CHAPTER 1

INTRODUCTION

1.1. Prologue

Today's supply chains are under tremendous pressure to compete in the market due to unexpected changes such as global competition, shorter product life cycles and dynamic changes of demand patterns (Tiwari et al., 2013). Success and survival of organization are becoming more and more difficult to ensure in such type of unexpected changes. However, the performance of an organisation will depend on its ability to sense and rapidly respond to these unexpected changes. Supply Chain Management (SCM) helps firms in integrating their business by collaborating with other value chain partners to cope with global competition and to meet the unpredictable demand of the end user (Agarwal et al., 2007). Therefore Supply Chain Management (SCM) is the significant area of research among practitioners and researchers around the world.

The term 'Supply Chain Management' arose in the late 1980s and came into widespread use in the 1990s. Prior to that time, instead of supply chain management, businesses used terms such as 'logistics' and 'operations management' (Hugos, 2003). Since then, supply chain is defined by many researchers. Some definitions of supply chain are as follow:

A supply chain may be defined as an integrated process wherein a number of various business entities (i.e., suppliers, manufacturers, distributors, and retailers) work together in an effort to:

- Acquire raw materials,
- Convert these raw materials into specified final products, and
- Deliver these final products to retailers.

This chain is traditionally characterized by a forward flow of materials and a backward flow of information (Beamon, 1998).

Christopher (1998) writes: *A supply chain is a network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate customer*.

Chopra and Meindl (2004) defined supply chain as: *A supply chain consists of all stages involved, directly or indirectly, in fulfilling a customer request*.

Chen and Paulraj (2004) stated that: *A typical supply chain is a network of materials, information, and services processing links with the characteristics of supply, transformation and demand*.

At the core of it, all supply chains are concerned with three important flows i.e. material, information and finances as they move in a process from one end to other end. Supply chain management involves coordinating and integrating these flows both within and among companies. The material flow includes the movement of goods from a supplier to a customer, as well as any customer returns or service needs flow from customer to supplier. The information flow involves the request for quotation, purchase order, monthly schedules, engineering change requests and quality complaints from customer side to supplier. The financial flow consists of credit terms, payment schedules, and consignment and title ownership arrangements from customer to supplier.

1.1.1. Supply Chain Players

Simple supply chain format consists of three players (Scott et al., 2011). The first player is a company which produces goods or services, the second player is supplier which supplies

raw and packaging materials and finally the third player is customer which is the consumer of goods or services. Figure 1.1 shows the simple supply chain structure.

Figure 1.1: Simple supply chain

In an extended supply chain three additional players will be considered. On the upstream supply chain there is the supplier's supplier (can be called as ultimate supplier). On the downstream supply chain there is customer's customer (can be called as ultimate customer). Ultimate supplier is at the beginning of the extended chain and ultimate customer is at the end of the extended chain. Finally third and last additional player is service provider which provides service (like transportation, warehousing etc) to the other players in the supply chain. Figure 1.2 is schematic diagram for extended supply chain structure.

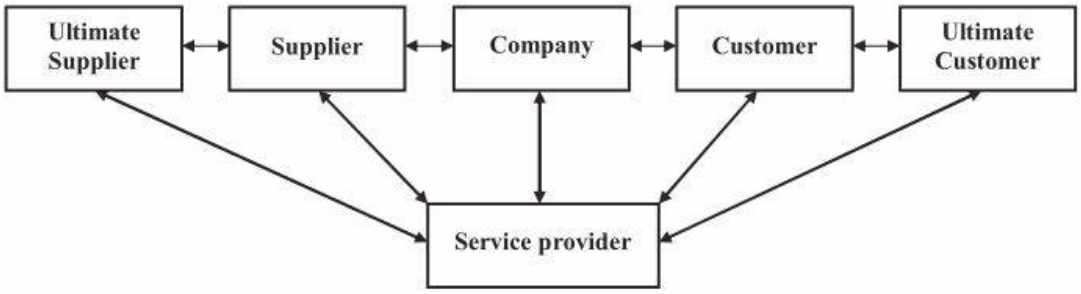

Figure 1.2: Extended supply chain

1.1.2. Issues in supply chain

In order to manage supply chains, the people in charge have several issues to deal with. These issues are quite challenging and necessary to work on, in order to truly pursue sustainable business development. To get success in business, a manager has to focus on these issues. Some supply chain management issues are given below.

