers can be done with the help of IT which can result in better integration of supply chain. IT facilitates supply chain professionals in decision making process on selection of suppliers, identifying capability and product or service

customization. Designing of a facility can be done with the help of ICT tools which helps in development of mathematical model to analyze effect of different parameters. IT in inventory management helps to maintain optimum inventory thereby reducing the inventory carrying cost without affecting the manufacturing process. IT also helps in gathering and processing of vital information which is the core aspect of planning and decision making process in the supply chain. Sourcing can also be done with the help of IT, which refers to the vendor selection for performing various activities. Transportation models can also be developed with the help of IT in selecting different modes of transport which are economical. Pricing of a product can also be done with the help of IT in balancing the immediate demands of a customer.

The advancements in information and communication technology (ICT) tools has a great impact on improving the efficiency of supply chains. Firms use networks to communicate regarding status of the order, inventory, and delivery schedule [3]. The vigorous nature of supply chain and the application of information technology (IT) tools helps in managing supply chain effectively. In order to be successful in the long run and to survive in competitive business environment, companies should have an effective and efficient supply chain. The adoption of ICT tools for drastically changes the effectiveness of decision making under risk and uncertain environments. Collaboration and coordination among the partners in supply chain by sharing real time information can be facilitated through integration of supply chain by using ICT tools. The physical barriers in a supply chain can be managed by using most modern ICT tools, which helps to co-ordinate and communicate within and beyond the boundaries of business organizations. Beyond the traditional process, integration of supply chain can be done by extending it to cross functional and their external supply chain partners by using ICT tools.

Supply chain integration comprises planning, organizing and management of all the activities involved in the process of purchasing, manufacturing and transportation of products and services. The integration of supply chain by using ICT tools will result in reduction in the lead time as the supply chain partners are well equipped with real time information sharing system. The transactions details between the supply chain partners are available on real time basis with the help of ICT tools for enabling quick decision making. The integration of supply chain partners in supply

chain using ICT tools is a challenging task for supply chain professionals.

ICT tool in supply chain management is an emerging topic with great significance from societal, economical and technical point of view. The ICT tools facilitate the capability to compute and generate process and exchange required data with least human intervention. Even though vide development has occurred in the area with respect to ICT tools in supply chain, global attention has gained on areas like hacking, concerns regarding monitoring and privacy issue. Challenges from various technical grounds, policy related and legal issues are also emerging in supply chain.

Business organizations using ICT tools for managing supply chain has a competitive edge over other organizations not doing so. The availability and accessibility of information as per the requirement facilitates in taking on the spot decisions which enhances the efficiency of the organizations. Various enablers of ICT tools in supply chain helps in implementing and managing the supply chain effectively.

This paper is further organized as follows. Next section deals with the literature review followed by a section on the research framework for implementation of ICT tools in supply chain integration. Further the model is tested by using a real time case study which is explained in the next section followed by analysis of results, conclusions and recommendations.

II. LITERATURE REVIEW

The recent development in ICT tools has made supply chain management a vital area for conducting businesses. The technological advancements and the change in customer requirement has necessitated the need for an integrated supply management. ICT tools can be used for value addition to the products and services based on customer perceptions and demands which are to be considered while manufacturing the products. Thus the digital environment created by using ICT tools integrates seamlessly the activities that are to be carried out by various partners in the supply chain. The end to end supply chain thus developed through integration will expedite the processes in the supply chain and avoid blockages in the supply chain. The application of ICT tools in supply chain management will enhance information exchange among supply chain partners which facilitates in the reduction of cost in the areas of inventory carrying cost and production cost.

ICT tools have fully automated the supply chain starting from invoicing electronically to tracking and delivery of the goods to the end users with real time tracking. It helps the managing the supply chain effectively through proper visibility and accountability by gaining competitive advantage. Adoption of ICT tools in supply chain management will help the supply chain partners in creating a very reliable and robust supply chain which helps in avoiding constraints.

