A

DISSERTATION REPORT

ON

Developing a Coordination Framework for a Supply Chain Using Fuzzy Analytical Hierarchy Process in Small Scale Manufacturing Firm

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JUNE 2016

CERTIFICATE

This is to certify that the dissertation entitled "**Developing a Coordination Framework for a Supply Chain Using Fuzzy Analytical Hierarchy Process in Small Scale Manufacturing Firm**" being submitted by Gourav Kumar Jain (2014PIE5187) is a bonafide work carried out by him under my supervision and guidance, and hence approved for submission to the Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur in partial fulfillment of the requirements for the award of the degree of Master of Technology (M Tech) in Industrial Engineering. The matter embodied in this dissertation report has not been submitted anywhere else for award of any other degree or diploma.

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CANDIDATE'S DECLARATION

I hereby declare that the work which is being presented in this dissertation entitled "**Developing a Coordination Framework for a Supply Chain Using Fuzzy Analytical Hierarchy Process in Small Scale Manufacturing Firm**" in partial fulfilment of the requirements for the award of the degree of Master of Technology (M Tech.) in Industrial Engineering, and submitted to the Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur is an authentic record of my own work carried out by me during a period of one year from July 2015 to June 2016 under the guidance and supervision of Prof. (Dr.) Rakesh Jain of the Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur.

The matter presented in this dissertation embodies the results of my own work and has not been submitted anywhere else for award of any other degree or diploma.

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This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

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- Gourav Kumar Jain

ABSTRACT

As a result of globalization and liberalization, Indian small and medium enterprises (SMEs) have been passing through a transitional period. SMEs are facing tough competition. Small and medium enterprises (SMEs) in India and other developing countries face problems in coordinating their supply chain due to lack of resources and improper directions. Increasing competition due to market globalization, product diversity and technological breakthroughs stimulates independent firms to collaborate in a supply chain that allows them to gain mutual benefits. Supply chain management is one of the most important areas for competitiveness and growth of industries.

Managing independent members who share common goals is a frequent concern in any supply chain. More specifically, due to the critical role of the manufacturing industry in producing and delivering the right product to the right people at the right time, coordination of supply chain members is a critical factor. Therefore, the purpose is to identify and prioritize factors affecting coordination of a Supply Chain.

Table of Contents

LIST OF FIGURES

LIST OF TABLES

CHAPTER – 1

INTRODUCTION

1.1 Background

During the past decades, organizations have used cost reduction through, performance improvement, total quality Management and just-in-time (JIT) processes as the main strategies to compete and achieve their goals. Nowadays, customer`s demands and expectations have increased and diversified due to globalization. In regard to cost, quality, and product variety, companies need to meet increased customer demand; thus, organizations seek a coordinated and harmonized relationship within a supply chain. The development of supply chain management (SCM), therefore, can provide higher value for the consumers, and increase supply chain profitability as well.

Because of different goals and interests assumed for each component of the supply chain, coordination can play a key role in defining the supply chain performance as a whole. Performance of all components of the supply chain may be promoted through the shared aims. SCM can leverage competitive advantages, customer satisfaction, and profitability for all components through coordinated activities. Coordination also is necessary for integrated activities based on the nature of interdependence of the supply chain components. With rapid globalization, efficient coordination has a key role in achieving competitive advantage in terms of innovation, flexibility, etc. Integrated processes of all components in the supply chain, information sharing, and technology transfer are some actions that are recognized as coordination. With increasing market dynamics and outsourcing, management of distinct, but dependent members, and improvement of coordination and communication with their parties are the most substantial problems facing SCM.

Although well-coordinated individuals will gain better organizational performance, providing an accurate definition for coordination is still no easy. Scientists have discussed coordination from different viewpoints. One realistic approach to ensure coordination within a supply chain is to manage issues by central authority control. Decentralized control is another means by which members try locally to improve efficiency, without considering other supply chain members and the impact of their decisions on supply chain performance as a whole. Contracts are useful tools for enforcing supply chain members' behaviors with regard to coordination. In regard to resources and information, supply chain components are highly dependent on each other; hence, managing the dependencies with coordination mechanisms appears critical. Furthermore, it encourages supply chain members to decide along the SCC.

In India small medium enterprises plays a very important role in the industries. Small medium enterprises considered as the backbone of economic growth in all countries.in India 95% of industrial divisions are in small scale sector with 40%value addition in manufacturing sector and 6.92% contribution to the Indian gross domestic product.in India small medium enterprises contributes 60% in employment.

Small and medium enterprises (SMEs) show a critical role in the success of supply chains because in most of the situations they work as suppliers for bigger organizations. SMEs need a coordinated supply chain to face dynamic market requirements in terms of short product life cycle, less delivery lead time and continuous cost reduction. So to achieve better coordination in the SMEs the factors are identified and prioritize using fuzzy analytical hierarchy process.

Analytic hierarchy process has been extensively used as a useful MCDM tool or a weight estimation technique in many areas such as selection, evaluation, planning and development, decision-making, forecasting, and many more. The traditional AHP requires exact judgments, however, due to the complexity and uncertainty involved in real-world decision problems, a decision-maker (DM) may sometimes feel more confident to provide fuzzy judgments than exact comparisons. Fuzzy AHP is a simple AHP approach but the only difference is it uses fuzzy number for pair wise comparison among the decision variables.

1.2 Research Motivation

As a outcome of globalization and liberalization, Indian small and medium enterprises (SMEs) have been passing through a intermediate period. With slowing down of economy in India and abroad, countries like China is giving hard competition by offering value products at lower cost. To overcome this tough competition of open global markets, SMEs must have coordinated and flexible supply chain (SC).

To face dynamic and complex global environment, SMEs need to coordinate its activities with members of its supply chain. In a coordinated supply chain both buyers and suppliers should be willing to accommodate the uncertainties and variations in each other's business. Variations and uncertainties of global open market can be handled by strategic implementation of supply chain management (SCM). Coordination and flexibility of supply chain (SC) increases the robustness of the buyer–supplier relationship in changing global conditions. While intensifying competition, globalization has also opened the doors of opportunities for Indian SMEs.

According to (singh, 2013) In 1980s, most of the firms were competing on discrete basis mostly in terms of cost. They used to attention on business methods such as TQM, just in time, benchmarking to optimize their individual performance. After globalization of markets, consumers have become more penetrating for other parameters also in addition to product price. Market requirements are changing very fast. Firms are required to satisfy their customer in terms of cost, quality, variety, delivery on time etc. In such a situation, administrations have realized that performance at the individual level will not help them in achieving these objectives. To meet these objectives, organizations have to work in integration of suppliers, customers, distributors and retailers. Numerous organizations working together through shared goals and integrated processes may improve the performance of each of the individual members. This can be only possible through coordinated supply chain management (SCM).

1.3 Research objectives

The literatures have their prime focus on supply chain coordination in small medium enterprises in manufacturing sector. The study aims to develop coordination frame work to overcome the competitive environment which is very different for the past. So the proposed study aims to create better coordination in manufacturing firm.

The specific research objectives of the study are as follow:

1. The first objective of the study is to identify the factors which affect the supply chain coordination in small scale manufacturing firm.
2. To prioritize the factors of the supply chain coordination using fuzzy analytical hierarchy process.

1.4 Research Approach

In order to fulfill the research objective mentioned in the previous section, the research study divides the work in two stages

In the first stage the factors which are responsible for the supply chain coordination of small scale manufacturing firm are identified from the literature review. After identification the factors are categorized in different factors and sub factors.

In second stage after the identification and categorization of factors the analysis of these factors is done. For the analysis the pair wise comparison is held and then using fuzzy extent analysis the prioritization of factors is done for the coordination.

1.5 Structure of Thesis

The remainder of this thesis consists of 4 chapters. Chapter 2 presents a detailed review of the literature on supply chain coordination in small scale manufacturing.

Chapter 3 focuses about the methodology used for this research work in a systematic and step by step manner.

Chapter 4 detailed out the methodology and approach used to prioritize the factors and gives the calculation used for the proposed work.

Chapter 5 concludes the thesis with final discussion including the future scope of the research work undertaken.

CHAPTER – 2

LITERATURE REVIEW

2.1 Supply Chain

A supply chain or logistics network is the structure of firms, people, technology, activities, information and resources involved in moving a product or service from supplier to customer. In the 1980s the term SCM was developed to express the need to integrate the key business processes from end user through original suppliers. SCM is the management of flow of inventory, information, and money between the different members of supply chain (Mentzer et al. 2001). The basic idea behind the SCM is that companies and corporations involve themselves in a supply chain by exchanging information concerning market variations and production abilities. Incorporating SCM successfully leads to a new kind of competition on the global market where competition is no longer of the company versus company form but rather takes on a supply chain versus supply chain form.

Disney and Towill (2003) stated that the dependencies between the supply chain members can be managed with the help of coordination mechanisms such as invoking supply chain contracts, information sharing, information technology, collaborative decision-making, meetings with supply chain members and technical support.

Arend and Wisner (2005) observed that SMEs in general are not able to implement SCM to its full extent, mainly because they depend on bigger customer and follow the norms stipulated by them. Larger companies consider SMEs as being easy to replace, buyers are reluctant to form partnerships with SMEs(Arend and Wisner 2005; Tan 2 001).

Christopher (1998) stated that the main benefits of SCM are shorter delivery times, more reliable delivery promises, fewer schedule disruptions, cost savings and risk reductions. Singh (2011) stated that in SCM, its members perform different functions or activities like logistics synchronization, inventory management, ordering, collaborative decision making, forecasting and product design, management of flow of goods, information and money. In traditional supply chains, individual members of supply chain have been performing these activities independently. The supply chain members may earn benefits by coordinating these various activities. Soroor et al. (2009) stated that supply chain coordination plays a critical role in integrating different factors along the supply chain. Grittell and Weiss (2004) stated that for achieving coordination in supply chain efforts are required to take initiatives such as: sharing of knowledge, scheduling of frequent meetings of stakeholders for conflict resolution, understanding of nature of intermediaries, and knowledge of supply chain concepts, status or power difference and resistance in following the instructions of other organizations. Coordinating actions across firms is tough because organizations have different cultures and companies cannot count on shared beliefs or loyalty to motivate their partners (Narayanan and Raman 2004).

Chen and Paulraj (2004) observed that supply chain members are dependent on each other to effectively transfer goods and information among each other. Increasing global cooperation, vertical disintegration and a focus on core activities have led to the notion that organizations are links in a networked supply chain. Volatile market, highly aware customers, customized products, short product life cycle and short lead time leads to uncertainty in business environment these days. To respond these uncertainties researchers stressed on strategic importance of flexibility (Krajewski et al. 2005; De Toni and Tonchia 2005).

Upton (1994) stated that flexibility is a crucial weapon to increase the competitiveness in volatile market. Garavelli (2003) stated that flexibility reflects the ability of a system to respond rapidly to changes occur inside and outside the system. Swafford et al. (2006) and Kumar et al. (2007) have extended the concepts of flexibility to other activities of supply chain such as sourcing flexibility, logistics flexibility, product design and development flexibility and information systems flexibility. Supply chain flexibility includes the operation systems flexibility, market flexibility, logistics flexibility, supply flexibility, organizational flexibility, and information systems flexibility (Adrian et al. 2007).

Singh (2008) has observed that for improving their competitiveness, SMEs should develop their strategy to improve their value chain effectiveness by making it more flexible. Singh (2011) has observed that, SMEs should follow holistic approach to improve overall coordination and responsiveness of supply chain. Liu et al. (2013) observed that in Chinese firms, operational coordination effects both operational and business performance, while information sharing affects operational performance. Singh (2013) observed that coordinated supply chain is concerned with managing dependencies between various members and joint efforts of all members to achieve mutually defined goals in more flexible manner. Basnet (2013) observed that internal supply chain involves multiple functions within companies such as sales, production, and distribution. According to Ponis et al. (2012) innovative e-collaboration, new manufacturing and supply chain practices can improves the competitiveness of clothing SMEs. Arshinder and Deshmukh (2008) reviewed different perspectives on supply chain coordination and mechanisms available for coordination. Supply chain coordination relies on the availability of prompt and accurate information that is visible to all actors in the supply chain. However, new demands in the supply chain system require changes to information flow and exchange. Systems, tools and methods also represent significant differences between SMEs and larger companies, in relation to adoption of electronic interfaces between actors in the supply chain. For example, larger companies have the resources and technical budgets to implement e-business and e-supply strategies but SMEs continue to be challenged by resource limitations (Wagner et al. 2003).

Supply chain management is one of the most significant areas of focus for competitiveness and growth of industries. Majority of SMEs lack resources and don't know how to support the coordination and flexibility of their supply chain. Coordination includes many activities such as integration of process of one supply chain with processes of other supply chain, information sharing, relationship management, technology transfer etc. Flexibility of supply chain reflects the ability of a system to properly and rapidly respond to changes, coming from inside as well as outside the system. It is important due to the fact that market demand is generally unpredictable and supply chain planning based on conventional forecast often result into bullwhip effect and related problems such as high inventory and stock out (Paik and Bagchi 2007).

Supply chain is a network of facilities and distribution options that performs the functions of procurement of materials, transformation of these materials into intermediate and finished products and the distribution of these finished products to customers (Kaihara, 2003). According to Lau et al. (2004) and Hervani et al. (2005), supply chain is coordination of independent enterprises in order to improve the performance of the whole supply chain by considering their individual needs. Supply chain activities transform natural resources, raw materials and components into a finished product that is delivered to the end customer. Recent years have seen a growing globalization of markets and the concentration of companies on their core competencies resulting increased coordination in supply chain (Xue et al., 2007). According to Arshinder et al. (2008), supply chain is generally complex and is considered by numerous events spread over several functions and organizations, which pose exciting challenges for effective supply chain coordination. To encounter these challenges, supply chain members must work towards a joined system and coordinate with each other.

2.2 Supply Chain Coordination

The concept of coordination means managing the activities of two or more components through sharing their ongoing condition until they are able to work together efficiently. In other words, supply chain components are each assigned and responsible for an individual activity, however, they work interdependently to achieve their shared goals that cannot be met individually. (Simatupang and Sridharan, 2002). SCC refers to any effort of information exchange and integration during the process of developing, producing, and delivering a product or service to the customer by different components in the supply chain (SC), which have diverse and conflicting goals and interests (Arshinder, 2008). Once all decisions are integrated to achieve the supply chain's shared goals, it can be considered fully coordinated. (Cao et al., 2008, and Deshmukh, 2008). According to Ballou et al. (2000), "coordination is a central lever of SCM". According to(Anand and Mendelson, 1997), information sharing and giving decision rights among supply chain members are the two factors which make coordination capability. (Cooper, 1997) stated that SCM desires to coordinate various levels of activities within and between organizations through the sharing of common goals. In another definition, Ballou et al. (2000) considered coordination as the ability of a logistics manager to harmonize interrelated activities across supply chain components that have different lines of organizational authority and responsibilities.