- Supplier selection
- Procurement, production and delivery planning
- Risk management
- Vehicle routing problem
- Agility

Out of these issues agility is identified as one of the most salient issues of contemporary supply chain management (Lee, 2004). Agility is the ability to cope with unexpected challenges, to survive unprecedented threats of business environment and to take advantage of changes as opportunities (Sharifi and Zhang, 1999).

1.2. The concept of agility and its origin

The word 'Agility' is defined by Oxford dictionary is '*ability to move quickly and easily*'. In supply chain also it contains same meaning. In supply chain, agility is associated with ability to adapt unpredictable changes quickly and easily. Agility is the fundamental characteristic of a supply chain needed for survival in turbulent and volatile markets (Agarwal et al., 2007).

The original concept of agility was introduced by a group of researchers at Iaccoca Institute, Lehigh University, in 1991 (Bottani, 2009). Since then it has become very popular amongst researchers, managers and consultants. Agility, as a concept in manufacturing, was coined by Iaccoca Institute's researchers to describe the practices observed and considered as important aspects of manufacturing during their investigation

(Yusuf et al., 1999). The group involved many of the senior executives of US companies and the study culminated into a two volume report conveying an industry-led vision for a possible profound shift in manufacturing paradigm. The group originally defined agility as a manufacturing system that has the capability to meet the rapidly changing needs of the marketplace by quickly shifting among product models or between product lines (Yusuf et al. 1999). After the introduction in the report of Iaccoca Institute agile manufacturing become popularised concept and it is advocated as the 21st century manufacturing paradigm.

Agile manufacturing is cited as a new paradigm that will supplant that prevailing mass production, or industrial, paradigm. The content of this new paradigm is still ill-defined, reflecting its recent appearance (Burgess, 1994). Burgess (1994) argues that more work is needed to be done to refine the concept.

1.3. Agility in different scenarios

Agility is not only unique to manufacturing but it can also address different business competences. Some of them are as follows:

- Business agility
- Enterprise agility
- Agile workforce
- IT agility
- Agile manufacturing
- Supply chain agility

It is not necessary that the concept of agility is to be uniformly defined in all those fields but the general objective of all has to be same i.e. sustainable profitable business. The different disciplines address it from different points of view and at different levels. It is not obvious how exactly the different dimensions and levels of agility are related to each other.

1.3.1. Business agility

Business agility is being able to swiftly and easily change businesses and business processes outside the normal level of flexibility to effectively deal with highly unpredictable external and internal changes (Oosterhout et al., 2005).

1.3.2. Enterprise agility

Enterprise agility is important element of firm's success to achieve a competitive edge in turbulent and volatile markets. Enterprise agility is the ability of the firm to accurately identify and understand opportunities and threats in the turbulent and volatile markets, and to make quick and effective response to them by dynamically adjusting resources and processes (Yang et al., 2013).

1.3.3. Workforce agility

Workforce agility is the ability of organization's workers to respond strategically to uncertainty (Qin and Nembhard, 2010). Workforce agility is an essential aspect of an organization's overall agility.

1.3.4. IT agility

Information Technology (IT) plays an important role for making supply chain agile. Information technology includes the use of internet, Computer-Aided Design / Manufacture (CAD/CAM), MRP, MRP II, ERP, EDI, Incorporation of RFID technology etc (Hasan et al., 2009). Firms are increasingly dependent on IT for supply chain management as a competitive tool to facilitate agility (Wu and Angelis, 2007). IT Agility is the ability of information technology to quickly deliver the required information effectively and efficiently.

1.3.5. Agile manufacturing

Agile manufacturing is a very important characteristic for manufacturing companies in order to maintain their survival in competitive business environment. Agile manufacturing is the capability of manufacturing system to meet the rapidly changing needs of the marketplace (Sohal, 1999). Agile manufacturing integrates organizations, people and technology into a meaningful unit by deploying advanced information technologies and flexible and nimble organization structures responding to the dynamic changes of demand patterns (Gunasekaran and Yusuf, 2002).

1.3.6. Supply chain agility

Supply chain agility is defined as the firm's ability to adjust its supply chain tactics and operations quickly in order to respond the changes in the markets (Gligor et. al., 2016). Supply chain agility is essential for any organization, as managers need to re-form and re-construct their supply chains much more frequently to meet fast changing customer demands (Wu and Barnes, 2014).

