DEVELOPMENT OF A SYSTEM BASED MODEL TO MEASURE SERVICE QUALITY IN SUPPLY CHAIN

THESIS

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by

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CANDIDATE'S DECLARATION

I, hereby declare that this thesis entitled **DEVELOPMENT OF A SYSTEM BASED MODEL TO MEASURE SERVICE QUALITY IN SUPPLY CHAIN** by **TARUN KUMAR GUPTA**, **Registration no. YMCAUST/Ph33/2010** being submitted in fulfillment of the requirements for the Degree of Doctor of Philosophy in MECHANICAL ENGINEERING under Faculty of Engineering & Technology of YMCA University of Science & Technology Faridabad, during the academic year 2017-2018, is a bonafide record of my original work carried out under guidance and supervision of **Dr. VIKRAM SINGH, PROFESSOR, DEPARTMENT OF MECHANICAL ENGINEERING** and has not been presented elsewhere.

I, further declare that the thesis does not contain any part of any work which has been submitted for the award of any degree either in this university or in any other university.

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CERTIFICATE OF THE SUPERVISOR

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I further declare that to the best of my knowledge, the thesis does not contain any part of any work which has been submitted for the award of any degree either in this university or in any other university.

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ABSTRACT

The performance of a supply chain is characterized by its ability to remain market-sensitive without losing the integration through the chain. One of the difficulties in designing and analyzing a supply chain is that its processes are governed by the strategic factors of the supply chain. With the emergence of a business era that embraces change as one of its major characteristics, increasing the market share and survival are becoming more and more difficult to ensure. The emphasis is on adaptability to changes in the business environment and on addressing market and customer needs proactively. To combat these challenges, organizations are focusing and re-structuring their supply chain.

The word service quality was introduced in 1975 but it needs more research and scholarly attention for manufacturing perspective. This thesis focuses the service quality in supply chain keeping manufacturing perspective. In this thesis following research questions are address:

1. What is service quality?
2. What are the famous definitions of service quality?
3. What are the various studies in India for service quality?
4. How can service quality be measure?
5. What are the various methods to measure the service quality?
6. How are service quality, customer satisfaction and customer loyalty linked?

Service quality can be seen as a different strategy for supply chain. Though there are many studies available on service quality but most of them are retail, banking, insurance, hospitality etc. the attention on service quality related issues along the entire supply chain, particularly in manufacturing sector, is still almost nil.

The research methodology adopted in this research is based on combination of literature review and discussions with academia and industry experts. The factors were identified for different drivers from the available literature from 1975 to 2015. The considered supply chain have total five drivers i.e. supplier, organization, distributor, retailer and customer. A model was developed which depicts the relations between all the drivers. Questionnaires were designed to evaluate the service quality of different drivers. The Likert five point scale was used to get the responses from the

respondents. All the questionnaires were taken to get the response from respondents. Snow ball sampling was used. Then all the attributes and variables, better known as factors, were divided into various groups through SPSS 20. Various MADM techniques were used to find the value of service quality of different drivers. Finally, GTA was used to evaluate the overall service quality of supply chain.

Three factors comprises the performance indicators of supply chain i.e. service quality, customer satisfaction and customer loyalty. In this research an attempt has been made to develop a model showing the relationship between all the three.

This study may be a benchmark to manufacturing supply chain, especially in automobile sector, interested in improving their service quality.

Key words: Service quality, Supply chain, Supply chain management, SSQ, OSQ, DSQ, RSQ and CSQ

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LIST OF ABBREVIATIONS

SC- Supply Chain

SCM – Supply chain management

SSQ – Supplier service quality

OSQ – Organization service quality

DSQ – Distributor service quality

RSQ – Retailer service quality

CSQ – Customer service quality

GT – Graph theory

GTA – Graph theory approach

ANN – Artificial neural network

FGT – Fuzzy graph theory

KMO – Kaiser-Meyer-Olkin

LISREL – Linear Structural Relationships

SPSS – Statistical Package for Social Science

AMOS – Analysis of Motion Structure

VPM – Variable Permanent Matrix

FL – Fuzzy Logic

ANN – Artificial Neural Network

GTA – Graph Theoretic Approach

OEM – Original Equipment Manufacturer

CRM – Customer Relationship Management

CHAPTER-I INTRODUCTION

1.1 BACKGROUND

Manufacturing and service are the key areas of any industry. All the industries may be considered as services industries to an extent, some industries more than others. Few would argue with the fact that services dominate the economies of the world's most advanced nations. In the U.S., services represent over eighty percent of GDP and labor force. Further, it is apparent that services are increasing as an economic force in countries such as China, India and other fast-growing and developing nations (Bitner and Brown, 2008). In the recent years several changes in the market place have stimulated the theory and practice of supply chain management. The government of India has declared on February 1, 2017 in the financial budget 2017 that the revenue collection through service tax is much more than sum of collection of all other taxes.

In today's global scenario, organizations can no longer compete as independent entities, but rather as an integral part of supply chain links. The ultimate success of an organization will depend on its ability to integrate and coordinate the intricate network of business relationships among supply chain members.

Also, in order to meet the today's competitive market requirement & to respond the customer's expectations, organizations have no choice other than to offer high quality product and service quality. As, this study is for service quality, so it is better to discuss about service quality rather than product quality. Service quality may be defined as the difference between customer's expectation and perception (Parasuraman et al 1985). Service quality has been the subject of concentration for academic and business contest as organizations have increasingly paid more interest to the quality of services they delivered to the customers. It is the moral responsibility of everyone in the supply chain to give their best service quality as it is very easy to calculate the loss due to poor sale but it is impossible to calculate the loss due to poor service quality. There are several reasons why customers must be given best service quality. Most important of them are:

- Industry has become so competitive that customers now have a variety of alternatives, if the customer is lost, it can be extremely difficult to win back the individual.

- Most customers do not complain when they experience the problems. These customers simply opt out and take their business elsewhere (Lovelock et al 2008).

1.2 INTRODUCTION TO SUPPLY CHAIN

Enterprises are continuously paying attention in responding to the customer demand for maintaining competitive advantage over their rivals. Supply Chain Management (SCM) has gained attention as it focuses on material, information and cash flows from vendors to customers or vice-versa (Gupta & Singh, 2012). Supply chain management (SCM) has been considered as the most popular operations strategy for improving organizational competitiveness in the twenty-first century (Gunasekaran et al, 2008). A supply chain is an integral process where in raw material is manufactured in to final product & delivers to customer through distribution channel (Beamon, 1999). Supply chain management is a degree to which a manufacturer strategically collaborates with its supply chain partners and collaboratively manages intra and inters organizational process, in order to achieve effective and efficient flow of products and services, information, money and decisions to provide maximum value to the customers (Flynn et al, 2010). Supply chain management is a big umbrella under which suppliers of supplier to end users are there. It consists of all parties which are directly or indirectly involve in fulfilling the customer's request. Everyone is a customer of its upstream so customer focus & customer satisfaction are the main key issues of supply chain management. Viewed from customer's side it is the quality of product, value for money & post sales facilities (Grover et al 2004). A key feature of present day business is the idea that it is the supply chains that compete, not companies and the success or failure of supply chains is ultimately determined in the marketplace by the end user i.e. consumer. As competition moves beyond a single firm into supply chain, focus is shifting from management of internal practice alone (Kaynak & Hartley 2008). Demanding competition in today's global markets, introduction of products with short life cycles, and the discriminating expectations of customers have forced organizations to invest in, and focus attention on supply chains as system which is affected by the environment. Supply chain management has increasingly become an inevitable challenge to most companies to be continuously survived and prospered in the global chain-based competitive environment.

The new age customers want customized products according to their tastes like automobile color, interior, audio system, etc. The customer behavior implies that dealers and manufacturers have to maintain adequate inventory to satisfy the customer (Mangal & Gupta, 2012). To improve profitability and efficiency, industries are seeking ways to achieve operational excellence, reduce operating cost and enhance customer service through efficient supply chain management. Supply chain management is a network of facilities that produce raw materials, transform them into intermediate goods and then final product and deliver the product to customer through a distribution system (Lee & Billington 1995). Supply chain management can also be defines as a hierarchical and strategic approach to planning supply and demand, sourcing raw materials and components, making products and parts, tracking inventory and order fulfillment, and delivering to the customer and end user (Chow et al 2008).

The ultimate aim of supply chain management is to satisfy the customer at optimum cost (Shah & Shrivastava 2012 & Kulkarni 2005). Due to globalization, liberalization and advancement in new technologies supply chain has become more complex, more global and a more critical business function than ever before (Shah & Shrivastava 2012).

1.3 DRIVERS OF SUPPLY CHAIN

The management of supply chain and the role and responsibilities of various persons involved varies from industry to industry. Due to which supply chain management has become a vital issue for manufacturing organizations, professionals and researchers. Also to survive in today's cut throat competition and to respond to the customer's demands, organizations have no choice other than to offer high quality product and services. It is felt that to manage the supply chain effectively, entire structure of supply chain must be understood properly.

The introduction of the term supply chain management (SCM) was in 1982 (Oliver and Webber, 1992). It has received ever-growing interest both in the literature as well as from industrial practice. A supply chain is a system of organizations, people, technology, activities, information and resources involved in moving a product or service from supplier to customer. Supply chain activities transform natural resources,

raw materials and components into a finished product that is delivered to the end user i.e. customer.

Supply chain management integrates suppliers, manufacturers, distributors, retailer and customers through the use of information technology to meet customer expectations efficiently and effectively. The main drivers of supply chain management are supplier, organization, distributor, retailer and customer. Organization has larger size and expending capacity among all these. Organization is the main driver which selects always its upstream and downstream except the customers i.e. end users. Customer is the king of market and main driving force. Fig. 1 shows the drivers of supply chain management. It shows that product moves from supplier to customer after value addition at every level while finance move from customer to supplier and every driver keeps its part.

Supply chain management constitutes the series of interdependent upstream, manufacturing and downstream processes targeted at transforming raw materials into products to meet customer demand. A supply chain is an inter-linked set of relationships connecting customer to supplier, perhaps through a number of intermediate stages such as manufacturing, warehousing and distribution. The supply chain consists of suppliers, manufacturing centers, warehouses, distribution centers, and retail outlets, as well as raw materials, work-in-process inventory, and finished products that flow between the facilities. Supply chain management is a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that product can be produced and distributed in the right quantities, to the right locations, and at the right time, in order to minimize system wide costs while satisfying service level requirements. Supply chain management revolves around efficient integration of suppliers, manufacturers, warehouses, and stores. It encompasses the firm's activities at many levels, from the strategic level through the tactical to the operational level.

1.4 INTRODUCTION TO SERVICE QUALITY

Service quality is a combination of two words – service and quality. Service may be considered as intangible activities which gives satisfaction to the customer, which also depends on the presentation of service. Service has been defined in various ways. Service may also be considered as intangible offer for making owner ship of any

tangible thing. In developing country like India service sector play a great role in economic growth. Service sector include those activities which consume at the time of production and cannot be stored and their output is not physical.

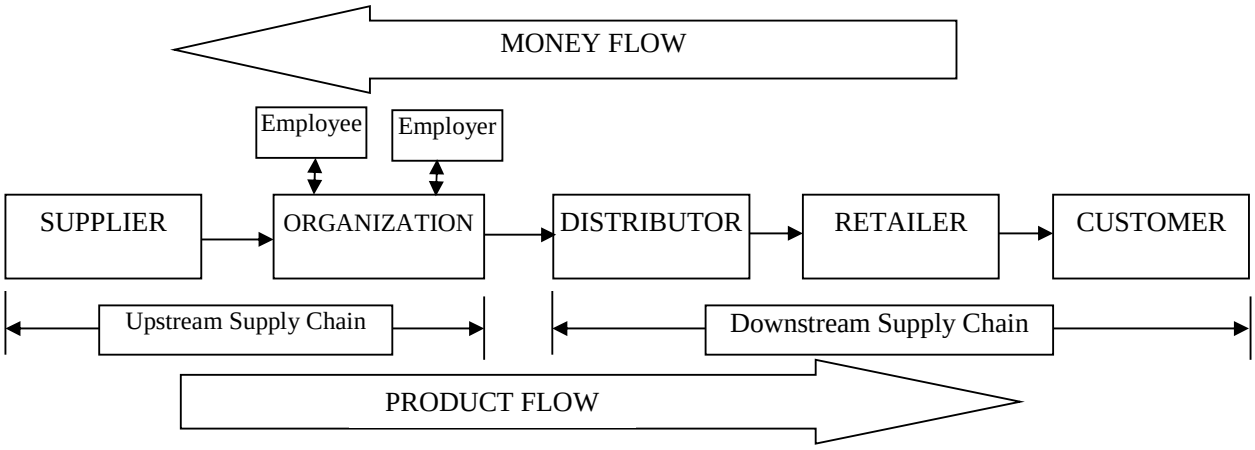


Fig. 1.1 Drivers of Supply Chain

Service gets highly influenced by four factors.

1. The immediate response of service provider.
2. The time and way of the delivery of service.
3. The behavior of the service provider
4. The knowledge and skill of the service provider

Services may be considered of four types: business, infrastructure, administration and social or personal. In every types of service, certain minimum basic requirements are needed which must be fulfilled. These basic requirements are better known as quality. Therefore, service quality may be defined as a number of inter-related factors together with the way in which individuals are treated by providers, the scope of services and contraceptives available to clients, the quality of the information provided to the clients and quality of the counseling skills, the promotion of individual choice, the technical competence of providers, and the accessibility and continuity of services. Service quality refers to collective effort of service performance, which determines the degree of satisfaction of user of all the services. The degree of consumer satisfaction bears a direct relationship with quality of service

where good quality of service gives better customer satisfaction and bad quality of service lead to dissatisfaction of the customers (Ramanigopal & Mani, 2011).

1.5 SIGNIFACNCE OF SERVICE QUALITY IN SUPPLY CHAIN

After the adopting the liberal financial policy by India in 1991, growth of industrial sector became many fold. In this growth the old traditional method of quality measurement was replaced by new methods. Up to the late 80's most of the customers wanted low cost of goods and services, but now large number of customers demand for good service quality with good product. So service quality has become an important issue.

There is consensus in the marketing literature that better service quality is a critical success factor in this era of intense competition. Service quality's conceptual and empirical link to customer satisfaction has turned it into a core marketing instrument (Venetis and Ghauri, 2004). Curiosity over the measurement of service quality is therefore high and researchers have devoted a great deal of attention to service quality research (Abdullah, 2006). Relationship of service quality with improved supply chain performance is widely accepted (Mentzer et al., 1999, 2001; Perry and Sohal, 1999) because satisfaction of each member of the supply chain can be increased only by putting aside the traditional arms-length relationship and by developing closer partnership type arrangements (Christopher, 2004). In the development of such partnership type arrangements, service quality is an important tool. Regardless of this universal recognition for realizing the importance of service quality in supply chains, it is little researched (Nix, 2001).

The following terms are frequently used in this research work

Supplier – It is the firm who supplies the goods or services directly to organization.
Organization – It is the focal firm who design and manufactures the product and considered for study.
Distributor – It is the firm which receives the product / service from organization & distributes to retailers.
Retailer – It is the firm which receives the product / service from distributor & sells the product to customer as per requirement.

Customer – It is the one who actually receives the product / service for its own use or it is the end user.

Supply chain – It relates the combination of all five components discussed above in a manner like supplier - organization – distributor – retailer – customer.

Several authors (Sinha and Babu, 1998; Perry and Sohal, 1999; Seth et al. 2006a) have attempted to expand the hypothetical sphere of service quality, however, there have been very few studies on the discussion of the measurement of service quality in supply chains, especially in manufacturing supply chain. As service quality in intangible and unique for every customer in nature, it cannot be calculate exactly, so an index value can be calculated.

Here it is necessary to mention that service quality is different than product quality as service is the conducive environment for individual while the product quality is maintained by the parent organization. Table 1.1 discussed the difference between the product and service.

Table 1.1: Difference between product and service orientations

Product	Service
The customer always owns the object due to tangible in nature	The customer only owns the memory with experiences which cannot be sold or passed on due to intangible in nature
The goal is always to produce uniformity in product	The goal of service is generally uniqueness
A product can be put into inventory	A service cannot be stockpiled
The customer is an end user who is not involved in the production process	The customer is a co-producer who is also a partner in creating the service
A defective product can be recalled or rejected	A bad or defective service cannot be recalled
Product can be touched	Service is a feeling.
Product can be transport from one place to other	Service cannot be transport

1.6 SERVICE QUALITY IN SUPPLY CHAIN IN MANUFACTURING INDUSTRY

According to Lokyer and Oakland (1987) the manufacturing and service sector have similarity in operations and the majority of operations combine aspects of both goods and services. They concluded that a distinction between services and manufacturing is untenable on close examination and that although processes may appear different when the end product is a service rather than goods. They are in fact identical, in that both involve the use of facilities to act on inputs to satisfy the needs of the customer.

1.7 MOTIVATION FOR RESEARCH

Service quality has become an important issue since last four decades. Earlier Indian manufacturing organizations was in dormant stage and shielded by Government of India by policy of reservation, quota and license etc., but the globalization had opened new market and challenges. Now, every organization focused on the service quality and wants to improve the same. A lot of work has been done on service quality and some of its factors as indicated by the available literature. Some articles were search on the internet (www.googlescholar.com) for different issues, results of which is shown in table 1.2.

Table 1.2: Results of internet search

Search issue	Search results as on 01.01.2016
Service quality in Supply chain in manufacturing industry	2*
Service quality in supply chain	175
Service quality	918000
Supply chain	1060000
Competitiveness	1570000
Customer satisfaction	785000
Customer loyalty	159000

* Articles from present thesis

The motivation to carry research on “Development of system based model to measure the service quality in supply chain” especially in manufacturing industry is due to following gaps identified in the literature.

- There are few studies that have been devoted to the analysis of "service quality in supply chain" (refer table 1.2) especially with manufacturing which indicates the lack of systematic effort in studying various aspects of service related issues in Indian context.

- Though, there are many qualitative studies on performances measurements (frames works, guidelines, reviews etc.) but no study has focused on measuring the service quality in a quantitative frame work based on supply chain orientation.

- Much of the research in service quality has focused on exploring relationships between few intangible factors (service quality, satisfaction and loyalty) on different service sectors, except for manufacturing sectors.
- There does not appear a systematic effort to study upstream, organizational and downstream issues to investigate impact of service quality in supply chain.
- Most of the researchers considered only few factors to discuss the service quality. There is no available literature which considers the tangible and intangible factors both to measure the service quality.
- Most of the researchers discussed the various techniques which can be used to compare the factors or some techniques which can be used to find an index value, but none of them have been applied to find the value of service quality in supply chain in manufacturing industry in quantitative form.

1.8 OBJECTIVES OF THE RESEARCH AND METHODOLOGY USED

The main objectives were identified for the present research:

1. To understand the importance of service quality in supply chain.

2. To identify the factors that affect service quality at various levels in supply chain i.e. Supplier – Organization – Distributor – Retailer – Customer.

3. End development of methodology for identification and measurement of supplier – organization –distributor – retailer and customer service quality in supply chain.

4. Development of a suitable model for establishing the links between service quality, satisfaction & locality in the context of Supply Chain.

5. End development of methodology for identification supply chain performance measure.

Based on the objectives of the research, extensive literature survey, discussion with professionals, academia, senior and experienced persons at every stage of supply chain i.e. Supplier – Organization – Distributor – Retailer – Customer were conducted. The findings of available literature and discussions with various persons are the factors which affect the service quality at different level and presented in a tabular form. A questionnaire was also designed for each level in consultation with experts to find the service quality of the supply chain in manufacturing industry. The reasons for choosing the field survey to fill the questionnaire were following:

- Selected supply chain was a leading two wheeler manufacturing organization of North India.
- Questionnaire technique is quiet simple, easy to understand and less time consuming.
- In India, people don't want to read in detail the things which do not give him anything of their interest.

Various responses were collected and analyze through the various techniques like Graph theory, ANN, FGT etc. to calculate the value of service quality index in numerical form for the entire supply chain. Some time it was necessary to get some data from experts, the brain storming sessions were conducted.

1.9 DEMARCATION OF THE STUDY

The proposed research has been to consist of the eight chapters. A brief outline of the chapters is given as under:

Chapter-1: Introduction

This chapter will discuss the importance of service quality and supply chain. The difference between service quality and product quality and various definitions of service quality will also be discussed followed by the need to study the service quality in supply chain in manufacturing industries.

Chapter-2: Literature Review

The relevant literature published in various reputed journals since 1975 were reviewed in search of different methods developed by researchers for service quality evaluation in different domain.

Chapter-3: Determinants of Service Quality

This chapter focuses on the determination of various factors which affect the service quality in supply chain management based on relevant literature and discussions from academia and industry experts. All the identified factors are grouped, defined and discussed in detail.

Chapter-4: Research Methodology

This chapter discusses the methodology in terms of the research design, questionnaire design, methods of data collection and the analysis of data. The pre-testing of the questionnaire, its validity and reliability, and the techniques used for analysis of the final data are outlined.

Chapter-5: Measurement of Service Quality of Different Levels

In this chapter, the service quality of all the five levels i.e. supplier, organization, distributor, retailer and customer has been calculated individually. The service quality of supplier has been calculated by using Graph Theoretic Approach. The service quality of organization has been calculated by Artificial Neural Network. The service quality of distributor, retailer and customer has been calculated by Fuzzy Graph Theoretic Approach.

Chapter-6: Assessing Service Quality of Supply Chain

This chapter will present a model linking supplier, organizations, distributor, retailer and customer. The overall service quality index of supply chain has been calculated with the help of Graph Theoretic Approach. Also maximum and minimum value of overall service quality index has been calculated.

Chapter-7: Assessment of Supply Chain Performance Indictors

In this chapter, a model having relation between service quality, customer satisfaction and customer loyalty has been developed. Further the model has been analyzed by AMOS v 20. An attempt has been made to find out the customer satisfaction and customer loyalty of existing supply chain.

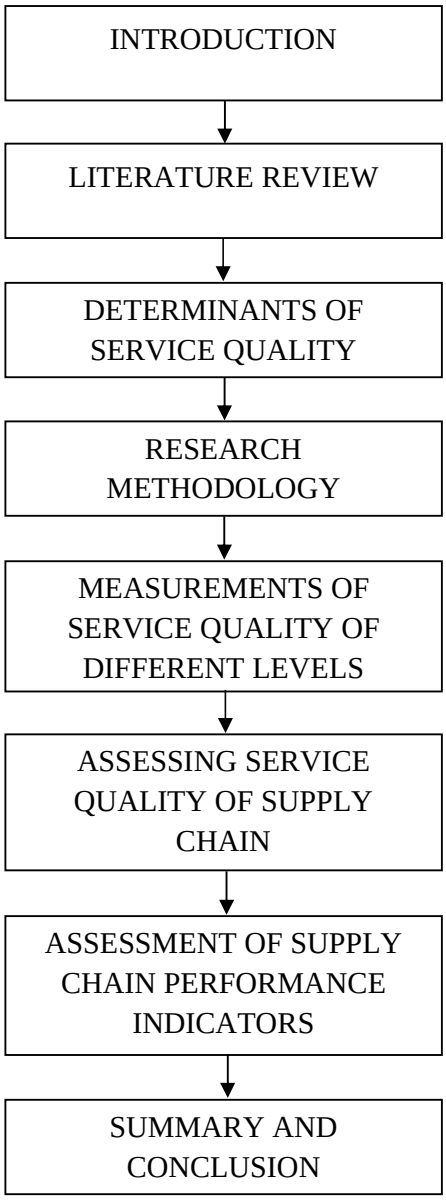


Fig. 1.2 Demarcation of proposed study

Chapter-8: Summary and Conclusion

This chapter will present the key result discussion along with significant contributions and limitations of the research. Implications for both academicians and professionals are also spelt out.

Fig. 1.2 depicts the study of all eight chapters.

CHAPTER-II LITERATURE REVIEW

2.1 INTRODUCTION

This chapter presents a review of literature available in journals, books and conferences. A large number of articles have been published since last forty years in the area of service quality, but the topic is still under research considerable and debate.

The considered research papers in this study are from 1975 to till date. It has been observed that majority of the papers in service quality have been published in journal of service research , International journal of Quality and Reliability management (IJQRM), International Journal of Physical Distribution and Logistics management (IJPDLM), Journal of Operational Management (JOM) , Journal of Industrial Engineering, Harvard business Review (HBR), Production and Operations Management (POM), International Journal of Logistics Systems and Management (IJLSM), International Journal of Production Research(IJPR), International Journal of Service Industry Management (IJSIM), Journal of Retailing , Managing Service Quality (MSQ) etc.

2.2 LITERATURE REVIEW

Whilst there has been considerable progress as to how service quality should be measured, there is little advancement as to what should be measured? Researchers generally have adopted one of two perspectives. These perspectives are the "Nordic perspective" and the "American perspective" (Brady and Cronin, 2001). The "Nordic perspective" was proposed by Gronroos (1984) and the "American perspective" was proposed by Parasuraman *et al.* (1985, 1988). In the "Nordic perspective", Gronroos (1984) identified two dimensions of service quality (technical quality and functional quality). He defined technical quality as "what the consumer receives as a result of interactions with a service firm" and identified employees technical ability, employees knowledge, technical solutions, computerized systems and machine quality as its five attributes. He defined functional quality as "the way in which the technical quality is transferred" and identified behavior, attitude, accessibility, appearance, customer contact, internal relationships, service-mindedness as its seven attributes. He concluded that the technical and functional quality of service built up the corporate

"image" of the company. The "Nordic perspective" of service quality was the first to be published in scholastic literature. However, the first seriously dedicated program of research to answer the questions "what's the best way to define service quality?" and "what's the best way to measure it?" was launched by Parasuraman *et al.* (1985,1988) (Schneider and White, 2004). This program developed the "American perspective" of service quality. Parasuraman *et al.*(1985) built up a 34-item service quality scale comprising ten dimensions (reliability, responsiveness, competence, access, courtesy, communication, credibility, security, understanding/knowing the customer and tangibles). Subsequent work by Parasuraman *et al.* (1988) resulted in the service quality measurement scale with 22-items on five dimensions. The dimensions reliability, responsiveness and tangibles were retained as identified in 1985 whereas communication, competence, credibility, courtesy and security merged as a new dimension "assurance". Access and understanding / knowing the customer merged to form the dimension "empathy". Parasuraman *et al.* (1988) codified this scale as SERVQUAL and defined its 5 dimensions as:

Tangibility: Appearance of physical facilities, equipment and communication material.

Reliability: Ability to perform the promised service dependably and accurately.

Responsiveness: Willingness to help customers and provide prompt service.

Assurance: Knowledge and courtesy of the employees and their ability to convey trust and confidence.

Empathy: The caring and individualized attention, organization provides to its customers.

While there is no global consensus that either the "Nordic perspective" or the "American perspective" is the more appropriate approach, the "American perspective" dominates the literature (Schneider and White, 2004) because the development of the "American perspective" generated a "cottage industry" of replicative studies in various conditions, sectors and countries. Parasuraman *et al.* (1988) claimed that the five dimensions and 22 items proposed in their "American perspective" are generic in nature and applicable to all service organizations. However, the service quality measurement scale developed by Parasuraman *et al.* (1988) has been the subject of criticism since its development (Johnston, 1995). Buttle (1996) provides a detailed critique of the issues surrounding the five dimensions of the Parasuraman *et al.* (1988) service quality scale, mainly on the basis of number of

dimensions and contextual stability. Carman (1990) was first researcher who found that the five dimensions of service quality measurement scale proposed by Parasuraman *et al.* (1988) are not so generic that users should not add new dimensions they believe are important. He found that if a dimension is extremely significant to customers it is possible to be decomposed into a number of sub-dimensions and vice versa. Babakus and Boller (1992) also empirically assessed the scale proposed by Parasuraman *et al.* (1988) and suggested that the number of service quality dimensions is dependent on the service being offered. Mukherjee and Nath (2005) stressed that performance of a service organization on all the dimensions of service quality may not always move in the same direction. Seth *et al.* (2006) concluded that there seems to be no agreement on the measurement side (attributes) of service quality because different researchers propose different attributes for different applications. Chowdhary and Prakash (2007) also report variations from unidimensionality to two, three, four, six and even eight factor structures in the previous service quality studies. Next is the issue of contextual stability. Cronin and Taylor (1992) suggest flexibility in the Parasuraman *et al.* (1988) service quality measurement scale items and argue that high involvement services such as healthcare or financial services have different service quality items than low involvement services such as fast food or dry cleaning. Researchers must also therefore consider the individual items of service quality for each service industry. Cronin and Taylor (1992) developed a new scale to measure the service quality which was known by SERVPERF. The difference between the SERVQUAL and SERVPERF that former was based on expectation and perceptions while later was only performance based. Both scales were used by the researchers for measurement of service quality. Brady and Cronin (2001) also suggested that from a theoretical perspective, even if the five service quality dimensions proposed by Parasuraman *et al.* (1988) are generic, something specific must be reliable, responsive, empathetic, assured and tangible. To identify this "something" for each context is critical.

Moreover, this scale was developed in Western culture so its contextual stability across diverse cultures is also an issue (Parikh, 2006). Based on Hofstede's dimensions of culture, Donthu & Yoo (1998) studied the effect of culture on consumer service quality expectations and concluded that as a consequence of cultural orientation, consumers differ in their overall expectations with regard to service quality dimensions. On the basis of this literature review, it may therefore be

concluded that despite the fact that the "American perspective" dominates the service quality literature and many service quality studies are based on the service quality measurement scale proposed by Parasuraman et al. (1988), there is actually no generic scale for measurement of service quality. There is no universal set of dimensions and items that determine the service quality across a section of service industries in different cultures, so service quality measurement must be adapted to fit the context. Therefore, there is a need for the development of context specific service quality measurement scales. Such context specific service quality measurement scales may help managers to gauge, manage and improve service quality in particular sectors with more simplicity and effectiveness. In today's global marketplace, individual firms no longer compete as independent entities but compete as an integral part of supply chain links (Seth et al. 2006). Christopher (1992) also argued that a key aspect of business is that supply chains compete, not companies. According to Waters (2003), organizations do not work in isolation; they act as a customer, not the end user, when buy materials from their own suppliers and act as a supplier when they deliver materials to their own customers. A wholesaler for example acts as a customer when buying goods from manufacturers, and then acts as a supplier when selling goods to retailers. It is important to satisfy each member of the supply chain. There is a change in the landscape of supply chain management in recent years and satisfaction of each member of the supply chain can be increased only by putting aside the traditional arms-length relationship and by developing closer partnership type arrangements (Christopher, 2004). In the development of such partnership type arrangements, service quality is an important tool because the relationship of service quality with improved supply chain performance is widely accepted (Mentzer et al., 1999, 2001; Perry and Sohal, 1999). Regardless of this universal recognition for realizing the importance of service quality in supply chains, it is little researched (Nix, 2001). Most of the previous service quality research has been aimed at the end-use customer (Faulds and Mangold, 1995; Perry and Sohal, 1999). There have been very few studies on the development of service quality measurement scales in supply chains (Beinstock et al. 1997; Mentzer et al. 1999, Rafele, 2004). These few studies are also confined to specific sectors and are based in developed countries. Generalization of findings of these studies in the global economy is not possible without further empirical research (Rafele, 2004). To reduce this research gap, this study is focused on service quality scale development at the supplier- organization-

distributors-retailers and customer (i.e. end user) interface of the industrial supply chains in India. This interface is chosen as it has many no contractual dimensions in contrast to supply chains which is frequently characterized by contractual agreements (Mangold and Faulds, 1993). India (a developing country) is selected for this study because little work has been done to examine the applicability of service quality measurement scales to the service industries in developing countries (Jain and Gupta, 2004). The authors could find no studies on the development of supply chain specific service quality measurement scale studies in any of the developing countries. The aim of this research is to develop a scale for the measurement of service quality in the supplier- organization- distributors-retailers and customer (i.e. end user) interface of industrial supply chains using India as the context. This research will contribute to reduce the current lack of supply chain specific service quality scale development studies. It extends supply chains specific service quality scale development research into developing countries and into a new sector (supplier- organization- distributors-retailers and customer (i.e. end user) interface of industrial supply chains). The scale developed as an outcome of this research will assist managers in industrial distribution companies in India to gauge, manage and improve service quality.

2.3 SERVICE QUALITY LITERATURE CLASSIFICATION

Service quality and its impact on business is very hot and most discussing topic among the professionals and academicians. But, there is meager attention of researchers in measuring the service quality in manufacturing context.

Gupta and Singh (2017) discussed that customer is the king of market and decide the future of any product and organization. For any organization it is necessary to satisfy the end users i.e. customer. Even after designing and manufacturing a good vehicle, it is difficult to sale without providing good service quality and customer satisfaction. So it is utmost important to maintain the service quality as good service quality helps to increase the customer base. In this context, the service quality literature is classified to provide a clear understanding of its different aspects. The main objectives are to understand the available literature and identify the gaps areas. In this context the literature is classified in figure 2.1

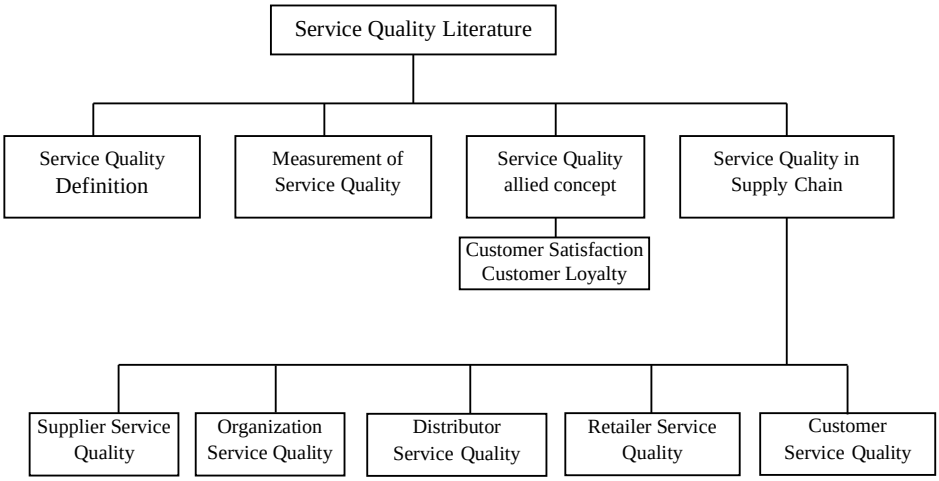


Fig. 2.1 Classification of service quality literature

2.4 SERVICE QUALITY DEFINITIONS

The word service quality was introduced in 1975 but its scientific form was initially discussed by Lewis and Booms (1983) and it gain momentum after the pioneer work of Gronroos (1984) and Parasuraman at al (1985). The literature is very rich in terms of definitions. Some of the important definitions of service quality from the literature are presented in table 2.1.

Table 2.1: Definitions of service quality

S.No	Author (Year)	Definitions
1	Lewis and booms (1983)	How well the service level delivered matches the customer's expectations.
2	Gronroos (1984)	Service quality is an outcome of an evaluation process where the consumer compares his expectation with the service he perceiver he has received.
3	Parasuraman at al (1985)	Service quality can be defined as the comparison between customer expectation and perceptions of service
4	Parasuraman at al (1988)	Service quality can be defined as the global judgment or attitude relating to the superiority of service
5	Zeithaml (1988)	Service quality can be defined as the customers judgment about superiority or excellence of a product

6	Berry et al (1989)	Service quality is the conformance of services to customer specifications
7	Bitner et al (1990)	Service quality is the overall impression of relative inferiority/superiority of the organization and its services to the consumers.
8	Christopher et al. (1993)	Service quality is the ability of the organization to meet or exceed customer expectations.
9	Zeithaml and Bitner (1996)	Service quality can be defined as the delivery of excellent or superior service relative to customer expectations.
10	Seth et al. (2002)	Service quality in supply chain can be defined as the difference between the expectation and perception at each level within supply chain and for the chain as a whole.
11	Singh et al (2007)	Service quality is a measure of how efficiently the total service package meets customer's expectations

Table 2.1 clearly shows that researchers are not agreed on a single definition. Further the focus of researcher shift from just to discuss the service quality to measurement of service quality. Also, attention of measurement of service quality moved from service industries to supply chain. Service quality in supply chain can be defined as how well an organization meets or exceeds the customer's expectation in unidirectional or bidirectional for each driver of a supply chain i.e. supplier, organization, distributor, retailer and customer or end user.

2.5 MEASUREMENT OF SERVICE QUALITY

Measurement of service quality is a difficult task as it possesses some unique characteristics like intangibility, perish ability and inseparability. However many researcher have attempt to measure the service quality for different industries and with different perspectives. Initially, Gronroos (1984) measured the service quality by identifying three factors of service quality and collect the data from 219 organizations included banks, insurance sector, hotels, restaurants, shipping, airline, cleaning and maintenance, car rental companies, travel agencies, engineering consultants, architects, business consultants, advertisement agencies and some public sector firms

and concluded that word of mouth is an important factor and should not be under estimated.