Singh et al. (2012) studied that most of SMEs cannot afford the high adoption costs of joining inter organizational information systems and information sharing. Therefore, it is essential to investigate the conditions under which supply chain coordination is beneficial for SMEs, so that it should not result in higher supply chain costs and imprecise information. Wagner et al. (2003) studied that companies exploiting the benefits of SCM have indicated improvements in individual supply chain functions ranging from 10 to 80 %. The integration of key business processes is achieved by connecting suppliers, through manufacturing and assembly companies, to distributors, retailers and end customers. This integration makes the process more efficient and the product and services more differentiated. Coordination means organizing the activities of two or more groups so that they work together efficiently and know what the others are doing. In other words, the groups are responsible for individual activity tasks but work interdependently for common goals (Cao et al., 2008).

To effectively compete in global market, a firm must have effective SCM. A SC involves disparate but inter-dependent stages who are dependent on each other to manage numerous resources (such as inventory, currency and information). The differing objectives and lack of integreration between these members may frequently result in uncertainties in supply and demand. Coordination may help in working inter dependencies and decreasing uncertainties. Usually, a mechanism is essential to streamline the whole SC and motivate all stages to be a part of the whole SC (Arshinder et al., 2009). A Supply Chain is known as a network of services and distribution options that executes the functions of procurement of materials, transformation of these materials into intermediate and end products, and the distribution of these end products to customers. Supply chain coordination plays a serious role in integrating different actors along the Supply chain to enhance performance (Soroor et al., 2009). Recent biggest challenge in the Supply chain is to manage distinct but dependent members of the Supply chain. Malone and Crowston (1994) defined coordination as the act of managing interdependencies between activities performed to achieve a goal. In the SC context coordination can be viewed as an act of properly combining (relating, harmonising, adjusting and aligning) a number of objects (actions, objectives, decisions, information, knowledge, funds) for the achievement of the chain goal.

Thakkar et al. (2009) in their study described some of key areas that influence management of the SCs in SMEs sector. Ahuja et al. (2009) in their study stated that information and communication technology helps in effective coordination and collaboration between multiple project members in construction SMEs. Pandey et al. (2010) studied the effect of different types of information sharing on the competitive strength of the Indian manufacturing enterprises. The authors found that information sharing has significant impact on the competitive strength of the manufacturer in order winning parameters like cost effectiveness and service level. SMEs are the critical links and their own business decisions affect the competitiveness of the whole SC. Charles (2006) focused on selection of right SC strategy and mapping of relations in context of SMEs. Muir and Meeham (2008) in their study on Merseyside SMEs stated that SCM improves customer responsiveness for SMEs. Coordinated SC increases the agility, i.e., flexibility in the SC and ensures delivery of product or services on time. In a coordinated SC, actual demand data is available and inventory at SC nodes is minimised (Mehrjerdi, 2009). Coordination reduces lead time and cost of product. As a result coordinated SC increases the service reliability (Stanley et al., 2008). For a lean SC, accurate forecasting of data is required. Accurate forecasting of data results in inventory reduction, agility in SC and finally a responsive SC (Stanley et al., 2009).

Arshinder and Deshmukh (2009) stated that to compete in global market, a firm must have effective SCM. A supply chain consists of disparate but inter-dependent stages who are dependent on one another to manage various resources (such as inventory, money and information). The conflicting objectives and lack of coordination between these members may often cause uncertainties in supply and demand. Coordination may help in managing inter dependencies and reducing uncertainties. Typically, a mechanism is required to streamline the whole supply chain and motivate all the members to be a part of the entire supply chain.

2.3 Importance Of Supply Chain Coordination

Supply chain components depend on each other to effectively transfer goods and information along the chain. The networked supply chain is a popular approach due to increasing global cooperation and vertical disintegration, and organizations try to focus on their core activities that create competitive advantage. This strategic perspective illustrates the challenge of effective coordination along the supply chain, from upstream to downstream activities (Chen and Paulraj, 2004).

Due to the problems of managing relationships between supply chain components, a need has arisen to solve such problems using coordination theory (Kanda and Deshmukh, 2008). Outcomes of the ineffective coordination include inaccurate forecasts, low capacity utilization, excessive inventory, deficient customer service, increased inventory turns and costs, longer times-to-market, order fulfillment response, and customer dissatisfaction (Ramdas and Spekman, 2000). In contrast, there are some benefits gained by effective SCC, including the elimination of excess inventory, reduction of lead-times, increased sales, improved customer service, more efficient product development activities, lower production costs, increased agility to tackle high demand uncertainty, increased customer retention, and increased revenue (Nam 2003; Lee et al., 2004).

The relationship among supply chain components can be managed by coordination mechanisms, such as developing supply chain contracts, information sharing, information technology, collaborative decision-making, meetings with supply chain components, and technical support (Cachon and Fisher 2000). Because integrating inter-organizational information systems and information sharing are costly, some supply chain components may be damaged (Zhao and Wang, 2002); thus it is essential to determine the conditions under which SCC is cost-effective for all supply chain components.

Coordination lessens lead time and unit cost of product. As a result coordinated SC increases the service reliability (Stanley et al., 2008). For a lean SC, accurate forecasting of data is required. Accurate forecasting of data results in inventory reduction, agility in SC and finally a responsive SC (Stanley et al., 2009). Based on

Table 2.1
Benefits of coordinated SC

Abbreviation	Benefits of coordinated SC	References
AOFD	Accurate forecasting of data	Campbell and Sankaran (2005), Charles (2006), Francesca et al. (2008), Mehrjerdi (2009), and Kaipia (2009)
ASC	Agility in supply chain	Campbell and Sankaran (2005) and Mehrjerdi (2009)
SR	Service reliability	Campbell and Sankaran (2005), Stanley et al. (2008), and Mehrjerdi (2009)
IR	Inventory reduction	Disny and Towill (2003), Kross et al. (2006), Mehrjerdi (2009), and Kaipia (2009)
DOT	Delivery on time	Kaipia (2009) and Mehrjerdi (2009)
CR	Cost reduction	Stanley et al. (2008) and Mehrjerdi (2009)
LTR	Lead time reduction	Leonard and Davis (2006) and Morrissey and Pittaway(2006)

literature review seven major benefits of coordinated SC over non-coordinated supply are identified. These are accurate forecasting of data, agility in SC, service reliability, and inventory reduction, delivery on time, cost reduction and lead time reduction (Table 2.1).

2.4 SMEs in India

Indian Small and Medium Enterprises (SME) sector has emerged as a highly vibrant and dynamic sector of the Indian economy over the last five decades. SMEs not only play crucial role in providing large employment opportunities at comparatively lower capital cost than large industries but also help in industrialization of rural areas. SMEs are complementary to large industries as ancillary units and this sector contributes enormously to the socioeconomic development of the country. The Sector consisting of 36 million units, as of today, provides employment to over 80 million persons. The Sector through more than 6,000 products contributes about 8% to GDP besides 45% to the total manufacturing output and 40% to the exports from the country. The SME sector has the potential to spread industrial growth across the country and can be a major partner in the process of inclusive growth.

SMEs also play a significant role in Nation development through high contribution to Domestic Production, Significant Export Earnings, Low Investment Requirements, Operational Flexibility, Location Wise Mobility, Low Intensive Imports, Capacities to Develop Appropriate Indigenous Technology, Import Substitution, Contribution towards Defence Production, Technology – Oriented Industries, Competitiveness in Domestic and Export Markets thereby generating new entrepreneurs by providing knowledge and training.

Despite their high enthusiasm and inherent capabilities to grow, SMEs in India are also facing a number of problems like suboptimal scale of operation, technological obsolescence, supply chain inefficiencies, increasing domestic & global competition, working capital shortages, not getting trade receivables from large and multinational companies on time, insufficient skilled manpower, change in manufacturing strategies and turbulent and uncertain market scenario. To survive with such issues and compete with large and global enterprises, SMEs need to adopt innovative approaches in their operations. SMEs that are innovative, inventive, international in their business outlook, have a strong technological base, competitive spirit and a willingness to restructure themselves can withstand the present challenges and come out successfully to contribute 22% to GDP. Indian SMEs are always ready to accept and acquire new technologies, new business ideas and automation in industrial and allied sectors.

2.5 Supply Chain Coordination in SMEs

The significance of SMEs in the national economy cannot be overlooked due to the contribution they make to national and economic growth, as well as providing significant employment opportunities (Koh et al., 2007; Sharma, 2009; Eyaa et al., 2010). As mentioned, the global economic environment creates uncertainty in the business atmosphere, which produces the necessity for companies to consider rebuilding and restructuring to develop their techniques to maintain the business and returns, and to remain competitive in the market (Zailani et al., 2012). Nowadays, with the rapid global economy, SMEs have become a key source of energy, innovation, and flexibility in growing and developing nations, as well as to the economies of the more industrialized countries. According to Chin et al. (2012), since the SMEs are becoming the main expansion force in many countries, more focus can be detected to enhance Malaysian SMEs by implementing SCI techniques. The needs, logistics fulfilment, operating necessities, and financial potentials of SME manufacturers are vastly different from first-tier manufacturers. In addition, the implementation of IT in SMEs in South-East Asia is relatively limited. Management of SMEs needs precision, speed, and effective decision making to deal with complex dynamic processes as well as merciless uncertainty from external order and factors (Huin et al., 2002).

SCs involve the firms as well as the business activities required to design, create, distribute, and use a service or product. Businesses rely on their SCs to offer them what they really need to survive and prosper. Most firms work with a number of SCs and play a role in using each of them. The pace of transformation and the uncertainty concerning how marketplaces will progress makes it essential for businesses to pay attention to the SCs in which they take part and to understand the functions that they practice. However, SCM means much more than just new business principles. Instead, it demonstrates a strategic change in an enterprise’s essential governing ideology and culture, and increases this to outside members to achieve the planning goals of optimization and proficiency. Hence, the value of an effective SCM can easily be found in an organization’s capability to maintain a good competitive advantage (Meehan and Muir, 2008).

Since a SC is a closed-loop business, accordingly, SCM is known as the task of integrating organizational units along a SC and coordinating the movement of products, services, and information, whilst reducing overall SC costs in order to maintain the desired level of quality and customer service (Stadtler and Kilger, 2005). Ultimately, this produces benefits for the ultimate customers as well as the stakeholders. Therefore, most companies experienced in the practice of SCM believe it to be a key reason behind a firm's competitiveness and overall success (Li et al., 2006; Spens and Wisner, 2009). Eyaa et al. (2010) have pointed out various challenges that face SMEs in Uganda. These include structural and operational challenges, and technology systems, which affect their business performance and sustainability in the market. SMEs also suffer from the delivery of poor-quality products and delays in delivery, which demonstrate the fragile performance of SME SCs. Moreover, in a report describing the poor competitive advantage of SMEs in Thailand by Virasa and Hunt (2008), they revealed that many stakeholders and managers have insufficient knowledge concerning business practices or the ability to evaluate the performance of their SCs. Most of the previous studies clarified that the SC network consists of the supplier, manufacturer, distributor, and customer, and coordination and integration of these members are critical for an effective SCM. In fact, SCM is acknowledged to experience high levels of difficulty, owing to the complexity of the many relationships and interactions among the investing members. These relationships are not only complex by their size and variation in operations, but, in addition, via the complexity inherent in the dependencies that occur within parties in time and space (Meehan and Muir, 2008; Kamaruddin and Udin, 2009). Moreover, despite the fact that performance measurement is an essential function of management aimed at providing and controlling organizational direction (Bhagwat and Sharma, 2007), many companies have identified a lack of relevant performance measures as a major problem for operations management (Gunasekaran et al., 2004; Shepherd and Gunter, 2006). Therefore, it is significant to expand the understanding of these issues that explain the SCM of small and medium enterprises, and provide clear insights to decision makers for improving firm performance.

2.6 Supply Chain Issues in SMEs

According to Bhagwat and Sharma (2007), many companies have discovered the potential of supply chain management (SCM) in daily business control, where the SC is a net involving supplier, manufacturer, logistics, and customer. Although there are many definitions in the literature, SCM is essentially concerned with controlling operational processes and managing partnerships with customers and suppliers to distribute the best customer value at lowest costs and achieve targeted goals. Currently, many firms have realised the potential of SCM in daily operational management (Bhagwat and Sharma, 2007). A continual controlling of both flows through the SC group is extremely important for appropriate and efficient performance of the business. Thus, an integrated SC has an evident benefit for the competitiveness of single firms (Koh et al., 2007).

Competitive climates require that SC managers take action rapidly on competitive issues, stock shortages, buyer complaints, imprecise demand processing, and unreliable delivery activities (Smith et al., 2004). Producers face increasing pressure from customers' requests in item customization, quality improvement, and order responsiveness. On the other hand, they have to lower manufacturing cost, shorten cycle times, and reduce inventory ranges (Yadav and Sharma, 2015; Kamaruddin and Udin, 2009) to ascertain profitability. In an effort to meet these challenges, increasingly companies are aiming to build long-term strategic relationships with some qualified SC members and work together in product development, stock management, delivery, and non-core procedure participation (Chan and Qi, 2003). Performance assessment can provide critical observational data to permit SC leaders to monitor practices, disclose growth, improve communication, and detect problems. Additionally, it can provide ideas regarding the usefulness of the systems available and procedures utilized, and aid recognition of success and potential chances. It can make a requisite contribution to making decisions in SCM (Sharma and Bhagwat, 2007; Chan et al., 2006). Bhagwat and Sharma (2007) asserted that existing studies entrench the link between SC implementation and its effect on how a business performs. The desire for overall SC efficiency has additionally forced companies to review, assess, and consider the adoption of convenient performance measures for SCM.