Notably the concepts of agility in all those fields are the same. The agility of any kind of system is to how fast system will respond to opportunities or threats in order to become competitive. Although the general objective of agility in all fields is same but the different disciplines address it from different points of view and at different levels. The present thesis focuses only on supply chain agility because supply chain agility has been identified as one of the most important issues of contemporary supply chain management (Lee, 2004).

1.4. Relevance of supply chain agility

Unexpected changes (such as global competition, shorter product life cycles and dynamic changes of demand patterns) in business environment of the firms decrease the consistency

of supply chain in terms of delivering the right quantity of product at right time. These unexpected changes are an inhibitor to firms business and to counter it supply chains must have ability to respond quickly to the changing environments. Agility is the fundamental characteristic of a supply chain needed for survival in unexpected changes such as global competition, shorter product life cycles and dynamic changes of demand patterns in business environment. Agility further helps in delivering the right amount of product, at the right time to the consumer, which is the main objective of any supply chain (Agarwal et al., 2007).

Supply chain agility particularly becomes more relevant tool for the organisation to respond quickly and effectively from unforeseen events. Saleeshya et al. (2012) stated that agility plays a vital role in supply chain management to overcome the problem of unexpected changes which are explained above, hence implementation of agility in supply chain is quite necessary. Agility in supply chain is one of the solutions to achieve competitive advantage as it provides many opportunities for reducing operating cost and improving customer service and satisfaction (Anatan, 2006). Supply chain agility enables an organization to react quickly and more effectively to marketplace volatility and other uncertainties, thereby allowing the firm to establish a superior competitive position (Aziz and Zailani, 2011).

1.5. Enablers to supply chain agility

To make the supply chain agile, large numbers of variables play their role and hence enable the supply chain to be agile (Pandey and Garg, 2009). These variables are known as enablers of ASC. Enablers are enabling technologies and methodologies which are very much significant to achieve agility (Haq and Boddu, 2015). In words of Bottani (2010), '*enabler is the capability which allows promptly responding to change in business environment and the available leverages to achieve the agile capabilities*'. ASC enablers

can be also acknowledged with many different names among practitioners like ASC drivers (Bustelo et al., 2007), ASC pillars (Lin et al., 2006), etc. The need to identify and deploy agility enablers is a means of boosting the attainment of a supply chain. In other words, if agility enablers were correctly identified and deployed, it should be possible to minimise trade-offs amongst competitive objectives and compete from all fronts (Dauda, 2008).

1.6. Motivation for this research

In recent years severity and frequency of supply chain disruptions seems to be increasing due to some undesirable events in a business environment. For example Royal Philips Electronics plant, producer of micro chips caught fire on March 17, 2000 due to lightning hit on the connected power line in Albuquerque, New Mexico (Chopra and Shodi, 2004). Due to this incident millions of microchips were damaged. Telefon AB L.M. Ericsson, a producer of mobile phone, was the customer of Philips plant and it works on the basis of single-sourcing policy. After the fire, Ericsson had no other source of chips. As a result, productions of mobile phones were shut down for months. Ultimately, Ericsson lost $400 million in sales. In another incident, on September 11, 2001, after the terrorist attack the U.S. government closed the country's borders which resulted in impacting many supply lines. Ford Motor Co., Toyota Motors Corp. and many more companies halted their production because raw materials were delayed from other countries (Sheffi and James, 2005). The March 11, 2011, earthquake and tsunami in Japan caused widespread devastation that affected many supply chains around the globe. Business disruptions due to natural disaster were very large (Nanto et al., 2011). Over the last two decades, many companies faced such types of supply chain challenges that stretched their capabilities to the breaking point. The best supply chains are not just fast and cost-effective they should

also be agile and they should ensure that all their companies' interests stay aligned (Lee, 2004).

Therefore, it is a major challenge to the managements of the global corporate firms to counter uncertainties and unexpected changes. It is required to build in resiliency and agility in supply chain for aforementioned reasons. According to Lee (2004) great companies create such type of supply chain that respond to sudden and unexpected changes in markets. Sangari et al., (2015) advocate that supply chain agility is a key determinant of competitiveness in today's dynamic and turbulent business environment. Organizations with supply chain agility can better respond to unforeseen events (Swafford et al., 2008).

