Tampere University

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IDENTIFYING PHARMACEUTICAL SUPPLY CHAIN AGILITY FACTORS

Industrial Engineering and Management
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ABSTRACT

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The objective of this research is to present the most important factors that affect the agility of pharmaceutical supply chains. In today's dynamic competitive environment, agility is the characteristic that affects the ability of supply chains to adapt their products and processes to changing market conditions and customers' needs in reasonable time and cost. There are plenty of studies in the literature addressing the agility of supply chains; however, few researches are done about the agility of pharmaceutical companies and those who worked on the agility of pharmaceutical supply chains, presented the agility factors according to companies' role in the supply chain. This study provides the agility factors regardless of the fact that firms are producers, distributors or retailers. Moreover, this study has presented five additional agility factors that cannot be found in the literature. The methodology of this study is desk research considering the problems and challenges of pharmaceutical supply chains discussed in the literature. Nevertheless, the research methodology imposes some limitations on research. The most important one is the fact that it has not been applied in a case company and no expert has been interviewed about the agility factors and their priority which can be compensated in future researches.

Keywords: pharmaceutical supply chain, supply chain management, agility

PREFACE

I am pleased that the thesis is finished. Since I could not find any case company, it was a little difficult to gather data and make analysis and inferences accordingly. However, working on a thesis is a very rewarding activity that provides the student with the opportunity of learning a lot about the subject. The most difficult part of doing a thesis was writing, at which I was not very good in the beginning. Fortunately, gradually I became more interested and skilled in it.

At this point, I would like to thank the supervisors of this thesis Professor Jussi Heikkilä and Mohammad Moshtari that guided me in my research. Their optimistic and helpful attitude encouraged me to continue the research process when everything was unclear and uncertain.

I am also very grateful to Mr. Hossein Matin for his advice about the agility concept in supply chain management. In addition, I should thank the administration of Tampere University of Technology for giving me the opportunity to attend the major of Industrial Management. Particularly, I appreciate Dr Jouni Lyly-Yrjänäinen for his teachings at the beginning of the program and Ms Minna Baggström for her supports during the study period.

Tampere, 26 November 2019

Vahid Mohammadi

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LIST OF SYMBOLS AND ABBREVIATIONS

B2B	Business to Business
B2C	Business to Consumer
BOM	Bill of Material
CRM	Customer Relationship Management
FIMEA	Finnish Medicines Agency
HRM	Human Resource Management
IT	Information Technology
NPD	New Product Development
OLAP	Online Analytical Processing
QMS	Quality Management Systems
R&D	Research and Development
RFID	Radio Frequency Identification
SC	Supply Chain
SCM	Supply Chain Management
SMED	Single-minute exchange of die
SN	Supply Networks
WHO	World Health Organisation

1. INTRODUCTION

1.1 Problem Statement

Organisations usually desire to be able to adjust to the rapid changes in business environment. For instance, Nokia wants to have the ability for quick adjustment to ever-changing expectations of its customers; or a pharmacy wants to have a framework for analysing market reaction to new medicine releases.

Business managers are willing to evaluate the changes in market condition and adapt accordingly. However, such investigation and adjustment are difficult for some reasons. Firstly, to remain profitable, changing business processes should be cost efficient. Secondly, companies should provide their employees with sustainable training programs to enable them keep up with changeful processes. Moreover, hiring such versatile workforce can be extremely costly. Above all, adjusting or procurement of facilities, machinery, IT systems, etc., will be exorbitant.

Other problems that organisations deal with are:

- Rapid changes resulted from globalization and their effects on product development strategy; (Cooper, 2014)
- Reduction in cycle time for product development and introduction; (Barczak et al., 2009)
- Overcoming constraints that enlarge product development duration, such as higher product variety and complexities, increases in business process steps and quality standards; (Griffin, 2002)

On the other hand, the pharmacy business is confronted with dynamic and serious issues (Holdford, 2005). Healthcare legislation agencies and final consumers have high expectations about marketing, consumer involvement and medicines with lower costs. This force the companies to adopt strategic planning techniques for designing and optimizing pharmaceutical supply chains (Birdwell, 1994).

In economic recessions, many people lose jobs and many of other's income are reduced. Besides, the global competition is continually diminishing profit margins. Moreover, quick technological change is a characteristic of business globalization.

Companies must invest a lot in R&D to get the infrastructure needed for sustainable technological growth. To keep up with technological changes, companies should also invest in machinery and IT systems.

The pharmaceutical supply chains are important parts of social healthcare systems. They make the stream of drugs with optimum price and minimum delay/shortage possible (HDMA, 2009).

One of the main challenges that dynamic markets brings to pharmaceutical industry is New Product Development (NPD). Product development projects, in which new platforms or production lines, new processes or small technical changes are created, can be carried out with customized processes to match the specific requirements of the project type (Jarrat et al., 2011). For instance, it is unnecessary to apply an extensive managerial decision-making process for small technical modifications. The ability to adjust the NPD processes can give the companies agility and competitive advantage (Ettlie & Elsenbach, 2007).

This thesis aims to help to resolve above-mentioned problems by studying how pharmaceutical supply chains work and how agile factors can be applied to improve their competitive advantage.

1.2 Objective of the Study

The main goal of this research is to determine the requirements to design and manage supply chains in the way that they could remain competitive in the dynamic environment of pharmaceutical industry. When market condition changes or new technologies are developed, firms need to have enough flexibility to adapt their business processes and manufacturing operations to new circumstances.

Furthermore, due to rapid expansion of the Internet and social media, customers know full well about new products and their features. This raises their expectations and necessitates quick responsiveness in product development. In addition, agility is usually known as an effective framework to acquire flexibility and responsiveness needed to remain competitive in today's unstable business environment. Thus, the objective of this study is ….

> …. *to discuss how pharmaceutical companies can identify key factors to achieve an agile supply chain.*

This thesis intends for developing a theoretical framework that displays improvement in responsiveness and flexibility, when agility factors are applied in the operations of pharmaceutical supply chains. Moreover, in this thesis, the most important agility factors are extracted from literature and prioritized according to the analysis of the case industry.

It is noticed that having long-term effective relationship with suppliers and clients is a big challenge for drug companies. Mistrust or having reluctance to information sharing can be a barrier for successful collaboration. Additionally, as a result of globalization, firms operating within supply chains are located in different countries. Therefore, it is necessary that decision makers consider the unique requirements of each market location. At the same time, different countries may have various regulations that should be complied. On the other hand, new standards or rules are frequently established, thus companies should always monitor and analyse legislative changes in all the countries that supply chains are involved and make compliance preparation. All of what have been discussed require agility as the key characteristic of supply chains.

To obtain above-mentioned objectives and responding to the research problems, this thesis is outlined as follows. The second chapter grasps the idea of supply chain management concerning agility factors in the literature. In chapter three, the research and data collection method are illustrated. Then the case industry and its characteristics and limitations are discussed. In the fourth chapter, the collected data is analysed and agility factors is identified from the literature and prioritized. Finally, in the last chapter the conclusions are made.

2. AGILITY IN SUPPLY CHAIN MANAGEMENT

2.1 Supply Chain Management

The term ‘’management’’ has different aspects which has been emphasized by each management expert. For instance, engineering aspects have been emphasized by F.W. Taylor, human relations have been emphasized by Elton Mayo, decision making is highlighted by George R. Terry, Ralph Davis has pointed up the leadership aspect, and Barry Richman has underscored the aspect of coordination and integration.

According to F.W. Taylor (1911), management is the art of knowing what you want to do and then seeing that they do it in the best and the cheapest manner. In addition, Fayol (1917), has mentioned basic tasks of management as:

- Forecasting
- Planning
- Organising
- Commanding
- Coordinating
- Controlling

The most challenging task for every manager is decision making. In the business problems of the real world, there is always information deficiency which enforces managers to make decisions under uncertainty. Furthermore, a high number of parameters and variables affecting the decision problem, makes it difficult for the manager to take all of them into account.

George R. Terry (1971), has considered this problem and gave the definition of management as: “Management is a distinct process consisting of planning, organizing, actuating and controlling, performed to determine and accomplish the objectives by the use of people and resources.”

When reviewing different approaches toward management, the most important thing to consider is that, in traditional definitions, the process of planning, organizing and controlling of activities and resources by utilizing human labour is reiterated. On the contrary, in modern approaches of management, the main focus is on productivity of organisation, making a proper organisational environment and handling the dynamic

nature of external environment. The concentration of this research is to solve the problem of changing environment by boosting the agility of supply chains.

According to Cooper et al. (1997), the concept of supply chain management (SCM), became a trending topic in 1990s. Many reasons have caused the popularity of the SCM. According to Mentzer et al. (2001), trends in global sourcing as well as competition over time, cost and quality, are main drivers that have made SCM a favourite topic.

The globalization of supply has made it challenging to coordinate with different suppliers. This requires companies to have a stronger link with suppliers (Mentzer et al., 2001). They have also mentioned that customers are expecting products delivered faster with no damage, which needs better coordination with suppliers and distributors. The globalization, fierce competition and changing environment lead to marketplace uncertainty. To handle this uncertainty, individual companies and integrated supply chains should have more flexibility. The importance of flexibility will be discussed in detail on section 2.2.