As a crucial management strategy, performance evaluation can offer permanent support for performance enhancement in the quest for SC quality. On the other hand, a number of serious barriers divert the available performance evaluation techniques from making an important contribution to the growth and enhancement of SCs. The key obstacles to the offered techniques comprise: inability to capture holistic features, absence of suitability to the various stages of measurement, complexity in strategies, the need for complex information, insufficient to catch the mystery in person's judgement, etc. It is crucial to create an appropriate construction that can consider the parallels of practical SCs, especially when evaluating performance (Chithambaranathan et al., 2015). Gunasekaran et al. (2004) stated that, even so, companies often lack the foresight to build up efficient performance metrics and measurements required to possess a completely integrated SCM, owing to the insufficiently balanced method and clear differences between the measures at operational, tactical, and strategic stages. Sharma and Sharma (2010) argued that further challenges occur in SMEs owing to different factors such as decision-making scarcities, inadequate information resources, competition, change of economic circumstances, marketing, irregular delivery of the initial material, and the use of outdated technology; the majority of these can clearly hinder the excellent performance of the companies. Therefore, the collaboration of internal processes of organization with customers and suppliers is the aim behind supply chain integration (SCI) and management (Koh et al., 2007).

Despite the fact that the needs and functioning environment of SMEs are quite different from those of big companies (Sharma and Bhagwat, 2006), there is a scarcity of literature concerning the effective use of SCM practices on SMEs' performance in growing market economies (Koh et al., 2007) such as Malaysia (Ab Rahman et al., 2011; Chin et al., 2012; Awheda et al., 2014). However, most of the performance measurement studies essentially cover the idea of modality of performance metrics in the company (Mathur et al., 2011) and require to be indexed by precise measurements in each of their fields to become workable. The majority of the performance measurement studies have their relative advantages and restrictions, with the most prevalent restriction being that little assistance is provided for the real choice and practices of the metrics selected (Medori and Steeple, 2000; Mathur et al., 2011).

Selecting suitable measures is a main mission in the development of an efficient performance system, so that it is able to give a clear picture of the performance with a small group of measurements in an effort to facilitate evaluation. Therefore, the authors designed a questionnaire based on the factors in previous research to underline and investigate the relationship between those factors and supply chain members (SCMs), and to provide a broad discussion concerning how these factors affect the performance of the chain members. The outcomes of this research will give some direction and knowledge to SMEs that are organizing or have recently started applying SCM practices, as well as new insight into improving operations procedures for better performance success.

2.7 Effect of Lack of Coordination in SMEs

A supply chain lacks coordination if each stage optimizes only its local objective, without considering the impact on the complete chain. Total supply chain profits are thus less than what could be achieved through coordination. Each stage of the supply chain, in trying to optimize its local objective, takes actions that end up hurting the performance of the entire supply chain. Lack of coordination also results if information distortion occurs within the supply chain. As a result of the lack of coordination, orders receives from the distributors are much more variable than demand. We discuss the impact of this increase in variability on various measures of performance in the supply chain.

2.7.1 Manufacturing Cost

The effect of lack of coordination increases manufacturing cost in the supply chain. As a result of lack of coordination, manufacturer must satisfy a stream of orders that is much more variable than customer demand. Manufacturer can respond to the increased variability by either building excess capacity or holding excess inventory, both of which increase the manufacturing cost per unit produced.

2.7.2 Inventory Cost

The lack of coordination increases inventory cost in the supply chain. To handle the increased variability in demand, firm has to carry a higher level of inventory than would be required in the absence of the bullwhip effect. As a result, inventory costs in the supply chain increase. The high levels of inventory also increase the warehousing space required and thus the warehousing cost incurred.

2.7.3 Replenishment Lead Time

The lack of coordination increases replenishment lead times in the supply chain. The increased variability makes scheduling at plants much more difficult compared to a situation with level demand. There are times when the available capacity and inventory cannot supply the orders coming in. This results in higher replenishment lead times in the supply chain.

2.7.4 Transportation Cost

The lack of coordination increases transportation cost in the supply chain. The transportation requirements over time at firm and its suppliers are correlated with the orders being filled. As a result of the bullwhip effect, transportation requirements fluctuate significantly over time. This raises transportation cost because surplus transportation capacity needs to be maintained to cover high-demand periods.

2.7.5 Labor Cost For Shipping and Receiving

The lack of coordination increases labor costs associated with shipping and receiving in the supply chain. Labor requirements for shipping at firm and its suppliers fluctuate with orders. A similar fluctuation occurs for the labor requirements for receiving at distributors and retailers. The various stages have the option of carrying excess labor capacity or varying labor capacity in response to the fluctuation in orders. Either option increases total labor cost.

2.7.6 Level of Product Availability

The lack of coordination hurts the level of product availability and results in more stock outs in the supply chain. The large fluctuations in orders make it harder for firm to supply all distributor and retailer orders on time. This increases the likelihood that retailers will run out of stock, resulting in lost sales for the supply chain.

2.7.7 Relationships across the Supply Chain

The lack of coordination has a negative effect on performance at every stage and thus hurts the relationships between different stages of the supply chain. There is a tendency to assign blame to other stages of the supply chain because each stage feels it is doing the best it can. The lack of coordination thus leads to a loss of trust between different stages of the supply chain and makes any potential coordination efforts more difficult.

2.8 Factors of Supply Chain Coordination

For an efficient supply chain, it is expected that the supply chain members behave coherently to achieve common goal. The centralized control of supply chain assures supply chain coordination but it may not be realistic. In a decentralized control, the supply chain members optimize local decisions without considering the impact of their decision on the other member’s performance and on the overall performance of supply chain. Thus, a coordination mechanism may be necessary to motivate the members to achieve coordination. Supply chain members are dependent on each other and these members need to be coordinated by efficiently managing dependencies between each other (Arshinder and Desmukh, 2009).

As mentioned earlier, the authors define coordination as an approach to manage dependencies among activities, so coordination theory was proposed to analyze and redesign the organization. Previous literature addressed several models and factors for SCC, so the purpose of this study is to identify and prioritize critical factors affecting coordinated SC. To facilitate the process of decision-making, the 23 factors influencing the coordinated supply chain were classified into five strategic groups: management commitment (MC), mutual understanding (MU), relationship and decision-making (RDM), and organizational structure (OS). A brief explanation of each factors is provided in the next section.

2.8.1 Management Commitment

Management commitment is critical to develop goals and vision, integrate the units within the organization, perform cross-functional training, and vendor development, for a profitable supply chain (Kannabiran and Bhaumik, 2005). More specifically, in small- and medium-sized enterprises, top management commitment plays a very important role in activities such as resource allocation, supplier and IT utilization, and long-term investment in SCM implementation (Sing et al., 2012).

2.8.2 Mutual Understanding

Mutual understanding among components of the supply chain is critical for its global view. This factor also contributes to the development of trust in each other as well as an agreed joint vision and goals for all supply chain components. Trust is a desirable attitude and is attained when one supply chain component relies on other components (Anderson and Narus, 1990). Furthermore, trust is essential for information flow within the SC, and risk and reward sharing can affect individual supply chain components' behaviors and their interactions with other supply chain participants. Conflicts of interest are more likely to happen when existing risk and reward sharing increase the individual benefit, regardless of the benefit of all the supply chain components (Cachon and Lariviere, 2005).

2.8.3 Relationship and Decision-Making

Establishment of a strong relationship among supply chain components and collaborative decision-making group are essential for a coordinated supply chain. Collaborative decision making by supply chain components can improve forecasting demand, develop trust among supply chain members, and enhance the flow of information (Mehrjerdi, 2009).

2.8.4 Information Technology

Information sharing is an important element for a coordinated supply chain. It enables the integration of organizations to enable dependable delivery and rapid product release times. Information sharing influences supply chain performance in terms of both total cost and service level. Furthermore, to achieve an effective and responsive supply chain, information sharing among all supply chain components is essential (Zhao and Wang, 2002; Fawcett et al., 2009).

SCC relies highly on the availability of rapid and accurate information that is visible and perceptible to all components. The bullwhip effect is one of the common consequences of traditional communication between vendors and purchasers, which would fundamentally be reduced by the information available between actors in the supply chain. Considering information sharing, point-to-point sales data are provided to all components of the supply chain, which helps manage inventory among supply chain sectors (Michelino et al., 2008; Pawlak and Malyszek, 2008).

2.8.5 Organizational Structure

A coordinated supply chain is directly associated with the organizational structure of its components. Whereas a coordinated supply chain is basically determined by the context of division of labor, basic departmentalization, and a task-process activity matrix, it is mainly based upon the extent of task structuring, flexibility, and adaptability (Larsen, 2000). The lack of organizational flexibility and rigidity of some structures makes it challenging for companies in the supply chain to act in a coordinated and networked manner. A well-designed organizational structure can establish an integrated department within a company that can elucidate the cross functional training of employees, supportive culture for JIT and lean supply chain practices (Grittell, 2004; Arshinder and Desmukh, 2006).

Table 2.2
Main factors and their sub factors for coordinated supply chain

S.no	Mainfactors/sub factors	Reference	Abbreviation
1	Management commitment		MC
	a. Strategy development for supply chain	Shin et al. (2000), Ganesan and Saumen (2005),	SD
	b. Long term investment motive	Morgan and Hunt (1994), Ganesan (1994), Shin et al. (2000), Olorunniwo and Hartfield (2001)	LTIM
	c. Management skills	Lee et al. (1997), Sanders (2008), Stanley et al. (2009)	MS
	d. Optimize resource allocation	Shin et al. (2000), Ford (2002), Singh et al. (2012	ORA
	e. Leadership in management	Chakraborty and Philip (2008), Chen and Kang (2010)	LM
2	Organizational structure		OS
	a. Lean structure	Grittell and Weiss (2004), Melton (2005)	LS
	b. Cross functional training of employees	Ganesan and Saumen (2005), Singh et al. (2010a, b)	CFTE
	c. Benchmarking in supply chain	Monden (1998), Kakuro (2002), Grittell and Weiss (2004), Arshinder and Desmukh (2006)	BM
	d. Establishing superior-subordinate relationship	Grittell and Weiss (2004)	ER
	e. Financial Capabilities	Larsen (2000), Soo (2006)	FC
3	Information technology		IT
	a. Transition data of sales, inventory, quality & demand	Ramdas and Spekman (2000), Reddy and Rajendran (2005), Francesca et al. (2008), Marek and Malyszek (2008), Selc¸uk (2008)	TD

	b. Information sharing	Ozer (2003), Moinzadeh (2002), Wu and Cheng (2008), Marek and Malyszek (2008)	IS
	c. Integrating new information systems	Lee et al. (1997), Sanders (2008), Stanley et al. (2009)	INIS
	d. Dashboard systems	Narus and Anderson (1996), Lambert et al. (1999), Francesca et al. (2008)	DS
4	Mutual understanding		MU
	a. Trust in SC members	Anderson and Narus (1990), Sahay (2003), Burt et al. (2004), Kwon and Suh (2005	TS
	b. Risk and reward sharing by SC members	Ramsay (1996), Lee (2000), Lambert et al. (1999), Cachon and Lariviere (2005)	R&RS
	c. Agreed vision and goals of SC members	Simatupang et al. (2002), Arshinder and Desmukh (2006), Singh et al. (2012)	AV&G
	d. Supervision mechanism in SC operation	Aviv (2001), Hill and Omar (2006), Chen and Chen (2005)	SM
	e. Negotiation mechanisms	Aviv (2001), Hill and Omar (2006), Chen and Chen (2005)	NM
5	Relationship and decision making		R&DM
	a. Logistic synchronization	Bowersox (1990), Simatupang et al. (2002), Kang and Kim (2010)	LS
	b. Collaborative decision making and planning	Tsay (1999), Cachon and Fisher (2000), Disny and Towill (2003), Mehrjerdi (2009a)	CD&P
	c. Long-term relation between suppliers and customers	Ganesan (1994), Olorunniwo and Hartfield (2001), Lyu et al. (2010)	LTR
	d. Partnership selection and evolution	Lee (2000), Ballou et al. (2000), Arshinder and Desmukh (2006)	PS&E

CHAPTER – 3

METHODOLOGY

The objective of this study is to develop to identify and prioritize the factors for the better supply chain coordination in small manufacturing firm. Due to the liberalization and globalization the small scale firm are facing very difficult scenario as compared to the protective environment which was before. So to face this tough competition SME’s must have coordinated and flexible supply chain.

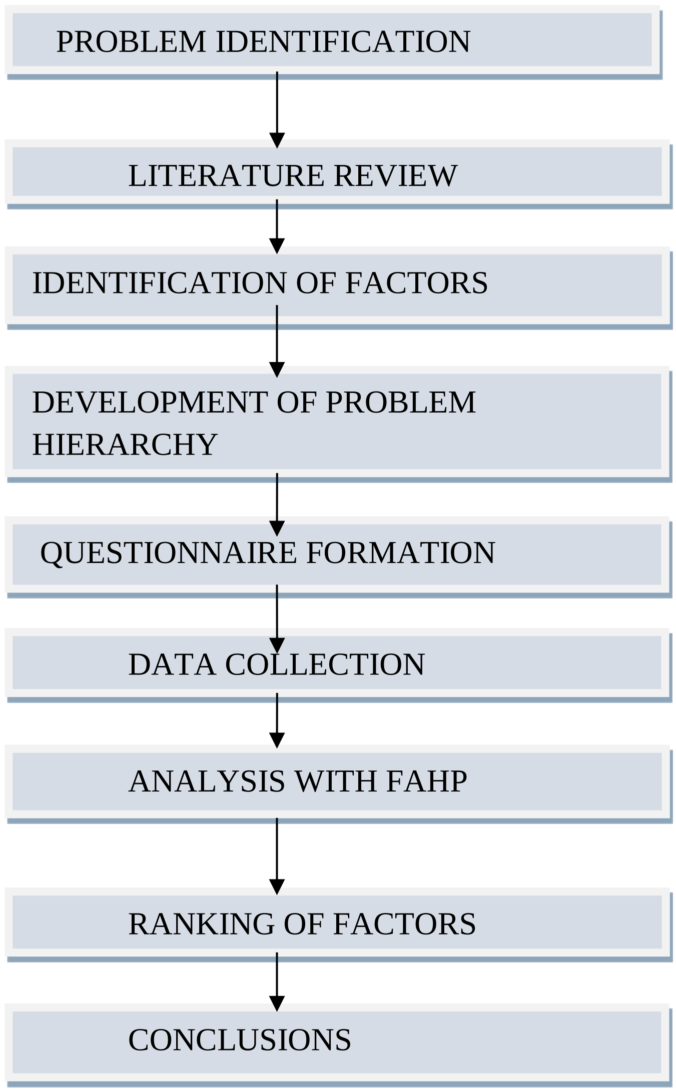

Figure 3.1: Research Methodology

For the coordination of supply chain by the literature review some factors and sub factors are identified. Five main factors and 23 sub factors are identified on the basis of literature review. The factors are categorized in five categories.