According to Li et al., (2008) agility is a very broad and multi-dimensional concept that involves various aspects. Some aspects of agility are agility evaluation, modelling the agility enablers, maximizing agility, leagility, information system agility, agile manufacturing system design etc. After thorough review of the literature it has been observed that agility evaluation and modelling of the agility enablers have always been major areas of concern for researchers. Though sufficient work has been covered in these two areas, the research is still being continued and outcome are being reported which indicates that there is still enough scope for further research. Maximizing agility is another concept of agility. Saleeshya and Babu, (2011) have reported that, the overall objective of any organisation is to maximise its agility. There is negligible research available in literature related to maximization of agility. This dissertation addresses the major research gap related to the maximization of agility of firm's supply chain. In addition to these three, sufficient research has been carried out in remaining dimension of agility which indicates that remaining dimensions of agility are saturated for the research point of view. This observation is based on the volume of literature that has been studied. Author of present

dissertation cannot claim that he has reviewed every academic publication related to all the aspects of agility but he has gone through the detailed literature review (as much as it could be collected). On this basis of inspection made by author of the present dissertation, four problems are identified, statements for which are explained in section 1.7.

1.7. Research problem statements

In order to fill the research gap identified through scrutinizing the literature available on supply chain agility and its periphery has led to the development of some objectives of this thesis. The objectives of this research are shown in Figure 1.3 and explained below:

Problem 1: To develop interrelationship amongst agile supply chain enablers

As discussed earlier agility of the supply chain depends upon large number of variables. These variables can be called as Agile Supply Chain (ASC) enablers. It is important for the organization to identify these variables which can be deployed collectively to make the organization, a profit making one, in the competitive market place. It is not economical and efficient to give same focus and attention to all agility variables. To overcome this problem Interpretive Structural Modelling (ISM) is used to develop a hierarchy of enablers. In this problem, ISM is applied to derive interrelationships among agile supply chain enablers that influence supply chain agility. ASC enablers have been also categorized according to their driving power and dependence using MICMAC analysis.

Problem 2: To evaluate agility in supply chains using fuzzy logic approach

Manufacturing organizations are moving towards agile practices to achieve a competitive edge in the rapidly changing business environment. To know, how much of the supply chain is agile; it needs to evaluate the agility of supply chain. Present problem reports a research carried out for the assessment of agility in supply chain using fuzzy logic approach. A human perceptions-based framework is proposed for the calculation of agility

in supply chain. The case study was carried out in an Indian manufacturing organization. The evaluation exercise indicated whether the case organization is agile or not? There are few barriers within the supply chain which impacts the agility level. To identify these barriers fuzzy performance importance index (FPII) is calculated. With the help of identified barriers, managers can improve the weaker areas of the supply chain.

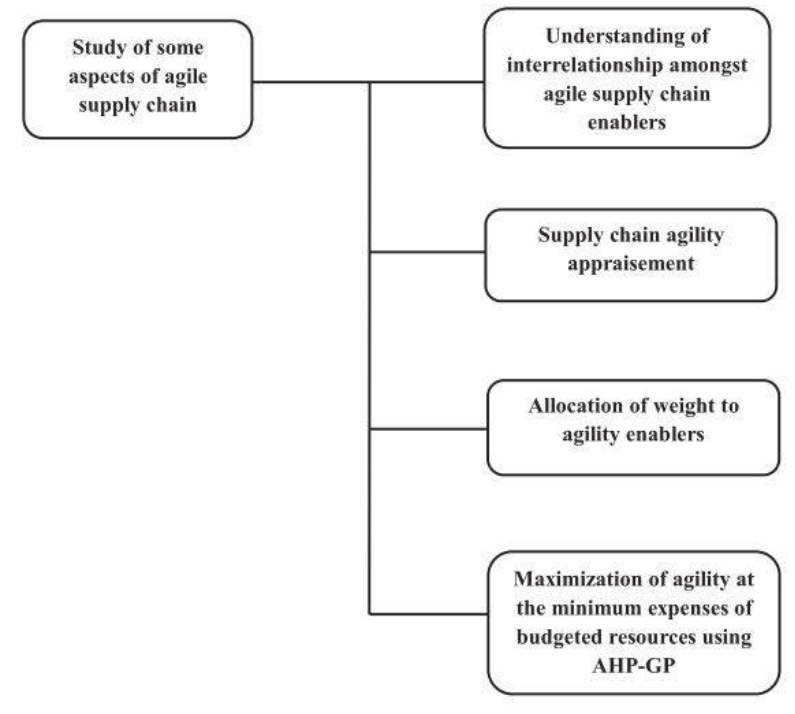

Figure 1.3: Research problems of the present dissertation

Problem 3: To allocate weight to agile supply chain enablers

Present problem contributes by allocation of weights to ASC enablers identified in problem 1 using Multiple Criterion Decision Making (MCDM). Weights to enablers would help decision maker to concentrate on the most effective enablers and develop strategies to improve them (enablers) according to their relative importance. This provides effective management of budgeted resources available to implement agility in the supply chains.