IT in supply chain will further enhance the visibility and accountability of the entire supply chain. The tools help in assessing the customer demands and requirements, plan the production schedule, thus facilitating to have better control over the product and information flow across the supply chain. It helps in achieving the financial goals with maximum profit by managing the entire activities in the supply chain effectively.

Application of IT generates competitive edge and widen the business prospects [4, 5]. In the research [6] has detailed IT as a principal enabler for supply chain integration. IT supports companies in facilitating strategic advantage by proper planning in the daily operational activities of an organization especially in logistics [7]. The requirement of IT as a key ingredient has discussed [8] for networking between organizations. An interaction effect of collaboration and decision support IT to enhance the effectiveness of supply and customer integration was also suggested [9]. It is found out that a significant relationship exists in the supply chain management between the use of ICT and strategies implemented by the companies to achieve operational efficiency and competitive advantage [10].

The actual investment made by organizations in IT tools have also elaborated in the study [11]. The investments in IT will benefit in revenue generation by improving quality, even though the return can be expected after a specific time period. Effective utilization of ICT, sharing of information and knowledge will give a momentum in boosting the benefits of the companies. It is opined that IT in supply chain imparts a reduction in lead time and also in inventory carrying cost [12]. The impact of IT aided with Internet of Things (IoT) will be very significant and its impact on the business will be much more in the years to come. Some of the literature review on ICT in supply chain management is given in Table-1. A diagrammatic representation of the impact of ICT in supply chain is depicted in Fig.1.

Sl. No.	Area	References
1	IT implementation	[13]
2	Information Sharing and Quality	[14]
3	ICT Adoption	[15]
4	Information Sharing	[16]
5	e-innovative firms	[17]
6	ICT tools	[18]
7	ICT change	[19]
8	IT Flexibility	[20]
9	Information Systems	[21]
10	ICT for Integration	[22]

Table 1:- Literature Review on ICT in Supply Chain Management
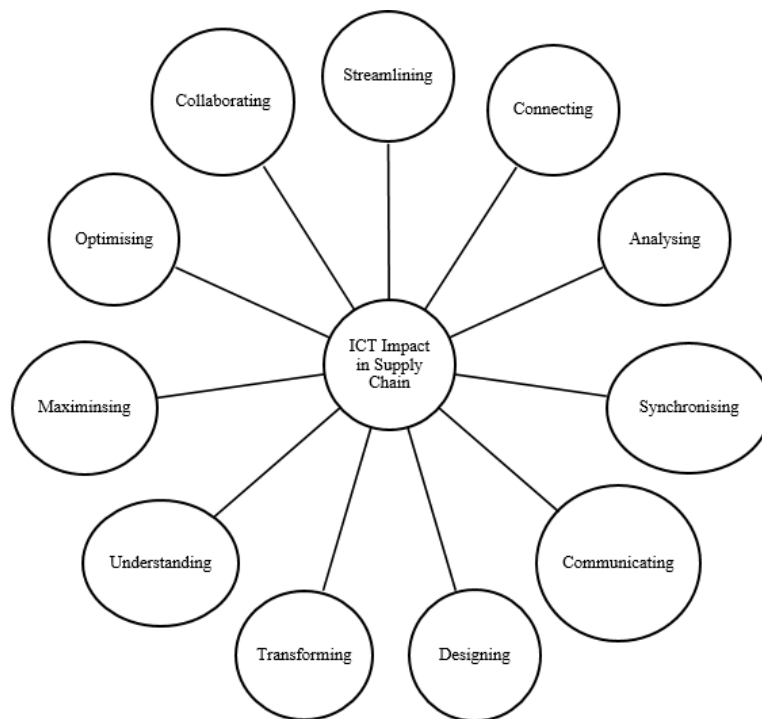

Fig 1:- Impact of ICT tools in Supply Chain Integration

A. Statement of Research Problem

The stiff competition in the global market can be survived by adopting most innovative technologies in the day to day management of the organizations. A strong and real time communication shall be maintained with the supply chain partners to gain competitive advantage. In this scenario, electronics industry being one of the robust industry having a very dynamic supply chain is considered in this study. The implementation of ICT tools in the supply chain gets affected by various factors, which are to be considered while designing a supply chain with the help of IT. Effective supply chain management by using ICT tools can be considered as a strategic weapon to improve the efficiency of supply chain through effective integration. An attempt has been made to identify the major dimensions and various factors which are having an influence on the implementation of ICT tools in supply chain of an electronics firm.