According to La Londe & Masters (1994), a normal supply chain is consisted of several independent companies some of which are involved in producing raw material and components, some are involved in assembling, transportation, wholesale distribution, or retailing. This definition considers the final consumer as part of the supply chain.

Mentzer et al. (2001) have defined the supply chain as a “set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer.” They have also claimed that if none of the firms involved in a supply chain implement management concepts the supply chain still exists. Thus, supply chains are phenomena that exist in business usually mentioned as distribution channels. Nevertheless, the term supply chain management necessitates applying management techniques by firms that are contained in the supply chain.

In practice, each company can be a part of several supply chains. LiDL, for instance, can belong to the supply chain of dairy products, meat products, candy, clothing, etc. Therefore, there are infinite alternative supply chain formations, which describes the network nature of supply chains. For example, Nokia can play the role of supplier, customer, partner or competitor in different supply chains.

Mentzer et al. (2001) have categorized the definitions of SCM into three classifications: “a management philosophy, implementation of a management philosophy, and a set of management processes.”

Different authors have provided distinct definitions for SCM. According to Monczka et al. (1998), the primary goal of SCM is “to integrate and manage the sourcing, flow, and control of materials using a total systems perspective across multiple functions and multiple tiers of suppliers.”

La Londe & Masters (1994) have investigated different aspects of supply chain strategy. This includes long-term agreements between firms, building mutual trust and commitment, integration of activities, data and information sharing, etc.

According to Stevens (1989), “The objective of managing the supply chain is to synchronize the requirements of the customer with the flow of materials from suppliers in order to achieve a balance between what are often seen as conflicting goals of high customer service, low inventory management, and low unit cost.”

The common concept between different definitions of SCM is handling the flow of materials from suppliers to users. For example, Jones & Riley (1985) state that: “Supply chain management deals with the total flow of materials from suppliers through end users.” In addition, according to Cooper et al. (1997), SCM is “… an integrative philosophy to manage the total flow of a distribution channel from supplier to the ultimate user.”

In order to carry out an effective SCM system, various activities have been suggested in the literature, which can be seen in table 1.

Table 1. *SCM activities.*

Activity	Author
Integrated behavior	(Bowersox & Closs, 1996)
Risks and rewards sharing	(Cooper & Ellram, 1993)
Information sharing	(Novack et al., 1995)
Cooperation	(Tyndall et al., 1998)
Integrated objectives to prevent overlap	(Lassar & Zinn, 1995)
Integration of processes	(Ellram & Cooper, 1990)
Developing long-term partnerships	(Cooper et al., 1997)

The ultimate goal of SCM is enhancing the competitive advantage (Monczka et al., 1998). According to Porter (1985), there are two ways for companies to obtain competitive advantage:

- Differentiation advantage
- Cost advantage

Porter also states that the ability of an organization for customer value creation has great impact on its competitive advantage. Moreover, Giunipero & Brand (1996), claim that competitive advantage can be achieved by improving customer satisfaction.

Therefore, it is argued that SCM activities improve customer satisfaction, that results in improved competitive advantage of the SCM and its constituent firms (Huolihan, 1988). Furthermore, according to Cooper & Ellram (1993), customer satisfaction can also be enhanced by increasing inventory availability and decreasing order lead time. Moreover, by developing unconventional solutions and unique services customer satisfaction can also be increased (Ross, 1998). Consequently, SCM can bring cost reduction, customer satisfaction and value creation to gain competitive advantage and profitability (Mentzer et al., 2001).

2.2 Flexibility of Supply Chain

As discussed in section 2.1, becoming customer-oriented is an important element of competitive advantage for handling ever-changing market conditions. In today's market, customers are expecting more variation of products, higher quality, zero defect and faster delivery. Technological innovations are being developed more rapidly that lead to faster business process modifications and product development. This situation has brought about drastic changes in business strategies. Lau (1996) has defined flexibility as:

> "… a firm's ability to respond to uncertainties by adjusting its objectives with the support of its superior knowledge and capabilities."

According to Aquilano et al. (1995), the primary constraints affecting this century's business strategies are higher quality, lower costs and enhanced responsiveness. Mass production idea lowers the per unit cost. Deming and Juran have contributed significantly to quality concepts. Due to enhanced business competition in the 1970s, responsiveness became another strategic constraint (Duclos et al., 2003). Maintaining cost efficiency resulted from mass production became very difficult with these amounts of changeability and uncertainty.

When studying supply chain flexibility, the internal manufacturing flexibility of individual firms should also be included. This is because of the fact that the concepts and methods for the flexibility of separate business processes can help us to find the elements of supply chain flexibility (Duclos et al., 2003). Vokurka & O'Leary-Kelly (2000) has identified 15 factors for the flexibility of manufacturing processes, such as facilities, operation, delivery, program and market flexibility, etc.

In a literature review of flexibility performed by Koste & Malhotra (1999), four dimensions of flexibility in business processes has been identified. These aspects are:

- Number of tasks, products, etc.
- Differences between tasks, products, etc.
- Time and cost needed for transition
- Similarity of outcomes for different alternatives, in terms of quality, time, costs, etc.

As an example, market flexibility indicates the capability for a quick and efficient adjustment of product design and features with changes in market demand. If the firms can change the products in good ranges, costs and time, then it means they have acceptable market flexibility. According to Hyun & Ahn (1990), ‘’flexibility is not only a component of manufacturing strategy, but it can also be an element of marketing, R&D or business growth strategy.’’

Individual firms’ flexibility is the building block of supply chain flexibility. Mason-Jones et al. (2000) emphasize matching supply chain strategies with customer demand. They combine waste reduction objectives of the lean approach with volatile market research methods. According to Vickery et al. (1999), flexibility of SCs should be achieved by integration and customer-oriented approach. Vickery et al. also described five dimensions of flexibility that include:

- Flexibility of products
- Flexibility of new products
- Flexibility of volume
- Flexibility of distribution
- Responsiveness

Flexibility of products indicates the capability for product customization to respond to the requests of the customers. New product flexibility means the capability of companies to launch new products or revise existing products. Volume flexibility implies the competence to adapt capacity to fulfil the changes in customer order size. By the same token, responsiveness indicates the capacity of firms to meet the needs of the target customers. Finally, distribution flexibility denotes the ability to make products and services broadly available.

According to Duclos et al. (2003), different departments of a company take the responsibility of different dimensions of flexibility. For instance, manufacturing and production planning take over volume flexibility. Product management and R&D accept new product flexibility, logistics accept distribution flexibility, and so on. Duclos et al. (2003) have also defined components of the flexibility of supply chains. They include:

- Flexibility of operations system
- Market flexibility
- Logistics flexibility
- Supply flexibility
- Organisational flexibility
- Flexibility of information systems

Flexibility of operations systems considers both aspects of manufacturing and service processes. This include the ability to modify products, change or replace equipment, employees and processes. In other words, assets, people and operations should be reconfigured to respond quickly to the changes in market trends considering both products and geographic areas. On the contrary, Radjou (2000), defined inflexibility as the incompetence of a firm in production and capacity modification.

An important element of supply chain flexibility is the flexibility of operations at different firms in a chain. To satisfy the end customer's demands, all the firms should provide their output at the right time and quality.

Market flexibility is the ability of companies to adapt to the changes in market conditions and to fulfil the changes in customers' needs and expectations. This constituent of flexibility has some dimensions, such as launching new products, product modification and after delivery service. When new technologies are developed, new materials are produced or customers' requirements change, companies need to be able to redesign their existing products or design and manufacture new products. To do so, supply chains should have parallel engineering activities (Duclos et al., 2003). This means engineers from different companies of the chain gather to develop new products and services. This needs relationship development techniques that will be discussed in the next section.

Today, companies must estimate the amount of demand without certitude. Fisher (1997) believes that the main goal of supply chains that want to have market flexibility is the ability to respond to unpredictable market demand to minimize shortages as well as

outdated inventory. Fisher also suggests modular product designs in order to make prospective modifications easier.

According to Ricker & Kalakota (1999), logistics management involves all the activities needed for transporting items from production point to the final consumer. These activities incorporate paper work, packaging, shipping, inventory management, transportation and delivery. Logistics flexibility is an important concept ensuring supply chain's each customer's needs is fulfilled (Fuller et al., 1993).

They suggest that, in order to achieve a flexible logistics system, components and distribution centres should be designed or selected in a way that they can tolerate extensive changes in market demand in an acceptable time. They should also have flexible return policies along with the ability to adjust products near the end consumer to make sure that they match customer's needs.

According to Anderson et al. (1997), customizing distribution properties can bring distinction and uniqueness to the companies. On the other hand, Lummas & Vokurka (1999) claim that to succeed, supply chains should develop tailored logistics systems according to each market segment.

Another aspect of flexibility is supply flexibility that needs modifying combination, volume and variety of products in addition to new product development. To do so, companies should have flexibility in all the activities of their supply processes from sourcing raw material to outsourcing their manufacturing process (Duclos et al., 2003). In other words, companies should have coalition with other companies with needed abilities to perform the tasks.

After completion of tasks, in case that those tasks are no longer needed, the coalition should be broken up (Jordan & Michel, 2000). According to Rich & Hines (1997), to have flexibility in supply processes, companies should adapt to the changes in product life cycles, production volume needs, processes and partnerships.