Analytic Hierarchy Process (AHP) method is used as multiple criterion decision making method.

Problem 4: To maximize the agility in supply chain by deploying the yearly budget resources

In this problem an attempt has been made to develop a GP model to link the agility index of enablers and the real world resource limitations (*i.e.* budget, hour, labour). The agility of any supply chain will depend upon how system deploys its input resources. Optimum deployment of input resources of supply chain gives maximum agility. For this problem ASC enablers identified in problem 1 are considered as decision variables. To deploy the resources optimally we should know the agility index and weightages of each decision variable. Agility index of each variable will be taken from problem 2 and weightages (local weight and global weight both) of decision variables will be taken from problem 3. Each decision variable would also require various levels of input resources. Data for the yearly input resources are taken from the case-organization.

1.8. Agility in the context of case organization

This dissertation consists of empirical research which was carried out in a manufacturing company situated in North India. Since the management of the company does not allow revealing its identity, this company is designated in this dissertation as 'ABC'. 'ABC' manufactures diesel locomotive, Diesel Generator sets and its spare parts. 'ABC' supplies its products not only in India but exports to a number of countries such as Tanzania, Sri Lanka, Bangladesh, Vietnam, Malaysia, Myanmar, Angola, Senegal, Mali, Sudan and Mozambique. A flagship production unit of 'ABC' offers a complete range of products in its area of operation with an annual turnover of over INR 2,124 crore. The considered case-organization 'ABC' faces continuous and unpredictable changes due to business situations

such as global competition, dynamic changes of demand patterns, complexity and uncertainty in a business environment. Agility is required to sense and rapidly respond to these changes.

1.8.1. Global competition

Global competition is the services or products provided by competing companies that serve international customers. There is huge global competition for case-organization 'ABC' as many countries around the globe manufacture the locos and DG sets. Table 1.1 shows the list of countries which produced locos and DG sets.

Table 1.1: Manufacturers worldwide producing similar kind of product as 'ABC'

S.N.	Continent	Country
1.	Africa	South Africa
2.	Asia	China, Iran, Japan, South Korea, Pakistan, Turkey
3.	Europe	Belgium, Croatia, Czech Republic, Denmark, Finland, France, Georgia, Germany, Greece, Hungary, Italy, Netherlands, Poland, Romania, Russia, Serbia, Slovakia, Spain, Sweden, Switzerland, Ukraine, United Kingdom
4.	North America	Canada, United States
5.	Oceania	Australia, New Zealand
6.	South America	Argentina, Brazil, Chile, Uruguay

1.8.2. Dynamic changes of demand patterns

Demand pattern of case-organization 'ABC' is unpredictable. According to senior executive from the case-organization 'ABC' there is uncertainty in customer demand *i.e.* demand is not fixed. Due to uncertainty in demand 'ABC' forecasts for two years based on previous data and procure components and spares accordingly.

1.8.3. Complexity in a business environment

Case organization 'ABC' has huge and complex working areas such as design office, material control office, store department, inspection department, account department, planning office, progress office, production shops, heavy welding shop, heavy machine shop, Engine Erection Shop, Engine Testing Shop, Light Machine Shop, Sub Assembly Shop, Rotor Shop, Heat Treatment Shop, Engine Frame Shop, Pipe Shop, Truck Machine Shop, Sheet Metal Shop, Engine Assembly Shop, Engine Paint Shop, Engine Test Shop, Service Shops, Electrical Department, Technical Training Centre, Research & Development. These working areas are interlinked with different process flow. The flow of materials and information across these can make the environment very complex.

