Integration and Flexibility through ICT in Supply Chains: C-F-P Modeling Approach

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***Abstract**:- In the recent past supply chain Management and Information and communication Technology (ICT) has caught the attention of the researchers and practitioners. Integration and flexibility through ICT in the supply chain to cope up the uncertainties and variabilities has been the approach followed. This approach has resulted in improving the performance of the supply chain but in many cases such intervances has increased the cost of operations. It is proposed that the process of building flexibility and integration of ICT in the supply chain should start after measuring the complexities of the supply chain. In the given scenario we find that the variables cost of ICT-SCM Integration (0.6), Compatibility with existing system (0.6), Productivity (0.66) and Human resources (0.62) have major contribution SCM- ICT Integration Decision function. Then comes the variables Technology changes in SCM (0.35), Competitiveness in the market (0.41), Customer Preference (0.45) and Government policies (0.31). The product life cycle (0.5) is seen to be a neutral variable. The variable Uncertainty in the market (0.16) is seen to be the least contributing variable. In this paper, the various facets of Flexible Supply chain, ICT and their integration are described in detail. Taking view of the current industrial scenario, the different variables of these three factors are analyzed using Complexity-Flexibility- Performance (C-F-P) analysis using data obtained from industry. From this analysis decision making regarding ICT-SCM integration can be easily performed to remain competitive.*

***Keywords:-** Integration, Flexibility, ICT, Supply Chain, Performance*

1. INTRODUCTION

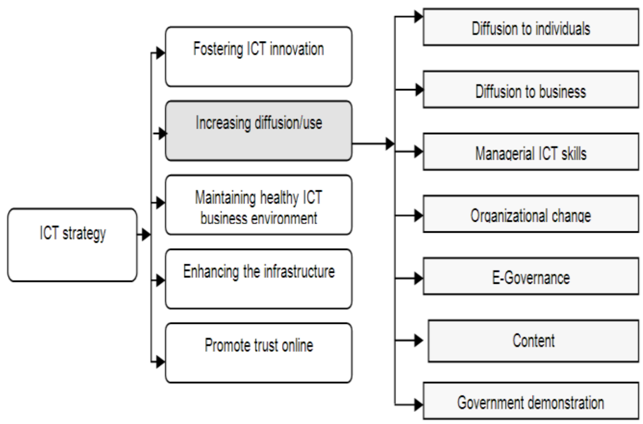
Turbulent environment has brought about drastic changes in how we define and manage today's industry. Intense worldwide industrial competition has endangered the volatile dynamics of business environment change. The importance of the concept of flexibilities in supply chains and the economical design and integration of flexible supply chains are the crucial areas in this competitive and unpredictable environment. These two factor i.e. competition and complexities have brought a number of changes in the nature and structure of global industry.

David .et. al (2000) , have defined supply chain Management as " a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouse, and stores, so that merchandise is produced and distributed at the right quantities , to the right locations, and at the right time, in order to minimize system wide costs while satisfying service level requirements". Thus Supply chain management has emerged as the term defining the integration of all these activities into a seamless process.

David et. al (2000), have also identified why supply chains are so complex. They said that supply chain is a complex network of facilities and organizations with different conflicting objectives, matching supply and demand is a major challenge in this area, system variations over time is an important consideration here and that many supply chain problems are new and there is no clear understanding of all the issues involved.

Information and Communication Technology (ICT) platforms have evolved over time to assist in process integration, initially within departments, then within locations, then within enterprises and currently, within limited supply chains. Over the past few years, many parallel developments have taken place in a number of disciplines as well as ICT, such as manufacturing philosophies, supply chain management, business software and artificial intelligence. These developments have affected the way that business is done and they have created a plethora of new methodologies such as e-commerce, e-business, m-commerce and, recently, silent commerce. Most studies on supply chain optimization, especially material optimization, have taken an intra-organizational focus. The growing power of routing electronic information has increased the need to view the entire supply chain or, more specifically, the supply network, of organizations involved from raw material to finished product (McLellan, 2003 and Huhns et. al, 2001).