According to Bensaou (1999), the most important aspect of supply flexibility is the flexibility in starting and finishing relationships with business partners. Companies can have long-term or short-term contracts or even strategic alliances with their suppliers or customers. Therefore, companies should find the best relationship type for different market segments, suppliers or products, and find the best management approach for that relationship style. Due to the importance of relationship management it will be discussed in details in next section.

Organisational flexibility deals with the flexibility that each company within a supply chain should achieve (Duclos et al., 2003). They should have enough flexibility in hiring

and releasing employees, changing organisational chart, business processes and corporate culture. According to Duclos et al. (2003), the adaptation of business activities can be possible only if there is plenty of flexibility in the organisation.

Miles (1989), has emphasized the importance of good training of employees. Lau (1996) has conducted a research about organisational chart and claims that complex power structures hinder cooperation and integration of different departments within a supply chain. At the same time, workforce flexibility should be enhanced. Wright & Snell (1998) study various aspects of the flexibility of human resource management (HRM). They state that the availability of different job skills along with the flexibility of organizational culture can provide firms with workforce flexibility.

Changes in business operations and activities require adaptation of information and data processing tools and methods. Moreover, business integration requires data and information sharing between different companies. Therefore, firms constituting the supply chains should adjust their information systems to be compatible with the IT systems of other partners and new business processes (Duclos et al., 2003).

According to Reddy & Reddy (2002), using compound old data warehousing systems storing large amounts of data is an effective barrier for the flexibility of information systems. Lau (1996) has almost the same opinion as he claims that using up-to-date information technologies can help the flexibility of supply chains. Similarly, Vokurka & O'Leary-Kelly (2000), argue that automation of manufacturing technologies, that require using IT systems, can support the manufacturing flexibility. Furthermore, when it comes to supply chains, in addition to the manufacturing automation, other processes such as purchasing should also be computerized. From what have been discussed, it can be concluded that flexibility of information systems can affect both organisational and manufacturing flexibility and agility.

2.3 Relationship Management in Supply Chains

Development of new technologies, especially IT systems, can help to improve the logistics and other processes within the supply chains. Nevertheless, they can also affect inter-firm relationships. For example, doing purchasing process using ERP systems means fewer face-to-face meeting and interaction between sales people of suppliers and sourcing staff of customers. However, managing inter-firm relationship is still an important issue (Ndubisi et al., 2005).

To address this issue, promoting a supplier-customer relationship to gather information about suppliers and customers can be beneficial. Moreover, developing such relationships help firms to understand their partners' needs. Kirchmer (2004), explained the application of the Internet to integrate firms and inter-firm processes.

Better perception and fulfilment of customers' expectations make the loyal, and as Ndubisi et al. (2005) argued, gaining new customers is much more expensive than providing service for loyal customers.

Ndubisi et al. (2007) described the contributing factors of customer loyalty as shown in Figure 1.

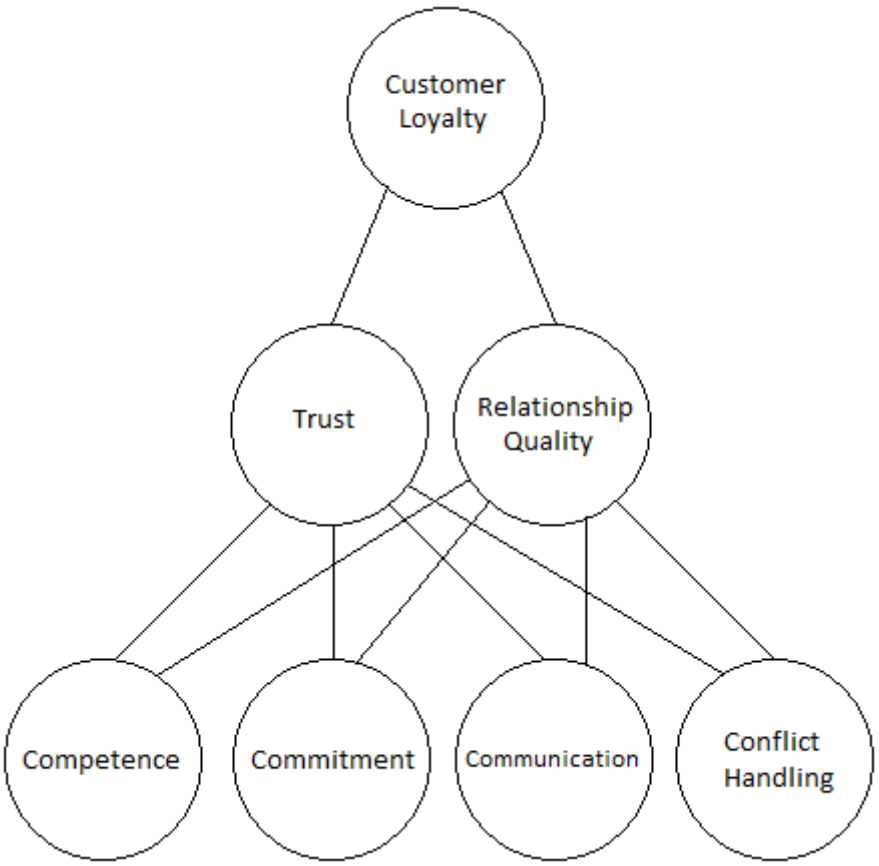

Figure 1. *Elements of customer loyalty*

The term relationship quality indicates a client's understandings of to what extent the relationship satisfies his or her expectations and objectives (Jarvelin & Lehtinen, 1996). On the other hand, according to Moorman et al. (1993), trust is the tendency to count on a partner. An abuse of this confidence can result in agitation. Gronroos (1990) emphasized the assets of the supplier should be applied in a way that customer put faith

in them. Schurr & Ozanne (1985) explained the trust as the opinion that a partner's pledge is reliable and it will meet its obligations.

Another important aspect for determination of the quality of the relationship is commitment. Kiesler (1971) provided a psychologic definition for the term. According to Kiesler, commitment is determination and understanding that adjust and connect a person to a behavioural tendency. In business relationships, according to Moorman et al. (1993), commitment is a permanent tendency to keep an esteemed relationship. This means a great degree of responsibility to make a relationship pleasant and helpful for both parties. commitment increases when people assume that they get more benefit from a relationship.

Competence is a client's judgement of its supplier's commercial and technological capabilities (Ndubisi et al., 2007). Ndubisi et al. have introduced four elements that are related to competence. This include:

- Supplier's knowledge regarding the market in which the client is working.
- Supplier's ability to issue recommendations about its client's business problems.
- Supplier's ability to assist the client to plan its purchases.
- Supplier's capability to make impressive sales support material (e.g. marketing and training pamphlets).

Communication factor indicates the capability to deliver reliable information in appropriate time. When companies do business with their suppliers or customers, they should inform their customers if any problem occurs. They should also collect customer feedback to modify their business processes. They should use this information to find customers' desires and expectations. In addition, in case that there are displeased customers, the company should inform them what is being done to solve the problem.

Conflict management is the ability of firms to minimize the adverse effects of disagreements (Dwyer et al., 1987). Firms should be able to prevent possible conflicts as well as solving existing ones. According to Dwyer et al. (1987), the reaction of firms to conflicts is influenced by their previous satisfaction of relationship, the enormity of what they have put forward in relationship and the variety of available options.

Nowadays, consumers do not buy only based on product features. Their relationship with suppliers also affects their decisions. Moreover, in today's business environment, companies can exploit psychographic information and various customer approach methods to better understand their clients.

Modern IT products can help to evaluate customers' behaviour and satisfaction. Customer Relationship Management (CRM) systems are efficient IT tools that can be applied for gathering, storing and analysing customer data. By exploiting this information companies can find the preferences of casual customers and change them into regular ones (Ling & Yen, 2001).

The relationship within supply chains may vary depending on the scale and time. In a small retailing or grocery store, in a rural area, there are usually personal relationships between suppliers and customers. Information about intimate zones of customers is a key to have loyal customers. However, this kind of relationship is not good for large scale businesses (Ling & Yen, 2001).

In mass production, the products are distributed widely throughout a large geographical area. The communication with the final consumer is usually done by mass media and brand recognition is important. Supplier-customer relationship is usually done in a more formal way. However, customers do not feel intimacy so the loyalty is low (Ling & Yen, 2001).

From the middle of 1980s, target marketing became widely used in business. In this kind of marketing IT tools like mail or telephone is used to target a particular group of customers. Firms get feedback from customers and feedback rate is an important measure. Nevertheless, like the previous approach there is no deep customer-supplier relationship (Ling & Yen, 2001).

In customer relationship marketing, companies take advantage of large-scale production and distribution methods. By applying modern IT tools, firms will be able to acquire enough knowledge about their customers and gain their faith and loyalty. Nonetheless, the problem with this approach is that it has many different business functions and is hard to exploit. Moreover, it can normally be applied in B2C marketing rather than B2B (Ling & Yen, 2001).

According to Ling & Yen (2001), applying CRM systems include four stages of evaluation, planning implementation and review. In the evaluation period, behaviour of suppliers or customers is modelled based on available data. Because of the importance of data in this phase, IT technologies is widely used to store and manage information. For analysing data, technologies like Online Analytical Processing (OLAP) as well as statistical methods can be utilized to discover patterns in data. In the evaluation phase target segment of the market is chosen and the needs of that target are investigated (Ling & Yen, 2001).