1.8.4. Risk and Uncertainty in business environment

There are number of risk and uncertainty in supply chain of case-organization 'ABC' which may disrupt the flow of materials. The risk and uncertainty which may affect the flow of materials in case-organization are follows:

- **Disruption risk:** It may arise due to Natural and Manmade disaster, Terrorism and wars, Labour disputes.
- **Delay risk:** Transportation breakdowns, Excessive handling due to border crossings or change in transportation mode, Port capacity and congestion, Custom clearances at ports.
- **Transportation risk:** Paperwork and scheduling, Port strikes, Delay at ports due to port capacity.
- **Political uncertainty:** Political uncertainty normally referred to, in the context of major changes in political regimes. A weak government could impact firms within the country and consequently, their trading partners in other countries as well.
- **Policy uncertainty:** Policy uncertainty refers to changes in government policy that impact the business community.
- **Natural uncertainty:** Natural uncertainty may include various phenomena such as earthquakes, floods, and fires, which could impair business functions and decrease the productive capacity of firms operating in the affected region.

The classification of delay and all other risk are due to the author only. The author has visited the plants and analysed himself. These risks are specific to case-organization 'ABC' and it can be the same for other manufacturing organizations as well as. The remaining part of this section (1.8) is also about 'ABC' company. These risks and delays highlighted have not been identified by the company previously. Other risks like that of supply and distribution were not present in case-organization and hence these are not considered here.

According to James (2005), 'agility is ability to respond to change, uncertainty and unpredictability in the business environment. After visiting the plant it has been observed that the considered case-organization 'ABC' also faces number of risk and uncertainty in its business environment. Agility is required to sense and rapidly respond to these risks and uncertainties. Hence an effort has been given to study some aspect of agility of the case-organization.

Though Delay risk and Transportation risk seems to list same things but it is slightly different from each other. Delay risk occurs in material flows when a supplier, through overly high utilization or other causes of inflexibility, cannot respond to changes in demand. Other culprits include like labour disputes, plant shut down, inspections during border crossings, or changing transportation modes during shipping. Transportation risk occurs in material flows where transportation breakdown due to natural disasters, manmade disasters, fires and terrorism can all halt the flow of materials (Chopra & Sodhi, 2004) and (Tummala & Schoenher, 2011).

1.9. Experts' opinions of the present dissertation

Some problems of the present dissertation rely on the opinion of experts. The experts' opinions of the thesis are based on four phases.

Phase 1: In this phase author of the thesis was looking to finalize the ASC enablers as well as to get contextual relationship among the enablers. For this purpose author of dissertation has conducted the brain-storming sessions. Two experts took part in brain-storming sessions, one from academia and one from industry. The expert from academia is the senior most professor of IIT (BHU) Varanasi in the area of Industrial Engineering and Management and the expert from industry is the senior manager from the case-organization. There were three sessions conducted and each session took more than two hours. In first session author of dissertation introduced about the problem and the requirements of the problem. Since in first attempt scenario of the problem was not clear much hence author was asked to come with the Supervisor. Now in second session the problem scenario was cleared and the seven ASC enablers were finalized. After few months third session was conducted which was for developing a contextual relationship among the identified enablers. During the third visit in this phase, the author of dissertation has also visited all the workshops of case-organization.

Phase 2: During the second phase author of dissertation visited the case-organization four times. Agile capabilities were identified with help of literature review and finalized with help of two experts from academia. First one is the supervisor and the second is the one who took part in phase 1. After identifying and finalizing agile capabilities, the author of dissertation and his supervisor visited the case-organization and presented the agile capabilities in front of group of six members (including senior manager who took part in phase 1). All six members are senior managers in different area. After 2 hours of exercise and with some modification, agile capabilities (7 ASC enablers, 25 ASC attributes and 101 ASC sub-attributes) were finalised. Now based on agile capabilities conceptual model was developed. In second visit the same six experts from the case-organization were approached with data sheets in order to assess the performance ratings and importance

weights of agility capabilities. In this visit four experts didn't respond due to their busy schedule. After 40 days they called the author of dissertation again to explain the model and the data requirement; the author of the dissertation explained them the model again. After understanding the model they asked to come after few weeks. Finally in fourth visit they all responded in form of data sheets.

Phase 3: Phase 3 concern about the collection of the data for pair-wise comparison of criteria with respect to goal and pair-wise comparisons of alternatives with respect to each of the criterion. Author of dissertation approached to the respondents of case-organisation for the pair-wise comparison data. Before the commencement of comparison, the objective of the survey was briefly introduced to the targeted respondents to ensure full understanding of the survey questionnaire, overall goals and objectives of the research and how data would be used. Four of the executives from the case organization were there to give their precious time for brain storming session. The remaining two were have some other schedule. This time author was fortunate because in this phase, he got the information in single visit.