B. Research Questions

The literature reviews as stated above highlights the issues related to integration of supply chain using ICT tools. It is understood that there are various dimensions and factors that are to be considered while implementing ICT tools in supply chain. Adopting such a practice will enhance the efficiency and performance of the supply chain. A case study done on an electronics firm leads to following research questions that are addressed in this research:

➢ What are the major dimensions to be considered for implementation of ICT tools in supply chain?
➢ What are the major criteria which are to be considered under the major dimensions in the context of integration of supply chain using ICT tools?
➢ Whether a single comprehensive framework can incorporate all these dimensions and criteria for easy implementation?
➢ What are the various type of ICT tools which can be used for integration of supply chain management?

C. Research Methodology

This paper aims at studying the major dimensions and criteria to be considered while integrating the supply chain using ICT tools. For this four major dimensions and ten criteria were identified through literature review, and a framework is developed.

III. RESEARCH FRAMEWORK

Integration of supply chain by using ICT can be done among the supply chain partners by efficiently integrating the suppliers, manufacturers, distributors and customers. IT facilitates the availability of real time information. Further, planning can be done effectively to ensure that the goods and services are reaching the customers at the right time as per their requirement. ICT tools helps in maintaining real time connection among the supply chain partners through effective flow of goods, information and funds in both upward and downward directions. It also helps in gaining competitive advantage in comparison with the traditional supply chain models. Thus a closely tied communication network can be maintained among the supply chain partners with the help of effective integration of supply chain by using ICT tools.

Based on the literature review on integration of supply chain using IT, a framework for SC integration by using ICT tools is developed which is shown in Fig. 2.
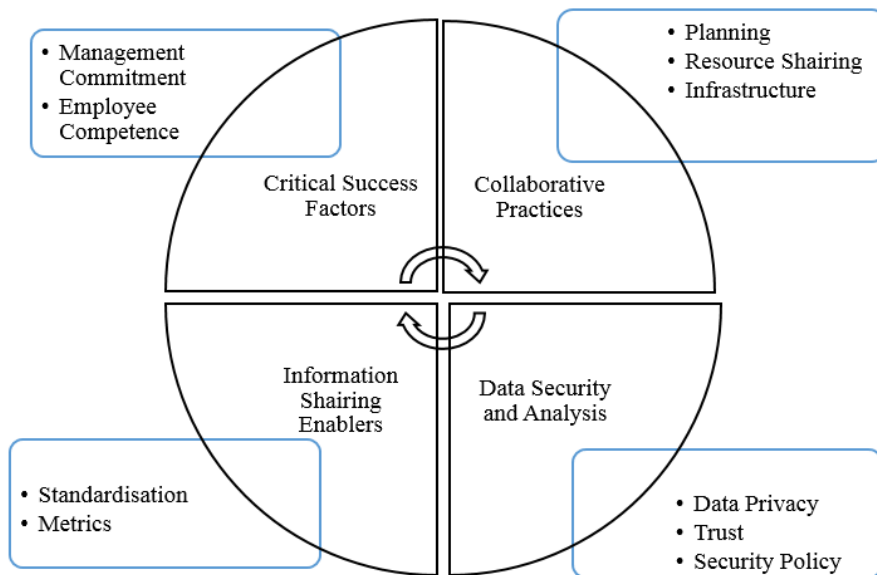

Fig 2:- An integrated Framework for integration of supply chain by using ICT tools

This framework provides more insights to the various dimensions and criteria to be considered while integrating the supply chain. The framework can be used for ICT integration in supply chain and also can be used as an analytical framework in supply chain integration using IT. It offers a set of dimensions and criteria that are to be considered while exploring the implementation of ICT on integration in supply chain. This framework mainly facilitates for an overall explorative method and can be used for exploratory studies. Details of the literature mentioning about the dimensions and criteria is mentioned in Table2.

