PROJECT REPORT MAJOR-II

ON

"PERFOMANCE EVALUATION OF IT ENABLED SUPPLY CHAIN MANAGEMENT SYSTEMS"

Submitted by:

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VIth Semester 2016

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Candidate declaration

I hereby declare that the work, which is being presented in this dissertation, entitled "Performance evaluation of IT enabled Supply Chain Management Systems" towards the partial fulfillment of the requirements for the award of the degree of Master of Technology with specialization in Production Engineering, from Delhi Technological University Delhi, is an authentic record of my own work carried out under supervision of Dr Saurabh Agrawal, Assistant Professor and Dr Mohit Tyagi Assistant Professor, Department of Mechanical Engineering, Delhi Technological University, Delhi.

The matter embodied in this dissertation report has not been submitted by me for the award of any other degree.

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Certificate

This is to certify that the dissertation entitled "**Performance evaluation of IT enabled supply chain management systems**" submitted by Mr. Sanjeev Kumar, 2K13/PIE/24, in the partial fulfillment for the award of Degree of Master of Technology in Production Engineering, Delhi Technological University, is an authentic record of the research work carried out by him under our guidance and supervision.

To the best of my knowledge, the results contained in this dissertation have not been submitted to any university or institute for the award or any degree.

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Acknowledgements

I take this opportunity to convey my sincere gratitude to my project guide, **Dr. Saurabh Agrawal, Assistant Professor and Dr. Mohit Tyagi Assistant Professor** in the Department of Production Engineering, and to their family members for their honest efforts, able guidance and precious suggestions in making this project feasible.

I would like to acknowledge with appreciation the numerous and valuable comments, suggestions, criticism and praise by Head of our department **Dr. R. S Mishra** and all the Production Engineering Department faculty members of the institute as and when required.

Above all, I am indebted to my parents without whose blessings and constant help this would not have been achievable. No work can be said to be absolute and without mistakes which is due to the constraint of our experience. I will be grateful to the readers if they will be kind enough to bring to my notice such shortcomings which, I am sure, it will enable me to improve in future.

Date:…… Sanjeev Kumar

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Abbreviations

1.	AHP	Analytic Hierarchy Process
2.	APIs	Application Programming Interfaces
3.	DEMATEL	Decision Making Trial and Evaluation Laboratory
4.	e-commerce	Electronic Commerce
5.	EDI	Electronic Data Interchange
6.	EIS	Executive Information Systems
7.	eSCMS	electronic Supply Chain Management Systems
8.	IOS	Organizational information systems
9.	KPI	Key Performance Indicators
10.	MCDM	Multi Criteria Decision Making
11.	SaaS	Software-as-a-Service
12.	SDKs	Software Development Kits
13.	TOPSIS	Technique for Order of Preference by Similarity to Ideal Solution

Abstract

The increasing use and application of information technology in supply chain management can be attributed to the performance improvements and value creation in organizations. There has been a considerable evolution of scientific investigations over the past few years. From a comprehensive and updated literature review, it has been observed that various aspects e.g. use of IT systems have a great impact on performance of the organization. **T**he use of EDI, ERP systems, such as SAP and Oracle, has been extended to supply chain partnership, enabling supply chain partners to plan and synchronize their processes**.** Effective performance measurement is key area to successful implementation of strategy. Individual firms must choose the performance measures that reflect the unique operations of their business. The performance parameters of strategic, tactical, and operational level were identified. In this work the quantitative modeling has been performed. DEMATEL approach was applied. A questionnaire is developed on five point liker scale. To perform statistical analysis, principal component extraction method of factor analysis with varimax rotation was applied using SPSS software. Causal diagram and fish bond diagram were constructed. The components for performance evaluation were arranged priority according to their importance. Also components are divided into the cause and effect group.

Key Words: Supply chain management, Performance parameter, Performance evaluation, Factor analysis, DEMATEL,

Chapter 1
Introduction

1.1 Theoretical Background

Any business is composed of three main activity namely input, processing and output. If we consider the manufacturing sector the processing activity is performed the firm itself, the input to the firm are man machine and material and further the output is the product of the company. If a business unit is considered as the processing centered or manufacturing centered than responsible for the manufacturing is known as manufacturer and input is made in the form of supply while the delivery is made in the form of product to the customer. As the size of the business is increases, the number of the parties is also increases. All these parties perform the function of value addition to the material and finally deliver to the customers to fulfill their need. The sequence of these parties or units is like a chain in which material flows from one direction to another to get its final shape and ultimately delivered to the customer and money flows in the reverse direction from customer to manufacturer or to supplier. This sequence may be called as supply chain. According to Sukati et. al. (2012), supply chain is the set of nodes or activities through which values are added and connects the enterprise's suppliers as well as its customers. Also in the study of supply chain emphasizes is given to maximize the overall value of the company by better utilization and resources deployment across the entire chain. A supply chain is said to be dynamic as it involves the constant flow of information, product and funds between different stages. Each stage in a supply chain is connected through the flow of product, information and funds. These flows happen in both ways and may be achieved by one of the stages or an intercessor. A typical supply chain may be understood with the help of figure 1.1.According to Chopra et. al. (2008), Supply chain may be considered as the combination of

the every step from the demand generation to the customer demand fulfilled It is also told that generally a supply chain may involve a variety of stages, which includes customers, retailers, distributor, manufacturer and supplier.

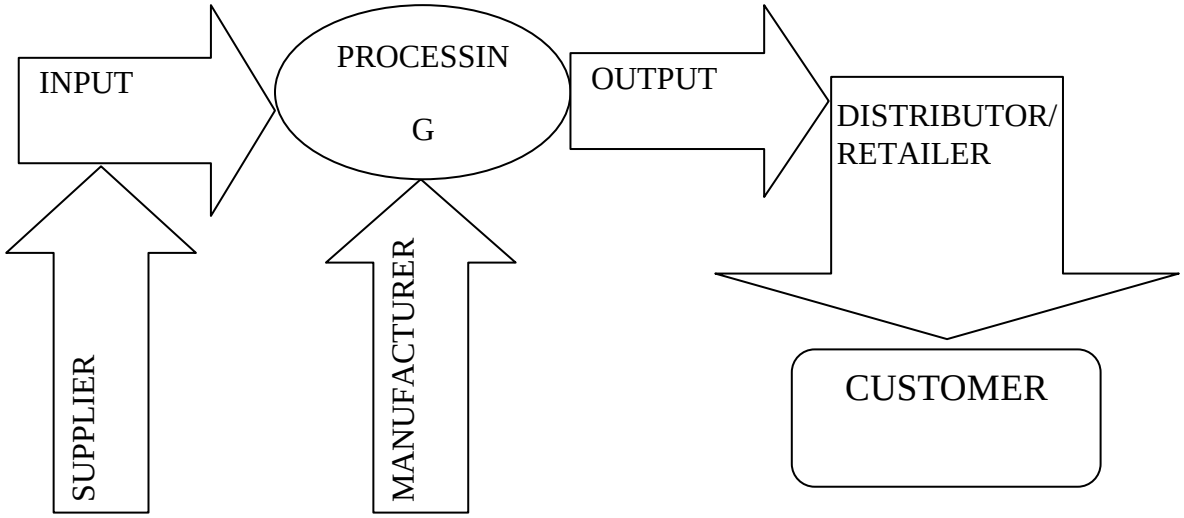


Figure 1.1 Elements or Stages of a Supply Chain.

As the size of the organization or business increases the number of the intermediate units or sub units also surges and the supply chain network become large and complex and this complex network is very difficult to manage or coordinate. But with the advent of the electronic information system or technology and computer it is become quite easy to handle or coordinate such complex network. Information is a key supply chain driver because it serves as the glue that allows the other supply chain driver to work together with the goal of creating an integrating, coordinating supply chain

1.2 Introduction to supply chain management

In this era of high level of competition in all area, it is necessary for the management to have the deep eye on every issue related to the company. Consequently, to decrease cost and

increase service levels, effective supply chain plans must be taken into account for the interactions at the various levels in the supply chain. Bernard (1996) defines supply-chain management as, "The distribution of improved customer and financial value through coordinated management of the flow of physical goods and related information from tracking to consumption. According to him Sourcing to consumption portion of the description suggests, though, attaining the actual potential of supply-chain management needs incorporation, of not only of these things within the association, but also of the outside partners, which include the suppliers, suppliers, transporters, customers, and the eventual consumers. It is also told that the goal of the extended enterprise is to do an improved job of aiding the eventual consumer and grander service results to enhanced market share. Ketchen et al. (2008); Marinagi et. al. (2014) differentiate between traditional and modern supply chain management as that the traditional supply chain management is a process for receiving and moving goods and services while in modern aspects focus is given on the strategic supply chain management, where supply chains are used as a means to stand in competition and increase firm performance. Hence it may be said that supply chain management is a set of method used to professionally assimilate suppliers, manufacturers, warehouses and provisions, so that item is manufactured and distributed at the correct quantities, to the accurate locations, and at the accurate time, in order to lessen organization wide costs while sustaining service level requirements.

1.3 The role of IT in supply chain

As already discussed a supply chain is a system that consists of suppliers, warehouses, manufacturers, distributors and retailers who coordinate their strategies and activities to convert raw materials to finished goods and to deliver the same to the ultimate consumer. According to Turek (2013) techniques of information technology and methods can help companies to become

efficient, increase their productivity and thereby respond rapidly to customer needs. The implementation of information technology in businesses should be incorporated in active areas, such as the management of the supply chain, because much better controls in the management of material resources allowed, preventing delays in production and so enhancing compliance with customers. Subramanian and Gunasekaran (2015) concluded that the information technology or information system of a supply chain refers to managing information flows in modern, worldwide supply chains. Information technology drives sophisticated information technologies that support information intricacy, propagation, diffusion, and velocity.

Barros et. al. (2015) proposed a model depicting the evaluation of the influences of the adoption of Information technology in supply chain management, which is comprised of the dimensions i.e. Cost reduction, Operational efficiency and process improvement, Quality, reliability, and accuracy of information, Integration and collaboration, represented by the diagram as shown in Figure 1.2:

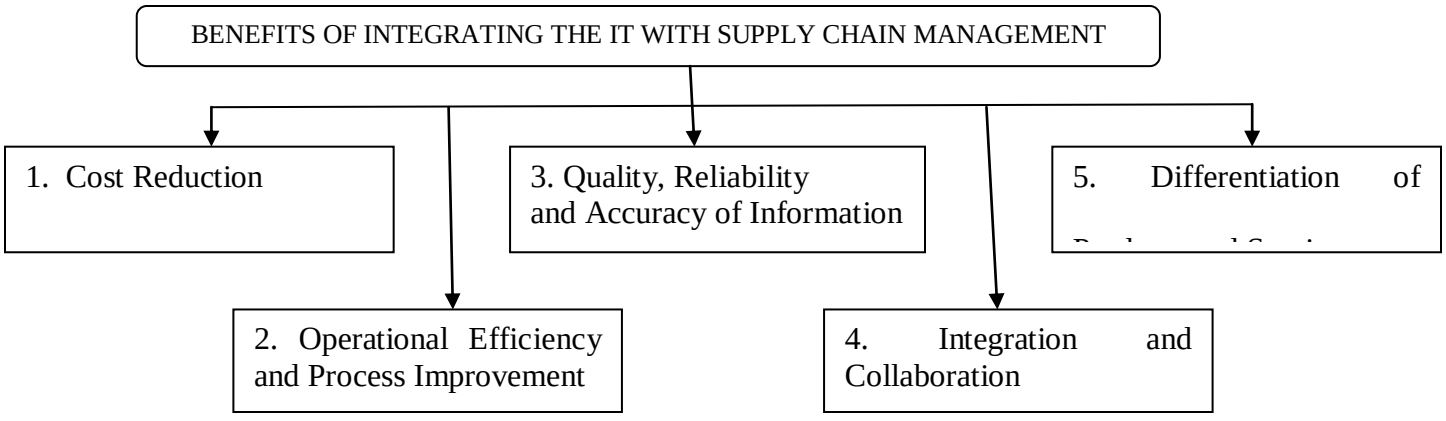


Figure 1.2: Diagram for the evaluation of the benefits of IT on SCM

Hence it may be concluded that proper adoption of Information technology will enable the supply chain management to have a reliable management information system so that the

accurateness of the data gives assurance to the business association, especially in terms of procurement with an adequate inventory control, a good forecasts system and a better computer control status of material resources and allow these kinds of businesses to have competitive advantages and better performance.

Yanjing (2009), explained that data integration ensures the correctness of data and prevents data idleness and repetitions of data. Moreover, enterprise resource planning reports can be used to forecast production and make choices. Recently, many enterprise resource planning vendors provide an ERP-CRM integration platform, since many business groups have expressed an interest in integrating a new CRM system with their legacy ERP system. Then, companies can exploit the advances in IT techniques and methods to enable the integration of their external business functions. Companies can become "extended" by enabling connectivity to business partners, suppliers, and customers.

According to Norris et al. (2000) described that supplier resource management systems are information systems for supply chain management, shipping management, strategic planning, warehousing, inventory, manufacturing, supplier management, and customer management Premkumar (2000); Grover and Saeed (2007); Shaik and Abdul-Kader (2013), explained that the adoption of inter organizational information systems (IOS) for supply chain management has been proposed to enable external integration which include Electronic Data Interchange (EDI) networks, extranets, customer oriented strategic systems, electronic commerce (e-commerce) and electronic markets. Turek (2013) told that for implementing information technology systems, software businesses provide bids, stages and services such as Internet Web services and Application Programming Interfaces (APIs), software-as-a-service (SaaS) growth platforms, and Software Development Kits (SDKs). Gunasekaran and Ngai, (2004); Jeyaraj and Seth, (2010) explained that organizations have to concentrate on the strategic business arrangement with IT

goals and objects, in order to maximize investment in information technology and achieve harmony with business strategies and plans. Marinagi et al., (2011) concluded that the strategic point of alignment is the value creation that enables a company to develop a strong competitive advantage and therefore not only to survive, but also to become a pioneer among the competitors.

1.4 Performance measurement of IT enabled supply chain

According to Rylkova and Bernatik (2013), performance measurement is vital for industry because if the efficiency of a process or activity is not measured, the activity cannot be properly controlled. Further for every organization having desires to be successful and lead the competitors, measurement of their performance is must. Effective performance measurement is important area to successful application of plan. Company has to measure costs, quality, flexibility, value and other dimensions of processes. Cho et. al.(2012), explained that to obtain objectives or ensure continuous improvement, the performance of the processes must be measured. Neely et al. (2002) define performance measurement as the process of measuring the efficiency and competence of past actions. It is also told that performance measurement provides the information essential for decision makers to strategizes, control, and directs the activities of the organization.

1.4.1 Performance measures

Gunasekaran et al., (2004) propose a framework for measuring the strategic, tactical and operational level enactment in a supply chain. In addition, a list of important performance metrics was presented. It is also explained that performance processes should deal with dealers, delivery performance, customer-service, and inventory and logistics costs in a supply chain management. Performance measures allow managers to measure performance, train employees

and suppliers on the important magnitudes of enactment and direct improvement activities by identifying deviations from standards.

1.4.2 Performance measurement system

Many authors in the area of supply chain wrote about the performance measurement system in their research work and explained different approaches of the performance measurement system. After studying the research papers of Gunasekaran et. al. (2001); Kurien and Qureshi (2011); Tracht et al. (2013); it is found that various performance measurement approaches have been developed, a few of those approaches of the performance measurement system used to measure supply chain management performance, which are discussed in literature review of this report.

1.5 Motivation

As already discussed that generally a supply chain includes a variety of stages i.e. customers, retailers, distributor, manufacturer and supplier. If any node of the supply chain has any difficulty to perform with its full efficiency and effectiveness, the performance of the whole organization gets affected. So to maintain proper coordination among the various parties of the supply chain is necessary for which techniques of information technology plays a vital role. According to Gunasekaran and Ngai (2004) the flexibility and receptiveness, globalization, new and innovative products, new markets and mergers and acquisitions are the major reasons for information technology in supply chain management**.** In addition, it is difficult to attain an actual supply chain deprived of information technology. Hence it is clear that for better performance, efficiency and effectiveness and to stand in the competition of today's era, a firm has to adopt the information technology. Further Rylkova and Bernatik (2013), told that performance measurement is essential for enterprises because if the efficiency of activity is measured, the

activity cannot be properly controlled. For every organization having desires to be successful and lead the opponents, it is essential to measure its performance. Gunasekaran and Ngai, (2001) told that Individual firms will certainly have enactment measurement needs that reproduce the unique operations of their business and all supply chains could not be identical. Therefore it can be concluded that for increase in performance in a supply chain and to achieve the aim of supply chain optimization and performance measurement is necessary all over the supply chain. Liu et al. (2013) investigate the influence of information technology capabilities on firm performance in the supply chain context and found that a company's information technology competences both flexible information technology arrangement and information technology integration can help the firm improve its absorptive capability. Ye and Wang (2013) investigate the effects of information technology alignment and information sharing on operative presentation in the context of supply chain. Based on the resource-based view, they identified information technology alignment and info sharing as exact resources or competences for supply chain partnership. Main focus was given on the operational performance of firms and cost efficiency and customer responsiveness are taken as the two important operational components of supply chain performance and the results of this study validate the direct effect of information technology alignment on customer responsiveness in the supply chain context. Tyagi et al. (2014) provides an approach to control the impact of various alternatives on the presentation of IT enabled supply chain. Alternatives are taken as top management support, information technology advancement and Supply chain integration on the account of performance development in IT enabled supply chain. An analytic hierarchy process (AHP) based model was proposed, which provides the decision methodology to give a ranking order of these alternatives, to improve the supply chain performance. In this study only three alternatives are evaluated for the purpose of the improvement of the supply chain performance. As per my concern the

research may be concentrated on that after integration or applying the information technology techniques in the supply chain, what are the parameters responsible for the firm's performance and how they affected. Gunasekaran and Ngai (2004) concluded that performance measures and metrics need to be established for measuring the presentation and appropriateness of information technology in SCM. For application of the multi criteria decision making method, According to the Kashi K. (2015), any 'multi criteria decision making' method can be a good tool for examination and evaluation purpose since they are able to use mixture of quality wise and measurable factors or criteria chiefly, DEMATEL method will shows which capabilities most affect other key capabilities and hence need pay a closer attention to those. It is clear that to measure or evaluate the performance of the supply is necessary to evaluate the efficiency and effectiveness of the product, service or organization. It was the matter of interest and motivation that with the integration and application of the techniques of the information technology, how the organization's performance can be evaluated. The literature it was found that many authors have performed in this direction. Hence there is a need to develop a performance evaluation model for a information technology enabled supply chain.

1.6 Research objectives

The research objectives of this work are summarized as given below.

(i) To study the IT enabled supply chain management

(ii) To identify the performance parameters for IT enabled supply chain

(iii) To develop a model of performance evaluation system for IT enabled supply chain.

1.7 Summary

A supply chain may be considered as the set of nodes or activities where value addition takes place and connects the enterprise to its suppliers as well as its customers. These nodes include customers, retailers, distributor, manufacturer and supplier. Management should emphasize to maximize the overall value of the company by better utilization and resources allocation. Also effective supply chain strategies must take into account the interactions at the various levels in the supply chain to reduce cost and improve service levels. As the size of the business or organization increases the number of the intermediary or units or sub units also increases and the supply chain network become large and complex and this complex network is very difficult to manage or coordinate. With the advent of the computer and information technology technique and increasing integration of information technology has led to favorable results in terms of goal accomplishment either generally or specifically in the functional areas of organizations. Gunasekaran and Ngai, (2004); Jeyaraj and Seth, (2010) explained that organizations have to concentrate on the strategic business alignment with IT goals and objectives, in order to maximize IT investment and achieve harmony with business strategies and plans. Hence, it is the necessity for the organizations to opt IT enabled supply chain, which includes EDI, ERP, SRM, CRM and IOS etc, to enhance the firm performance and stand in competition. According to Rylkova and Bernatik (2013), performance measurement is essential for enterprises because if the efficiency of activity is not measured, the activity cannot be properly controlled. Various approaches of performance measurement systems were explained in the Literature review. In chapter 2 contains the literature review about the IT enabled supply chain, a research gap analysis and the identified performance parameters. In chapter 3 research methodology is discussed. Chapter 4 consists of the statistical analysis of data received. In

chapter 5 performance evaluation using DEMATEL is performed. Chapter 6 contains the conclusion of this project. At last of this report references of research papers are given.

Chapter 2
Literature Review

2.1 Introduction

To learn about the IT enabled supply chain for this report, various research papers, books and articles of various journals of highly repute like Elsevier, Emarald, European Journal of Operational Research and Journal of Operations Management etc are studied. Most of research papers are enlisted as references at the last of this report. Literature review of this report may be divided into the sections, based on the questions that what is supply chain management, what do you mean by Information Technology enabled supply chain and what is the importance of IT enabled supply chain management and significance for industrial purpose and how the authors performs the performance evaluation of the supply chain and how many types of the performance evaluation of the supply chain are there and finally the conclusion of this literature review is given? A gap table is prepared at the last which shows the work done or research done by the authors and scope of the further study and research. On the basis of the literature review and discussion held with the field experts, performance parameters are identified as shown in table 2.2.