Phase 4: The final phase is related to the collection of the yearly input resources data (operating cost, management hour, and employee hour) for each of enabler. This phase is concerned about real data of the case-organization rather than the opinion of experts. Senior manager from the case-organization (who took part in all the phases) helped a lot in this exercise. In this phase author of dissertation visited case-organization two times. First time he explained about the information that he required (which took around 1 and half hours) and second time he went just to collect the data file. Two office-staff from the case-organization also helped him in this regard as they were directed by the Manager to do so.

1.10. Objectives of the thesis

The present research is focused towards the studies of some aspect of supply chain agility. The prime objectives of this thesis have been highlighted below

- To develop interrelationship amongst agile supply chain enablers
- To evaluate agility in supply chains using fuzzy logic approach
- To allocate weights to agile supply chain enablers using AHP
- To maximize the agility in supply chain by deploying the yearly input resources

1.11. Scope of the thesis

Since supply chain is a huge subject area, the study of supply chain agility in this dissertation is limited to certain aspects. Work on this thesis started by identifying the major enablers which are responsible for making the supply chain agile. There are seven critical enablers of supply chain agility that were identified. There may be other enablers to supply chain agility but for the considered case-organization only seven enablers were selected with the help of expert advice.

The work is further followed by evaluation of agility in supply chain. For the evaluation exercise, attributes and sub-attributes of enablers were identified. For the present problem 25 attributes and 101 sub-attributes were used. From the author's side mammoth effort is given to identify all the relevant attributes and sub-attributes. However some of them might still have missed out.

Final work of this thesis is to develop AHP-GP model to maximize the agility of supply chain. The AHP is first used to prioritize the seven enablers on the basis of five selection criteria. Then AHP results were used in GP model. This model maximizes the agility of supply chain deploying certain input resources (*i.e.* budget, hour, labour). Anything beyond the considered criteria and input resources are out of scope of this research.

In the present dissertation, all the problems were carried out in a single manufacturing organization. However the results of this research can reasonably represent the situation prevailing in companies implementing world class strategies. This is due to the reason that, the case-organization, implements world class manufacturing strategies such as TQM, ISO 9001 and TPM.

1.12. Contribution of the thesis

The major contributions of the thesis are as follows. The first one is to figure out the agility level of the organization. Then identifying the agility barriers and finally maximizing the agility of supply chain. The results of this research can reasonably represent the situation prevailing in companies implementing world class strategies. This is due to the reason that, the case-organization, implements world class manufacturing strategies such as TQM, ISO 9001 and TPM. There may slightly difference in ASC capabilities for different organizations. In such case using the same concept, the models can be re-developed and results could be obtained.

1.13. Organization of the thesis

This dissertation is organized into eight chapters. Flowchart of the structure of the thesis are presented in Figure 1.4 and an overview of the thesis chapters is given as follows

Chapter 1: Introduction

Chapter 1 is the introductory part of the present dissertation. It explains the concepts, origin of agility and agility in different disciplines. Some background of supply chain agility and its relevance in contemporary business environment is provided. Motivations to carry out research in the field of supply chain agility are discussed briefly with the help of few anecdotes and analyzing the real life business scenarios

which are often the cause of supply chain disruptions. Finally this chapter ends with Problem statement, scope and structure of the thesis.