In the stage of planning, marketing experts design strategies to approach and propose value to the targeted customers. Planning does not hinge on technology that much and is more creative than quantitative (Ling & Yen, 2001).

In the implementation stage, companies apply their knowledge about customers to approach them. They should interact with their customers in an effective way by launching marketing campaigns and customer management strategies. In the review phase, companies should collect feedback from customers after implementation of each stage. They should gather quality data, then analyse it to improve the whole process (Ling & Yen, 2001).

One of the problems that companies face is that their IT systems are designed for processes dealing with products and not with customers. Therefore, the data related to customers is spread across different product databases. To solve this problem, the databases should be designed in such a way that customer data is stored in specific data warehouses, and is processed only one time for all products and services related to the customer. In addition, customers should set the time and method of communication. Furthermore, customers that bring higher revenue to the firm, should be dealt with an exceptional level of service (Ling & Yen, 2001).

All the interactions between customers and suppliers should be retained and the communication should be easy. To achieve these two goals the firms must be provided with advanced infrastructure to build a powerful database of the behaviour of customers. The next step is taking advantage of the information about customers. The knowledge should be used to inform all the knowledge workers so that they can make better decisions. The new database that is oriented towards business partners must be efficient. Besides such databases should have plenty of flexibility to be able to handle launching new products in reasonable time (Ling & Yen, 2001).

An essential element in inter-firm relationships is collaborative communication that can be analysed considering different aspects such as frequency, bidirectionality, formality and content of influence attempts. Maintaining these aspects and emphasizing common interests and goals generate the feeling of respect, support and conformity (Mohr et al., 1996).

When the level of integration is significant, business partners yield some part of their independence and make decisions in collaboration with their trading allies. Moreover, collaborative communication helps to promote mutual support, values and interests that can raise coordination, satisfaction and commitment (Mohr et al., 1996).

Handling a supply network requires an effective management framework and maintaining relationships with participants (Nevin, 1995). According to Mohr et al. (1996), there are two management strategies to organize the supply chains. They are integration and control.

According to Brown (1981), supply chains can have three degrees of integration. In the first level, there is no integration. Companies in such chains make market-driven decisions independently. In the second level, companies' relationships depend on contracts between parties. Franchise agreement is an example of such integrations, in which the terms of contract determines the level of decision making that has been surrendered from franchisee to franchisor. The third degree of integration has the greatest intensity of integration in which a company is owned by another.

When a firm has control over the other one, it has affected its activities and processes with the aim of fulfilling objectives (Skinner & Guiltinan, 1985). According to Gaski (1984), power is the ability of one company to affect the other one. On the other hand, control is the consequence of power and can be seen when a company is successful in correcting other's activities and processes.

As Mohr et al. (1996) stated, the controlled company has surrendered some part of its independence in decision making. Therefore, it will have limited possibilities to perform its own strategies and processed.

2.4 Important Factors for Agility of Pharmaceutical Supply Chains

As discussed earlier integration of supply chains has several benefits, such as increasing flexibility, profit margins, and decreasing the wastes. According to Yusuf et al. (2003), data exchange and resource sharing is the key element of integration between different stages of supply chains. They have identified four dimensions of practices needed for supply chain integration. This include:

- Co-operative alliances with competitors
- Long-term collaboration with customers and suppliers
- Sharing the core resources with other companies
- Computer-based data integration with other companies.

Yusuf et al. (2003) has also categorized the agile supply chain practices into below four subsets:

- Customer sensitivity
- Network integration
- Process integration
- Virtual integration

According to Faisal et al. (2006), customer sensitivity is a characteristic that enables the firms to understand their targeted markets and customers better. Customer sensitive supply chains also helps reduce the delivery times and quick responses to changes in order quantity (Yusuf et al., 2003). In traditional approach of supply chain management, most of the inventory is finished goods stored to be sold. On the other hand, customer sensitive approach deals with work in progress inventory waiting for manufacture based on information gathered from customer. That is how customer sensitive supply chains adjust the final product with customer ever-changing needs (Hsieh & Chen, 2005).

Lin et al. (2006) has mentioned fast introduction of new products as well as retaining and growing customer relationships, as important factors affecting customer sensitivity. Christopher et al. (2004) has also defined the necessity of customer wise measures to quickly recognize the changes in customer needs.

According to Bosona & Gebresenbet (2011), supply network integration can make improvements in reaching potential markets, logistics efficiency, environmental issues and products quality. The literature implies that integrated supply networks has following benefits:

- Creation of coordinated transport of products and reducing the transportation distance and time; (Ljungberg, 2006)
- Expansion of markets for producers; (Jones et al., 2004)
- Reduction of cost and increase in competitiveness; (Sandberg, 2007)
- Encouraging the exchange of knowledge and information; (Saltmarsh & Wakeman, 2004)

Supply network integration necessitates that the companies in a supply chain have a shared identity, which means having commitment to agile practices, compatible organizational structure, integration of information systems and sharing competences (Yusuf et al., 2003). When network integration is done properly, producers, distributors and retailers would be able to work together with trust and mutual support to share

business information to be competitive and maintain sustainable growth (Bosona & Gebresenbet, 2011).

According to Chen et al. (2009), connectivity and simplification are most important basic factors in process integration. Porter (1980) has mentioned the significance of seamless and connected business processes in achieving overall organizational objectives. Lambert et al. (2005) have considered the connectivity as key element of integration of processes in both intra-company and inter-company context. They state that connectivity; provide the seamless flow of transactions between functional sections. Connectivity also helps to develop relationships between different companies.

As per Gunasekaran & Ngai (2004), developing an IT-integrated SCM has challenges as follows:

- Lack of integration between IT model and business model.
- Inappropriate strategic planning
- Lack of proper IT infrastructure
- Improper application of IT in supply chain management process
- Insufficient knowledge of IT implementation

Hooft & Stegwee (2001) state that fully utilization of capabilities of Internet technology is an essential initiative for setting up an e-business. They also claim that physical processes may have to be redesigned to better align the integrated supply chain. Then, physical processes and e-business applications should be integrated to achieve maximum results.

According to Mehralian et al. (2015), contributing factors of agile supply chains can be categorized into agile supply factors, agile manufacturing factors and agile distribution factors. Market research and monitoring (Baramichai et al., 2007) as well as forecasting of alternative suppliers (Tseng & Lin, 2011) are contributing factors for market segmentation dimension. Baramichai et al. (2007) have also mentioned setting standards for quality and cost as well as the updating the list of prequalified suppliers according to the standards, as remarkable factors for prioritizing the suppliers.

Exploiting IT tools is another agile boosting factor in dealing with supplier. For instance, efficient application of E-commerce technologies (Baramichai et al., 2007), electronic biding (Gunasekaran et al., 2008) and radio frequency identification (Agarwal et al., 2007) can be applied for detecting qualified suppliers. Integrating the processes between suppliers and clients can be achieved by collaborative inventory management

and product design (Agarwal et al., 2007; Christopher, 2000). Such integrations can result in improved responsiveness rate and reliable delivery.

Tseng & Lin (2011) has emphasized the importance of developing trust-based relationships with suppliers. They have also highlighted that reliability and responsibility can help to build trust and maintain a long-term relationship between business partners. Sharifi & Zhang (1999) explained how environmental factors including political, economic and social factors could affect the agility of supplying process. They emphasized the importance that business decision makers consider these factors and make decisions that can minimize the impact of these factors on business.

In order to achieve an agile supply chain, agile factors should also be applied in manufacturing level. To do so, employee empowerment activities is necessary. This include educating programs (Breu et al., 2001) and promotion of creativity and innovation (Gunasekaran et al., 2008). Second important dimension for agile manufacturing is efficient application of information technology and systems. The factors affecting this dimension would be developing IT skills (Agarwal et al., 2007), information sharing and E-commerce (Swafford et al., 2008; Tseng & Lin, 2011).

An agile manufacturer should be market sensitive as well. Therefore, product designers should take customer-oriented approach (Christopher, 2000), get regular customer feedback (Agarwal et al., 2007), manage relationships with customers (Lin et al., 2006) and monitor the changes in market behavior (Tseng & Lin, 2011). In addition, a firm's ability to respond quickly to the requirements of new products affects its agility. According to Swafford (2003), new products should be introduced as soon as possible. Moreover, technological innovations should be monitored and proper ones be applied in manufacturing processes (Braunscheidel, 2005).

The manufactured product should be delivered to customer on right time and place. Therefore, delivery speed is a remarkable dimension in terms of timeliness of delivery (Sharifi & Zhang, 1999) and delivery reliability (Antonio et al., 2007). In addition, cost reduction is a fundamental aspect of profitability. Inventory management techniques can help to calculate optimum order quantity and time to achieve minimum inventory cost (Antonio et al., 2007). Moreover, according to Tseng & Lin (2011), by reducing the machine tools' set up time production cost can be reduced.

Flexibility is the key characteristic of agile systems (Mehralian et al., 2015). Swafford (2003) has emphasized the prerequisites of supply flexibility while Braunscheidel (2005) has mentioned the manufacturing flexibility aspect. Just as discussed in supply agility,

environmental pressure including political, economic and social factors can also affect the agility of manufacturing level.