2.2 Supply chain management

Lau and Lee (2000), described the supply chain concept as the formation of a value chain network which consists of individual efficient entities maintained to provide information and resources, so that objectives of efficient management of suppliers as well as the flow of parts may be achieved. According to Azevdo et al., (2011); and Azfar (2014), it is explained that supply chain could be considered as that chain due to which connects the various components,

from last consumer to far most service providers, over the process of manufacturing and various facilities so that the way of information, resources and money efficiently be consummate for meeting the saleable needs. Sukati et al. (2012), told that a supply chain may be described as the set of values adding activities connecting the suppliers and its customers of the enterprise. The principle of supply chain activity may be defined as receiving input from firm's suppliers, add value and deliver to customers and it is also explained that the supply chain encompasses all the parties that involved, openly or ultimately, in satisfying a customer need i.e. manufacturer, suppliers, transporters, warehouses, retailers and even customers themselves. Olson (2012), described that the most important processes of the supply chain include product development, manufacturing, procurement, distribution physically, customer relationship management and performance evaluation. Chandra and Grabis (2007); Marinagi (2014), defines supply chain that a supply chain is a system that contains of dealers, producers, warehouses, distributors and retailers who coordinate their strategies and actions in order to translate raw resources to finished goods to deliver to the ultimate user. According to Thomas and Griffin (1996), supply chain management is the administration of material and information which flows in and between services, such as vendors, industrial and assembly plants and distribution centers. Lambert et al. (1998), described supply chain management as that it is defined as the integration of key business activities from end user through suppliers which provides products, services, and information and value is added for consumers and other stakeholders. Gunasekaran and Ngai (2004); Sufian (2010), explored in their research that effective supply chain management is important to build and sustain competitive advantage in product and services of the firms. It is also stated that the performance of supply chain was inclined by handling and assimilating key element of information into their supply chain. Sufian (2010), told that if an organization wants to achieve a reasonable benefit and better presentation, supply chain management strategy need

support the business strategy. Chopra and Meindl, (2007); Bayraktar et al. (2009) and Tseng (2010), described that the supply chain management practices includes the group of approaches and practices that effectively join with manufactures, suppliers, distributors, and clientele to increase the long term performance of business. Bayraktar et al. (2009), explained about the downward supply chain and upward supply chain and in this regard it is told that on the downward supply chain, supply chain management and supplier relationship management systems manage the procurement and relationships with suppliers in order to safe delivery of bought-out resources and constituents required for in house production. According to Gunasekaran et al. (2004), the whole supply chain may be divided as the top level, middle level and lower level. The supply chain functions at the strategic level are top echelon organizational decisions, very often reflecting investigation of comprehensive policies, business financial plans, competitiveness and level of adherence to goals of the organization. The supply chain functions at the tactical level are resource distribution and measuring performance against targets to be met in order to attain results stated at the planned level. Operational level supply chain functions are identifying the products, purchasing them, storing them and distributing the same. According to Shaik and Abdul (2013), and Marinagi (2014), it is explained that supply chain management aims to support the organization providing the means to attach technology and people and trying to align the expertise with the business competences and among its business partners. Supply chain management enables business partners to synchronize their actions through information sharing, which helps to facilitate supplier-customer interactions and minimize transaction cost. Gunasekaran and Ngai (2004), told that supply chain management is the 21st century worldwide processes plan for achieving organizational competitiveness. Kim (2006), has examined the linkages among supply chain administration practices, rivalry competence, the level of supply chain incorporation and firm enactment. His research discloses that supply chain integration is

extra critical in early stages and on completion of its supply chain integration; a company can focus on supply chain management practice and competition capability.

2.3 Role of information technology and it enabled supply chain

According to Barua et al. (2004), the advantages of utilising information management are reflected largely in relation to procurement by observing better collaboration and explicit sustained agreements with the purpose of avoiding or reducing delays in the delivery of material resources. Kumar et al., (2015), told that if the small and medium enterprises have to face challenges of global competition, they should be equipped with internally and externally coordinated supply chains. According to Handfield and Nichols (1999), to obtain effective integration of supply chain, the companies should implement Information Technology for example in the product development process, the application of computer aided design. According to Boyer and Pagell, (2000), computer aided process planning and computer aided manufacturing, aids in product and method design by the creation of a common language. Overby and Min (2001), told that use of enterprise resource planning systems i.e. SAP and Oracle has been implemented to supply Chain Corporation and enabling supply chain partners to plan and coordinate their processes**.** Kohli and Devaraj (2003), described that the relationship between Information Technology and firm performance is an innovative research matter in the literature of Information System. According to Petkovic et al. (2014); Konsynski and Tiwana (2004); Singh and Teng (2016), Inter organizational Information Systems are performing an increasing role in facilitating and making Inter-organizational collaboration as companies are investing in joint resources to manage increasingly complex and merged systems. Byrd and Davidson (2003), described that Information Technology impacts the supply chain effectiveness and also told that development and long term usage of Information Technology lead to better

performance in terms of return of investment, return of equity and market share. Vickery et al. (2003), suggested, supply chain coordination and integration is facilitated by expending assimilated information technology, which directly impacts a financial performance of the firms. Barua et al. (2004); Patnayakuni and Seth (2006); Huo et al. (2015), told that although information technology can potentially boost supply chain management, many firms fail to realize this potential due to the lack of supply chain coordination over information technology, or since their dealing associates may not have the capability to align with them. Rai et al. (2006), found that information technology infrastructure incorporation meaningfully improved supply chain process integration, which pave the way to enhancement in the firm performance. Zhu (2004), and Huo et al. (2015), distinguished today's supply chain management from the traditional supply chain management approach having focus to change from the connecting of physical procedures to the connecting of information based processes across the whole supply chain operations. Huo et al. (2015), found that Information Technology for both dealers and clients straightly improves supply chain harmonization, reproducing the importance of technological resources in reinforcing coordination capability, which enhances the firm's performance. Gunasekaran and Ngai, (2004), concluded that investigating relationships between supply chain strategy and supply chain performance suggest that the effective deployment of Information System into supply chains is associated with improved performance. It is also explained that companies are trying to find conducts to advance their tractability and receptiveness and in turn competitiveness by changing their processes strategy, methods and skills that include the implementation of SCM paradigm and information technology. Wu et al. (2006), and Ye and Wang (2013), described that there are numerous Information Technology properties in a firm, with computer aided design or engineering, computer aided production, computerized manufacturing planning and lesser rigid manufacturing systems. It is also

explained that for Information technology resources, to bring firms at competitive advantages in supply chain context, companies must be embedded IT in supply chain processes. Information technology alignment is a valuable, rare, inimitable, and non-substitutable resource embedded into supply chain processes. According to Lancioni et al (2003), the Internet helps supply chain partners for exchanging information on required products, inventory available, manufacturing processes, and delivery of the products. Ketchen et al. (2008), told that supply chain information systems is one of the key areas where best value supply chain differ from traditional supply chains. In the current era the best value supply chain equipped the development of information technology systems for supply chain management that support and speed up all business activities, improving decision making and productivity, can build competitive advantage throughout the supply chain. According to Papp (2001) and Marinagi et al., (2011), organizations have to focus on the strategic business arrangement with information technology goals and aims, in order to maximize IT investments and achieve accord with business strategies and tactics. This alignment is a prerequisite for a business to survive in the ferocious global rivalry and the digital age. The strategic point of alignment is the creation of value that enables a firm to develop a strong competitive advantage and hence not only to survive, but also to become a leader in the market. Marinagi et al., (2011) and Torabizadeh et al.(2012), told that alignment of information systems with supply chain management strategies and explained how they affect on supply chain and performance of the organization. Jeyaraj and Seth (2010), wrote that for taking advantage of the application of information technologies for supply chain management, organizations have also to understand that the design and implementation of their own information technology techniques and these methods must be at par with those of their supply chain partners and also the level of computerization between associates must be coordinated, otherwise, the organization will be isolated, or face gaps in supply chain visibility. Singh et al. (2012), and Kumar et. al.

(2015), told that since small and medium enterprises are under great pressure to reduce cost, for which an proper inventory management system at every point of the supply chain minimizes the inventory at supply chain points and observed that effectiveness of Indian small and medium enterprises can be improved if they focus on product customization, waste reduction, housekeeping, and information technology, applications to reduce lag of time in various processes. Gunasekaran and Ngai (2004); Jeyaraj and Seth (2010) and Marinagi et al. (2014), concluded that companies need to comply with standards and legal frameworks for the application of information technologies in supply chain management. Barros et al. (2015), wrote that the growth in the use and application of information technology and systems in supply chain management can be attributed to performance improvements and value creation in organizations. In their research paper cost reduction, operational efficiency and process improvement, quality, reliability, and accuracy of information, integration and collaboration, differentiation of products or services are mentioned as the benefits of the information technology. Marinagi (2014), concluded that the evolution of Information Technology practices and techniques is a factor that enabled the integration of supply chains into value systems and maximizing Information Technology investment could lead firms to higher profitability and effectiveness. Monica et al. (2015), explained that the use of Information Technology in the supply chain management has established to have an encouraging impact in companies that have implemented it, particularly in relation to procurement, since this boosts relationship, improving the quality of information shared between suppliers and buyers. Also found that there is a substantial link between the use of Information Technology and strategies implemented by the companies in the supply chain management, therefore proper functioning of this fundamental factor for achieving operational efficiency and that's why financial organizations depends heavily on the use of information technology. Subramanian and Gunasekaran (2015), demonstrate that the information technology

of a supply chain refer to handling information flows in modern, global supply chains. The information technology or information systems drive sophisticated information technologies that support complexity of information, its proliferation, diffusion, and pace. In their study it was highlighted that how the information tools can be used effectively to measure, control, and improve efficiency of energy in production management. Marinagi (2015), reached at the result in her research that information sharing has a arbitrating influence between info quality and supply chain performance. Bayraktar et al.(2009), told that due to intensifying competition in global markets, today's most of the companies have been increasingly integrating supply chain management with information systems practices. In their research they found that there is a moderating impact with regard to the relationship between information systems practices and operational performance. Denolf et al. (2015), explained that Supply chain information systems have emerged as the core of successful management in supply chains. In their research, a wider view is taken and the critical success factors are found which includes, Communicate effectively, Manage relationships, Compose project team, take top-management responsibility, align vision and build plans, share costs, benefits, and risks, Assess business & Information Technology legacy system, select standards, vendor and software package, reengineer processes, manage project, manage data exchanged, manage change and train users and monitor and evaluate performance. Qrunfleh et al. (2014), told in their research that supply chains are becoming gradually intricate, and their effective management progressively requires smart and suitable information dispensation. The result reveals the importance of arranging submissions in the supply chain that provision the particular supply chain strategy, e.g. enterprise resource planning and electronic data interchange, etc. Shi (2007) and Singh et al. (2016), suggested that where Interorganizational system empowered B2B e-commerce arrangements were found to reduce transactional costs. Singh et al. (2016), described that Information Technology plays an active

role in enhancing Supply Chain performance with a host of related factors. Also found in their research that with increase in business abilities over the time, the role of Information Technology too has shifted and it began with basic reduction of coordination expenses, stimulated to improvement in performance and finally now has the capability of influencing structures.

2.4 Performance evaluation of IT enabled supply chain

Gunasekaran et al. (2001), explained the supply chain performance as its overall productivity and effectiveness. Beamon (1999), recommends three aspects for measuring supply chain performance, namely, assets measurement, productivity measurement, and flexibility. As per their research it was also suggested that supply chain performance should be evaluated in terms of manufacturing and inventory expenses, receptiveness to variations in distribution supplies and incorporation with partners. Singh et al. (2016), define supply chain performance for tractability, incorporation, and customer responsiveness**.** Kazemkhanlou et al. (2014), concluded in their article that performance measurement is a power tool that assists firms or organizations to evaluate supply submission so that it can be strategically managed and incessantly controlled to achieve their aims and goals. According to Chan (2003); Bhagwat and Sharma (2007), performance measurement defines the feedback or information on events to fulfill customer prospects and intended aims. It reflects the need for improvement inareas with unsatisfactory performance and hence efficiency and quality can be improved. Motwani et al. (2000), told that companies need to invest large amount of money for redesigning internal organizational and technical processes, altering traditional and important supply channels and customer facility process and training staff to achieve IT-enabled supply chain. The study presented in the research paper of Ajay and Maharaj (2010), revealed that information system has a great impact on the overall budget of administration of an efficient supply chain and

progresses the all-inclusive administration of supply chain accomplishments. Tracht et al. (2013), suggested that Performance measurement systems can help to achieve corporate objectives, enhance consumer approval, improve reliability of planning tools and reduce costs for spare parts stocking. According to Kumar et al. (2015), performance measurement can be defined as the process of quantifying the effectiveness of various procedures being followed by the business. Performance measurement provides the information necessary for decision manufacturers to plan, regulate and direct the activities of the organization. Performance measures let administrators to quantify performance, to indicate and coach personnel and providers on the important magnitudes of performance, and to direct improvement activities by identifying deviations from standards. Chwelos et al. (2001), and Subramani (2004), explained that Internet-enabled Supply Chain Management systems are the technical enabler of the instrumentation of value chain processes across firm confines. These developments are identified by various scholars and academics and called them as a generic cure for many operational issues of the supply chain**.** Frohlich(2002), described that the Internet-enabled systems allow customer and supplier integration stronger comparatively, as they avoid the tradeoffs among low cost, rich content, real-time data, and broad channel deployment. It is also told that eSCM have a range of features for information sharing, capability of joint decision making, and integration of business processes. Ke et al. (2009), concluded that it may be said that with the integration of IT, channel partners are allowed to share rich content information such as inventory and new product ideas in real-time, enable global training services and procedural information sharing and thus enable the generation of synergistic effects with relatively low cost. They recognized that electronic supply chain management, such as SAP, Oracle and IBM e-business have been integrated with companies as very strong strategic tools for supply chain management. It is also explained that different from early forms of Information Operating Systems (IOS),, electronic supply chain

management systems (eSCMS), especially the Internet enabled supply chain management systems i.e. IT SCMS, have enhanced features, e.g. shared database and joint decision making support that allow the joining of fragmented, silo-oriented supply chain processes with less cost and opulent content. As per Chen et al. (2007), supply chain performance measures should take a process perspective and the progression metrics does add to better synchronization and integration among various departments. It is also stated that if initiatives encouraging integration come from the top levels of the organization, they are more likely to succeed. According to Kurien et al. (2011), there is a challenge in choosing the right "Measurement system design" and "finding what you aim to measure so as to focus on what is undeniably vital". Further, it is also described that a performance measurement system should be derived from the company's objectives and should be appropriately focused on present and future results, different types of enactments e.g. cost, quality, delivery, flexibility and dependability, various outlooks e.g. the client, the shareholder, the contender, the internal and the innovativenessperspective and various organizational levels e.g. global and local performance.

Soosay and Chapman (2006), explored that performance measurements are useful diagnostic tools for better decision-making and a main obligation of effective continuous innovation. Bai et al. (2014), wrote in their article that with the large set of possible maintainable supply chain performance procedures, recognizing key performance indicators (KPI), becomes best exercise strategy for procedures and supply chain management. As per Slack N. et al. (2010), there should be a clear link between the overall strategy of the operations, the most important or KPIs, that reflect strategic objectives, and the group of detailed measures that are used to flesh out each key performance indicator.

As described by Gunasekaran et al. (2004), that the works of various authors are used in establishing the essential for supply chain enactment measurement and to describe in general

terms how it should be addressed and emphasis is given on measurement systems and approaches as that opposed to specific measures. On studying the research papers i.e. Gunasekaran et. al. (2001); Kurien and Qureshi (2011); Tracht et al.(2013); it is found that various performance measurement methods have been established, a few of those approaches of the performance measurement system used to measure SCM performance, some of them are

(i) Supply Chain Council's SCOR Model

It advocates a set of supply chain performance measures contained of a blend of

- Cycle time metrics
- Cost metrics
- Service/quality metrics
- Asset metrics

(ii) The Logistics Scoreboard

It recommends the use of an integrated set of performance measures under the succeeding groups:

- Logistics economic performance
- Logistics productivity performance
- Logistics Quality performance
- Logistics cycle time performance

(iii) Strategic measurement analysis and reporting technique system

Thsis system was developed by Wang Laboratories, Inc. which consists of a four-level pyramid of measures and objectives:

(a) Corporate vision/strategy,

(b) Business unit market and financial objectives,

(c) Business unit operational objectives and priorities,

(d) Departmental level operational criteria and measures.

(iv) Performance measurement questionnaire

It involves a plant to improve, review, and redeploy the set of performance measures. It has the advantage of providing a appliance for recognizing the development areas of the firm and their associated performance measures. However, it cannot be deliberated a complete incorporated measurement scheme and does not consider incessant improvement.

(v) Strategic performance measurement system

This performance measurement system is an action-focused tool, which concentrates on the establishment's strategies. The ideas and concepts were developed by hands-on experience.

(vi) Integrated dynamic performance measurement system

This method is developed by Ghalayinin, Noble, and Crowe (1997), to achieve an integrated system by uniting three main areas of the firmadministration, procedure improvement team, and factory shop floor.

(vii) Holistic process performance measurement system

This performance measurement system is especially for modern process-based businesses. It evaluates the performance of the operations for five aspects:

- Customer view,
- Employee view,
- Financial view,
- Societal view, and
- Innovation view.

(viii) The Balance Score Card

It recommends the use of Executive Information Systems (EIS), whichtrail a number of stable metrics that are closely aligned to strategic objectives. The approach would recommend

that a small number of balance supply chain measures be tracked on the following four perspectives:

- Financial perspective
- Customer perspective
- Internal business perspective
- Innovative and learning perspective

2.5 Research gap analysis

With the extensive literature review, it may be understood that the research is a continuous process. One researcher complete e work. This work opens the ways for the new researcher for the further research and so on. A research gap analysis is performed and it is given in the table 2.1.

Table2.1: Research gap analysis

S. No.	Reference	Work Done	Gap Identified
1	Bhagwat and Sharma (2007),	A balanced scorecard is developed for supply chain management that measures and evaluates day-to-day business operations from following four perspectives: customer, internal business process, finance, learning and growth.	It is very difficult to establish relationship between key measures and performance drivers with the cause-and-effect relationships and if cause-and-effect relationships are not properly reflected in the balanced scorecard, firm's vision and strategy could not be communicated and translated properly.
2	Bayraktar et al, (2009),	This study has empirically tested a framework identifying the underlying links among supply chain management and information systems practices, related inhibiting factors and operational performance on the basis of 203 manufacturing sme operating in the manufacture of fabricated metal products and general purpose machinery.	In this study the parameters related to only operational performance was considered, strategic or tactical parameters for the firm performance were not considered.
3	Uysal (2012),	Method of The Decision Making Trial and Evaluation Laboratory (DEMATEL), was functional to deal with the importance & causal associations between sustainable performance measurements criteria by considering the interrelationships among them for selection of firms.	A few parameters are taken. Statistical analysis like factor analysis could be performed before applying DEMATEL method.
4	Tracht. et al. (2013),,	Demand planning based on performance measurement systems in closed loop supply chains	This paper was focused on the proper supply of the spare parts for the maintenance, repair and overhauling of aero plane, to reduce the down time. The manufacturing sector is not considered.

S. No.	Reference	Work Done	Gap Identified
5	Marinagi et al, (2014),,	The impact of Information Technology on the development of Supply Chain Competitive Advantage	The impact of contextual factors such as business environment, on the link between IT and SCM competitive advantage may be explored.
6	Tyagi et. al. (2015),	Determined the impact of various alternatives on the performance of IT enabled supply chain. Three alternatives namely, top management support, IT advancement, and Supply chain integration on the behalf of performance improvement in IT enabled supply chain, are taken. An analytic hierarchy process (AHP),-based model is proposed and provided the decision methodology to give a ranking order of these alternatives, to improve the supply chain performance.	If other multi criteria decision method like DEMATEL was used, the result may be different.
7	Monica et al. (2015),	Information and communication technology as a Key Strategy for Efficient Supply Chain Management in Manufacturing SMEs	The information and communication technology integration is considered for supply chain performance at strategic level. While information technology affects every aspect causing firm performance.
8	Singh and Teng, (2016),	Developed a research model that including five factors i.e. Information Technology Integration, Inter-organizational Trust, Relational Governance, Transaction Cost, and Supply Chain Performance.	In this study information technology integration, inter organizational trust, relational governance, transaction cost are considered for supply chain performance. While information technology affects every aspect causing firm performance, but not considered.

2.6 Identification of performance parameters

In the context of the literature available it is found that there are huge pool of actual performance measures to choose but in the case of the supply chain performance measurement a process perspective should be chosen and focus should be on some of the important key

measures or key performance indicators which may be considered to have a clear link to strategic goals of the organization such as case customer satisfaction of the company, inventory goals and accuracy of the forecasting. Frohlich (2002); Patnayakuni and Seth (2006), explained in their research paper that for effective measurement of performance and improvement, goals of measurement must represent organizational goals and metrics selected should show an equal approach between financial and non-financial measures that can be related to strategic, tactical and operational levels of decision making and control. According to Elrod et al. (2013), the supply chain should be measured to evaluate performance and that the measures most important to the performance of the organization should be selected. Carlucci (2010), described that in order to prevent information overload, it is preferable that any effective performance measurement system has to include a limited number of indicators, i.e. key performance indicators. By the extensive literature review twenty seven parameters are chosen, which are given in the Table2.1 on the next page:

Table 2.2: Performance parameters

S. No.	Parameter	References	Remarks
1	Proper responsiveness to urgent orders	Bhagwat R. and Sharma M. K.(2007),),, Rossiter J. R.(2009),, Joshi S.(2013),, Qrunfleh S. and Tarafdar M. (2014),, Huo B. et al. (2015),	Urgent orders are taken on priority as compared to the existing orders, and organization equipped with IT has to deal with this situation properly.
2	Forecast ease for market demand	Bhagwat R. and Sharma M. K.(2007),, Tracht K. et al. (2013),, Colin M. et al. (2015),, Kumar R. et. al. (2015),	IT enabled supply chain helps for market demand forecasting i.e. to know about the near future sale or consumption.
3	Productivity improvement	Marinagi C. et al. (2014),, Barros A. P. D. et al. (2015),	It means the number of item of required quality produced or amount of service given in a specified time.
4	Proper visualization of customer needs	Marinagi C. et al. (2014),, Qrunfleh S. and Tarafdar M. (2014),, Barros A. P. D. et al. (2015),, Huo B. et al. (2015),, Kumar R. et. al. (2015),	IT enabled supply chain helps in understanding that what the customer wants.
5	Total lead time reduction	Tracht K. et al. (2013),, Azfar K. R. W. et. al. (2014),, Colin M. et al. (2015),,	It means the time elapsed between the moment customer places an order and get the delivery. IT enabled supply chain helps in reduction of total lead time
6	Total Inventory cost reduction	Tracht K. et al. (2013),, Azfar K. R. W. et. al. (2014),, Qrunfleh S. and Tarafdar M. (2014),, Kumar R. et. al. (2015),	Less number of items for less time are stored in IT enabled supply chain.
7	Increase the level of Customer satisfaction	Tracht K. et al. (2013),, Barros A. P. D. et al. (2015),	
8	Improve the relationships with suppliers and customer relation	Tracht K. et al. (2013),, Marinagi C. et. al. (2014),, Barros A. P. D. et al. (2015),	In IT enabled supply chain it is very easy make fast and clear communication with supplier and customer hence improved relationship.
9	Proper visibility among the supply chain stages	Azfar K. R. W. et. al. (2014),, Qrunfleh S. and Tarafdar M. (2014),	IT enabled supply chain has proper visibility among its stages
10	Helps in enhancing the cooperation among the existing stages	Rylkova Z. and Bernatik W.(2014),, Marinagi C. et. al. (2014),, Subramanian N. and Gunasekaran A. (2015)	Information Technology enhances the cooperation among the existing stages of supply chain

S. No	Parameter	References	Remarks
11	Helps in Maintaining the stability in the competitive market place	Marinagi C. et. al. (2014),, Subramanian N. and Gunasekaran A. (2015),	IT enabled sc helps to understand the strategy of the competitor and the decision are taken accordingly, which helps in Maintaining the stability in the competitive market place.
12	Easiness in Decision making	Luthra S. and Haleem A. (2015),, Colin M. et al. (2015),, Singh A. and Teng J. T.C. (2016),	As the required information for making a decision is received fast and correct, the manager feels easiness in Decision making.
13	Reduction in coordination cost	Marinagi C. et. al. (2014),, Colin M. et al. (2015),, Singh A. and Teng J. T.C. (2016),	There is no need to go everywhere physically and the communication may be made easily and fast in IT enabled supply chain, which reduces coordination cost
14	Information processing capability	Marinagi C. et. al. (2014),, Colin M. et al. (2015),, Singh A. and Teng J. T.C., (2016),	IT enabled supply chain enhances information processing capability
15	partnership structure enhancement	Marinagi C. et. al. (2015),, Barros A. P. D. et al. (2015),, Singh A. and Teng J. T.C. (2016),	Due the transparency ease, clarity and proper visibility in the business, IT enabled supply chain enhances the structure of partnership
16	Helps in automation of exchange procedures	Singh A. and Teng J. T.C. (2016),	Automation means the no interfere of human for the activity and the IT enabled supply chain makes the automation of exchange procedures.
17	Reduction in uncertainty	Koh S.C.L. and Saad S. M. (2006),, Bayraktar E. et al. (2009),, Singh A. and Teng J. T.C. (2016),,	Use of the Information Technology reduces uncertainty in any business activity.
18	Reduction of non value added activities	Qrunfleh S. and Tarafdar M. (2014),, Azfar K. R. W. et. al. (2014),	IT enabled supply chain, non value added activities are reduced
19	Improve the Reengineering capability	Denolf J. M. et. al. (2015),, Barros A. P. D. et al. (2015),	Use of the Information Technology, due to its vast application in the business sphere, its reengineering capability is improved.
20	Improve the Capability to integrate different business activities	Bayraktar E. et al. (2009),, Marinagi C. et. al. (2014),, Barros A. P. D. et al. (2015),, Colin M. et al. (2015),,	Any business includes various smaller or sub activities and for a effective business all the sub activities are to be joined in proper manner.