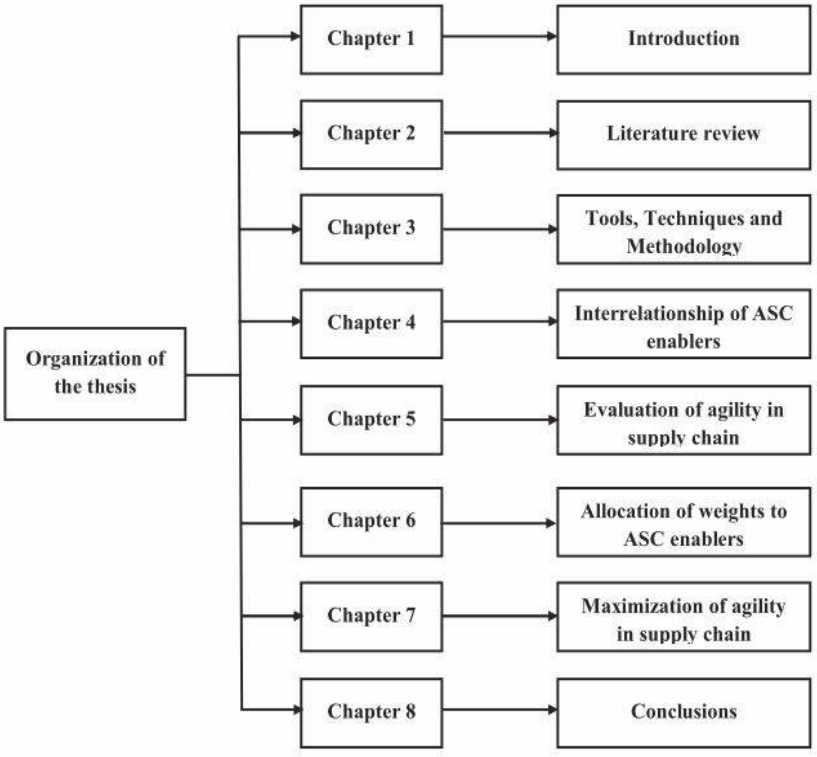

Figure 1.4: Structure of the thesis

Chapter 2: Literature review

Chapter 2 is the literature review which highlights rigorous study of the all the aspects of supply chain agility to explore the concept of the subject. Literature review is carried out from the year 1995 to 2016. For the purpose of literature review research papers were collected from the database of reputed publishers like Emerald, Taylor and Francis, Springer, Science direct, Elsevier and Inderscience using the key words such as agile manufacturing, agility, agile supply chain enablers, agility index etc. Only journal papers were included in the literature review. In addition to journal papers, research and

scientific articles, internet, blogs, conference papers and books are also combed in order to get better insight on the subject. A large number of definitions and dimensions of supply chain agility is available in the literature and many of them are discussed and tabulated in this chapter. Literature of supply chain agility are classified and explained in different areas. Finally, the gaps in the literature are identified which motivate to carry the research work ahead.

Chapter 3: Tools, Techniques and Methodology

This chapter reports the explanation of all the methodologies used in present dissertation. In this thesis four methodologies are used. These are Interpretive Structural Modelling (ISM), Fuzzy logic approach, multi criteria decision making (MCDM) technique and Goal Programming (GP). To develop a hierarchy and to derive interrelationships among agile supply chain enablers ISM is used. ISM is an interactive learning process in which a set of dissimilar and directly related elements are structured into a comprehensive systematic model. Multi-grade fuzzy logic approach is used to evaluate agility in supply chain. Fuzzy logic approach provides a useful tool for dealing with decisions in which the phenomena are imprecise and ambiguous. AHP is used as a Multi Criteria Decision Making (MCDM) to allocate weight to ASC enablers. MCDM method refers to making decisions in the presence of multiple, usually conflicting criteria. And finally a Goal Programming (GP) technique is used to maximize agility in supply chain.

Chapter 4: Understanding the interrelationship of ASC enablers

This chapter focuses on application of Interpretive Structural Modelling (ISM) and MICMAC analysis to identify interrelationship of ASC enablers and to categorise enablers into four categories towards assessing organizational agility in Indian context. For the structural modelling seven critical enablers are identified from the literature.

Chapter 5: Evaluation of Agility in supply chain

An attempt is made in this chapter to develop a conceptual model in order to estimate the agility of supply chain. Concept of generalized triangular fuzzy theory is tactfully utilized to facilitate agility evaluation and related decision-making. The proposed agility model is studied in an Indian manufacturing organization in order to investigate the agility of supply chain of the said organization.

Chapter 6: Allocation of weight to ASC enablers

Chapter 6 describes the allocation of weights (local weight and global weight both) to ASC enablers for effective management of input resources (like estimated cost, management hour and labour hour) available to implement agility in the supply chains. AHP is used for providing the weightages to ASC enablers. To judge the ASC enablers, decision maker has to know on what basis decision has to be taken. This basis is called as selection criteria. Selection process is influenced by a variety of criteria. For the judgement of the ASC enablers selection criteria such as competency, robustness, responsiveness, cost-effectiveness and quickness are selected.

Chapter 7: Maximization of agility in supply chain

This chapter proposed a decision aid that will allow maximizing the agility of supply chain by deploying the yearly budgeted resources. The yearly budgeted resources are budget, management hour and labour hour. It is the real world case study which illustrates the application of goal-programming approach in supply chain.

Chapter 8: Conclusion

This chapter complies and summarizes outcome of the present research. Based on summary of the research, concluding remarks on results are presented. After concluding remarks future research directions are also identified.