Strategic development, management skills, long term investment motive, leadership in management and optimize resource allocation are related to top management and for these factors management is responsible so these are taken into management commitment.

Lean structure, cross functional training of employees, establishing superior and sub-ordinate relationship, benchmarking in supply chain and financial capability are focus on the organization. These factors show the situation and environment of the organization so these are taken into organizational structure.

Transition data of sales, inventory, quality and demand, information sharing, integrating new information system and dashboard system are giving the focus on information about the product and service so these are taken into information technology.

Trust in SC member, risk and reward sharing, agreed vision and goals of SC members, supervision mechanism and negotiation mechanism are related to understanding between the supply chain members and trust so these are taken into mutual understanding.

Collaborative decision making and planning, logistic synchronization, long-term relation between suppliers and customers and partnership selection and evolution are the factors which are related to the relationship of the supply chain members. These factors are taken into relationship and decision making.

3.1 Identification of Factors

On the basis of the literature review five factors and 23 sub-factors are chosen for the coordination of supply chain in this study. These factors are organizational structure, management commitment, mutual understanding, information technology and relationship and decision making. The brief description of these factors is as follow:

3.1.1 Management Commitment

Management commitment is critical to develop goals and vision, integrate the units within the organization, perform cross-functional training, and vendor development, for a profitable supply chain (Kannabiran and Bhaumik, 2005). In small and medium sized enterprises a very critical role is played in supplier and IT utilization resources allocation and long term investment in supply chain implementation.

A. Strategic development

Strategic development involves the formulation and implementation of the major goals and initiatives taken by firm`s top management on behalf of owners based on consideration of resources and an assessment of the internal and external environment in which the organization competes. Strategic management provide overall direction to the enterprise and involve specifying the organization`s objectives, developing policies and plans designed to achieve these objectives and then allocates the resources to implement the plans.

B. *Management skills*

Managers are responsible for making sure that things are done properly and leader may bring us vision inspiration and challenges. These things count for nothing without the efficient implementation brought about by good management. The manager having good management skills may implement supply chain coordination very effectively.

C. *Long term investment motive*

Long term investment motive of the firm result the better relationship in the supply chain. The firm having long term investment motive can create good relationship with their supplier and buyer.

D. *Leadership in Management*

Leadership is an important function in small medium enterprises. Leadership is establishing a clear vision, communicating the vision with others and resolving the conflicts between various individuals which are responsible for completing the supply chain vision.

E. Optimize Resource Allocation

The top management is responsible for optimization of resources according to the demand. Due to the fluctuation in the demand the resources are allocated according to the demand. Optimize resource allocation can help in coordination of supply chain by fulfilling the resources at the right place at right time.

3.1.2 Organizational Structure

A coordinated supply chain is directly associated with the organizational structure of its components. Whereas a coordinated supply chain is basically determined by the context of division of labor, basic departmentalization, and a task-process activity matrix, it is mainly based upon the extent of task structuring, flexibility, and adaptability (Larsen, 2000). A well-designed organizational structure can establish an integrated department within a company that can elucidate the cross functional training of employees, supportive culture for JIT and lean supply chain practices (Grittell, 2004; Arshinder and Desmukh, 2006).

A. *Lean structure*

Lean means creating more values for customers with fewer resources. A Lean organization understands customer value and focuses its key process to continually increase it. The Lean structure also focuses on the inventory of the firm. The Lean structure contributes in supply chain coordination by eliminating rationing and shortage gaming.

B. Cross functional training of employees

For the better coordination of the supply chain every stage has to appoint a manager for managing the supply chain coordination. These managers are trained for the entire supply chain profit rather than local profit.

C. Establishing superior and sub-ordinate relationship

Superior and sub-ordinate communication refers to the interaction between organizational leaders and their sub-ordinate and how they work together to achieve organizational and supply chain goals. The relationship is essential for a supply chain because it close the gap between members by increasing trust, support and the frequency of their interaction.

D. Benchmarking in supply chain

Benchmarking is an assessment process which measures the performance of supply chain by taking into consideration of quality, quantity and value. Benchmarking gives a tangible measure of efficiency of different process in the supply chain.

E. Financial capability

Financial capability of the firm also affects the coordination of supply chain. For the coordination of supply chain the member which is financially strong have to be interested to achieve better supply chain coordination.

3.1.3 Information Technology

Information sharing is an important element for a coordinated supply chain. It enables the integration of organizations to enable dependable delivery and rapid product release times. Information sharing influences supply chain performance in terms of both total cost and service level. Furthermore, to achieve an effective and responsive supply chain, information sharing among all supply chain components is essential (Zhao and Wang, 2002; Fawcett et al., 2009).

A. Transition data of sales, inventory, quality and demand

For the better coordination of the supply chain the information of the data of the sales, inventory, quality and demand must be share by the supply chain members to avoid the bullwhip effect. The exact data of demand must be share throughout the supply chain to overcome the bullwhip effect.

B. Information sharing

Information sharing serves as an essential approach for the survival of enterprises and enabler of supply chain integration. The lack of information sharing within the firm result in inefficiency of coordinating action within the unit in the organization.

C. *Integrating new information system*

The advancement in information and communicating technology, information sharing has become more conceivable. The broad use of advanced information technologies in supply chain such as electronic data interchange and web technologies demonstrate that organization has come to substantiate the importance of integrating information.

D. Dashboard system

Dashboard system is an easy to read often single page, real time user interface, showing a graphical presentation of the current status and historical trend of an organization`s or computer appliances key performance indicators to enable instantaneous and informed decision to be made at a glance. Human resources dashboard may show numbers related to staff recruitment, retention and composition.

3.1.4 Mutual Understanding

Mutual understanding among components of the supply chain is critical for its global view. This factor also contributes to the development of trust in each other as well as an agreed joint vision and goals for all supply chain components. Trust is a desirable attitude and is attained when one supply chain component relies on other components (Anderson and Narus, 1990).

A. ***Trust in SC member***

Good relationships may be a consequence of trust and commitment among members that improves over time. The willingness to share information, provide and transfer accurate and timely information, awareness and understanding of the information and information systems, and dedication to work jointly by developing more trust among enterprises will result in continuous communication.

B. ***Risk and reward sharing***

For the coordination of supply chain the risk and reward sharing must be distributed so that the moral of the member enhance. By sharing rewards to the supply chain the member of supply chain get self-motivation and they work for the better coordination of supply chain. The greatest hurdle to coordination is the feeling on the part of any stage that the benefits of the coordination are not being shared equitably. So the managers from the strong party must be sensitive to this fact and ensure that all parties perceive that the way benefits are shared is fair.

C. ***Agreed vision and goals of SC members***

For the better coordination of supply chain the member have their agreed vision for the entire supply chain. The supply chain member should work for the maximization of global objective of entire supply chain. Managers can help to achieve coordination in the supply chain by aligning goals and incentives across different functions and stages of the supply chain.

D. ***Supervision mechanism***

In the supply chain coordination every member has to work for the better global maximization of the profit so to ensure that every member is working good the supervision has to be done. All members are responsible for the entire chain and has to work to gain global objective of the supply chain.

E. ***Negotiation mechanism***

When any member of supply chain is not agree to apply supply chain coordination then rest member should eliminate that member from the supply chain and negotiate for the better option for the coordinated supply chain.

3.1.5 Relationship and Decision Making

Establishment of a strong relationship among supply chain components and collaborative decision-making group are essential for a coordinated supply chain.

Collaborative decision making by supply chain components can improve forecasting demand, develop trust among supply chain members, and enhance the flow of information (Mehrjerdi, 2009).

A. Logistic synchronization

Logistics synchronization also assists participating members to resolve role conflict, so each member can perform specific tasks and assume certain responsibility to ensure the attainment of chain profitability. The real challenges include focusing on core activities that provide real value to the customer, and subordinating other supporting activities to ensure the value creation process. Analyzing the value creation process across the supply chain can provide a road-map for strategic initiatives that clarify specific roles for each participating member.

B. Collaborative decision making and planning

The partners determine the scope of the collaboration and assign roles, responsibilities and clear check points. A collaborative sales forecast projects the partners best estimate of customer demand at the point of sale. This is then converted to a collaborative order plan that determine future orders and delivery requirements based on sales forecast, inventory position and replenishment lead time.

C. Long-term relation between suppliers and customers

The long term relationship between supplier and customer can be created by satisfying the customer with product and service and by the fulfillment of the demand at the right time. The supply chain can achieve better coordination by maintaining long term relationship between supplier and customer.

D. Partnership selection and evolution

In the coordination of entire supply chain every member of supply chain is responsible for the coordination. So the members of supply chain should be selected properly so that the coordination can be achieved. If the member of supply chain having conflict goal is not working for the coordination then the entire supply chain will be harmed.

3.2 Formation of Problem Hierarchy

To prioritize the factors Fuzzy Analytical Hierarchy process is used for that the problem hierarchy is developed. Based on the factors of the supply chain discussed above the problem hierarchy is structured, as shown in Figure 3.2

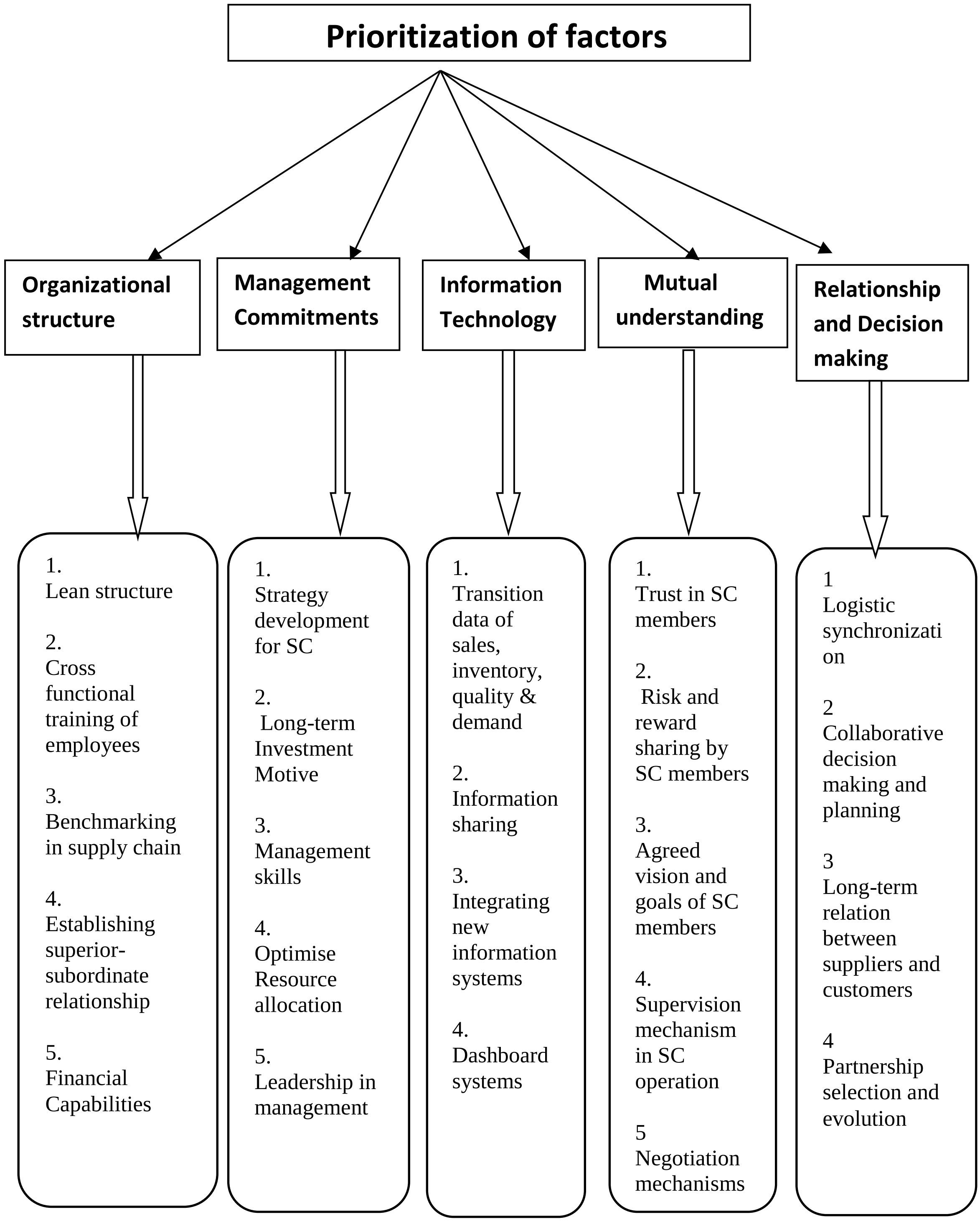

Fig3.2: problem hierarchy for supply chain coordination

After the identification of factors and sub-factors the prioritization is done using fuzzy extent analysis. For that pair wise comparison is done. Pair wise comparison matrix is formed for the factors and sub-factors. There are six pair wise comparison matrix for the factors and sub-factors.

For the pair wise comparison four manufacturing firms are chosen. The data for the analysis is taken by visiting interviewing managers of these firms. The matrixes are filled with linguistic variable that are converted into fuzzy triangular number as given in fuzzy extent analysis for the prioritization. The analysis is done by fuzzy extent analysis which is as follows:

3.3 Fuzzy Set Theory

Fuzzy set theory has proven advantages within vague, imprecise and uncertain contexts and it resembles human reasoning in its use of approximate information and uncertainty to generate decisions. This theory firstly introduced by Zadeh (1965). It was specially designed to mathematically represent uncertainty and vagueness and provide formalized tools for dealing with the imprecision intrinsic to many decision problems. Fuzzy set theory implements classes and grouping of data with boundaries that are not sharply defined (i.e. fuzzy). Fuzzy set theory includes the fuzzy logic, fuzzy arithmetic, fuzzy mathematical programming, fuzzy graph theory and fuzzy data analysis, usually the term fuzzy logic is used to describe all of these. The major contribution of fuzzy set theory is its capability of representing vague data.