			Dimensions	References
I	**CSF**		**Critical Success Factors**	
(i)	MC		Management Commitment	[23], [24], [25]
(ii)	EC		Employee Competence	[26]
II	**CLP**		**Collaborative Practices**	
(iii)	PL		Supply chain planning	[27], [28]
(iv)	RS		Resource Sharing	[29], [30], [31] [32]
(v)	IR		Infrastructure	[33], [34] [35]
III	**DSA**		**Data Security and Analysis**	
(vi)	DP		Data Privacy	[36], [37]
(vii)	TR		Trust	[38]
(viii)	SP		Security Policy	[39], [37]
IV	**ISE**		**Information Sharing Enablers**	
(ix)	SD		Standardisation	[40], [41], [42]
(x)	MT		Metrics	[43], [39]

Table 2:- Major Dimensions and Criteria to be considered in the implementation of ICT tools in supply chain

A. Major Dimensions and Criteria to be Considered in the Implementation of ICT Tools in Supply Chain

➢ *Critical Success Factors (CSF)*

The CSFs identified will help in the effective integration of Supply Chain Management by using ICT tools. Among various CSFs, the main factors considered for this study are Management Commitment (MC) and Employee Competence. (EC).

• *Management Commitment (MC)*

One of the crucial factors for the success of integration of supply chain using ICT depends on the commitment of top management [24]. The decision of the top management to quickly adapt and implement changes based on the technological advancement enables the organization to gain competitive advantage. Hence, the commitment of top management will influence the organization to acquire technological capabilities such as integration of supply chain using ICT tools.

• *Employee Competence (EC)*

The Employee Competence can be ensured by possessing the skills in the areas of global orientation, leadership, technically savvy and systems thinking. The change in the global scenario has tremendously changed the supply chains and the same is to be managed effectively by the supply chain professionals. The cross functional complexity in the supply chain is to be assessed effectively with the help of ICT tools and appropriate decisions should be taken. The competence of an employee depends on the ability to foster relationships and build reliability across the supply chain for the benefit of the organization [26].

➢ *Collaborative Practices (CLP)*

The collaborative practices to be followed in a supply chain by using ICT tools helps in gaining real time information sharing. The activities among the supply chain partners need to be tracked with proper visibility among the partners without compromising on data privacy and security. Tracking the activities helps in making effective decisions and forecast the demands and requirements, ensures timely availability of raw materials and funds required for production. The final product developed should be delivered to the customer in a time bound manner ensuring satisfaction and customer retention. The ICT tools can be used for speedy delivery and update the customer about the sequence of actions. Further the entire manufacturing process right from the designing of the product as per customer requirement to final production can be communicated to the customer to ensure customer satisfaction by incorporating modifications as per customer requirements.

Technological advancement in the entire supply chain including production phase avoids hindrances in the manufacturing activities results in cost reduction. The availability of real time data can be analyzed and decisions can be taken based on the data to bring more efficiency across the supply chain and in the manufacturing process as well.

• *Supply Chain Planning (PL)*

Supply chain planning involves all the activities that comprise the conversion of raw material into finished goods and its onward transmission to the consumer. The customer requirements can be planned based on the demand plan finalized from the information available. Supply chain planning mainly comprises of supply planning, demand planning, production planning, sales and distribution planning. It helps in balancing the demand and supply, thus facilitates in achieving the financial objective of the firm [27]. Planning activities considers the available resources like materials, manpower, production capacity so as to ascertain, whether the demand can be met with the available resources. Planning of supply chain activities can be done by effectively connecting the supply chain by using ICT tools. The demand is anticipated and ensures timely availability of the goods to the satisfaction of the customers [31]. The supply chain visibility created across the supply chain by using the interconnected supply chain partners helps in sensing the demand and customer requirements to improve profitability. Block chain, Artificial Intelligence and Machine Learning are the emerging technologies which can be used while doing planning in supply chain by using ICT.