Parasuraman et al (1985) measured the service quality on the basis five dimensions of proposed gap model and collect the data from 298 organizations included credit card, retail banking, securities, brokerage, product repair and maintenance. They proposed SERVQUAL tool to measure the service quality which is a function of expectations and perceptions.

Haywood- Farmer (1988) identified that a service organization has high service quality if it meets customer preferences and expectations consistently.

Cronin and Taylor (1992) argued the presence of expectation dimension of SERVQUAL and introduced SERVPERF which was a performance only model and used the same to measure the service quality by collecting the data from 660 customers of banks, pest control, dry cleaning and fast food.

Mattson (1992) and Oh (1999) each measured the service quality of luxury hotels. Teas (1993) measured the service quality of departmental stores. Dabholkar (1996), Spreng and Mackoy (1996), Dabholkar (2000) and Smith and Ennew (2001) computed the service quality of educational organization. Sweeney et al (1997) computed the service quality of electrical stores. Frost and Kumar (2000) measure the service quality of Singapore airline. Soteriou and Stavrinides (2000), Broderick and Vachirapornpuk (2002) and Zhu et al (2002) measured the service quality of banks from different perspectives. Many more studies (Kang and James 2004, Chen et al 2011, Gupta 2012, Das 2014 etc.) were focused only service industries.

There were only few studies which measure the service quality of supply chain. Seth et al (2006 a ,b) and Prakash (2011) compute the service quality of supply chaining . Former studies were focus on logistic supply chain while later on manufacturing supply chain.

Summarizing the available studies of measurement of service quality, it can be revealed that there are mainly two types of methodologies. First, which give some empirical models and tools and second, the empirical analysis and experimentation of the model developed by other researchers.

2.6 SERVICE QUALITY ALLIED CONCEPT

Today high customer satisfaction is the key issue and a great challenge for the organizations. The customer satisfaction is a result of customer expectation and perceived performance of product/service, which is necessary not only to retain the existing customer but also to attract the new customer through word of mouth. A highly satisfied customer not only purchases the service or product from same organization, also refer the other people to the organization through word of mouth for purchasing the service or product. The main key of customer satisfaction is excellent service quality. Good service quality leads to customer satisfaction.

When a satisfied customer engage itself in the repurchasing the product or services from the same organization, the customer is said to be loyal. Organizations are spending millions of dollar to improve the service quality to make the customer loyal. Customer loyalty is one of the major sources of sustaining for service providing organizations (Bhardwaj et al, 1993). Researchers are now exploring and analyzing the relation between the service quality, customer satisfaction and customer loyalty and measuring the customer satisfaction and customer loyalty. Customer satisfaction can be checked through survey while customer loyalty can checked through repurchase the product/ service or referred someone to purchase the product /service from the organization.

2.7 SERVICE QUALITY STUDIES IN INDIA

There is no lagging in India for the study of service quality. Though concept of service quality and research on service quality introduced very late in India, but now it is very focal and hot topic for research and discussion. Table 2.2 depicts some of the key service quality studies in India.

Table 2.2: Service quality studies in India

Sr. no.	Author (year)	Focus Area
1	Sinha and Babu (1998)	Developed Depot Service Index to measure the customer service quality
2	Madhukar et al. (1999)	Measure the service quality of banks
3	Sinha and Ghoshal (1999)	Indian steel industry
4	Sureshchander et al. (2001)	Service quality of bank
5	Banwet and Datta (2002)	Service quality of library

6	Malhotra et al. (2005)	Service quality of bank
7	Banerji et al. (2005)	Service quality of various service sectors
8	Mukharjee and Nath (2005)	Service quality of bank
9	Seth et al. (2006)	Service quality in manufacturing industries
10	Hazra and Srivastava (2009)	Service quality of bank
11	Parkash and Shanker (2009)	Service quality in manufacturing industries
12	Jain et al. (2012)	Service quality in technical education
13	Gupta and Datta (2012)	Service quality at Indian railway station
14	Das and Pandit (2014)	Service quality of bus transit service
15	Sharma and Kaushal (2014)	Service quality in Management education
16	Pandit and Balyan(2016)	Service quality in Indian banks

Table 2.2 depicts the few selected service quality studies which takes place at doctorate or post graduate level, though there may be some other studies available in various organization/ institutions.

2.7 GAPS IN LITERATURE

After referring a large number of research papers, doctoral and postgraduate thesis following gaps were identified during the study of literature

1. There are a lot of studies devoted to service quality from different perspective, few of them have been devoted to service quality of supply chain specially in manufacturing.
2. There is a lack of systematic study in India to measure the service quality of supply chain in manufacturing.
3. There are no studies which consider the all five drivers i.e. supplier, organization, distributor, retailer and customer for service quality of supply chain.
4. There are no studies which assess the service quality of all the five drivers i.e. supplier, organization, distributor, retailer and customer individually in a single study.

5. There are no studies which assess the service quality of complete supply chain based on the all five drivers.
6. There are no studies available which use different multi attribute decision making (MADM) techniques to assess the service quality of all five drivers and complete supply chain.

2.6 CONCLUSION

This chapter discussed various studies for service quality across the globe and in India. Review of existing literature on service quality highlight the need to identify the various factors which affect the service quality in supply chain for different drivers for a specific sector (manufacturing of automobile vehicle – specifically two wheelers in present research). An attempt has been made to identify the gap in literature which are very crucial and provide a better scope to discuss the service quality in supply chain in a different manner.

CHAPTER-III

DETERMINANTS OF SERVICE QUALITY IN SUPPLY CHAIN

3.1 INTRODUCTION

The first step of assessment of service quality of supply chain is to identify the determinants. The present study is focused with the overall assessment of service quality in supply chain, the search for various determinants related to the service quality that have influence on the service quality of supply chain. The environment in an organization must reflect its effort to achieve its objectives (Grover et al, 2004). It is the supply chain management environment, which help to implement the supply chain management function & achieve success.

3.2 IDENTIFICATION OF FACTORS

Extensive literature on supply chain management for the last four decades has motivated various researchers to identify & classify service quality of supply chain factors based on literature review. Beamon (1999) discussed & listed five factors to measure the supply chain performance. Kaynak (2003) identified ten factors which further modified by eleven and establish the relationship among them. Petersen et al (2003) discussed five factors. Gunasekaran et al (2005) classify the four categories of factors which further sub divide into twelve factors and a framework was developed & discussed. Li et al (2006) found mainly three factors which further subdivide into twelve factors. Kaynak & Hartley (2008) identified eight factors which affect the supply chain management and established the relation between them. Wu et al (2012) discussed twelve factors for hi-tech industries of Taiwan and found that there is a positive relationship between trust & commitment.

A large no. of papers has been referred for identification of factors. The various factors which help in creating a supply chain management environment, will lead to mathematical complexity in the analysis, these are identified and grouped under four broad categories as shown in table 3.1.

Table 3.1: Factors affecting the service quality of manufacturing organization

Group	Factors
Supplier	**Strategic Supplier Partnership** Balsmeier & Voisin 1996, Jacobson & Aaker 1987, Li et al 2002, Monczka et al 1998, Narsimhan & Jayram 1998, Noble 1997, Sheriden 1998, Spekman et al 1998, Stuart 1997, Yoshino & Rangan 1995, Zylbersztajn & Filho 2003, Li et al 2005, Flynn et al 1994, Lamming & Hampson 1996, Buzzell et al 1975, Li et al 2006
	Supplier quality Management Feigenbaum 1982, Juran 1986, Deming 1986, Garvin 1988, Saraph et al 1989, Deming 1993, Flynn et al 1994, Crosby 1984, Mohrman et al 1995, Powell 1995, Ahire et al 1996, Black & Porter 1996, Easton & Jarrell 1998, Forza & Flippini 1998, Dow et al 1999, Das et al 2000, Wilson & Collier 2000, Ho et al 2001, Kaynak 2003
	Supplier Performance Seth et al 2006, Viswahadham 2000
	Faster Response time Kocoglu et al 2011
	Trust on Trading Partner Achim & Ritter 2003, Anderson & Narus 1990, Crotts et al 2001, Ruyter et al 2001, Ganesan & Shankar 1994, Handfield & Nicholas 1999, Kumar et al 1995, Mariotti 1999, Monczka et al 1998, Moorman et al 1992, Morgan& Hunt 1994, Spekman et al 1998, Tan et al 1998, Li et al 2006, Abdullah et al 2012, Dominic et al 2013
	Commitment of Trading Partner Achim & Ritter 2003, Balsmeier & Voisin 1996,Burnell 1999, Crotts et al 2001, Ruyter et al 2001, Hamel & Prahalad 1989, Handfield & Nicholas 1999, Kumar et al 1995,Lee & Kim 1999, Morgan & Hunt 1994, Spekman et al 1998, Tan et al 1998, Li et al 2006, Talib et al 2011
	Quality of Product

	Gunasekaran et al 2001, Harland 1996, Krajewski & Ritzman 2002, Li et al 2002, Luning et al 2002, Li et al 2006
	Safety ABL 2001
	Strategy Elahi et al 2013, Hicks et al 2000
	Procurement Policy Lee & Billington 1993, Hicks et al 2000
	Delivery Coyle et al 2003, Krajewski & Ritzman 2002
	Logistic ABL 2001, Sadler & Hines 2002
	Capacity Krajewski & Ritzman 2002
	Efficiency Li et al 2006
	Flexibility Range Beamon 1999, Chopra & Meindl 2001,Kocoglu et al 2011, Krajewski & Ritzman 2002, Viswanadham 2000, Voudouris & Vasilios 1996, Li et al 2006
	Cost Beamon 1999, Cohen & Lee 1989, Gunasekaran et al 2004, Ishii 1988, Krajewski & Ritzman 2002, Lee & Edward 1995, Newhart et al 1993, Peterson et al 2001, Pyke et al 1994, Towill et al 1992
	Cost of Activity Time Arntzen et al 1995, Beamon 1999
	Resource Utilization Viswanadham 2000
	Quality Data and Reporting Feigenbaum 1982, Juran 1986, Deming 1986, Saraph et al 1989, Deming 1993, Flynn et al 1994, Crosby 1994, Mohrman et al 1995, Powell 1995, Black & Porter 1996, Adam et al 1997, Samson & Terziovski 1999, Wilson & Collier 2000, Douglas & Judge 2001,

	Ho et al 2001, Kaynak 2003	
	Financial Performances Macmillan et al 1982, Philiips et al 1983, Woo & Willard 1983, Cleveland et al 1989, Dess & Robinson 1984, Jacobson & Aaker 1987, Venkatraman & Ramanujam 1987, Keats 1988, Kaynak & Hartley 2008, Parthsarthy & Sethi 1993, Vickery et al 1993, Droge et al 1994, Buzell et al 1975, Zeithaml et al 1981, Ward et al 1994, Li et al 2006, Longo & Mirabelli 2008, Yalcin et al 2012, Teller 2013	
	Inventory Level Viswandham 2000	
	Lean System Li et al 2002, Li et al 2006	
	Quality System Bindon & Jones 2001, Hepner et al 2004, Sadler & Hines 2002	
Organization	**Employer**	**Information Sharing** Balsmeier & Voisin 1996, Berry et al 1994, Childhouse & Towill 2003, Chizzo 1998, Choi & Hartley 1996, Feldmann & Muller 2003, Holmberg 2000, Jones 1998, Kocoglu et al 2011, Lalonde 1998, Lee et al 1997, Li et al 2002, Mason-Jones & Towill 1997, McAdam &McCormack 2001, Mentzer et al 2004, Metters 1997, Moberg et al 2002, Monczka et al 1998, Novack et al 1995, Stein & Sweat 1998, Tompkins & Ang 1999, Towill 1997, Turner 1993, Yu et al 2001, Li et al 2005, Ho et al 2001, Cook et al 2011, Teller 2013
		Information Quality Choi & Hartley 1996, Li et al 2002, Li et al 2006
		Material Flow Information Mohr & Spekman 1994, Nicoll & Andrew 1994, Viswanadham 2000
		Management Leadership

		Feigenbaum 1982, Juran 1986, Deming 1986, Garvin 1988, Kaynak & Hartley 2008, Saraph et al 1989, Flynn et al 1994, Crosby 1984, Anderson et al 1995, Powell 1995, Ahire et al 1996, Black & Porter 1996, Grandzol & Gershon 1997, Rungtusanatham et al 1998, Samson & Terziovski 1999, Wilson & Collier 2000, Douglas & Judge 2001, Kayank 2003
		Cost of Activity Time Arntzen et al 1995, Beamon 1999
		Buy Back Contract Elahi et al 2013
		Efficiency Li et al 2006
		Financial Performances Macmillan et al 1982, Philiips et al 1983, Woo & Willard 1983, Cleveland et al 1989, Dess & Robinson 1984, Jacobson & Aaker 1987, Venkatraman & Ramanujam 1987, Keats 1988, Kaynak & Hartley 2008, Parthsarthy & Sethi 1993, Vickery et al 1993, Droge et al 1994, Buzell et al 1975, Zeithaml et al 1981, Ward et al 1994, Li et al 2006, Longo & Mirabelli 2008, Yalcin et al 2012, Teller 2013
		Inventory Level Viswandham 2000
		Lean System Li et al 2002, Li et al 2006
		Revenue Sharing Elahi et al 2013
		Risk Consideration Hahn & Kuhn 2012, Elahi et al 2013
		Marketing Hicks et al 2000
		Procurement Policy

		Lee & Billington 1993, Hicks et al 2000
		Quality of product Gunasekaran et al 2001, Harland 1996, Krajewski & Ritzman 2002, Li et al 2002, Luning et al 2002, Li et al 2006
		Process Management Feigenbaum 1982, Juran 1986, Deming 1986, Saraph et al 1989, deming 1993, Flynn et al 1994, Crosby 1984, Anderson et al 1995, Mohrman et al 1995, Powell 1995, Ahire et al 1996, Black & Porter 1996, Grandzol & Gershon 1997, Forza & Flippini 1998, Rungtusanatham et al 1998, Samson & Terziovski 1999, Wilson & Collier 2000, Kaynak 2003
		Engineer to order Hicks et al 2000
		Production Planning Beamon 1999, Lee & Billington 1993, Li et al 2005, Hicks et al 2000
		Manufacturing Systems ABL (2001), Bindon and Jones (2001), Hepner et al. (2004), Lee and Billington (1993), MLA (2002, 2004), Spekman et al. (1998), Teller (2013)
		partnership & Collaboration McNeil & Wilson 1997, MLA 2004, Palmer 1996, Sadler & Hines 2002, Spekman et al 1998, Yu et al 2001, Zylbersztajn & Filho 2003, MLA 2002
		Technology & Organization ABL 2001, Palmer 1996,Yu et al 2001
		Strategy Elahi et al 2013, Hicks et al 2000
		Resource Utilization Viswanadham 2000
		Product/ Service Design

		Feigenbaum 1982, Juran 1986, Deming 1986, Garvin 1988, Kaynak & Hertley 2008, Saraph et al 1989, Deming 1993, Flynn et al 1994, Ahire et al 1996, Black & Porter 1996, Adam et al 1997, Easton & Jarrell 1998, Wilson & Collier 2000, Kaynak 2003, Hicks et al 2000.
		Recycling Guide et al 2000
		Environment Friendly Product Guide et al 2000
		Product Development Teller 2013
		Traceability Calder & Marr 1998, Viaene &Verbeke 1998
		Delivery Coyle et al 2003, Krajewski & Ritzman 2002
		Logistics ABL 2001, Sadler & Hines 2002
		Capacity Krajewski & Ritzman 2002
	Employee	**Employee Relations** Feigenbaum 1982, Juran 1986, Deming 1986, Kaynak & Hartley 2008, Saraph et al 1989, Deming 1993, Flynn et al 1994, Crosby 1984, Mohrmann et al 1995, Powell 1995, Ahire et al 1996, Black & Porter 1996, Adam et al 1997, Easton & Jarell 1998, Forza & Flippini 1998, Dow et al 1999, Samson & Terziovski 1999, Das et al 2000, Wilson & Collier 2000, Ho et al 2001, Kayank 2003
		Training Feigenbaum 1982, Juran 1986, Deming 1986, Garvin 1988, Kaynak & Hartley 2008, Saraph et al 1989, Deming 1993, Crosby 1984, Anderson et al 1995,

		Powell 1995, Ahire et al 1996, Adam et al 1997, Grandzol & Gershon 1997, Easton & Jarell 1998, Rungtusanatham et al 1998, Dow et al 1999, Das et al 2000, Douglas & Judge 2001, Ho et al 2001, Kayank 2003
		Safety ABL 2001
		Risk Management Keats 1988, Viswanadham 2000
		Attitude Farmer 1988
		Response Flexibility Beamon 1999, Voudouris & Vasilios 1996
		Flexibility Range Beamon 1999, Chopra & Meindl 2001,Kocoglu et al 2011, Krajewski & Ritzman 2002, Viswanadham 2000, Voudouris & Vasilios 1996, Li et al 2006
		Strategy Elahi et al 2013, Hicks et al 2000
Distributor & Retailer	**Competitive Advantages** Cleveland et al 1989, Handfield & Pannesi 1995, Jones 1998, Kessler & Chakrabarti 1996, Koufteros et al 1997, McGinnis & Vallopra 1999, Nathan 2005, Novack et al 1995, Porter 1985, Rondeau et al 2000, Roth & Miller 1990, Safizaden et al 1996, Skinner 1985, Stalk 1988, Tracey et al 1999, Vesey 1991, Vickery et al 1999, Zhang 2001, Li et al 2006	
	Lead Time Krajewski & Ritzman 2002, Viswandham 2000, Longo & Mirabelli 2008	
	Buy Back Contract Elahi et al 2013	
	Logistics ABL 2001, Sadler & Hines 2002	

	Price Aramyyan 2006, Beamon 1999, Gunasekaran et al 2004, Hall 1993, Li et al 2002, Luning et al 2002, Rondeau et al 2000 , Li et al 2006
	Financial Performances Macmillan et al 1982, Philiips et al 1983, Woo & Willard 1983, Cleveland et al 1989, Dess & Robinson 1984, Jacobson & Aaker 1987, Venkatraman & Ramanujam 1987, Keats 1988, Kaynak & Hartley 2008, Parthsarthy & Sethi 1993, Vickery et al 1993, Droge et al 1994, Buzell et al 1975, Zeithaml et al 1981, Ward et al 1994, Li et al 2006, Longo & Mirabelli 2008, Yalcin et al 2012, Teller 2013
	Capacity Krajewski & Ritzman 2002
	Delivery Coyle et al 2003, Krajewski & Ritzman 2002
	Quality Data Reporting Feigenbaum 1982, Juran 1986, Deming 1986, Saraph et al 1989, Deming 1993, Flynn et al 1994, Crosby 1994, Mohrman et al 1995, Powell 1995, Black & Porter 1996, Adam et al 1997, Samson & Terziovski 1999, Wilson & Collier 2000, Douglas & Judge 2001, Ho et al 2001, Kaynak 2003
	Inventory Level Viswandham 2000
	Efficiency Beamon 1999, Li et al 2006
	Strategy Elahi et al 2013, Hicks et al 2000
	Time to Market Beamon 1999, Gunasekaran et al 2004, Handfield & Pannesi 1995, Kessler & Chakrabarti 1996, Li et al 2002, Luning et al 2002, Stalk 1988, Vesey 1991, Li et al 2005, Li et al 2006
	Sales Growth Aramyyan 2006, Beamon 1999, Gunasekaran et al 2004, Li et al

	2002, Luning et al 2002, Li et al 2006
	Traceability Calder & Marr 1998, Viaene &Verbeke 1998
	Safety ABL 2001
	Profit Sharing Elahi et al 2013
	Attitude Farmer 1988
	Welfare Activity Industry Experts
Customer	**Customer Focus** Feigenbaum 1982, Deming 1986, Garvin 1988, Kaynak & Hartley 2008, Parasuraman et al 1985, Viswanadham 2000, Deming 1993, Li et al 2005, Flynn et al 1994, Mohrman et al 1995, Powell 1995, Ahire et al 1996, Black & Porter 1996, Adam et al 1997, Grandzol & Gershon 1997, Easton & Jarell 1998, Forza & Flippini 1998, Dow et al 1999, Samson & Terziovski 1999, Das et al 2000, Wilson & Collier 2000, Douglas & Judge 2001, Cronin & Taylor 1992, Longo & Mirabelli 2008, Hicks et al 2000, Talib et al 2011,Teller 2013
	Customer Satisfaction Christopher & Martin 1994, Li et al 2002, Viswanadham 2000, Rego et al 2013
	Customer Responsiveness Beamon 1999, Ishii et al 1988, Lee & Billington 1993, Newhart et al 1993, Peterson et al 2001, Towill et al 1992, Li et al 2006
	Customer Relationship Management Claycomb et al 1999, Day 2000, Li et al 2002, Magretta 1998, McNeil & Wilson 1997, Moberg et al 2002, Noble 1997, Tan et al 1998, Verbeke 2000, Wines 1996, Li et al 2006, Prakash 2013
	Faster Response Time Beamon 1999, Kocoglu et al 2011

	Buy Back Contract Elahi et al 2013
	Cost Beamon 1999, Cohen & Lee 1989, Gunasekaran et al 2004, Ishii 1988, Krajewski & Ritzman 2002, Lee & Edward 1995, Newhart et al 1993, Peterson et al 2001, Pyke et al 1994, Towill et al 1992
	Delivery Coyle et al 2003, Krajewski & Ritzman 2002
	Traceability Calder & Marr 1998, Viaene &Verbeke 1998
	Order Fulfillment Teller 2013, Sahoo & Mishra 2013
	Quality of Product Gunasekaran et al 2001, Harland 1996, Krajewski & Ritzman 2002, Li et al 2002, Luning et al 2002, Li et al 2006
	Technology and Organization ABL 2001, Palmer 1996,Yu et al 2001
	Environmental Friendly Product Guide et al 2000
	Society Perceptions Peterson et al 2001

3.3 DESCRIPTION OF THE FACTORS

The various factors have been identified in table 3.1. The detail description of these factors with different perspective are given below

3.3.1 Description of the Factors Responsible for Service Quality of Supplier

The first driver of supply chain management is supplier. A supplier is the person / firm who helps the organization to achieve its goal through on time delivery of quality product in right quantity (Singh et al 2013). The evolution of supplier in the context of supply chain involves measures important at the strategic, operational & tactical level (Gunasekaran et al 2004). The financial position of supplier must be sound enough so that he can enhance economic processes, manage risks & absorb market shocks. Suppliers who had participated early in initial technology sharing discussion, later

contributed to setting goals regarding project outcomes always fulfills his commitment, makes a long-term association (Peterson et al 2003). Supplier plays an important role in assuring that incoming materials are defects free, which means that the buyer does not have to hold as much as safety stock as a contingency in case of defects in incoming materials (Kaynak & Hartley 2008). Various factors which affect the service quality of supplier are discussed as below:

1. **Strategic Supplier Partnership** - Strategic supplier partnership is defined as the long-term relationship between the organization and its suppliers (McNeil & Wilson 1997, Spekman et al 1998). It is designed to leverage the strategic & operational capabilities of individual participating organization to help them achieve significant ongoing benefits (Li et al 206). A strategic partnership emphasizes direct, long term association & encourages mutual planning & problem solving. Strategic partnership with suppliers enables the organizations to work more effectively with a few important suppliers who are willing to share responsibility for the success of the product (Li et al 2006). Jie et al (2007) stated that strategic supplier partnership usually occur with a few major suppliers who are willing to contribute with more responsibility for the success of the product. Strategically aligned organizations can work closely together to eliminate waste effort & time to save money (Balsmeier et al 1996). An effective supplier partnership can be a critical component of a leading edge supply chain (Noble 1997).
2. **Supplier Quality Management** – It is fewer dependable on suppliers, reliance on supplier process control, strong interdependence of supplier and customer, purchasing policy emphasizing quality rather than price, supplier quality control and supplier assistance in product development (Saraph et al., 1989).
3. **Supplier Performance** – Supplier performance can be checked by service delivery, credibility, service completeness and intra-organizational communication (Seth et al 2006). In other words supplier performance is a measurement whether a supplier can fulfill order quantitatively and qualitatively.
4. **Faster Response Time** - When a customer gets response for his query on time, known as faster response time.
5. **Trust on Trading Partner** - It is the willingness to rely on a trading partner in whom one has confidence (Jie et al, 2008). Trust refers to a firm's expectations

that their partners will act to benefit their interest and would not act in an opportunistic manner even if there are short term incentives to do so, regardless of their availability to monitor such behavior (Kwon & Suh 2005). Lack of trust is one of the major factors which highly affect supply chain management.

6. **Commitment of Trading Partner** - It is the willingness of each partner to exert effort on behalf of the relationship (Jie et al, 2008).
7. **Quality of Product -** The quality of any product is solely depends on the raw material supplied by the supplier because if the raw material is not meeting the required level of expectations then there is no guarantee of good quality product (Singh et al 2013). Quality also refers that how an organization is capable of offering product quality & performance that creates higher value for customers (Rondeau et al, 2000)
8. **Safety -** Safety during processing, storing, transporting and using the product (ABL 2001).
9. **Strategy** – This includes business models, strategic alliances, and partnership formation with the objective of developing a sustainable supply chain that is flexible and responsive to changing market requirements, but at the same time meets the environmental regulations (Hicks et al 2000, Elahi et al 2013).
10. **Procurement Policy** – It refers to the policies used for procurement of raw material, tooling etc. it may be through invitation of tenders or by some other methods (Hicks et al 2000).
11. **Delivery** - Delivery includes delivery speed, production lead time and delivery reliability.
12. **Logistic** - It refers to transportation of raw material and finish product timely and in required quantity.
13. **Capacity** - Capacity of the machine, capacity of shipment and delivery truck.
14. **Efficiency** - It consider operation cost, inventory cost, waste cost, transportation cost, labor cost and profit.
15. **Flexibility Range -** Flexibility range is defined as the extent to which the operation can be changed (Slack 1991). The practice of moving forward one or more operations or activities to a much later point in supply chain (Li et al 2006).
16. **Cost -** In today's cut throat competition new industries are introducing with lesser price, so it becomes awkward for the manufacturing industries to remain their stake in the market & earn profits (Singh et al 2013). It includes inventory cost

and operational cost, risk cost, service cost and insurance cost (Beamon 1999 and Gunasekaran et al 2004).

17. **Cost of Activity Time** – It include the cost of various activities involve in manufacturing and selling the product.
18. **Resource Utilization -** It refers to effective utilization of resources available such as raw material, man power, electricity etc.
19. **Quality Data and Reporting -** Saraph et al (1989) discussed the Quality Data and Reporting factor as it is the

a. Use of quality cost data.
b. Feedback of quality data to employees and managers for problem solving.
c. Timely quality measurement.
d. Evaluation of managers and employees based on quality performance.
e. Availability of quality data.

20. **Financial Performance** – Financial performance is a result of quality performance, inventory management and process management (Kaynak & Hartley 2008). It is the Return on investment, Sales growth, Profit growth, Market share, Market share growth.
21. **Inventory Level** – It include the level of finish product which is available to supply at every time and availability of safety stock of raw material.
22. **Lean System** – The practices of eliminating waste (cost, time, etc.) in a manufacturing system, characterized by reduced set-up times, small lot sizes, and pull-production (Li et al, 2005).
23. **Quality System -** It indicates quality of all the systems followed.

3.3.2 Description of the Factors Responsible for Service Quality of Organization

The second driver of supply chain management is organization. All the factors which affect the service quality of organization can be divided into two sub factors - employer and employee. The employer is the main driving force in the supply chain as only he can invest money for various purposes like research, manufacturing, advertising, etc. Actually, it is the employer who sets the targets for the organization & provides various resources, facilities & guidance to achieve them. Employee is the people who converts the dream of employer into reality by designing, manufacturing and selling the product, and establish the reputation of organization.

The various factors affecting under sub factor employer are discussed below:

1. **Information Sharing** - Flow of accurate information from one end to other end on time. The supply chain which works on shared information performs better than those do not have access to information related to their partner (Lee et al 2002). Some industries like Dell, Wal-mart are sharing information with their supplier & customer to decrease cost & improve service (Handfield & Nicholas, 1999). Information sharing has two aspects: quantity & quality, both aspects are fundamental for practices of supply chain & have been considered as independently constructed in the past supply chain management studied (Choi et al 1996). Shared information can vary from strategic to tactical in nature & from logistic activities to general market (Li et al 2006).

2. **Information Quality** - It refers to the accuracy, timeliness, adequacy, and credibility of information exchanged (Monczka et al 1998, Moberg et al 2002). Though sharing of information is very important, the significance of its impact on supply chain management depends on what information is shared, how it is shared & with whom it is shared (Li et al 2006).

3. **Material Flow Information** - The extent to which all functions within the supply chain communicate information and transport material is material flow information (Jie et al 2007). Mohr & Spekman (2004) state that information of material flow refers to extent to which critical & proprietary information is communicated to supply chain partner.

4. **Management Leadership** - Saraph et al (1989) discuss the management leadership as it is

a. Acceptance of quality responsibility by top management.

b. Evaluation of top management on quality.

c. Participation by top management in quality improvement efforts.

d. Specificity of quality goals.

e. Importance attached to quality in relation to cost and schedule.

f. Comprehensive quality planning.

Management leadership is positively related to customer focus, training, employee relations, supplier quality management & product/service design (Kaynak & Hartley 2008). Management can promote customer involvement by allow them for plant visits, by providing detailed information about product (Flynn et al 1995).

5. **Cost of Activity Time** – It include the cost of various activities involved in manufacturing and selling the product.
6. **Buy Back Contract** – The organization buys back any unsold item from the retailer or used items from customer with a price lower than the wholesale price. Many automobile and pharmaceuticals organization has adopted this factor to increase the market reputation of the organization.
7. **Financial Performance** – Financial performance is a result of quality performance, inventory management and process management (Kaynak & Hartley 2008). It is the Return on investment, Sales growth, Profit growth, Market share, Market share growth.
8. **Inventory Level** – It include the level of finish product which is available to supply at every time and availability of safety stock of raw material.
9. **Lean System** – The practices of eliminating waste (cost, time, etc.) in a manufacturing system, characterized by reduced set-up times, small lot sizes, and pull-production (Li et al, 2005).
10. **Efficiency** – Efficiency measures the utilization of resources in the systems that are used to meet the system's objectives (Beamon 1999).
11. **Revenue Sharing** – The supplier offers a relatively low wholesale price but asks the retailer to share part of the revenue of every item sold.
12. **Risk Consideration** – If order quantity is more than demand then unsold inventory and if order quantity is less than demand then unmet demand
13. **Marketing** – It refers to that how well an organization has marketing team, how well organization advertise his product and convert luxury item into need full item (Hicks et al 2000).

14. **Procurement Policy** – It refers to the policies used for procurement of raw material, tooling etc. it may be through invitation of tenders or by some other methods (Hicks et al 2000).

15. **Quality of Product** - The quality of any product is solely depends on the raw material supplied by the supplier because if the raw material is not meeting the required level of expectations then there is no guarantee of good quality product (Singh et al 2013). Quality also refers that how an organization is capable of offering product quality & performance that creates higher value for customers (Rondeau et al, 2000).

16. **Process Management** – Saraph et al (1989) discussed the process management factor as it is

a. Clarity of process ownership, boundaries, and steps.

b. Less reliance on inspection.

c. Use of statistical process control.

d. Selective automation.

e. Foolproof process design. Preventive maintenance.

f. Employee self-inspection.

g. Automated testing.

Process management directly related to quality performance (Kaynak & Hartley 2008). Process management reduce the variation thorough practice such as fool proofing, stabilizing production schedule & equivalent preventive maintenance (Kaynak 2003)

17. **Engineers to Order** – Company build unique products designed to customer specifications. The characteristics of Engineer to Order (ETO) companies are described in terms of their markets, products and the internal processes of their organization. (Hick et al, 2000).

18. **Production Planning** – It focuses on the planning of the production in advance, setup the targets and complete those timely and economically. The practice of moving forward one or more operations or activities (making, sourcing and delivering) to a much later point in the supply chain (Li et al, 2005).

19. **Manufacturing Systems** – It refers to the manufacturing systems available to the organization.

20. **Technology & Organization** – it is the market reputation of organization, its product and technology used. The technology used by the organization must be latest and customer friendly.

21. **Partnership & Collaboration** – It refer to technical and financial assistance for increase market share. Collaborative supply chain partnership supports the development of flexibility, responsiveness & low cost/ low volume manufacturing skill (Hoyt & Huq 2000).

22. **Resource Utilization** – It refers to effective utilization of resources available such as raw material, man power, electricity etc.

23. **Product/Service Design** – Saraph et al (1989) discussed the product/ service design factor as it is

    a. Thorough scrub-down process.
    b. Involvement of all affected departments in design reviews.
    c. Emphasis on producibility.
    d. Clarity of specifications.
    e. Emphasis on quality, not roll-out schedule.
    f. Avoid frequent redesigns.

    Earlier product/ service design activities took place primarily within the organization but now main supplier & customers work together during product & service design (Kaynak & Hartley 2008, Peterson et al 2003). It is the management who limit the involvement of customer & supplier during product/Service design.

24. **Strategy** – This includes business models, strategic alliances, and partnership formation with the objective of developing a sustainable supply chain that is flexible and responsive to changing market requirements, but at the same time meets the environmental regulations (Hicks et al 2000, Elahi et al 2013).

25. **Recycling** – After completing its life cycle, the waste can be used for making new product without harming the environment.

26. **Environment Friendly Product** – The product should not be harmful to the environment during its usage, storage and decomposing.
27. **Product Development** – It refers to development of new product or make existing product better and more useful for users at reasonable price.
28. **Delivery** - Delivery includes delivery speed, production lead time and delivery reliability.
29. **Logistic** - It refers to transportation of raw material and finish product timely and in required quantity.
30. **Capacity** - Capacity of the machine, capacity of shipment and delivery truck.
31. **Traceability** - It include latest and fast tracing systems which can used for tracing of raw material to finish goods.

The various factors affecting under sub factor employee are discussed below:

1. **Employee Relations** – Saraph et al (1989) discussed the employee relations factor as it is:

a. Implementation of employee involvement and quality circles.
b. Open employee participation in quality decisions.
c. Responsibility of employees for quality.
d. Employee recognition for superior quality performance.
e. Effectiveness of supervision in handling quality issues.
f. Ongoing quality awareness of all employees

Employee relations are directly related to quality data reporting & customer focus (Kaynak & Hartley 2008). Those employees, who participate in decision making are recognized for better quality performance and aware for customer satisfaction, are like by the management.

2. **Training** – it is the Provision of statistical training, trade training, and quality-related training for all employees (Saraph et al., 1989). Kaynak's (2003) indicated clearly that training is directly related to employee's relations & quality data reporting. Training increase the healthy work environment & increase the

involvement of employees, though only training will not sustain an improvement (Kaynak & Hartley 2008).

3. **Safety** - Safety during processing, storing, transporting and using the product (ABL 2001).
4. **Risk Management** – The degree to which the effect of risks is minimized (Johnsons & Scott, 1995).
5. **Attitude** - It is the favor or disfavor toward a person, place, thing, or event (Farmer 1988).
6. **Flexibility range** –Flexibility range is defined as the extent to which the operation can be changed (Slack 1991). The practice of moving forward one or more operations or activities to a much later point in supply chain (Li et al 2006).
7. **Response Flexibility** – Response flexibility is defined as the ease (in terms of cost, time, or both) with which the operation can be changed (Slack 1991).
8. **Strategy** – This includes business models, strategic alliances, and partnership formation with the objective of developing a sustainable supply chain that is flexible and responsive to changing market requirements, but at the same time meets the environmental regulations (Hicks et al 2000, Elahi et al 2013).

3.3.3 Description of the Factors Responsible for Service Quality of Distributor & Retailer

The next drivers of supply chain management are distributor & retailer. The distributor is that entity who helps organization to sell the product into market through various retailers. Distributor may be called as authorized stockiest who store finish goods inventory because of trust, commitment and market reputation of parent organization and supply the material to retailer according to demand. Retailer is that driver who really and directly faces the demand & reaction of customer. So feedback of retailer is very much important. Though reputation & service quality of retailer is very much important for customer but quality of product is also matter. Various factors which affect the service quality of distributor and retailer are discussed below:

1. **Competitive Advantages** – It is the extent to which an organization is able to create a defensible position over its competitors (Porter 1985, McGinnis et al 1999). It comprises capabilities that allow an organization to differentiate itself

from its competitors & is an outcome of critical management decisions (Tracey et al 1999). The dimensions of the competitive advantages are cost, quality, delivery, dependability, product innovation & time to market (Li et al 2006).

2. **Lead Time** - It is the end to end delay in a business process (Viswanadham, 2000).
3. **Buy Back Contract** – The organization buys back any unsold item from the retailer or used items from customer with a price lower than the wholesale price. Many automobile and pharmaceuticals organization has adopted this factor to increase the market reputation of the organization.
4. **Logistic** - It refers to transportation of raw material and finish product timely and in required quantity.
5. **Price** - How much an organization is capable of competing against major competitors based on low prices (Gunasekaran et al 2004).
6. **Financial Performance** – Financial performance is a result of quality performance, inventory management and process management (Kaynak & Hartley 2008). It is the Return on investment, Sales growth, Profit growth, Market share, Market share growth.
7. **Capacity** – Capacity of the machine, capacity of shipment and delivery truck.
8. **Delivery** - Delivery includes delivery speed, production lead time and delivery reliability
9. **Quality Data and Reporting -** Saraph et al (1989) discussed the Quality Data and Reporting factor as it is the

a. Use of quality cost data.
b. Feedback of quality data to employees and managers for problem solving.
c. Timely quality measurement.
d. Evaluation of managers and employees based on quality performance.
e. Availability of quality data.