A fuzzy set is characterized by a membership function, which assigns to each object a grade of membership ranging between 0 and 1. In this set the general terms such as ‘large’, ‘medium’ and ‘small’ each will be used to capture a range of numerical values. A fuzzy set is represented by putting a tilde ‘~’ on a letter. If l, m and u, respectively, denote the smallest possible value, the most promising value and the largest possible value that describe a fuzzy event then the triangular fuzzy number (TFN) can be denoted as a triplet (l, m, u). A fuzzy number $\tilde{N}$ expresses the meaning of ‘about N’. A TFN $\tilde{N}$ is shown in figure 3.3.

Some basic definitions of the fuzzy sets and fuzzy numbers

Definition 1: The membership function of a TFN which associated with a real number in the interval [0, 1] can be defined as:

$$\mu(x/\tilde{N}) = \begin{cases} (x-l)/(m-l), x\epsilon[l,m] \\ (u-x)/(u-m), x\epsilon[m,u] \\ 0, \ otherwise \end{cases}$$

A fuzzy number can be given by its corresponding left and right representation of each degree of membership:

$\tilde{N} = (N^{l(y)}\ , N^{r(y)})$

$= (l + (m\text{-}l)y\ , u+(u\text{-}m)y), \qquad y \in [0,1]$

Where, l(y) and r(y) denote the left and right side representation of a fuzzy number respectively. A non-fuzzy number ‘r’ can be expressed as (r, r, r).

Definition 2: A fuzzy set Ñ in the universe of discourse Y is defined as convex if and only if:

$\mu_x(y N_1 + (1+y) N_2) \geq \min (\mu_x (N_1) , \mu_x (N_2))$

For all N_1, N_2 in Y and all y $\in$ [0, 1], where min denotes the minimum operator.

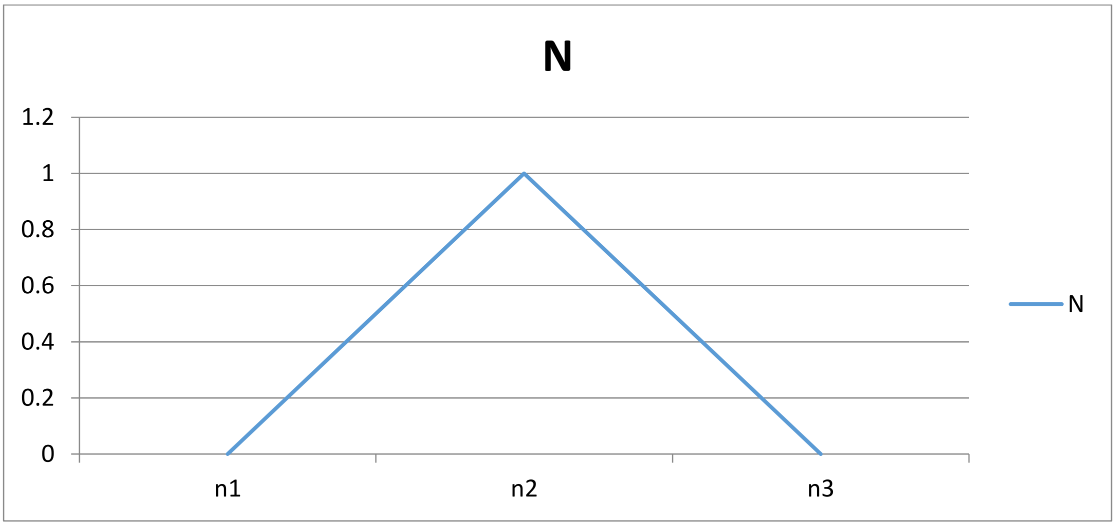

Figure 3.3 – A Triangular Fuzzy Number Ñ

Definition 3: The height of a fuzzy set is the largest membership grade attained by any element in that set. A fuzzy set Ñ in the universe of discourse Y is called normalized when the height of Ñ is equal to 1.

Definition 4: A matrix Ũ is called a fuzzy matrix if at least one element of it is a fuzzy number. The fuzzy sum + and fuzzy subtraction - of any two triangular fuzzy numbers are also a triangular fuzzy number, but the multiplication X of any two triangular fuzzy numbers is only an approximate triangular fuzzy number. If $\tilde{N}_1 = (l_1, m_1, u_1)$ and $\tilde{N}_2 = (l_2, m_2, u_2)$ are two triangular fuzzy numbers then the operational laws of them can be expressed as follows:

$\tilde{N}_1 + \tilde{N}_2 = (l_1 + l_2 , m_1 + m_2 , u_1 + u_2)$

$\tilde{N}_1 - \tilde{N}_2 = (l_1 - l_2 , m_1 - m_2 , u_1 - u_2)$

$\tilde{N}_1 \text{ x } \tilde{N}_2 = (l_1 l_2 , m_1 m_2 , u_1 u_2)$

$\lambda \text{ x } \tilde{N}_1 = (\lambda l_1 , \lambda m_1 , \lambda u_1)$, where $\lambda > 0$, $\lambda \in R$

$\tilde{N}_1^{-1} = (1/u, 1/m_1, 1/l_1)$

3.4 Extent Analysis Method for FAHP

In this work, a fuzzy-AHP approach is proposed to address the prioritization problem in manufacturing firm. Basically, fuzzy-AHP is an integrated approach, which consist fuzzy sets theory and analytical hierarchy process. Fuzzy sets theory resembles the human reasoning and mathematically represents the uncertainty and vagueness. In this study Chang’s extent analysis method is used to select the best supplier among the number of alternative supplier available. Chang (1996) uses triangular fuzzy numbers (TFN) for the pair-wise comparison in AHP. Chang’s approach is less time taking and less computational expense than many other FAHP approaches.

Let $X = \{ x_1, x_2, x_3, \ldots\ldots, x_n \}$ be an object set, and $U = \{ u_1, u_2, u_3, \ldots.., u_m \}$ be a goal set. According to the method of Chang’s extent analysis, each object is taken and extent analysis for each goal, g_i, is performed respectively. Therefore, m extent analysis values for each object can be obtained, with the following signs:

$$M_{gi}^1, M_{gi}^2, M_{gi}^3, \ldots\ldots, M_{gi}^m ; \qquad i = 1,2,3,\ldots,n$$

$$\text{Where all } M_{gi}^j \text{ are TFN}; \qquad j = 1,2,3,\ldots,m$$

The steps of Chang's (1996) extent analysis can be given as in the following:

Step 1: The fuzzy synthetic extent with respect to i^th^ object is defined as:

$$S_i = \sum_{j=1}^{m} M_{gi}^j \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j\right]^{-1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

To obtain $\sum_{j=1}^{m} M_{gi}^j$ the fuzzy addition operation of m extent analysis values for a particular matrix is performed such that

$$\sum_{j=1}^{m} M_{gi}^j = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

and to obtain $\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j\right]^{-1}$ the fuzzy addition operator of M_{gi}^jvalues is performed such that

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i\right) \ldots\ldots\ldots\ldots\ldots\ldots \text{(3)}$$

and then inverse of the vector of computed, such that

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right) \ldots\ldots\ldots\ldots\ldots \text{(4)}$$

Step 2: The degree of possibility of $M_2 = (l_2,m_2,u_2) \geq M_1 = (l_1,m_1,u_1)$ can be defined as

$$V(M_2 \geq M_1) = \sup_{y \geq x}\left[\min(\mu_{M1}(x), \mu_{M2}(y))\right] \ldots\ldots\ldots\ldots\ldots \text{(5)}$$

Equation 5 can be expressed as follows:

$$V(M_2 \geq M_1) = hgt(M_1 \cap M_2) = \mu_{M2}(d)$$

$$= \begin{bmatrix} 1, & if\ m_2 \geq m_1 \\ 0, & if\ l_1 \geq u_2 \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & otherwise \end{bmatrix} \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

where d is the ordinate of the highest intersection point D between μ_{M1} and μ_{M2}. In Fig. 1, the intersection between M_1 and M_2 can be seen. To compare M_1 and M_2, both the values of $V(M_1 \geq M_2)$ and $V(M_1 \leq M_2)$ are needed.

Step 3: The degree of possibility for a convex fuzzy number to be greater than k convex fuzzy numbers M_i (i=1, 2,..., k) can be defined by

$V(M \geq M_1, M_2, \ldots, M_k) = V[(M \geq M_1)$ and $(M \geq M_2)$ and …… and $(M \geq M_k)] = \min V(M \geq M_i)$……. (7)

Assume that

$d'(A_i) = \min V(S_i \geq S_k)$………. (8)

For k = 1,2,…..,n; k ≠ i, weight vector is given by equation (9)

$W' = (d'(A_1), d'(A_2), \ldots, d'(A_n))^T$………(9)

Where A_i (i = 1,2, …,n) are n elements.

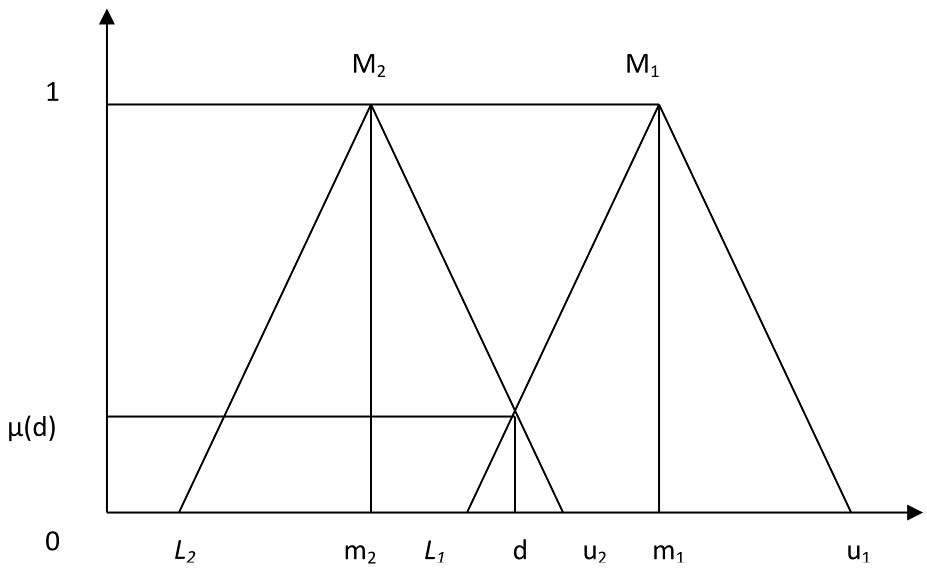

Figure 3.4 – Intersection between M_1 and M_2

Step 4: After normalization, the normalized weight vectors are:

$W = (d(A_1), d(A_2), \ldots, d(A_n))^T$…………..(10)

Where W is a non- fuzzy number.

3.5 Calculation of Weights for Factor and Sub-Factor

After construction of the problem hierarchy, the different priority weights of each factor and sub-factor were calculated using the extent analysis method of FAHP approach. The comparison of the importance of factor and sub-factor over another were achieved by the help of the questionnaire administered to managerial staff of the company responsible for the activities of supply chain. The questionnaires facilitated the answering of pair-wise comparison questions. The preference of one measure over another was decided by the experience of managers. First, the managers compared the factor s then compared the sub-factors. The linguistic variables were used to make the pair-wise comparisons. Then the linguistic variables were converted to TFNs. Table 3.1 shows the linguistic variables and their corresponding TFNs.

Table3.1 .

Linguistic variables with corresponding fuzzy numbers

Linguistic variables	***Corresponding fuzzy numbers***
Equally preferred	(1, 1, 1)
Weakly preferred	(2/3, 1, 3/2)
Fairly strongly preferred	(3/2, 2, 5/2)
Very strongly preferred	(5/2, 3, 7/2)
Absolutely preferred	(7/2, 4, 9/2)

Chapter 4

RESULT AND DISCUSSION

In this chapter, a Fuzzy Analytical Hierarchy Process (FAHP) based supply chain coordination model is developed and discussed for small manufacturing firms. The inputs of the model are preferences for the factors and sub-factors which were given by the managers of the firms. The outcome of this model is priorities of the factors of supply chain coordination. Ranking of the factors is made on the basis of these priorities. The input of the model is taken from four manufacturing firm which is in table 4.1 and these linguistic variables are converted into TFN and the average is taken of these four firms which is in table 4.2.