S. No.	Parameter	References	Remarks
21	Reduce the customer order path	Gunasekaran A. et. al. (2004),, Denolf J. M. et. al. (2015),	Use of the Information Technology, reduces the customer order path i.e. the channels or the steps which have to approach by the customer to place an order.
22	Reduce the Purchase order cycle time	Gunasekaran A. et. al. (2004),, Colin M. et al. (2015),, Kumar R. et. al. (2015),	Use of the Information Technology, reduces the Purchase order cycle time i.e. the time elapsed to place a purchase order; hence the IT enabled supply chain.
23	Flexibility capability Enhancement	Gunasekaran A. et. al. (2004),, Azfar K. R. W. et. al. (2014),	Flexibility means to fulfill the varying demand of the customer without the major change in the existing setup of the organization.
24	Helps in Quality improvement	Gunasekaran A. et. al. (2004),, Qrunfleh S. and Tarafdar M. (2014),	IT enabled supply chain helps in Quality improvement
25	Improvement in the Effectiveness of scheduling techniques	Gunasekaran A. et. al. (2004),, Tracht K. et al. (2013),	Scheduling means that the clock and calendar time fixed to do an activity and use of the Information Technology in scheduling techniques i.e. JIT, MRP and MIS etc improves the effectiveness of scheduling techniques
26	Reduction in customer query time	Gunasekaran A. et. al. (2004),, Qrunfleh S. and Tarafdar M. (2014),, Kumar R. et. al. (2015),	When a customer seeks the information about the product or service, the time elapsed for it is reduced by use of the Information Technology.
27	Helps the Top Management in taking Initiative for an activity	Luthra S. and Haleem A. (2015),, Denolf J. M. et. al. (2015),, Kumar R. et. al. (2015),	IT enabled supply chain helps the Top Management in taking Initiative for an activity

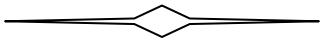
In the context of the performance evaluation and identifying the important elements, Kabra and Ramesh (2015), described that DEMATEL approach is utilized for identification of the various influencing components and critical factors and uses a structural model, i.e. cause and effect diagram. Also told that other Multi Criteria Decision Making (MCDM), methods such as Analytic Hierarchy Process (AHP), technique for order of preference by similarity to ideal solution (TOPSIS), may be used to solve this problem but DEMATEL approach considers all

the components as interdependent on each other. According to the Kashi (2015), AHP and DEMATEL are the multiple criteria decision making methods (MCDM). It is also told that MCDM method can be a good tool for examination and evaluation of employees since they are able to use combination of qualitative and quantitative features or criteria particularly, DEMATEL approach will shows which competencies most affect other key competencies and hence need pay a closer attention to those components.

2.7 Summary

After this literature review it is became very clear that the supply chain management is both a very popular and wide topic and time to time data written and researched keeps adding up. The benefits of the effective supply chain management are lower inventories, lower costs, higher productivity, greater customer loyalty and higher profits. If widely considered for supply chain management a good question arises that who has the responsibility of effectiveness of the supply chain? In the current era, supply chains that often span to networks of supply, also on global level require co-operation, defined processes and responsibilities as well as measurements to follow and improve the implementation. It is not possible to operate the whole chain or network by one person and thus it is become necessary to learn cross-functional, cooperative and team-oriented approach for managing the processes with the customer satisfaction in the main focus. The effective cross-functional teams approach on intra-organizational level enables cooperation of effective inter-organizational. In addition, an effective supply chain needs shared forecasts and visibility to order status in real time as well as access to inventory data of all partners. As the structure of supply chain or network by nature is complicated, the development should focus on simplification, process reliability improvement, process variability reduction and complexity reduction. Process documenting enables the monitoring and improving the process functions as

well as helps standardizing the processes between supply chain member companies. To combat the situation of the complex network of the supply chain the information technology arise as the most powerful tool in the form electronic data interchange, enterprise resource planning etc. Many authors wrote about the competency of the information technology if integrated with the supply chain network. In the context of the integration of the information technology with the supply chain network i.e. IT enabled supply chain, the following questions arise in the mind that how the performance parameters affect the supply chain performance and how these parameters affect each other? For the performance evaluation there are so many methods suggested i.e. AHP, ANP, DEMATEL, TOPSIS etc. DEMATEL approach considers all the components as interdependent on each other. This approach is based on the graph theory and manager can easily take decision by seeing the impact of parameters to each other on the graph. In the next chapter the research methodology for this work will be discussed.



Chapter 3
Research Methodology

3.1 Introduction

In the previous chapter, an extensive literature review is performed in context of the supply chain keeping a particular view on the IT enabled supply chain. With reference to that extensive literature review and the discussion held with the field experts of the supply chain a research gap analysis is completed and twenty seven parameters are chosen for the purpose of the performance evaluation of IT enabled supply chain. The chosen performance parameters are composed of the strategic, tactical and operational level. In this chapter the research objective are written. A flow chart was made in which the steps of the methodology of the project are given. Procedure of the research methodology in this work includes, development of questionnaire, data collection, statistical analysis of the collected data followed by the performance evaluation using DEMATEL. In statistical analysis, principal component extraction method of factor analysis was explained. Varimax rotation method was also explained briefly. After the statistical analysis of the collected data quantitative modeling was performed. For quantitative modeling DEMATEL algorithm was explained.

3.2 Research objective

The research objectives of this work are summarized as given below.

(i) To study the IT enabled supply chain management

(ii) To identify the performance parameters for IT enabled supply chain

(iii) To develop a model of performance evaluation system for IT enabled supply chain.

3.3 Research algorithm

A flow chart is made as shown in figure 3.1. By having a look on the flow chart the steps of the methodology of the project can be easily understood.

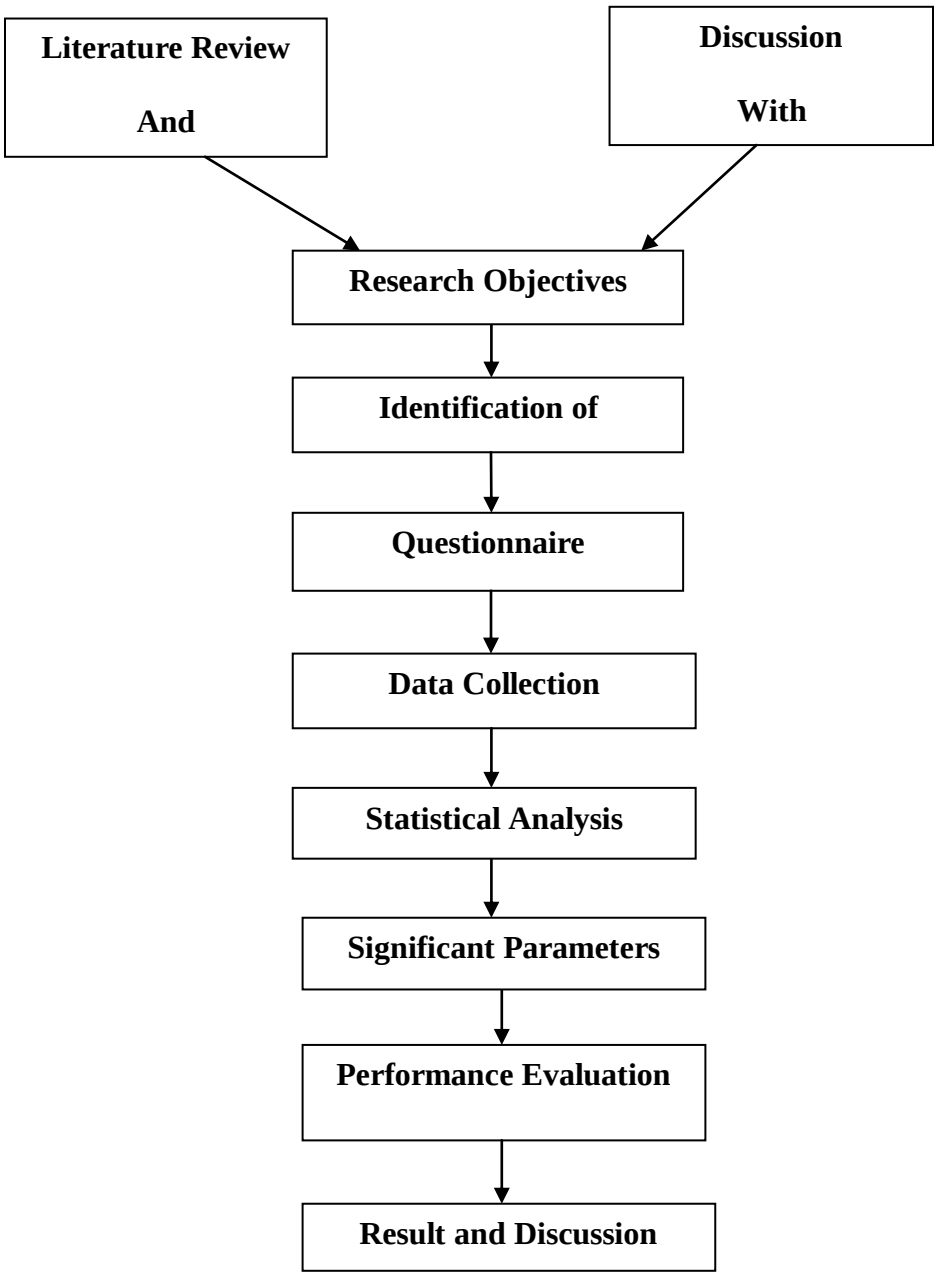


Figure: 3.1 Flow Chart for the Research Methodology of the project.

3.4 Survey Method

Kendall and Buckland (1971); Lamphier and Bailar (1978) wrote the definition of survey for social, statistical purpose that "survey is an examination of an aggregate of units, usually human beings or economic or social institutions. According to them the major technical aspects of the survey include definition of survey, domain of the study, survey characteristics to be measured, procedure of the data collection, procedures of data processing and types of the analysis of the data. The goal of the survey is also explained as that whether the survey successfully addressed each of the key technical issues.

Gunasekaran et al. (2001) has also presented the framework of the survey for the performance measurement of the supply chain, in which the performance measures of the strategic, tactical and operational level and further grouped into financial and non financial were utilized for the preparation of the questionnaire.

By taking the reference of the literature available, the survey method is prepared which includes development of questionnaire, data collection and analysis of the data received. The domain of the survey is manufacturing industry, particularly automobile industries located near about Delhi NCR. The brief explanation of the steps of this survey is given as hereunder:

3.4.1 Questionnaire development

A questionnaire is developed on five point likert scale, in which '1' is taken for the least importance and '5' for the most importance. The format of the questionnaire is given in the Annexure I. This questionnaire consists of three segments. In the first segment, the detail of industry was asked from field experts in which they are working. The second segment includes the twenty seven performance parameters of strategic, tactical and operational level in combined form. The third segment or the last segment of the questionnaire includes details of the profile of

the field expert. This questionnaire is uploaded on the google in the form of google form for data collection.

3.4.2 Respondents profile

The respondents for questionnaire are the field experts, working in different industries in Delhi NCR mostly in automobile sector; however some field experts are from other industries. The field experts were told to complete the questionnaire by clicking on the right option as per their opinion and also requested to submit their profile in the organization and details of the organization. Total sixty field expert responded to the questionnaire. The respondent profile may be understood by looking on the 1st and 3rd segment of the questionnaire, which shows the profile of the company and profile of the individual field expert. By looking on the company's profile it

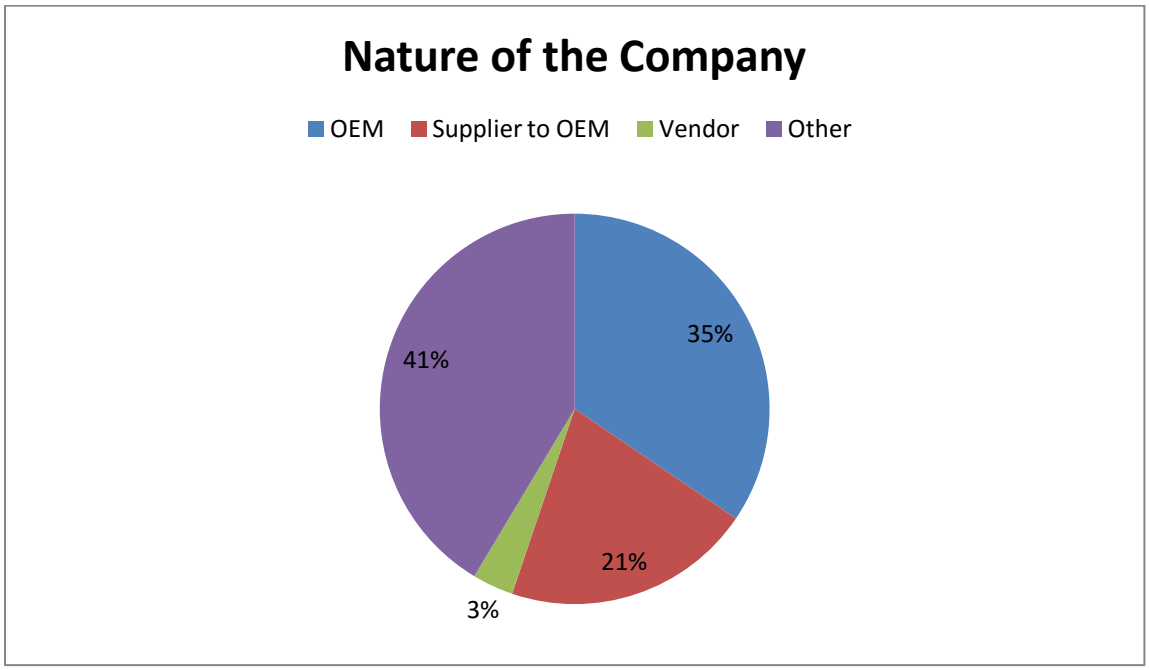


Figure 3.2: Nature of the company.

is seen that the percentage of original equipment manufacturing industries 35%, percentage of supplier to OEM are 21%, percentage of vendors are 3% and that of other industries is 41% as per the pie chart given in the figure 3.2. Out of the sixty respondents 76% belong to the

companies which are established before 2005, 3% belong to the companies, established between 2005 and 2009, 6% belong to the companies, established during 2009 to 2013 and that of 15% after 2013, as given in figure3.3. Out of the total, 38% of the companies have the number of employee; more than 1000, 15% companies have the number of employee from 500 to 1000;

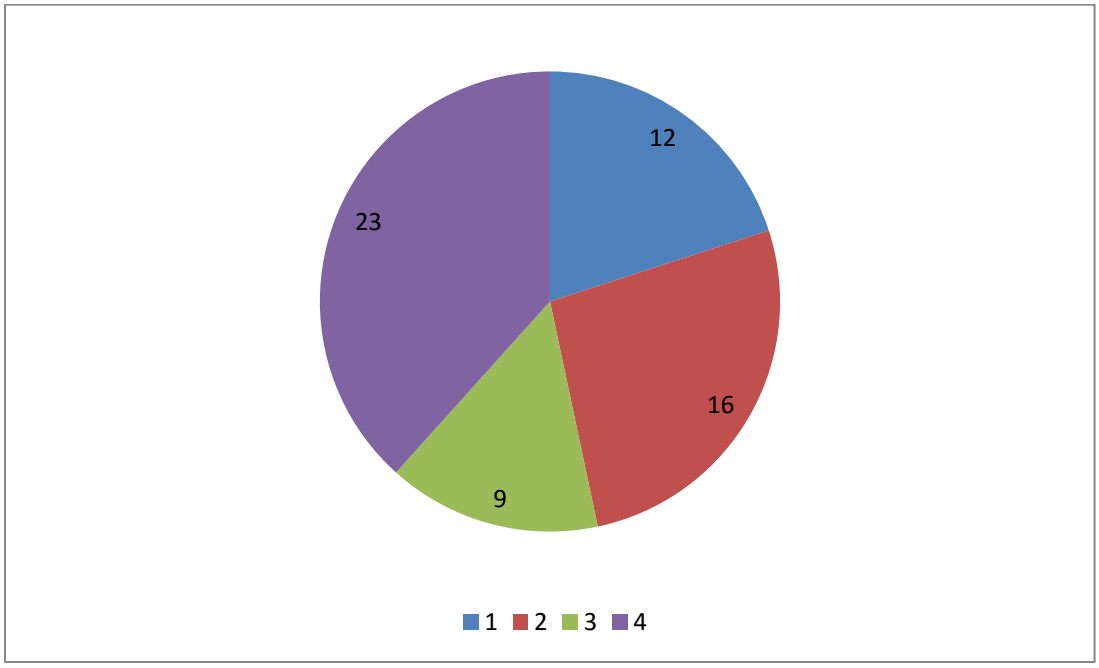


Figure 3.4: Number of the employee in the company.

27% companies have the number of employee between100 to 500 and that of companies have the number of employee less than100, as per the pie chart given in figure 3.4. If we have a look on the individual respondent's profile, 15% of the total respondents belong to the top management, 36% belongs to the middle management, 27% belongs to the middle management and that of others are 22%.

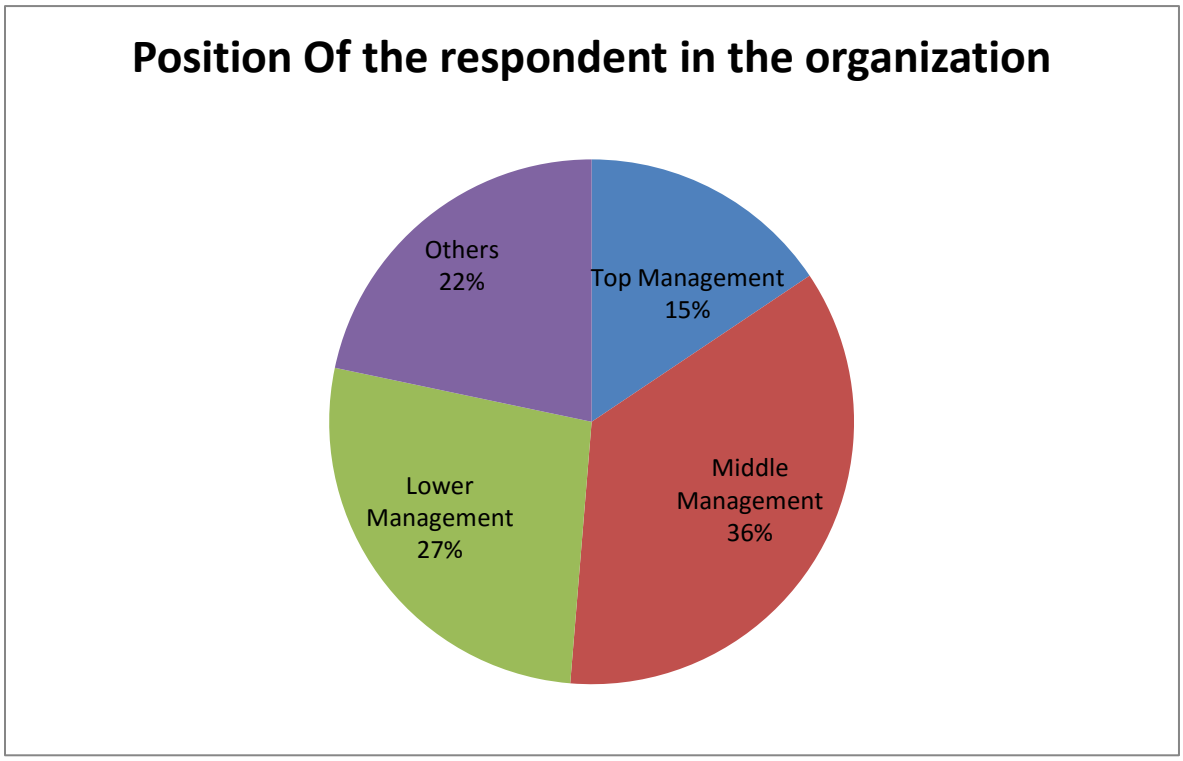


Figure 3.5: Position of the respondent in the organization.

The experience of the respondents was also asked and found that 23% of the total respondents have more than 10 years experience with the present company, also 23% of the total respondents have the experience between 5 to 10 years with the present company and 54% of the total respondents have less than 5 years experience with the present company.