Agile factors should be applied in distribution echelon too. Similar to what have been discussed about supply and manufacturing, information technology is applicable for distribution activities (Qureshi et al., 2008). The flexibility dimension can be applied in distribution phase by flexibility in warehouse allocation (Tseng & Lin, 2011). Flexibility in delivery (Agarwal et al., 2007) and using flexible equipment (Swafford et al., 2008). The distribution centers should always get feedback from customers (Agarwal et al., 2007). They should also have an estimation about possible contingencies and be prepared for it (Qureshi et al., 2008). Considering the fact that all the businesses should be efficient at the end, inventory cost as well as the transportation and delivery cost should be minimized (Patil, 2006).

Yeung (2008) has mentioned the importance of taking customer complaint into account for measuring the customer satisfaction. Moreover, according to Qureshi et al. (2008), appropriate geographical distribution range can help to long-term customer relationship.

In addition to the general agility dimensions mentioned above, cold supply chains have complexities that require the managers to consider extra criteria. Shashi et al. (2016) has mentioned some criteria for supplier selection in cold food chains some of which can be used to achieve agility. This include cold warehouses and vehicles, order fulfillment capacity, variety, credit-based sales, risk management, supply chain continuity, reverse logistics and lighter packaging. Shashi et al. (2016) has also mentioned some dynamic activities for cold chain managers to reach agility such as regular meetings, knowledge sharing, transparency, partner training and joint development of products.

According to Mehralian et al. (2015), important aspects of agility are responsiveness, speed, flexibility and quality that are essential for companies to survive in today's competitive business market. Therefore, companies need to be able to forecast changes in market conditions and have enough flexibility and responsiveness to adapt their processes to new circumstances.

The emphasis of supply chain management has been amended from competent production to customer-based and integration strategies that require effective cooperation between business counterparties (Mehralian et al., 2015). To handle these changes supply chains should take advantage of agility factors to gain flexibility and responsiveness needed for sustaining in the competition (Mehralian et al., 2015).

At this point all the agility factors that is discussed in the literature are summarized in below table:

Table 2. *SC agility factors in previous literature*

1. Employee training and knowledge sharing
2. Lighter packaging
3. Process flexibility and integration
4. Transparency and trust development
5. Assessment and prioritizing of suppliers
6. Reliability of cold warehouses and vehicles
7. Market research
8. Risk management
9. Credit based sales
10. Integration of Information Systems
11. Sharing competences
12. Order fulfilment capacity
13. Delivery speed
14. Proposing measures for customer satisfaction and product quality
15. Expanding and keeping customer relationships
16. Product variety
17. Seamless flow of transactions between functional sections
18. Joint production and inventory planning
19. Regular meetings with clients and suppliers
20. Commitment of different business partners to agile practices
21. Customer wise measures to quickly recognize the changes in customer expectations and needs
22. Maximum utilisation of capabilities of Internet technology
23. Flexible organisational structure
24. Joint cost reduction programs
25. Joint development of products
26. Considering environmental pressure in decision making
27. Fast introduction of new products
28. Efficient utilization of IT tools

The previous researches provide a helpful and worthy basis for pharmaceutical supply chains agility; however, when a thorough investigation is done on the literature, some imperfections and research gaps are revealed. Firstly, in previous studies, the agility factors are categorized into three groups of suppliers, manufacturers and distribution companies. The problem of such categorization is that in today's complex supply networks, one firm can be a supplier of one supply chain, and the manufacturer for another supply chain, or even a distributor for third supply chain. Therefore, a comprehensive categorization of agility factors that can be applied in all companies

regardless of their role in pharmaceutical supply chain can be a significant contribution that is the main focus of this thesis.

Second shortcoming of the literature is that each study considers some of the agility factors and there is a lack of research that mention all of them together. This thesis tries to cover all the agility factors in previous literature.

As will be discussed in section 4.2, there are twelve barriers for having effective cold chains including pharmaceutical supply chains. The agility factors that have been mentioned in the literature can overcome seven of them, which will be discussed with details in the chapter of conclusion and discussion. However, there is no agility factor in the literature addressing below barriers:

- Absence of appropriate system for evaluating quality and hygienic conditions of products.
- Having excessive numbers of nodes in the supply chain.
- Lacking standardization of processes, packaging, temperature, IT systems, logistics, etc.
- Lack of quick responsiveness to changes of regulations.
- Ignoring the infrastructure for location of nodes and paths in the stage of designing the supply chains.

In chapter 5, conclusion, a thorough analysis about agility factors that can help companies overcome above-mentioned barriers, is given.

3. RESEARCH METHODOLOGY

According to Saunders et al. (2009), the methodology of any research that is carefully designed has six layers. They are:

- Philosophies
- Approaches
- Methods
- Strategies
- Time horizons
- Techniques and procedures

Pharmaceutical companies need to have enough agility to sustain in dynamic markets. To handle this challenge, this thesis has been done to identify important agility factors in pharmaceutical supply chains. Therefore, the philosophy of this thesis is pragmatism, since it tries to solve problems of real organisations.

According to Saunders et al. (2009), researches can have three approaches for reasoning. They are deductive logic, inductive logic and abductive logic. In inductive logic, the conclusion is based on observations. Therefore, the validity of the conclusion is probable rather than certain, because it depends on the amount of observations. On the contrary, in deductive reasoning, the conclusion is certain. In fact, the conclusion is logically connected with two or more premises, and if the premises are true, then a certain logical conclusion is made.

In abduction approach, based on some observations a possible explanation is logically inferred. Unlike deductive logic, this approach does not guarantee the certainty of the conclusion. Since the reasoning and conclusion in this thesis is based on a limited number of observations from literature, the approach of it is a combination of inductive and abductive reasoning.

The research method of this thesis is qualitative. It contains analysis of literature and online interviews and subjective reasoning about problems and solutions. The main question that this thesis is trying to answer is: which agility factors can be applied to improve the responsiveness and agility of pharmaceutical supply chains. The research strategy to answer this question is case study. In other words, an extensive investigation

over the problems and challenges of pharmaceutical companies is made and then agility factors to solve these issues is proposed.

The time horizon of this study is cross-sectional. That is, collection and analysis of data is done in a short period of time. Moreover, the research technique used in this thesis is desk research. In other words, secondary data that have been gathered or generated by others is applied to analyse the agility factors in pharmaceutical supply chains. To do so, the difficulties and issues of pharmaceutical companies have been studied in literature and then it is discussed how and which agility factors can help to surmount the difficulties.

The desk research process started by searching the key words of problems of cold supply chains, pharmaceutical supply chains and agility in supply chains. Then various related articles with relevant information was found. In this stage, distinguishing the relevant information that can be used for solving the problem is challenging. In the final phase of this research, the collected information is analysed to solve the research problem.

4. THE CASE INDUSTRY

4.1 Cold Chain

Most of the pharmaceutical products should be stored and transported in certain temperature range and humidity condition to maintain their quality. Therefore, cold chain management techniques and strategies are crucial parts of the pharmaceutical supply chain. (Bishara, 2006).

According to Bishara (2006), %36 of important defections in pharmaceutical products is pertinent to the handling of retention and freighting temperature. Bishara mentioned critical logistic issues that include: controlling vehicles and their location, recording and monitoring temperature data, checking equipment such as transportation containers and cooling or heating devices, managing transportation contracts, training of logistics staff including drivers and warehouse workers, calibrating the temperature measurement instruments, sampling of goods for statistical analysis and interpretation, control of humidity, light, sanitation and waste disposal.

In addition to storage and transportation concerns, Bishara (2006) has emphasized the quality management system (QMS) to handle the cold chain issues. Remarkable QMS factors might include: responsibilities, business processes, knowledge workers, change management, timing and precision of product deliveries, continuous improvement and getting feedback from customers and measuring their satisfaction.

According to Montanari (2008), managing the temperature and time is a crucial concern in cold supply chain management, and companies need to invest in infrastructure and information technology to develop the required facilities for transportation and storage of pharmaceutical and cold food products.

Producers, distributors, retailers and final consumers of cold products should have integration to work effectively and efficiently. To obtain this cohesion, logistic operations such as loading, offloading, transportation and warehousing play a significant role (Montanari, 2008).

Different firms of cold chains need offloading, loading and storage that can cause possible challenges arise out of cargo magnitude, dependability of logistics tools and instruments, changes in ownership of shipments, hygiene regulations, shelf life and temperature or humidity conditions (Montanari, 2008).

Detecting the important factors influencing the quality of cold products and quantifying their interconnection by mathematical modelling can help managers control the quality and decaying of cold products (Montanari, 2008).

Another important parameter in handling cold chains is traceability, which means the ability of companies to trace the transaction history (Billiard, 2003). According to Moe (1998), the word traceability can be applied in four different environments as follows:

- Product
- Data
- IT
- Calibration

Product traceability considers raw materials, production records and products, location after distribution. It deals with physical properties like packing, weight and volume as well as mechanical characteristics and the life cycle. The bill of material (BOM) that contains information about parts and materials used in the production process can help to trace products (Montanari, 2008).