10. **Inventory Level** – It include the level of finish product which is available to supply at every time and availability of safety stock of raw material.
11. **Efficiency** – Efficiency measures the utilization of resources in the systems that are used to meet the system's objectives (Beamon 1999).
12. **Strategy** – This includes business models, strategic alliances, and partnership formation with the objective of developing a sustainable supply chain that is

flexible and responsive to changing market requirements, but at the same time meets the environmental regulations (Hicks et al 2000, Elahi et al 2013).

13. **Time to Market** - The extent to which an organization is capable of introducing new products faster than major competitors (Li et al, 2005).
14. **Sales Growth** - How much an organization is capable to increase the sale and explore new markets (Gunasekaran et al 2004).
15. **Traceability** - It include latest and fast tracing systems which can used for tracing of raw material to finish goods.
16. **Safety** - Safety during processing, storing, transporting and using the product (ABL 2001).
17. **Revenue Sharing** – The supplier offers a relatively low wholesale price but asks the retailer to share part of the revenue of every item sold.
18. **Attitude** - It is the favor or disfavor toward a person, place, thing, or event (Farmer 1988).
19. **Welfare Activity** – these are the activities done under Corporate Social Responsibilities (CSR)

3.3.4 Description of the Factors Responsible for Service Quality of Customer

Customer plays an important role in the performance of supply chain (Lummus et al 2001). Customer is the king of market and he decides good or bad. He is the main driving force. Robinson & Malhotra (2005) found that integration with customer is an important practice of supply chain management. Various factors which affect the service quality of customer are discussed below:

1. **Customer focus** – The entire practices that are employed for the purpose of managing customer complaints, building long-term relationships with customers, and improving customer satisfaction. Kaynak & Hartley (2008) stated that management provides the necessary action for quality training of customer to increase the faith of customer in the organization. Hicks et al (2000) discussed three stages of interaction with customer i.e. marketing, preliminary design and after design.
2. **Customer satisfaction** – The ability to generate higher levels of customer satisfaction is regarded as an important differentiator and has therefore become a key element of many firms' business strategies (Ellinger et al 2012). Customer

should be satisfied with the product or service which he received and it is the guarantee of repeat order. Customer satisfaction is a measure of how the products and services provided by a company meet or exceed customer expectations (Fornell, 1992, Olsen & Johnson, 2003). Christopher & Martin (1994) stated that there are three elements of customer satisfaction such as pre transaction satisfaction, transaction satisfaction and post transaction satisfaction.

3. **Customer Responsiveness** – Customer responsiveness refers to accurately and insightfully giving customers what they need, want or do not yet know they want. It include Customer response time, lead time, order fill rate, back order and on time delivery.
4. **Customer Relationship Management** – It include the complete practices which employed for managing customer complaints, building long term relationships with customer & improving customer satisfaction(Tan et al 1998, Claycomb et al 1999). CRM is a key element of supply chain practices (Noble 1997, Tan et al 1998). CRM allows an organization to differentiate its product from competitors sustain customer loyalty & dramatically extend the value it provide to its customer (Magretta 1998). Very good relations with customer are needed for successful implementation of supply chain management programs (Li et al 2006).
5. **Faster Response Time** – It is the amount of time between an order and its corresponding delivery (Beamon 1999).
6. **Buy Back Contract** – The organization buys back any unsold item from the retailer or used items from customer with a price lower than the wholesale price. Many automobile and pharmaceuticals organization has adopted this factor to increase the market reputation of the organization.
7. **Cost -** In today's cut throat competition new industries are introducing with lesser price, so it becomes awkward for the manufacturing industries to remain their stake in the market & earn profits (Singh et al 2013). It includes inventory cost and operational cost, risk cost, service cost and insurance cost (Beamon 1999 and Gunasekaran et al 2004).
8. **Delivery** - Delivery includes delivery speed, production lead time and delivery reliability.
9. **Traceability** - It include latest and fast tracing systems which can used for tracing of raw material to finish goods.

10. **Order Fulfillment** – It is the number of times when an organization fulfills the order quantitatively and qualitatively (Teller 2013). Better planning and coordination within and beyond the boundary of a manufacturing organization can achieve reduction in order fulfillment time. Technology and human resource related issues also play an important role in reducing the order fulfillment time (Sahoo & Mishra 2013).
11. **Quality of Product -** The quality of any product is solely depends on the raw material supplied by the supplier because if the raw material is not meeting the required level of expectations then there is no guarantee of good quality product (Singh et al 2013). Quality also refers that how an organization is capable of offering product quality & performance that creates higher value for customers (Rondeau et al, 2000)
12. **Technology & Organization** – it is the market reputation of organization, its product and technology used. The technology used by the organization must be latest and customer friendly.
13. **Environment Friendly Product** – The product should not be harmful to the environment during its usage, storage and decomposing.
14. **Society Perception** – It indicates the requirement of the society from the product, maintenance and life (Peterson et al 2001).

3.4 CONCLUSION

Total 97 determinants or factors of service quality have been identified from available literature. The most of the factors of distributor and retailer are common, so discussed in same article. The research works mostly used conventional rating scale data for analysis. The factors are further used to develop the questionnaire and to assess the service quality of different drivers.

CHAPTER IV RESEARCH METHODOLOGY

4.1 INTRODUCTION

This chapter presents a methodology that has been adopted in this research to determine the service quality of a manufacturing supply chain. The detail of adopted methodology is shown in fig. 4.1.

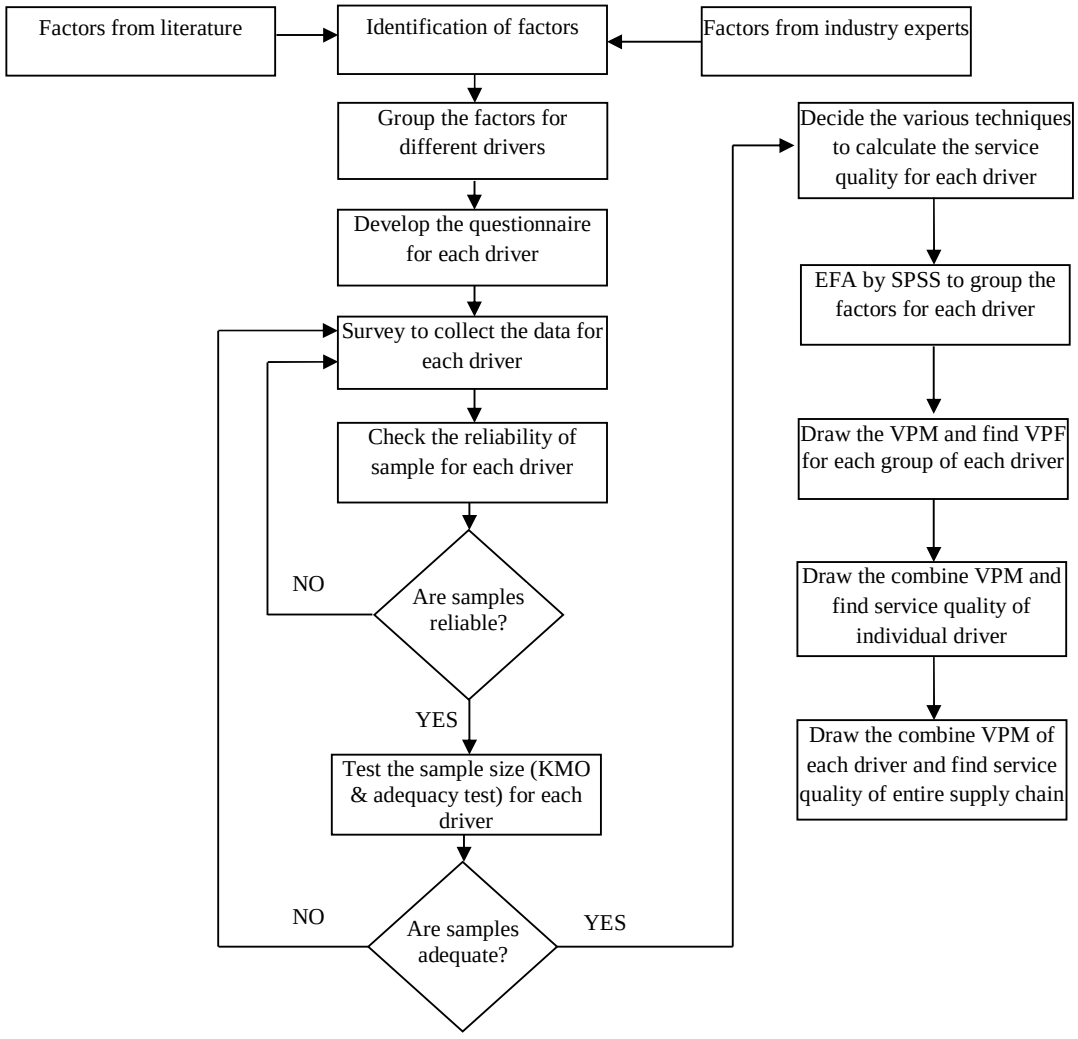


Fig. 4.1 Process adopted to find the performance of a supply chain

For this research initially the factors were identified through literature available and having strong discussions with the experts in the industry and academia. Then all the factors were grouped into five drivers i.e. supplier, organization, distributor, retailer and customer. Structured questionnaire were developed and techniques were

identified to calculate the service quality. The data for this study was collected from the supply chain of an Indian manufacturing organization.

4.2 METHODOLOGY USED

To achieve the objectives, a questionnaire based survey, Exploratory factor analysis (EFA), Fuzzy logic (FL), Graph theoretic approach (GTA), Artificial neural network (ANN) and Confirmatory factor analysis (CFA) have been used.

4.2.1 Questionnaire Based Survey

A questionnaire based on identified factors comprising questions related to expectations/ desire and what actually received was designed. The data collection approach (by survey) was used as it has been used earlier by many researchers (Seth et al 2006, Cronin & Taylor 1992, Teas 1993 etc.) in context of SCM. Snowball sampling was used to collect the data as the authors knew only a few persons in the entire supply chain. The responses were obtained on a five point Likert scale. In the Likert five point scale, 1 represents lowest or strongly disagree while 5 represents highest or strongly agree. Earlier different service quality studies (Seth et al 2006, Gronroos 1984 etc.) motivate the authors to choose the five point Likert scale.

4.2.2 Exploratory Factor Analysis

EFA is a multivariate statistical technique widely used in social and behavioral science and commonly used to explore the dimensionality of a measurement. The SPSS 20 was used for this purpose. The main objective of using EFA in this paper is to group the factors into various sub groups to make calculations simpler. The following steps was used during performing then EFA

1. Identify the variable from the available literature and from the discussion with industry experts.
2. Reliability test to be performed to check the internal consistency. For this Cronbach's alpha should be greater than 0.7.
3. To check whether the sample size is adequate or not, KMO (Kaiser-Meyer-Olkin) sample of adequacy and significant value test were performed. If the value of KMO is greater than 0.6 and the value for significant is less than 0.005, indicate that data size is sufficient for grouping the various relevant factors otherwise sample size is not adequate.

4. Extract initial factors (via principal component analysis)
5. Group the factors having highest values

4.2.3 Fuzzy Logic

The concept of Fuzzy Logic (FL) was developed by Prof. Zadeh et al. in 1965 as a mathematical tool for dealing with imprecise data but the application of this tool was found in industry in 1980 by Ebrahim Mamdani of Queen Mary College, London for controlling of a steam generator. After this fuzzy was used in neural network, control system, modeling and analysis, decision making, scheduling problems to minimize lateness, traffic management, railway applications etc. (Tzeng & Huang 2011). Sometimes it is not possible to get accurate data from respondents due to certain limitations. Also some times the detail is in linguistic form instead of numeral. Under these conditions FL can be used. FL is a problem solving methodology that provides a simple way to arrive at a definite conclusion based upon vague, ambiguous, imprecise, noisy or missing input information. The utility of fuzzy lies in its ability to provide decision for uncertain data. In FL all the values are 0.0 to 1.0 where 0.0 means absolute false or wrong and 1.0 means absolute truth or right.

4.2.4 Graph Theoretic Approach

Graph theoretic approach (GTA) consists of digraph, matrix and permanent function representation. It converts the intangible factors into tangible and is used to calculate the single numerical index for any issue. This powerful technique was developed by Euler in 1736 when he solved the famous Konigsberg bridge problem. After that, this technique was used by many researchers and practitioners in various fields (Gupta & Singh 2014). This technique consist the following components:

1. Digraph representation
2. Matrix representation
3. Permanent function representation

GTA is more relatively simple, easy to understand, less time consuming technique and has been suggested to quantify the presence of factors conducive to SCM. The graph theoretic representation is suitable for visual analysis, can be computer processed and can be expressed as a mathematical entity, whereas the conventional representations, like block diagrams, cause and effect diagrams and flow charts, although providing visual analysis, do not depict interactions among factors and are

not suitable for further analysis and cannot be processed or expressed in mathematical form, whereas, the digraph is the starting point for further analysis in the graph theoretical methodology(Grover et al, 2004).

The graph theory is an old technique and developed by Euler in 1736 when he solved the famous konigsberg bridge problem. subsequently, the graph theory has been applied in various fields like Mechanical Engineering (Agrawal & Rao 1989, Gandhi & Agrawal 1994, Wani & Gandhi 1999, Sehgal et al 2000, Rao 2006), Reliability (Gandhi et al 1991, Gandhi & Agrawal 1992) Automobile Engineering (Venkatasamy & Agrawal 1996, 1997), Manufacturing Engineering (Singh & Sekhon 1996, Mukhopadhyaya et al 2000, Rao & Gandhi 2002a, 2002b, Rao & Padmanabhan 2007, Singh & Agrawal 2008, Chakladar et al 2008, Jangra et al 2011a, Jangra et al 2011b), Design (Hakim et al 2000), Flexible Manufacturing Systems (Rao 2006), Robotics (Rao & Padmanabhan 2006), Sociology (Rao & Gandhi 2000) , Computer Technology (Saha & Grover 2011), Economics (Yadav et al 2010), Operation Research (Dou et al 2007, 2009), Industrial Engineering (Grover et al 2004, Kulkarni 2005, Grover et al 2005, 2006, Prabhakaran et al 2006, Qureshi et al 2009, Singh et al 2011), Thermal Engineering (Mohan et al 2004, Yadav et al 2010), Supplier-buyer Relationship (Thakkar et al 2007), Rating of Contractor (Darvish et al 2009), SCM (Faisal et al 2007, Wagner & Neshat 2010, Singh et al 2011) etc.

Graph theory is a systematic methodology consisting of digraph representation, matrix representation & permanent function (Singh et al 2013). The permanent function is obtained in a similar manner as determinant with a difference that all negative sign appears in the calculation, are replaced by positive sign (Faisal et al 2007).

Grover et al (2004) identified the various factors responsible for TQM environment and develop a mathematical model from these interacting factors with the help of graph theory. Kulkarni (2005) used graph theory to evaluate and ranks the various industries practicing TQM for a given period of time. Rao & Padmanabhan (2006) used digraph & matrix method for evaluation of alternative industrial robot. Rao (2006) discussed Flexible Manufacturing Systems & used graph theory to evaluate the alternative flexible manufacturing systems. Rao (2006) used graph theory for material selection for a given engineering component & proposed a material suitability index. Faisal et al (2007) used graph theory & matrix methods to quantify the Risk

Mitigation Environment & presented in the form of a single numerical index. Saha & Grover (2011) used graph theory to represent the overall effect of key website performance attributes. Singh et al (2011) used graph theory approach to assess the quality of manufacturing industries & quantify then in a single numerical index. Jangra et al (2011a) used graph theory to evaluate the performance of carbide compacting die. Jangra et al (2011b) used graph theory approach to evaluate the machinability of tungsten carbide composite with wire EDM. Singh & Khan (2013) adopted graph theory for evaluation & selection of vendors.

4.2.5 Artificial Neural Network (ANN)

ANN is a single layer or multilayer network, better known as direction assigned graph or digraph of simple interconnecting processing elements called artificial neurons. The most successful applications used feed forward design network. The multilayer feed forward networks have at least three layers. The first layer is known as input layer. It only receives the input and has no function except buffering the input. The last layer is known as output layer and it generates the output of the network. All the layers between input layer and output layer are known as hidden layers. The hidden layers do not have direct contact with the external environment and may be zero, one or more than one. Each neuron of ANN is connected to other neuron by direct link and each link is associated with the weightage which contains the information about the input signal.

In the context of this research, the input layer can be considered to represent the physical and psychological cues from service, the hidden layer plays the role of the cognitive processes that mediate between the cues and the semantic output, and the output layer represents the semantic labels that customers give to the quality of their service experience (McMillen & Henley 2001). All the responses from the respondents entered the neuron of input layer, were processed through the neurons of hidden layers and output was generated from the neurons of the output layer. This system of neural network is known as feed forwarded network.

4.2.6 Confirmatory Factor Analysis (CFA)

CFA is a theory testing model in contrast to a theory generating method like EFA. CFA is a statistical technique used to verify the factor structure of a set of observed variable. CFA allows to test the hypothesis of a relationship between the observed

variable and their underlying latent construct(s) exist. The use of CFA could be impacted by

- The research hypothesis being testing
- The requirement of sufficient sample size
- Measurement instruments
- Multivariate normality
- Parameter identification
- Outliners
- Missing data
- Interpretation of model fit indices (Schumacker and Lomax, 1996)

To perform CFA, Structure Equation Modeling (SEM) is one statistical test to determine the significance of the analysis to determine the adequacy of the model fit to the data. AMOS 20 was used for this. A variety of fit indices used as a guideline for SEM to confirm the model are given below

A. Absolute Fit Indices

AFI determine how well a model fit the sample data. In this, categories are the chi square test, GFI, AGFI, RMR and RMSEA.

Chi square test is traditional measure for evaluating the overall model

Goodness of fit indices (GFI) calculates the proportion of variance that is accounted for by the estimated population covariance (Tabachnick and Fidell, 2007). The GFI ranges 0 to 1, with value exceeding 0.9 indicating a good fit to the data.

The adjusted goodness of fit indices (AGFI) based upon the degree of freedom. AGFI tends to increase with sample size. The value 0.9 or greater indicates well fitting models.

Root mean squared residual (RMR) is the square root of the difference between the residuals of sample covariance matrix and hypothesized covariance matrix. If value for RMR is less than 0.05 is very good but up to 0.08 it is acceptable.

Root mean square error of approximation (RMSEA) tells how well the model with chosen parameters. The value below 0.10 is considered as good fit.

B. Incremental Fit Indices

Incremental fit indices are a group of indices which do not use the chi square in raw form but compare the chi square to a base line model. In this, categories are the NFI, NNFI, CFI and IFI

Normed fit indices (NFI) assess the model by comparing the chi square value of the model to the chi square value of the null model. The acceptable range is greater than 0.9.

Non normed fit indices (NNFI) adjust the NFI for degree of freedom in the model. Generally, the value more than 0.9 indicates the good fit.

Comparative fit index (CFI) is used as reported fit and the value greater than 0.9 indicate good fit of data.

Incremental fit index (IFI) having value more than 0.9 indicate good fit of the data.

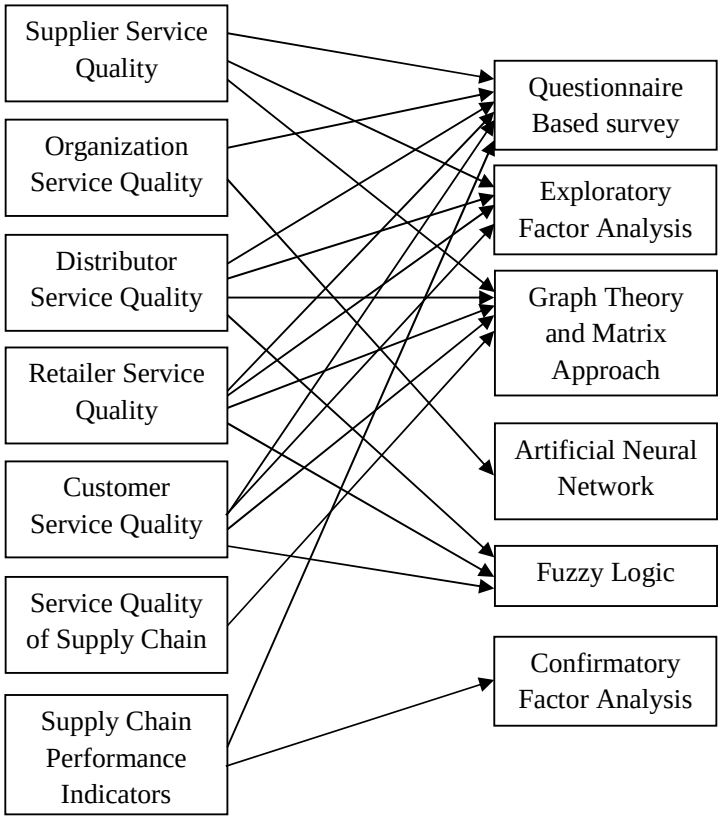


Fig. 4.2 Research objectives with proposed MADM techniques

4.3 JUSTIFICATION OF PROPOSED METHODOLOGY

In this research survey at every level is used to compute the service quality in supply chain in manufacturing industry. Survey is an established research and used to get the information from individual one. In general the survey involves gathering information from individual through personnel interaction, telephonic discussion or e-mail etc.

Kerlinger (1986) believed that survey research can contribute to advancement of scientific knowledge in different ways.

Survey can be divided into three categories: exploratory, confirmatory and descriptive.

Exploratory research is defined as a research used to explore situation through a problem to provide insight (Malhotra and Das, 2005). Exploratory research is characterized by flexibility and versatility with respect to the methods because formal research protocols and procedures are not employed.

According to Forza (2002) confirmatory research takes place when knowledge of a phenomenon has been expressed through well defined concepts and models.

Malhotra and Das (2005) specify that Descriptive Research design describe the characteristics of relevant group. Descriptive research is preplanned and well structured and its primary aim is not to develop theory. It is based on the large sample size.

Most organizations in India are not publicly traded firms and thus are not required to provide financial performances data to government regulators. In addition the exploratory investigations confirmed that the executives feel hesitation to share the data of their organizations. In such a scenario, gaining access to objective data company sources is extremely difficult. Under such conditions the survey is the only option to gather the data from the partners of the supply chain.

Thus the use of survey research is justified in present study. The questionnaire based survey was selected to assess the service quality of a supply chain in Indian manufacturing sector. Fig. 4.2 depicts the use of various techniques with proposed objectives.

4.4 DESIGN OF RESEARCH METHODOLOGY

The research methodology used in this research is a combination of extensive literature review and questionnaire based survey.

4.4.1 Sampling

Sampling included population, sample and sampling method. Here population refers to entire group of people of complete supply chain which included distributor - focal organization – distributor - retailer – customer. A sample is a subset of population and

comprises the individual persons which can be select for responses. Snowball sampling method was used to collect the responses as only two persons were known in the entire supply chain. Every time respondent was asked to suggest the name of someone who could contribute to the study. As there have been very few studies and this subjected quite new, it is very essential to reach the right respondent and therefore the use of snowball sampling for collection of data is justified.

4.4.2 Use of Likert scale

A Likert five point scale was used to get the responses of questionnaire from respondents as it was used by earlier different service quality researchers (Gronross1984, Salen & Ryan 1991, Babakus & Mangold 1992, Seth et al 2006, Collier & Bienstock 2006 etc.) and it was suggested by most of the managers in organizations. In the Likert five point scale, 1 represents lowest or strongly disagree while 5 represents highest or strongly agree.

The advantages of using the Likert scale are:

1. Easy to understand as they are the most universal method of data collection through survey.
2. Respondent is not forced to give yes or no, which may be a concrete answer.
3. It allows the respondents to respond in a degree of agreement which is very easy and comfort condition.
4. The responses are easily quantifiable and can be used for various mathematics calculations.
5. It allows the respondents to rate the any issue from unsatisfied to satisfied and even neutral condition.
6. The responses are very easy to code as always a single number represent the response.

Also, the use of Likert scale in survey makes quick, efficient and inexpensive method for data collection. They are highly versatile in nature and can be sent through e-mail or given personally.

Large advantages and used by many researches provide motivation to use the Likert five point scale for our research work.

4.4.3 Questionnaire Development

The available literature revealed that there is no universal accepted method for measurement of service quality and there is no universal accepted set of questionnaire. These two things motivated for design a new set of questionnaire for measurement of service quality at different levels.

Questionnaire development is an utmost important part of a survey research because respondent only responses accurately when he understand the question correctly. Researcher must ensure that the respondent must be familiar with the language used and the questions should be as simple as can be. In India there are following two reasons for which it is quiet tough to get correct responses:

a) People do not have time.
b) People do not want to devote the time for the activity for which pay them nothing.

Based on the above facts separate questionnaire for measurement of service quality of supplier, organization, distributor, retailer and customer were designed in consultation with academia and industry experts.

All the five questionnaire were in two parts. First part consist the demographic information and second part consist the questions related to service quality and all the question in second part were close ended to facilitate the quick response.

4.4.4 Profile of respondents

All the five set of questionnaires were taken to the various respondents to know the responses. Table 4.1 shows the corresponding respondent for measuring the service quality of different drivers.

Table 4.1: Details of respondents and responses

Category of questionnaire	Respondents	No. of responses
Supplier service quality	Organization	96
Organization service quality	Supplier and Distributor	103
Distributor service quality	Organization and Retailer	118
Retailer service quality	Distributor and Customer	131
Customer service quality	Customer	147

Profile of respondents for SSQ

The respondents of SSQ were the managers of organization. When they were contact for the responses, they kept the questionnaire. Total 350 questionnaires kept for the responses. Some respondents assured to send them by e-mail while others permit to collect later on. Only nine responses received through e-mail while 87 were collected later on. A total 96 responses were collected out of 350 so nearly 27.42% responses were received over all. The demographic detail of respondents is presented in table 4.2.

Profile of respondents for OSQ

The respondents of OSQ were the staff of the suppliers and distributors who came in contact to the organization directly or indirectly on daily basis. All the persons involved in the survey were experienced persons and of managerial or equivalent rank. When they were contact for the responses, they kept the questionnaire and promise to fill as soon as possible. Total 450 questionnaires kept for the responses. Out of these, approx. 255 were kept to the different suppliers and rest to the different distributors. Some respondents fill the questionnaire on the spot while most of them asked to collect later on. Only twelve responses filled on the spot while 91 were collected later on. A total 103 responses were collected out of 450 so nearly 22.89% responses were received over all. The demographic detail of respondents is presented in table 4.3.

Profile of respondents for DSQ

The respondents of DSQ were the staff of the organization and retailers who came in contact to the distributors directly or indirectly on daily basis. All the persons involved in the survey were experienced persons and of managerial or equivalent rank. When they were contact for the responses, they kept the questionnaire and promise to fill as soon as possible. Total 350 questionnaires kept for the responses. Out of these, approx. 165 were kept to the different persons of organization and rest to the different retailers. Some respondents fill the questionnaire on the spot while most of them asked to collect later on. Only ten responses filled on the spot from retailers while 108 were collected later on. A total 118 responses were collected out of 350 so

nearly 33.71% responses were received over all. The demographic detail of respondents is presented in table 4.4.

Table – 4.2: Demographic Details of Respondents for SSQ

Age Detail		Sex Detail		Qualification Detail		Designation Detail		Department Detail		Experience Detail	
Age	**%age**	**Sex**	**%age**	**Qualification**	**%age**	**Designation**	**%age**	**Department**	**%age**	**Exp.**	**%age**
up to 25 yrs	15.36	Male	76.04	Technical	64.58	Assistant Manager	35.41	Assembly	12.50	up to 5 years	17.71
25-30	3.84	Female	23.96	Non technical	35.62	Manager	36.45	Dispatch	9.38	6-10 years	36.46
30-35	61.44					Senior Manager	20.84	Mfg.	10.42	11-15 years	19.79
35-40	46.08					General Manager	7.30	Marketing	10.42	16-20 years	15.63
40-45	7.68							Pre- delivery Inspection	5.21	more than 20 years	10.42
above 45	19.2							Research & Design	25.00		
								Sales	5.21		
								Spare Parts Division	6.25		
								Store	11.46		
								Vendor Dev.	8.33		

Table – 4.3: Demographic Detail of Respondents for OSQ

Age Detail		**Sex Detail**		**Echelon Detail**		**Experience Detail**	
Age (Yrs.)	**%age**	**Sex**	**%age**	**Echelon**	**%age**	**Exp. (Yrs.)**	**%age**
up to 25	16.50	Male	78.64	Distributor	53.40	up to 5	27.18
26-30	25.25	Female	21.36	Supplier	46.60	6-10	37.86
31-35	27.18					11-15	13.59
36-40	11.65					16-20	8.74
41-45	4.86					>20	12.63
Above 45	14.56						

Table – 4.4: Demographic Detail of Respondents for DSQ

Age Detail		Sex Detail		Qualification Detail		Echelon Detail		Experience Detail	
Age (Yrs.)	**%age**	**Sex**	**%age**	**Qualification**	**%age**	**Echelon**	**%age**	**Exp. (Yrs.)**	**%age**
up to 25	4.24	Male	79.66	Technical	72.03	Organization	50.85	1- 5	19.49
25-30	22.03	Female	20.34	Non technical	27.97	Retailer	49.15	6-10	27.97
30-35	19.49							11-15	23.73
35-40	25.42							16-20	16.10
40-45	20.34							more than 20	12.71
above 45	8.47								

Profile of respondents for RSQ

The respondents of RSQ were the staff of the distributor and customers who came in contact to the retailers directly or indirectly on daily basis. All the persons involved in the survey were requested to fill the questionnaire on the spot. The staff of distributors kept the questionnaire and promise to fill as soon as possible. Total 370 questionnaires were distributed to know the responses. Out of these, approx. 155 were kept to the different persons of distributor and rest distribute to the customers. A total 131 completely fill responses were collected out of 370 so nearly 35.41% responses were received over all. The demographic detail of respondents is presented in table 4.5.

Table – 4.5: Demographic Detail of Respondents for RSQ

Age Detail		Sex Detail		Qualification Detail		Echelon Detail	
Age (Years)	**%age**	**Sex**	**%age**	**Qualification**	**%age**	**Echelon**	**%age**
up to 25	8.40	Male	63.36	Technical	74.05	Distributor	48.09
25-30	17.56	Female	36.64	Non technical	25.95	customer	51.91
30-35	35.88						
35-40	16.03						
40-45	15.27						
above 45	6.86						

Profile of respondents for CSQ

The respondents of CSQ were customers who came in contact to the retailers directly. Customers were requested to participate in the survey and fill the questionnaire on the spot. Total 430 questionnaires were distributed to know the responses. Out of these,

total 147 completely fill responses were collected. So, nearly 34.18% responses were received over all. The demographic detail of respondents is presented in table 4.6.

Table – 4.6: Demographic Detail of Respondents for CSQ

Age Detail		Sex Detail		Qualification Detail	
Age (Years)	**%age**	**Sex**	**%age**	**Qualification**	**%age**
up to 25	25.17	Male	70.07	Technical	42.18
25-30	21.77	Female	29.93	Non technical	57.82
30-35	19.05				
35-40	14.97				
40-45	9.52				
above 45	9.52				

4.4 PRETEST OF QUESTIONNAIRE

The purpose of pretest the questionnaire is to check the suitability of the questionnaire. Pre testing of all the five questionnaire was done to discuss the same with five academia experts and ten industry experts and target respondents.

The purpose to choose academia expert was to check the relevance of questionnaires to fulfill the study objectives. The purpose to choose the industry experts and target respondents was to get the feedback about the questionnaire, addition or removal of any question, check the statement of question whether it can be easily understand by relevant respondent or not.

4.5 SURVEY

Survey was conducted for the supply chain of a two wheeler manufacturing organization of north India. The questionnaire were given to the various managers of various department (assembly, dispatch, manufacturing, pre-delivery inspection, marketing, research and design, sales, spare parts division, store and vender development etc.) in the organization. No specific preference was given to select the respondents at any level. Boyer and Pagell (2000) also discussed that the improvements in various findings when data was collected from multiple respondents within organization.

The pretest was conducted in August and September 2013 and the main survey was conducted from October 2013 to May 2014 by approaching the working executives and respondents personally. Kang and Bradley (2002) also advocated 'in person distribution and collection method' for improving the response rate in the survey.

Some of the executives fill the questionnaire on the spot while Most of the executive kept the questionnaire and promise to fill them when they have time. Some of them promised to send the responses through e-mail/ what's app while other advised to collect questionnaire personally on some scheduled dates.

4.6 ANALYSIS OF DATA

Analysis of data was done to extract some useful output from the data collected. Before analyzing the data to get some useful output, it was utmost important to check the reliability of data and sufficiency of data. Also when the variables and attributes are more in numbers, it was necessary to divide them into various sub groups.

In the present research, the reliability issue for all level was checked by Cronbach coefficient alpha (Cronbach, 1951). The data sufficiency for all level was checked by KMO. The factors and attributes were divided into various subgroups by using exploratory factor analysis with the help of SPSS 20. The details of data analysis are provided in the following sections:

4.6.1 Reliability Test

Reliability test is mandatory on collected data to develop some valid and reliable measure. Reliability indicates dependability, stability, predictability, consistency and accuracy (Seth 2006) and is checked after data collection. The most popular and widely used method is the Cronbach coefficient alpha (α). There are many software available to test the reliability by measuring the value of Cronbach coefficient alpha. The value of alpha must be greater than 0.7 for reliability of data collected (Nunnaly, 1978). In this research, SPSS 20 was used to test the reliability of data for measuring the service quality of every driver and the results of reliability test are shown in respective sections of respective chapters..

4.6.2 Data Sufficiency Test

Data sufficiency or sample adequacy test is mandatory on collected data. Data sufficiency is checked after data collection and based on correlation and partial

correlation. It is measured by the value of Kaiser-Meyer-Olkin (KMO) and the value of KMO varies from 0.0 to 1.0. The overall value of KMO must be greater than 0.6 for sample adequacy (Nunnaly,1978). Data sufficiency test was conducted with the help of SPSS 20 and detailed results are shown in corresponding sections of corresponding chapters.

4.6.3 Exploratory Factor Analysis

Exploratory Factor Analysis (EFA) is an effective tool used to divide the factor into smaller sub groups with minimum loss of information (Hair et al. 2005). EFA is used in such type of studies where there is very little or no existing evidence, as in the case of present research (Prakash 2011). Out of various methods available for factoring in EFA, principal component analysis (PCA) is preferred by most of the researchers (Parasuraman et al., 1988; Saleh and Ryan, 1991; Cronin and Taylor, 1992; Babakus and Mangold, 1992; Seth, 2006; Prakash, 2011; etc.) in combination with varimax rotation method. In the present research, PCA is used with varimax rotation to divide the factors into various sub groups. EFA is performed by using SPSS 20. The results of EFA are shown in different sections of respective chapters.

4.7 DEVELOPMENT OF SCALE TO MEASURE THE SERVICE QUALITY

The data was collected from various respondents to measure the service quality of various drivers. Various techniques like GTA, ANN, FGTA used for this purpose. The service quality index of individual drivers is evaluated in chapter 5. Further the association of the score is also computed to know the overall service quality index of entire supply chain and is presented in chapter 6. The evaluated value of entire supply chain is converted in the absolute value on 100 point scale.

4.8 CONCLUSION

In this chapter, research methodology and research sequence have been discussed. The research process starts from identification of factors from available literature and experts of same field to the questionnaire development and end with final analysis through various techniques. Proper justifications of various procedures are discussed. Demographic details of survey respondents are also covered.

CHALPTER V
MEASUREMENT OF SERVICE QUALITY AT DIFFERENT LEVEL

5.1 INTRODUCTION

Measurement of service quality is a tough task due to its unique characteristics like intangible, perishable, heterogeneous in nature. The exact value of service quality in supply chain cannot be measured, only an index can be measured. The service quality in supply chain depends on the service quality of its trading partners i.e. supplier, organization, distributor, retailer and customer. The factors, on which service quality rely, already identified in chapter 4. The summary of the factors is given in table 5.1. In this chapter an attempt has been made to measure the service quality index of different levels through different multi attributes decision making techniques. Fig 5.1 depicts the basic process that has been adopted for measuring the service quality of any trading partners.