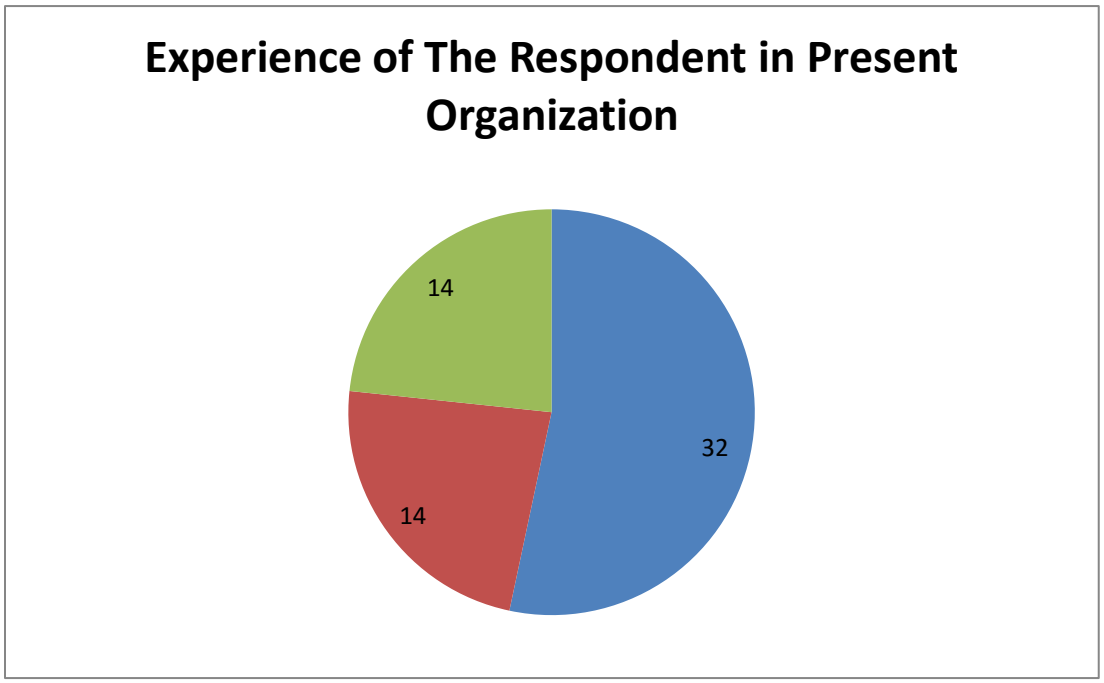


Figure 3.6: Experience of the Respondent in the present organization.

3.4.3 Data collection

The Questionnaire is sent to two hundred seventeen number of the field experts, working in different organization located near about National Capital Region Delhi for their response. The mode of communication of the questionnaire was mainly email; however the responses were received on the google form. Total sixty responses were received as per the table given in the annexure II; hence the response rate is 27.64%. In the response the data related to the company profile and the field expert profile was also collected and may be seen in annexure II.

3.4.4 Statistical analysis

After the data received in the form of responses from the field experts, statistical analysis of the data was performed. For this purpose factor analysis with principal component extraction method with varimax rotation is applied. The brief explanation of the method is given below.

3.4.4.1 Factor analysis

According to Panneerselvam (2004), in many fields of real-life applications, the number of independent variables used in predicting a response variable will be too many. In the survey method the number of responses is made very high to reach the more accurate result. But, there are some difficulties for handling too many independent variables, which may be given as follows:

- computational time Increases to get solution
- data collection time Increases
- expenditure in data collection is too much
- Presence of redundant independent variables
- Difficulty for making inferences.

These can be avoided using factor analysis. Factor analysis aims at grouping the original input variables into factors which underline the input variables. Each factor will account for one or more input variables. Theoretically, the total number of factors in the factor analysis is same as the total number of input variables. But, after performing factor analysis, the number of factors in the study can be reduced by dropping the insignificant factors based on certain criterion.

3.4.4.2 Principal components extraction method

Panneerselvam (2004) described that Principal components method maximizes the sum of squares of loadings of each identified factor. This is a popular technique which determines loadings of variables on different factors by using the standard normal values of the observations of the original input variables.

According to Panneerselvam (2004), let *n* be the total number of input variables m, the total number of sets of observations for the variables i.e.total number of respondents *n*, the total number of factors which is same as the total number of variables; X_j the input variable u, j = 1, 2, 3, ..., *n;* a_{if} the fth original opinion (marked by the i^{th} respondent) for the jth input variable; $\overline{X_j}$ the mean of the original opinions of the variable j; σ, the standard deviation of the original observations of the variable *j;* and z_{ij} be the standard normal value of the ith observation of the *j*th variable given by the following formula:

$$z_{ij} = \frac{a_{ij} - \overline{X_j}}{\sigma_j}$$

3.4.4.3 Steps of principal component method

The steps of the principal components analysis are summarized as follows:

Step –1: Input the original sets of observations $[a_{ij}]$, i =1, 2, 3…..m and j = 1, 2, 3, ….n

Step-2: Find the standardized sets of observations $[z_{ij}]$ from $[a_{ij}]$ using the following formula;

$$z_{ij} = \frac{a_{ij} - \overline{X_j}}{\sigma_j} \quad \text{i =1, 2, 3…..m and j = 1, 2, 3, ….n}$$

where z_{ij} is the standardized observation of the ith original observation under the variable j; a_{ij} the ith original observation of the fth variable; $\overline{X}_j$ -, the mean of the original observations of the variable j; and σ_j the standard deviation of the "original observations of the variable j.

Step-3: Determine the weights of variables in different linear composites of factors $[w_{ij}]$ such that the variance of the un standardized factor scores of the entire set of observations is maximal. These weights are nothing but directional cosines of the respective vectors.

Step-4: Find the unstandardized factor scores using the following formula:

$$\left(f_{ij}\right)_{m\times n} = \left(z_{ij}\right)_{m\times n} \times \left(w_{ij}\right)_{m\times n}$$

Step-5: Find the loadings of the variables on the factors [L_{ij}]. The value of L_{ij} is the correlation coefficient between the values in column *i* of matrix [f_{ij}] and that of column/ of the matrix *[z_{ij}]* for i = I, 2, 3, ..., *n* and j= 1, 2, 3, ..., *n*.

Step-6: Find the standardized factor scores using the following formula:

$$S_{ij} = \frac{f_{ij} - \overline{M_j}}{s_j} \quad \text{i =1, 2, 3…..m and j = 1, 2, 3, ….n}$$

here S_{ij} is score of the standardized factor of the ith set of observations on the factor j, $\overline{M}_j$ is the mean of the scores of the unstandardized factor of the factor j and S_j is the standard deviation of the scores of the unstandardized factor of the factor j.

Step-7: The following formula is to be used to find the prediction of the standardized original observations:

$$\left(Z_{ij}\right)_{m\times n} = \left(S_{ij}\right)_{m\times n} \times \left(L_{ij}\right)_{m\times n}$$

Step-8: Calculation of the sum of squares of loadings of every column-j (principal component-j factor-j) it is termed as eigen value of the column j.

Step-9: Drop the insignificant principal components having eigen values less than 1. Suppose that number of principal components retained after dropping to be *X*.

Step-10: Perform the rotation of the retained principal components for better interpretation. The rotation can be done by varimax rotation method of promax rotation method.

Step-11: Assign each variable -to the principal component i.e. factor with which it has the maximum absolute loading.

Step –12: Find the sum of squares of loadings for each variable i (row i) it is denoted by h_1^2 Also, find the common variance, whose formula is given below:

Common variance = $\sum_{i=1}^{X} h_1^2$

where X is the number of retained principal components.

Step –13: For each retained principal component, k (k = 1, 2, 3, …X) find the following and state interferences :

Proportion of total variance of the principal component k

$$= \frac{\text{Eigenvalue of prinicpal component k}}{\text{Total Variance}}$$

where the total variance is equal to the number of variables, n. Also,

$$= \frac{\text{Eigenvalue of prinicpal component k}}{\text{Common Variance}}$$

$$= \frac{\text{Eigenvalue of prinicpal component k}}{\text{Sum of the eigenvalues of the retained principal components}}$$

3.4.4.4 Varimax method of factor rotation

After obtaining factor loadings using any one of the methods, one should examine whether the factor loading matrix possesses simple structure. If a factor loading matrix has a simple structure, it is easy to make interpretations about factors. If there is no simple structure, then the factor axes should be rotated by an angle such that the factor loadings are revised to have a simple structure which will simplify the process of interpretation of factors. The communalities of each variable before and after factor rotation will be the same.

3.5 Quantitative modeling

According to the Kashi (2015), AHP and DEMATEL are the multiple criteria decision making methods (MCDM). It is also told that MCDM method can be a good tool for examination and evaluation of employees since they are able to use mixture of qualitative and

quantitative factors or criteria particularly, DEMATEL approach will shows which competencies most affect other key competencies and hence need pay a closer attention to those components.

3.5.1 Benefits of DEMATEL

According to Wu and Lee (2007) the Decision-Making Trial and Evaluation Laboratory (DEMATEL) technique is a comprehensive method for building and analyzing a structural model involving causal relationships between complex factors. According to the Wu and Lee (2007); Lin and Tzeng (2009); and Sumrit and Anuntavoranich (2013), DEMATEL method has been widely accepted as one of the best tools to solve the cause and effect relationship among the quantitative evaluation criteria. Kashi (2015) told that managers may use either of the AHP or the DEMATEL to study the design of competency models as a HR strategic management system but the most challenging issues remain in the handling of dependencies in DEMATEL.

Sumrit and Anuntavoranich (2013) applied the DEMATEL approach for the determination of impact-relationship map of competency model factors and told that this method has been widely accepted by the scholars in the form of the best tools to get solution of the cause and effect relationship among the various evaluation criteria. Yang et al., (2008) describe that this method is applied to analyze and form the relationship of cause and effect among evaluation criteria. Lin and Tzeng G.H., (2009) used the application of DEMATEL to derive inter relationship among factors.

3.5.2 Procedure of DEMATEL approach

According to the Wu and Lee (2007); Lin and Tzeng (2009); and Sumrit and Anuntavoranich (2013) described the procedure of DEMATEL method, which may be summarized as given below:

Step 1: collection of experts' views and calculation of the average matrix (say P)

For this step, let there are m experts and n factors. The expert is asked to give their view the degree of direct influence two factors each other if compared pair-wise. These views are collected in the form of a matrix. The degree to which the expert perceived affects of factor i on factor j is denoted as the elements of the matrix i.e. x_{ij}. The opinions of the experts or the elements of the matrix is collected in the form of integer score, which is ranged from 0 (no influence), 1 (low influence), 2 (medium influence), 3 (high influence), and 4 (very high influence), respectively same as the likert scale. For each expert, an n x n non-negative matrix is constructed as $x^k = [R_{ij}]$, where k is the expert number of involving in the evaluation process with $1 \leq k \leq m$. Thus, R_1, R_2, R_3,.., R_m are the matrices from m experts.

To aggregate all judgments from m experts, the average matrix P = $[P_{ij}]$ is shown below.

$$P_{ij} = \frac{1}{m}\sum_{i=1}^{m} x_{ij}^{k} \quad (1)$$

Step 2: Calculation of the Normalized Initial Direct- Relation Matrix

The normalized initial direct-relation matrix (say Q) = $[q_{ij}]$, where value of each element in matrix N is ranged between [0, 1]. The calculation is shown below.

$$Q = \lambda * P, \quad (2)$$

or

$$[q_{ij}]_{nxn} = \lambda * [P_{ij}]_{nxn} \quad (3)$$

Where,

$$\lambda = \text{Min}\left[\frac{1}{\max 1 \leq i \leq n \sum_{j=1}^{n} |p_{ij}|}, \frac{1}{\max 1 \leq i \leq n \sum_{i=1}^{n} |p_{ij}|} \right] \quad (4)$$

Based on Markov chain theory, Q^m are the powers of matrix Q, e.g. Q2, Q3… Q∞ guarantees the convergent solutions to the matrix inversion as shown below.

$$\lim_{m=\infty} Q^m = |[0]nxn|, \quad (5)$$

Step 3: Total Relation Matrix H

The total-influence matrix T is obtained by utilizing Eq. (7), in which, I is an (n x n) identity matrix. The element of t_{ij} represents the indirect effects that factor i had on factor j, then the matrix H reflects the total relationship between each pair of system factors.

$$H = \lim_{m=\infty}[\, Q + Q^1 + Q^2 + Q^3 \dots\dots\dots Q^m] \quad (6)$$

$$= \sum_{m=1}^{\infty} H^i$$

Where, $\sum_{m=1}^{\infty} H^i = Q + Q^1 + Q^2 + Q^3 \dots\dots\dots Q^m$

$$= Q(I + Q^1 + Q^2 + Q^3 \dots\dots\dots\dots Q^{m-1})$$

$$= Q(I + Q^1 + Q^2 + Q^3 \dots\dots\dots\dots Q^{m-1})$$

$$= Q(I-Q)^{-1}(I-Q)(I + Q^1 + Q^2 + Q^3 \dots\dots\dots\dots Q^{m-1})$$

$$= Q(I-Q)^{-1}(I-Q^m)$$

$$H = Q\ (I-Q)^{-1} \quad (7)$$

Step 4: Sum of Rows and Columns of Matrix H

The sum of rows and the sum of columns are represented by vectors r and c, respectively.

$$r = [\, r_i \,]_{n*1} = \left(\sum_{j=1}^{n} n_{ij}\right)_{n*1} \quad \dots\dots\dots (8)$$

$$c = [\, c_j \,]'_{1*n} = \left(\sum_{i=1}^{n} n_{ij}\right)_{1*n} \quad \dots\dots\dots (9)$$

Where $[c_j]'$ is denoted as transposition matrix.

Suppose r_i is the sum of ith row in matrix H. The value of Σr_i indicates the total given both directly and indirectly effects, that component i has on the other components. Suppose Σc_j is the sum of the j^{th} column of matrix H. (Tzeng et al., 2007; Liou et al., 2007; Yang et al., 2008; Lee et al., 2009), explained that the value of c_j shows the both directly and indirectly, total received effects that all other components have on component j. If j = i, the value of $(\Sigma r_i + \Sigma c_j)$ shows the total effects both given by component i and also received by component 'i' and also known as Prominence. While, the value of $(\Sigma r_i - \Sigma c_j)$ shows the net effect by component i on the all components and it is also called as Relation. Further, if $(\Sigma r_i - \Sigma c_j)$ is positive, components i is a net cause. While $(\Sigma r_i - \Sigma c_j)$ is negative, factor i is a net receiver.

Step 5: Determine a Threshold value (α)

We can calculate the threshold value (α) by the adding all of the elements in matrix H. The aim of this calculation is to remove the minor effects of elements in matrix H. Yang et al., (2008).

$$\alpha = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} h_{ij}}{N} \quad \text{..... (10)}$$

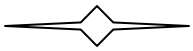
Where, N is taken as the total number of elements in the matrix H.

Step 6: Cause and Effect Relationship Diagram

Shieh et al., (2010) explained that the cause and effect diagram is made by mapping all coordinate sets of prominence and relation (Σri + Σci, Σri - Σci) to show the complex interrelationship and provide information to determine the most important components and how this component influence affected components.

3.6 Summary

With reference to the extensive literature review, discussed in the last chapter and after having the discussion with field experts, the research objectives were derived in this chapter. After that a flow chart is made which shows the steps of the methodology of this project. Survey method is described for the social and statistical purpose. Questionnaire development is also discussed. The two segments of the questionnaire were about company's profile and respondent profile. Data is collected through email with the help of google form. The methodology of statistical analysis is given. For the statistical analysis, the factor analysis is explained and also the principal components extraction method with varimax rotation is described. At last section of this chapter methodology of the DEMATEL approach is explained, which is to be applied for the performance evaluation. In the next chapter statistical analysis of the data received will be performed.



Chapter 4
Statistical Analysis

4.1 Introduction

After collecting the data, reliability test is performed to ensure whether the collected data is fit for the exploratory study or not. Then principal component factor analysis method with varimax rotation method is used to retain the significant factors. SPSS software is used for the analysis purpose. The retained components are given at the last of this chapter.

4.2 Reliability test

The reliability test of collected data is done using SPSS software and result of the test is given in table 4.1 and table 4.2. The value of Cronbach's alpha (α) for the collected data comes as 0.932. According to Kumar et al (2015) and Nunnally (1978), the value of Cronbach's α, should exceeds the minimum requirements of 0.5 for an exploratory study. Liu et al., (2013), explained in their research that the benchmark value Cronbach's alpha ranged is considered as 0.70. Hence we can say that as per the reliability test on the basis of the Cronbach's α, our data may be utilized for further exploratory study.

Table: 4.1: Case Processing Summary

Case Processing Summary			
		N	%
Cases	Valid	56	93.3
	Excluded[a]	4	6.7
	Total	60	100.0
a. Listwise deletion based on all variables in the procedure.			

Table: 4.2: Reliability Statistics

Reliability Statistics	
Cronbach's Alpha	N of Items
.932	27

4.3 Factor analysis principal component extraction method

The result of the reliability test shows that the collected data is fit for the exploratory study. To perform the factor analysis, principal component extraction method was applied with spss software support. It resulted communalities and total variance as shown in table 4.3 and table 4.4.

Table: 4.3: Communalities

Communalities		
	Initial	Extraction
VAR00001	1.000	.722
VAR00002	1.000	.718
VAR00003	1.000	.752
VAR00004	1.000	.683
VAR00005	1.000	.769
VAR00006	1.000	.707
VAR00007	1.000	.782
VAR00008	1.000	.731
VAR00009	1.000	.794
VAR00010	1.000	.721
VAR00011	1.000	.737
VAR00012	1.000	.779
VAR00013	1.000	.791
VAR00014	1.000	.768
VAR00015	1.000	.635
VAR00016	1.000	.738
VAR00017	1.000	.732
VAR00018	1.000	.783
VAR00019	1.000	.788
VAR00020	1.000	.753
VAR00021	1.000	.741
VAR00022	1.000	.668
VAR00023	1.000	.744
VAR00024	1.000	.584
VAR00025	1.000	.786
VAR00026	1.000	.801
VAR00027	1.000	.710
Extraction Method: Principal Component Analysis.		

Table 4.4: Total Variance Explained

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	10.250	37.962	37.962	10.250	37.962	37.962	3.764	13.941	13.941
2	2.275	8.425	46.388	2.275	8.425	46.388	3.423	12.676	26.617
3	1.854	6.865	53.253	1.854	6.865	53.253	3.227	11.952	38.569
4	1.634	6.053	59.306	1.634	6.053	59.306	3.036	11.244	49.813
5	1.422	5.265	64.571	1.422	5.265	64.571	2.399	8.884	58.697
6	1.369	5.071	69.643	1.369	5.071	69.643	2.378	8.806	67.503
7	1.113	4.121	73.764	1.113	4.121	73.764	1.691	6.261	73.764
8	.976	3.615	77.380						
9	.788	2.919	80.298						
10	.675	2.501	82.800						
11	.673	2.492	85.292						
12	.543	2.013	87.305						
13	.500	1.852	89.157						
14	.421	1.559	90.716						
15	.370	1.372	92.088						
16	.342	1.268	93.355						
17	.289	1.070	94.426						
18	.265	.983	95.409						
19	.260	.961	96.370						
20	.221	.820	97.190						
21	.210	.776	97.966						
22	.161	.596	98.562						
23	.134	.496	99.058						
24	.096	.357	99.415						
25	.079	.291	99.706						
26	.047	.173	99.879						
27	.033	.121	100.000						
Extraction Method: Principal Component Analysis.									

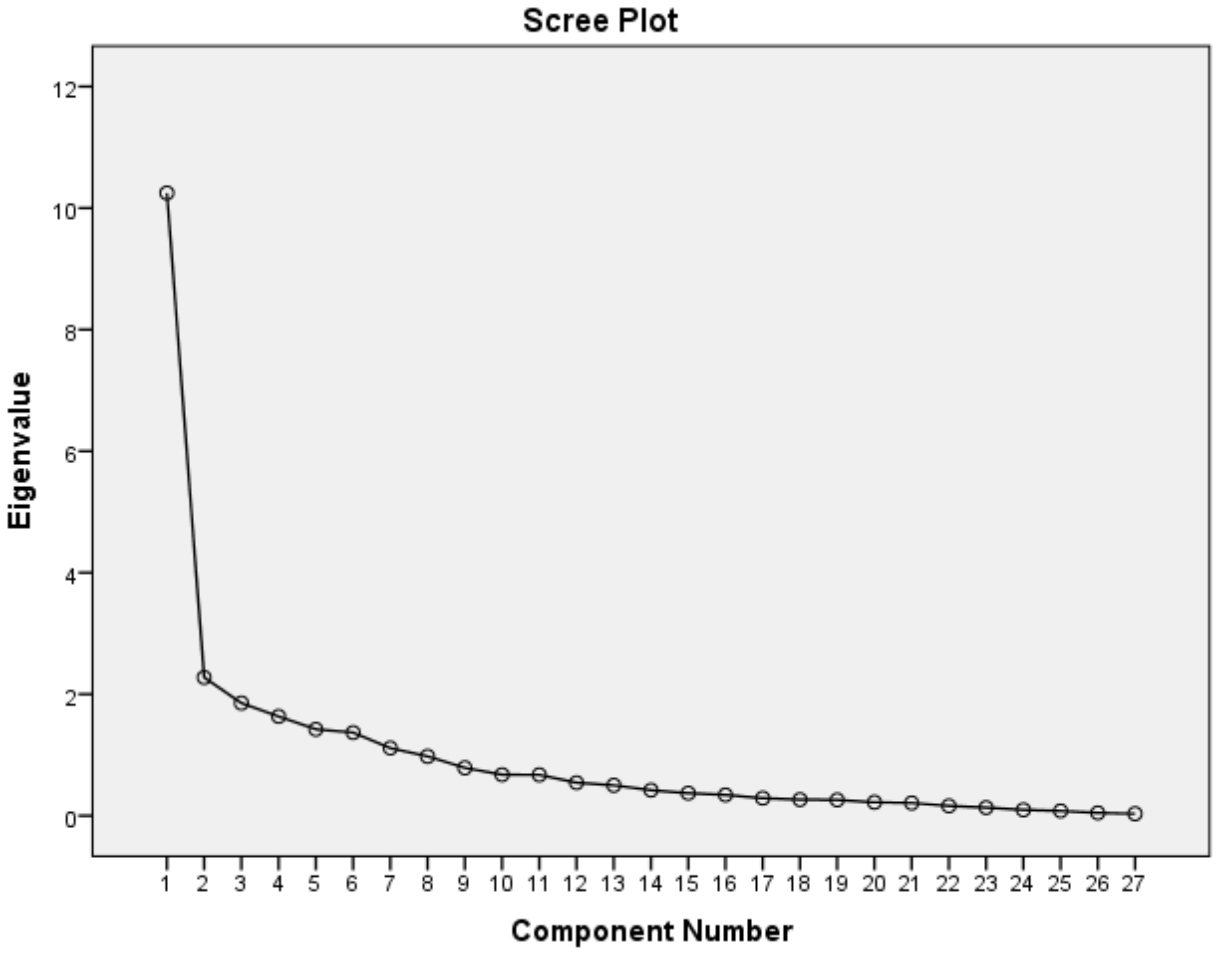


Figure 4.1: Scree Plot

In the figure 4.1 the scree plot is drawn, showing eigen values of the all of the twenty seven parameters. In this plot, the components are taken on the horizontal axis and the eigen value of the parameters are given on the vertical axis. It may be seen from the scree plot that there are seven parameters those have the eigen value more than 1.