Data traceability is about tracking the data created in business processes (Moe, 1998). It deals with issues like data type, privacy level and so forth. Recently, continuous controls and automatic alerts have been embedded in many applications (Montanari, 2008).

Information technology (IT) traceability considers the IT infrastructure required to support the business processes in firms. The IT system should have the ability to record and store product related information. This include product life cycle, production processes, times of activities, equipment and their characteristics (Montanari, 2008).

Calibration traceability is about measuring tools and their adjustment according to universal standards. In actual situations, various techniques can be applied to develop a calibration traceability system, such as bar code or radio frequency identification (RFID). As Montanari (2008) discussed, choosing the traceability tool depends on:

- Level of compatibility
- Level of automation in business processes of cold supply chain
- Data accuracy and cost

According to Montanari (2008), traceability systems can validate the quality of cold chain products which provide the capability for decision makers to trace the root cause of errors.

Applying traceability systems and methods might require large funds, but benefits outweigh it. It can bring process efficiency in transportation and marketing. However, the traceability system should have some characteristics to be effectively implemented. According to Montanary (2008), they should apply proper identification methodologies such as bar code. However, the problem is that in bar code technology, the reading process is done manually. RFID technology addresses these constraints in which there is completely automated identification without manual interfering. In addition, RFID allows simultaneous identification of several items with higher reliability and precision in comparison with the bar code.

Montanari (2008) has developed a managerial framework for handling cold chains. At the beginning, he identified the constraints and needs of the systems which are data tracing and controlling the humidity and temperature. He proposed that humidity and temperature should be monitored at some levels of supply chain such as storage. On the other hand, the product tracing should be done at all levels. However, his work can be much improved applying agile management concepts and frameworks that have been emphasized in this research.

A cold chain is a supply chain of decaying products including agricultural, dairy, food, chemical and pharmaceutical products. In a cold chain, such products are protected from inappropriate circumstances of temperature, light, contaminants or humidity to lengthen their shelf life (Joshi et al., 2009).

In cold chain products, the likelihood of deterioration exists from production phase to the final consumption, whereas there is no decaying in the transportation and storage of other chains. That is why management of cold chains differs from other supply chains (Joshi et al., 2009).

According to Joshi et al. (2009), cold chains involve thermally responsive goods while other supply chains deal with products that do not degrade in normal temperature. Moreover, as stated by Fearne et al. (2006), in normal supply chains the decision-making team analyse data and information about location (e.g. warehouse, road) and transaction (e.g. ordering, payment), while in cold chains, in addition to transaction and location, time and condition should be considered.

As Joshi et al. (2009) argued, vehicles used in transaction of cold chain items should have certain features to keep required temperature and humidity while in other chains there is no such a need that result in less logistics expenditure.

Furthermore, storing cold chain products necessitates the warehouses to maintain the cooling system always on while in other supply chains cooling system is not needed that give rise to costs. On the other hand, as stated by Mannina et al. (2006), in other supply chains different goods can be stored and transported in same space, while in cold chains different products should be kept in various temperature ranges. Therefore, different cold items cannot be stored and transported in same container.

Another difference between cold chains and other supply chains is stated by Ovca & Jevsnik (2008). When products of cold chains are delivered to customers, they should also take care of temperature and other conditions while in other chains customers do not need to have such concerns.

According to Montanari (2008), the structure of an ordinary cold chain usually includes cooling equipment, cold warehouses, cooling containers for transportation, packaging, traceability, retailers and consumers, all of which are managed with the aid of information systems.

According to Joshi et al. (2009), different levels of supply chains including producers, distributors, retailers and final consumers need to have integration to be able to compete effectively. They also stated that to avoid losses the cold chains should be managed efficiently.

There are several factors discussed in literature that affect the integration and efficiency of supply chains. Fearne & hughes (2000) identified improving cost control system and innovation as success factors for cold chains. Jahre & Hatteland (2004) have emphasized normalization of packaging and distribution processes as key factors for improving the integrity and efficiency of supply chains. To improve the traceability capability Montanari (2008) has suggested investment in IT infrastructure. Since there is deterioration in cold chains, it is important to maintain a balance between supply and demand to avoid shortage or surplus (Fearne et al., 2006). Therefore, monitoring the demand and adjusting the production amount to it can enhance the customer service (Dunne, 2008). Hsu et al. (2007) have highlighted inventory control techniques and following an appropriate return policy of decaying products for improving cold chain management. In the literature of cold chain management discussed above, the importance of agility factors has not been considered that will be discussed in more detail in the next chapter.

As discussed earlier, cold chain management, if applied properly, can ensure the quality of perishable products for end consumers, and one of the most important aspects of handling cold chains is temperature monitoring and control. In order to manage the temperature or other environmental factors such as humidity and brightness, firms need to collect and store relevant data in comprehensive databases. Such databases should incorporate data and information about different stages of cold supply chains, including producers, distributors, retailers and final consumers that can be exploited in descriptive and predictive data analysis to make managerial decisions (Gogou et al., 2015).

After the production of perishable goods, efficient management of their storage and transportation can contribute to the better estimation of expiration dates. This is especially important for cold chains since an estimation of the shelf life that is too high can result in impairing the quality of perishable products. On the other hand, a too low approximation of shelf life can bring about high rates of increase in waste (Gustavsson et al., 2011). In addition to the shelf life, information about temperature situations can also be applied to assess the possible risks and quality of perishable products when they reach the final consumer (Gogou et al., 2015).

In the real world, there are noticeable contrasts between planned and actual temperature conditions. Therefore, temperature variation should be considered in management and monitoring of cold chains (Gogou et al., 2015). By applying agility concepts and factors in the management of cold chains, decision making team can devise practical plans to respond quickly and effectively to these deviations.

Gogou et al. (2015) have developed a systematic method for collecting and storage of data. The proposed database can be used to pinpoint the weak nodes of cold chains for analysing their problems and finding solutions for them. They designed a web-based platform for collection and storage of data. The stored data can be exploited to develop simulation models for actual scenarios of cold chains and can aid managers in taking remedial steps to increase efficiency and shelf life. By field testing the required data for the cold chain database can be gathered.

In addition to the database, Gogou et al. (2015) have also developed a software for evaluating the collected data and making descriptive and predictive analysis out of it. This analysis is applied to predict the temperature condition in different stages of supply chain as well as predicting the remaining shelf life of goods in each stage.

The expiry date and perishability of products of cold supply chains make their management more complicated. One of the most important parameters for holding decaying products and increasing their shelf life is temperature management (Aung &

Chang, 2014). Perishable products such as foods and pharmaceutical products, should be in environments with controlled temperature, light and humidity, whether they are in production phase, warehousing, transportation or retailing. In the literature, this is called “cold chain management” (Aung & Chang, 2014).

According to Aung & Chang (2014), appropriate temperature management needs precise monitoring of cooling facilities as well as containers and warehouses. Cold chains are complicated and dynamic. Because of technological advances, operations and processes are being more complex constantly. Customer needs and expectations change frequently and new regulations every now and then force them to adapt their business processes. Such problems require agility methods and factors to be applied to deal with uncertainties. In addition, agile chains can also help to temperature control and timing of business processes (Montanari, 2008). For instance, chains that adopted agility factors effectively, can react sooner to a damaged cooling machine.

In addition to the temperature management and control, decayable products themselves should be continuously controlled for their quality at different stages of a cold chain (Aung & Cheng, 2014). Controlling of the supply chain necessitates visibility and traceability of products and processes. Real time data and information sharing between different nodes of supply chains helps to achieve this goal. Therefore, applying technologies like sensors, RFID, wireless networks in addition to advanced datamining and analytical software can help decision makers handle complex problems (Terreri, 2009).

Temperature monitoring and control, if applied properly, can delay the expiration date of cold products. To ensure the best quality, cold products should be kept in their optimum temperature just after their production (Aung & Cheng, 2014). To achieve this goal, business processes should be designed to allow such preservation methods. Moreover, cold chains should have enough agility to react quickly to changes in temperature requirements.

In practice, different products need different temperature and other warehousing conditions (Aung & Cheng, 2014). Product diversity and multifarious needs in temperature, brightness and humidity make the management of cold chains extremely complicated. Therefore, the first step in designing cold supply chains is recognizing the characteristics and logistical requirements of products involved in the cold chain (Aung & Cheng, 2014).

Both excessive cooling or warming can damage the quality and durability of cold goods. According to Aung & Cheng (2014), a large portion of warehousing cost of

perishable products can be attributed to the reduction of quality over time. Aung & Cheng also stated that the larger the difference between actual warehousing temperature and optimal temperature, the higher the costs of impaired quality. Preventive or corrective actions to discover and resolve temperature deviations can be achieved through concepts of agile supply chains applied in cold chains.

To conserve the cold products, facilities like containers with cooling systems or large refrigerators are needed. Nevertheless, diversity of products and their various needs of environmental conditions, make it difficult and complex to properly assign the products to facilities. In real world, most of the repositories have limited space available for cold products, and they cannot provide the specific temperature conditions for each type of product (Aung & Cheng, 2014).