Integration of information systems with one another and with business processes has been a problem in business computer applications since the beginning of the data processing era. Advances in technology have changed the scope and complexity of the integration problem and the solutions proposed, ranging initially from interfacing two information systems (usually via file interchange) through enterprise application integration (getting rid of islands of information) to integration of information flow between enterprises in a supply network. Integration of ICT to SCMis examined by the available indicators and describes the current and previous strategies aimed at ICT uptake in firms. The role of various actors with regard to ICT use can be illustrated by the framework as shown below

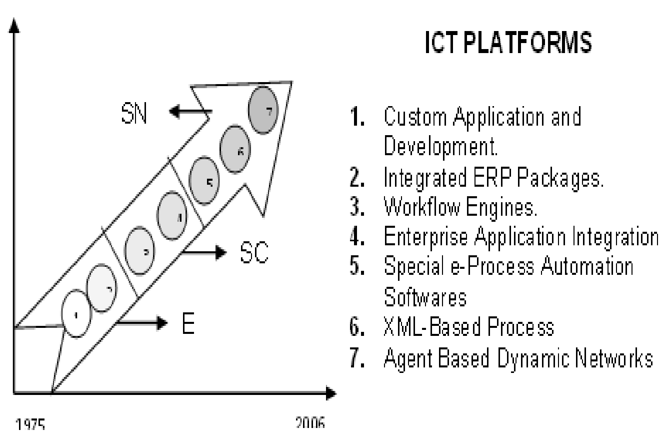


The ICT strategy will in turn be refined to identify suitable ICT infrastructure and its related processes to map to the needs of the organizational structure in performing their business processes. However, if the identified infrastructure is not feasible to support these needs, then the repercussion will force the business and ICT strategy to be changed before the cycle is reversed again.

1.1 ICT platforms for business process integration

We have now entered the age of "dynamic information processing" and "knowledge management". ICT has provided the platforms on which enterprises do business. Due to the recent developments in ICT platforms, we have been exposed to the *xcommerces*; e-commerce, e-business, c-commerce (collaborative), and others. One of the latest *x-commerces* is s-commerce, i.e. silent commerce (Accenture, 2004). El.Sawy.O.A., (2001) stated that the basic purpose of these methodologies is to provide process integration, not only within an enterprise, but also between enterprises. Preferably, the process should integrate seamlessly, automatically and should be synchronized. How well this is done will depend on the ICT platform. The evolution of ICT platforms for business process integration is as depicted below.

Within the supply chain, each enterprise typically has many suppliers and many customers. As a result, it is now acknowledged that the supply chain is, in fact, a supply network and the ICT platform serves as an enabler for this network incorporating electronic nervous systems. The updated version of the ICT platform evolution diagram is as depicted below.is to reduce the lead time and to deliver products to customer with in time.



Enterprise (E), Supply Chain (SC) and Supply Network (N) Focus

Each platform has not been insulated and exclusive of the steps on either side of it. Quite the contrary; there has been considerable overlap between the adjacent steps and even between non-adjacent steps. From a supply chain perspective, each platform introduction has been accompanied by an increase in the speed in which participating enterprises in the supply chain can react i.e. the speed with which buyers and sellers can respond to new demand or changes in demand. It is also usually accompanied by a reduction in safety stocks requirements for the participants.

1.2 ICT driving changes in supply chain management

As stated before, ICT has two main influences on supply chain management:

1. Vertical integration between trading partners (both shippers and logistic service providers)

2. The appearance of completely new functions and companies.

Vertical integration between trading partners pertains to information sharing, common planning and exchange of existing functions. The new functions are centered on information services. Besides functions maintaining the information infrastructure (middleware providers, repositories for messages and dictionaries) the most important new functions, especially for logistics services, is that of the *infomediaries.* Supply chain integration is both supported and driven by ICT. The main requirement for proper coordination and management of supply chains is that partners in the chain are sufficiently informed about each others' processes, so that they can anticipate each other's needs and reach an overall optimum, instead of reacting to each other for a sub-optimal result. Technological advances in ICT support SCM because it improves information exchange significantly in terms of lead time, completeness and transparency.

1.3 Supply chain planning via ICT

Well-known examples of companies using the ICT to steer their supply chain are Intel, Cisco, Sap and Dell. Key to SCM effectiveness is the sharing of data among supply chain partners. Clearly ICT can help, but implementing shared database systems is not easy. Lack of systems compatibility, non-integrated organizational structures and the loss of good local information are three key barriers to effective database implementation. Van Der Laan et.al (2003) stated that, so far, ICT seems to increase the efficiency and quality of SCM, especially related with operational aspects on the time and distance dimension

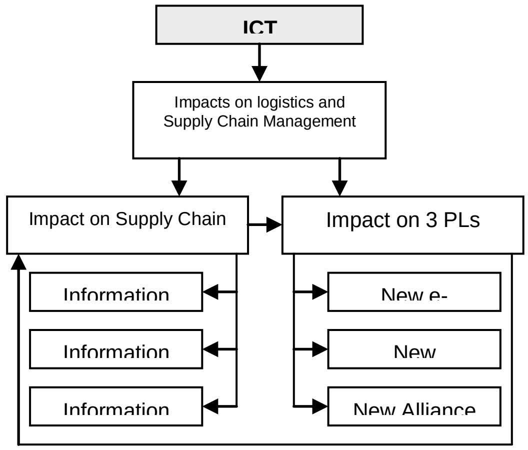
1.4 Supply Chain Innovation.