5.2 MEASUREMENT OF SUPPLER SERVICE QUALITY

Manufacturing of high quality product consists of a combination of good quality raw material and very attentive and quality processing. Many times organizations outsource many components and many services. Also in the globalization of business, organizations are more focused on developing their core competencies to survive under the complex and turbulence business environment. In these circumstances supplier plays an important role and it is the supplier who helps the organization to achieve good market share through the supply of good quality raw material at right time, in right quantity, at very attractive price with good quality processing. Therefore most organizations devote a considerable amount of time & efforts for selection and evaluation of supplier (Ordoobadi & Wang 2011) and to measure their service quality. The process for measuring the service quality of supplier is indeed a problem-solving process, which unfolds the problem definition, formulation of criteria, qualification and choice and use of various techniques. It mainly includes two parts: the study of factors which are responsible for service quality of supplier and the study of approaches for supplier evaluation. The frontier of a supply chain, suppliers act as a

key component for success because the right service of suppliers reduces cost, increases profit margins, improves component quality and ensures timely delivery. Frequently, for an organization, the relationship with suppliers is directly related to the development of the product or service (Mettler and Rohner, 2009) and begins as a strategic sourcing initiative (Gecker, 2008) subsequently evolving data and performance indicators (Emiliani, 2010).

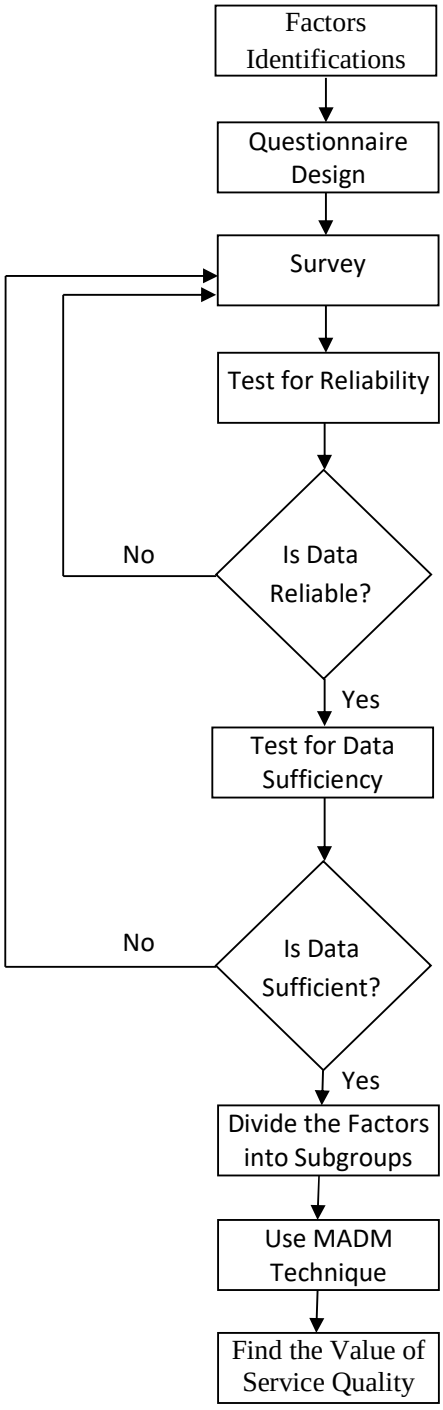


Fig. 5.1 Basic Process adopted to measure the service quality

The supplier service quality measurement process would be simple if only one factor was used in the decision making process. There are ranges of criteria in making their decisions during supplier service quality measurement. If several factors are used then it is necessary to determine how far each factor influences the decision making process, whether all are to be equally weighted or whether the influence varies accordingly to the type of criteria. It is evident that service quality has impact not only supplier/ distributor, employees and customer but also it affects the overall business & growth of organization (Seth et al 2006).

Table 5.1: Summary of identified factors

Name of driver	No. of factors identified
Supplier	28
Organization	39
Distributor	19
Retailer	17
Customer	14

5.2.1 Role of Supplier

Companies of all sizes are realizing that they no longer have complete control over their market success. This is because they rely heavily on the performance of their supply chain trading partners. Market-leading retailers and original equipments manufacturers (OEMs) know this fact, and they are looking for partners that work to ensure their success. Many large companies are now insisting that their small and medium industrial suppliers help them to improve supply chain cost, responsiveness and reliability. These market heavy weights are measuring suppliers' performance against key indicators and giving preferred status to those who perform well. This put a pressure on many small and medium manufacturers. Those that have not invested heavily in supply chain management practices or solutions beyond ERP to date are now driven to consider seriously making the investment. The business justification will rest on traditional cost savings and on revenue and customer compliance issues. Supply chain improvements will not only improve internal performance, but will also create benefits that will ripple through to customers and partners as well. Cost savings through reduced inventory levels, expediting, fulfillment and premium freight costs

could allow a company to provide more favorable prices or terms to customers. Likewise, effective planning and execution can help companies and their customers adapt to the market's demand shifts. When the company can purchase, produce and distribute the right products to the right channels in the right quantities at the right time, both supplier and customer will increase revenue capture by channel and region. Therefore supplier plays an important role as it will help the organization to achieve the excellence (Shah & Shrivastava, 2012). Closer long term relationship with suppliers implies the use of joint quality planning and joint production planning between buyer and supplier (Theodorakioglou et al 2010). In the area of manufacturing arena, supplier selection is a crucial strategic decision that has long term impacts on a company's profitability and efficiency (Muralidhar et al 2010). Selection of appropriate suppliers in supply chain management (supply chain management) is a challenging issue because it requires battery of evaluation criteria/attributes, which are characterized with complexity, elusiveness, and uncertainty in nature (Ming-Lang et al 2009). According to Choi & Hartley (1996) with a well developed long term relationship a supplier becomes a part of a well managed supply chain and it will have a lasting effect on the competitiveness of the entire supply chain. Shah & Shrivastava (2012) had discussed the following role of a supplier

a) Improving transportation facilities, delivering performances
b) Proper stocking & fulfilling the requirements timely
c) Inventory & finance management
d) Proper communication with organization & market.

Dowlatshahi (1998) stated that to improve communication the supplier should be involved in the early phases of product design. Supplier performance measures were based on the price variation rejects on receipt and on time delivery (Gunasekaran et al, 2004). The contribution of suppliers in delivering values to customers, hence, building competitive capabilities (quality, delivery, flexibility, and cost) has been well recognized (Olhager & Prajogo 2012).

5.2.2 Analysis to Measure the Service Quality of Supplier

Various factors on which service quality of supplier depends are already identified in chapter 4. It was necessary to use appropriate technique to measure the service quality of supplier. Following steps were used to measure the service quality of supplier

1. Design a questionnaire based on identified factors (already discussed in chapter 3).
2. Collect the response from the related respondents through survey (already discussed in chapter 4).
3. Check the reliability of data.
4. Test the data for sufficiency.
5. Use of factor analysis to group the related factors.
6. Use of Graph Theoretic Approach to measure the service quality.

5.2.2.1 Reliability Test

Reliability test indicates the consistency among the scales in their measurement for any issue (Shin et al. 2000). Reliability can be measured through Cronbach alpha. In the present study, reliability is assessed by internal consistency method which reflects equivalence, homogeneity and inter-correlation of the items used in a measure. Output of this analysis is provided by SPSS 20 and indicates significantly high reliability of data and is depicted in table 5.2. Nunnaly (1978) suggested the acceptable value of Cronbach alpha as 0.7. So, the value of Cronbach alpha is satisfactory which itself indicates the correctness of data.

Table 5.2: Reliability analysis of SSQ

Service quality measurement	Supplier service quality measurement
Value of Cronbach α	0.891
Finding	Quiet good

5.2.2.2 Data Sufficiency Test

Data sufficiency test is necessary to verify whether the data size is suitable for factor analysis or not. Kaiser- Meyer- Olkin (KMO) sample of adequacy value and Barlett's test of sphericity are the simple methods for the same. This can be done with the help of SPSS 20. The value of KMO test ranges from 0 to 1 and should be more than or

equal to 0.6 while the significant value of Barlett test should be 0.05 or smaller for sample adequacy (Pallant, 2007). The Table 5.3 depicts that the value of KMO test is more than 0.6 and significant value is less than 0.05 which indicates that the data size is suitable for factor analysis.

Table 5.3: KMO and Bartlett's Test for SSQ

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.721
Bartlett's Test of Sphericity	Approx. Chi-Square	749.089
	Df	276
	Sig.	0.000

5.2.2.3 Exploratory Factor Analysis

When it has been found that data is reliable and data size is suitable for factor analysis, again PASW 20 was used to generate pattern matrix by factor analysis which grouped the related factors. Table 5.4 is pattern matrix table and it shows that all 28 factors can be sub divided into six sub groups.

The factors whose value is more than 0.5 having strong effect and whose value is less than 0.5 having very lean effect, so the later can be avoid. First five groups having many factors whose values are more than 0.5 but sixth group does not have any factor whose value is more than 0.5, so sixth group can also be avoided. Also, some factors having value more than 0.5 in more than one group, the largest value must be considered. Only 17 factors were qualified the criteria and considered and clustered into five sub groups as quality in supply chain (QSC), waste control analysis (WCA), partnership strategy (PS) strategy compliance (SC) and supplier management (SM) as depicted in table 5.5 and fig. 5.2

Table 5.4 :Pattern Matrix for factor analysis

Factors	Components					
	1	2	3	4	5	6
Quality System	0.837					
Commitment of Trading Partner	0.770					
Delivery	0.747					
Efficiency	0.655					
Supplier Performance	0.612				0.463	
Logistic	0.528			0.393		
Resource Utilization	0.427			0.336		
Lean System		0.739				
Quality Data Reporting		0.639			0.351	
Financial Performances	0.525	0.575				
Procurement Policy		0.493			0.409	
Welfare Activity		0.460				
Capacity		0.444	0.364			
Trust on Trading Partner			0.846			
Cost of Activity Time			0.603			
Inventory Level		0.419	0.490			
Flexibility Range			0.454		0.364	
Strategy				0.881		
Safety				0.857		
Honesty						0.382
Quality of Product	0.575			0.581		
Strategic Supplier Partnership					0.936	
Personal behavior	0.325	0.319				
Supplier Quality Management					0.731	
Cost					0.921	
Faster Response Time	0.322		0.358			0.484
Timeliness				0.192		0.208
Sincerity						0.268

Extraction Method: Principal Component Analysis.

Table 5.5: Groupism of factors responsible for service quality of supplier

Group	Sub Group	Factors					
Supplier	*Quality in Supply Chain (QSC)*	Quality System (QS)	Commitment of Trading Partner (CT)	Delivery (DL)	Efficiency (EF)	Supplier Performance (SP)	Logistic (LG)
	Waste Control Analysis (WCA)	Lean System(LS)	Quality Data Reporting (QD)	Financial Performances (FP)			
	Partnership Strategy (PS)	Trust on Trading Partner (TT)	Cost of Activity Time (CA)				
	Strategy Compliance (SC)	Strategy (ST)	Safety (SF)	Quality of Product (QP)			
	Supplier Management (SM)	Strategic Supplier Partnership (SS)	Supplier Quality Management (SQ)	Cost (CO)			

Quality in Supply Chain (QSC) consist six factors, Waste Control Analysis (WCA) contains three factors, Partnership Strategy (PS) contains two factors, strategy compliance (SC) and supplier management (SM) each contains three factors.

After dividing the 17 factors into five groups, the next step was to measure the service quality of supplier through graph theoretic approach.

5.2.2.4 Digraph Representation

A digraph is a direction assigned graph & used to represent the factors & their interdependencies in term of nodes & edges. The supply chain management digraph represents the supply chain management environmental factors (S_i's) through its nodes & edges & their dependencies (S_{ij}'s). S_{ij} indicates the degree of dependence of the j^{th} factor on i^{th} factor. Based on the discussion with industry and academy expert, the fig. no. 5.3 to 5.8 were drawn. Fig. 5.3 is a schematic representation of all the five sub groups and fig. 5.4 to 5.8 show the relations between various factors of the same sub group.

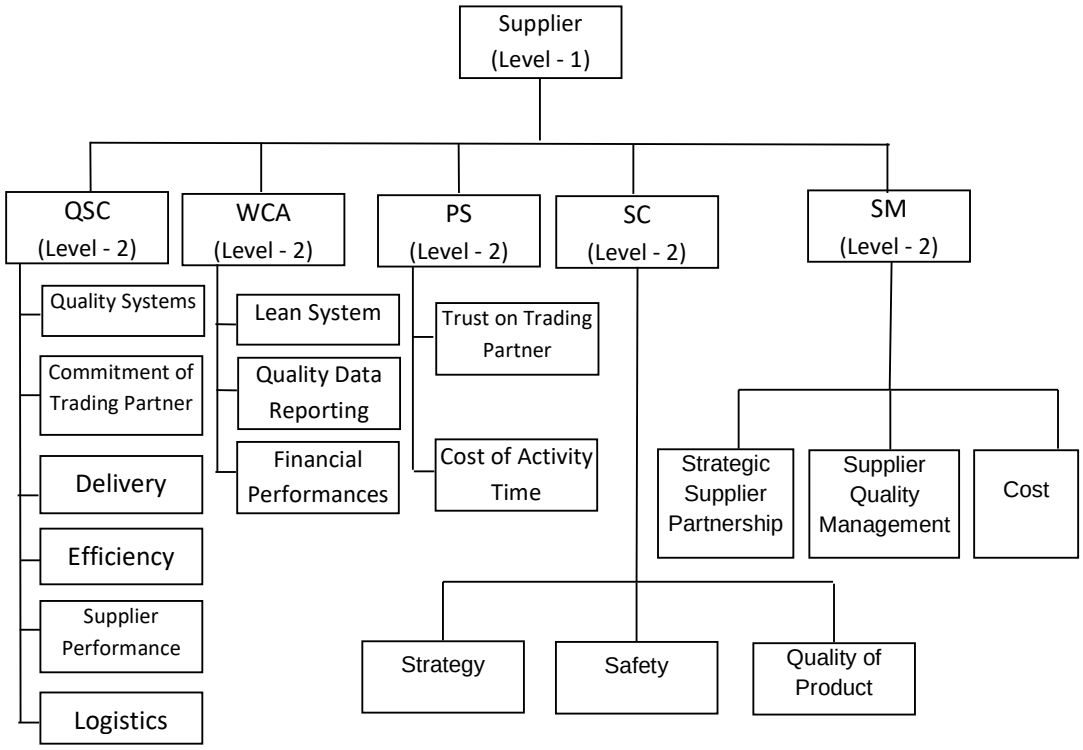


Fig. 5.2 groups and subgroup of factors showing the relationship of supplier

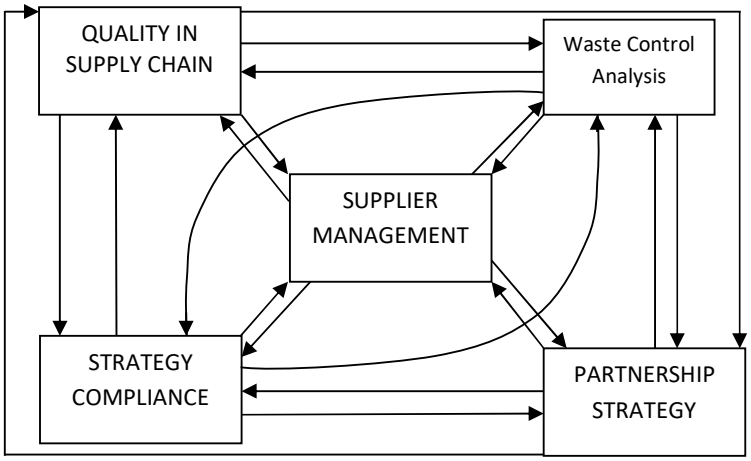


Fig.5.3 Schematic representation of supplier sub group

Quality in Supply Chain (QSC) consists of quality systems, commitment of trading partners, delivery, efficiency, supplier performance and logistic. Quality systems, efficiency and supplier performance reduces wastes, so related to lean system and relates to Waste Control Analysis. Commitment of trading partners, quality systems and supplier performance create trust on trading partners while delivery, efficiency

and logistic are directly related to cost of activity time. So, Quality in Supply Chain (QSC) has direct relationship with Partnership Strategy. Similarly, quality system and commitment of trading partner are responsible for maintaining the quality of product and long term relationship with supplier. On the other side supplier performance indicate the supplier quality management while delivery, efficiency and logistic are directly related to cost of product. In this manner, Quality in Supply Chain (QSC) has direct relation with Strategy Compliance and Supplier Management.

Waste Control Analysis consists of lean system, quality data reporting and financial performances. The first and last factors are related to quality in supply chain while the last two factors are directly related to the factors of Partnership Strategy, which indicate that there is direct relation between Waste Control Analysis and Partnership Strategy. Also lean systems affects the cost of product, quality data reporting and financial performances improve the quality of product and supplier partnership and show the supplier quality management. It means that Waste Control Analysis having relationship with strategy Compliance and Supplier Management also.

Factors of Partnership Strategy are trust on trading partner and cost of activity time. The former factor is due to quality of product and strategy and commitment of trading partners and quality data reporting while later is related to safety systems used by the supplier. Also both the factors are related to supplier partnership, supplier quality management and cost of product. So, Partnership Strategy has relationship with quality in supply chain, waste control analysis, Strategy Compliance and Supplier Management.

Factors of Strategy Compliance are strategy, safety and quality of product, which are depends on supplier quality management, cost, quality systems, delivery, efficiency, supplier performances quality data reporting cost of activity time and logistic. So Strategy Compliance having relationship with Supplier Management, Quality in Supply Chain, waste control analysis and partnership strategy.

Factors of Supplier Management are strategic supplier partnership, supplier quality management and cost which are directly related to quality systems, supplier performances, financial performances, trust on trading partner and quality of product. So Supplier Management having relationship with Quality in Supply Chain, Waste Control Analysis, Partnership Strategy and Strategy Compliance.

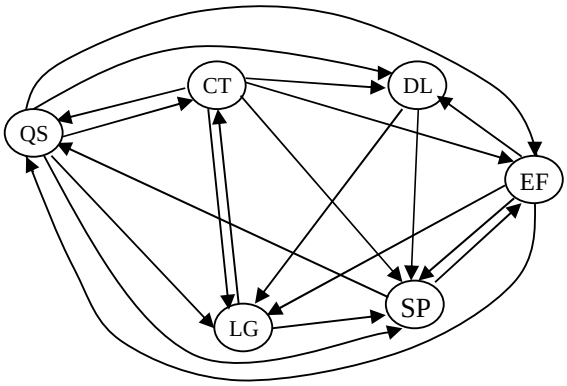


Fig. 5.4 Digraph of Quality in Supply Chain

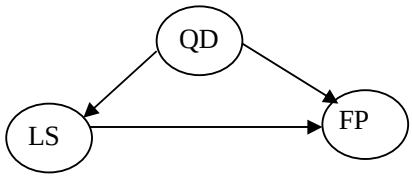


Fig. 5.5 Digraph of Waste Control Analysis

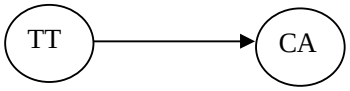


Fig. 5.6 Digraph of Partnership Strategy factors

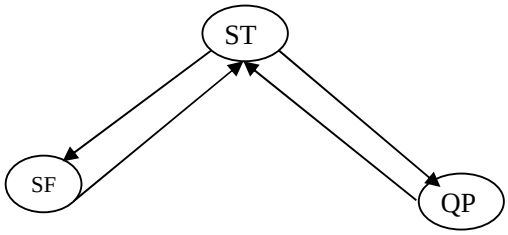


Fig. 5.7 Digraph of Strategy Compliance factors

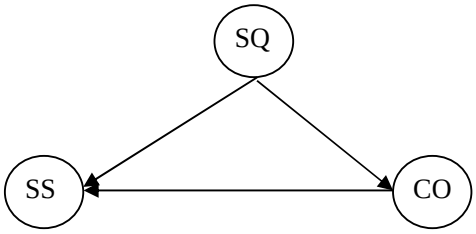


Fig. 5.8 Digraph of Supplier Management

5.2.2.5 Algorithm of Graph Theoretic Approach

The graph theoretic approach evaluates the supplier performance in terms of a single numerical index. This takes into consideration the inheritance effect of factors and their interdependencies. The algorithm of the proposed approach is presented here.

1. First of all, identify various factors that affect supply chain performance. The factors affect the performance of a supplier in a supply chain discussed in chapter -3.
2. Broadly divide these factors into groups and sub groups as in table -5.5.
3. Develop a digraph between the factors of various groups and sub groups depending on their interdependencies (Figure 5.3 to 5.8). The nodes in the digraph represent factors while edges represent interaction among factors.
4. Develop group and sub group variable permanent matrix (VPM) with diagonal elements representing inheritances and the off diagonal elements representing interactions among them.
5. At the sub-system level use Tables -5.6 and 5.7. This will provide numerical values for inheritance of attributes and their interactions with the help of experts.

6. Find the value of VPM which is known as permanent function (PF) for each subgroup, which can be obtained in a similar manner as determinant with only difference that all the negative signs of determinant are replaced by positive sign.

7. Find the value of permanent function for the system. This is the value of the supplier service quality index for a supply chain.

   The performance of a supplier in a supply chain can thus be evaluated based on the above discussed methodology. The interdependencies among these variables are developed with the help of expert opinion from automobile industry and academic. A small brain storming session was conducted where experts from the automobile industry and academia participated. The interdependency of these factors is shown in fig. 5.3 to 5.8. Based on interdependencies of these elements, sub-system and sub subsystem digraphs have been developed wherein these elements form a VPM for sub-system and sub subsystem

The Variable permanent matrix for system, subsystems and sub subsystems of supplier can be written as

$$\text{VPM} - \text{supplier} = \begin{array}{c} \\ 1 \\ 2 \\ 3 \\ \vdots \\ m \end{array} \begin{array}{c} \begin{array}{ccccc} 1 & 2 & 3 & \cdots & m \end{array} \\ \begin{pmatrix} S_1 & S_{12} & S_{13} & \cdots & S_{1m} \\ S_{21} & S_2 & S_{23} & \cdots & S_{2m} \\ S_{31} & S_{32} & S_3 & \cdots & S_{3m} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ S_{m1} & S_{m2} & S_{m3} & \cdots & S_m \end{pmatrix} \end{array} \quad \text{(M-1)}$$

5.2.2.6 Quantification of S_i's &S_{ij}'s (Diagonal & Off Diagonal Elements)

Quantification of diagonal & off diagonal elements of VPM-supplier i.e. S_i's &S_{ij}'s is necessary for the evaluation of VPM- supplier. Table -5.6 suggests the inherent value over a scale of 0.1 –0.9 for the qualitative measure of an attribute.

Table -5.6: Inheritance values of attributes

Qualitative measure of attributes	Assigned value of the attributes (Si)
Exceptionally low	0.1

Very low	0.2
Low	0.3
Below normal	0.4
Normal	0.5
Above normal	0.6
High	0.7
Very high	0.8
Exceptionally high	0.9

Similarly, the relative importance between the two characteristics or attributes is also assigned an interaction value on a scale of 0.1–0.5 and is arranged into classes as mentioned in Table – 5.7.

Table -5.7: Interaction values of attributes

Dependency effect of attribute 'j on attribute i'	**Assigned value of the attributes (S_{ij})**
Very weak	0.1
Weak	0.2
Medium	0.3
Strong	0.4
Very strong	0.5

Variable permanent matrix (VPM) for sub group Quality in supply chain, waste control analysis partnership strategy, strategy compliance and supplier management is given as M-2, M-3, M-4, M-5 and M-6 respectively, while table - 13, 14, 15, 16 and 17 are the VPM after putting the inheritance and interaction values of factors.

$$\text{VPM- QSC (level-2)} = \begin{array}{c} \\ QS \\ CT \\ DL \\ EF \\ SP \\ LG \end{array} \begin{array}{c} \begin{array}{cccccc} QS & CT & DL & EF & SP & LG \end{array} \\ \begin{pmatrix} S_1 & S_{12} & S_{13} & S_{14} & S_{15} & S_{16} \\ S_{21} & S_2 & S_{23} & S_{24} & S_{25} & S_{26} \\ 0 & 0 & S_3 & 0 & S_{35} & S_{36} \\ S_{41} & 0 & S_{43} & S_4 & S_{45} & S_{46} \\ S_{51} & 0 & 0 & S_{54} & S_5 & 0 \\ 0 & S_{62} & 0 & 0 & S_{65} & S_6 \end{pmatrix} \end{array} \qquad \text{(M-2)}$$

Inheritance values for M-2 to M-6 are mean value of the responses filled by the respondents. The respondents fill the response on the scale 1 to 5 of 5 point Likert

scale but here the values are on the 0.1 to 0.9 of 9 point scale. So unitary system are used to convert five point scale value into nine point scale value (divide by 5 to convert in to 0 to 1 scale, multiply by 0.9 to convert 0.1 to 0.9 scale). Interaction values M-2 to M-6 are taken from the discussion of expert from automobile industry and academia.

$$\text{VPM- QSC (level-2)} = \begin{array}{c} \\ QS \\ CT \\ DL \\ EF \\ SP \\ LG \end{array} \begin{array}{c} \begin{array}{cccccc} QS & CT & DL & EF & SP & LG \end{array} \\ \begin{pmatrix} 0.596 & 0.4 & 0.2 & 0.3 & 0.3 & 0.1 \\ 0.2 & 0.704 & 0.3 & 0.2 & 0.3 & 0.2 \\ 0 & 0 & 0.74 & 0 & 0.2 & 0.1 \\ 0.3 & 0 & 0.2 & 0.66 & 0.4 & 0 \\ 0.2 & 0 & 0 & 0.2 & 0.724 & 0 \\ 0 & 0.1 & 0 & 0 & 0.2 & 0.756 \end{pmatrix} \end{array} \quad \text{(M-2)}$$

The value of this VPM or Permanent Function (PF) = 0.269.

$$\text{VPM-WCA (level-2)} = \begin{array}{c} \\ LS \\ QD \\ FP \end{array} \begin{array}{c} \begin{array}{ccc} LS & QD & FP \end{array} \\ \begin{pmatrix} S_1 & 0 & S_{13} \\ S_{21} & S_2 & S_{23} \\ 0 & 0 & S_3 \end{pmatrix} \end{array} \quad \text{(M-3)}$$

$$\text{VPM-WCA (level-2)} = \begin{array}{c} \\ LS \\ QD \\ FP \end{array} \begin{array}{c} \begin{array}{ccc} LS & QD & FP \end{array} \\ \begin{pmatrix} 0.66 & 0 & 0.4 \\ 0.3 & 0.788 & 0.3 \\ 0 & 0 & 0.68 \end{pmatrix} \end{array} \quad \text{(M-3)}$$

The value of this VPM or Permanent Function (PF) = 0.354.

$$\text{VPM-PS (level-2)} = \begin{array}{c} \\ TT \\ CA \end{array} \begin{array}{c} \begin{array}{cc} TT & CA \end{array} \\ \begin{pmatrix} s_1 & s_{12} \\ 0 & s_2 \end{pmatrix} \end{array} \quad \text{(M-4)}$$

$$\text{VPM-PS (level-2)} = \begin{array}{c} \\ TT \\ CA \end{array} \begin{array}{c} \begin{array}{cc} TT & CA \end{array} \\ \begin{pmatrix} 0.652 & 0.1 \\ 0 & 0.632 \end{pmatrix} \end{array} \quad \text{(M-4)}$$

The value of this VPM or Permanent Function (PF) = 0.412.

$$\text{VPM- SC (level-2)} = \begin{array}{c} \\ ST \\ SF \\ QP \end{array} \begin{array}{c} \begin{array}{ccc} ST & SF & QP \end{array} \\ \begin{pmatrix} S_1 & S_{12} & S_{13} \\ S_{21} & S_2 & 0 \\ S_{31} & 0 & S_3 \end{pmatrix} \end{array} \quad \text{(M-5)}$$

$$\text{VPM- SC (level-2)} = \begin{array}{c} \\ ST \\ SF \\ QP \end{array} \begin{array}{c} \begin{array}{ccc} ST & SF & QP \end{array} \\ \begin{pmatrix} 0.664 & 0.2 & 0.2 \\ 0.3 & 0.676 & 0 \\ 0.3 & 0 & 0.736 \end{pmatrix} \end{array} \quad \text{(M-5)}$$

The value of this VPM or Permanent Function (PF) = 0.415.

$$\text{VPM-SM (level-2)} = \begin{array}{c} \\ SS \\ SQ \\ CO \end{array} \begin{array}{c} \begin{array}{ccc} SS & SQ & CO \end{array} \\ \begin{pmatrix} s_1 & 0 & 0 \\ s_{21} & s_2 & s_{23} \\ s_{31} & 0 & s_3 \end{pmatrix} \end{array} \quad \text{(M-6)}$$

$$\text{VPM-SM (level-2)} = \begin{array}{c} \\ SS \\ SQ \\ CO \end{array} \begin{array}{c} \begin{array}{ccc} SS & SQ & CO \end{array} \\ \begin{pmatrix} 0.808 & 0 & 0 \\ 0.4 & 0.704 & 0.3 \\ 0.4 & 0 & 0.62 \end{pmatrix} \end{array} \quad \text{(M-6)}$$

The value of this VPM or Permanent Function (PF) = 0.353.

5.2.2.7 Digraph for Present Study

Now a digraph (fig. 5.9) and VPM (M-7) is drawn for supplier group (level -1). In this VPM the inheritance values are the values find in M-2 to M-6 for S_1, S_2, S_3, S_4 and S_5 respectively. The interaction values are taken with the help of expert opinion from automobile industry and academic. Then actual value, maximum value and minimum value of VPM is to be find out to compare the supplier index.

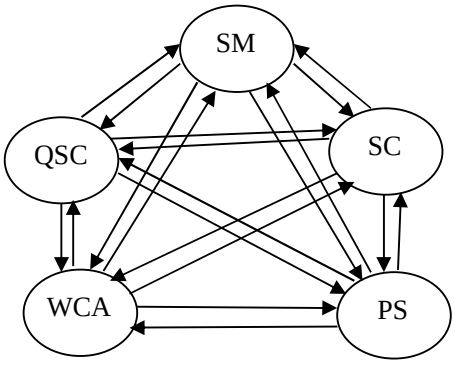


Fig 5.9 Digraph of Supplier Group

Matrices (M-7 to M-9) are used to calculate the actual value, maximum and minimum value of the supplier service quality index (SSQI). Result of table -18 shows that the actual position of the index or relations between the supplier and organization.

$$\text{VPM-Supplier (level-1)} = \begin{array}{c} \\ G1 \\ G2 \\ G3 \\ G4 \\ G5 \end{array} \begin{array}{c} \begin{array}{ccccc} G1 & G2 & G3 & G4 & G5 \end{array} \\ \begin{pmatrix} S_1 & S_{12} & S_3 & S_{14} & S_{15} \\ S_{21} & S_2 & S_{23} & S_{24} & S_{25} \\ S_{31} & S_{32} & S_3 & S_{34} & S_{35} \\ S_{41} & S_{42} & S_{43} & S_4 & S_{45} \\ S_{51} & S_{52} & S_{53} & S_{54} & S_5 \end{pmatrix} \end{array} \qquad \text{(M-7)}$$

$$\text{VPM-Supplier (level-1)} = \begin{array}{c} \\ G1 \\ G2 \\ G3 \\ G4 \\ G5 \end{array} \begin{array}{c} \begin{array}{ccccc} G1 & G2 & G3 & G4 & G5 \end{array} \\ \begin{pmatrix} 0.269 & 0.4 & 0.4 & 0.2 & 0.3 \\ 0.2 & 0.354 & 0.4 & 0.2 & 0.4 \\ 0.2 & 0.2 & 0.412 & 0.3 & 0.3 \\ 0.3 & 0.2 & 0.3 & 0.415 & 0.4 \\ 0.3 & 0.2 & 0.2 & 0.2 & 0.353 \end{pmatrix} \end{array} \text{(M-7)}$$

Actual Value of this VPM or Permanent Function (PF) for supplier service quality index (SSQI) is 0.264

$$\text{VPM-Supplier (level-1)} = \begin{array}{c} \\ G1 \\ G2 \\ G3 \\ G4 \\ G5 \end{array} \begin{array}{c} \begin{array}{ccccc} G1 & G2 & G3 & G4 & G5 \end{array} \\ \begin{pmatrix} 0.269 & 0.5 & 0.5 & 0.5 & 0.5 \\ 0.5 & 0.354 & 0.5 & 0.5 & 0.5 \\ 0.5 & 0.5 & 0.412 & 0.5 & 0.5 \\ 0.5 & 0.5 & 0.5 & 0.415 & 0.5 \\ 0.5 & 0.5 & 0.5 & 0.5 & 0.353 \end{pmatrix} \end{array} \text{(M-8)}$$

Maximum Value of this or Permanent Function (PF) for supplier service quality index (SSQI) is 2.834

$$\text{VPM-Supplier (level-1)} = \begin{array}{c} \\ G1 \\ G2 \\ G3 \\ G4 \\ G5 \end{array} \begin{array}{c} \begin{array}{ccccc} G1 & G2 & G3 & G4 & G5 \end{array} \\ \begin{pmatrix} 0.269 & 0.1 & 0.1 & 0.1 & 0.1 \\ 0.1 & 0.354 & 0.1 & 0.1 & 0.1 \\ 0.1 & 0.1 & 0.412 & 0.1 & 0.1 \\ 0.1 & 0.1 & 0.1 & 0.415 & 0.1 \\ 0.1 & 0.1 & 0.1 & 0.1 & 0.353 \end{pmatrix} \end{array} \quad \text{(M-9)}$$

Minimum Value of this or Permanent Function (PF) for supplier service quality index 4(SSQI) is 0.015

5.3 MEASUREMENT OF ORGANIZATION SERVICE QUALITY

The automobile sector is going through a revolutionary change, which dramatically affect the ways in which human live and work. New automobiles are continuously being launched to satisfy the existing and potential needs of customers. The size of automobile sector is increasing in almost all economies around the world. Supply chain of automobile organizations varies widely in size. On the upstream side there are suppliers of suppliers and on the downstream side distributors, retailers and end users. For any organization it is necessary to satisfy the end users i.e. customer. Even after designing and manufacturing a good vehicle, it is difficult to sale without providing good service quality and customer satisfaction. There are several reasons why customers must be given good service quality. Most important of them are:

- Industry has become so competitive that customers now have variety of alternatives, if the customer is lost, it can be extremely difficult to win back the individual.
- Most customers do not complain when they experience the problems. These customers simply opt out and take their business elsewhere (Lovelock et al 2008).

In automobiles, it is the customer who defines the service quality. Therefore human side of automobile is the key to deliver service quality (Lovelock et al 2008). It can be seen as how well the service provided satisfies the expectations of customers (Bouman and vander Wiele, 1992). Service quality has an effect on customer satisfaction and customer loyalty (Kandampully, 1998) and creates competitive advantage for organizations and is associated with successful organizations (Kandampully, 1998). Good service affects the relationships and marketing, as

customers are willing to build relationships with the organizations that provide good service quality (Zeithamal and Bitner, 2003). Service quality also has an effect on profitability and costs (Buttle, 1996).

Service quality in automobile industries has major influence on customer satisfaction as customers buy the products due to service quality they are getting. With the aim of sustaining long term relationships with their customers, many businesses have changed their strategic focused to emphasize customer retention (Peng and Wang 2006). Preserving their long term customer relationships requires that these businesses measure and appropriately adjust the service quality of their customer to the good service quality. So it is necessary to identify the various factors which are responsible for the service quality of the organization. Also the measurement of the service quality is important as it indicates the need of improvement. There are very few methods (GTA, Fuzzy-GTA) by which service quality may be measured in numerical form. In this study, artificial neural network (ANN) used to measure the service quality of organization. This technique was nowhere used earlier for this purpose, the outcome was cross checked by already existing technique i.e. Graph Theory Approach.

5.3.1 Role of Manufacturing Organization

For more than a decade, supply chain management has increased attention among the industries for achieving competitive advantage. Some of the benefits of supply chain management, which are predominantly discussed in the literature, include lower inventory levels (Closs et al 1998, Pagel 1999, Stank et al 1999, Quinn 2000), better responsiveness (Lalonde & James 1994, Stank et al 1999), and lower throughput time (Stank et al 1999). Some key issues such as IT-enablement of supply chains, buyer-supplier relationships, and inventory management are at the core of the supply chain research and have been given a lot of attention in the literature (e.g., Monczka 1996, Nielson 1998, Bensaou 1999, Pagel 1999, Handfield & Nichols 1999, Ballou et al 2000, Handfield et al 2000). There are, however, some other issues such as postponement (Anderson et al 1997, Metz 1998), attitude of major stakeholder of the supply chain (Ballou et al 2000, Munson et al 2000), top management commitment (Higginson and Alam 1997), disparity in trading partners capability (Kwan 1999, Sohal et al 2001) etc., which influence these core issues. The literature on supply chain management has many references about these issues but lacks in providing

enough empirical evidence of these relationships. Further, it is the people who often talk about supply chain strategies to cope-up with the ever-changing trends and expectations of market. Sometimes, the operational level processes involved in a supply chain are ignored, which results in unexpected inefficiencies in the system. The end goal of any company is a satisfied customer which is a guarantee of repeat order. The process of locating, obtaining and transporting the inputs needed to do this is the core function of supply chain management. Supply chain design in the manufacturing industry requires a great deal of focus on physical product and a broader supplier base. The business strategy does not matter, if the operations function can't deliver, its game over. Despite years of experience with operations improvement methods such as Lean and Six Sigma, many manufacturers aren't able to conduct rapid, integrated operations transformations across a complex production system. Companies that can rapidly develop high performing production systems can also develop competitive advantage. Today's supply chains have to be more nimble than ever before, able to respond quickly to the slightest changes in direction, more global, new products, greater risk of disruption, faster-paced, and more. All while meeting new demands for lower costs and increased productivity in a ferociously competitive global environment. Manufacturing organization has investing capacity for research, development and manufacturing. It is the trust, commitment and market reputation of the manufacturer which motivates distributor and retailer to invest and kept inventory. The increasing competition has driven firms to not only improve their internal operations, but also focus on integrating their suppliers into overall value chain processes (Olhager & Prajogo 2012).