• *Resource Sharing (RS)*

Supply chain resource sharing included the resources that can be transferred across the organization and can be shared by the supply chain partners. It aims in integrating various resources in the supply chain by setting goals and identifying the resources that can be shared to achieve the targeted goal [32]. Hence, visibility in the supply chain will be more and very economical when the resources are shared.

• *Infrastructure.(IR)*

Supply chain infrastructure comprises of all the assets and facilities required for a supply chain. It includes both physical and non-physical assets like informational assets [34]. The cost of a supply chain depends upon the amount spend on creating and maintaining infrastructure.

➢ *Data Security and Analysis (DSA)*

Data security is needed to protect the information and data against various attacks. Various security measures should be used to protect and prevent the data from such attacks. The security aspect shall be considered for all the components and partners in the supply chain. The mandatory compliance requirements to provide security also need to be followed.

• *Data Privacy (DP)*

Data privacy is one of the key factors which is to be considered while integrating the supply chain using information technology. Accordingly, the data that are transmitted in the supply chain should be structured in such a way that it is compliant with the regulations and have enough security [36]. The supply chain professionals shall be made aware of the precautions to be taken to protect the data by giving right information to maintain privacy of the data. Data privacy can be ensured provided all the supply

chain partners complies with all the regulations while interconnecting among themselves. The success of effective management of supply chain while integration depends upon the concept of handling the data in a secured and protected manner.

- *Trust (TR)*

Trust is one of the most crucial factors which is to be considered while integrating the supply chain using ICT tools [38]. Collaboration among the supply chain partners can be effective, only if the supply chain partners are willing to communicate among themselves by trusting the partners in the supply chain, orelse, it will result in poor performance. An integrated supply chain wherein trust is established among the partners can become very agile and flexible. The partners must agree among themselves that each one will not try to exploit the other partners' weakness.

- *Security Policy (SP)*

The major areas to be considered while proceeding with the implementation of ICT tools are IT Infrastructure, security, privacy, interoperability, regulatory and legal compliance. The privacy of data transmitted across the supply chain is an integral part and to be secured to safeguard the whole process [36]. Further the security of data is to be maintained by following suitable security policy so that the supply chain is protected from external and internal threats for ensuring the safe transmission of data. In order to ensure the compliance with the environmental aspects, the legal and regulatory compliance shall be followed without compromising the security and privacy issues while integrating supply chain by using ICT tools.

➢ *Information Sharing Enablers (ISE)*

- *Standardization (SD)*

Standardization in supply chain management is the process of developing and implementing standardized practices and procedures to be followed while integrating supply chain using ICT tools. Standardization helps in customization of the processes to be followed by improving quality, simplifying the processes which helps in the production of final product and services which meets the customer requirements. The standards set describes the expected outcome and also defines how the tasks and processes shall be followed to achieve the desired task or output.[42] It helps in technological change as new technologically advanced products can be considered during the process of standardization. Standardization helps in reducing cost as innovative and variety of changes with respect to the processes are taking place at the right time.

- *Metrics (MT)*

The decision making in an ICT integrated supply chain is inbuilt within the process. Metrics plays an important role in evaluating the implication and success of integration of supply chain using information and communication technology tools [39]. Metrics is used to communicate the information among the partners and the supply chain professionals in a firm. The metrics finalized shall align with the integration objectives and overall strategy of the firm. The management can access the metrics and the reports in a periodic manner to find out the positioning of the firm and also to make better decisions.