In table 4.4 the eigen value, extraction sum of square loading and rotation sum of square loading of the components are calculated in terms of the total, percentage variable and percentage cumulative using principal component analysis of extraction method. The component matrix is given in table 4.5, showing the factor loading of the components and on the basis of the

factor loading, seven components have been extracted. In the table 4.6 and in table 4.7 the rotated component matrix and transformation matrix is given respectively.

Table: 4.5: Component Matrix

Component Matrix[a]							
	Component						
	1	2	3	4	5	6	7
VAR00022	.784						
VAR00011	.776						
VAR00026	.775						
VAR00012	.768						
VAR00020	.751						
VAR00008	.744						
VAR00003	.674		-.534				
VAR00019	.670				-.552		
VAR00024	.654						
VAR00005	.651						
VAR00021	.624						
VAR00027	.620						
VAR00014	.604	.509					
VAR00017	.597						.469
VAR00013	.590						
VAR00007	.589		-.535				
VAR00015	.567		.465				
VAR00018	.566	-.475					
VAR00002	.560						
VAR00004	.549		-.449				
VAR00016	.545		.418				
VAR00006	.540				.484		
VAR00009	.537	-.515					
VAR00025	.496	.565					
VAR00023		.563	.406				
VAR00001				.771			
VAR00010	.540					.550	
Extraction Method: Principal Component Analysis.							
a. 7 components extracted.							

Table: 4.6: Rotated Component Matrix

Rotated Component Matrix[a]							
	Component						
	1	2	3	4	5	6	7
VAR00013	.728				.436		
VAR00005	.707	.440					
VAR00019	.690					.445	
VAR00020	.575		.491				
VAR00022	.569						
VAR00012	.510			.419			
VAR00004		.775					
VAR00003		.749					
VAR00007		.744					
VAR00026		.544			.419		
VAR00016			.668			.431	
VAR00027			.660				
VAR00021	.567		.608				
VAR00006		.441	.579				
VAR00015			.504	.415			
VAR00010				.814			
VAR00009				.785			
VAR00011				.627			
VAR00008		.462		.487			
VAR00024							
VAR00025					.746		
VAR00023					.743		
VAR00014	.446				.560		
VAR00018						.784	
VAR00017						.743	
VAR00001							.795
VAR00002			.533				.541
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.[a]							
a. Rotation converged in 27 iterations.							

Table: 4.7: Component Transformation Matrix

Component Transformation Matrix							
Component	1	2	3	4	5	6	7
1	.508	.445	.445	.414	.259	.313	.095
2	.230	-.113	.062	-.396	.722	-.445	.234
3	-.178	-.770	.441	.208	.203	.311	.002
4	-.368	.115	-.139	.139	.031	.153	.888
5	-.654	.361	.507	.100	.126	-.347	-.199
6	-.070	-.083	-.501	.720	.354	-.246	-.180
7	-.298	.216	-.276	-.284	.478	.634	-.277
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.							

In the rotated component matrix, it is shown that which factor contributes a component significantly. Factor loading above 0.6 is taken as the significant loading. The factors having loading less than 0.6 will be eliminated from the further study. Also, using the rotated component matrix, the remaining factors are grouped into the seven components based upon the factor loading i.e. the factors having factor loading above 0.6 for a component will be part of that component. For example, factors 13, 5, 19, 20, 22, 12, 21 and 14 have loading 0.728, 0.707, 0.690, 0.575, 0.569, 0.510, .567 and 0.446 respectively, for component 1. So, the factors 20, 22, 12, 21 and 14 may be considered as eliminated and the factors 13, 14 and 19 will be considered as the part of the component 1 for the further study. Similarly, component 2 comprises of factors 4, 3 and 7, component 3 comprises factors 16, 27 and 21, component 4 comprises of factors 10, 9 and 11, component 5 comprises of factors 25 and 23, component 6 comprises of 18 and 17 and component 7 comprises of factors 1. The factors, which are retained for the further study, are given in table 4.8 on the next page.

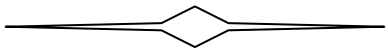
Table 4.8: Retained Factors after Factor Analysis

Retained Factors After Factor Analysis			
S. No.	**Parameter Number and Name**	**Combined variable name**	**Combined variable no.**
1	(5) Total lead time reduction	Cost Oriented Approach	Component 1(C1)
	(13) Reduction in coordination cost		
	(19) Improve the Reengineering capability		
2	(4) Proper visualization of customer needs	Customer oriented approach	Component 2(C2)
	(3) Productivity improvement		
	(7) Increase the level of Customer satisfaction		
3	(16) Helps in automation of exchange procedures	Reduced product cycle time	Component 3 (C3)
	(27) Helps the Top Management in taking Initiative for an activity		
	(21) Reduce the customer order path		
4	(10) Helps in enhancing the cooperation among the existing stages	Maintaining Proper Visibility and Cooperation	Component 4 (C4)
	(9) Proper visibility among the supply chain stages		
	(11) Helps in Maintaining the stability in the competitive market place		
5	(25) Improvement in the Effectiveness of scheduling techniques	Improvement in Effectiveness and Flexibility	Component 5 (C5)
	(23) Flexibility capability Enhancement		
6	(18) Reduction of non value added activities	Wastage reduction	Component 6 (C6)
	(17) Reduction in uncertainty		
7	(1) Proper responsiveness to urgent orders	Proper responsiveness to urgent orders	Component 7 (C7)

4.4 Summary

The reliability test is performed to ensure whether the received data is fit for further exploratory study or not. On the basis of the value of chronbach alpha, the collected data found satisfactory for the further exploratory study. After that factor analysis was performed. Principal

components extraction method with varimax rotation was performed, which gives the communalities, total variance, component matrix, rotated component matrix and the scree plot is also drawn. The scre plot shows that there are only seven components having eigen value more than 1. On the basis of the poor factor loading, some of the factors are dropped from the further study, while factors having significant loading are retained and grouped into the seven components. The retained components are given in table 4.8. These components will be utilized for the performance evaluation using DEMATEL approach in the next chapter.



Chapter 5
Performance Evaluation Using DEMATEL Approach

5.1 Introduction

In the previous chapter, the statistical analysis of twenty seven factors was performed by applying principal component extraction method of factor analysis with varimax rotation using SPSS software support. Through this analysis, the factors having poor loading has been left out, while the factors having significant loading were grouped into the seven components as per the table 4.8 in the chapter 4. The retained factors were utilized as the significant components for the purpose of performance evaluation. DEMATEL approach was applied. A flow chart was constructed, which shows the DEMATEL algorithm. For that purpose a questionnaire was developed and sent to the ten field experts through email for the purpose of submission of their opinion. The responses were collected through the email and by having a personnel meeting with them. The responses from the field experts were utilized as the input for the application of the DEMATEL for the purpose of evaluation of the performance. At last causal diagram and fish bond diagram is drawn. All steps are given below.

5.2 DEMATEL algorithm

One sight view of DEMATEL approach is given in the flow chart as shown in figure 5.1

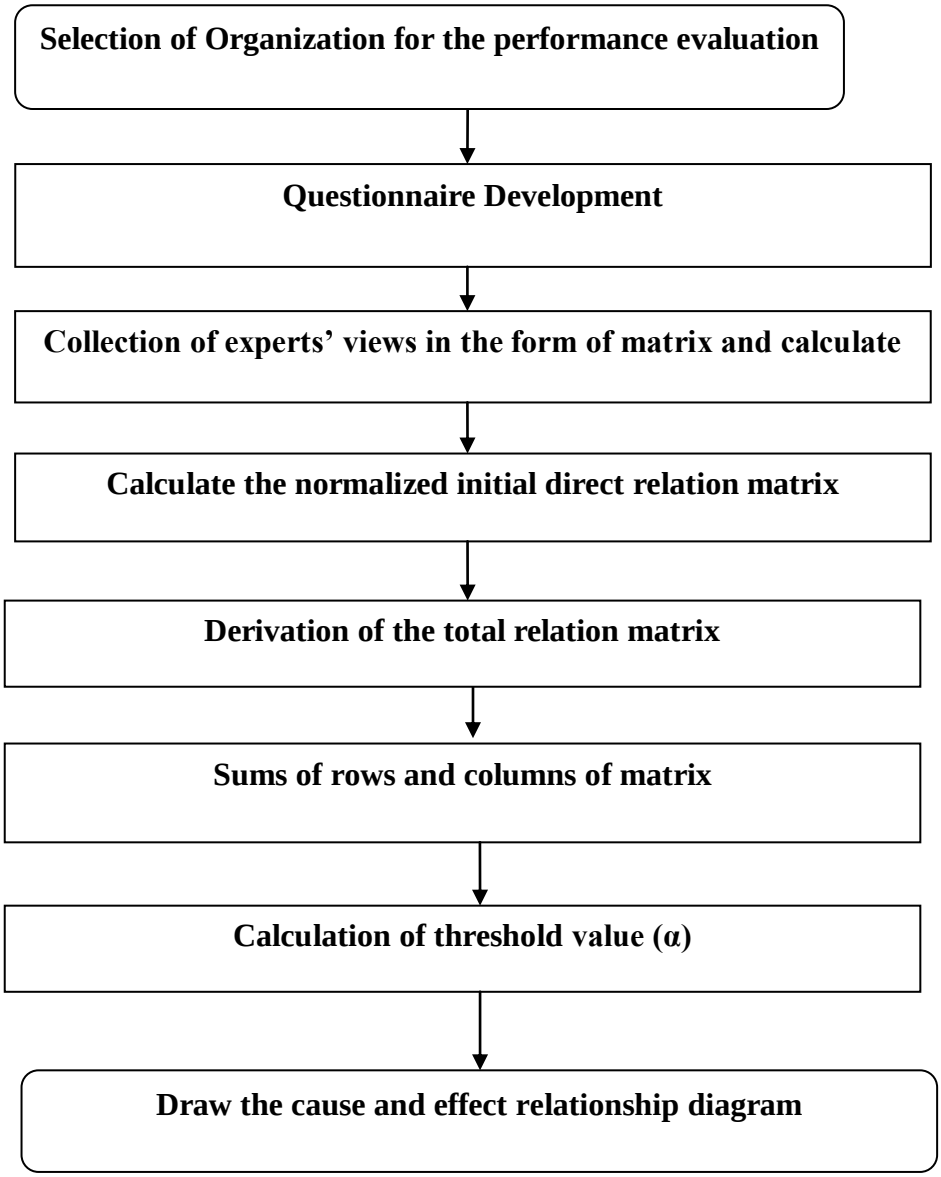


Figure: 5.1, Flow Diagram for the DEMATEL

5.3 Application of DEMATEL approach for performance evaluation

In the previous chapter seven components were retained, which are to be utilized to evaluate the performance of the IT enabled supply chain system. Company detail, questionnaire development and the stepwise application of the DEMATEL approach in detail is described as given below:

5.3.1 Company profile

For the performance evaluation many firms are visited in the industrial area of west Delhi, i.e. Badli industrial area and Bawana industrial area. A firm "Vishwa Industries" is chosen for the performance evaluation. The detail of this company is given below:

Name of the Industry:	Vishwa Industries
Location:	Near Bawana Industrial Area, Delhi
Address:	156/210, Pooth Khurd Industrial Area, Near Bawana, Delhi
Phone Number:	9873778540
Email ID:	vishwa_2@yahoo.com
Nature of Job:	Manufacturing; Supplier to Original Equipment Manufacturer.
Type of Product:	Manufacturing of Automobile Parts
Number of Employee:	117
Structure of the Organization:	Top Management; Middle Management; Lower Management/ Supervisor; Other Employees
Annual Turnover:	5 Crore approx.

In this company the raw material, tools and equipments utilized in production is purchased after studying the websites of various supplier and compared in terms of rate, quality, transportation and history of the supplier, while the raw material, for day to day use are purchased the from the local supplier by placing an order telephonically. The customers of this company are the original manufacturers of automobiles or their supplier like Maruti Suzuki, TVS and Hero Motors etc.

5.3.2 Questionnaire development

Through the statistical analysis seven components were retained, which has been utilized for the performance evaluation. A questionnaire was developed by placing these seven components in the top row and first column of a matrix form so that the influence of a component on others or vice versa may be record as the elements of this matrix in the form of the integers. For the factor i and j, up to what degree, they affects each other as perceived by the expert is denoted as the elements of the matrix i.e. xij. The opinions of the experts or the elements of the matrix were collected on the five point likert scale [0 (no influence), 1 (low influence), 2 (medium influence), 3 (high influence), and 4 (very high influence)]. Diagonals of the matrix were filled with zero, assuming no effect of a factor on itself. The variates brain storming sessions were conducted with the field experts (ten experts). Five experts were taken from the vishwa industry, three from academics and two of them are taken from the other industries.

Step 1 Collection of Expert's views and calculation of the average matrix

A questionnaire was developed as discussed in the previous section and sent to these experts. The opinions in the form of a matrix from the ten field experts were collected. The factor i affects the factor j up to what degree, as perceived by the expert is denoted as the elements of the matrix i.e. x_{ij}. For each expert, an (n x n) non-negative matrix is constructed as $x^k = [R_{ij}]$, where k is the expert number of involving in the evaluation process with $1 \leq k \leq m$. Thus R_1, R_2, R_3,.., R_m are the matrices from 'm' experts.

These opinions hereinafter will be called as R1, R2, R3,R4, R5, R6, R7, R8, R9 and R10 as shown in table 5.1 in the matrix form.

Table 5.1: Expert's View in the form of Matrices

		C1	C2	C3	C4	C5	C6	C7			C1	C2	C3	C4	C5	C6	C7
	C1	0	3	2	4	3	4	0		C1	0	2	3	2	4	3	2
	C2	3	0	0	2	4	1	3		C2	0	0	3	3	2	3	2
	C3	2	0	0	3	3	2	0		C3	1	2	0	2	3	2	3
R1	C4	4	2	3	0	2	3	4	R2	C4	2	3	2	0	2	3	2
	C5	3	4	3	2	0	2	3		C5	3	2	3	3	0	4	3
	C6	4	1	2	3	2	0	0		C6	4	3	2	3	4	0	2
	C7	0	3	0	4	3	0	0		C7	3	2	2	2	3	2	0
	C1	0	2	0	4	1	2	0		C1	0	2	1	3	1	4	2
	C2	2	0	1	0	4	3	2		C2	2	0	2	4	2	3	3
	C3	3	2	0	1	0	2	1		C3	1	2	0	3	2	2	3
R3	C4	2	3	1	0	2	2	0	R4	C4	2	3	2	0	4	2	3
	C5	1	3	2	0	0	2	2		C5	2	2	1	3	0	2	2
	C6	2	1	2	2	0	0	1		C6	4	2	1	2	2	0	2
	C7	2	0	3	2	1	0	0		C7	2	3	3	1	2	2	0
	C1	0	4	4	3	4	3	4		C1	0	4	3	2	1	3	4
	C2	2	0	4	4	4	3	4		C2	0	0	2	3	1	3	1
	C3	4	3	0	3	4	3	4		C3	3	4	0	4	4	3	2
R5	C4	3	3	4	0	3	4	3	R6	C4	0	2	3	0	3	0	1
	C5	4	4	4	4	0	4	4		C5	1	0	1	3	0	2	0
	C6	1	3	2	3	4	0	3		C6	4	3	3	0	4	0	4
	C7	4	2	3	2	4	3	0		C7	3	2	2	2	0	0	0
	C1	0	2	3	3	4	3	3		C1	0	3	2	3	1	2	3
	C2	2	0	2	3	3	4	4		C2	1	0	3	3	1	3	2
	C3	2	3	0	3	2	2	3		C3	3	2	0	2	2	3	2
R7	C4	4	2	3	0	3	4	4	R8	C4	0	2	3	0	2	0	1
	C5	2	3	3	2	0	2	3		C5	2	0	1	4	0	2	2
	C6	4	2	2	3	3	0	2		C6	4	3	3	0	4	0	4
	C7	3	4	4	3	4	3	0		C7	1	2	0	2	0	1	0
	C1	0	3	3	2	2	3	4		C1	0	2	2	3	2	2	4
	C2	2	0	2	3	4	2	1		C2	2	0	2	3	4	2	1
	C3	3	2	0	4	2	2	2		C3	3	2	0	4	2	2	3
R9	C4	2	3	3	0	3	2	3	R10	C4	2	3	3	0	3	2	2
	C5	2	3	1	2	0	4	2		C5	2	3	2	2	0	4	2
	C6	3	1	2	3	3	0	4		C6	3	3	2	3	3	0	4
	C7	3	2	3	4	3	2	0		C7	3	2	3	4	3	2	0

To calculate the average matrix of the opinion matrices, sums of all the opinion matrices from the ten experts was calculated which is given in the table 5.2.

The average matrix (say P) = $[P_{ij}]$ was calculated by using the equation 1.

$$P_{ij} = \frac{1}{m}\sum_{i=1}^{m} x_{ij}^{k} \quad (1)$$

The average matrix P is given in the table 5.2.

Table 5.2: Average Matrix (say P)

Average Matrix= Sum of these 10 matrices divided by 10 = (R1+R2 +R3+R4+R5+R6+R7+R8+R9+R10)/10 =		C1	C2	C3	C4	C5	C6	C7
	C1	0	2.7	2.3	2.9	2.3	2.9	2.6
	C2	1.6	0	2.1	2.8	2.9	2.7	2.3
	C3	2.5	2.2	0	2.9	2.4	2.3	2.3
	C4	2.1	2.6	2.7	0	2.7	2.2	2.3
	C5	2.2	2.4	2.1	2.5	0	2.8	2.3
	C6	3.3	2.2	2.1	2.2	2.9	0	2.6
	C7	2.4	2.2	2.3	2.6	2.3	1.5	0

Step 2 Normalized initial direct- relation matrix (say Q)

After calculating the average matrix the sum of rows and columns are calculated as given in the table 5.4.The normalized initial direct-relation matrix (say Q) = [qij], where value of each element in matrix **N** is ranged between [0, 1]. The calculation is given below.

$$Q = \lambda * P, \quad (2)$$

or

$$[q_{ij}]_{nxn} = \lambda * [P_{ij}]_{nxn} \quad (3)$$

Where,

$$\lambda = \text{Min}\left[\frac{1}{\max 1\le i\le n \sum_{j=1}^{n} |p_{ij}|}, \frac{1}{\max 1\le i\le n \sum_{i=1}^{n} |p_{ij}|}\right] \quad (4)$$

To calculate the value of the Normalized initial direct relation matrix, the value of λ was calculated as given below:

$$\text{Max } \Sigma\, p_{ij} \quad i^{th} = 15.7$$

$$\text{Max } \Sigma\, z_{ij} \quad j^{th} = 15.9$$

$$1/\text{ Max } \Sigma\, p_{ij} \quad i^{th} = 1/15.7 = 0.0637$$

$$1/\text{ Max } \Sigma\, p_{ij} \quad j^{th} = 1/15.9 = \quad 0.0629$$

$$\text{Min } [1/\, p_{ij} \quad i^{th},\ 1/p_{ij} \quad j^{th}] = 0.0629 = \lambda$$

$$\text{Hence, } \lambda = 0.0629$$

Therefore, Normalized initial direct relation matrix (Say Q), may be calculated by multiplying the value of λ, which is equal to 0.0629. The Normalized initial direct relation matrix is given in the table 5.5.

Table 5.3: Normalized initial direct relation matrix Q

0	0.17	0.145	0.182	0.145	0.182	0.164
0.101	0	0.132	0.176	0.182	0.17	0.145
0.157	0.138	0	0.182	0.151	0.145	0.145
0.132	0.164	0.17	0	0.17	0.138	0.145
0.138	0.151	0.132	0.157	0	0.176	0.145
0.208	0.138	0.132	0.138	0.182	0	0.164
0.151	0.138	0.145	0.164	0.145	0.094	0

In the normalized initial direct relation matrix sum of each column represents total direct effects that component gives to the other component. Similarly the sum of each row represents total direct effects received by that component. Further maximum of the sum of the columns represents the largest total direct effect for all components and maximum of the sum of the rows represents the largest total direct effect received of all components. It can be seen that each element of normalized initial direct relation matrix 'Q' is between zero and one.

Step 3 Total relation matrix (say H)

To calculate the Total relation matrix H, first, subtract Normalized initial direct relation matrix (Q), from the Identity matrix. It is given in the table 5.6.

Table 5.4: Subtraction of I & Q

Subtraction of I & Q						
1	-0.17	-0.145	-0.182	-0.145	-0.182	-0.164
-0.101	1	-0.132	-0.176	-0.182	-0.17	-0.145
-0.157	-0.138	1	-0.182	-0.151	-0.145	-0.145
-0.132	-0.164	-0.17	1	-0.17	-0.138	-0.145
-0.138	-0.151	-0.132	-0.157	1	-0.176	-0.145
-0.208	-0.138	-0.132	-0.138	-0.182	1	-0.164
-0.151	-0.138	-0.145	-0.164	-0.145	-0.094	1

Now, calculate the inverse of (I - Q), which is given in table 5.7.

Table 5.5: Inverse of (I - Q)

Inverse of (I - Q)						
2.536	1.7047	1.6212	1.8572	1.7997	1.7203	1.7106
1.51429	2.4418	1.49892	1.7242	1.7024	1.5939	1.5780
1.5768	1.5848	2.4029	1.7528	1.7003	1.5963	1.5993
1.5553	1.6019	1.5458	2.5965	1.7127	1.5894	1.5969
1.5375	1.5677	1.4935	1.7045	2.5416	1.5933	1.5730
1.67794	1.6481	1.5790	1.7888	1.7903	2.5342	1.6777
1.4563	1.4691	1.41857	1.6136	1.5709	1.4411	2.3557

The Total relation matrix H is given in the equation (7) in the chapter 4, as below:

$$H = \quad Q(I - Q)^{-1}$$

Calculate the product of Q and 1/ (I - Q) i.e. the total relation matrix. It is given in the table 5.8.