5.3.2 Analysis to Measure the Service Quality of Focal Organization

Various factors, on which service quality of focal organization depends, are already identified in chapter 4. It was necessary to use appropriate technique to measure the service quality of focal organization. Artificial Neural Network (ANN) is used for this purpose. Following steps were used to measure the service quality of focal organization

1. Design a questionnaire based on identified factors (already discussed in chapter 3).
2. Collect the response from the related respondents through survey (already discussed in chapter 3).

3. Check the reliability of data.
4. Test the data for sufficiency.
5. Group the related factors.
6. Use ANN to measure the service quality of focal organization

The factors identified in table 3.1 used to calculate the service quality of organization. All these factors grouped into dimensions and sub dimensions as shown in fig. 5.10 which shows the criteria of evaluating the service quality of organization. Here, service quality of organization depends on two broad dimensions i.e. employers and employee. Dimension employer divide into six sub dimensions which contains various factor and dimension employee divide into two sub dimensions containing various factors.

5.3.2.3 Algorithm for the Construction of ANN Network

Following algorithm used during constructing the network (Fig. 5.11) for the calculation of service quality of organization (Sivanandam & Deepa, 2012)

Step 0: for each training input pattern x(y), y = 1 to Y. Perform step 1 & 2

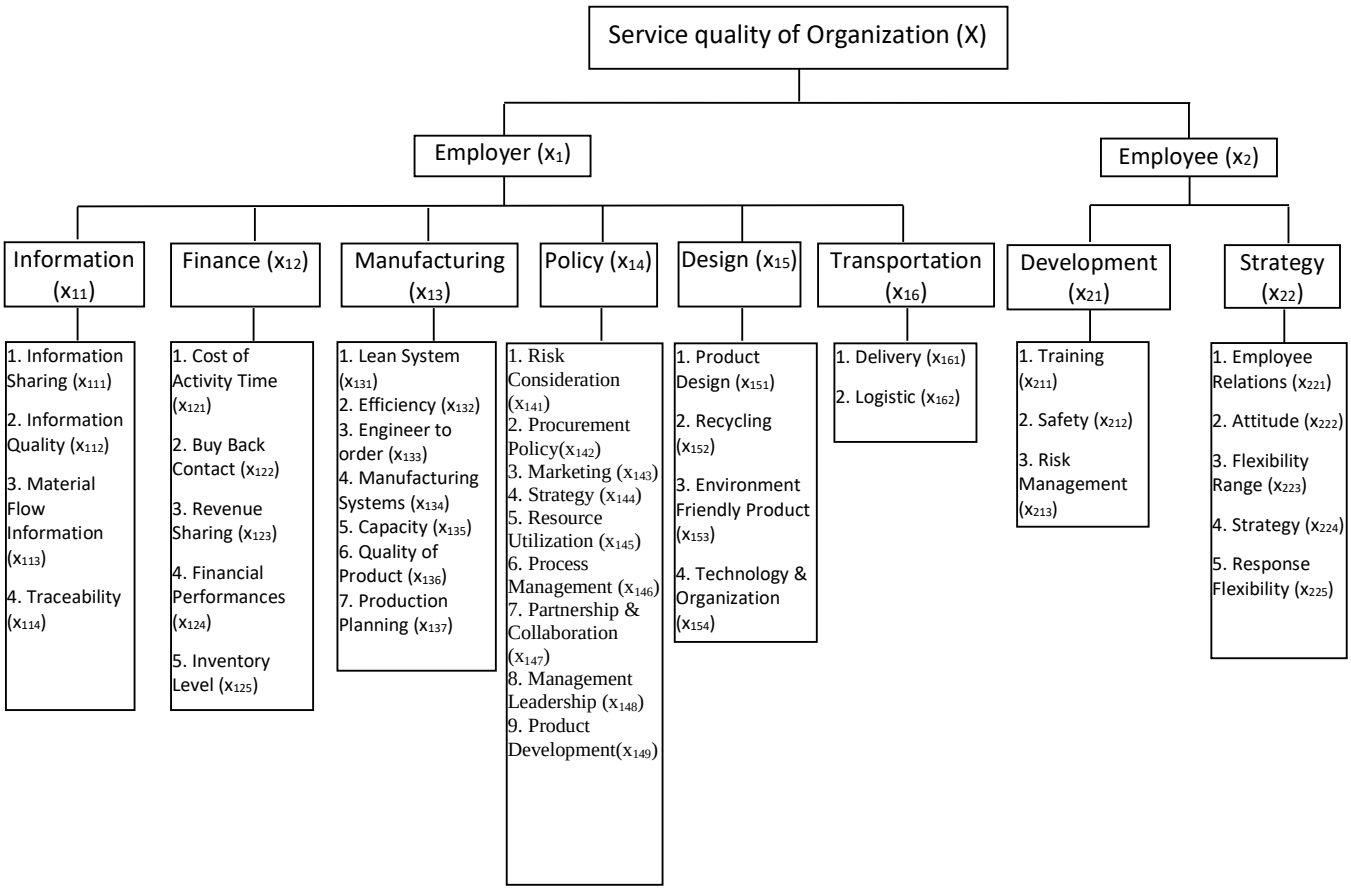


Fig.5.10 Criteria of evaluating service quality of Organization

Step1: create pattern unit z_a (hidden layer-1 unit). Weight vector for unit z_a is given by $W_a = x(y)$

Step 2: connect the hidden layer -1 unit to the hidden layer -2 unit.

If x(y) belongs to class 1, then connect the hidden layer unit z_a to the hidden layer unit X_1. Otherwise, connect pattern hidden layer unit z_a to the hidden layer unit X_2.

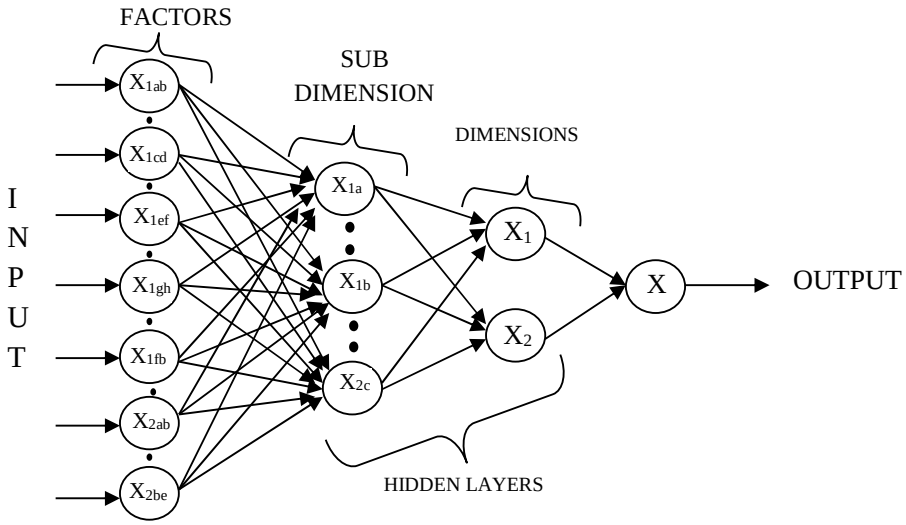


Fig. 5.11 ANN Network to calculate the service quality of Organization

5.3.2.4 Calculation and Results

Service quality of automobile organization can be calculated by using ANN. For this purpose three types of data required, one was input data, second was weight vectors or weightage and third was bias if any. The input for ANN is kept on 0 to 1 scale, weightage is calculated by SPSS 20 and it was assumed that there is no bias. So, convert all the responses into 0 to 1 scale. In the present study, the responses were on 1 to 5 point scale, converted into 0 to 1 scale by dividing them by 5.The algorithm is as follows:

1. Find the input value for input layer. The average value of responses considered for the same.

2. Find the weightage between input and hidden layer-1. SPSS 20 by using principal component analysis used for this purpose.

3. Calculate the input for hidden layer -1. (step 2 to 4 are shown in table -5.8)

4. Calculate the input for hidden layer – 2. For this purpose value of weightage for X_1 and X_2 was required which can be calculated by same method as used in step 2. (this is shown in Table – 5.9)

5. Calculate the final output of neural network, for this purpose value of weightage for final output X was required. After a long discussion with various persons involved in survey, a conclusion came that the employers have double the responsibility than the employee as they have to manage the whole supply chain i.e. upstream and downstream side. So the weightage for employer was kept double than the employee. Table – 5.10 shows the net output which indicates that the service quality of organization is 9.48.

Table-5.8: Calculation for hidden layer-1

Dimensions	Sub Dimensions	Factors	Input value	Value of Weightage for								Input value for sub dimensions
				X11	X12	X13	X14	X15	X16	X21	X22	
X1	X11	X111	0.6	0.150	-0.077	-0.308	0.479	-0.191	-0.205	0.428	0.006	12.09753
		X112	0.71	0.249	0.508	0.225	0.304	0.363	0.044	0.261	-0.103	
		X113	0.69	0.090	0.365	-0.168	0.555	0.489	0.216	0.195	0.120	
		X114	0.67	0.376	0.208	0.217	0.484	0.060	0.026	0.314	-0.280	
	X12	X121	0.60	0.508	-0.208	-0.309	0.381	0.096	0.134	-0.229	-0.136	0.51248
		X122	0.43	0.453	0.561	0.194	-0.091	-0.042	-0.085	0.114	0.229	
		X123	0.50	0.505	0.278	0.076	0.307	-0.102	0.005	-0.015	-0.196	
		X124	0.69	0.423	0.644	0.085	-0.150	0.304	-0.008	-0.110	-0.176	
		X125	0.53	0.166	0.699	0.125	-0.001	0.260	-0.141	-0.044	0.410	
	X13	X131	0.64	0.555	0.339	0.238	-0.012	-0.024	-0.216	-0.343	-0.118	-0.04239
		X132	0.51	0.639	0.273	0.043	0.070	0.189	-0.203	0.044	-0.024	
		X133	0.52	0.803	0.046	0.010	0.220	-0.257	-0.116	-0.042	-0.119	
		X134	0.58	0.377	0.384	-0.100	0.355	-0.197	0.247	-0.386	-0.103	
		X135	0.68	0.652	0.119	0.138	0.129	-0.228	-0.207	-0.377	0.178	
		X136	0.73	0.544	0.365	-0.134	-0.145	0.098	-0.018	-0.266	-0.221	
		X137	0.65	0.490	0.483	0.098	-0.307	-0.133	-0.099	0.027	0.266	
	X14	X141	0.51	0.500	-0.165	0.398	-0.041	-0.192	-0.187	0.270	-0.046	0.41754
		X142	0.62	0.359	0.150	-0.136	-0.416	0.108	-0.342	0.288	-0.101	
		X143	0.61	0.583	-0.248	-0.125	0.347	0.028	0.115	-0.223	0.419	
		X144	0.74	0.466	0.021	-0.688	-0.138	0.039	-0.008	-0.129	-0.116	
		X145	0.73	0.569	-0.005	-0.696	-0.146	0.088	0.042	-0.015	-0.003	
		X146	0.63	0.636	0.013	-0.603	-0.245	-0.058	0.058	0.023	-0.067	
		X147	0.74	0.664	0.224	-0.227	-0.383	0.048	-0.052	0.010	-0.074	

		X148	0.65	0.609	0.023	-0.296	-0.143	-0.128	0.360	0.251	0.128	
		X149	0.69	0.653	-0.093	0.245	0.005	-0.293	0.308	-0.108	-0.076	
	X15	X151	0.73	0.613	-0.286	0.266	0.080	-0.330	0.106	-0.102	-0.179	1.10169
		X152	0.65	0.569	0.380	0.294	-0.113	-0.229	0.030	0.220	0.278	
		X153	0.65	0.703	-0.273	-0.039	-0.006	-0.174	0.083	0.332	0.036	
		X154	0.73	0.622	-0.315	-0.146	0.087	-0.335	0.019	0.254	0.190	
	X16	X161	0.71	0.466	-0.362	0.064	0.199	0.047	-0.065	-0.093	0.201	0.3838
		X162	0.77	0.303	0.009	0.145	-0.285	0.252	0.729	0.195	0.003	
X2	X21	X211	0.61	0.387	-0.055	0.416	-0.278	0.062	0.477	0.023	-0.145	0.37294
		X212	0.66	0.415	-0.358	0.154	0.110	0.239	-0.107	-0.039	-0.222	
		X213	0.69	0.495	-0.376	0.303	-0.063	0.350	-0.140	0.042	-0.373	
	X22	X221	0.66	0.608	-0.447	0.060	-0.238	0.108	-0.283	0.063	-0.103	0.04471
		X222	0.60	0.512	-0.521	0.333	0.043	0.057	-0.031	-0.107	0.248	
		X223	0.58	0.292	-0.363	-0.072	0.128	0.565	0.030	-0.102	0.232	
		X224	0.62	0.408	-0.496	0.238	-0.275	0.367	0.037	-0.198	0.212	
		X225	0.63	0.479	-0.393	-0.100	0.067	0.335	-0.239	0.168	0.086	

Table 5.9: Calculation for hidden layer-2

Dimension	Sub dimension	Input value for sub dimension	Value of Weightage for		Input value for dimensions
			X1	X2	
X1	X11	12.09753	0.628	0.653	9.26
	X12	0.51248	0.716	0.816	
	X13	-0.04239	0.926	0.933	
	X14	0.41754	0.679	0.804	
	X15	1.10169	0.367	0.527	
	X16	0.3838	0.862	0.886	
X2	X21	0.37294	0.734	0.822	9.88
	X22	0.04471	0.874	0.894	

Table-5.10: Calculation for final output

Service quality of organization	Dimensions	Input value for dimension	Value of Weightage for X	Net output
X	X1	9.26	0.666	9.48
	X2	9.88	0.334	

It was required to find the maximum and minimum value of service quality of

organization keeping the factors, neutral network, input value and method of calculation same to know the status of service quality of organization. Table – 5.11 shows the maximum and minimum value for sub dimensions, dimensions and final output.

Table – 5.11: Calculation for maximum and minimum values

Sub Dimensions	Maximum Value	Minimum Value	Dimensions	Maximum Value	Minimum Value	Net Output	Maximum Value	Minimum Value
X11	24.94	-24.94	X1	199.52	-199.52	X	399.04	-399.04
X12	24.94	-24.94						
X13	24.94	-24.94						
X14	24.94	-24.94						
X15	24.94	-24.94						
X16	24.94	-24.94						
X21	24.94	-24.94	X2	199.52	-199.52			
X22	24.94	-24.94						

The proposed method converts the intangible service quality into a measuring index value. The index value of service quality for the organization is 9.48 which is a very low value. Though, results will be different for different organizations and also depend upon the response of respondents.

5.3.3 Cross Validation of Result

Nowhere ANN was used to calculate the value of service quality, so it was necessary to cross validate the results of ANN by any existing methods. The same result may be find out by using graph theory, an existing, most widely and accepted method, keeping the input same as used in ANN technique. Graph theory is a systematic methodology consisting of digraph representation, matrix representation & permanent function. The permanent function (PF) is obtained like determinant with a difference that all negative sign appears in the calculation are replaced by positive sign. To apply the graph theory first of all, inheritance and interaction values have to be found out. Then the variable permanent matrix (VPM) was prepared for each sub groups and groups and permanent function was calculated. Table 5.12 listed the same mean values for various factors along with the groups as used in table 5.8 for ANN.

Table - 5.12: Mean values of the factors

X11	**X111**	**X112**	**X113**	**X114**					

Mean values	0.6	0.71	0.69	0.67					
X12	**X121**	**X122**	**X123**	**X124**	**X125**				
Mean values	0.6	0.43	0.5	0.69	0.53				
X13	**X131**	**X132**	**X133**	**X134**	**X135**	**X136**	**X137**		
Mean values	0.64	0.51	0.52	0.58	0.68	0.73	0.65		
X14	**X141**	**X142**	**X143**	**X144**	**X145**	**X146**	**X147**	**X148**	**X149**
Mean values	0.51	0.62	0.61	0.74	0.73	0.65	0.74	0.65	0.69
X15	**X151**	**X152**	**X153**	**X154**					
Mean values	0.73	0.65	0.65	0.73					
X16	**X161**	**X162**							
Mean values	0.71	0.77							
X21	**X211**	**X212**	**X213**						
Mean values	0.61	0.66	0.69						
X22	**X221**	**X222**	**X223**	**X24**	**X225**				
Mean values	0.66	0.6	0.58	0.63	0.62				

The inheritance and the interaction values were calculated by the same method as used by Goyal & Grover (2013) and Gupta & Singh (2015b). To calculate the inheritance value the eq. 5.1 was used.

$$\textit{Normalized value} \text{ or inheritance value} = \frac{M}{M_{\max}}$$

(Eq.5.1)

Where, M= Mean value of responses for an individual factor

M_{max} = Maximum mean value of any factor in the same group. Table 5.13 gives the inheritance values.

Table - 5.13: Normalized value or Inheritance value

X11	**X111**	**X112**	**X113**	**X114**					
	0.85	1.00	0.97	0.94					
X12	**X121**	**X122**	**X123**	**X124**	**X125**				
	0.87	0.62	0.72	1.00	0.77				
X13	**X131**	**X132**	**X133**	**X134**	**X135**	**X136**	**X137**		
	0.88	0.70	0.71	0.79	0.93	1.00	0.89		
X14	**X141**	**X142**	**X143**	**X144**	**X145**	**X146**	**X147**	**X148**	**X149**
	0.69	0.84	0.82	1.00	0.99	0.85	1.00	0.88	0.93

X15	**X151**	**X152**	**X153**	**X154**					
	1	0.89	0.89	1					
X16	**X161**	**X162**							
	0.92	1							
X21	**X211**	**X212**	**X213**						
	0.88	0.96	1						
X22	**X221**	**X222**	**X223**	**X224**	**X225**				
	1	0.91	0.88	0.95	0.94				

For interaction values, find the pair wise difference of mean of two factors as shown in table 5.14 to 5.21 which can be considered as VPM for various groups. As table no. 5.8 indicates that all the factors of same group having some relations with each other, same is considered here. For every table inheritance values are taken from table 5.13 and permanent function (PF) was calculated

Table - 5.14: Pair wise difference for X11 or VPM for X11(interaction values)

	X111	**X112**	**X113**	**X114**
X111	0	-0.11	-0.09	-0.07
X112	0.11	0	0.02	0.04
X113	0.09	-0.02	0	0.02
X114	0.07	-0.04	-0.02	0

PF-X11 = 0.75

Table – 5.15: Pair wise difference for X12 or VPM for X12 (interaction values)

	X121	**X122**	**X123**	**X124**	**X125**
X121	0	0.17	0.1	-0.09	0.07
X122	-0.17	0	-0.07	-0.26	-0.1
X123	-0.1	0.07	0	-0.19	-0.03
X124	0.09	0.26	0.19	0	0.16
X125	-0.07	0.1	0.03	-0.16	0

PF-X12 = 0.21

Table – 5.16: Pair wise difference for X13 or VPM for X13 (interaction values)

	X131	**X132**	**X133**	**X134**	**X135**	**X136**	**X137**
X131	0	0.13	0.12	0.06	-0.04	-0.09	-0.01
X132	-0.13	0	-0.01	-0.07	-0.17	-0.22	-0.14
X133	-0.12	0.01	0	-0.06	-0.16	-0.21	-0.13

X134	-0.06	0.07	0.06	0	-0.1	-0.15	-0.07
X135	0.04	0.17	0.16	0.1	0	-0.05	0.03
X136	0.09	0.22	0.21	0.15	0.05	0	0.08
X137	0.01	0.14	0.13	0.07	-0.03	-0.08	0

PF-X13 = 0.19

Table – 5.17: Pair wise difference for X14 or VPM for X14 (interaction values)

	X141	**X142**	**X143**	**X144**	**X145**	**X146**	**X147**	**X148**	**X149**
X141	0	-0.11	-0.1	-0.23	-0.22	-0.12	-0.23	-0.14	-0.18
X142	0.11	0	0.01	-0.12	-0.11	-0.01	-0.12	-0.03	-0.07
X143	0.1	-0.01	0	-0.13	-0.12	-0.02	-0.13	-0.04	-0.08
X144	0.23	0.12	0.13	0	0.01	0.11	0	0.09	0.05
X145	0.22	0.11	0.12	-0.01	0	0.1	-0.01	0.08	0.04
X146	0.12	0.01	0.02	-0.11	-0.1	0	-0.11	-0.02	-0.06
X147	0.23	0.12	0.13	0	0.01	0.11	0	0.09	0.05
X148	0.14	0.03	0.04	-0.09	-0.08	0.02	-0.09	0	-0.04
X149	0.18	0.07	0.08	-0.05	-0.04	0.06	-0.05	0.04	0

PF-X14 = 0.18

Table – 5.18: Pair wise difference for X15 or VPM for X15 (interaction values)

	X151	**X152**	**X153**	**X154**
X151	0	0.08	0.08	0
X152	-0.08	0	0	-0.08
X153	-0.08	0	0	-0.08
X154	0	0.08	0.08	0

PF-X15 = 0.77

Table – 5.19: Pair wise difference for X16 or VPM for X16 (interaction values)

	X161	**X162**
X161	0	-0.06
X162	0.06	0

PF-X16 = 0.92

Table – 5.20: Pair wise difference for X21 or VPM for X21 (interaction values)

	X211	**X212**	**X213**
X211	0	-0.05	-0.08
X212	0.05	0	-0.03

X213	0.08	0.03	0

PF-X21 = 0.84

Table – 5.21: Pair wise difference for X22 or VPM for X22 (interaction values)

	X221	**X222**	**X223**	**X224**	**X225**
X221	0	0.06	0.08	0.03	0.04
X222	-0.06	0	0.02	-0.03	-0.02
X223	-0.08	-0.02	0	-0.05	-0.04
X224	-0.03	0.03	0.05	0	0.01
X225	-0.04	0.02	0.04	-0.01	0

PF-X22 = 0.72

Now the PF for all the groups were calculated. Next iterations were to calculate the permanent function for X1 and X2 followed by X. Table 5.22 & 5.23 shows the VPM to calculate the value of PF-X1 and PF-X2. In the table 5.22 & 5.23, the inheritance values were the values of permanent functions calculated in table 5.14 to table 5.21. The interaction values were obtained with the help of expert opinion from automobile industry and academic. For this purpose, a small brain storming session was conducted where experts from the automobile industry and academia were participated. Based on the brain storming session, table no 17 & 18 prepared and permanent function was calculated.

Table – 5.22: Matrix to calculate the value of VPM-X1

	X11	**X12**	**X13**	**X14**	**X15**	**X16**
X11	0.75	0.5	0.4	0.6	0.6	0.4
X12	0.5	0.21	0.5	0.3	0.6	0.7
X13	0.5	0.6	0.19	0.5	0.6	0.6
X14	0.2	0.5	0.6	0.18	0.4	0.4
X15	0.5	0.5	0.6	0.5	0.77	0.6
X16	0.4	0.6	0.7	0.4	0.6	0.92

PF-X1 = 10.92

Table – 5.23: Matrix to calculate the value of VPM-X2

	X21	**X22**
X21	0.84	0.5

X22	0.5	0.72

PF-X2 = 0.85

Once the value of permanent function of X1 and X2 was calculated, then the last iteration was to calculate the value of service quality of distributor. The weightage for the X1 and X2 was kept same as in table 5.10. Table 5.24 discussed the VPM to calculate the value of service quality of distributor. In this table the inheritance values were the same as obtained by table 5.22 & 5.23. Then permanent function was calculated as earlier.

Table – 5.24: Matrix to calculate the value of VPM-X

	X1	**X2**
X1	10.92	0.66
X2	0.33	0.85

PF-X = 9.49

The value of service quality of distributor calculated by graph theory is nearly same as calculated by ANN technique i.e. 9.48.

5.4 MEASUREMENT OF DISTRIBUTOR SERVICE QUALITY

Supply chain management has gained much more attention for both academician and practitioners in the past three decades. Supply chain management is a big umbrella under which suppliers of supplier to end users are there. The main elements of supply chain management consist a chain starting from supplier to organization, distributor, retailer and end user i.e. customer. As time to time checks and measures are necessary to maintain the efficiency and to increase motivation of every person or any organization, so recent study focuses on to calculate the service quality of the distributor of a leading two wheeler manufacturing industry of North India, one of the most important element of supply chain management, who actually receives the product directly from the organization and supply the same to the retailers in small quantity as and when required. Distributor may be called as authorized stockiest who store finish goods inventory because of trust, commitment and market reputation of parent organization and supply the material to retailer according to demand (Gupta & Singh, 2015). In the current competitive world's business model distributor is a key aspect and therefore, it is very important to choose the correct distributor for the business. Therefore a large number of studies have been done for evaluation of distributors.

5.4.1 Role of Distributor

In the ever-changing industry, distributors play an important role in the supply chain. From just-in-time procurement strategies to risk management, distributors can bring real value to customers. In today's economic environment, distributors are being relied on heavily as our customers are more likely to order smaller volumes of products on a more frequent basis. Established partnerships with distributors provide for continuity and trust of supply. Wholesalers give distributors the opportunity to purchase in small quantities or can be relied on for special orders. Thus, distributors are not stuck tying up capital in inventory that otherwise might end up being dead stock. Distributors can also benefit by receiving shorter order lead times from wholesalers, which in turn help them turn product faster. While competition exists not only on the organizations but also on the supply chains, organizations are seldom worked alone and will form a lot of strategic partners or align with their suppliers so as to empower synergy. They will focus on their core competency and outsource the other business process or form partnership with each other. The main idea is to make

sure that every party of the supply chain is more efficient and effective than its competitors of other supply chains. The performance of the supply chain is determined by the achievement of the collaboration of every party. Every person in the supply chain is not earning profit till the last customer is paying satisfactory. With this understanding, every organization in the supply chain has to move out all the obstacles between them and find out a win-win scenario which emphasis a partnership relationship. However, most of research works concerning supply chain management put the emphasis on the aspect of responding to customer demands by a responsive strategy in correspondence to the front line demand (also called real demand), for example, Dell's Virtual Integration Model (Magretta, 1998), Benetton and Zara's Quick Response Model (Dapiran, 1992, Christopher et al 2004) and the Vendor Managed Inventory System between P&G and Wal-Mart (Vergin & Barr 1999, Waller et al 1999). Actually, the prime goal for these practices is to meet the customers' value without sacrificing on inventory cost (Ketzenberg et al 2000), to shorten the lead time (Lampel & Mintzberg 1996, Pagh & Cooper 1998), and to alleviate the bullwhip effect (Lee et al 1997). Consequently, improvement in manufacturer-retailer relationships becomes a hot topic since Kumar (1996). It seems that the collaboration between manufacturer and retailer is the vital solution to manage demand uncertainty for having a good supply chain performance.

5.4.2 Analysis to Measure the Service Quality of Distributor

Various factors, on which service quality of distributor depends, are already identified in chapter 3. It was necessary to use appropriate technique to measure the service quality of distributor. Fuzzy Graph Theoretic Approach (FGTA) is used for this purpose. Following steps were used to measure the service quality of distributor

1. Design a questionnaire based on identified factors (already discussed in chapter 3).
2. Collect the response from the related respondents through survey (already discussed in chapter 4).
3. Check the reliability of data.
4. Test the data for sufficiency.
5. Use exploratory factor analysis to group the related factors.
6. Use FGTA to measure the service quality of distributor

5.4.2.1 Reliability test

Reliability test indicates the consistency of data. The most common test is to find the value of Cronbach alpha coefficient. SPSS 20 used for this purpose which gives the value of Cronbach alpha coefficient and depicted in table 5.25 as 0.817 which is well above the satisfactory limit i.e. 0.7 (Nunnaly, 1978).

Table 5.25: Reliability analysis of DSQ

Service quality measurement	Supplier service quality measurement
Value of Cronbach α	0.817
Finding	Quiet good

5.4.2.2 Data sufficiency test

Data sufficiency test is carried out to check the right quantity of data size. KMO sample of adequacy and significant value test is used for this purpose. If the value for KMO is greater than 0.6 and the value for significant is less than 0.005 indicate that data size is sufficient for grouping the various relevant factors. Table 5.26 shows the results of KMO and significant test.

Table 5.26: KMO and Bartlett's Test for DSQ

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.688
Bartlett's Test of Sphericity	Approx. Chi-Square	530.874
	Df	190
	Sig.	0.000

5.4.2.3 Exploratory factor analysis

To address all the issues of distributor service quality (DSQ) in an integrated and engineering way and for making calculations simple and easy to understand, all the factors must be classified in various groups. Factor analysis by SPSS 20 is used to group the related factors. The score of factor analysis is shown in table 5.27 and based on this score the factors identified in table 3.1 can be grouped into four major sub groups shown in table 5.28.

Each of the four sub systems is identified by a hierarchical tree (fig. 5.12) to indicate its contribution towards the DSQ. First of all the values of all the groups or level 1 will calculate individually then a cumulative score of DSQ or level 0 will calculate.

Table 5.27: Score of factor analysis

Factors	Group No.			
	1	2	3	4
Competitive Advantages (CA)	0.327		0.837	0.423
Lead Time (LT)		0.521	0.712	
Buy Back Contract (BB)	0.435	0.389	0.655	
Logistics (LO)	0.857		0.543	0.431
Price (PR)		0.764		0.234
Financial Performances (FP)		0.596	0.432	
Capacity (CP)	0.235	0.578		
Delivery (DL)	0.768		0.589	
Quality Data Reporting (QD)		0.598	0.602	0.638
Inventory Level (IL)	0.558	0.798	0.489	
Efficiency (EF)	0.254		0.523	0.624
Strategy (ST)	0.789		0.345	0.541
Time to Market (TM)		0.49	0.603	
Sales Growth (SG)		0.543	0.765	
Traceability (TR)	0.578		0.479	
Safety (SF)			-0.453	0.627
Profit Sharing (PS)		0.812	-0.192	
Attitude (AT)	0.324		0.628	
Welfare Activity (WA)		0.418		0.564

Table 5.28: Distribution of factors into various sub groups based on table 5.27

Group No.	Factors

G-1	Traceability	Delivery	Strategy	Logistics		
G-2	Price	Profit Sharing	Financial Performances	Inventory Level	Capacity	
G-3	Competitive Advantages	Time to Market	Lead Time	Attitude	Buy Back Contract	Sales Growth
G-4	Quality Data Reporting	Efficiency	Safety	Welfare Activity		

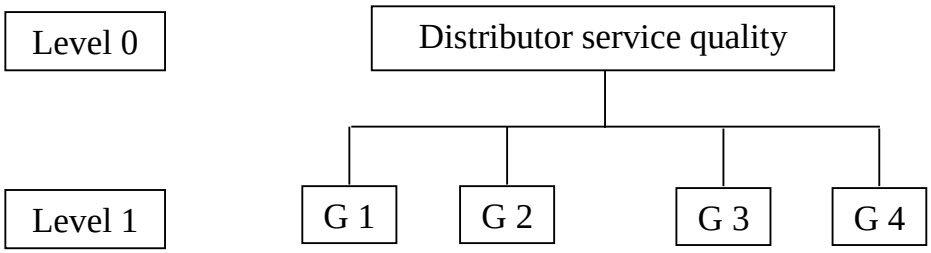


Fig. 5.12 Tree structure of distributor

5.4.2.4 Algorithm for Fuzzy graph theoretic approach

The Fuzzy graph theoretic approach evaluates the Supply chain performance in terms of a single numerical index for vague, ambiguous, imprecise, noisy or missing input information. This considered the inheritance effect of factors and their interdependencies. The various steps in the proposed approach are presented here, which will help in evaluation process of the distributor service quality.

1. Identify the various factors that affect supply chain performance. Different supply chains may have a different set of factors affecting supply chain performance depending on the type of supply chain. Identified factors are discussed in chapter 3.
2. Broadly group these factors (as four groups are framed in table – 5.28 based on Table 5.27).

3. Convert all the fuzzy data, which is in linguistic or vague or noisy form, in to fuzzy number and then these fuzzy number convert into crisp score. Tzeng & Huang (2011) computed the crisp score based on the following equations:

$$\mu_{max}(y) = \begin{cases} y, 0 \le y \le 1 \\ 0, otherwise \end{cases} \quad \text{(Eq.5.2)}$$

$$\mu_{\min}(y) = \begin{cases} 1-y, 0 \le y \le 1 \\ 0, otherwise \end{cases} \quad \text{(Eq.5.3)}$$

The maximum and minimum fuzzy number must be selected in such a manner that they can be automatically fitted into comparison scale. The left and right score of the fuzzy number is calculated as follows

$$\mu_L(W_i) = Sup_y \left\{ \mu_{\min}(y)^{\mu_{wi}(y)} \right\} \quad \text{(Eq. 5.4)}$$

$$\mu_R(W_i) = Sup_y \left\{ \mu_{\max}(y)^{\mu_{wi}(y)} \right\} \quad \text{(Eq.5.5)}$$

The total score of eq. 3 & 4 is given as follows

$$\mu_T(W_i) = \left\{ \mu_R(W_i) + 1 - \mu_L(W_i) \right\} / 2$$

(Eq. 5.6)

By using eq. 5.2 to 5.6, Tzeng & Huang (2011) computed the crisp score which is shown in table-5.29

4. Calculate the normalized score of the factors (Table 5.31). To calculate the normalized score first of all find the mean value of response for all the factors individually (Table 5.30) and then following formula (eq. 5.7) was used

$$Normalized\ value = \frac{M}{M_{\max}} \quad \text{(Eq. 5.7)}$$

Where M= Mean value of responses for an individual factor

M_{max} = Maximum mean value of any factor in the same group. This normalized value can be used as inheritance value for calculating the permanent function in graph theory.

5. Convert all the factors into crisp score of fuzzy by using the table-5.29. For getting fuzzy score, find the pair wise difference of mean of two factors for all the groups as shown in table 5.32. As for group 1 first row - the mean value of traceability is 3.325 and all the values are subtract individually from the value of traceability and similar method was adopted for all other values.

   Then compute the Mean range on 5 point scale modification for pair wise difference as shown in table 5.33. The reason for computing the mean range on 5 point scale is due to getting the responses of questionnaire on 5 point scale.

   Then prepared the table 5.34 with the help of table 5.32 & 5.33. As for group 1, the crisp score for the value of -0.375 of table 5.32 will be 0.115 from table 5.33. And similar method was adopted to convert the values of group 1, 2, 3 and 4 factors into crisp score.

6. Logically develop the digraphs between the factors of different groups depending on their interdependencies. The relations between various factors are depending upon the responses of industries expert. The nodes in the digraph represent factors while edges represent interaction among factors. Fig. 5.13 to 5.16 showing the digraphs for factors of group 1, 2, 3 & 4 respectively and the values of tables 5.31 can be used for inheritance value and the values of table 5.34 can be used for interactions value of factors.

7. Prepared the permanent matrix with the help of digraph. Find the value of permanent function for each group factor. The permanent function is similar to determinant with a difference that all the negative sign of determinant are replaced by positive sign.

8. Develop the digraph and performance matrix at group level by the same method as explained in steps (6) and (7). Fig. 5.17 shows the digraph between various groups.

9. At group level, the permanent value of each group -factor [obtained in step (7)] provides inheritance of supply chain performance factor. The quantitative value of interactions among factors is obtained from Table 5.29 through proper interpretation by experts. This will form performance matrix at group level.

10. Find the value of permanent function for the system. This is the value of the distributor service quality index. The performance of a distributor can thus be evaluated based on the above- discussed methodology.