Table 4.1:
Pairwise comparison matrix for main factors with linguistic variable

FACTOR	**OS**				**MC**				**IT**				**MU**				**R&DM**			
	f1	**f2**	**f3**	**f4**	**f1**	**f2**	**f3**	**f4**	**f1**	**f2**	**f3**	**f4**	**f1**	**f2**	**f3**	**f4**	**f1**	**f2**	**f3**	**f4**
OS	ep	ep	ep	Ep				Vsp	fsp	wp	vsp	wp	vsp	Vsp	fsp	fsp	fsp		Fsp	vsp
MC	wp	fsp	vsp		ep	ep	ep	Ep	vsp		vsp		ap	Wp	vsp	fsp	vsp	wp	Vsp	
IT						fsp		vsp	ep	ep	ep	ep			wp	fsp	wp		Fsp	vsp
MU									wp	wp			ep	ep	ep	ep	wp	wp	Fsp	fsp
R&DM		wp						fsp		wp					fsp		ep	ep	Ep	ep

In order to find the priority weights of the factors, first the fuzzy synthetic extent values of the factors were calculated by using Equation (1)

$$S_{OS} = (6.84, 8.45, 10.26) * \left(\frac{1}{39.36}, \frac{1}{31.86}, \frac{1}{25.77}\right)$$

$$= (0.17, 0.26, 0.39)$$

$$S_{MC} = (7.21, 8.66, 10.27) * \left(\frac{1}{39.36}, \frac{1}{31.86}, \frac{1}{25.77}\right)$$

$$= (0.18, 0.27, 0.39)$$

Table 4.2:
Pairwise comparison matrix for main factors with TFN

factor	OS			MC			IT			MU			R&DM		
OS	1.00	1.00	1.00	0.96	1.21	1.52	1.34	1.75	2.25	2.00	2.50	3.00	1.54	2.00	2.50
MC	1.24	1.58	1.98	1.00	1.00	1.00	1.42	1.71	2.02	2.04	2.50	3.00	1.52	1.88	2.29
IT	0.51	0.71	1.02	1.14	1.42	1.70	1.00	1.00	1.00	0.88	1.25	1.75	1.34	1.75	2.25
MU	0.34	0.42	0.54	0.39	0.52	0.71	0.60	0.88	1.29	1.00	1.00	1.00	1.09	1.50	2.00
R&DM	0.44	0.58	0.81	0.69	0.92	1.20	0.51	0.71	1.02	0.81	1.13	1.54	1.00	1.00	1.00

$$S_{IT} = (4.85, 6.12, 7.17)*\left(\frac{1}{39.36}, \frac{1}{31.86}, \frac{1}{25.77}\right)$$

$$= (0.12, 0.19, 0.29)$$

$$S_{MU} = (3.42, 4.31, 5.53)*\left(\frac{1}{39.36}, \frac{1}{31.86}, \frac{1}{25.77}\right)$$

$$= (0.08, .013, 0.21)$$

$$S_{R\&DM} = (3.43, 4.12, 5.56)*\left(\frac{1}{39.36}, \frac{1}{31.86}, \frac{1}{25.77}\right)$$

$$= (0.08, 0.13, 0.215)$$

The degree of possibility of Si over Si ($i \neq j$) was determined by using Equation (6)

$$V(S_{OS} \geq S_{MC}) = \frac{(0.18-0.39)}{(0.26-0.39)-(0.27-0.18)} = 0.95$$

$V(S_{OS} \geq S_{IT}) = 1$

$V(S_{OS} \geq S_{MU}) = 1$

$V(S_{OS} \geq S_{R\&DM}) = 1$

$V(S_{MC} \geq S_{OS}) = 1$

$V(S_{MC} \geq S_{IT}) = 1$

$V(S_{MC} \geq S_{MU}) = 1$

$V(S_{MC} \geq S_{R\&DM}) = 1$

$V(S_{IT} \geq S_{OS}) = \frac{(0.17-0.29)}{(0.19-0.29)-(0.26-0.17)} = 0.63$

$V(S_{IT} \geq S_{MC}) = \frac{(0.18-0.29)}{(0.19-0.29)-(0.27-0.18)} = 0.57$

$V(S_{IT} \geq S_{MU}) = 1$

$V(S_{IT} \geq S_{R\&DM}) = 1$

$V(S_{MU} \geq S_{OS}) = \frac{(0.17-0.21)}{(0.13-0.21)-(0.26-0.17)} = 0.23$

$V(S_{MU} \geq S_{MC}) = \frac{(0.18-0.21)}{(0.13-0.21)-(0.27-0.18)} = 0.17$

$V(S_{MU} \geq S_{IT}) = \frac{(0.12-0.21)}{(0.13-0.21)-(0.19-0.12)} = 0.6$

$V(S_{MU} \geq S_{R\&DM}) = 1$

$V(S_{R\&DM} \geq S_{OS}) = \frac{(0.17-0.21)}{(0.13-0.21)-(0.26-0.17)} = 0.23$

$V(S_{R\&DM} \geq S_{MC}) = \frac{(0.18-0.21)}{(0.13-0.21)-(0.27-0.18)} = 0.17$

$V(S_{R\&DM} \geq S_{IT}) = \frac{(0.12-0.21)}{(0.13-0.21)-(0.19-0.12)} = 0.6$

$V(S_{R\&DM} \geq S_{MU}) = 1$

With the help of Equation (8), the minimum degree of possibility was stated as below:

$d'(S_{OS}) = V(S_{OS} \geq S_{MC}, S_{IT}, S_{MU}, S_{R\&DM})$

$= \min(0.95, 1, 1, 1) = 0.95$

$d'(S_{MC}) = V(S_{MC} \geq S_{OS}, S_{IT}, S_{MU}, S_{R\&DM})$

$= \min(1, 1, 1, 1) = 1$

$d'(S_{IT}) = V(S_{IT} \geq S_{MC}, S_{OS}, S_{MU}, S_{R\&DM})$

$= \min(0.63, 0.57, 1, 1) = 0.57$

$d'(S_{MU}) = V(S_{MU} \geq S_{MC}, S_{OS}, S_{IT}, S_{R\&DM})$

$= \min (0.23, 0.17, 0.6, 1) = 0.17$

$d' (S_{R\&DM}) = V (S_{R\&DM} \geq S_{MC}, S_{OS}, S_{IT}, S_{MU})$

$= \min (0.23, 0.17, 0.6, 1) = 0.17$

Therefore the weight vector was given as W'(0.95, 1, 0.57, 0.17, 0.17). After normalization process, the local weight vector factors was found to be W (0.33, 0.34, 0.19, 0.05, 0.05)T. The management commitment got highest weight (0.34).

Table 4.3 shows the pairwise comparison of sub-factors which are related to organizational structure. Table 4.4 shows average TFN values of the sub-factors of organizational structure.

Table 4.3:
Pairwise comparison matrix for sub-factor of organizational structure

OS	**LS**				**CFTE**				**BM**				**ER**				**FC**			
	f1	**f2**	**f3**	**f4**	**f1**	**f2**	**f3**	**f4**	**f1**	**f2**	**f3**	**f4**	**f1**	**f2**	**f3**	**f4**	**f1**	**f2**	**f3**	**f4**
LS	ep	ep	ep	ep	vsp		ap	vsp	fsp		ap		vsp		Ap	fsp	wp	vsp	ap	
CFTE		fsp			Ep	ep	ep	ep			wp		wp	vsp	Vsp			fsp	wp	
BM		wp		vsp	Fsp	wp		fsp	ep	ep	ep	ep	fsp	wp	Fsp	fsp	wp	fsp	wp	
ER		wp						fsp					ep	ep	Ep	ep			fsp	
FC				fsp	Fsp			vsp				vsp	vsp	wp		vsp	ep	ep	ep	ep

In order to find the priority weights of the sub- factors, first the fuzzy synthetic extent values of the sub- factors were calculated by using Equation (1)

$S_{LS} = (8.48, 9.82, 11.8) *(\frac{1}{40.02}, \frac{1}{32.82}, \frac{1}{26.92})$

$= (0.21, 0.29, 0.43)$

$S_{CFTE} = (4.29, 5.25, 6.46) *(\frac{1}{40.02}, \frac{1}{32.82}, \frac{1}{26.92})$

$= (0.10, 0.15, 0.23)$

S_{BM} = (5.09, 6.51, 8.20) *$(\frac{1}{40.02}, \frac{1}{32.82}, \frac{1}{26.92})$

= (0.12, 0.19, 0.3)

S_{ER} = (3.21, 3.96, 4.98) *$(\frac{1}{40.02}, \frac{1}{32.82}, \frac{1}{26.92})$

= (0.08, 0.12, 0.18)

Table 4.4:
Pairwise comparison matrix for sub-factor of organizational structure with TFN

OS	LS			CFTE			BM			ER			FC		
LS	1.00	1.00	1.00	2.23	2.63	3.04	1.49	1.83	2.23	2.04	2.50	3.00	1.77	2.13	2.54
CFTE	0.57	0.73	0.90	1.00	1.00	1.00	0.54	0.75	1.09	1.52	1.88	2.29	0.69	0.92	1.20
BM	0.95	1.19	1.49	1.09	1.50	2.00	1.00	1.00	1.00	1.29	1.75	2.25	0.78	1.08	1.48
ER	0.39	0.52	0.71	0.69	0.92	1.20	0.47	0.63	0.88	1.00	1.00	1.00	0.69	0.92	1.20
FC	0.67	0.90	1.17	1.52	1.88	2.29	1.06	1.38	1.79	1.52	1.88	2.29	1.00	1.00	1.00

S_{FC} = (5.74, 7, 8.54) *$(\frac{1}{40.02}, \frac{1}{32.82}, \frac{1}{26.92})$

= (0.14, 0.21, 0.31)

The degree of possibility of Si over Si (i≠ j) was determined by using Equation (6)

V ($S_{LS} \geq S_{CFTE}$) = 1

V ($S_{LS} \geq S_{BM}$) = 1

V ($S_{LS} \geq S_{ER}$) = 1

V ($S_{LS} \geq S_{FC}$) = 1

V ($S_{CFTE} \geq S_{LS}$) = $\frac{(0.21-0.23)}{(0.15-0.23)-(0.29-0.21)} = 0.12$

V ($S_{CFTE} \geq S_{BM}$) = $\frac{(0.12-0.23)}{(0.15-0.23)-(0.19-0.12)} = 0.73$

$V\ (S_{CFTE} \geq S_{ER}) = 1$

$V\ (S_{CFTE} \geq S_{FC}) = \frac{(0.14-0.23)}{(0.15-0.23)-(0.21-0.14)} = 0.6$

$V\ (S_{BM} \geq S_{LS}) = \frac{(0.21-0.3)}{(0.19-0.3)-(0.29-0.21)} = 0.32$

$V\ (S_{BM} \geq S_{CFTE}) = 1$

$V\ (S_{BM} \geq S_{ER}) = 1$

$V\ (S_{BM} \geq S_{FC}) = \frac{(0.14-0.3)}{(0.19-0.3)-(0.21-0.14)} = 0.89$

$V\ (S_{BM} \geq S_{LS}) =0$

$V\ (S_{FC} \geq S_{LS}) = \frac{(0.21-0.31)}{(0.21-0.31)-(0.29-0.21)} = 0.55$

$V\ (S_{FC} \geq S_{CFTE}) = 1$

$V\ (S_{FC} \geq S_{BM}) = 1$

$V\ (S_{FC} \geq S_{ER}) = 1$

With the help of Equation (8), the minimum degree of possibility was stated as below:

$d'\ (S_{LS}) = V\ (S_{LS} \geq S_{CFTE,}\ S_{BM,}\ S_{ER,}\ S_{FC})$

$= \min\ (1, 1, 1, 1) = 1$

$d'\ (S_{CFTE}) = V\ (S_{CFTE} \geq S_{LS,}\ S_{BM,}\ S_{ER,}\ S_{FC})$

$= \min\ (0.12, 0.73, 1, 0.6) = 0.12$

$d'\ (S_{BM}) = V\ (S_{BM} \geq S_{LS,}\ S_{CFTE,}\ S_{ER,}\ S_{FC})$

$= \min\ (0.32, 1, 1, 0.89) = 0.32$

$d'\ (S_{ER}) = V\ (S_{ER} \geq S_{LS,}\ S_{CFTE,}\ S_{BM,}\ S_{FC})$

$= \min\ (0) = 0$

$d'\ (S_{FC}) = V\ (S_{FC} \geq S_{LS,}\ S_{CFTE,}\ S_{ER,}\ S_{BM})$

$= \min\ (0.55, 1, 1, 1) = 0.32$

Therefore the weight vector was given as W'(1, 0.12, 0.32, 0, 0.55). After normalization process, the local weight vector factors was found to be W (0.5, 0.06, 0.16, 0, 0.27)T. The lean structure got highest weight (0.5) which the sub- factor of organizational structure.

Table 4.5 shows the pairwise comparison of sub-factors which are related to management commitment. Table 4.6 shows average TFN values of the sub-factors of management commitment.

Table 4.5:

MC	**SD**				**LTIM**				**MS**				**ORA**				**LM**			
	f1	**f2**	**f3**	**f4**	**f1**	**f2**	**f3**	**f4**	**f1**	**f2**	**f3**	**f4**	**f1**	**f2**	**f3**	**f4**	**f1**	**f2**	**f3**	**f4**
SD	**ep**	**ep**	**ep**	**ep**	**Fsp**	**fsp**	**vsp**	**vsp**	**fsp**		**vsp**	**Fsp**	**vsp**	**vsp**	**vsp**	**fsp**	**vsp**	**fsp**	**wp**	
LTIM					**Ep**	**ep**	**ep**	**ep**	**fsp**	**wp**	**fsp**		**wp**	**vsp**	**fsp**		**wp**	**fsp**	**vsp**	
MS		**wp**						**vsp**	**ep**	**ep**	**ep**	**ep**		**wp**	**fsp**			**fsp**	**fsp**	
ORA								**fsp**	**wp**			**fsp**	**ep**	**ep**	**ep**	**ep**	**wp**		**wp**	
LM				**vsp**				**vsp**	**wp**			**vsp**		**wp**		**vsp**	**ep**	**ep**	**ep**	**ep**

Pairwise comparison matrix for sub-factor of management commitment

Table 4.6:
Pairwise comparison matrix for sub-factor of management commitment with TFN

MC	**SD**			**LTIM**			**MS**			**ORA**			**LM**		
SD	1.00	1.00	1.00	2.00	2.50	3.00	1.54	2.00	2.50	2.25	2.75	3.25	1.24	1.58	1.98
LTIM	0.34	0.42	0.54	1.00	1.00	1.00	0.99	1.33	1.73	1.27	1.63	2.04	1.24	1.58	1.98
MS	0.44	0.58	0.81	0.99	1.25	1.59	1.00	1.00	1.00	0.81	1.13	1.54	0.99	1.33	1.73
ORA	0.31	0.37	0.47	0.71	0.96	1.27	0.81	1.13	1.54	1.00	1.00	1.00	0.57	0.83	1.23
LM	0.44	0.58	0.81	0.71	0.96	1.27	0.74	1.00	1.34	1.13	1.50	2.00	1.00	1.00	1.00

In order to find the priority weights of the sub- factors, first the fuzzy synthetic extent values of the sub- factors were calculated by using Equation (1)

S_{SD} = (8.02, 9.83, 11.72) *$(\frac{1}{37.57}, \frac{1}{30.39}, \frac{1}{24.52})$

= (0.21, 0.32, 0.47)

S_{LTIM} = (4.81, 5.94, 7.27) *$(\frac{1}{37.57}, \frac{1}{30.39}, \frac{1}{24.52})$

= (0.12, 0.19, 0.29)

S_{MS} = (4.21, 5.28, 6.65) *$(\frac{1}{37.57}, \frac{1}{30.39}, \frac{1}{24.52})$

= (0.11, 0.17, 0.27)

S_{ORA} = (3.4, 4.27, 5.48) *$(\frac{1}{37.57}, \frac{1}{30.39}, \frac{1}{24.52})$

= (0.09, 0.14, 0.22)

S_{LM} = (4, 5.03, 6.4) *$(\frac{1}{37.57}, \frac{1}{30.39}, \frac{1}{24.52})$

= (0.1, 0.16, 0.26)

The degree of possibility of Si over Si (i≠ j) was determined by using Equation (6)