ICT also enables supply chain innovation – new forms of collaborative relationships within industry and business supply chains, with suppliers at the beginning of the chain, and with retailers (and increasingly final consumers) at the other. ICT enables manufacturers to work closely with supply chain integrators who link initial supply with retail outlets. The ability to move data at the same time as physical goods is the essence of an efficient supply chain. Bar codes, radio frequency identification devices (RFIDs) and remote sensors are key ICT enablers in this process. Through the aggressive integration of multiple companies, supply chain speed and flexibility can be achieved while, at the same time, providing a higher quality of products and services to a broader spectrum of customers in a dynamic marketplace. ICT has been and will continue to be a critical enabler in this evolving production and market environment. Inclusion in ICT enabled supply chains requires manufacturers to have an ongoing commitment to quality, consistency, reliability and product integrity.

2. METHODOLOGY/APPROACH: **-** Various attributes of complexities of a supply chain from literature and in discussion with practitioners are identified related to supply; production and distribution sides are identified. A Complexity -Flexibility-Performance (CFP) model is proposed to select the right dimension of flexibilities based on complexity index of the supply chain. The proposed model will enhance the responsiveness of the supply chain and ICT integration at minimum cost and efforts leading to greater competitiveness.

3. TRENDS AND EFFICIENCY OF ICT IN SCM

Evangelista (2002) described that ICT are fast becoming one of the main drivers of change, posing new strategic challenges. International literature has been reviewed to analyze current and future trends that are connected to dissemination of ICT. The current and future trends of ICT developments are as shown below.

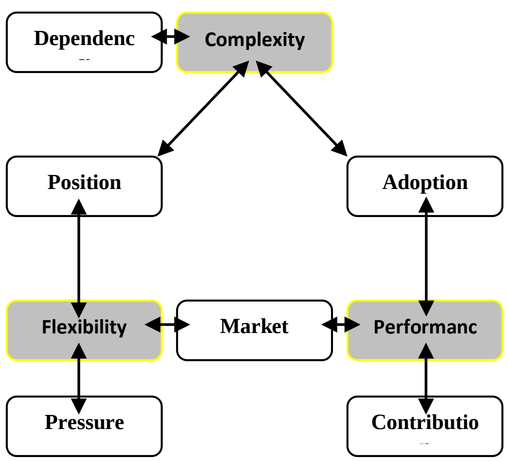


Current and Future Trends of ICT

One of the main areas of interest that has emerged in recent years concerns the effects of ICT on SCM. In the literature there are a plethora of research that has analyzed general aspects (Introna, 1993; Hammant, 1995) and specific effects (Peel, 1995; Kia *et al.*, 2000) of these technologies in SCM. Pontrandolfo et.al (1999) described the various ICT applications in SCM.

3.1 C-F-P Frame Work

In Complexity- Flexibility- Performance framework (C-F-P framework), the various perspectives are interdependent and tightly interrelated. The concept of influence relationship- be it preference, pressure or power - is the pertinent relationship between the three types of concepts.