Table 5.29: Conversion of fuzzy number into crisp score

Intangible factor	Intangible factor meaning	Fuzzy Number	Crisp Score
Poor	One factor is very less important than the other	D_1	0.115
Fair	One factor is less important than the other	D_2	0.295
Good	Both factors are equally important	D_3	0.495
Very Good	One factor is much important than the other	D_4	0.695
Excellent	One factor is very much important than the other	D_5	0.895

Table 5.30: Mean value of distributor service quality factors

G1	Traceability	Delivery	Strategy	Logistics		
	3.325	3.7	3.425	3.525		
G2	Price	Profit Sharing	Financial Performances	Inventory Level	Capacity	
	2.925	3.25	4.45	4.425	4.075	
G3	Competitive Advantages	Time to Market	Lead Time	Attitude	Buy Back Contract	Sales Growth
	4.175	3.425	4.025	3.575	3.225	3.125
G4	Quality Data Reporting	Efficiency	Safety	Welfare Activity		
	3.375	3.975	3.275	2.825		

Table 5.31: Normalized value of service quality factors (inheritance value)

G1	Traceability	Delivery	Strategy	Logistics		
	0.90	1.00	0.93	0.95		
G2	Price	Profit Sharing	Financial Performances	Inventory Level	Capacity	
	0.66	0.73	1.00	0.99	0.92	
G3	Competitive Advantages	Time to Market	Lead Time	Attitude	Buy Back Contract	Sales Growth
	1.00	0.82	0.96	0.86	0.77	0.75
G4	Quality Data Reporting	Efficiency	Safety	Welfare Activity		
	0.85	1.00	0.82	0.71		

Table 5.32: Pair wise difference between various groups

Factors	TR	DL	ST	LO	PR	PS	FP	IL	CP	CA	TM	LT	AT	BB	SG	QD	EF	SF	WA
TR	0	-0.375	-0.1	-0.2															
DL	0.375	0	0.275	0.175															
ST	0.1	-0.275	0	-0.1															
LO	0.2	-0.175	0.1	0															
PR					0	-0.325	-1.525	-1.5	-1.15										
PS					0.325	0	-1.2	-1.175	-0.825										
FP					1.525	1.2	0	0.025	0.375										
IL					1.5	1.175	-0.025	0	0.35										
CP					1.15	0.825	-0.375	-0.35	0										
PR										0	-0.325	-1.525	-1.5	-1.15	0				
PS										0.325	0	-1.2	-1.175	-0.825	0.325				
FP										1.525	1.2	0	0.025	0.375	1.525				
IL										1.5	1.175	-0.025	0	0.35	1.5				
CP										1.15	0.825	-0.375	-0.35	0	1.15				
PR										0	-0.325	-1.525	-1.5	-1.15	0				
QD																0	-0.6	0.1	0.55
EF																0.6	0	0.7	1.15
SF																-0.1	-0.7	0	0.45
WA																-0.55	-1.15	-0.45	0

Table 5.33: Mean range on 5 point scale modification of table 5.32

Fuzzy Number	Mean Range for factors of				**Crisp Score**
	G-1	G-2	G-3	G-4	
D_1	-0.225 to -0.375	-0.915 to -1.525	-0.63 to -1.05	-0.69 to -1.15	0.115
D_2	-0.075 to -0.225	-0.305 to -0.915	-0.21 to -0.63	-0.23 to -0.69	0.295
D_3	-0.075 to 0.075	-0.305 to 0.305	-0.21 to 0.21	-0.23 to 0.23	0.495
D_4	0.075 to 0.225	0.305 to 0.915	0.21 to 0.63	0.23 to 0.69	0.695
D_5	0.225 to 0.375	0.915 to 1.525	0.63 to 1.05	0.69 to 1.15	0.895

Table 5.34: Conversion of table 5.32 in relative importance with crisp score using table 5.33(off diagonal element)

Factors	TR	DL	ST	LO	PR	PS	FP	IL	CP	CA	TM	LT	AT	BB	SG	QD	EF	SF	WA
TR	0	0.115	0.295	0.295															
DL	0.895	0	0.895	0.695															
ST	0.695	0.115	0	0.295															
LO	0.695	0.295	0.695	0															
PR					0	0.295	0.115	0.115	0.115										
PS					0.695	0	0.115	0.115	0.295										
FP					0.895	0.895	0	0.495	0.695										
IL					0.895	0.895	0.495	0	0.695										
CP					0.895	0.695	0.295	0.295	0										
PR										0	0.895	0.495	0.695	0.895	0.895				
PS										0.115	0	0.295	0.495	0.495	0.695				
FP										0.495	0.695	0	0.695	0.895	0..895				

IL		0.295	0.495	0.295	0	0.695	0.695				
CP		0.115	0.495	0.115	0.295	0	0.495				
PR		0.115	0.295	0.115	0.295	0.495	0				
QD								0	0.295	0.495	0.695
EF								0.695	0	0.895	0.895
SF								0.495	0.115	0	0.695
WA								0.295	0.115	0.295	0

5.4.2.5 General Matrix Representation for Digraph Approach

Suppose a system contain N factors and represents as a digraph. Then most general matrix which is also known as Variable permanent matrix (VPM) is given below (M1)

$$VPM = \begin{pmatrix} S_1 & S_{12} & S_{13} & .... & S_{1m} \\ S_{21} & S_2 & S_{23} & .... & S_{2m} \\ S_{31} & S_{32} & S_3 & .... & S_{3m} \\ .... & .... & .... & .... & .... \\ S_{m1} & S_{m2} & S_{m3} & .... & S_m \end{pmatrix} \quad \text{(M1)}$$

The Variable permanent factor (VPF) for matrix (M1) is given by eq. (5.8)

$$per(E) = \prod_i^N S_i + \sum_i \sum_j .... \sum_N (S_{ij}S_{ji})S_kS_l..... + \sum_i \sum_j .... \sum_N (S_{ij}S_{jk}S_{kl} + S_{ik}S_{kj}S_{ji})S_l..... + \left(\sum_i \sum_j ... \sum_N \left(S_{ij}S_{ji}\right)\left(S_{kl}S_{lk}\right)S_m..... + \sum_i \sum_j .... \sum_N \left(S_{ij}S_{jk}S_{kl}S_{li} + S_{il}S_{lk}S_{kj}S_{ji}\right)S_m..... \right) + ...$$

(Eq. 5.8)

The total number of terms are N!, where N is the no. of factors. So if the number of factors is known, then VPM can be constructed and PF can be calculated.

5.4.2.6 Digraph for present study

The model of present study has been shown in fig. 5.12. Initially digraphs for level 1 will be constructed and their permanent function will be calculated. There are four groups at level 1 i.e. G1, G2, G3 & G4. The fig. 5.13 to 5.16 shows the digraph for G1, G2, G3 & G4 respectively.

In fig. 5.13, all four factors of G1 and their inter relations are shown. These interrelations are based on the discussions with industry experts. Traceability and delivery has direct relation with all the factors while strategy and logistic has no dependency on traceability.

In fig. 5.14, all five factors of G2 and their inter relations are shown. Again these interrelations are based on the discussions with industry experts. The price and financial performances of any product depends on all the factors. Profit sharing depends on price and financial performances. Inventory level depends on the price of the product and the financial performances and capacity depends on the price, profit sharing and financial performances.

In fig. 5.15, all six factors of G3 and their inter relations are shown. Again these interrelations are based on the discussions with industry experts. Competitive advantages and attitude depend on all the factors, while time to market depends on two factor i.e. competitive advantages and attitude. Lead time depends on attitude, sales growth and competitive advantages. Buy back contract depends on sales growth and competitive advantages and sales growth depends on attitude and buy back contract.

In fig. 5.16, all four factors of G4 and their inter relations are shown. These interrelations are based on the discussions with industry experts. Quality data reporting depends on rest three factors, safety depends on efficiency and welfare activities and welfare activities depends on safety.

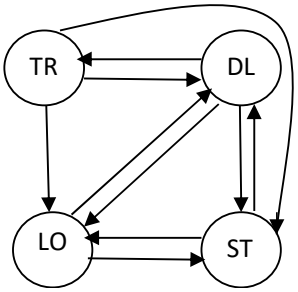


Fig. 513 Digraph of group 1 factors

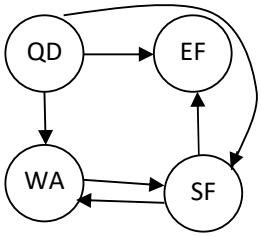
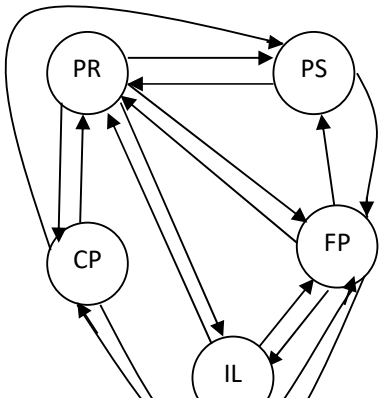
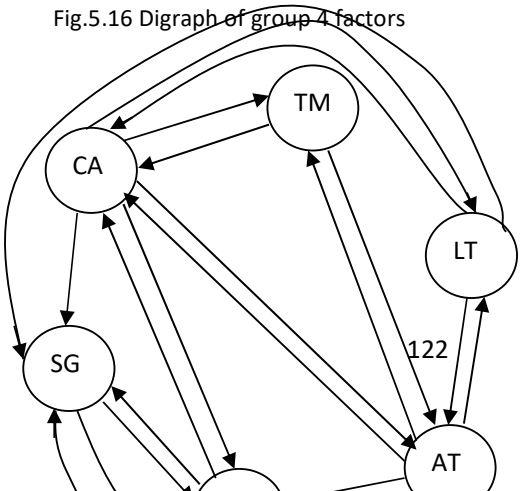


Fig.5.16 Digraph of group 4 factors





The VPM for all the groups are given below. The inheritance values in the matrices (M2, M3, M4 & M5) can be put from table 5.31, while the interaction value can be put from table 5.34 for matrices (M2, M3, M4 & M5) respectively.

VPM for group 1 factors

$$\text{VPM- G1} = \begin{array}{c} \\ TR \\ DL \\ ST \\ LO \end{array} \begin{array}{c} \begin{array}{cccc} TR & DL & ST & LO \end{array} \\ \begin{pmatrix} S_1 & S_{12} & S_{13} & S_{14} \\ S_{21} & S_2 & S_{23} & S_{24} \\ 0 & S_{32} & S_3 & S_{34} \\ 0 & S_{42} & S_{43} & S_4 \end{pmatrix} \end{array} \quad \text{(M2)}$$

The inheritance i.e. diagonal values can be taken from table 5.31 and interaction i.e. off diagonal values can be taken from table 5.34, so VPM for group 1 factors is

$$\text{VPM- G1} = \begin{array}{c} \\ TR \\ DL \\ ST \\ LO \end{array} \begin{array}{c} \begin{array}{cccc} TR & DL & ST & LO \end{array} \\ \begin{pmatrix} 0.9 & 0.115 & 0.295 & 0.295 \\ 0.895 & 1.0 & 0.895 & 0.695 \\ 0 & 0.115 & 0.93 & 0.295 \\ 0 & 0.295 & 0.695 & 0.95 \end{pmatrix} \end{array}$$

VPF – G1 = 1.52

VPM for group 2 factors

$$VPM-G2 = \begin{array}{c} \\ PR \\ PS \\ FP \\ IL \\ CP \end{array} \begin{array}{c} \begin{array}{ccccc} PR & PS & FP & IL & CP \end{array} \\ \begin{pmatrix} S_1 & S_{12} & S_{13} & S_{14} & S_{15} \\ S_{21} & S_2 & S_{23} & 0 & 0 \\ S_{31} & S_{32} & S_3 & S_{34} & S_{35} \\ S_{41} & 0 & S_{43} & S_4 & 0 \\ S_{51} & S_{52} & S_{53} & 0 & S_5 \end{pmatrix} \end{array} \quad \text{(M}$$

3)

The inheritance i.e. diagonal values can be taken from table 5.31 and interaction i.e. off diagonal values can be taken from table 5.34, so VPM for group 2 factors is

$$VPM-G2 = \begin{array}{c} \\ PR \\ PS \\ FP \\ IL \\ CP \end{array} \begin{array}{c} \begin{array}{ccccc} PR & PS & FP & IL & CP \end{array} \\ \begin{pmatrix} 0.66 & 0.295 & 0.115 & 0.115 & 0.115 \\ 0.695 & 0.73 & 0.115 & 0 & 0 \\ 0.895 & 0.895 & 1.0 & 0.495 & 0.695 \\ 0.895 & 0 & 0.495 & 0.99 & 0 \\ 0.895 & 0.895 & 0.295 & 0 & 0.92 \end{pmatrix} \end{array}$$

VPF – G2 = 1.84

VPM for group 3 factors

$$VPM-G3 = \begin{array}{c} \\ CA \\ TM \\ LT \\ AT \\ BB \\ SG \end{array} \begin{array}{c} \begin{array}{cccccc} CA & TM & LT & AT & BB & SG \end{array} \\ \begin{pmatrix} S_1 & S_{12} & S_{13} & S_{14} & S_{15} & S_{16} \\ S_{21} & S_2 & 0 & S_{24} & 0 & 0 \\ S_{31} & 0 & S_3 & S_{34} & 0 & S_{36} \\ S_{41} & S_{42} & S_{43} & S_4 & S_{45} & S_{46} \\ S_{51} & 0 & 0 & 0 & S_5 & S_{56} \\ 0 & 0 & 0 & S_{64} & S_{65} & S_6 \end{pmatrix} \end{array} \quad \text{(M}$$

4)

The inheritance i.e. diagonal values can be taken from table 5.31 and interaction i.e. off diagonal values can be taken from table 5.34, so VPM for group 3 factors

$$VPM-G3 = \begin{array}{c} \\ CA \\ TM \\ LT \\ AT \\ BB \\ SG \end{array} \begin{array}{c} \begin{array}{cccccc} CA & TM & LT & AT & BB & SG \end{array} \\ \begin{pmatrix} 1.0 & 0.895 & 0.495 & 0.695 & 0.895 & 0.895 \\ 0.115 & 0.82 & 0 & 0.495 & 0 & 0 \\ 0.495 & 0 & 0.96 & 0.695 & 0 & 0.895 \\ 0.295 & 0.495 & 0.295 & 0.86 & 0.695 & 0.695 \\ 0.115 & 0 & 0 & 0 & 0.77 & 0.495 \\ 0 & 0 & 0 & 0.295 & 0.495 & 0.75 \end{pmatrix} \end{array}$$

VPF – G3 = 2.49

VPM for group 4 factors

$$VPM-G4 = \begin{array}{c} \\ QD \\ EF \\ SF \\ WA \end{array} \begin{array}{c} \begin{array}{cccc} QD & EF & SF & WA \end{array} \\ \begin{pmatrix} S_1 & S_{12} & S_{13} & S_{14} \\ 0 & S_2 & 0 & 0 \\ 0 & S_{32} & S_3 & S_{34} \\ 0 & 0 & S_{43} & S_4 \end{pmatrix} \end{array} \quad \text{(M5)}$$

The inheritance i.e. diagonal values can be taken from table 5.31 and interaction i.e. off diagonal values can be taken from table 5.34, so VPM for group 4 factors

$$VPM-G4 = \begin{array}{c} \\ QD \\ EF \\ SF \\ WA \end{array} \begin{array}{c} \begin{array}{cccc} QD & EF & SF & WA \end{array} \\ \begin{pmatrix} 0.85 & 0.295 & 0.495 & 0.695 \\ 0 & 1.0 & 0 & 0 \\ 0 & 0.115 & 0.82 & 0.695 \\ 0 & 0 & 0.295 & 0.71 \end{pmatrix} \end{array}$$

VPF – G4 = 0.67

Now the digraph for level 0 or DSQ (Fig.5.12) can be prepared and shown in fig. 5.17. All the four groups i.e. G1, G2, G3 and G4 are interrelated to each other and depend on each other. Therefore, diagraph is made in this way. The Variable permanent matrix (VPM) for DSQ is given in matrix (M6). The inheritance values are the values of VPF of G1, G2, G3 & G4 while the interaction values are taken by the discussion of industry expert from table 5.29

$$VPM-D = \begin{array}{c} \\ G1 \\ G2 \\ G3 \\ G4 \end{array} \begin{array}{c} \begin{array}{cccc} G1 & G2 & G3 & G4 \end{array} \\ \begin{pmatrix} 1.52 & 0.295 & 0.495 & 0.295 \\ 0.695 & 1.84 & 0.495 & 0.295 \\ 0.495 & 0.495 & 2.49 & 0.495 \\ 0.695 & 0.695 & 0.495 & 0.67 \end{pmatrix} \end{array}$$ (M

6)

`VPF – D = 9.34

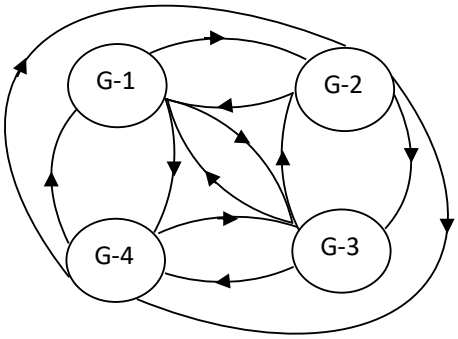


Fig. 5.17 Schematic Representation of distributor factors

The result shows that the actual value of service quality index of distributor is 9.34. This result is for a leading two wheeler manufacturing supply chain of North India. Though, with the help of above discussed procedure the service quality for any organization can be calculated.

For maximum value

$$VPM-D = \begin{array}{c} \\ G1 \\ G2 \\ G3 \\ G4 \end{array} \begin{array}{c} \begin{array}{cccc} G1 & G2 & G3 & G4 \end{array} \\ \begin{pmatrix} 1.52 & 0.895 & 0.895 & 0.895 \\ 0.895 & 1.84 & 0.895 & 0.895 \\ 0.895 & 0.895 & 2.49 & 0.895 \\ 0.895 & 0.895 & 0.895 & 0.67 \end{pmatrix} \end{array}$$

PF = 31.87

For minimum value

$$VPM-D = \begin{array}{c} \\ G1 \\ G2 \\ G3 \\ G4 \end{array} \begin{array}{c} \begin{array}{cccc} G1 & G2 & G3 & G4 \end{array} \\ \begin{pmatrix} 1.52 & 0.115 & 0.115 & 0.115 \\ 0.115 & 1.84 & 0.115 & 0.115 \\ 0.115 & 0.115 & 2.49 & 0.115 \\ 0.115 & 0.115 & 0.115 & 0.67 \end{pmatrix} \end{array}$$

PF = 4.89

5.5 MEASUREMENT OF RETAILER SERVICE QUALITY

Retailer is that driver who really and directly faces the demand & reaction of customer. So feedback of retailer is very much important. Though reputation & service quality of retailer is very much important for customer but quality of product is also matter.

5.5.1 Role of Retailer

To effectively deliver customer satisfaction, however, dominant retailers perform significant roles in providing the right products whenever and wherever customers want them. The closest to the end-customers are the retailers providing the link to the manufacturers and suppliers products. A dominant retailer acts as a leader and therefore directly or indirectly affects other players in the chain including the manufacturers. This will discuss how retailers dominate the supply chain and its vital leadership roles in order to achieve its ultimate goal of customer satisfaction. The discussion focuses on dominant retailer's roles; however, similar roles are also played by other dominant players in the supply chain, such as manufacturers or suppliers. Suppliers and manufacturers here are defined as the upstream players where retailers' products are coming from. Both these players are assumed to deliver goods to the retailers and maybe used interchangeably. The structure begins with a definition of a retailer in the supply chain. Then, a short discussion of how position of power in the industry is achieved by a retailer with examples of the dominant retailers in a number of leading industries. This will be followed by a discussion of the significant roles of a dominant retailer in the supply chain: leading the competition, value creation, stimulant of innovation, and price setter. Companies attempt to change their ways of doing business to find out new approaches to customers. Internationalization and consolidation of retailing turned traditional retail industry upside down. Fast and efficient operational models and new technologies constantly challenge retailers. The term supply chain management is relatively new in the literature, appearing first in 1982. Supply chain is a set of institutions that moves goods from the point of production to the point of consumption. Retailing is the last step in a supply chain. Successful managing of supply chain will achieve significant savings and increased customer satisfaction. Retailing is responsible for matching the individual demands of the consumer with quantities of supplies produced by huge range of manufacturers.

Supply chain management is to consider only strategically important suppliers in the value chain. Retailers cannot perform their role in supply chain without close interaction with other functions of supply chain. Companies in the retail industry resort to supply chain management to counter the increasing uncertainty and complexity of the marketplace and competitive situation to reduce inventory in the entire value chain. Efficient managing of retailers supply chain should support the satisfaction of end-users requirements. Retailers operate at the point closest to customers therefore are in best position to answer the questions when, where and how customers want particular product. Supply chain management in retail industry is a challenge to implement and practice.

5.5.2 Analysis to measure the service quality of retailer

All the factors, which are responsible for the service quality of retailer, are already identified and defined in chapter 3. Fuzzy Graph Theoretic Approach (FGTA) is used to measure the service quality of retailer. Following steps were used to measure the service quality of retailer

1. Design a questionnaire based on identified factors (already discussed in chapter 3).
2. Collect the response from the related respondents through survey (already discussed in chapter 3).
3. Check the reliability of data.
4. Test the data for sufficiency.
5. Use exploratory factor analysis to group the related factors.
6. Use FGTA to measure the service quality of distributor

5.5.2.1 Reliability Test

The value of Cronbach alpha coefficient is calculated to know the reliability of the data. SPSS 20 is used for this purpose which gives the value of Cronbach alpha coefficient in table 5.35 as 0.871 which is well above the satisfactory limit i.e. 0.7 (Nunnaly, 1978).

Table 5.35: Reliability analysis of RSQ

Service quality measurement	Supplier service quality measurement
Value of Cronbach α	0.871
Finding	Quiet good

5.5.2.2 Data Sufficiency Test

Data sufficiency test is carried out to check the right quantity of data size. KMO sample of adequacy and significant value test is used for this purpose. If the value for KMO is greater than 0.6 and the value for significant is less than 0.005 indicate that data size is sufficient for grouping the various relevant factors. Table 5.36 shows the results of KMO and significant test.

Table – 5.36: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.758
Bartlett's Test of Sphericity	Approx. Chi-Square	536.374
	Df	213
	Sig.	0.000

5.5.2.3 Exploratory factor analysis

To address all the issues of retailer service quality (RSQ) in an integrated and engineering way and for making calculations simple and easy to understand, all the factors must be classified in various groups. Factor analysis by SPSS 20 is used to group the related factors. The score of factor analysis is shown in table 5.37 and based on this score all the factors responsible for RSQ (identified in chapter 3) can be grouped into four major sub groups shown in table 5.38.

Table 5.37: Score of factor Analysis

Factors	Group No.			
	1	2	3	4
Competitive Advantages (CA)			0.827	0.523
Lead Time (LT)		0.521		0.772
Buy Back Contract (BB)	0.485		0.695	
Logistics (LO)	0.767		0.543	
Price (PR)		0.674		0.234
Financial Performances (FP)		0.646	0.432	
Capacity (CP)	0.235	0.578		
Delivery (DL)	0.678		0.589	
Quality Data Reporting (QD)			0.60	0.738
Inventory Level (IL)		0.748	0.489	

Efficiency (EF)	0.354		0.613	0.684
Strategy (ST)	0.659			0.541
Time to Market (TM)		0.549	0.653	
Sales Growth (SG)		0.533	0.865	
Traceability (TR)	0.618		0.479	
Profit Sharing (PS)		0.722		
Attitude (AT)	0.324			0.782

Table 5.38: Groupism of RSQ factors

Group No.	Factors				
G1	Traceability	Delivery	Strategy	Logistics	
G2	Price	Profit Sharing	Financial Performances	Inventory Level	Capacity
G3	Competitive Advantages	Time to Market	Buy Back Contract	Sales Growth	
G4	Quality Data Reporting	Efficiency	Lead Time	Attitude	

5.5.2.4 Algorithm for Fuzzy graph theoretic approach

The Fuzzy graph theoretic approach is used to evaluate the performance in terms of a single numerical index for vague, ambiguous, imprecise, noisy or missing input information. This considered the inheritance effect of factors and their interdependencies. The various steps in the proposed approach are presented here, which will help in evaluation process of the retailer service quality.

1. Identify the various factors that affect the service quality of retailer. Identified factors are discussed in chapter 3.
2. Broadly group these factors (as four groups are framed in table 5.38 based on Table 5.37).
3. Convert all the fuzzy data, which is in linguistic or vague or noisy form, in to fuzzy number and then these fuzzy number convert into crisp score. Tzeng & Huang (2011) computed the crisp score based on the equations 5.2 to 5.6 and depicted in table 5.29

4. Calculate the normalized score of the factors (Table 5.40). To calculate the normalized score first of all find the mean value of response for all the factors individually (Table 5.39) and then equation 5.7 was used

$$Normalized\ value = \frac{M}{M_{max}} \quad \text{(Eq. 5.7)}$$

Where M= Mean value of responses for an individual factor

M_{max} = Maximum mean value of any factor in the same group. This normalized value can be used as inheritance value for calculating the permanent function in graph theory.

5. Convert all the factors into crisp score of fuzzy by using the table 5.29. For getting fuzzy score, find the pair wise difference of mean of two factors for all the groups as shown in table 5.41. As for group 1 first row - the mean value of traceability is 3 and all the values are subtract individually from the value of traceability and similar method was adopted for all other values.

   Then compute the Mean range on 5 point scale modification for pair wise difference as shown in table 5.42. The reason for computing the mean range on 5 point scale is due to getting the responses of questionnaire on 5 point scale.

   Then prepare the table 5.43 with the help of table 5.41 & 5.42. As for group 1, the crisp score for the value of -0.72 of table 5.41 will be 0.115 from table 5.42. And similar method was adopted to convert the values of group 1, 2, 3 and 4 factors into crisp score.

6. Logically develop the digraphs between the factors of different groups depending on their interdependencies. The relations between various factors are depending upon the responses of industries expert. The nodes in the digraph represent factors while edges represent interaction among factors. Fig. 5.18 to 5.21 depicts the digraph for factors of group 1, 2, 3 & 4 respectively and the values of tables 5.40 can be used for inheritance value and the values of table 5.43 can be used for interactions value of factors.

7. Prepared the permanent matrix with the help of digraph. Find the value of permanent function for each group factor. The permanent function is similar to

determinant with a difference that all the negative sign of determinant are replaced by positive sign.

8. Develop the digraph and performance matrix at group level by the same method as explained in steps (6) and (7). Fig.5.22 shows the digraph between various groups.
9. At group level, the permanent value of each group -factor [obtained in step (7)] provides inheritance of supply chain performance factor. The quantitative value of interactions among factors is obtained from Table 5.29 through proper interpretation by experts. This will form performance matrix at group level.

Table 5.39: Mean value of Retailer service quality factors

G1	Traceability	Delivery	Strategy	Logistics	
	3	3.72	3.06	3.72	
G2	Price	Profit Sharing	Financial Performances	Inventory Level	Capacity
	2.52	2.56	3.06	3.06	3.14
G3	Competitive Advantages	Time to Market	Buy Back Contract	Sales Growth	
	3.24	2.92	2.3	2.92	
G4	Quality Data Reporting	Efficiency	Lead Time	Attitude	
	2.54	3.08	3.6	3.72	

Table 5.40: Inheritance value

G1	Traceability	Delivery	Strategy	Logistics	
	0.81	1	0.82	1	
G2	Price	Profit Sharing	Financial Performances	Inventory Level	Capacity
	0.8	0.82	0.97	0.97	1
G3	Competitive Advantages	Time to Market	Buy Back Contract	Sales Growth	
	1	0.93	0.73	0.93	
G4	Quality Data Reporting	Efficiency	Lead Time	Attitude	

	0.68	0.83	0.97	1	

Table 5.41: Pair wise difference between various groups

Factors	TR	DL	ST	LO	PR	PS	FP	IL	CP	CA	TM	BB	SG	QD	EF	LT	AT
TR	0	-0.72	-0.06	-0.72													
DL	0.72	0	0.66	0.72													
ST	0.06	-0.66	0	-0.66													
LO	0.72	-0.72	0.66	0													
PR					0	-0.04	-0.54	-0.54	-0.62								
PS					0.04	0	-0.5	-0.5	-0.58								
FP					0.54	0.5	0	0	-0.08								
IL					0.54	0.5	0	0	-0.08								
CP					0.62	0.58	0.08	0.08	0								
CA										0	0.32	0.94	0.32				
TM										-0.32	0	0.62	0				
BB										-0.94	-0.62	0	-0.62				
SG										-0.32	0	0.62	0				
QD														0	-0.54	-1.06	-1.18
EF														0.54	0	-0.52	-0.64
LT														1.06	0.52	0	-0.12
AT														1.18	0.64	0.12	0

10. Find the value of permanent function for the system. This is the value of the distributor service quality index. The performance of a distributor can thus be evaluated based on the above- discussed methodology.

Table 5.42: Mean range on 5 point scale modification of table 5.29

Fuzzy Number	Mean Range for group				Crisp Score
	G1	G2	G3	G4	
D_1	-0.432 to -0.72	-0.372 to -0.62	-0.564 to -0.94	-0.708 to -1.18	0.115
D_2	-0.152 to 0.432	-0.124 to -0.372	-0.188 to -0.564	-0.236 to -0.708	0.295
D_3	-0.152 to 0.152	-0.124 to 0.124	-0.188 to 0.188	-0.236 to 0.236	0.495
D_4	0.152 to 0.432	0.124 to 0.372	0.188 to 0.564	0.236 to 0.708	0.695
D_5	0.432 to 0.72	0.372 to 0.62	0.564 to 0.94	0.708 to1.18	0.895

Table 5.43: Conversion of pair wise difference with crisp score using table 5.42

Factors	TR	DL	ST	LO	PR	PS	FP	IL	CP	CA	TM	BB	SG	QD	EF	LT	AT

TR	0	0.115	0.495	0.115														
DL	0.895	0	0.895	0.495														
ST	0.495	0.115	0	0.115														
LO	0.895	0.495	0.895	0														
PR					0	0.495	0.115	0.115	0.115									
PS					0.495	0	0.115	0.115	0.115									
FP					0.895	0.895	0	0.495	0.495									
IL					0.895	0.895	0.495	0	0.495									
CP					0.895	0.895	0.495	0.495	0									
CA										0	0.695	0.895	0.695					
TM										0.295	0	0.895	0.495					
BB										0.115	0.115	0	0.115					
SG										0.295	0.495	0.895	0					
QD														0	0.295	0.115	0.115	
EF														0.695	0	0.295	0.295	
LT														0.895	0.695	0	0.495	
AT														0.895	0.695	0.495	0	

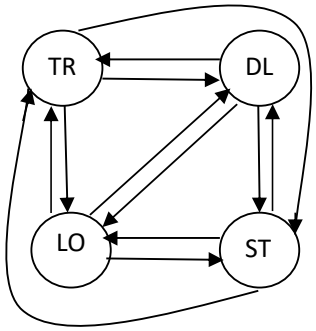


Fig. 5.18 Digraph of group 1 factors

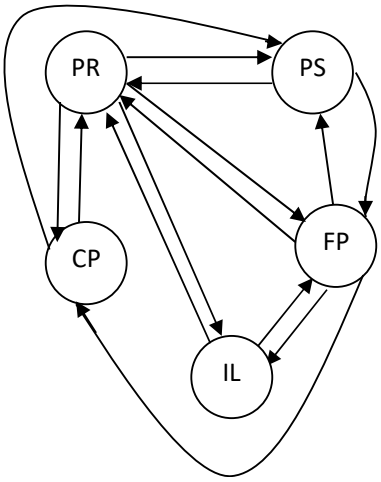
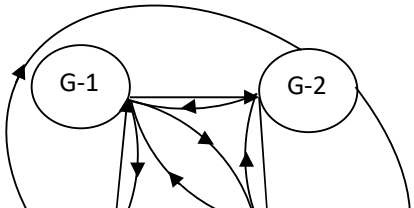


Fig. 5.19 Digraph of group 2 factors



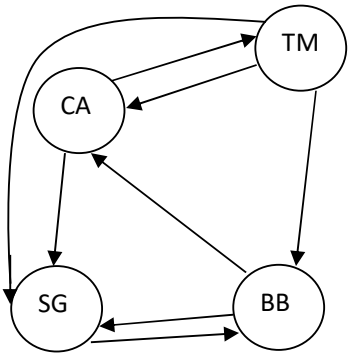


Fig. 5.20 Digraph of group 3 factors

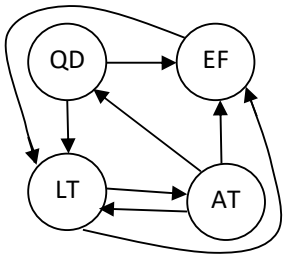


Fig.5.21 Digraph of group 4 factors

5.5.2.5 General matrix representation for digraph approach

$$per(E) = \prod_{i}^{N} S_i$$
$$+\sum_{i}\sum_{j}....\sum_{N}(S_{ij}S_{ji})S_kS_l.....$$
$$+\sum_{i}\sum_{j}....\sum_{N}(S_{ij}S_{jk}S_{kl}+S_{ik}S_{kj}S_{ji})S_l.....$$
$$+\left(\sum_{i}\sum_{j}...\sum_{N}\left(S_{ij}S_{ji}\right)\left(S_{kl}S_{lk}\right)S_m.....+\sum_{i}\sum_{j}....\sum_{N}\left(S_{ij}S_{jk}S_{kl}S_{li}+S_{il}S_{lk}S_{kj}S_{ji}\right)S_m.....\right)$$
$$+.....$$

VPM for group 1 factors

$$\text{VPM- G1} = \begin{array}{c} \\ TR \\ DL \\ ST \\ LO \end{array} \begin{array}{c} \begin{array}{cccc} TR & DL & ST & LO \end{array} \\ \begin{pmatrix} S_1 & S_{12} & S_{13} & S_{14} \\ S_{21} & S_2 & S_{23} & S_{24} \\ S_{31} & S_{32} & S_3 & S_{34} \\ S_{41} & S_{42} & S_{43} & S_4 \end{pmatrix} \end{array} \quad \text{(Eq. 2)}$$

VPM for group1 factor is

$$\text{VPM- G1} = \begin{array}{c} \\ TR \\ DL \\ ST \\ LO \end{array} \begin{array}{c} \begin{array}{cccc} TR & DL & ST & LO \end{array} \\ \begin{pmatrix} 0.81 & 0.115 & 0.495 & 0.115 \\ 0.895 & 1 & 0.895 & 0.495 \\ 0.495 & 0.115 & 0.82 & 0.115 \\ 0.895 & 0.495 & 0.895 & 1 \end{pmatrix} \end{array}$$

= 1.198

VPM for group 2 factors

$$VPM-G2 = \begin{array}{c} \\ PR \\ PS \\ FP \\ IL \\ CP \end{array} \begin{array}{c} \begin{array}{ccccc} PR & PS & FP & IL & CP \end{array} \\ \begin{pmatrix} S_1 & S_{12} & S_{13} & S_{14} & S_{15} \\ S_{21} & S_2 & S_{23} & 0 & 0 \\ S_{31} & S_{32} & S_3 & S_{34} & S_{35} \\ S_{41} & 0 & S_{43} & S_4 & 0 \\ S_{51} & S_{52} & S_{53} & 0 & S_5 \end{pmatrix} \end{array} \quad \text{(Eq. 3)}$$

VPM for group 2 factors

$$VPM-G2 = \begin{array}{c} \\ PR \\ PS \\ FP \\ IL \\ CP \end{array} \begin{array}{c} \begin{array}{ccccc} PR & PS & FP & IL & CP \end{array} \\ \begin{pmatrix} 0.80 & 0.495 & 0.115 & 0.115 & 0.115 \\ 0.495 & 0.82 & 0.115 & 0 & 0 \\ 0.895 & 0.895 & 0.97 & 0.495 & 0.495 \\ 0.895 & 0 & 0.495 & 0.97 & 0 \\ 0.895 & 0.895 & 0.495 & 0 & 1 \end{pmatrix} \end{array}$$

= 2.30

VPM for group 3 factors

$$VPM-G3 = \begin{array}{c} \\ CA \\ TM \\ BB \\ SG \end{array} \begin{array}{c} \begin{array}{cccc} CA & TM & BB & SG \end{array} \\ \begin{pmatrix} S_1 & S_{12} & 0 & S_{13} \\ S_{21} & S_2 & S_{23} & S_{24} \\ S_{31} & 0 & S_3 & S_{34} \\ 0 & 0 & S_{43} & S_4 \end{pmatrix} \end{array} \quad \text{(Eq. 4)}$$

VPM for group 3 factors

$$VPM-G3=\begin{array}{c} \\ CA \\ TM \\ BB \\ SG \end{array}\begin{array}{c} \begin{array}{cccc} CA & TM & BB & SG \end{array} \\ \begin{pmatrix} 1 & 0.695 & 0 & 0.695 \\ 0.295 & 0.93 & 0.895 & 0.495 \\ 0.115 & 0 & 0.73 & 0.115 \\ 0 & 0 & 0.895 & 0.93 \end{pmatrix} \end{array}$$

= 1.056

VPM for group 4 factors

$$VPM-G4=\begin{array}{c} \\ QD \\ EF \\ LT \\ AT \end{array}\begin{array}{c} \begin{array}{cccc} QD & EF & LT & AT \end{array} \\ \begin{pmatrix} S_1 & S_{12} & S_{13} & 0 \\ 0 & S_2 & S_{23} & 0 \\ 0 & S_{32} & S_3 & S_{34} \\ S_{41} & S_{42} & S_{43} & S_4 \end{pmatrix} \end{array} \quad \text{(Eq. 5)}$$

VPM for group 4 factors

$$VPM-G4=\begin{array}{c} \\ QD \\ EF \\ LT \\ AT \end{array}\begin{array}{c} \begin{array}{cccc} QD & EF & LT & AT \end{array} \\ \begin{pmatrix} 0.68 & 0.295 & 0.115 & 0 \\ 0 & 0.83 & 0.295 & 0 \\ 0 & 0.695 & 0.97 & 0.495 \\ 0.895 & 0.695 & 0.495 & 1 \end{pmatrix} \end{array}$$

= 0.975

5.5.2.6 Digraph for present study

$$VPM-R=\begin{array}{c} \\ G1 \\ G2 \\ G3 \\ G4 \end{array}\begin{array}{c} \begin{array}{cccc} G1 & G2 & G3 & G4 \end{array} \\ \begin{pmatrix} S_1 & S_{12} & S_{13} & S_{14} \\ S_{21} & S_2 & S_{23} & S_{24} \\ S_{31} & S_{32} & S_3 & S_{34} \\ S_{41} & S_{42} & S_{43} & S_4 \end{pmatrix} \end{array} \quad \text{(Eq. 6)}$$

$$VPM-R = \begin{array}{c} \\ G1 \\ G2 \\ G3 \\ G4 \end{array} \begin{array}{c} \begin{array}{cccc} G1 & G2 & G3 & G4 \end{array} \\ \begin{pmatrix} 1.198 & 0.295 & 0.495 & 0.295 \\ 0.695 & 2.30 & 0.495 & 0.295 \\ 0.495 & 0.495 & 1.056 & 0.495 \\ 0.695 & 0.695 & 0.495 & 0.975 \end{pmatrix} \end{array}$$

= 7.11

Maximum Value

$$VPM-R = \begin{array}{c} \\ G1 \\ G2 \\ G3 \\ G4 \end{array} \begin{array}{c} \begin{array}{cccc} G1 & G2 & G3 & G4 \end{array} \\ \begin{pmatrix} 1.198 & 0.895 & 0.895 & 0.895 \\ 0.895 & 2.30 & 0.895 & 0.895 \\ 0.895 & 0.895 & 1.056 & 0.895 \\ 0.895 & 0.895 & 0.895 & 0.975 \end{pmatrix} \end{array}$$

PF = 25.26

Minimum Value

$$VPM-R = \begin{array}{c} \\ G1 \\ G2 \\ G3 \\ G4 \end{array} \begin{array}{c} \begin{array}{cccc} G1 & G2 & G3 & G4 \end{array} \\ \begin{pmatrix} 1.198 & 0.115 & 0.115 & 0.115 \\ 0.115 & 2.30 & 0.115 & 0.115 \\ 0.115 & 0.115 & 1.056 & 0.115 \\ 0.115 & 0.115 & 0.115 & 0.975 \end{pmatrix} \end{array}$$

PF = 2.99

5.6 MEASUREMENT OF CUSTOMER SERVICE QUALITY

Customer plays an important role in the performance of supply chain (Lummus et al 2001). Customer is the king of market and he decides good or bad and the future of any organization. He is the main driving force. Robinson & Malhotra (2005) found that integration with customer is an important practice of supply chain management.