Table 5.6: Total Relation Matrix H

Product of Q and 1/(I - Q)							
1	1.5361	1.70474	1.62107	1.85697	1.79946	1.7201	1.71133
2	1.51409	1.44192	1.49879	1.72401	1.70228	1.59189	1.57868
3	1.57661	1.58498	1.40288	1.75267	1.70028	1.5933	1.59989
4	1.55511	1.60199	1.54562	1.59629	1.71254	1.58685	1.59711
5	1.528	1.55821	1.48422	1.68874	1.53115	1.58111	1.56401
6	1.67769	1.64822	1.57888	1.7885	1.79019	1.53019	1.67811
7	1.44707	1.45462	1.40938	1.603	1.56075	1.42861	1.34672

Step 4: Sum of rows and columns of matrix H

Sum of rows and columns of total relation matrix H is given in the table 5.9. According to Tzeng (2007) sum of rows and columns i.e. ($\Sigma r_i+\Sigma c_j$) known as 'prominence' determine an index which represents the total effects both given and received by the factor *i* or determine the degree of the importance that the factor *i* have in the system. The difference i.e. ($\Sigma r_i-\Sigma c_j$) known as "relation" shows the net effect that the factor *i* have to the system. Based on the value of ($\Sigma r_i-\Sigma c_j$), if positive, the component *i* is a net causer and if **($\Sigma r_i - \Sigma c_j$)** is negative, is a net receiver

Table 5.7: Sum of rows and columns of matrix S

Σr_i	Σc_j	$\Sigma r_i+\Sigma c_j$	$\Sigma r_i-\Sigma c_j$
11.949	10.835	22.784	1.114
11.051	10.995	22.046	0.056
11.21	10.54	21.75	0.67
11.2	12.01	23.21	-0.81
10.94	11.8	22.74	-0.86
11.69	11.03	22.72	0.66
10.25	11.08	21.33	-0.83

Step 5 Threshold value (α)

Threshold value (α) = 1.597.

Threshold value (α) = 1.597.

The values of c_{ij} in Table 5.10, which were greater than threshold value α (1.597), are suffixed with *, which shows the interaction between the components, e.g. the value of c_{14} (1.856) > α (1.597). The cause and effect diagram of these seven components is constructed as Figure 5.2.

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Table 5.8: Total Relation Matrix showing the elements values greater than Threshold Value

Component	C1	C2	C3	C4	C5	C6	C7
C1	1.536	1.705*	1.621*	1.857*	1.799*	1.72*	1.711*
C2	1.514	1.442	1.499	1.724*	1.702*	1.592	1.579
C3	1.576	1.585	1.403	1.753*	1.7*	1.593	1.599*
C4	1.555	1.602*	1.546	1.597	1.713*	1.587	1.597
C5	1.528	1.558	1.485	1.689*	1.531	1.58	1.564
C6	1.677*	1.648*	1.579	1.789*	1.79*	1.53	1.678*
C7	1.447	1.455	1.41	1.603*	1.561	1.427	1.347

Step 6 Cause and effect relationship graph

On the basis of the sum of rows and columns ($\Sigma r_i+\Sigma c_j$) i. e. prominence and difference of rows and columns i.e. 'relation' a cause and effect graph is constructed. It is easily understood with the help of this graph that the value of difference of the sum of rows and columns i.e. ($\Sigma r_i - \Sigma c_j$) is positive for the components 1, 2, 3 and 6 (C_1, C_2, C_3 and C_6) hence these components are net causer or affect the system, while for the components 4, 5 and 7 (C_4, C_5 and C_7) is negative so these components are net receiver or get affected by the system.

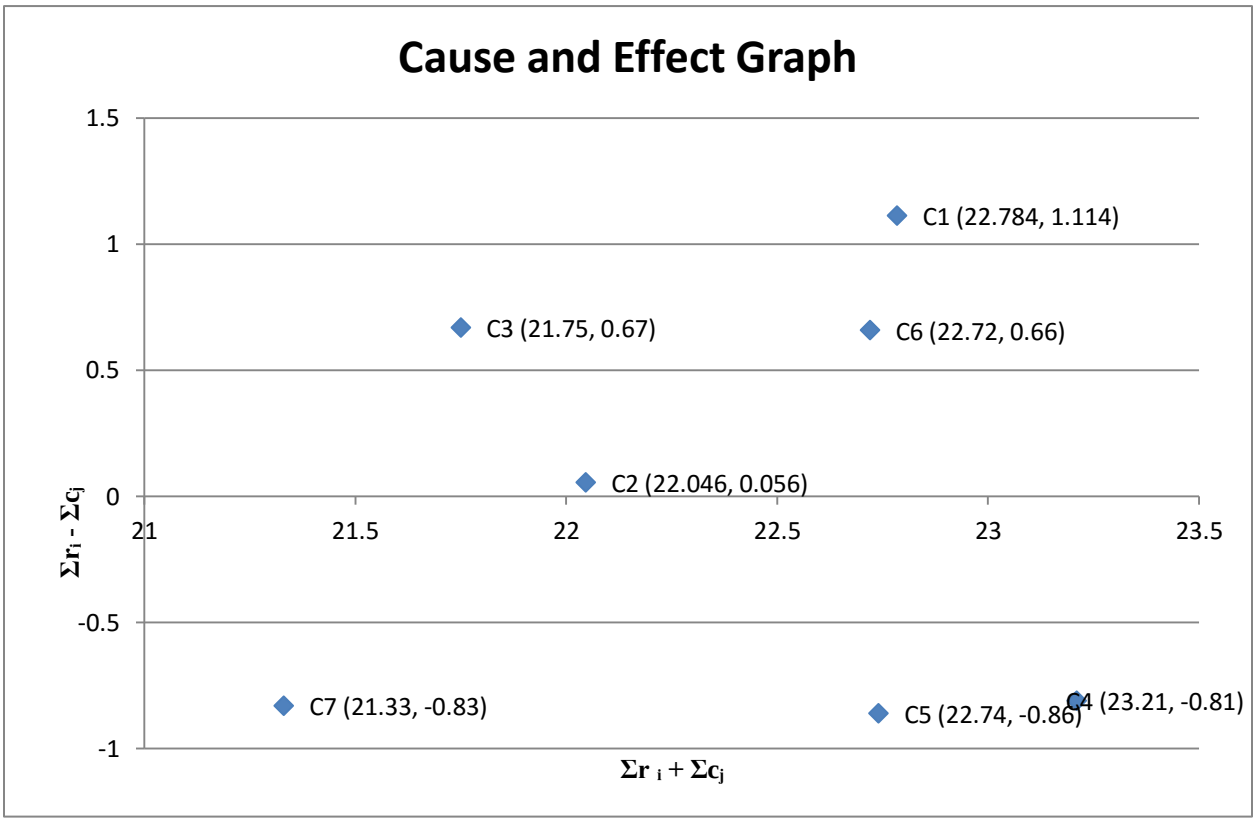

Figure 5.2: Cause and Effect Graph

To know the cause and effect group behavior of the considered components a causal diagram has been drawn as shown in figure5.2. It can be seen from this diagram that four component namely, Cost Oriented Approach (C_1), Customer oriented approach (C_2), Reduced product cycle time (C_3) and Wastage reduction (C_6) falls in the cause group, while, Maintaining Proper Visibility and Cooperation (C_4), Improvement in Effectiveness and Flexibility (C_5), and Proper responsiveness to urgent orders (C_7) in the effect group.

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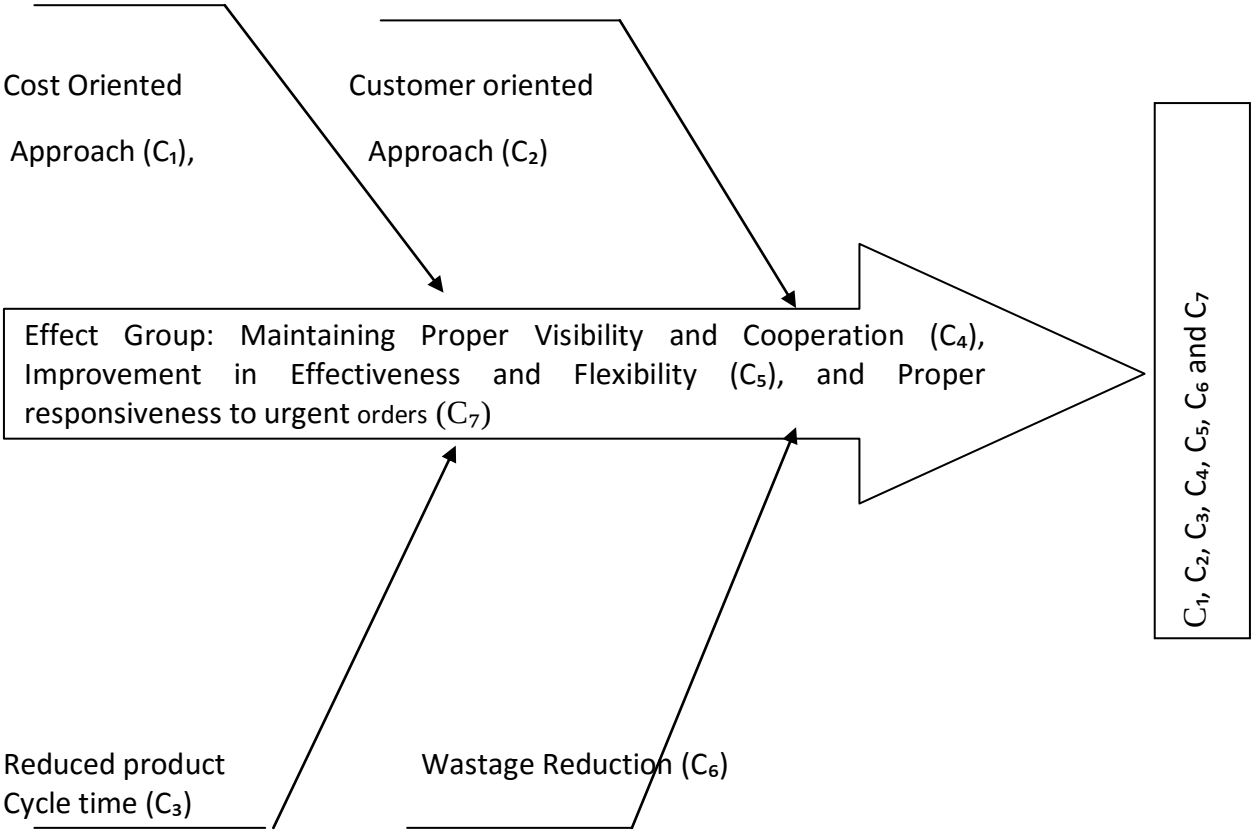


Figure 5.3: Cause and Effect Diagram

A fish bond diagram was drawn as shown in figure 5.3. In the fish bond diagram, the main arrow contains the effect group components and the arrows directing towards the middle arrow contains the cause group components. From the fish bond diagram, at one site, it become clear that four components are affecting other three components and ultimately all components get affected responsible for the performance of the organization.

5.4 Result and Discussion:

The literature review is performed in which various research paper, article, books and reports from 2005 up to 2016 are studied. However some important research papers before 2005 were also studied. Also discussions were held with the experts of area related to supply chain. Through these exercise twenty seven performance parameters were obtained. After the obtaining

the performance parameters research methodology for the performance evaluation is described in which the research objective of the project were also decided. Survey method is described for the social and statistical purpose. A questionnaire is developed. There were three segments of questionnaire out of which the two segments were about company's profile and respondent profile and one segment was about the performance measure. Data is collected through email with the using google form support. Statistical analysis was performed. The principal components extraction method of the factor analysis with varimax rotation was applied using twenty seven parameters. The parameters having poor loading were left out from the study and the parameters having significant loading were grouped into seven components. These seven components were utilized for the performance evaluation using DEMATEL approach.

According to Sumrit D. and Anuntavoranich P. (2012), the importance of evaluation perspectives are determined by ($\Sigma r_i+\Sigma c_j$) values. As shown in table 5.7, the value of the component '4' (Maintaining Proper Visibility and Cooperation) is 23.21, the highest value among all seven components, so it will be considered as the most important parameter. Similarly, value for the component '7', (Proper responsiveness to urgent orders) has least value i.e. 21.33, so it will be considered as the least important parameter.

In context of ($\Sigma r_i + \Sigma c_j$) values, the prioritization of the importance of seven components may be given as $C_4 > C_1 > C_5 > C_6 > C_2 > C_3 > C_7$ i.e. Maintaining Proper Visibility and Cooperation (C_4)> Cost Oriented Approach (C_1) > Improvement in Effectiveness and Flexibility (C_5) >Wastage reduction (C_6) > Customer oriented approach (C_2)> Reduced product cycle time (C_3) > Proper responsiveness to urgent orders (C_7).

Based on the difference of the sum of rows and sum of column i.e. ($\Sigma r_i - \Sigma c_j$) values, these seven components were divided into (i) cause group and (ii) effect groups given as below.

(i) If the value of $(\Sigma r_i - \Sigma c_j)$ is positive, then the component will fall in the cause group, so this component will directly affected the others. The factors having highest value of $(\Sigma r_i - \Sigma c_j)$ also had the highest direct impact on the others. In this study, Cost Oriented Approach (C_1), Customer oriented approach (C_2), Reduced product cycle time (C_3) and Wastage reduction (C_6) are classified in the cause group. The values of $(\Sigma r_i - \Sigma c_j)$ of these four components are 1.114, 0.056, 0.67 and 0.66 respectively. It also shows that C_1 (Cost Oriented Approach) has the most critical impact on the others.

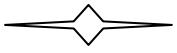
(ii) If the value of $(\Sigma r_i - \Sigma c_j)$ was negative it means net receive, such perspective will be classified as the effect group, and greatly influenced by the others. From this work, it is found that "Maintaining Proper Visibility and Cooperation (C_4)", "Improvement in Effectiveness and Flexibility (C_5)", and "Proper responsiveness to urgent orders (C_7) are categorized in the effect group, because the values of (r-c) are -0.81, -0.86 and -0.83, respectively. And "Improvement in Effectiveness and Flexibility (C_5)" was the most affected by the other factors i.e. Cost Oriented Approach (C_1), Customer oriented approach (C_2), Reduced product cycle time (C_3) and Wastage reduction (C_6).

As per the table 5.8, It was concluded that Cost Oriented Approach (C_1) and Wastage reduction (C_6) had a mutual interaction because the value of c_{16} (1.720) and c_{61} (1.677) are greater than the threshold value α (1.597). Similarly Customer oriented approach (C_2) and Maintaining Proper Visibility and Cooperation (C_4), had a mutual interaction because the value of c_{24} (1.724) and c_{42} (1.601) are greater than the threshold value α (1.597). Maintaining Proper Visibility and Cooperation (C_4) and Improvement in Effectiveness and Flexibility (C_5), also had

a mutual interaction as the value of c_{45} (1.712) and c_{54} (1.688) are greater than the threshold value α (1.597).

5.5 Summary

In this chapter retained components after statistical analysis were utilized as the significant components for the purpose of performance evaluation. DEMATEL approach was applied and a flow chart was constructed to show its algorithm. In this context, a questionnaire was developed and sent to the ten field experts through mail for the purpose of expressing their opinion. The responses were collected through the mail and through discussions with the field experts. These responses in the form of matrices were utilized as input for the application of the DEMATEL and average matrix is calculated using matrix form of the expert's opinion. Normalized initial direct relation matrix was calculated by multiplying with the value of λ to the average matrix and the Total relation matrix is derived as a result the sum of rows and the sum of columns was calculated. Threshold value of Total relation matrix was also calculated, by which direction of effect is known. On the basis of the sum of rows and columns ($\Sigma r_i+\Sigma c_j$) i. e. prominence the seven components were arranged in ranking order for their importance towards the performance of the organization and on the basis of difference of rows and columns i.e. ($\Sigma r_i-\Sigma c_j$) is also known as 'relation' components were divided into two group i.e. cause group and effect group. In cause group there were four components while in effect group there were three components. A causal diagram and a fish bond diagram were also constructed. In the next chapter naming conclusion, synthesis of the work done, findings of the work done, limitations and its future scope for research were discussed.



Chapter 6
Conclusion

6.1 Introduction

Now at the last of this report it may be understood that a supply chain is the set of nodes or activities where values addition takes place and connects the enterprise's suppliers as well as its customers and throughout this chain, it is the emphasized to maximize the overall value of the company by better utilization and deployment of resources. Based on Literature review, it may be concluded that using information technology and web based technologies of Supply Chain Management system of an organization are crucial for enhancement of the performance of the organization. According to Turek (2013) IT techniques and methods can help companies to become efficient, improve their productivity, and respond rapidly to customer needs. Gunasekaran and Ngai, (2004); Jeyaraj and Seth, (2010) explained that organizations have to concentrate on the strategic business alignment with IT goals and objectives, in order to maximize IT investment and achieve harmony with business strategies and plans. Rylkova and Bernatik (2013) told that performance measurement is essential for enterprises because if the efficiency of activity cannot be measured, the activity cannot be properly controlled. Gunasekaran and Ngai, (2001) told that Individual firms will certainly have performance measurement needs that reflect the unique operations of their business and of course not all supply chains are identical. They further added that performance measures and metrics need to be established for measuring the performance and suitability of IT in SCM. Hence, based on the extensive literature review performance parameter were identified. On the basis of these performance parameter, a questionnaire is developed on five point likert scale, in which '1' is taken for the least importance and '5' for the most importance. This questionnaire is uploaded on

the google in the form of google form for data collection and sent to the field experts through mail. Total sixty responses were received and the response rate is calculated as 27.64%. After receiving the data, statistical analysis is performed. For this reliability analysis is done to examine whether the data received is fit for the further study. Factor analysis, principal component method with varimax rotation was applied. SPSS 21 software was used to perform the factor analysis. After factor analysis the total twenty seven parameters are reduced to the seven components. At last for the performance evaluation DEMATEL approach was applied. In the next sections synthesis of work done, finding of the work, contributions of the work, limitations and future scope is given.

6.2 Synthesis of work done

An extensive literature review about the IT enabled supply chain is performed and simultaneously a discussion was also held with the field experts of the supply chain. Based on Literature review and discussion held with the field experts a research gap analysis is performed. Also the parameters for the performance evaluation were identified which were twenty seven in number. Based on these parameters a questionnaire is developed on five point likert scale, in which '1' is taken for the least importance and '5' for the most importance. The format of the questionnaire is given in the Annexure I. This questionnaire consists of three segments. In the first segment, the detail of industry was asked from field experts in which they are working. The second segment includes the twenty seven performance parameters of strategic, tactical and operational level in combined form. The third segment or the last segment of the questionnaire includes details of the profile of the field expert. This questionnaire is uploaded on the google in the form of google form for data collection. The Questionnaire is sent to two hundred seventeen number of the field experts, working in different organization located near about National

Capital Region Delhi for their response. The mode of communication of the questionnaire was mainly email; however the responses were received on the google form. Total sixty responses were received as per the table given in the annexure II; hence the response rate is calculated as 27.64%. After the data received in the form of responses from the field experts, analysis of the data is done. The reliability test of received data is performed using SPSS software to examine whether the data received is fit for the further study. The value of Cronbach's alpha (α) for the data collected of these twenty seven parameters was calculated 0.932 and the data is found fit for an exploratory study. According to Kumar et al (2015) and Nunnally (1978), the value of Cronbach's α, should exceeds the minimum requirements of 0.5 for the exploratory study. After that factor analysis with principal component extraction method with varimax rotation is applied. On applying this method out of the twenty seven parameters, some of them were eliminated from the study due to their poor loading and remaining were grouped into the seven components. By taking these seven components the performance evaluation using DEMATEL approach was performed. According to the Wu and Lee (2007); Lin and Tzeng (2009); and Sumrit and Anuntavoranich (2013), DEMATEL method has been widely accepted as one of the best tools to solve the cause and effect relationship among the quantitative evaluation criteria.

6.3 Findings of the Work Done

In the work done for the performance evaluation of the IT enabled supply chain, the finding may be summarized as below:

(i) Twenty Seven Performance Parameters as per the table 1.2 were identified based on the literature review and the discussion held with the field experts of the supply chain.

(ii) Reliability test is performed, in which the value of Cronbach's alpha (α) for the data collected of these twenty seven parameters was calculated 0.932 and the data is found fit for an exploratory study.

(iii) Communalities initial and after extraction of all the parameters are calculated. Total variance, the eigen value, extraction sum of square loading and rotation sum of square loading of the components are calculated in terms of the total, percentage variable and percentage cumulative using principal component analysis of extraction method. The Scree plot for the components is given in the figure 1, which shows that there are seven components having Eigen values greater than 1.Scree plot is drawn, which shows there are seven components having eigen value greater than 1.

(iv) Based the statistical analysis the parameters having poor loading extracted from further study and remaining are grouped into seven components as per the table 4.10.

(v) On the basis of these seven components Performance evaluation using DEMATEL is performed.

According to Sumrit D. and Anuntavoranich P. (2012), the importance of evaluation perspectives are determined by $(\Sigma r_i+\Sigma c_j)$ values. In context of $(\Sigma r_i + \Sigma c_j)$ values, the prioritization of the importance of seven evaluation perspective may be given as $C_4 > C_1 > C_5 > C_6 > C_2 > C_3 > C_7$ i.e. Maintaining Proper Visibility and Cooperation (C_4)> Cost Oriented Approach (C_1) > Improvement in Effectiveness and Flexibility (C_5) >Wastage reduction (C_6) > Customer oriented approach (C_2)> Reduced product cycle time (C_3) > Proper responsiveness to urgent orders (C_7).

(vi) Based on the difference of the sum of rows and sum of column i.e. $(\Sigma r_i - \Sigma c_j)$ values, these seven components may be divided into (i) cause group and (ii) effect groups, as given below.

(a) If the value of (Σr_i-Σc_j) is positive, then the component will fall in the cause group, so this component will directly affected the others. The factors having highest value of (Σr_i-Σc_j) also had the highest direct impact on the others. In this study, Cost Oriented Approach (C_1), Customer oriented approach (C_2), Reduced product cycle time (C_3) and Wastage reduction (C_6) are classified in the cause group. The values of (Σr_i-Σc_j) for these components are 1.114, 0.056, 0.67 and 0.66 respectively. It also shows that C_1 (Cost Oriented Approach) has the most critical impact on the others.