B. Types of ICT use in SCM

➢ *Essential Types of SCM Tools*

The various areas for application of ICT tools that can be used in supply chain for integration is illustrated in Figure 3.
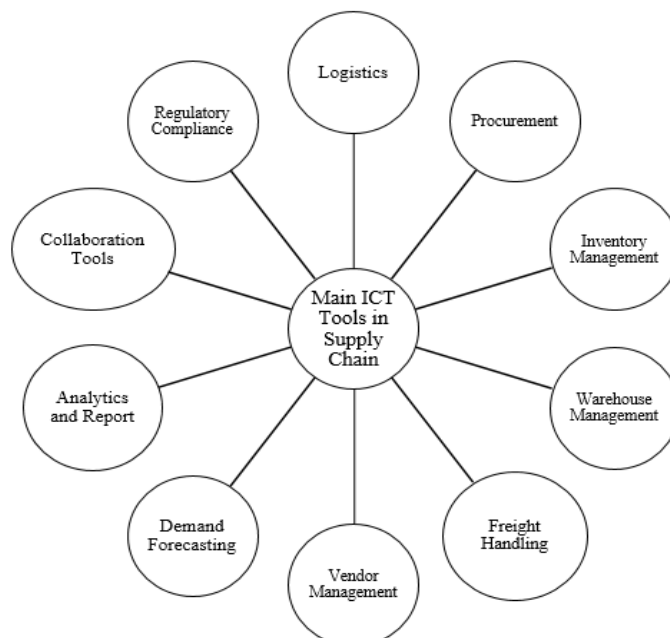

Fig 3:- Various Areas for Application of ICT Tools in Supply Chain

IV. RESEARCH FRAMEWORK APPLIED TO A CASE COMPANY

The methodology explained is applied in the supply chain of an ABC compnay in the electronics industry, which is dealing with consumer electronics having an annual turnover of Rs.11800 crores.Innovations and development of new products will enhance the profit and decide the competitiveness of the firm. The supply chain of the consumer electronics industry needs to extend its scope and output by adopting innovative technologies. Investment in areas like integration of data, data analytics, knowledge management, tracking, etc., ensures that supply chain can respond quickly to the demands and changes. The major functional classificaiton and various types of ICT tools used byABC company is finalised based on literature review and in consultation with the experts in the company and academia. The experts consulted is having an experience of over 15 years in area of supply chain management. The functional classification done based on the case study is detailed in Fig. 4.
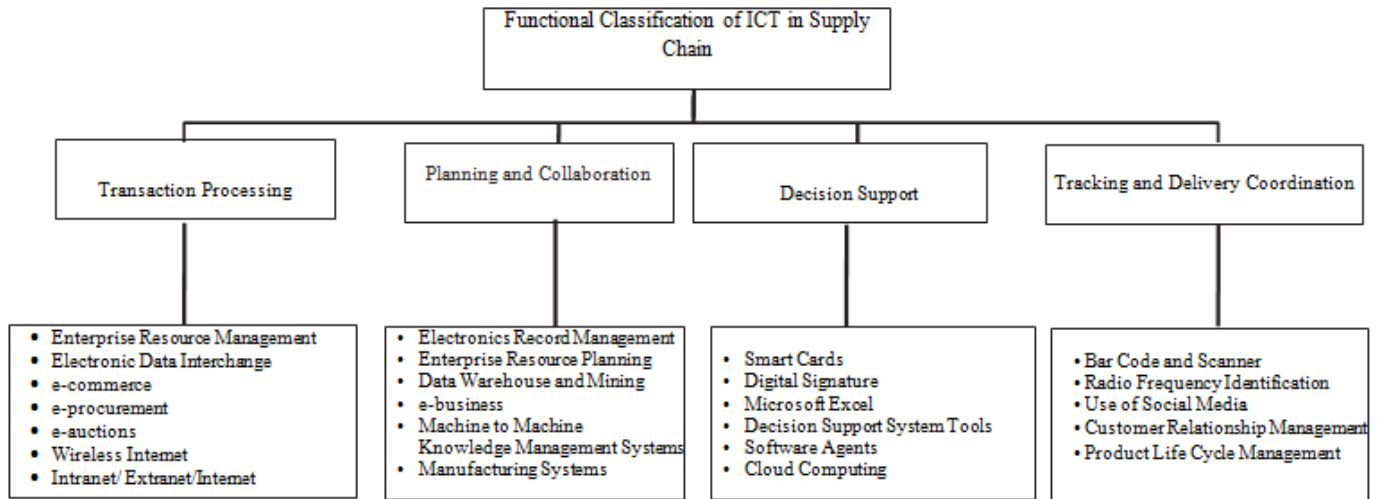