5.6.1 Role of Customer

Customer is the main driving force of the market. He decides the future of the organization. The customer service management process is the firm's face to the customer. It provides the single source of customer information, such as product availability, shipping dates and order status. Real-time information is provided to the customer through interfaces with the firm's functions, such as manufacturing and logistics. Whether it is the age of the "new consumer", the experience economy or the era of post-modernism, it is clear that there has been a significant shift in most market-places. Fuelled by increasing market fragmentation, the desire to consume "experiences" and increased market literacy, consumers are becoming increasingly discerning. It would be convenient to dismiss this as a "marketing problem" and to ignore the logistics implications; but such fundamental shifts in consumer behavior and the demand creation patterns they cause must be addressed by equally fundamental shifts in the way that demand is fulfilled. This has significant implications for supply chain management. It is time to understand the needs of the end-customer and to align supply chain strategy behind end-customer needs in the market-place.

When all the drivers work together for a specific purpose, create a working environment which is known as supply chain management environment. There are many factors which affect the environment of the supply chain management. In the next section an effort has been done to identifying those factors which affects the supply chain management environment. It gives an insight to the relations, responsibilities, functional approaches etc. and see the sights of supply chain management.

5.6.2 Analysis to Measure the Service Quality of Customer

Various factors, on which service quality of customer depends, are already identified in chapter 3. It was necessary to use appropriate technique to measure the service

quality of customer. Fuzzy Graph Theoretic Approach (FGTA) is used for this purpose. Following steps were used to measure the service quality of distributor

1. Design a questionnaire based on identified factors (already discussed in chapter 3).
2. Collect the response from the related respondents through survey (already discussed in chapter 4).
3. Check the reliability of data.
4. Test the data for sufficiency.
5. Use exploratory factor analysis to group the related factors.
6. Use FGTA to measure the service quality of distributor

5.6.2.1 Reliability Test

Reliability test is to check the consistency of data. The most common test is to find the value of Cronbach alpha coefficient. SPSS 20 used for this purpose which gives the value of Cronbach alpha coefficient shown in table 5.44 as 0.876 which is well above the satisfactory limit i.e. 0.7 (Nunnaly, 1978).

Table 5.44: Reliability analysis of CSQ

Service quality measurement	Supplier service quality measurement
Value of Cronbach α	0.876
Finding	Quiet good

5.6.2.2 Data Sufficiency Test

Data sufficiency test is carried out to check the right quantity of data size. KMO sample of adequacy and significant value test is used for this purpose. If the value for KMO is greater than 0.6 and the value for significant is less than 0.005 indicate that data size is sufficient for grouping the various relevant factors. Table 5.45 shows the results of KMO and significant test.

Table – 5.45: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.798
Bartlett's Test of Sphericity	Approx. Chi-Square	576.417
	Df	193
	Sig.	0.000

5.6.2.3 Exploratory Factor Analysis

To address all the issues of customer service quality (CSQ) in an integrated and engineering way and for making calculations simple and easy to understand, all the factors must be classified in various groups. Factor analysis by SPSS 20 is used to group the related factors. The score of factor analysis is shown in table 5.46 and based on this score all the factors responsible for CSQ can be grouped into four major sub groups shown in table 5.47.

Table 5.46: Score of factor analysis for CSQ

Factors	Group No.		
	1	2	3
Customer Focus	0.836	0.635	
Customer Satisfaction	0.743		0.585
Customer Responsiveness	0.735	0.619	
Customer Relationship Management	0.654		
Quality of Product	0.632		
Order Fulfillment		0.658	
Faster Response Time		0.628	
Delivery		0.837	0.548
Society Perceptions	0.412		0.834
Traceability		0.764	
Technology and Organization			0.644
Buy Back Contract			0.628
Environmental Friendly Product			0.746
Cost			0.782

Table 5.47: Groupism of factors of CSQ from table 5.46

Group No.	FACTORS				
G1	Customer Focus	Customer Satisfaction	Customer Responsiveness	Customer Relationship Management	Quality of Product
G2	Order	Faster	Delivery	Traceability	

	Fulfillment	Response Time			
G3	Technology and Organization	Environmental Friendly Product	Society Perceptions	Buy Back Contract	Cost

5.5.2.4 Algorithm for Fuzzy Graph Theoretic Approach

The Fuzzy graph theoretic approach is used to evaluate the performance in terms of a single numerical index for vague, ambiguous, imprecise, noisy or missing input information. This considered the inheritance effect of factors and their interdependencies. The various steps in the proposed approach are presented here, which will help in evaluation process of the retailer service quality.

1. Identify the various factors that affect the service quality of retailer. Identified factors are discussed in chapter 3.
2. Broadly group these factors (as three groups are framed in table 5.46 based on Table 5.45).
3. Convert all the fuzzy data, which is in linguistic or vague or noisy form, in to fuzzy number and then these fuzzy number convert into crisp score. Tzeng & Huang (2011) computed the crisp score based on equations 5.2 to 5.6 which is shown in table 5.29.
4. Calculate the normalized score of the factors (Table 5.49). To calculate the normalized score first of all find the mean value of response for all the factors individually (Table 5.48) and then following formula was used

$$Normalized\ value\ = \frac{M}{M_{\max}} \qquad \text{(Eq. 5.7)}$$

   Where M= Mean value of responses for an individual factor

   M_{max} = Maximum mean value of any factor in the same group. This normalized value can be used as inheritance value for calculating the permanent function in graph theory.

5. Convert all the factors into crisp score of fuzzy by using the table 5.29. For getting fuzzy score, find the pair wise difference of mean of two factors for all the groups as shown in table 5.50. As for group 1 first row - the mean value of

customer focus is 3.41 and all the values are subtract individually from the value of customer focus and similar method was adopted for all other values.

Then compute the Mean range on 5 point scale modification for pair wise difference as shown in table 5.51. The reason for computing the mean range on 5 point scale is due to getting the responses of questionnaire on 5 point scale.

Then prepared the table 5.52 with the help of table 5.50 & 5.51. As for group 1, the crisp score for the value of 0.36 of table 5.50 will be 0.695 from table 5.51. And similar method was adopted to convert the values of group 1, 2 and 3 factors into crisp score.

6. Logically develop the digraphs between the factors of different groups depending on their interdependencies. The relations between various factors are depending upon the responses of industries expert. The nodes in the digraph represent factors while edges represent interaction among factors. Fig. 5.23, 5.24 & 5.25 shows the digraph for factors of group 1, 2 & 3 respectively and the values of tables 5.49 can be used for inheritance value and the values of table 5.52 can be used for interactions value of factors.

7. Prepared the permanent matrix with the help of digraph. Find the value of permanent function for each group factor. The permanent function is similar to determinant with a difference that all the negative sign of determinant are replaced by positive sign.

8. Develop the digraph and performance matrix at group level by the same method as explained in steps (6) and (7). Fig. 5.26 shows the digraph between various groups.

9. At group level, the permanent value of each group -factor [obtained in step (7)] provides inheritance of supply chain performance factor. The quantitative value of interactions among factors is obtained from Table 5.29 through proper interpretation by experts. This will form performance matrix at group level.

Find the value of permanent function for the system. This is the value of the distributor service quality index. The performance of a distributor can thus be evaluated based on the above- discussed methodology

Table 5.48: Mean value of customer service quality factors

G1	Customer Focus	Customer Satisfaction	Customer Responsiveness	Customer Relationship Management	Quality of Product
	3.41	3.41	3.05	2.78	3.32
G2	Order Fulfillment	Faster Response Time	Delivery	Traceability	
	3.63	3.20	3.24	3.63	
G3	Technology and Organization	Environmental Friendly Product	Society Perceptions	Buy Back Contract	Cost
	3.34	3.39	3.34	3.39	3.51

Table 5.49: Normalized value of service quality factors (inheritance value)

G1	Customer Focus	Customer Satisfaction	Customer Responsiveness	Customer Relationship Management	Quality of Product
	1	1	0.894	0.815	0.974
G2	Order Fulfillment	Faster Response Time	Delivery	Traceability	
	1	0.882	0.893	1	
G3	Technology and Organization	Environmental Friendly Product	Society Perceptions	Buy Back Contract	Cost
	0.952	0.967	0.952	0.967	1

Table 5.50: Pair wise difference between various groups of CSQ

Factors	CF	CS	CR	CRM	QP	OF	FRT	DL	TR	TO	EFP	SP	BB	CO
CF	0	0	0.36	0.63	0.09									
CS	0	0	0.36	0.63	0.09									
CR	-0.36	-0.36	0	0.27	-0.27									
CRM	-0.63	-0.63	-0.27	0	-0.64									
QP	-0.09	-0.09	0.27	0.64	0									
OF						0	0.43	0.39	0					
FRT						-0.43	0	-0.04	-0.43					
DL						-0.39	0.04	0	-0.39					
TR						0	0.43	0.39	0					
TO										0	-0.05	0	-	-

					0.05	0.17
EFP	0.05	0	-0.05	0	0.12	
SP	0	0.05	0	-0.05	-0.17	
BB	0.05	0	0.05	0	-0.12	
CO	0.17	-0.12	0.17	0.12	0	

Table 5.51: Mean range on 5 point scale for modification of table 5.50

Fuzzy Number	Mean Range for factors of			Crisp Score
	G-1	G-2	G-3	
D_1	-0.384 to -0.64	-0.238 to -0.43	-0.102 to -0.17	0.115
D_2	-0.128 to -0.384	-0.046 to -0.238	-0.034 to -0.102	0.295
D_3	-0.128 to 0.128	-0.046 to 0.046	-0.034 to 0.034	0.495
D_4	0.128 to 0.384	0.046 to 0.238	0.034 to 0.102	0.695
D_5	0.384 to 0.64	0.238 to 0.43	0.102 to 0.17	0.895

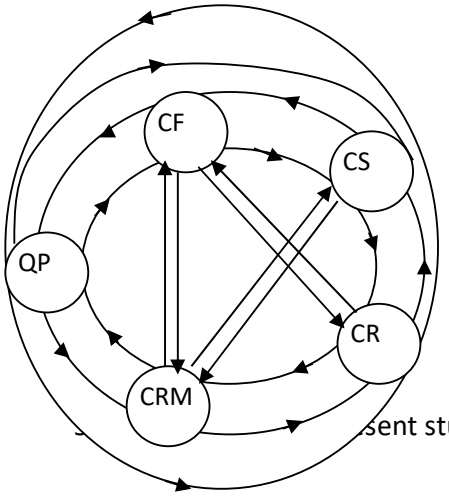
Table 5.52: Conversion of table 5.50 in relative importance with crisp score using table 5.51

Factors	CF	CS	CR	CRM	QP	OF	FRT	DL	TR	TO	EFP	SP	BB	CO
CF	0	0.495	0.695	0.895	0.495									
CS	0.495	0	0.695	0.895	0.495									
CR	0.295	0.295	0	0.695	0.295									
CRM	0.115	0.115	0.295	0	0.115									
QP	0.495	0.495	0.695	0.895	0									
OF						0	0.895	0.895	0.495					
FRT						0.115	0	0.495	0.115					
DL						0.115	0.495	0	0.115					
TR						0.495	0.895	0.895	0					
TO										0	0.295	0.495	0.295	0.115
EFP										0.695	0	0.295	0.495	0.895
SP										0.495	0.695	0	0.295	0.115
BB										0.695	0.495	0.695	0	0.115
CO										0.895	0.115	0.895	0.895	0

5.6.2.5 General matrix representation for digraph approach

$$per(E)=\prod_{i}^{N} S_i$$
$$+\sum_i\sum_j....\sum_N (S_{ij}S_{ji})S_kS_l.....$$
$$+\sum_i\sum_j....\sum_N (S_{ij}S_{jk}S_{kl}+S_{ik}S_{kj}S_{ji})S_l.....$$
$$+\left(\sum_i\sum_j...\sum_N \left(S_{ij}S_{ji}\right)\left(S_{kl}S_{lk}\right)S_m.....+\sum_i\sum_j....\sum_N \left(S_{ij}S_{jk}S_{kl}S_{li}+S_{il}S_{lk}S_{kj}S_{ji}\right)S_m.....\right)$$
$$+.....$$

5.6.2.6 Diagraph for present study



sent study

Fig. 5.23 Digraph of group 1 factors

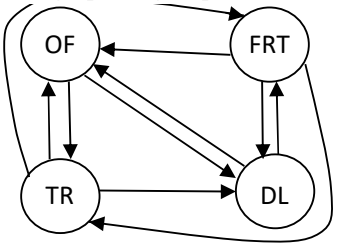


Fig.5.24 Digraph of group 2 factors

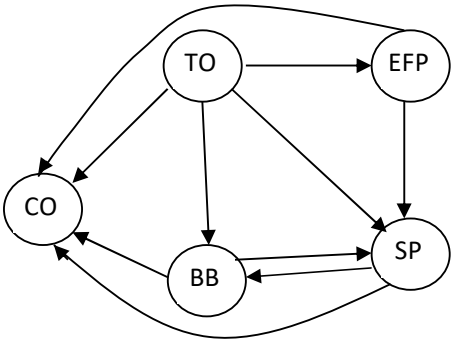


Fig.5.25 Digraph of group 3 factors

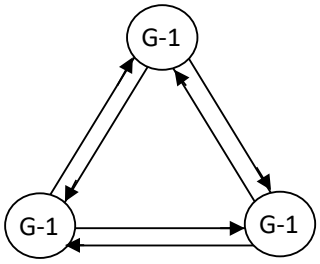


Fig. 5.26 Digraph of CSQ groups

$$VPF-G1=\begin{array}{c} \\ CF \\ CS \\ CR \\ CRM \\ QP \end{array}\begin{array}{c} \begin{array}{ccccc} CF & CS & CR & CRM & QP \end{array} \\ \begin{pmatrix} R_1 & R_{12} & R_{13} & R_{14} & R_{15} \\ R_{21} & R_2 & R_{23} & R_{24} & 0 \\ R_{31} & R_{32} & R_3 & R_{34} & R_{35} \\ R_{41} & R_{42} & R_{43} & R_4 & R_{45} \\ R_{51} & R_{52} & R_{53} & R_{54} & R_5 \end{pmatrix} \end{array}$$

$$VPM-G1 = \begin{array}{c} \\ CF \\ CS \\ CR \\ CRM \\ QP \end{array} \begin{array}{c} \begin{array}{ccccc} CF & CS & CR & CRM & QP \end{array} \\ \begin{pmatrix} 1 & 0.495 & 0.695 & 0.895 & 0.495 \\ 0.495 & 1 & 0.695 & 0.895 & 0 \\ 0.295 & 0.295 & 0.894 & 0.695 & 0.295 \\ 0.115 & 0.115 & 0.295 & 0.815 & 0.115 \\ 0.495 & 0.495 & 0.695 & 0.895 & 0.974 \end{pmatrix} \end{array}$$

= 4.63

For group 2 factors

$$VPF-G2 = \begin{array}{c} \\ OF \\ FRT \\ DL \\ TR \end{array} \begin{array}{c} \begin{array}{cccc} OF & FRT & DL & TR \end{array} \\ \begin{pmatrix} R_1 & 0 & R_{13} & R_{14} \\ R21 & R2 & R23 & R24 \\ R_{31} & R_{32} & R_3 & 0 \\ R_{41} & R_{42} & R_{43} & R_4 \end{pmatrix} \end{array}$$

Putting the values

$$VPM-G2 = \begin{array}{c} \\ OF \\ FRT \\ DL \\ TR \end{array} \begin{array}{c} \begin{array}{cccc} OF & FRT & DL & TR \end{array} \\ \begin{pmatrix} 1 & 0 & 0.895 & 0.495 \\ 0.115 & 0.882 & 0.495 & 0.115 \\ 0.115 & 0.495 & 0.893 & 0 \\ 0.495 & 0.495 & 0.895 & 1 \end{pmatrix} \end{array}$$

PF = 1.67

For group 3 factors

$$VPM-G3 = \begin{array}{c} \\ TO \\ EFP \\ SP \\ BB \\ CO \end{array} \begin{array}{c} \begin{array}{ccccc} TO & EFP & SP & BB & CO \end{array} \\ \begin{pmatrix} R_1 & R_{12} & R_{13} & R_{14} & R_{15} \\ 0 & R_2 & R_{23} & 0 & R_{25} \\ 0 & 0 & R_3 & R_{34} & R_{35} \\ 0 & 0 & R_{43} & R_4 & R_{45} \\ 0 & 0 & 0 & 0 & R_5 \end{pmatrix} \end{array}$$

PUTTING THE Values

$$VPM-G3=\begin{array}{c} \\ TO \\ EFP \\ SP \\ BB \\ CO \end{array}\begin{array}{c} \begin{array}{ccccc} TO & EFP & SP & BB & CO \end{array} \\ \begin{pmatrix} 0.952 & 0.295 & 0.495 & 0.295 & 0.115 \\ 0 & 0.967 & 0.295 & 0 & 0.895 \\ 0 & 0 & 0.952 & 0.295 & 0.115 \\ 0 & 0 & 0.695 & 0.967 & 0.115 \\ 0 & 0 & 0 & 0 & 1 \end{pmatrix} \end{array}$$

PF = 1.04

Digraph for CSQ

$$VPM-CSQ=\begin{array}{c} \\ G1 \\ G2 \\ G3 \end{array}\begin{array}{c} \begin{array}{ccc} G1 & G2 & G3 \end{array} \\ \begin{pmatrix} C_1 & C_{12} & C_{13} \\ C_{21} & C_2 & C_{23} \\ C_{31} & C_{32} & C3 \end{pmatrix} \end{array}$$

PUTTING THE VALUES

$$VPF-CSQ=\begin{array}{c} \\ G1 \\ G2 \\ G3 \end{array}\begin{array}{c} \begin{array}{ccc} G1 & G2 & G3 \end{array} \\ \begin{pmatrix} 4.63 & 0.495 & 0.495 \\ 0.495 & 1.67 & 0.495 \\ 0.495 & 0.495 & 1.04 \end{pmatrix} \end{array}$$

PF = 10.08

Maximum value

$$VPM-CSQ=\begin{array}{c} \\ G1 \\ G2 \\ G3 \end{array}\begin{array}{c} \begin{array}{ccc} G1 & G2 & G3 \end{array} \\ \begin{pmatrix} 4.63 & 0.895 & 0.895 \\ 0.895 & 1.67 & 0.895 \\ 0.895 & 0.895 & 1.04 \end{pmatrix} \end{array}$$

PF = 15.35

Minimum Value.

$$VPM - CSQ = \begin{array}{c} \\ G1 \\ G2 \\ G3 \end{array} \begin{array}{c} \begin{array}{ccc} G1 & G2 & G3 \end{array} \\ \begin{pmatrix} 4.63 & 0.115 & 0.115 \\ 0.115 & 1.67 & 0.115 \\ 0.115 & 0.115 & 1.04 \end{pmatrix} \end{array}$$

PF = 8.1415

5.7 CONCLUSION

Various techniques used to measure the service quality of different drivers. GTA is used to measure the service quality of supplier while ANN is used for organization. There is no literature available which shows the measurement of service quality by ANN. So the results are cross checked by FGTA . Results shows that the index value of ANN and FGTA is same. FGTA is used to measure the service quality of distributor, retailer and customer.

CHAPTER-VI

ASSESSING SERVICE QUALITY OF SUPPLY CHAIN

6.1 INTRODUCTION

The assessment of service quality of supply chain is very important aspect. It is quiet important to indicate that world's most successful organizations are putting more efforts to improve and assess the service quality of their supply chain as they knows very well that success of any organization depends on the service delivered. It helps in reducing the cost and increasing the customer satisfaction. Service quality will need to exceed the customer's needs and expectations. The following are the objectives addressed in this chapter

1. Development of model established the relation between service quality of supplier, organization, distributor, retailer and customer with service quality of supply chain
2. Assess the service quality of supply chain in manufacturing sector.

In this chapter, initially there is a discussion for service quality of supply chain followed by development of a model. In the next section, assessment of service quality of supply chain takes place. Graph theoretic approach is used for this purpose. Actual, minimum and maximum values of service quality of supply chain to be find out. Finally, the value of service quality converts on a 100 point scale.

6.2 SERVICE QUALITY OF SUPPLY CHAIN

Service quality of supply chain comprises the overall index value for the service quality of complete supply chain i.e. collective score of service quality of supplier, organization, distributor, retailer and customer. Service quality begins with the focal organization and spread upstream and downstream by the commitment of top management.

The index values of service quality of different drivers have already computed in chapter 5. Various techniques used for this purpose. The supplier service quality was computed by using GTA while the service quality of organization was computed by ANN. FGTA was used to find the value of service quality of distributor, retailer and

customer. Fig. 6.1 shows a conceptual model linking the service quality of supplier, organization, distributor, retailer and customer to service quality of supply chain.

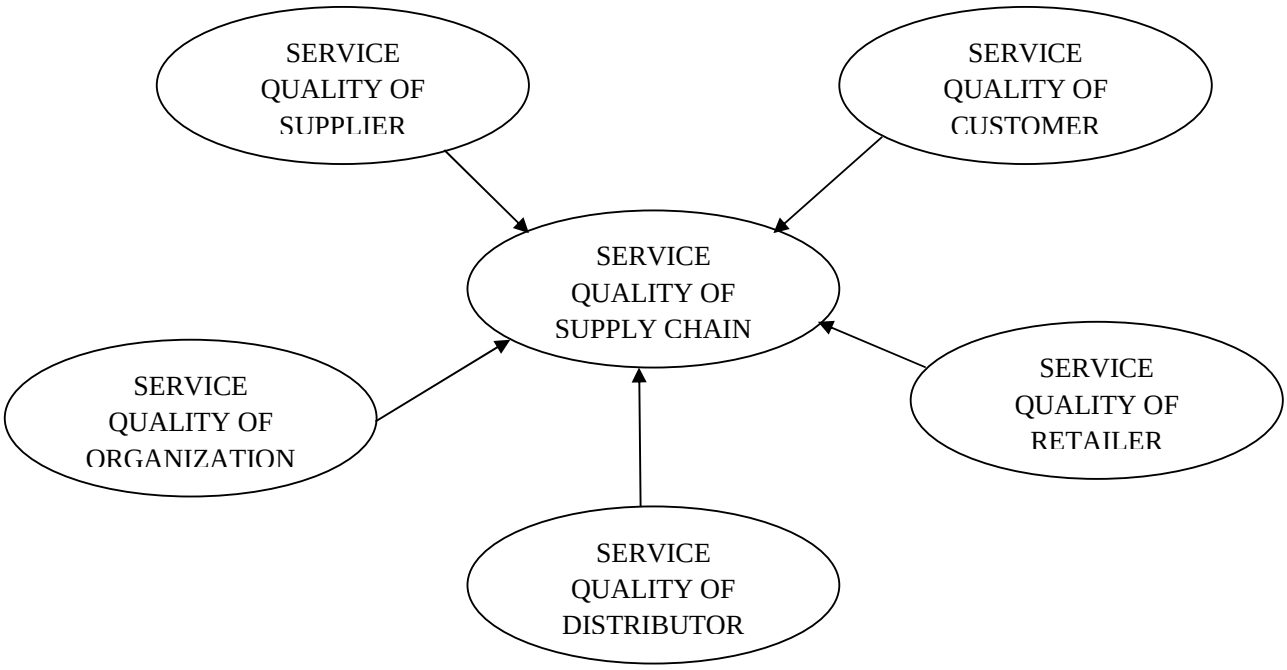


Fig. 6.1 Service quality of supply chain

6.3 DEVELOPMENT OF MODEL FOR SERVICE QUALITY OF SUPPLY CHAIN

Fig. 6.2 shows a detailed model of service quality of supply chain with all the drivers. This figure shows that the considered supply chain have five drivers i.e. supplier, organization, distributor, retailer and customer. The products flow from supplier to customer through organization, distributor and retailer while money flows in opposite manner. Supplier and organization are termed as upstream supply chain while distributor, retailer and customer are termed as downstream supply chain. There is direct and frequently feedback between supplier and organization, between organization and distributor, between distributor and retailer, between retailer and customer. Sometimes customer gives its feed back to distributor and organization directly. Also retailer shares its feedback to organization direct and occasionally.

6.4 MEASUREMENT OF SERVICE QUALITY OF SUPPLY CHAIN

Service and various activities involved in providing the service are perishable and multifunctional in nature. During the time of service providing, certain minimum requirements are expected which are better known as service quality. The measurement of service quality is become an utmost important issue when it is used in context with supply chain. Though the concept of service quality is almost four decade old but the study of service quality in supply chain (especially in the field of manufacturing) needs more attention of researchers. Recent study concentrated on the same issue. The considered supply chain is a leading two wheeler manufacturing supply chain of North India. Different drivers of the supply chain have already identified along with the various factor affecting their service quality. The assessment of service quality of drivers individual has already done in chapter 5 and given in table 6.1. Now the service quality of entire supply chain has to be assessed with the help of graph theoretic approach.

Table 6.1: Service quality index for individual driver

Sr.No.	Service Quality of Different Drivers	Service Quality Index
1	Supplier service quality	0.264
2	Organization service quality	9.48
3	Distributor service quality	9.34
4	Retailer service quality	7.11
5	Customer service quality	10.08

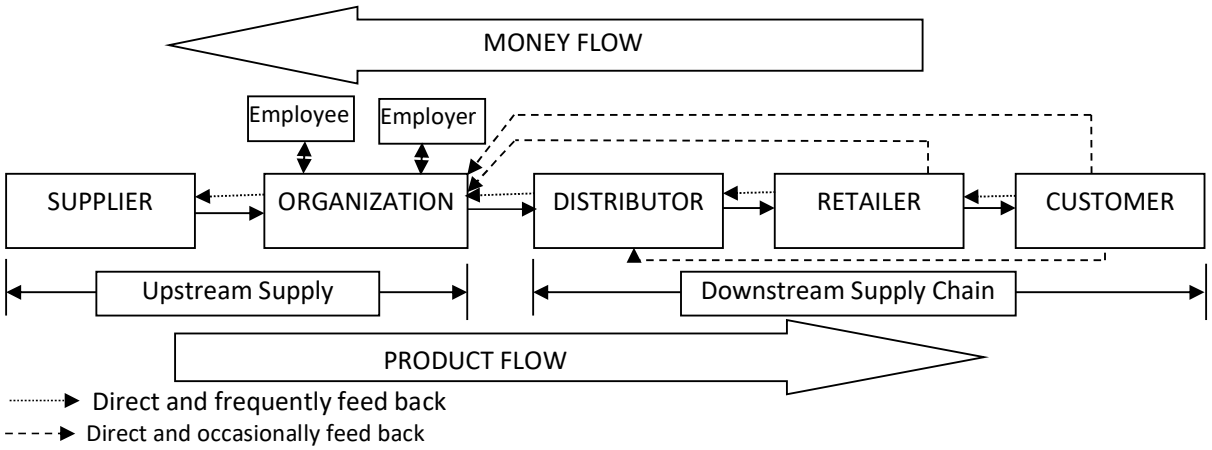


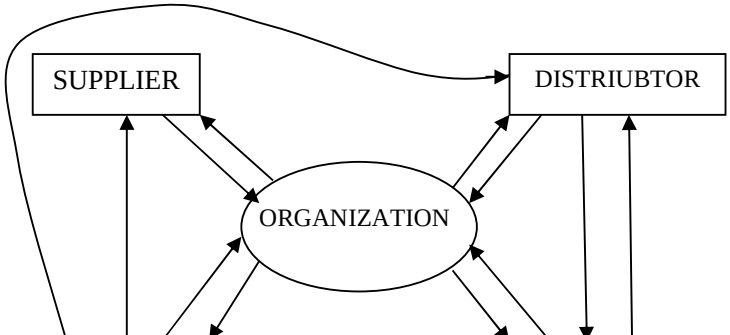
Fig. 6.2 Model of Service quality in Supply Chain

6.3.1 Algorithm of Graph Theoretic Approach

The graph theoretic approach used here to evaluates the service quality of supply chain in terms of a single numerical index. This takes into consideration the inheritance effect of factors and their interdependencies. The algorithm of the proposed approach is presented here.

1. First of all, assess the service quality index of individual drivers of the supply chain with the help of various techniques. Table 6.1 shows the index value of service quality of different driver of the considered supply chain which assessed in chapter 5.
2. Develop a digraph between the various drivers of supply chain depending on their interdependencies (Figure 6.3 and 6.4). The nodes in the digraph represent drivers while edges represent interaction among drivers. Fig. 6.3 showing the digraph from organization perspective while fig. 6.4 showing the digraph from customer perspective.
3. Develop the variable permanent matrix (VPM) with diagonal elements representing inheritances and the off diagonal elements representing interactions among them.
4. The numerical values for inheritance elements are the same value shown in table 6.1 while the numerical values for interactions elements are taken from the literature and with the help of experts as they are global in nature and does not vary from industry to industry.
5. Find the value of VPM which is known as permanent function (PF), which can be obtained in a similar manner as determinant with only difference that all the negative signs of determinant are replaced by positive sign. This is the index value of the service quality of supply chain.

   The performance of any supply chain can thus be evaluated based on the above discussed methodology. The interdependencies are developed with the help of literature and expert opinion from automobile industry and academic. A small brain storming session was conducted where experts from the automobile industry and academia participated.



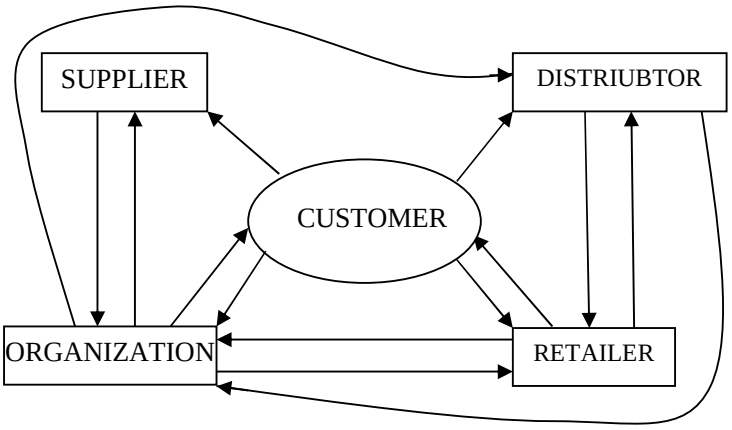


Fig. 6.4 Digraph of manufacturing SCM from customer perspective

6.3.2 Variable Permanent Matrix Representation

Variable permanent matrix used to find the value of service quality of supply chain give its one to one representation. This is a 5X5 matrix (M-6.1) and considers the present of all five drivers as attributes. M-6.1 is a general matrix for this case.

$$VPM-SC = \begin{array}{c} \\ S \\ O \\ D \\ R \\ C \end{array} \begin{array}{c} \begin{array}{ccccc} S & O & D & R & C \end{array} \\ \begin{pmatrix} S_1 & S_{12} & 0 & S_{14} & 0 \\ S_{21} & S_2 & S_{23} & S_{24} & S_{25} \\ 0 & S_{32} & S_3 & S_{34} & 0 \\ 0 & S_{42} & S_{43} & S_4 & S_{45} \\ S_{51} & S_{52} & S_{53} & S_{54} & S_5 \end{pmatrix} \end{array} \qquad \text{(M-6.1)}$$

Inheritance values are not global in nature. The inheritance values are considered from table 6.1. M-6.2 is the matrix after putting the inheritance values.

$$VPM-SC = \begin{array}{c} \\ S \\ O \\ D \\ R \\ C \end{array} \begin{array}{c} \begin{array}{ccccc} S & O & D & R & C \end{array} \\ \begin{pmatrix} 0.264 & S_{12} & 0 & S_{14} & 0 \\ S_{21} & 9.48 & S_{23} & S_{24} & S_{25} \\ 0 & S_{32} & 9.34 & S_{34} & 0 \\ 0 & S_{42} & S_{43} & 7.11 & S_{45} \\ S_{51} & S_{52} & S_{53} & S_{54} & 10.08 \end{pmatrix} \end{array} \quad \text{(M-6.2)}$$

A brainstorming session was conducted with academia and industry expert to assign the interaction values. Interaction value may be taken from table 6.2. M-6.3 is the matrix after placing the interaction values.

Table -6.2: Interaction values of attributes

Dependency effect of attribute 'j on attribute i'	**Assigned value of the attributes (S_{ij})**
Very weak	0.1
Weak	0.2
Medium	0.3
Strong	0.4
Very strong	0.5

$$VPM-SC = \begin{array}{c} \\ S \\ O \\ D \\ R \\ C \end{array} \begin{array}{c} \begin{array}{ccccc} S & O & D & R & C \end{array} \\ \begin{pmatrix} 0.264 & 0.4 & 0.1 & 0.1 & 0.1 \\ 0.3 & 9.48 & 0.4 & 0.3 & 0.5 \\ 0.1 & 0.4 & 9.34 & 0.5 & 0.3 \\ 0.1 & 0.2 & 0.4 & 7.11 & 0.5 \\ 0.1 & 0.2 & 0.3 & 0.4 & 10.08 \end{pmatrix} \end{array} \quad \text{(M-6.3)}$$

Permanent function for the matrix M-6.3 is

PF = 1804.98

The actual value of service quality seems very strange and does not provide any information till it is guarded by minimum and maximum values. To find the maximum value, interaction values of attributes must be maximum while to find the minimum value, interaction values must be minimum. Matrix M-6.4 is used to find

the maximum value of service quality of supply chain while matrix M-6.5 is used to find the minimum value of service quality of supply chain.