V ($S_{SD} \geq S_{LTIM}$) = 1

V ($S_{SD} \geq S_{MS}$) = 1

V ($S_{SD} \geq S_{ORA}$) = 1

V ($S_{SD} \geq S_{LM}$) = 1

V ($S_{LTIM} \geq S_{SD}$) = $\frac{(0.21-0.29)}{(0.19-0.29)-(0.32-0.21)} = 0.38$

V ($S_{LTIM} \geq S_{MS}$) = 1

V ($S_{LTIM} \geq S_{ORA}$) = 1

V ($S_{LTIM} \geq S_{LM}$) = 1

V ($S_{MS} \geq S_{SD}$) = $\frac{(0.21-0.27)}{(0.17-0.27)-(0.32-0.21)} = 0.28$

$V(S_{MS} \geq S_{LTIM}) = \frac{(0.12-0.27)}{(0.17-0.27)-(0.19-0.12)} = 0.88$

$V(S_{MS} \geq S_{ORA}) = 1$

$V(S_{MS} \geq S_{LM}) = 1$

$V(S_{ORA} \geq S_{SD}) = \frac{(0.21-0.22)}{(0.14-0.22)-(0.32-0.21)} = 0.05$

$V(S_{ORA} \geq S_{LTIM}) = \frac{(0.12-0.22)}{(0.14-0.22)-(0.19-0.12)} = 0.67$

$V(S_{ORA} \geq S_{MS}) = \frac{(0.11-0.22)}{(0.14-0.22)-(0.17-0.11)} = 0.78$

$V(S_{ORA} \geq S_{LM}) = \frac{(0.1-0.22)}{(0.14-0.22)-(0.16-0.1)} = 0.85$

$V(S_{LM} \geq S_{SD}) = \frac{(0.21-0.26)}{(0.16-0.26)-(0.32-0.21)} = 0.23$

$V(S_{LM} \geq S_{LTIM}) = \frac{(0.12-0.26)}{(0.16-0.26)-(0.19-0.12)} = 0.17$

$V(S_{LM} \geq S_{MS}) = \frac{(0.11-0.26)}{(0.16-0.26)-(0.17-0.11)} = 0.93$

$V(S_{LM} \geq S_{ORA}) = 1$

With the help of Equation (8), the minimum degree of possibility was stated as below:

$d'(S_{SD}) = V(S_{SD} \geq S_{LTIM,} S_{MS,} S_{ORA,} S_{LM})$

$= \min(1, 1, 1, 1) = 1$

$d'(S_{LTIM}) = V(S_{LTIM} \geq S_{SD,} S_{MS,} S_{ORA,} S_{LM})$

$= \min(0.38, 1, 1, 1) = 0.38$

$d'(S_{MS}) = V(S_{MS} \geq S_{SD,} S_{LTIM,} S_{ORA,} S_{LM})$

$= \min(0.28, 0.88, 1, 1) = 0.28$

$d'(S_{ORA}) = V(S_{ORA} \geq S_{SD,} S_{MS,} S_{LTIM,} S_{LM})$

$= \min(0.05, 0.67, 0.78, 0.85) = .05$

$d'(S_{LM}) = V(S_{LM} \geq S_{SD,} S_{MS,} S_{ORA,} S_{LTIM})$

$= \min(0.23, 0.82, 0.93, 1) = 0.23$

Therefore the weight vector was given as W'(1, 0.38, 0.28, 0.05, 0.23). After normalization process, the local weight vector factors was found to be W (0.51, 0.19, 0.14, 0.02, 0.11)T. The strategic development got highest weight (0.51) which is the sub- factor of management commitment.

Table 4.7 shows the pairwise comparison of sub-factors which are related to information technology. Table 4.8 shows average TFN values of the sub-factors of information technology.

Table 4.7:
Pairwise comparison matrix for sub-factor of information technology

IT	**TD**				**IS**				**INIS**				**DS**			
	f1	**f2**	**f3**	**f4**	**f1**	**f2**	**f3**	**f4**	**f1**	**f2**	**f3**	**f4**	**f1**	**f2**	**f3**	**f4**
TD	Ep	ep	ep	ep		fsp	wp			wp	fsp	vsp			fsp	fsp
IS	Wp			vsp	Ep	ep	ep	ep	fsp	fsp	vsp	vsp	vsp	vsp	vsp	vsp
INIS	Fsp								ep	ep	ep	ep	vsp	vsp	fsp	fsp
DS	Wp	wp											ep	ep	ep	Ep

Table 4.8:
Pairwise comparison matrix for sub-factor of information technology with TFN

IT	**TD**			**IS**			**INIS**			**DS**		
TD	1.00	1.00	1.00	0.78	1.08	1.48	1.27	1.63	2.04	1.09	1.50	2.00
IS	1.06	1.38	1.79	1.00	1.00	1.00	2.00	2.50	3.00	2.50	3.00	3.50
INIS	0.71	0.96	1.27	0.34	0.42	0.54	1.00	1.00	1.00	2.00	2.50	3.00
DS	0.54	0.75	1.09	0.29	0.33	0.40	0.34	0.42	0.54	1.00	1.00	1.00

In order to find the priority weights of the sub- factors, first the fuzzy synthetic extent values of the sub- factors were calculated by using Equation (1)

$$S_{TD} = (4.12, 5.02, 6.51) * \left(\frac{1}{24.62}, \frac{1}{20.44}, \frac{1}{16.89}\right)$$

$$= (0.16, 0.25, 0.38)$$

S_{IS} = (6.56, 7.87, 9.29) *$(\frac{1}{24.62}, \frac{1}{20.44}, \frac{1}{16.89})$

= (0.26, 0.38, 0.55)

S_{INIS} = (4.05, 4.86, 5.79) *$(\frac{1}{24.62}, \frac{1}{20.44}, \frac{1}{16.89})$

= (0.16, 0.23, 0.34)

S_{DS} = (2.15, 2.49, 3.01) *$(\frac{1}{24.62}, \frac{1}{20.44}, \frac{1}{16.89})$

= (0.08, 0.12, 0.17)

The degree of possibility of Si over Si (i≠ j) was determined by using Equation (6)

$V (S_{TD} \geq S_{IS}) = \frac{(0.26-0.38)}{(0.25-0.38)-(0.38-0.26)} = 0.48$

$V (S_{TD} \geq S_{INIS}) = 1$

$V (S_{TD} \geq S_{DS}) = 1$

$V (S_{IS} \geq S_{TD}) = 1$

$V (S_{IS} \geq S_{INIS}) = 1$

$V (S_{IS} \geq S_{DS}) = 1$

$V (S_{INIS} \geq S_{TD}) = \frac{(0.16-0.34)}{(0.23-0.34)-(0.25-0.16)} = 0.9$

$V (S_{INIS} \geq S_{IS}) = \frac{(0.26-0.34)}{(0.23-0.34)-(0.38-0.26)} = 0.9$

$V (S_{INIS} \geq S_{DS}) = 1$

$V (S_{DS} \geq S_{TD}) = \frac{(0.16-0.17)}{(0.12-0.17)-(0.25-0.16)} = 0.07$

$V (S_{DS} \geq S_{TD}) = 0$

With the help of Equation (8), the minimum degree of possibility was stated as below:

$d' (S_{TD}) = V (S_{TD} \geq S_{IS,} S_{INIS,} S_{DS})$

= min (0.48, 1, 1) = 0.48

$d' (S_{IS}) = V (S_{IS} \geq S_{TD,} S_{INIS,} S_{DS})$

$= \min(1, 1, 1) = 1$

$d'(S_{INIS}) = V(S_{INIS} \geq S_{TD}, S_{IS}, S_{DS})$

$= \min(0.9, .034, 1) = 0.34$

$d'(S_{DS}) = V(S_{DS} \geq S_{TD}, S_{IS}, S_{INIS})$

$= \min(0.07, 0) = 0$

Therefore the weight vector was given as W'(0.48, 1, 0.34, 0). After normalization process, the local weight vector factors was found to be W (0.26, 0.54, 0.18, 0.)T. The information sharing got highest weight (0.54) which is the sub- factor of information technology.

Table 4.9 shows the pairwise comparison of sub-factors which are related to mutual understanding. Table 4.10 shows average TFN values of the sub-factors of mutual understanding.

In order to find the priority weights of the sub- factors, first the fuzzy synthetic extent values of the sub- factors were calculated by using Equation (1)

$$S_{TM} = (8.28, 9.95, 11.76) * \left(\frac{1}{40.37}, \frac{1}{33.55}, \frac{1}{27.7}\right)$$

$$= (0.2, 0.29, 0.42)$$

$$S_{R\&RS} = (6.02, 7.23, 8.58) * \left(\frac{1}{40.37}, \frac{1}{33.55}, \frac{1}{27.7}\right)$$

$$= (0.14, 0.21, 0.30)$$

Table 4.9:
Pairwise comparison matrix for sub-factor of mutual understanding

MU	**TM**				**R&RS**				**AV&G**				**SM**				**NM**			
	f1	**f2**	**f3**	**f4**	**f1**	**f2**	**f3**	**f4**	**f1**	**f2**	**f3**	**f4**	**f1**	**f2**	**f3**	**f4**	**f1**	**f2**	**f3**	**f4**
TM	**Ep**	**ep**	**ep**	**ep**	**vsp**	**fsp**	**fsp**	**fsp**	**vsp**		**vsp**		**ap**		**vsp**		**ap**		**ap**	**fsp**
R&RS					**ep**	**ep**	**ep**	**ep**		**Vsp**	**fsp**		**fsp**	**fsp**	**fsp**		**vsp**	**ap**	**vsp**	**wp**
AV&G		**wp**		**vsp**	**fsp**			**vsp**	**ep**	**Ep**	**ep**	**ep**			**fsp**		**vsp**	**vsp**	**fsp**	**vsp**
SM		**wp**		**fsp**				**vsp**	**fsp**	**Fsp**		**fsp**	**ep**	**ep**	**ep**	**ep**	**wp**		**fsp**	**wp**
NM		**wp**												**wp**			**ep**	**ep**	**ep**	**ep**

Table 4.10:
Pairwise comparison matrix for sub-factor of mutual understanding with TFN

MU	TM			R&RS			AV&G			SM			NM		
TM	1.00	1.00	1.00	1.75	2.25	2.75	1.49	1.83	2.23	1.77	2.13	2.54	2.29	2.75	3.25
R&RS	0.37	0.46	0.60	1.00	1.00	1.00	1.17	1.46	1.77	1.20	1.58	1.98	2.29	2.75	3.25
AV&G	0.94	1.17	1.45	1.17	1.46	1.77	1.00	1.00	1.00	0.68	0.88	1.13	2.25	2.75	3.25
SM	0.67	0.90	1.17	0.93	1.13	1.38	1.23	1.63	2.04	1.00	1.00	1.00	0.88	1.25	1.75
NM	0.38	0.50	0.69	0.37	0.48	0.65	0.31	0.37	0.47	0.60	0.88	1.29	1.00	1.00	1.00

$S_{AV\&G}$ = (6.02, 7.23, 8.58) $*(\frac{1}{40.37}, \frac{1}{33.55}, \frac{1}{27.7})$

= (0.14, 0.21, 0.30)

S_{SM} = (4.67, 5.88, 7.33) $*(\frac{1}{40.37}, \frac{1}{33.55}, \frac{1}{27.7})$

= (0.11, 0.17, 0.26)

S_{NM} = (2.64, 3.21, 4.07) $*(\frac{1}{40.37}, \frac{1}{33.55}, \frac{1}{27.7})$

= (0.06, 0.09, 0.14)

The degree of possibility of Si over Si (i≠ j) was determined by using Equation (6)

$V(S_{TM} \geq S_{R\&RS}) = 1$

$V(S_{TM} \geq S_{AV\&G}) = 1$

$V(S_{TM} \geq S_{SM}) = 1$

$V(S_{TM} \geq S_{NM}) = 1$

$V(S_{R\&RS} \geq S_{TM}) = \frac{(0.2-0.3)}{(0.21-0.3)-(0.29-0.2)} = 0.55$

$V(S_{R\&RS} \geq S_{AV\&G}) = 1$

$V\ (S_{R\&RS} \geq S_{SM}) = 1$

$V\ (S_{R\&RS} \geq S_{NM}) = 1$

$V\ (S_{AV\&G} \geq S_{TM}) = \frac{(0.2-0.3)}{(0.21-0.3)-(0.29-0.2)} = 0.55$

$V\ (S_{AV\&G} \geq S_{R\&RS}) = 1$

$V\ (S_{AV\&G} \geq S_{SM}) = 1$

$V\ (S_{AV\&G} \geq S_{NM}) = 1$

$V\ (S_{SM} \geq S_{TM}) = \frac{(0.2-0.26)}{(0.17-0.26)-(0.29-0.2)} = 0.33$

$V\ (S_{SM} \geq S_{R\&RS}) = \frac{(0.14-0.26)}{(0.17-0.26)-(0.21-0.14)} = 0.75$

$V\ (S_{SM} \geq S_{AV\&G}) = \frac{(0.14-0.26)}{(0.17-0.26)-(0.21-0.14)} = 0.75$

$V\ (S_{SM} \geq S_{NM}) = 1$

$V\ (S_{NM} \geq S_{TM}) = 0$

With the help of Equation (8), the minimum degree of possibility was stated as below:

$d'\ (S_{TM}) = V\ (S_{TM} \geq S_{R\&RS,}\ S_{AV\&G,}\ S_{SM,}\ S_{NM})$

$= \min\ (1, 1, 1, 1) = 1$

$d'\ (S_{R\&RS}) = V\ (S_{R\&RS} \geq S_{TM,}\ S_{AV\&G,}\ S_{SM,}\ S_{NM})$

$= \min\ (0.55, 1, 1, 1) = 0.55$

$d'\ (S_{AV\&G}) = V\ (S_{AV\&G} \geq S_{R\&RS,}\ S_{TM,}\ S_{SM,}\ S_{NM})$

$= \min\ (0.55, 1, 1, 1) = 0.55$

$d'\ (S_{SM}) = V\ (S_{SM} \geq S_{R\&RS,}\ S_{AV\&G,}\ S_{TM,}\ S_{NM})$

$= \min\ (0.33, 0.75, 0.75, 1) = 0.33$

$d'\ (S_{NM}) = V\ (S_{NM} \geq S_{R\&RS,}\ S_{AV\&G,}\ S_{SM,}\ S_{TM})$

$= \min\ (0) = 0$

Therefore the weight vector was given as W'(1, 0.55, 0.55, 0.33, 0). After normalization process, the local weight vector factors was found to be W (0.41, 0.22, 0.22, 0.13, 0)T. The trust in SC member got highest weight (0.41) which is the sub-factor of mutual understanding.