(b) If the value of (Σr_i-Σc_j) was negative it means net receive, such perspective will be classified as the effect group, and greatly influenced by the others. From this work, it is found that "Maintaining Proper Visibility and Cooperation (C_4)", "Improvement in Effectiveness and Flexibility (C_5)", and "Proper responsiveness to urgent orders (C_7) are categorized in the effect group, because the values of (Σr-Σc) are -0.81, -0.86 and -0.83, respectively. And "Improvement in Effectiveness and Flexibility (C_5)" was the most affected by the other factors i.e. Cost Oriented Approach (C_1), Customer oriented approach (C_2), Reduced product cycle time (C_3) and Wastage reduction (C_6).

(vii) A cause and effect graph is plotted as per the figure 5.2, in which component 1, 2, 3 and 6 i.e. (C_1), Customer oriented approach (C_2), Reduced product cycle time (C_3) and Wastage reduction (C_6) are above the horizontal axis and it is easily identified that these are the components of cause group.

(viii) A cause and effect diagram is made as per the figure 5.3 in which the relation of the components of the cause and effect group is shown for the firm's performance i.e. Cost Oriented Approach (C_1), Customer oriented approach (C_2), Reduced product

cycle time (C_3) and Wastage reduction (C_6) falls in the cause group, while, Maintaining Proper Visibility and Cooperation (C_4), Improvement in Effectiveness and Flexibility (C_5), and Proper responsiveness to urgent orders (C_7) in the effect group.

6.4 Contribution of the Work

The implication of this work is that the management should concentrate on improving the four components in the cause group Cost Oriented Approach, Customer oriented approach, Reduced product cycle time and Wastage reduction for better firm performance. The three remaining perspectives were found in the effect group i.e. Maintaining Proper Visibility and Cooperation, Improvement in Effectiveness and Flexibility, and "Proper responsiveness to urgent orders, which they were also affected by the ones in the cause group.

6.5 Limitations and future scope

Firstly limitation of the work is the area from which the data is collected. The response data for the questionnaire developed is collected from the industries located in Delhi NCR, mostly Automobile Industries. So the result obtained cannot be applied to the larger area i.e. North India or all over India or globally. Secondly the parameter identified were twenty seven, while there may be more parameter which affect the firm's performance.

Future scope for research on the basis of this work is that larger area may be taken for the data collection. More parameters may be taken for the development of the questionnaire. We use the DEMATEL approach for the performance evaluation. Other multi criteria decision making method may be applied, by which different results may be obtained.

6.6 Summary

Based on Literature review, it may be concluded that using information technology and web based technologies of Supply Chain Management system of an organization are very important. In this work of performance evaluation of the IT enabled supply chain, twenty seven parameters are chosen at first from the extensive literature review. To these chosen parameters Factor analysis, principal component method with varimax rotation was applied. SPSS 21 software was used to perform the factor analysis. After factor analysis the total twenty seven parameters are reduced to the seven components. These components are retained as (1) Cost Oriented Approach (2) Customer oriented approach (3) Reduced product cycle time (4) Maintaining Proper Visibility and Cooperation (5) Improvement in Effectiveness and Flexibility (6) Wastage reduction (7) Proper responsiveness to urgent orders. DEMATEL method was applied for further analysis. The result implied that the management should concentrate on improving the four components mainly in the cause group Cost Oriented Approach, Customer oriented approach, Reduced product cycle time and Wastage reduction. The three remaining perspectives were found in the effect group i.e. Maintaining Proper Visibility and Cooperation, Improvement in Effectiveness and Flexibility, and "Proper responsiveness to urgent orders, which they were also affected by the ones in the cause group.

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Annexure i

Section 1 of 3

PERFORMANCE EVALUATION OF IT ENABLED SUPPLY CHAIN

I am the student of M. TECH. (Production & Industrial Engineering) in Delhi Technological University, (formerly Delhi College of Engineering Delhi) and currently working on a project "PERFORMANCE MEASUREMENT OF IT ENABLED

PERFORMANCE MEASUREMENT OF IT ENABLED SUPP

QUESTIONS RESPONSES 60

information obtained will not be used for any commercial use.
We have kept the questionnaire very simple and it won't take more than couple of minutes to complete.

Name of The Organization

Short answer text

Type of Industry

Multiple choice

- Supplier to OEM
- Original equipment manufacturer (OEM)
- Vendor

Other...

Add option

Required

Approximate Turnover

Short answer text

Establishment of the company

- 2005 to 2009
- 2009 to 2013
- After 2013

Please indicate the number of employees at your

- Less than 100
- Between 100 to 500
- Between 500 to 1000
- More than 1000

After section 1 **Continue to next section**

Section 2 of 3

Part II:- Performance Improvement Parameters

Please mark the parameters in order to improving the organizational supply chain performance (Five point Likert Scale:- for least important=1 ... and for most important=5)

1. Proper responsiveness to urgent orders

1 2 3 4 5

2. Forecasting ease for market demand

1 2 3 4 5

3. Productivity improvement

1 2 3 4 5

4. Proper visualization of customer needs

1 2 3 4 5

5. Total lead time reduction

1 2 3 4 5

6. Total Inventory cost reduction

1 2 3 4 5

7. Increase the level of Customer satisfaction

1 2 3 4 5

8. Improve the relationship with suppliers and

1 2 3 4 5

9. Proper visibility among the supply chain stages

1 2 3 4 5

10. Helps in enhancing the cooperation among the existing

1 2 3 4 5

11. Helps in maintaining the stability in the competitive market

1 2 3 4 5

12. Easiness in Decision making

1 2 3 4 5

13. Reduction in coordination cost

1 2 3 4 5

14. Information processing capability

1 2 3 4 5

15. Partnership structure enhancement

1 2 3 4 5

16. automation of exchange procedures

1 2 3 4 5

17. Reduction in uncertainty

1 2 3 4 5

18. Reduction of non value added activities

1 2 3 4 5

19. Improve the Reengineering capability

1 2 3 4 5

20. Improve the Capability to integrate different business

1 2 3 4 5

21. Reduce the customer order path

1 2 3 4 5

22. Reduce the Purchase order cycle time

1 2 3 4 5

23. Helps in Flexibility capability

1 2 3 4 5

24. Helps in Quality improvement

1 2 3 4 5

25. Effectiveness of scheduling techniques

1 2 3 4 5

26. Reduction in customer query time

1 2 3 4 5

27. Helps The Top Management in taking Initiative for an

1 2 3 4 5

After section 2 **Continue to next section**

Section 3 of 3

Part III. Respondents Profile

Please tell us something about yourself.

1. Name of respondent

Short answer text

2. Your position in the organization

Top Management

- ○ Middle Management
- ○ Lower Management
- ○ Supervisor
- ○ Other...

3. How long you have been working with present

- ○ Less than 5 years
- ○ Between 5 to 10 years
- ○ More than 10 years

4. Your E-mail address *

Short answer text

Annexure- ii

Trying to connect...

60 responses

SUMMARY | INDIVIDUAL

Accepting responses

Name of The Organization (42 responses)

JPC

JPC

JPC

JPC

JPC

radical solar

radical solar

radical solar

radical solar

zeco aircon pvt ltd

zeco aircon pvt ltd

zeco aircon pvt ltd

GNDIT

GNDIT

Radical Solar

Radical Solar

gndit

gndit

MMT

MMT

RBS

TPDDL

CPWD

Hero MotoCorp Ltd.

Ahluwalia contracts I ltd

MINDA CORPORATION LTD

hindusthan national glass and industries limited

ordinance factory murdnagar ghaziabad(up)

param krishna enterprises

GPIL

JINDAL STEEL AND POWER LTD

Jbm industries

gs e&c delhi pvt ltd

IREDA Ltd

HAMDARD LABORATORIES (INDIA)

Search pharma pvt ltd

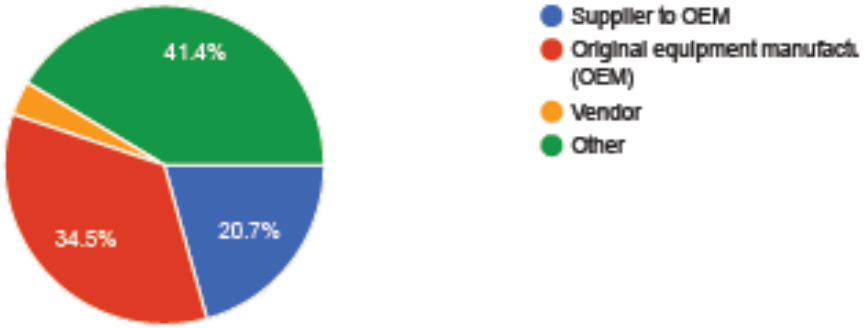
hcl infosystem

JBM Industries Limited

Delphi Powertrain

PERFORMANCE MEASUREMENT OF IT ENABLED SUPPI

QUESTIONS RESPONSES 60



Approximate Turnover (4 responses)

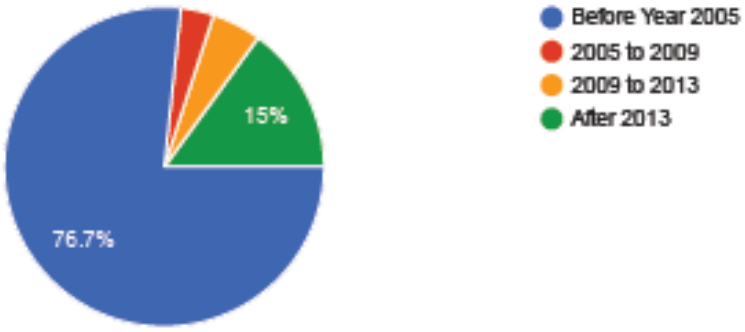
40cr

60 Cr.

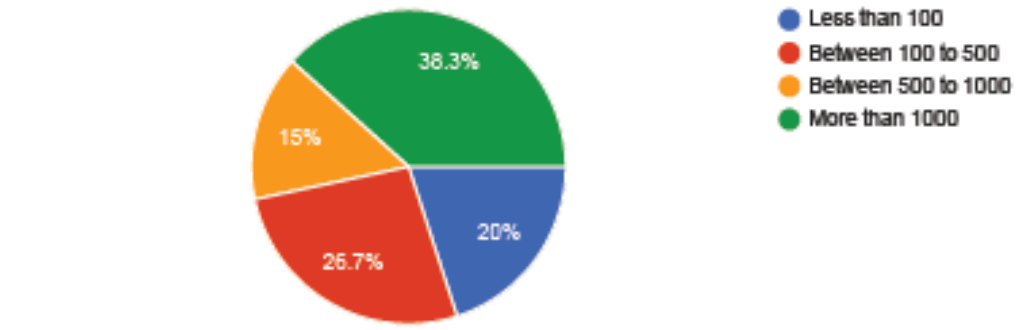
50-60 crore

60 CR

Establishment of the company (60 responses)

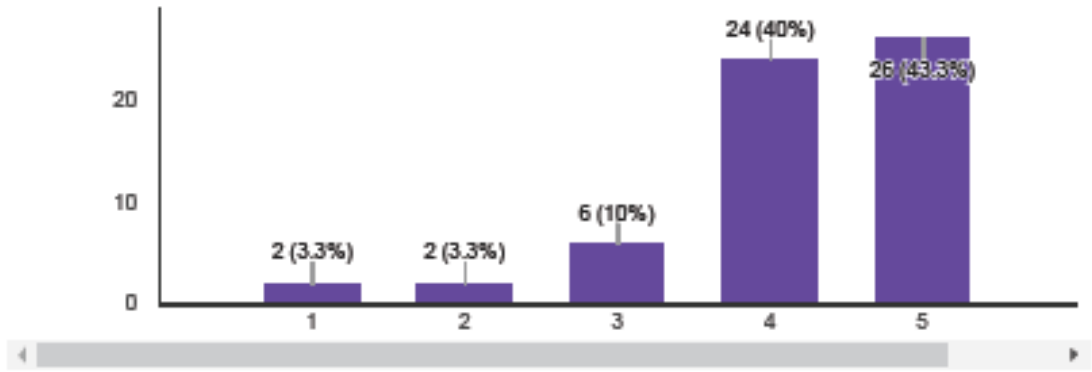


Please indicate the number of employees at your company (60 responses)

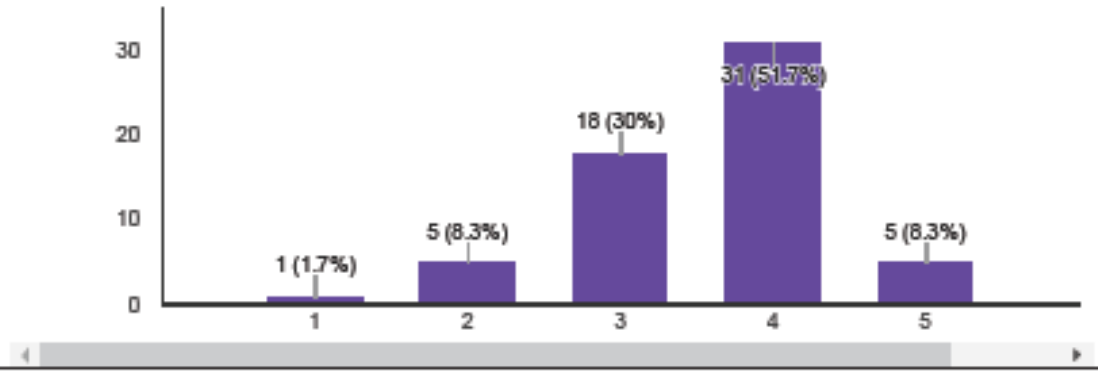


Part II:- Performance Improvement Parameters

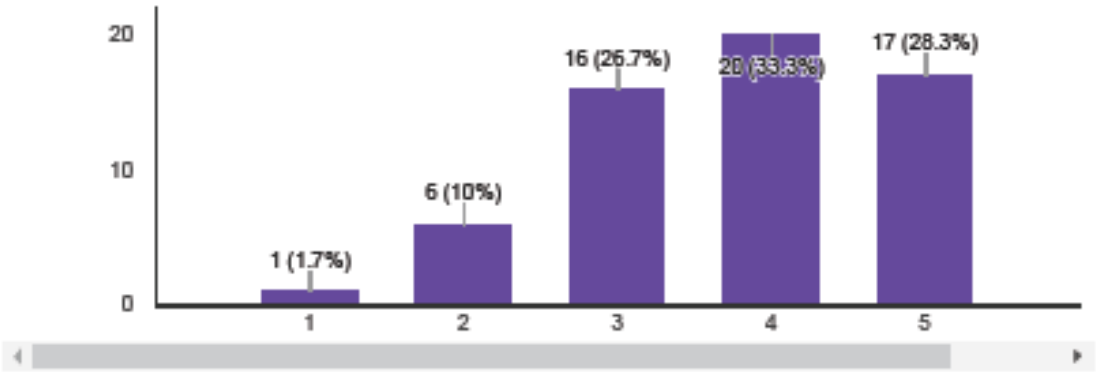
1. Proper responsiveness to urgent orders (60 responses)



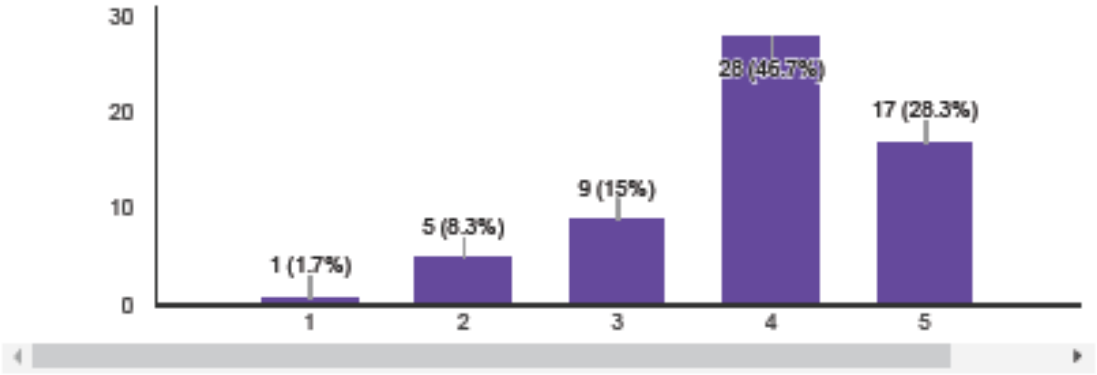
2. Forecasting ease for market demand (60 responses)