Fig 4:- A Framework of Forms of IT in Supply Chain based on Functional Classification

V. RESULTS AND DISCUSSIONS

In this paper we have analyzed the impact of ICT tools on SCM. Further the aspects of integration in supply chain and its benefits were examined. The management of supply chains using traditional methods has changed dramatically over the last decade. ICT significantly improve SC performance and helps in SC integration. Responsiveness and efficiency can be achieved by designing the supply chain in such a way that it leads to an efficient flow of goods and services. The planning and coordination of supply chain by using ICT by using online sharing of information has greater relevance in the future. Integration of supply chain using ICT tools requires various types of infrastructure to ensure connectivity between various partners in a supply chain. Proper training and support from the top management is a crucial factor in order to fully utilize the application of IT in integrating supply chain. Financial investment in establishing the IT infrastructure and training to the employees in order to enhance their skills is another factor which determines the success of IT implementation in supply chain.

Further, the study mainly focused on how ICT tools impacts the integration of supply chain in an electronics firm. The framework developed identified major dimensions and ten criteria which are mainly to be considered while implementing ICT tools in supply chain. All the dimensions and criteria identified shall be prioritized and given due importance. Necessary tools with the help of IT can be used to integrate the supply chain among the partners. The Critical Success Factors, Collaboration and Planning, Data and Security Analysis and Information Sharing Enablers which are classified as part of the integrated supply chain as the major dimensions. Further a classification of the major ICT tools, forms of ICT in supply chain is also developed to emphasis the impact of ICT in supply chain.

The model developed in this study can be used while studying the ICT tools in supply chain and its integration. It answers the four research questions framed and also represents how the different types of ICT tools can be used in the supply chain effectively among various partners for information sharing. The main focus of this study is on the inter and intra organizational aspects that affects the supply chain. Hence the ICT tools that are applicable and used both internally and externally are considered. While assessing the impact of ICT tools it can be measured in terms of different dimensions of supply chain integration. The effect of this can be both direct and indirect which affects the performance and efficiency of the supply chain. Altogether the frameworks developed forms the basis for how the information and technology tools affects the integration of supply chain.

VI. CONCLUSIONS AND MANAGERIAL IMPLICATIONS

The impact of ICT on the integration of the supply chain can be easily assessed and the core areas to which more emphasis to be given can be easily identified. It is developed based on the available literature on ICT in supply chain and supply chain integration perspective. The framework developed represents a set of process and factors that are relevant while assessing the impact of IT in supply chain. The quick accessibility and coordination between various partners in a supply chain using IT tools and real time sharing of information really strengthens the networking and relationship between the supply chain partners. It is found that ICT is a significant ingredient for the success of any organization in order to achieve competitive advantage.

This study provides further insights to the relationship between ICT tools and integration of supply chain. It provides an overview of the major areas that are significant while considering the aspect of integration in supply chain. Further it also facilitates the researchers who would like to investigate on the topic on ICT tools in supply chain and how IT influences supply chain integration.

The framework developed has considered the available and limited number of literature on the topic. Further scope for study and development can be done based on the advanced IT tools and innovative developments in the area. The future research can be in the field of development of theoretical models based on the new emerging tools and technologies that are applicable to supply integration.

ACKNOWLEDGMENT

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