For Maximum Value

$$VPM-SC = \begin{array}{c} \\ S \\ O \\ D \\ R \\ C \end{array} \begin{array}{c} \begin{array}{ccccc} S & O & D & R & C \end{array} \\ \begin{pmatrix} 0.264 & 0.5 & 0.5 & 0.5 & 0.5 \\ 0.5 & 9.48 & 0.5 & 0.5 & 0.5 \\ 0.5 & 0.5 & 9.34 & 0.5 & 0.5 \\ 0.5 & 0.5 & 0.5 & 7.11 & 0.5 \\ 0.5 & 0.5 & 0.5 & 0.5 & 10.08 \end{pmatrix} \end{array} \quad \text{(M-6.4)}$$

PF =2368.32

For Minimum Value

$$VPM-SC = \begin{array}{c} \\ S \\ O \\ D \\ R \\ C \end{array} \begin{array}{c} \begin{array}{ccccc} S & O & D & R & C \end{array} \\ \begin{pmatrix} 0.264 & 0.1 & 0.1 & 0.1 & 0.1 \\ 0.1 & 9.48 & 0.1 & 0.1 & 0.1 \\ 0.1 & 0.1 & 9.34 & 0.1 & 0.1 \\ 0.1 & 0.1 & 0.1 & 7.11 & 0.1 \\ 0.1 & 0.1 & 0.1 & 0.1 & 10.08 \end{pmatrix} \end{array} \quad \text{(M-6.5)}$$

PF = 1706.29

6.5 CONVERSION OF SERVICE QUALITY VALUE INTO INDEX VALUE

The actual value of service quality calculated in section 6.4 seems very strange and does not provide any information. So, it is guarded by minimum and maximum values but still it seems to look very peculiar. The best method to memorize and understand this value is the conversion of this value from a non standard scale to a 100 point standard scale. This can be done in same manner as thermometer calibrates.

Minimum Value = 1706.29 ~ 1706 (Considered as 0 on 100 point scale)

Maximum Value = 2368.32 ~ 2368 (Considered as 100 on 100 point scale)

Difference between maximum and minimum values = 2368-1706 = 662

These 662 points will distribute among 100 points on standard scale.

Every 1 point on 100 scale = 662/100 = 6.62 point of SQ

Actual value of SQ of SC = 1804.98 ~ 1805

Value on 100 point standard scale = (1805-1706)/6.62 = 14.95

Or it is better to say that considered supply chain has only 14.95% service quality

6.6 CONCLUSION

In this chapter an attempt has been made to find out the service quality of supply chain in a single numerical value with the help of frequently used approach i.e. graph theoretic approach. The actual, minimum and maximum values are also computed to know the status of service quality of considered supply chain. Further these values are transferred on a 100 point scale to understand better the existing status of the service quality of supply chain.

CHAPTER-VII

ASSESSMENT OF SUPPLY CHAIN PERFORRMANCE INDICATORS

7.1 INTRODUCTION

A supply chain is a system of organizations, people, technology, activities, information and resources involved in moving a product or service from supplier to end user. Supply chain is a big umbrella which covers suppliers of supplier to end users. Supply Chain is a continuous chain, with its two terminal ends being the primary supplier, and the end user. It is the chain that includes within itself, in context of a product/service, the sourcing of raw material, its processing, giving it to final shape, storage, transportation, sale, purchase and finally consumption. In nutshell, it is an unbroken chain of activities and interventions that starts from its constituent raw material and moving it to the final consumer.

Today, in the era of intense competition and globalization, organizations want to sustain the customer, striving to develop the long term relationship with its upstream as well as downstream. Also organizations feels more pressure from customer side due to requirement of high quality of product and service, use of latest technology and incorporate of latest features in the product at very attractive price. So researchers agree that performance measurement or effective performance measurement can facilitates the better understanding among the supply chain members.

In spite of having the need for measurement of performance of supply chain, very few studies are available. In the present study, the assessment of supply chain performance indicators is carried out. The relevant data was collected through survey from the customers of a two wheeler automobile supply chain.

7.2 SUPPLY CHAIN PERFORMANCE INDICATORS

The important supply chain performance indicators, which have been studied in this research, are service quality, customer satisfaction and customer loyalty.

7.2.1 SERVICE QUALITY

Service quality may be defined as set of those activities which must be performed to satisfy the existing and new customers. The main aim behind to provide good service quality is to increase customer satisfaction which in turn increases the customer loyalty.

7.2.2 CUSTOMER SATISFACTION

Customer satisfaction may be defined as the degree of satisfaction provided by selling the goods or service and measured by customer loyalty in terms of the number of repeat order. Customer satisfaction is a measure of how the product and services provided by the company meets the expectation of the customer. Customer satisfaction plays an important role for the success and survival of a firm. Over the period of time, customer satisfaction has been used as one of the key to predict the customer behavior. Kotler (1994) clearly stated that customer satisfaction is the only key of customer retention. Christopher & Martin (1994) stated that there are three elements of customer satisfaction such as pre transaction satisfaction, transaction satisfaction and post transaction satisfaction. These elements are depict in fig. 7.1

Pre transaction satisfaction

The satisfaction, which customer feels in pre transaction phase or before the delivery of products or services. This may be due to good customer service policy in written form, education and training to the customer and good designing of the systems etc.

Transaction satisfaction

The satisfaction, which customer feels during transaction phase or during the delivery of products or services. This may be due to commitment to fulfill the order at right time, proper demo of product or services, good behavior during transaction period, product substitute etc.

Post transaction satisfaction.

The satisfaction, which customer feels after the transaction or after the delivery of products or services. This may be due to timely installation and commissioning,

frequently feedback about the product or service, timely attending the complaints and claims, proper training to customer etc.

Customer satisfaction is a multidimensional concept which includes employee competence, employer promise, reliability, product innovation, qualitative manufacturing systems, value for money, safety and physical convenience. A customer becomes satisfied customer only due to his good experience with service providers. Table 7.1 depicts the differences between service quality and customer satisfaction.

Table 7.1: Service quality Vs customer satisfaction

SERVICE QUALITY	CUSTOMER SATISFACTION
Expectation of quality is based on ideals.	Customer satisfaction judgment can be formed by a large number of non quality issues.
Quality perceptions do not require any experience with the service provider	Satisfaction judgment requires experience with service provider.
Good service quality leads to customer satisfaction	High customer satisfaction leads to customer loyalty.

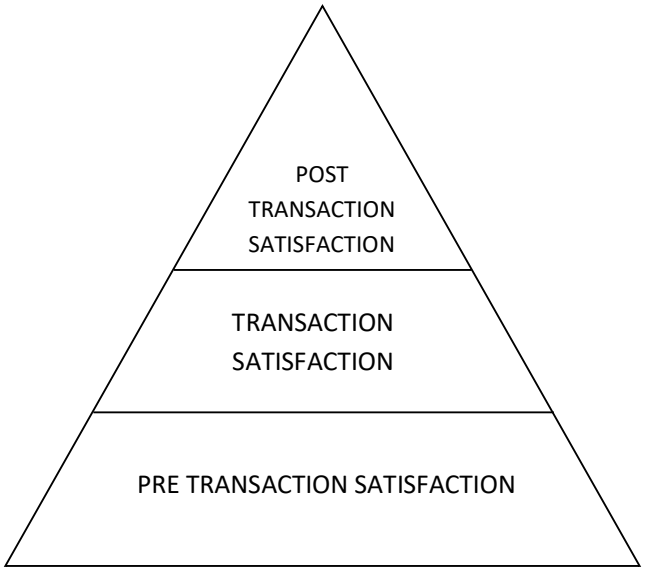


Fig. 7.1 Elements of satisfaction

7.2.3 Customer Loyalty

Customer loyalty is a tendency of customer to prefer the products or services of one brand over the others. This may be due to functional satisfaction due to product or service, performance satisfaction, user friendly, safety etc. customer loyalty increases the customer base and reduce the expanses on advertising and marketing. Customer loyalty can be defined as repeat purchase and referring the products or service of same company to others without personal interest. Table 7.1 discussed that customer loyalty is the outcome of customer satisfaction. Loyal customers do not want to change the company for small financial benefits and purchase more as compared to other customers. It is well known proverb that a loyal customer is better than ten new customers.

7.3 DEVELOPEMENT OF QUESTIONNAIRE

Chapter 4 presents the research methodology in detail along with the details of questionnaire development for measurement of service quality in supply chain for different drivers. The same method and guidelines were used to draft the questionnaire for measuring the performance of supply chain indicators. All the questions designed were close ended questions and Likert five point scale was used for the responses where 1 represent the least important and 5 represent the most important. The targeted respondents were the customers of a two wheeler manufacturing organization of North India.

7.4 DEVELOPMENT OF MODEL

A model has been developed to understand the relationships between the supplier service quality, organization service quality, distributor service quality, retailer service quality, customer service quality, customer satisfaction and customer loyalty.

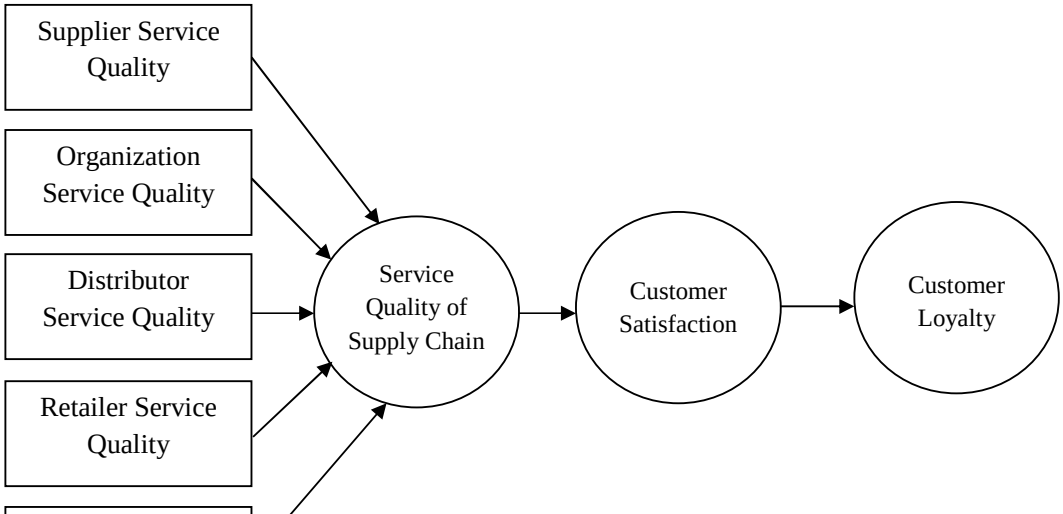


Fig. 7.2 depicts the relation between service quality, customer satisfaction and customer loyalty.

7.5 ANALYSIS OF MODEL

Fig. 7.2 depicts the model developed while fig. 7.3 depicts the structural model to understand the relationships between service quality of the different drivers, customer satisfaction and customer loyalty. This model is analyzed by AMOS 20 to find the customer satisfaction and customer loyalty.

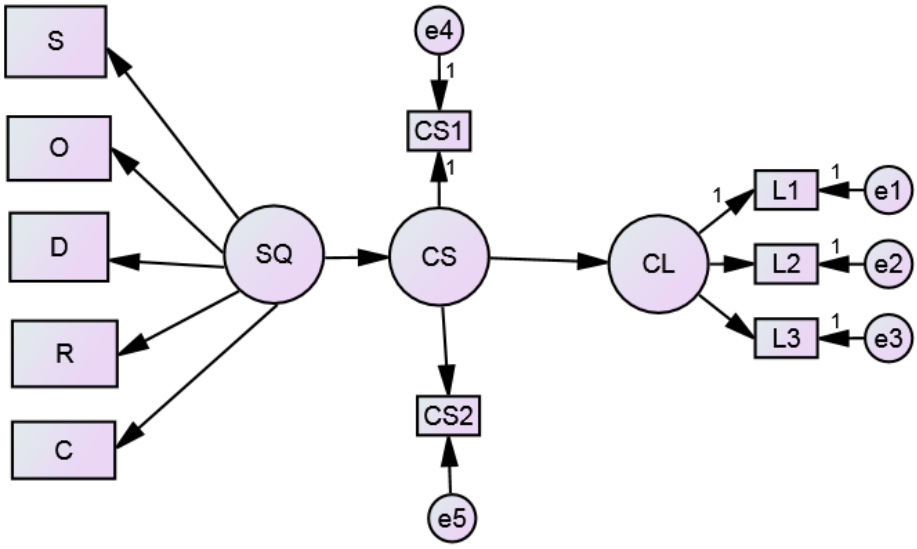


Fig. 7.3 CFA model for measuring customer satisfaction and customer loyalty

7.4.1 Reliability test

Reliability is assessed by internal consistency method which reflects equivalence, homogeneity and inter correlation of the items used in a measure. The measurement of Cronbach alpha coefficient is the value of reliability. Output of this analysis is

provided by SPSS 20 and indicates the high reliability of data as the value of alpha is more than 0.7 (Cronin and Taylor 1992) and is depicted in table 7.2

Table 7.2: Reliability analysis of supply chain performance indicators

Reliability measurement	Supply chain performance indicators
Value of α	0.904
Findings	Meritorious

7.4.2 Data Sufficiency Test

Data sufficiency test is a measure to check whether the sample size (144 in this case) is quantitatively adequate or not. KMO and Barlett test of sphericity are used for this purpose. The score of KMO and Barlett is provide by SPSS 20 and is depicted in table 7.3. The KMO value above 0.6 is considered significant and indicates adequacy of sample size.

Table 7.3: KMO and Barlett test of sphericity

KMO Measure of Sample of Adequacy		0.819
Barlett's Test of Sphericity	Approx. Chi-square	2221
	Df	231
	Sig.	0.000

7.4.2 Confirmatory Factor Analysis

CFA confirms the factor structure by testing the fit of CFA model. CFA model is run by using AMOS 20. Based on the methodology of Sureshchander et al (2002) and Beinstock et al (1997), the model fit was examined. Table 7.4 depicts the key model fit indices for the model

Table 7.4: Key fit indices for the model

Sr. no.	Index	Accepted Range	Actual Value
1	Goodness of fit indices (GFI)	≥0.9	0.921
2	The adjusted goodness of fit indices (AGFI)	≥0.9	0.902
3	Root mean squared residual (RMR)	≤0.05	0.048
4	Root mean square error of approximation (RMSEA)	≤0.10	0.09

5	Normed fit indices (NFI)	≥0.9	0.912
6	Non normed fit indices (NNFI)	≥0.9	0.921
7	Comparative fit index (CFI)	≥0.9	0.923
8	Incremental fit index (IFI)	≥0.9	0.918

All the values are within the range which clearly provides the validation of CFA model. The customer satisfaction and customer loyalty were 48.75 % and 29.68% which was found to be significant.

7.6 CONCLUSION

This chapter covered the detail analysis of data for performance indicators covering various assessments viz. reliability, data sufficiency and CFA. Further the detailed structural analysis on the conceptual model is also presented in this chapter. The results clearly indicate that service quality is positively linked with customer satisfaction and customer satisfaction is positively linked with customer loyalty.

CHAPTER VIII SUMMARY AND CONCLUSION

8.1 INTRODUCTION

Service quality is a main concern which can be sighted as development in service industries and it is an integral part of company strategy. Increased pressure on organizations due to global competition forces the organizations to think and improve the service quality.

Service quality word introduced by Buzell in 1975 but it gains momentum after the pioneer work of Gronroos (1984) and Parasuraman et al (1985, 1988). Since then numerous article and researches have been published in various reputed journals, but the topic is still under considerable for research, development and debate by practitioners, academician and researchers.

This research was focused to find the service quality of already established supply chain through questionnaire survey. An automobile manufacturing supply chain of North India was selected for this purpose. The broad objective of this study was to measure the service quality of supply chain and to examine the impact of service quality attributes on customer satisfaction and customer loyalty. The following specific objectives were identified:

1. Study the available literature
2. Identified the various attributes and variable
3. Develop valid set of tools to distribute the factors into smaller group
4. Develop valid set of tools to evaluate the service quality of different drivers of supply chain i.e. supplier, organization, distributor, retailer and customer.
5. Develop a valid tool to evaluate the service quality of supply chain
6. Identify the supply chain performance indicators i.e. service quality, customer satisfaction and customer loyalty.
7. Evaluate the customer satisfaction and customer loyalty.

In order to achieve these objectives, a detailed and focused review of relevant literature has been done. Based on this review of literature, an understanding of the role of service quality in supply chain has been developed. Detailed questionnaire were designed to know the responses and surveys were conducted to know the feedback. Majority of responses collected personally and using snow ball sampling

method. The collected data was analyzed through various tools and the results were validates as per the guidelines proposed by various researchers time to time.

This chapter summarizes the work done in this research along with contribution of the researcher. Implication of this research also discussed in following section. This chapter will close with enumerating the limitations and scope for further work.

8.2 SUMMARY OF WORK DONE

The brief discussion of the work done in this research is as under:

1. An in-depth literature survey was carried out to identify the various attributes and variables. The literature used was from 1975 to 2015. Also there was a healthy and many round discussions with industry experts to identify the variables and attributes. As an outcome of survey and discussion, total 100 factors (variables and attributes) were identified out of which only five factors were recommended by industry experts. The complete list is prepared in the relevant sections and it is expected that this list will be useful for researchers and practitioners of this field.
2. Based on the discussion and literature, all the factors were divided for various drivers.
3. Questionnaires were designed and surveys were conducted to collect the responses.
4. Snow ball sampling was used to reached the respondents
5. Data was analyzed through various techniques including reliability test, data sufficiency test, EFA using SPSS 20.
6. The service quality for different drivers was evaluated through different MADM techniques including graph theoretic approach, artificial neural network, and fuzzy graph theoretic approach.
7. A model was developed and the service quality of supply chain was evaluated through graph theoretic approach.
8. A model was derived showing the relation of service quality, customer satisfaction and customer loyalty and testing the relations between them using AMOS 20.

8.3 CONTRIBUTION OF THE RESEARCH

This research has a modest contribution to investigate service quality attributes in supply chain of manufacturing industries. The major contributions of this research are elaborated in this section.

First, an extensive review of literature has been undertaken. A comprehensive list of bibliography from 1975 to 2015 dealing with various aspects of service quality, supply chain and manufacturing industries has been prepared.

Second, the research comes out with 100 factors and conceptual model that link all the drivers of supply chain. A comprehensive list of all the factors has been prepared for each driver of considered supply chain.

Third, various MADM techniques have been identified and used to evaluate the service quality of different drivers of supply chain.

Fourth, the present work highlighted the systematic study to evaluate the service quality in supply chain in manufacturing industries in Indian context.

Fifth, the research comes out with a conceptual model that links service quality, customer satisfaction and customer loyalty in the manufacturing supply chain and empirically validated it. The frame work suggested in this research extends Heskett et al.'s (1994) "putting the service profit chain to work" frame work in manufacturing supply chain domain.

8.4 IMPLICATIONS OF THE RESEARCH

This study was focused on identifying the factors which affect the service quality in manufacturing supply chain. The insight achieved may be implemented for managerial as well as academia perspective, which may become important leads for future research and discussions in this area.

8.4.1 Managerial Implications

This research may provide the several implications for practitioners. Some of them are discussed as under:

1. The study identified the upstream and downstream supply chain and their relations. Also this study identified various factors responsible for service quality for different drivers. So, managers may be considered this study as a bench mark for factors identifications and are expected to use this study for identifying the various factors for their upstream and downstream trading partners.
2. In this study, various MADM techniques were used to evaluate the service quality of different drivers of supply chain. So, managers are expected to use this study for evaluating the service quality of their organization and can compare with this study.

3. Managers can be used this study for continuous measuring and monitoring the service quality of their upstream and downstream partners. Further the service quality rating can be used for trading partner selection.
4. The linkage of service quality, customer satisfaction and customer loyalty can be viewed as very important drivers for success of any supply chain. As this study indicates that service quality leads to customer satisfaction and customer satisfaction leads to customer loyalty. So, managers are also expected to use this study to increase the customer loyalty.

In short, most of the conceptual developments of this research could be meaningful used in the organizations. So, this study has got considerable amount of practical values.

8.4.2 Implications for Academia

This study also provides significant implications for academicians, which may also become the directions for future research

1. This study identified 100 factors responsible for service quality in supply chain, indicates the use of this study.
2. The compilation of research papers from 1975 to 2015 for service quality will help academician in their researches.
3. The present research has attempted to evaluate the service quality based on all five drivers.
4. The present work evaluates the service quality of supply chain based on tangible and intangible factors both.

Further, similar studies may be done on service quality using the factors, methods of evaluations of this research.

8.5 LIMITATIONS OF PRESENT WORK

Though lots of efforts have been made in this research work to evaluate the service quality of supply chain in Indian manufacturing supply chain, but this research is not free from the limitations. The limitations of the present work are as follows:

1. Though large number of factor has been considered for evaluation, some external factors like legal, political etc. not considered.
2. Factors for this study have been identified from the available literature which published in various reputed journals. There are chances that more research articles can be cited which are not included in the present research.

3. This study is based on the collection of data with the opinion of experts, hence there is a chance of biasing.
4. The data collection is for manufacturing supply chain.
5. This study used survey method which was restricted to North India. While application of this methodology in other regions may change the predict result of this study.

8.6 CONCLUSIONS FROM THE RESEARCH

In this research, an attempt was made to study and evaluate the service quality in supply chain. Service quality is a main concern in supply chain and provides a useful framework to explore consequences of service quality for both upstream and downstream the chain and reports a strong significance.

The present research is an attempt to understand the role and need of service quality in developing country like India. It become more delight when consider in manufacturing industries. The results of the study reveal that service quality at all drivers of supply chain can be used to improve the business performance.

A detailed literature review and healthy discussions with academia and industry experts help to identify the factors which were responsible for service quality of different drivers. The detail of these factors is discussed in chapter 4.

The methodology adopted for developing the different scales in this research is primarily based on Cronin & Taylor's (1992) work on SERVPERF scale. The scale used in this research is five point Likert scale. Questionnaires were designed to evaluate the service quality of all five drivers (supplier, organization, distributor, retailer and customer) of supply chain. This is the first research exploring the attributes and variables of service quality in supply chain for all five drivers.

The data collected for this research is limited to OEM supply chain in India, a developing country. The data analyzed by various MADM techniques like GTA, ANN and FGTA. ANN is used first time for evaluation of service quality so, the results was cross checked by FGTA. However the findings are consistent with those obtained in more developed countries for service sector. The results are not only interesting but also significant. OEMs are less number in India and most of them are owned by foreigner. The results suggest that service quality is one of the important aspect for supply chain and important for customer satisfaction which in turn affect the customer loyalty.

The study and analysis of assessment and modeling of service quality for different drivers in supply chain highlights that focal organization have to focus not only on its own service quality but also service quality of upstream and downstream partners. The focus on singular link may not represent the holistic perspective.

Service quality is a continuous journey to organization's success and will act as an essential step in enhancement of supply chain management initiatives.

8.7 SCOPE FOR FUTURE RESEARCH

There are always chances of improvements in every work or research. Following are the expected scope for future work:

1. The data collection approach used in the present study was snow ball sampling method, other sampling methods may be adopted for the same purpose.
2. As Few MADM techniques were used to evaluate the service quality in present study, some other technique may be used for the same purpose.
3. This study was restricted to Northern region of India, Other region of India may be considered for the same study.
4. Some more number of factors may be identified for each drives of supply chain.
5. The considered supply chain in this study was manufacturing supply chain, others supply chains may be considered.

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YMCA UNIVERSITY OF SCIENCE & TECHNOLOGY
FARIDABAD – 121006, INDIA
Department of Mechanical Engineering

Subject : Interview Schedule on Service Quality in Manufacturing Supply Chain

Purpose : Measure the Service Quality of manufacturing Supply Chains

Research Supervisor(s) : Dr. Vikram Singh

Dear Respondent,

Greetings from YMCAUST
Faridabad!

The purpose of this survey is to find out what you think about issues related to **Service Quality** and **Supply Chain Management** in your esteemed organization. We recognise that manufacturing firms often have a significant different set of business factors and resources than service firms. Rating a practice as "low" in importance does not in any way suggest poor management. Your answers may reflect unique business factors or resources constraints in your company. In fact, there is no company, large or small, that extensively implements all of the practices of Service Quality. Please answer the questions as completely and honestly as possible. This should not take more than **30 minutes** of your time. We will be indebted to you for your valuable time and assure that the information collected during this survey will be used for research purpose only.

All responses will be held in strictest confidence. **NO INDIVIDUAL FIRM DATA WILL BE MADE AVAILABLE TO ANY PERSON OR ORGANISATION AT ANY TIME**. By participating in this research, respondents are giving consent to the use of data for scientific research purposes.

This questionnaire consists of following sections:

Section-I deals with issues related to demographic information.
Section-II deals with issues related to service quality of supplier.
Section-III deals with issues related to service quality of organization.
Section-IV deals with issues related to service quality of distributor.
Section-V deals with issues related to service quality of retailer.
Section-VI deals with issues related to service quality of customer.
Section-VI deals with issues related to service quality, customer satisfaction and loyalty.

Since this is pure academic work, your earliest response will be highly appreciated.

Thanks & best regards,
Sincerely,

(Tarun Kumar Gupta)
Research Scholar (Registration No.: YMCAUST/2010/Ph33)
Department of Mechanical Engineering
YMCA UST Faridabad – 121006.
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General Demographic Information

Name of organization: ……

1. Product of organization: ……
2. Name of respondent: ……
3. Age……
4. Sex M ☐ F ☐
5. Education ……..
6. Designation ……..
7. Department ……..
8. Experience ……..
9. Name the component of SCM for which response is made

☐	☐	☐	☐	☐
Supplier	Organization	Dealer	Retailer	Customer

10. Annual Turnover of the above component

More than 100 Cr.	☐
75- 100 Cr.	☐
50 – 75 Cr.	☐
25- 50 Cr.	☐
1-25 Cr.	☐
Less Than 1 Cr.	☐

RESPONSE SHEET TO MEASURE THE SERVICE QUALITY OF SUPPLIER

Directions:

- Please rate the degree/level/extent of performance of **your suppliers** (general perception about majority of suppliers) by responding to the following questions.
- Please ***encircle*** one of the numbers [1] to [5] to express your views.

Scale: [1] Very Low [2] Low [3] Medium [4] High [5] Very High

Suppliers' Service Quality i.e. Organization's Assessment of Performance of its Suppliers

Q. No.	Questions
1	How long the relationship supplier wants to keep with organization?
2	What is the extent of latest Technology being used by supplier?
3	How good a supplier fulfill order quantitatively and qualitatively?
4	How much prompt response to the problems/ Query?
5	What is the level of secrecy maintained by the supplier?
6	To what extent supplier fulfills his commitment to supply the material quantity wise, quality wise, pricewise and timely?
7	To what extent supplier fulfilling the specified quality of product?
8	To what extent the manufacturing systems of the supplier are certified?
9	What is the extent of using strategy of business models, alliances and partnership?
10	To what extent supplier fulfills the terms & conditions for purchasing raw material & machines for manufacturing the product specified quality of product?
11	To what extent supplier delivers the product/services at right time?
12	To what extent supplier delivers the product/services in right quality?
13	To what extent supplier delivers the product/services in right quantity?
14	To what extent the supplier is accommodative of the varying demands & specifications of the product?
15	To what extent the supplier adjust the cost of the product depending upon the variation of input cost?
16	What is the cost of time elapsed in operations/ process?
17	What is the extent of utilization of resources available at supplier's disposal?
18	How extent the supplier is maintaining the frequency of supplying the quality data & reports?
19	What is the financial condition of supplier?
20	What is the extent of inventory maintained by the supplier in order to fulfill the requirement of organization?
21	What is the extent to which the supplier is putting in effects to reduce the waste at all levels?
22	To what level supplier is using safety standards?
23	What is the level of attitude/ behavior of supplier?
24	What is the extent of doing the welfare activity by supplier?

RESPONSE SHEET TO MEASURE THE SERVICE QUALITY OF ORGANIZATION

Directions:

- Please rate the degree/level/extent of performance of **your Focal organization** (general perception about organization) by responding to the following questions.
- Please ***encircle*** one of the numbers [1] to [5] to express your views.

Scale: [1] Very Low [2] Low [3] Medium [4] High [5] Very High

Organization's Service Quality i.e. Supplier and Distributor's Assessment of Performance of its focal organization.

Q. No.	Questions
1	How often organization shares the information?
3	How many times information is relevant?
4	How often the material flow information is timely?
5	How effective is the management leadership?
6	What is the cost of time elapsed in operations/ process?
7	To what extent organization is ready to buyback the depreciated/ unsold product?
8	To what extent the organization is accommodative of the varying demands & specifications of the product?
9	What is the financial condition of organization?
10	What is the extent of inventory maintained by the organization in order to fulfill the requirement of organization?
11	What is the extent to which the organization is putting in effects to reduce the waste at all levels?
12	To what extent the profit is shared to downstream?
13	How often the risks are studied?
14	How well spread the marketing is?
15	To what extent organization fulfills the terms & conditions for purchasing raw material & machines for manufacturing the product specified quality of product?
16	To what extent supplier fulfilling the specified quality of product?
17	How effective is the process management?
19	How often the engineer has to order for specific items?
20	How effective is the production planning?
21	How often the manufacturing systems are reviewed?
22	How effective the partnerships and collaborations are?
23	To what extent the technology innovations are used by the organization?

24	What is the extent of using strategy of business models, alliances and partnership?
25	What is the extent of utilization of resources available at organization's disposal?
26	How often the latest designs are adopted?
27	What %age of product is recycling?
28	To what extent the product is environment friendly?
29	How frequently the product development is taking up?
30	What is the extent of chasing to their customer?
31	To what extent organization delivers the product/services at right time?
32	To what extent organization delivers the product/services in right quality?
33	To what extent organization delivers the product/services in right quantity?
34	How good the employee relations are maintained?
35	How frequently the training is imparted?
36	To what level organization is using safety standards?
37	How frequently the risks are insured?
38	How helpful is the attitude of employee for business development?
39	To what extent the organization adjust the cost of the product depending upon the variation of input cost?
40	How often the strategy are reviewed and improved in order to achieve the targets?
41	To what extent the response is flexible to the market demand?

RESPONSE SHEET TO MEASURE THE SERVICE QUALITY OF DISTRIBUTOR

Directions:

- Please rate the degree/level/extent of performance of **<u>your distributors</u>** (general perception about majority of distributors) by responding to the following questions.
- Please ***encircle*** one of the numbers [1] to [5] or [U] to express your views.

Scale: [1] Very Low [2] Low [3] Medium [4] High [5] Very High [U] Unable to respond

Distributors' Service Quality i.e. Organization and retailer's Assessment of Performance of its distributors

Q. No.	Questions
1	What is the market reputation of the distributor?
2	What are the discounts (in terms of schemes & services) offered by the distributor?
3	To what extent he is putting in efforts for the market growth?
4	How much time he is devoting to increase the retailer base?
5	What is the extent of expectations of lead time?
6	What is the financial strength of distributor?
7	What is the extent of stock keeping capacity?
8	How extent the distributor is maintaining the frequency of supplying the quality data & reports?
9	To what extent distributor is ready to buyback the depreciated/ unsold product?
10	To what extent the profit is shared to downstream?
11	To what extent the laid target is fulfilled?
12	What is the overall efficiency of the distributor?
13	What is the extent of chasing to their customer (retailers)?
14	How many times he delivers the product / service to his downstream timely?
15	How many times he delivers the product / service to his downstream in right quantity & quality?
16	What is the quality of service provided to their downstream?
17	What is the extent of using strategy to develop business model?
18	To what level distributor is using safety standards?
19	What is the level of attitude/ behavior of distributor?
20	What is the extent of doing the welfare activity by distributor?

RESPONSE SHEET TO MEASURE THE SERVICE QUALITY OF RETAILER

Directions:

- Please rate the degree/level/extent of performance of **your retailer** (general perception about retailer) by responding to the following questions.
- Please ***encircle*** one of the numbers [1] to [5] to express your views.

Scale: [1] Very Low [2] Low [3] Medium [4] High [5] Very High

Retailer's Service Quality i.e. Distributor and Customer's Assessment of Performance of its retailer

Q. No.	Questions
1	What is the market reputation of the retailer?
2	What are the discounts (in terms of schemes & services) offered by the retailer?
3	To what extent he is putting in efforts for the market growth?
4	How much time he is devoting to increase the customer base?
5	What is the extent of expectations of lead time?
6	What is the financial strength of retailer?
7	What is the extent of stock keeping capacity?
8	How extent the retailer is maintaining the frequency of supplying the quality data & reports?
9	To what extent retailer is ready to buyback the depreciated/ unsold product?
10	To what extent the profit is shared to downstream?
11	To what extent the laid target is fulfilled?
12	What is the overall efficiency of the retailer?
13	What is the extent of chasing to their customer?
14	How many times he delivers the product / service to his downstream timely?
15	How many times he delivers the product / service to his downstream in right quantity & quality?
16	What is the quality of service provided to their downstream?
17	What is the extent of using strategy to develop business model?
18	To what level retailer is using safety standards?
19	What is the level of attitude/ behavior of retailer?
20	What is the extent of doing the welfare activity by retailer?

RESPONSE SHEET TO MEASURE THE SERVICE QUALITY OF CUSTOMER

Directions:

- Please rate the degree/level/extent of performance of **your's** (general perception about retailer) by responding to the following questions.
- Please ***encircle*** one of the numbers [1] to [5] to express your views.

Scale: [1] Very Low [2] Low [3] Medium [4] High [5] Very High

Customer's Service Quality i.e. Customer's Assessment of Performance of its retailer

Q. No.	Questions
1	To what extent the customer requirement was kept in focus strategically?
2	To what extent the retailer is concerned about the customer satisfaction?
3	To what extent the retailer is concerned for responding to the customer feedback?
4	How frequently the retailer interacting with the customer to take feed back?
5	How fast retailer respond to the redressal of the customer complaint?
6	To what extent retailer is prepared to offer service?
7	To what extent retailer is ready to buyback the depreciated product at reasonable cost?
8	To what extent the retailer delivers the product/ service at right time?
9	How sincerely the follow up is put up to create new customer?
10	To what extent the retailer is successful in fulfilling the order?
11	To what extent the retailer fulfilling the specified quantity of product/ service?
12	To what extent the retailer is using the latest technology?
13	To what extent the retailer's organization systems are certified?
14	To what extent the product is environment friendly?
15	What is the perception of the society about the product?
16	To what level retailer is using safety standards?
17	What is the level of attitude/ behavior of retailer?
18	What is the extent of doing the welfare activity by retailer?

List of Papers Published in International Journals

S. No	Title of the paper along with volume, Issue No, year of publication	Publisher	Impact factor	Referred or Non-Referred	Whether you paid any money for publication	Remarks
1	Service quality in supply chain: A review, vol. 2, No. 8, 2012	International journal of Engineering & Technology, IJET Publication, UK		Referred	NO	
2	A systemic approach to evaluate supply chain management environment index using graph theoretic approach, Vol. 21, N0.1, 2015	IJLSM, Inderscience		Referred	NO	
3	Fuzzy graph theoretic approach to compare the factors affecting the service quality of distributors, Vol. 10, No. 78, 2015	IJAER, RIP		Referred	NO	
4	Ranking the Factors Affecting the Service Quality of Retailer by SDV-MOORA Technique, Vol. 1, Issue 1. Pp 1-12, 2016	Journal of Automation & Auto mobile Engineering, MAT Journal		Referred	NO	
5	A framework to measure the service quality of distributor with fuzzy graph theoretic approach, Vol. 2016, Article id 6847540, 12 pages.	Journal of Industrial Engineering, Hindawi		Referred	NO	
6	Measurement of service quality of automobile organization by Artificial Neural Network, Vol. , No. , Pp ,	IJMCP, Inderscience		Referred	NO	

List of Papers Published in International Conferences

S. N.	Title of the paper	Conference Name	Publisher
1	A systematic approach to calculate the best price of a product using graph theory	Int. Con. on Computer Applications in Mfg. and Food Technologies and Bio-Nano Engg. (CAMBTE-2014)	UIT Hansi, Hissar
2	Fuzzy graph theoretic approach to compare the factors affecting the service quality of distributors	Emerging Trends in Mechanical and Industrial Engineering (ICETMIE-2015)	ITMU Gurgaon

List of Papers Published in National Conferences

S. No	Title of the paper	Conference Name	Publisher
1	Systematic model development to analyze service quality in supply chain for a manufacturing organization	Trends & Advances in Mechanical Engineering (TAME-2012)	YMCAUST Faridabad
2	Application of graph theory: A Review	National Conference on Emerging Technologies (NCETME-2014)	Echelon institute of technology Faridabad
3	To compare the factors affecting the service quality of customers using fuzzy graph theoretic approach	Trends & Advances in Mechanical Engineering (TAME-2017)	YMCAUST Faridabad

List of Papers communicated in International Journals

S. No	Title of the paper	Journal Name	Publisher
1	A framework to identify most important and least important factor responsible for customer service quality	YMCAUST International Journal of Research	YMCAUST Faridabad

BRIEF BIO DATA OF RESEARCHER

Tarun Kumar Gupta is working as an Associate Professor and Head in Department of Mechanical Engineering at NGF College of Engineering & Technology, Palwal (HR) India. He has passed his Bachelor of Engineering with Honors in Mechanical Engineering from C.R. State College of Engineering, Murthal (Sonepat) in 2000, Master of Engineering (Gold Medalist) in Manufacturing and Automation from Career Institute of Technology and Management, Faridabad in 2007 and persuing his Ph.D. from Mechanical Engineering Department of YMCA University of Science and Technology, Faridabad, India. He is having seventeen years of experience including teaching and research. He is currently doing research on service quality of supply chain. His areas of interest are service quality, Industrial Engineering, graph theory etc. He has published more than 30 research papers in various international and national journals and conferences and guided 5 M.Tech Scholars. He is also the author of two engineering text books.