Table 4.11 shows the pairwise comparison of sub-factors which are related to relationship and decision making. Table 4.12 shows average TFN values of the sub-factors of relationship and decision making.

Table 4.11:
Pairwise comparison matrix for sub-factor of relationship and decision making

R&DM	**LS**				**CD&R**				**LTR**				**PS&E**			
	f1	**f2**	**f3**	**f4**	**f1**	**f2**	**f3**	**f4**	**f1**	**f2**	**f3**	**f4**	**f1**	**f2**	**f3**	**f4**
LS	ep	ep	ep	ep			fsp	fsp			wp		wp		vsp	fsp
CD&R	vsp	vsp			ep	Ep	Ep	ep	Fsp	fsp	fsp		vsp	wp	fsp	Fsp
LTR	fsp	wp		vsp				vsp	Ep	ep	ep	ep	fsp		vsp	Vsp
PS&E		fsp								vsp			ep	ep	ep	Ep

Table 4.12:
Pairwise comparison matrix for sub-factor of relationship and decision making with TFN

R&DM	**LS**			**CD&R**			**LTR**			**PS&E**		
LS	1.00	1.00	1.00	0.89	1.17	1.45	0.51	0.71	1.02	1.27	1.63	2.04
CD&R	1.45	1.75	2.04	1.00	1.00	1.00	1.20	1.58	1.98	1.54	2.00	2.50
LTR	1.34	1.75	2.25	0.93	1.13	1.38	1.00	1.00	1.00	1.70	2.08	2.48
PS&E	0.71	0.96	1.27	0.44	0.58	0.81	0.87	1.04	1.24	1.00	1.00	1.00

In order to find the priority weights of the sub- factors, first the fuzzy synthetic extent values of the sub- factors were calculated by using Equation (1)

S_{LS} = (3.74, 4.46, 5.5) $*(\frac{1}{24.43}, \frac{1}{20.35}, \frac{1}{16.81})$

= (0.15, 0.21, 0.33)

$S_{CD\&P}$ = (5.18, 6.33, 7.51) $*(\frac{1}{24.43}, \frac{1}{20.35}, \frac{1}{16.81})$

$= (0.21, 0.31, 0.44)$

$S_{LTR} = (4.94, 5.95, 7.09) * (\frac{1}{24.43}, \frac{1}{20.35}, \frac{1}{16.81})$

$= (0.20, 0.29, 0.42)$

$S_{PS\&E} = (3.01, 3.57, 4.31) * (\frac{1}{24.43}, \frac{1}{20.35}, \frac{1}{16.81})$

$= (0.12, 0.17, 0.25)$

The degree of possibility of Si over Si ($i \neq j$) was determined by using Equation (6)

$V (S_{LS} \geq S_{CD\&P}) = \frac{(0.21-0.33)}{(0.21-0.33)-(0.31-0.21)} = 0.54$

$V (S_{LS} \geq S_{LTR}) = \frac{(0.2-0.33)}{(0.21-0.33)-(0.29-0.2)} = 0.47$

$V (S_{LS} \geq S_{PS\&E}) = 1$

$V (S_{CD\&P} \geq S_{LS}) = 1$

$V (S_{CD\&P} \geq S_{LTR}) = 1$

$V (S_{CD\&P} \geq S_{PS\&E}) = 1$

$V (S_{LTR} \geq S_{LS}) = 1$

$V (S_{LTR} \geq S_{CD\&P}) = \frac{(0.21-0.42)}{(0.29-0.42)-(0.31-0.21)} = 0.91$

$V (S_{LTR} \geq S_{PS\&E}) = 1$

$V (S_{PS\&E} \geq S_{LS}) = \frac{(0.15-0.25)}{(0.17-0.25)-(0.21-0.15)} = 0.71$

$V (S_{PS\&E} \geq S_{CD\&P}) = \frac{(0.21-0.25)}{(0.17-0.25)-(0.31-0.21)} = 0.22$

$V (S_{PS\&E} \geq S_{LTR}) = \frac{(0.2-0.25)}{(0.17-0.25)-(0.29-0.2)} = 0.29$

With the help of Equation (8), the minimum degree of possibility was stated as below:

$d' (S_{LS}) = V (S_{LS} \geq S_{PS\&E,} S_{CD\&P,} S_{LTR})$

$= \min (0.54, 0.47, 1) = 0.47$

$d' (S_{CD\&P}) = V (S_{CD\&P} \geq S_{PS\&E,} S_{LS,} S_{LTR})$

$= \min (1, 1, 1) = 1$

$d' (S_{LTR}) = V (S_{LTR} \geq S_{PS\&E,} S_{CD\&P,} S_{LS})$

$= \min (1, 0.91, 1) = 0.91$

$d' (S_{PS\&E}) = V (S_{PS\&E} \geq S_{LS,} S_{CD\&P,} S_{LTR})$

$= \min (0.71, 0.22, 0.29) = 0.22$

Therefore the weight vector was given as W'(0.47, 1, 0.91, 0.29). After normalization process, the local weight vector factors was found to be W (0.17, 0.37, 0.34, 0.1)T. The Collaborative decision making and planning got highest weight (0.37) which is the sub- factor of relationship and decision making.

Table 4.13 shows the final weights of the main factor and their sub-factor for a coordinated supply chain. Management commitment (0.34) is perceived to be the most important factor, followed by the organizational structure (0.33), information technology (0.19), mutual understanding (0.05), and relationship and decision making (0.05),

To calculate the final weight of each sub- factor, relative weights of the main factor was multiplied to relative weight of each sub- factor. Among the sub-criteria of management commitment, strategic development (0.173) is perceived to be the most important sub-factor, followed by long term investment motive (0.064), management skills (0.047), leadership in management (0.037) and optimize resource allocation (0.006).

The second important factor affecting supply coordination is organizational structure, lean structure (0.165) is perceived to be the most important sub-factor, followed by financial capabilities (0.0891), benchmarking (0.052), cross functional training of employees (0.019) and establishing superior–subordinate relationships (0.00).

The third important factor for coordination in supply chain is information technology. Information sharing (0.102) is the most important sub-factor of information technology, followed by integrating new information systems (0.061), transition data of sales, inventory, quality, and demand (0.049) and dashboard systems (0.00).

Table4.13:
Final weight of main factor and related sub-factor

Main factor and related sub-factor	Relative weight of Main factor Matrix	Local weight of the sub-factor	Global weight to each sub-factor
1. Management commitment	0.34		0.34
Strategy Development for SC		0.51	0.173
Long-term Investment Motive		0.19	0.064
Management skills		0.14	0.047
Optimize recourse allocation		0.02	0.006
Leadership in management		0.11	0.037
2. Organizational structure	0.33		0.33
Lean structure		0.50	0.165
Cross functional training of Employees		0.06	0.019
Benchmarking in supply chain		0.16	0.052
Establishing superior-subordinate Relationship		0	0.0
Financial Capabilities		0.27	0.089
3. Information Technology	0.19		0.19
Transition data of sales, inventory, quality & demand		0.265	0.049
Information sharing		0.54	0.102
Integrating new information systems		0.18	0.061
Dashboard systems		0.0	0.0
4. Mutual understanding	0.05		0.05
Trust in SC members		0.41	0.02
Risk and reward sharing by SC members		0.22	0.011
Agreed vision and goals of SC members		0.22	0.011
Supervision mechanism in SC operation		0.13	0.006
Negotiation mechanisms		0.0	0.0
5. Relationship and Decision making	0.05		0.05
logistic synchronization		0.17	0.008
collaborative decision making and planning		0.37	0.018
Long-term relation between suppliers and Customers		0.34	0.017
Partnership selection and evolution		0.10	0.005

Mutual understanding and relationship and decision making got equal weightage importance for a coordinated supply chain. Among sub-criteria of mutual understanding risk and reward sharing by supply chain members (0.011) and agreed vision and goals of SC members (0.011), is perceived to be the most important factor, followed by trust in supply chain members (0.02), supervision mechanisms in SC operations (0.006).

Among the sub-factor of relationship and decision making collaborative decision making and planning (0.018) is perceived the most important factor followed by long-term relation between suppliers and customers (0.17), logistic synchronization (0.008) and partnership selection and evaluation (0.005).

Chapter 5

CONCLUSION

This is the study conducted on the identification and prioritization of SCC factors in manufacturing supply chain context. The FAHP method is used for organizing, analyzing, as well as prioritizing different main and sub-factor of a coordinated supply chain.

As mentioned in the results section, among the main factors, management commitment has the highest rank among the others (organizational structure information technology, relationship and decision-making mutual understanding). These findings imply the necessity of considering the management commitment to improve coordination in the supply chain. For implementing any SCM initiative, management commitment should be conducive for the change. The effective management of a relationship is important for the success of supply chain coordination. Top management activities include aligning goals and incentives, improving information accuracy, improving operational performance, designing pricing strategies to stabilize orders, as well as building strategic partnerships and trust. In this study, the experts believe that long-term investment is an important strategy in the manufacturing industry.

In the case of highly rigid systems not ready for change, the chances of SCM success would be far from realization. Before planning a coordinated supply chain, management should endeavor to plan the long term investment motive and strategic development. Employees in all supply chain parts must be aware of the corporate vision and mission, as well as the core strategies of the supply chain, so that they can adjust and coordinate their activities and attempts with global supply chain goals. Individuals must understand each process conducted in the sub-units that may have a direct or indirect impact on overall supply chain performance.

Organizational structure is placed on the second level of priority. These findings imply the necessity of considering the organizational structure to improve coordination in the supply chain. For implementing any SCM initiative, organizational culture and structure should be conducive for the change. In the case of highly rigid systems not ready for change, the chances of SCM success would be far from realization. Before planning a coordinated supply chain, organizations should endeavor to plan the cross functional training of employees. Employees in all supply chain parts must be aware of the corporate vision and mission, as well as the core strategies of the supply chain, so that they can adjust and coordinate their activities and attempts with global supply chain goals.

After Organizational structure Information technology is placed on level of priority. The literature shows that coordination and collaboration, when used as SCM strategies, can be promoted through information technology. To design and coordinate a successful competitive supply chain that can adjust to changes in a rapidly evolving marketplace, companies and their partners depend on accurate information (Fawcett et al., 2009).

As the results show, the exchange of inventory, quality and demand, and information sharing are the most important sub-criteria confirmed by previous studies (Kanda and Deshmukh, 2008; Fawcett et al., 2009). To establish SC coordination and collaboration, a firm must be able to share relevant information with important SC partners at the correct time. The need for instant information requires technologies that collect and transfer large volumes of different information (Ofek and Sarvary, 2001).

Unfortunately, many companies have been “disappointed with the returns from IT investments” (Jap and Mohr, 2002). (Fawcett and Magnan, 2001) asserted that, to increase returns on IT investments, an organizational culture of information sharing must be supported and a new attitude toward this practice encouraged. Most companies have invested substantial amounts of money to build powerful information systems capable of collecting, analyzing, and disseminating accurate, real-time information regarding forecasts, inventory, delivery, quality, and just about anything else a manager could ask for. Unfortunately, most of these companies have found that their investments do not produce better information sharing; thus, many managers are simply reluctant to share important information (Fawcett et al., 2009). Although IT infrastructure is important, information sharing, accessibility of inventory, quality, and demand for information in a timely manner are more important for coordination among supply chain members.

The next strategic area gained from the fourth level is mutual understanding. Mutual understanding among all members of the supply chain has an essential role in coordination in supply chain. Mutual understanding encourages members to think globally for optimization of the supply chain (Singh, 2013). Among sub-criteria of mutual understanding, risk and reward sharing and agreed vision and goal is noted as the most important sub-factor, followed by trust. Negotiation leads to conflict dispute mechanisms, which create greater trust among supply network members; when trust is formed in a positive loop, trust and negotiation will reinforce each other.

Good relationships may be a consequence of trust and commitment among members that improves over time. The willingness to share information, provide and transfer accurate and timely information, awareness and understanding of the information and information systems, and dedication to work jointly by developing more trust among enterprises will result in continuous communication. These coordination mechanisms arrange all supply chain members within a unique system (Kanda and Deshmukh, 2007). One of the obstacles of SCC is a lack of trust among supply chain members. Trust is explained as the obligatory force in most vendor– purchaser transactions (Agarwal et al., 2003). Trust is demonstrated when a company believes that its partner is credible and compassionate (Heikkila, 2002). Chung et al. (2008) assert that human relations such as trust and long-term tendency have important roles in establishing good relationships. Scientists have suggested that trust is necessary for understanding interpersonal behavior and economic exchanges. According to (Cetindamar et al., 2005) a lack of trust is seen as the most important reason for difficulties in establishing collaborations, and it is accepted as the basic issue for establishing relationships among supply chain members.

The next important strategic area for coordination in supply chain is relationship and decision-making. Developing strong relations among partners also contributes to improved “mutual trust among the members” (Singh, 2013). Among sub-factor within the relationship and decision-making area, collaborative decision making is perceived to be the most important factor.

The potential benefits of integrating supply chain will be made real only if the connections and inter-relationships between different parts of the supply chain are identified, and proper alignment is ensured between the plan and practice of the company's competitive strategy (Stevens, 1989). Scientists note that the process of SC integration should start from internal logistics processes and progress to external integration with upstream and downstream partners. Internal integration can be completed by automation and standardization of each internal logistics activity under a centralized organizational structure. External integration can be attained by information sharing and strategic linking with suppliers and customers, as well as the standardization of logistics processes between the firms (Kim, 2006).

Supply chain has become an important agenda for policy makers and managers. Furthermore, coordination of the supply chain is going to be one of the most critical challenging issues for today's business development. Coordination has been a popular concept and managers have paid more attention to it recently. Indeed, if manufacturing companies want to deliver products at right time, they must work as a coordinated network in which members execute their roles through shared goals. Based on aforementioned issues, this is the first study to address the identification and prioritization of the most important factors for establishing a coordinated network, in the manufacturing context using the FAHP approach; it also contributes to create an evidence- based structure to management of interdependent activities among network members using perceptions of experts involved in manufacturing practice. Further research can highlight strategies which provide good structures for supply chain coordination as well as how to implement them, and investigate the effect of supply chain coordination on supply chain performance.

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