According to Olsson (2004), transportation with distinct containers is only feasible for delivering goods to big retailers, whereas for small retailers, delivery can be done in mixed batches. In other words, goods with different environmental needs are conveyed in shared containers to make the best use of container capacity and avoiding delays in delivery. As Olsson (2004) stated, new technologies such as containers with zones of various temperature can be applied to handle the situation. These kinds of vehicles are equipped with dividing walls and cooling systems with thermal regulators that can increase the transportation costs significantly.

According to Aung & Cheng (2014), vehicles that can provide only one temperature can be utilised to carry and store products that have limited range of storage temperature requirements. This results in several deliveries to handle the transportation of different product segments which is not efficient. In practice, to decide about which type of vehicle to use, managers should consider the constraints and calculate the costs of both methods and find the optimum solution.

As Martin & Ronan (2000) argued, transportation or warehousing of different products in common containers can be detrimental to their quality or shelf life since many products are not adaptable to such conditions. This include being affected by the cooling process, smell or colour changes because of cross-contaminations.

According to Aung & Cheng (2014), warehouses for multiple cold products should have several compartments to be able to keep different product groups with various storing needs in terms of temperature, humidity, brightness, exposure to odour or gases. Aung & Cheng also state that efficiency in the storage of cold products depends on optimal use of space, air conditioning and a proper inventory turnover to avoid long time storing of perishable products.

On the other hand, designing equipment for preservation of different cold products depend on their duration of storage, transportation and warehousing methods and packaging (Aung & Cheng, 2014). According to Ashby (2006), trucks with several temperature compartments usually have three separate rooms with the below temperature ranges:

***Table 3**. Temperature levels for different cold product groups*

Temperature Range	Cold Product Groups
Below -18°C	Frozen products
Around 2°C	Chilled products
Around 13°C	Chill-sensitive products

4.2 Pharmaceutical Supply Chains

According to Shah (2004), little part of the researches about scientific management techniques, such as optimisation, have been applied in pharmaceutical industry. Shah also stated that when designing the pharmaceutical supply chains, a significant challenge is matching forthcoming capacity with predicted demand. Market conditions like governmental regulations and competitors' performance make predictions about future market demand extremely difficult. Forecasting the market demand also affect the workload of facilities and employees and investments in growth and infrastructure. To address such challenges in pharmaceutical supply chains applying agility factors can help a lot which is the contribution of this thesis. In addition to workload decisions, product management plays a crucial role in making decisions about choosing products to develop and development process. By developing agile pharmaceutical supply chains, firms can acquire needed responsiveness to changes in market needs in terms of quick product adaptation and development.

As per Shah (2004), a pharmaceutical supply chain is consisted of processes and firms concerned with new medications' discovery and manufacturing. According to a definition offered by World Health Organisation (WHO), drugs or pharmaceutical products are substances that are produced to restore or modify the organic functions with the aim of prevention, diagnosis, mitigation or treatment of diseases.

According to Shah (2004), important players in pharmaceutical supply chains are as follows:

- Multinational research and development organisations with a lot of manufacturing sites in different locations.
- Large generic manufacturing organisations that have their own brands.
- Local manufacturers that produce under licence.
- Manufacturers that produce intermediates or ingredients.
- New start-ups trying to discover new pharmaceutical products.

According to Shah (2004), there used to be a good efficiency of research and development (R&D) in pharmaceutical industry to produce new medicines. These medicines could be used for long periods and there were technological and legislative entry barriers for other firms. Therefore, firms could invest a substantial part of their sales in R&D.

Shah (2004), also argued that in recent years R&D productivity is lowering, the duration that drugs can be used in the market is shortening and other companies can enter the market and produce the same medicines more easily. In addition, newly discovered medicines can be replaced by other products and new products should have substantial benefits in terms of both price and power. Therefore, a more systematic analysis is required for addressing these issues in terms of agility factors to help the firms respond quickly to the changes.

Moreover, in today's market conditions, there is a tough competition and governmental regulations. According to Shah (2004), governments place tighter constraints on the prices of new medicines and encourage the use of generic medicines wherever possible. Furthermore, according to Butler (2002), many large pharmaceutical companies, are dependent on their previous successful products and they cannot adapt their processes to new market trends. This is where agility factors can contribute so much to help the companies change their routines and processes as soon as possible.

According to Shah (2004), launching time of new medicines is the most important factor for successful business in pharmaceutical industry. In the beginning stages of selling new products to the market, the competition is not intense, therefore companies can make substantial profits. After some years, companies have to handle competition with similar products and then, the same products. To tackle with this problem designing an agile supply chain can play an important role.

Since there is always a significant risk of side-effects for new medicines, governments usually impose strict regulations. These regulations deal with evaluation of safety of ingredients as well as manufacturing operations. The main regulator of pharmaceutical

products in Finland is Finnish Medicines Agency (FIMEA). There are many cases that governmental regulations restrained launching new products that affect the responsiveness of pharmaceutical companies to new market demands (Shah, 2004). Therefore, one of the most important agility factors that has not been mentioned in the literature of supply chain agility, is consistent check of changes in regulatory rules and developing new products accordingly.

The auditing process by regulators, takes a lot of time and cost that should be considered by pharmaceutical companies. Moreover, complex processes needed to produce chemical substances, and activities for process modification and capacity adjustment make market responsiveness of pharmaceutical companies extremely difficult and time-consuming. According to a survey by Grabowski (1997), 200-400 million pounds of money and 8-12 years of time is needed to launch a new pharmaceutical product. These figures indicate that investment in applying agility factors to pharmaceutical companies can be beneficial for reducing the time and costs of the development of new products.

According to Booth (1999), large pharmaceutical companies tend to relinquish their manufacturing activities to local companies, and be a part of an international supply chain. Management of such supply chains is so complicated with high logistics costs. On the other hand, according to Ballance et al. (1992), reward to cost's ratio of R&D is decreasing. Thus, the cost of discovering new medicines is rising. To handle these issues there have been lots of mergers and acquisitions in pharmaceutical supply chains that result in improvement in R&D activities. From what have been discussed, it can be concluded that agility factors that deal with integration of different firms in pharmaceutical supply chains is the most urgent priority.

As argued by Shah (2004), previously in pharmaceutical supply chains, the main focus of management was on the discovery of new medicines and sales and marketing, but recently the main focus is on optimisation of integrated supply chain and value creation for all parties. This is another support for the idea of this research that in applying agility factors on pharmaceutical supply chains, factors that are related to the integration of different levels, should be given the highest priority.

According to Shah (2004), life-cycle of pharmaceutical products differ slightly from other products. In the discovery stage, thousands of compounds are randomly tested to find their remedial capabilities. It usually takes a long time, about 10 years, to discover a potential new medicine. Then this potential medicine should pass the efficacy and safety tests. At the stage of safety tests, toxicology studies are done on new drugs. For efficacy

tests, the ability of the drugs to cure the illness and relieve the symptoms is evaluated. After passing tests successfully, pharmaceutical companies involve in process development that took about 6-8 years to achieve an optimum chemical process to produce the dugs in large scales. At the end of the cycle, there are the activities of manufacturing and distribution.

Shah (2004), stated that pharmaceutical supply chains usually consist of all or some of below nodes:

- Primary manufacturers
- Secondary manufacturers
- Warehouses
- Distribution sites
- Wholesalers
- Retailers
- Hospitals

Primary manufacturers produce active ingredients of medicines. In other words, they produce chemical compounds that are used to make complex molecules. They also do some processes such as fermentation or purification in biochemical processes. In primary manufacturers, the processes have long times and consisted of multiple stages with large amounts of inventories between them. Moreover, because of strict regulations, materials should pass several quality control tests to be used in the production processes of next stages. This increase the manufacturing time significantly. Therefore, agility factors should be applied in quality control activities to adapt quickly to new regulations and technology changes.

According to Shah (2004), in the traditional process of drug production, because of small amounts of production, equipment is exploited for multiple products to share and minimize the overall capital costs. There should not be any contamination transferred from the shift of production of one product to another. Thus, standard cleaning activities and machine adjustment transitions are needed which increase the waiting time between productions. In the manufacturing phase of pharmaceutical products, long waiting times result in big production batch sizes to avoid low utilization rates. For example, the need for one-year usage of a product should be produced in one batch and stored in warehouses until next year. It is obvious that this method of production decreases the responsiveness of pharmaceutical supply chains. Therefore, to increase the agility of

pharmaceutical supply chains, efficient methods for reducing the adjustment times should be applied in production nodes that have not been mentioned in the literature.

According to Shah (2004), previously, waiting times were several weeks, but recently, by applying methods like single-minute exchange of die (SMED) that was used originally in car industry, the waiting times have been slightly reduced. According to Moser et al. (2000), three efficient approaches to reduce set-up times are:

- Performing Single-Minute Exchange of Die (SMED)
- Visualizing set-up time
- Making early announcement of changeovers

Moser et al. (2000), argued that SMED method can be used to obtain huge decreases in set-up time. In SMED technique the set-up process is broken down into ordered small elements. The goal of SMED technique is doing largest possible number of elements in the times that the equipment is working. The second goal of SMED method is eliminating the rest of elements or doing them in parallel with other elements. The third objective in SMED technique is streamlining, that is to say, finding ways to do the elements faster.