3. Productivity improvement (60 responses)

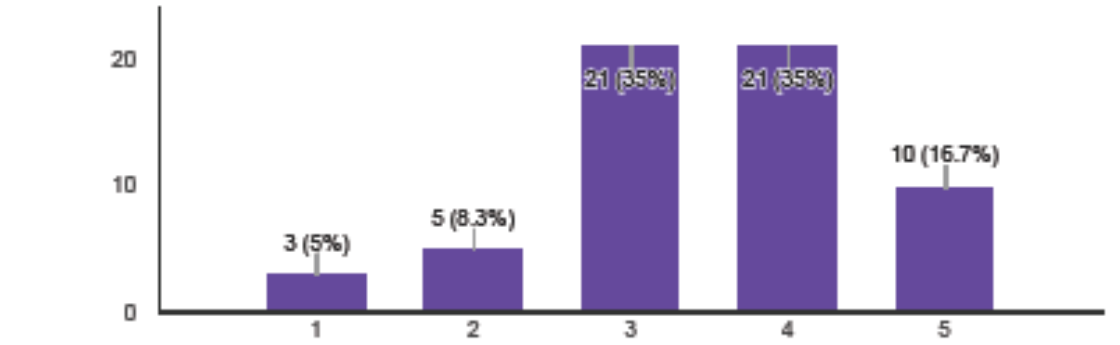


4. Proper visualization of customer needs (60 responses)

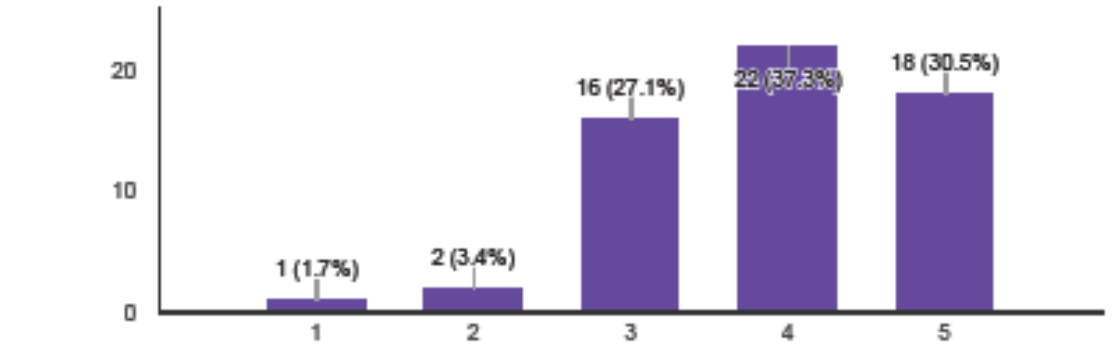


5. Total lead time reduction (60 responses)

6. Total Inventory cost reduction (60 responses)

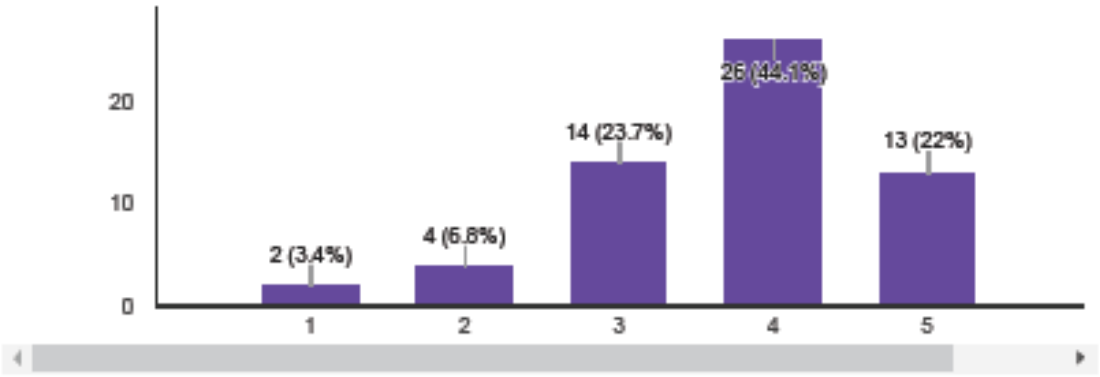


7. Increase the level of Customer satisfaction (59 responses)

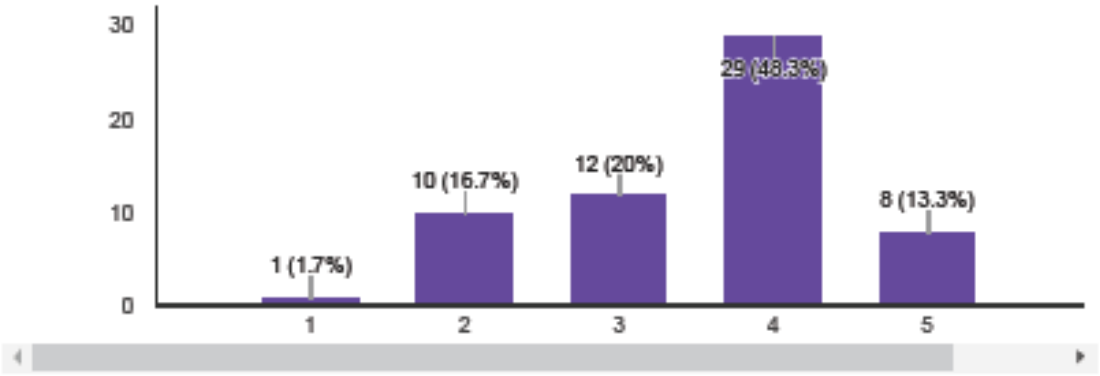


8. Improve the relationship with suppliers and customers (56 responses)

9. Proper visibility among the supply chain stages (59 responses)

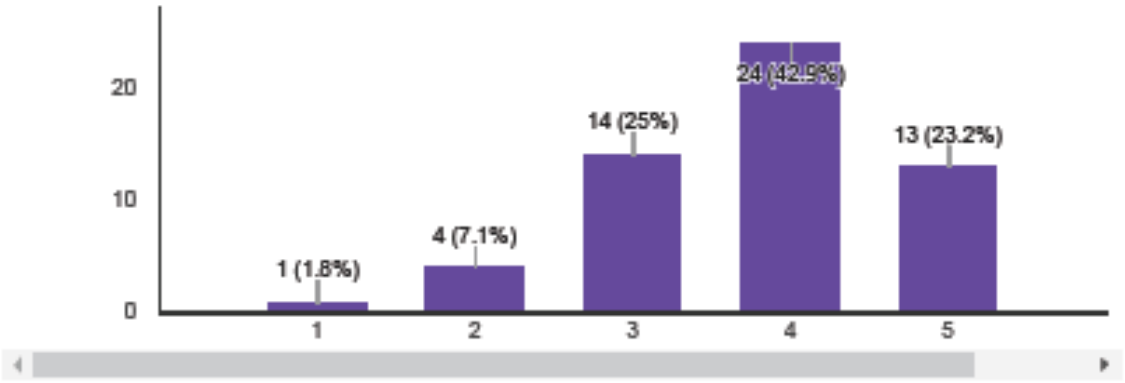


10. Helps in enhancing the cooperation among the existing stages
(60 responses)

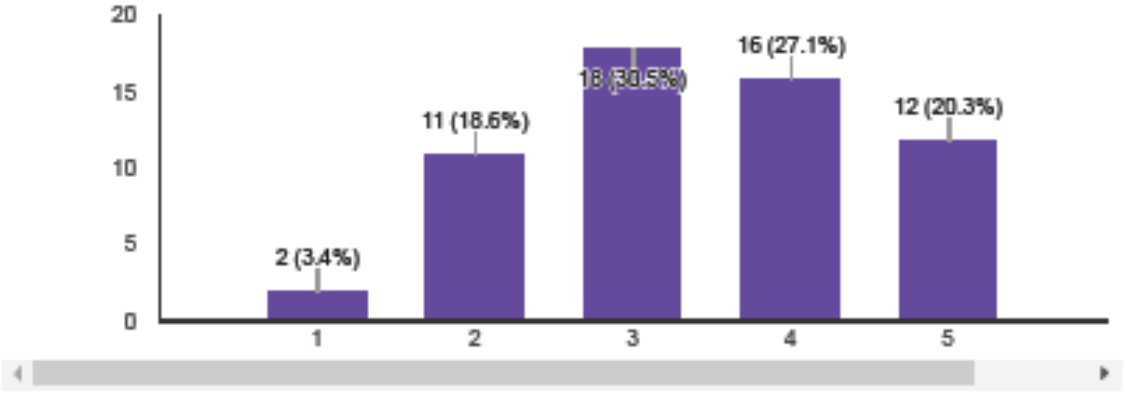


11. Helps in maintaining the stability in the competitive market place
(60 responses)

12. Easiness in Decision making (56 responses)

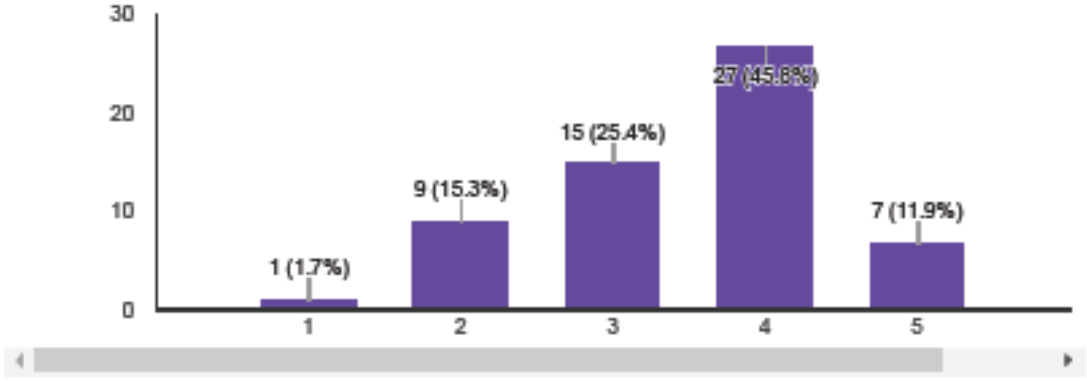


13. Reduction in coordination cost (59 responses)

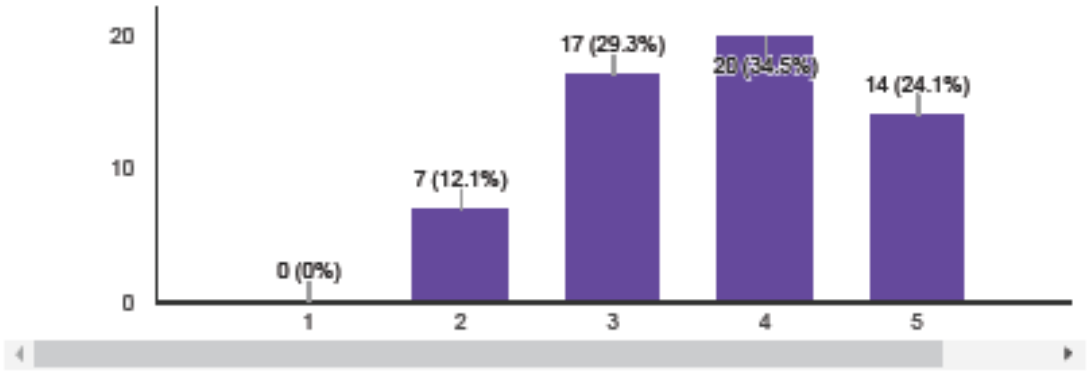


14. Information processing capability (60 responses)

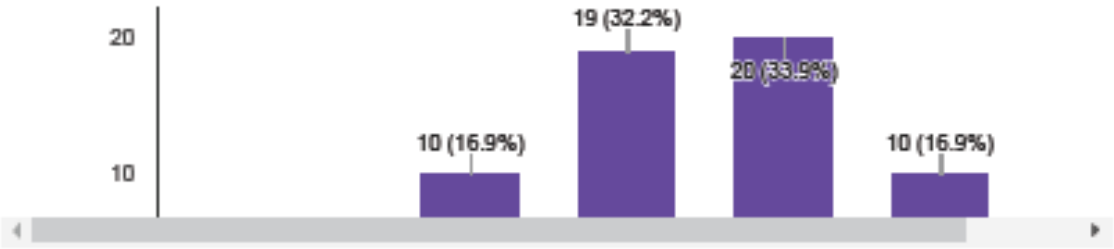
15. Partnership structure enhancement (59 responses)



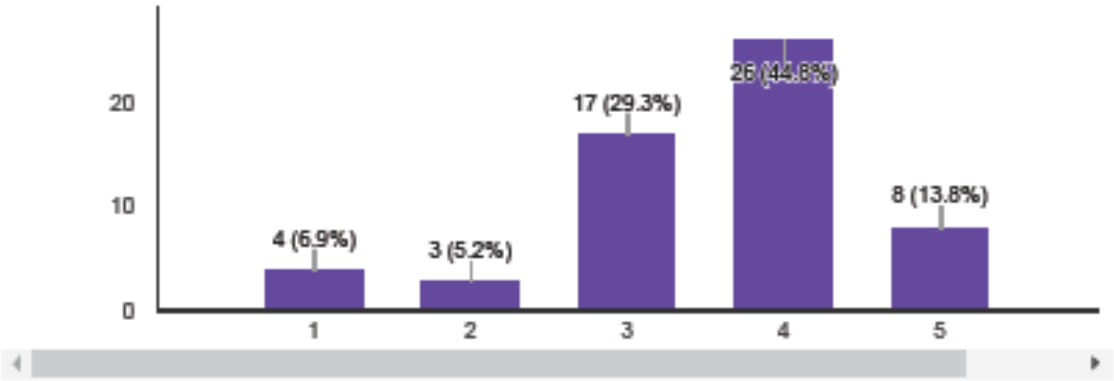
16. automation of exchange procedures (58 responses)



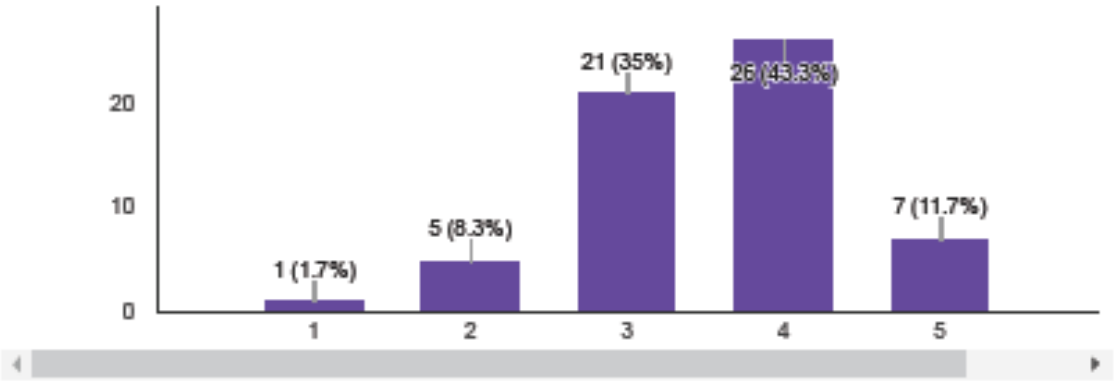
17. Reduction in uncertainty (59 responses)



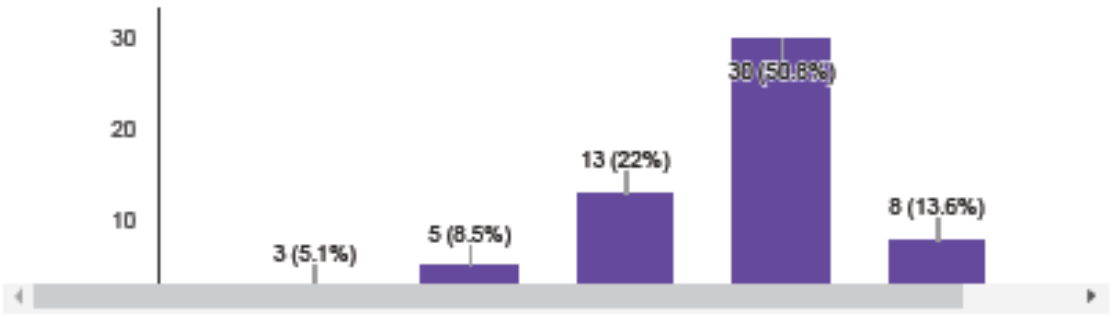
18. Reduction of non value added activities (58 responses)



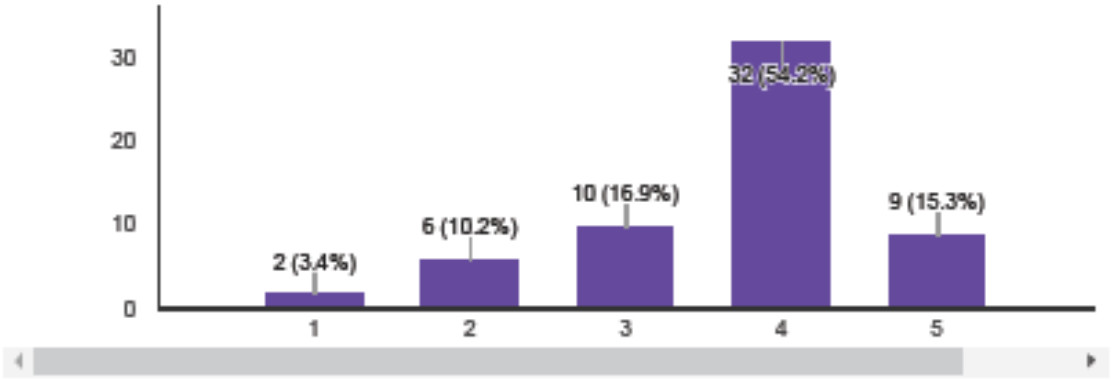
19. Improve the Reengineering capability (60 responses)



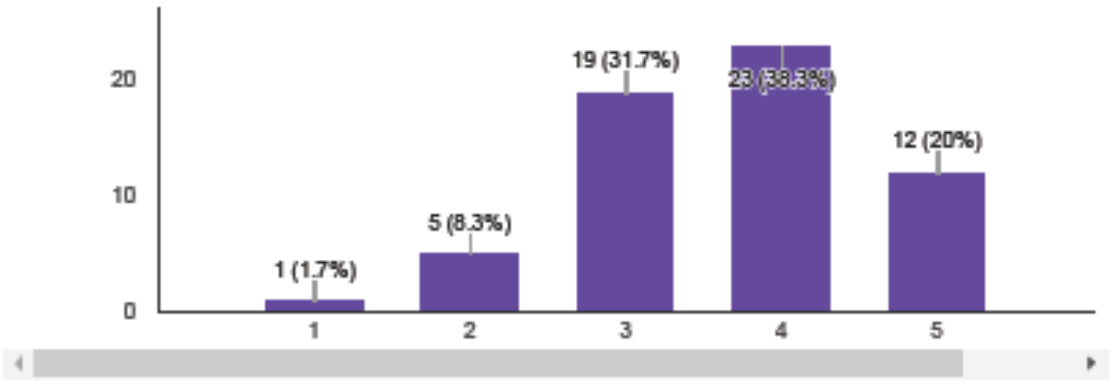
20. Improve the Capability to integrate different business activities (59 responses)



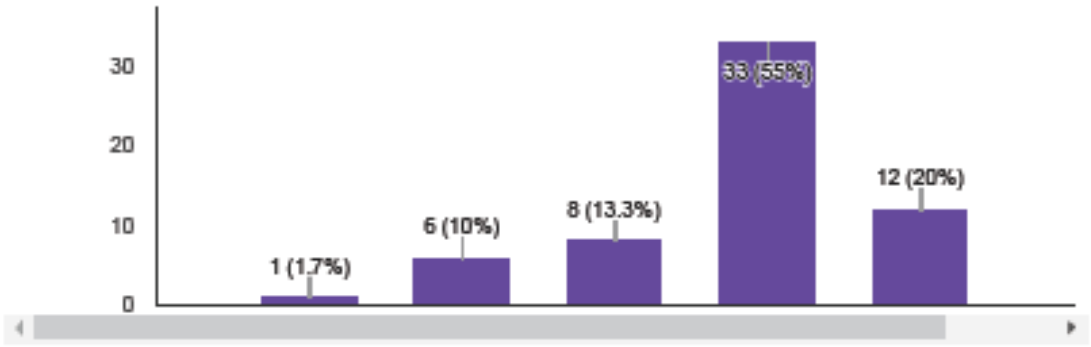
21. Reduce the customer order path (59 responses)



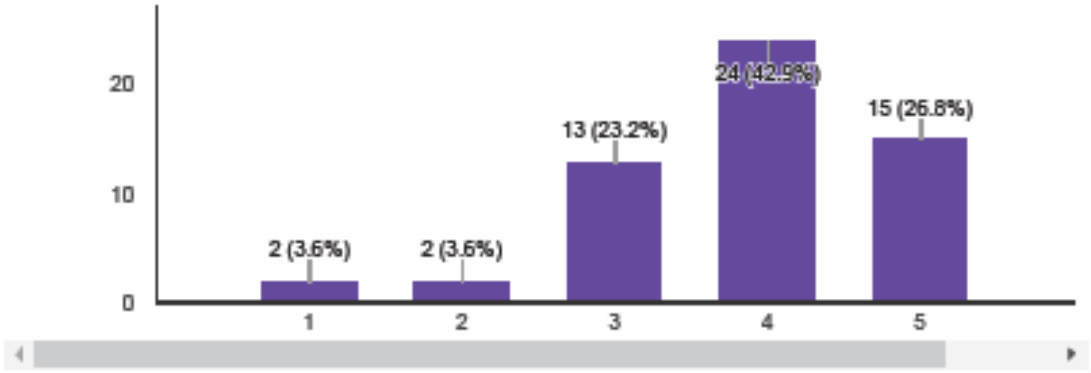
22. Reduce the Purchase order cycle time (60 responses)



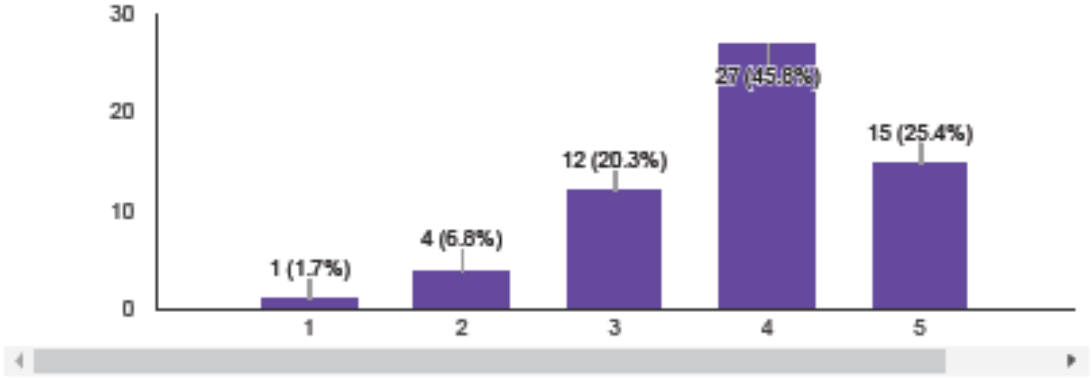
23. Helps in Flexibility capability (60 responses)



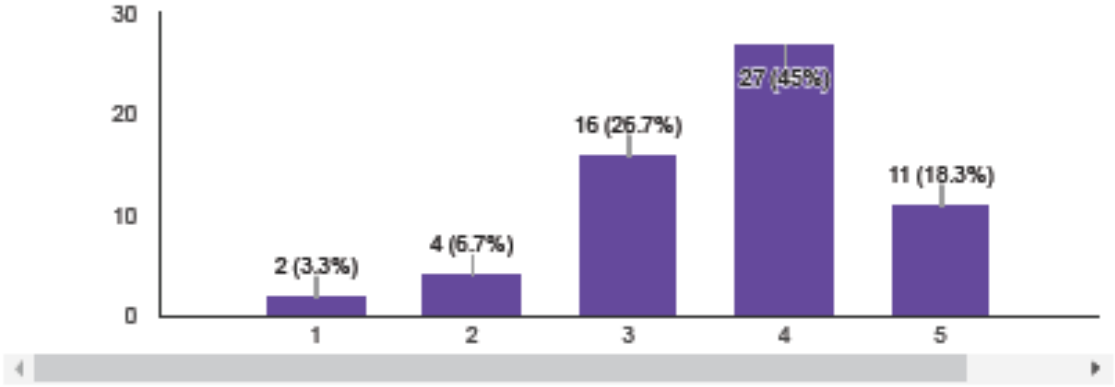
24. Helps in Quality improvement (56 responses)



25. Effectiveness of scheduling techniques (59 responses)

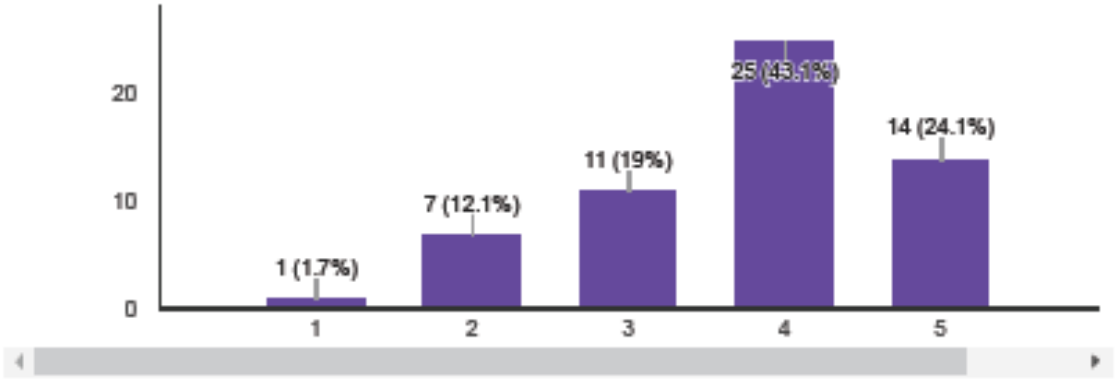


26. Reduction in customer query time (60 responses)



27. Helps The Top Management in taking Initiative for an activity

(58 responses)



Part III. Respondents Profile

1. Name of respondent (54 responses)

naveen dogra

naveen dogra

naveen dogra

Andrish

Andrish

mohit

mohit

Sachin

Dinesh Kumar

Yogesh kumar

R P S

UMESH DUTT SHARMA

Sourav

Neeraj Sharma

pratap singh

Prabhakar sharma

Nikhil

Pravin Kumar

Prashant kumar

ANURAG KUMAR

Yogesh Sharma

SUNIL AGGARWAL

SUDHAKER SHARMA

Pradeep

Nanak Ram

ajay chhillar

Shubham kumar

sharad

Ajit Singh

SHAMSHAD ALI

Siddharth Nigam

Jai Pal Panchal

Sanjai

Nitesh

ankur

ashish

balchand yadav

vivek

satish

dharmendra

shoorveer

yogender

Sunil gupta

ANUJ SHARMA

Mukesh

Yashpal

Ankur Parshav

Durga Singh

Balraj Singh

soval pal

Lata Rawat

sohan

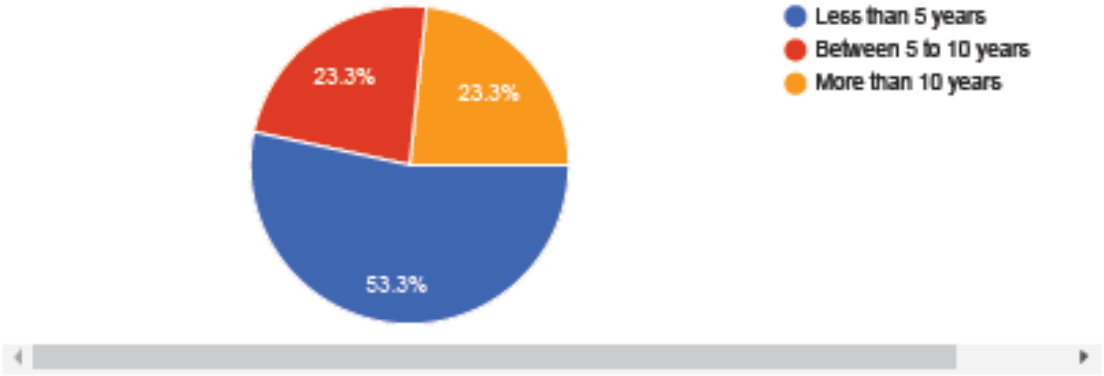
Rajesh Chadner

Devender Kumar

2. Your position in the organization (60 responses)

3. How long you have been working with present organization?

(60 responses)



4. Your E-mail address (60 responses)

naveendogra31@ gmail.com

naveendogra31@ gmail.com

naveendogra31@ gmail.com

peharmahal@gmail.com

peharmahal@gmail.com

er.andrish@gmail.com

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mohitkumarjassal@gmail.com

sachindudeja@gmail.com

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sonupahuja16@gmail.com

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devender.kumar@jpc-india.com