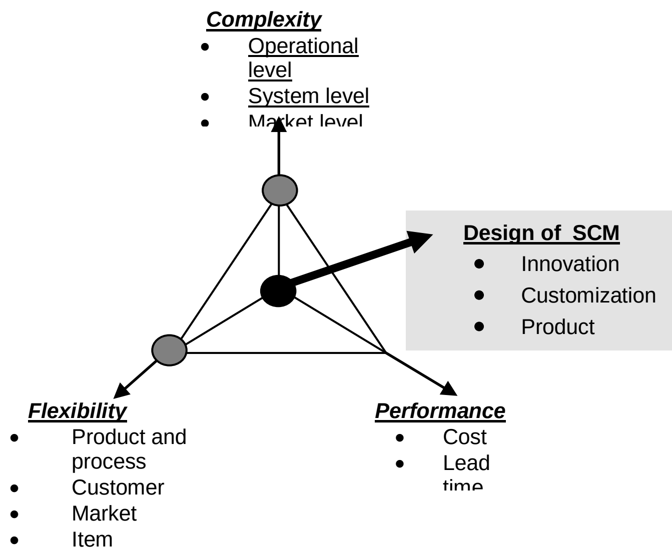


While the influence concept is generic, relationships between a particular pairs of elements have an adapted meaning. Flexibility and Performance are linked by a ***"market"*** relationship. By adopting certain value scheme as an expression of their needs, end users influence the type of products that are offered by the different flexibility systems and determine their relative power (market pull). Conversely, flexibility can often shape and even create user (Performance) needs by offering innovative value propositions (technology push).Flexibility and Complexity is linked by a ***"position"*** relationship. On the one hand, Flexibility can influence the outcome of certain issues by strategically positioning themselves on them and exerting their power. On the other hand, the awareness of certain issues constrains the strategic positioning that flexibility can take and influences their power.

Performance and Complexity are linked by an ***"adoption"*** relationship in the sense that the awareness of complexity issues can affect end user needs and, therefore, their decision to adopt a particular value offer or technology. Conversely, the adoption of certain solutions may affect, positively or negatively, the future outcome of certain complexity issues. Flexibility is influenced by ***"pressure"*** relationship which may stem from an uneven power balance in a business negotiation, competitive threats or other kinds of intentional and social relationships.

Complexities are influenced by ***"dependency"*** relationship i.e. The realization of a particular outcome of an issue can have an impact on the likelihood of realization of the outcomes of other issues. Finally, Performance is influenced by ***"contribution"*** relationships i.e. The adoption of a particular use or technology can influence another one. The contribution can be positive, such as with complementary uses, but also negative, such as with substitute uses, as well as disruptive.

From the above framework it has been seen that complexities in supply chain leads to the need of flexibilities which in turns leads to the improvements in performance and level of competitiveness. The C-F-P analysis for the design of SCM is as shown below.



4. MAPPING OF ATTRIBUTES FOR THE SCM-ICT INTEGRATION OF ABC LTD.

For C-F-P analysis the first step is identification of the variables which make the system complex. These variables can be from the following categories:-

- Product related
- Process related
- Customer related
- Market related
- Supplier related
- Logistics related

After identifying these variables, they are described for the conditions of low complexity and high complexity at five levels. A score of 0 is given for negligible complexity and 1.0 if variable is highly complex. After having this format, a company can be mapped and its complexity score and dimensions of complexity can be identified. Based on this diagnosis, a plan for incorporating suitable dimensions of flexibility can be prepared. The plan can be simulated to see its impact on the key performance areas of the organization.

5. FINDINGS: **-** In the given scenario we find that the variables cost of ICT-SCM Integration (0.6), Compatibility with existing system (0.6), Productivity (0.66) and Human resources (0.62) have major contribution SCM- ICT Integration Decision function. Then comes the variables Technology changes in SCM (0.35), Competitiveness in the market (0.41), Customer Preference (0.45) and Government policies (0.31). The product life cycle (0.5) is seen to be a neutral variable. The variable Uncertainty in the market (0.16) is seen to be the least contributing variable

6. CONCLUSION

The variables analyzed during the SCM-ICT Integration are:

1. Cost of SCM (0.60)
2. Compatibility with existing system (0.60)
3. Technology change in SCM(0.35)
4. Competitiveness in the market (0.41)
5. Uncertainty in market (0.16)
6. Customer preferences (0.45)
7. Productivity (0.66)
8. Product life cycle (0.5)
9. Human resources (0.62)
10. Government policies (0.31)

It is seen that the variable greater than the C-F-P index play a greater role in the flexible SCM decision making process and that less than the C-F-P index play a small role.

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Taking the variables as a whole, we find that the obtained index of 0.46 is less than the taken C-F-P index. So the SCM design and ICT integration decision regarding the organization as a whole is not so complex.

In this table the ten SCM design and integration variables are grouped into three broad categories namely technology, market and production system, with the exception of the last variable i.e. government policy which have a separate existence in itself.

Then based on this analysis and Figure 9, a decision table is prepared.

Scenario	SCM Design and ICT Integration Decisions Due To		
	Technology Condition	Market Condition	Production Condition
1.	Low	Low	Low
2.	Low	Low	High
3.	Low	High	Low
4.	Low	High	High
5.	High	Low	High
6.	High	Low	Low
7.	High	High	Low
8.	**High**	**High**	**High**

Then based on the conditions the following comments are done according to the scenario as shown below.

Scenario	Comment
1.	**No need for ICT- SCM integration**
2.	**Limited automation**
3.	**Need base ICT- SCM integration as Integration technology is not available or expensive**
4.	**Strategies for manufacturing to improve competition (like JIT, FMS, Kanban, Kaizan, simulation etc…), then go for Integration**
5.	**Full automation and exploitation of easy availability of flexibility , specific SCM designs**
6.	**Need base ICT- SCM integration as the market and is very low**
7.	**Need base ICT- SCM integration as the production is low and market is high**
8.	**Full scale ICT- SCM integration as the conditions are very conducive, the technology, market and production all are high**

The variables coming under technology are cost of SCM, compatibility with existing system and technology change in SCM; the variables coming under market are competitiveness in the market, uncertainty and customer preferences; and the variables coming under production system are productivity, product life cycle and human resources.

The three categories are examined and eight different scenarios are found to exist, these scenarios decide integration and design of SCM needed, based on the complexity of each category and the relationship within each variable.

The first scenario is when market is low, technology is low and production is also low. In this case there is very limited need for any SCM. The second scenario is when technology is low, market is also low but production is high, it is required to limited need for SCM and automation processes to improve the competitiveness. The third scenario is when technology is low, market is high and production is low, in this case integration and design is need based. The forth scenario is when technology is low and market and production is high, here since the technology is low we have to go for the various indigenous SCM strategies and technology management process to remain competitive. The fifth scenario is when technology is high, market is low and production is high, in this case it is seen that the management usually go for full automation in their manufacturing system and specific SCM designs are developed. In the sixth and seventh scenario i.e. when technology is high, market is low and production is low; and technology is high, market is high and production is low, in both these cases the integration and design of SCM is need based. In the final scenario i.e. when technology, market and production all are high then the management is required to go for full integration and design of SCM to survive in the market.

The variable Government policies have an indirect and superficial affinity to all the three categories. If the value of this variable increases then the decision making process regarding the SCM integration and design will be complex and difficult and if the value is low then the decision making process will be simple and easy.

7. REFERENCES

1. Accenture (2004):

   Http://Www.Accenture.Com/Xd/Xd.Asp?It=Enweb&Xd=Services\Technology\Vision\Tech_Breaking_Silence.Xml.
   Http://Www.Accenture.Com/Xd/Xd.Asp?It=Enweb&Xd=Services\Technology\Vision\Silent_Commerce.Xml

2. David Simchi- Levi, Philip, K., Edith Simchi- Levi, (2000), "Designing and Managing The Supply Chain: Concepts, Strategies, and Case Studies", Irwin Mcgraw-Hill, Singapore

3. El Sawy O. A., (2001), "Redesigning Enterprise Processes for E-Business". Mcgraw-Hill Irwin.

4. Evangelista P., (2002), "Information and Communication Technology Key Factor in Logistics and Freight Transport", in Ferrara G. and Morvillo A. (Edited By), Training in Logistics and Freight Transport Industry. The Experience of the European Project Adapt-Fit, Ashgate Publishing Ltd, London, Uk.

5. Hammant J., (1995), "Information Technology Trends in Logistics", Logistics Information Management, Vol. 8, N. 6, pp. 32-37. Spring, Vol. 36, N. 3, Pp. 5-17.

6. Huhns, M. N. and L. M. Stephens., (2001), "Automating Supply Chains". IEEE Internet Computing: Vol.1pp.90-93.

7. Introna. L.D., (1993), "The Impact of Information Technology on Logistics", Logistics Information Management, Vol. 6, N. 2, pp. 37-42.

8. Kia M., Shayan E, Ghotb F., (2000), "The Importance of Information Technology in Port Terminal Operations", International Journal of Physical Distribution & Logistics Management, Vol. 30, N. 3/4, pp. 331-344.

9. Laan, L. Van Der and F. Van Oort., (2003), "Does ICT Lead to Anomalies in Agglomeration Theory? A Survey of ICT Impact on Space and External Economies". Paper Presented at the Nethur School "ICT and Spatial Behavior", Utrecht, 16 June 2003.

10. Mcclellan, M., (2003), "Collaborative Manufacturing: Using Real-Time Information to Support the Supply Chain". Boca Raton, St Lucie Press.

11. Peel R., (1995), "Information Technology in the Express Transport Industry", Logistics Information Management, Vol. 8, N. 3, 18-21.

12. Pontrandolfo P., Scozzi B., (1999), "Information and Communication Technology and Supply Chain Management: A Reasoned Taxonomy", Proceedings of the 4th International Symposium on Logistics "Logistics in the Information Age", 11-14 July, Florence, Italy.