According to Moser et al. (2000) SMED tasks have three phases:

- Separation
- Conversion
- Streamlining

In separation phase, elements are divided into smaller parts and then they are scheduled to be done in the times that equipment are working. In conversion phase, the elements are revised so that they can be done in the working time of devises or eliminate them from the processes. Finally, in streamlining stage, managers try to find solutions to perform the activities of elements in shorter times.

In practice, implementation of SMED techniques is complicated and can take a lot of time. According to Moser et al. (2000), an effective approach for applying SMED in supply chains is doing it as an iterative process. In this way, the SMED process is repeated several times. The target of each iteration can be reducing the set-up times, for example twenty percent.

Another approach for reducing the set-up time is visualizing the duration of adjustment. According to Moser et al. (2000), it happens many times that the operators and employees have no idea if they are doing a set-up in timely manner or they are behind the schedule. By visualizing the adjustment time, on manufacturing location the

actual set-up times is compared to the planned time. Thus, operators can adjust their pace to catch up with the schedule. For instance, a scoreboard can be installed in manufacturing site, displaying the target time, a countdown timer showing remainder of the time and overdue. Pharmaceutical companies can combine two strategies and use a time scoreboard for each element of the set-up process.

The third strategy for decreasing the set-up times is working early announcement of changeovers. According to Moser et al. (2000), there are many cases in manufacturing firms that operators, equipment or materials are not ready for set-ups on the planned time. Therefore, in this strategy, the information about the status of tasks completion can be used to alert the operators to start getting ready for a set-up session. The production process is broken down into small pieces. There are some indicators that display the overall activities of current task as well as the number of remaining activities. The percent of completion can be a good indicator for operators to prepare for new equipment adjustment.

When reviewing supply chain agility literature, it was realized that the importance of reducing the set-up times was not emphasized in the agility literature. Therefore, adding these techniques to agility factors of pharmaceutical supply chains can be beneficial.

Nowadays, outsourcing jobs to contractors is a growing tendency in supply chains. This trend brings some difficulties and simplicities to firms. According to Shah (2004), in pharmaceutical supply chains, R&D firms can focus on discovery of new drugs and outsource the manufacturing activities to those companies who have expertise and experience in manufacturing tasks. However, this can increase the problems of coordination between different nodes of supply chains. Therefore, the agility factors concerning the integration and coordination of nodes of supply chains is of great importance.

Another possible node of pharmaceutical supply chain is secondary manufacturers. According to Shah (2004), secondary manufacturers usually receive active ingredients from primary producers. Then, they add excipient materials and do some extra processes to manufacture the final products. For instance, processes needed to produce pills may include:

- Combination of active ingredients and excipient materials.
- Compressing the mixture and shaping the pills.
- Coating the pills.
- Controlling the quality

- Wrapping final products

The tax rate and real state prices vary in different areas. Considering these two factors along with the transportation costs, the locations of primary and secondary manufacturing sites are specified by optimisation techniques. The number of secondary manufacturers is usually higher than primary companies, and they serve regional markets. In other words, the majority of their products are delivered to local wholesalers while the remaining products are mostly delivered to hospitals in the region (Shah, 2004).

Details of processes may differ in various firms, however according to Shah (2004), significant pharmaceutical corporations go through the business processes that include:

- Market management
- Inventory and distribution planning
- Production planning

In market management, the market is divided into different segments according to their population's characteristics, requirements, interests or geographical locations. Then the demand for each segment is forecasted according to marketing data and mathematical models (Croxton et al., 2002).

Another process common in pharmaceutical companies is inventory planning and distribution management. According to Croxton et al. (2002), the estimated demand is used to calculate the raw material inventory order size and warehouse space dimensions. The next step would be planning and scheduling the production process. According to Shah (2004), the timing and quantity of production affect the inventory plan. Moreover, Shah (2004) also argued that in secondary production planning the estimates are based on orders, but in primary production, the plans are based on forecasts. Therefore, enough safety stocks of active ingredients should be stored to avoid shortages in production processes. Applying agility factors for all above-mentioned business processes can help the pharmaceutical companies handle the changes in market demand more effectively and rapidly.

According to Shah (2004), a big challenge in pharmaceutical supply chains can be decentralized decision making. If various nodes of supply chains do not have enough information about the objectives and constraints of other ones, the overall costs of the whole supply chain cannot be minimized. Consequently, integration of supply chains and agility factors addressing the integration of pharmaceutical chains is of great importance.

When designing pharmaceutical supply chains, couple of decisions should be made by panel of experts:

- Choosing the medicines for mass production and distribution
- Designing the manufacturing process
- Capacity estimation
- Choosing equipment

However, according to Shah (2004), expert team must deal with several problems. Firstly, they cannot rely on estimation of market demand for a long time. There is competition between different pharmaceutical companies and chances are that new drugs are launched to the market that will have negative impact on current drugs' demands. Secondly, in development of new medicines there are always some risks of failure in passing regulatory tests or being accepted by the market. Thirdly, in process development achieving the efficient and optimum is not usually reachable.

Moreover, uncertainties in demand rate and lead times and product life cycle, result in uncertainty in capacity planning that can lead to inventory shortage or overstock. The former can cause lost-sales and the latter will result in higher costs of storage. To handle all above-mentioned uncertainties, applying the agility factors in different nodes of pharmaceutical supply chains can contribute a lot, since it enables the companies react more quickly to changes in market conditions.

Joshi et al. (2009) have mentioned 12 barriers for effective cold chains. Firstly, inadequate knowledge of employees about how to use IT technologies can be a big challenge. Since, it is better for pharmaceutical supply chains to be managed in an integrated way. The personnel of different nodes should have enough knowledge that is required to do the business processes of entire supply chain.

Another problem mentioned by Fearne et al. (2006) is lack of appropriate cooperation between different nodes of supply chains. There should be a good coordination between different parties in various shared processes such as delivery timing.

Joshi et al. (2009), have emphasized the importance of job-related skills. In today's market, there is a rapid change in technology and customer expectations. Therefore, employees should update their job-related skills continuously. According to Joshi et al. (2009), cold warehouse managers, loading and offloading foremen and vehicle drivers should develop their knowledge and skills about latest equipment and IT technologies.

Another barrier for having effective cold chain is considerable expenses of equipment used for temperature control that increase the storage cost significantly. Energy costs should also be included when estimating the total costs. In addition to capital cost needed for cold chains, the expenses of installation, running and maintenance of equipment

should be added to total costs. When considering the total costs, managers may refuse to invest in cold warehouses and vehicles (Joshi et al., 2009).

Joshi et al. (2009) highlighted the necessity of having an appropriate system for evaluating hygienic conditions, quality and safety of products to ensure an efficient and effective cold chain. According to Amjadi (2005), such systems require calibrated equipment, optimized operations and appropriate information system.

The next barrier for achieving efficient cold chain is existence of excessive numbers of nodes in the supply chain. Too many dealers in the supply chain can increase the prices significantly (Joshi et al., 2009). On the other hand, Joshi et al. (2009) also highlighted that standardization of processes, packaging, temperature, IT systems, logistics, etc, can improve the efficiency of cold chains.

Governmental and non-governmental organizations may always make new regulations that can affect the performance and efficiency of supply chains negatively (Joshi et al., 2009). Therefore, when prioritizing agility factors in pharmaceutical supply chains, factors considering responsiveness to regulatory changes should be given a high priority.

Products should be tracked easily and effectively in different stages of supply chains. Lacking effective tracking system decrease the efficiency of supply chains and should be resolved by managers (Joshi et al., 2009). According to Montanari (2008), tracing determines the time, place and situation of products in different stages of supply chains. Joshi et al. (2009) also argued that lacking effective tracing system can result in inefficient inventory management that lead to shortage or overstock of products in different nodes of supply chains.

According to Joshi et al. (2009), inadequate infrastructure brings about problems in logistics and transportation. This include roadways and transportation vehicles as well as power and water supplies. Therefore, to achieve an agile supply chain, firms need to consider the infrastructure of the location of nodes and transportation paths.

Commitment of senior managerial staff is another important factor affecting the efficiency of supply chains. This is especially important for integration programs in which different firms share their resources to maximize the efficiency of whole supply chains (Joshi et al., 2009).

Furthermore, customers and final consumers play a substantial role in supply chains. This is because of the fact that buying decision is eventually made by them. If they decide to buy products with lower prices without considering their inferior quality, all the efforts of managers to achieve an efficient supply chain will be neutralized (Joshi et al., 2009).

5. CONCLUSIONS

5.1 Contributions of This Thesis

In section 2.4, a complete review of agility factors for cold chains in the literature is done. At this stage, a framework for evaluating the agility of pharmaceutical supply chains is outlined. There are two main contributions made by this study that diversify from other researches in the field of agility:

- New categorization of agility factors based on their purpose
- Adding new agility factors, which are specific in pharmaceutical supply chains

As discussed in section 2.4, most of previous studies, categorized the agility factors based on the role of the firms in the supply chain. In other words, some agility factors are offered for suppliers, some for manufacturers and some for distributors. The problem of such classification is that companies usually work in different supply chains. A company can play the role of supplier in some supply chains while it is a manufacturer in other chains.

Instead, in this study, the agility factors are grouped according to their target. Some agility factors aim to improve the integration of pharmaceutical supply chains. Some intend to boost the responsiveness of companies in new product development. There are also factors that are proposed to improve the storing and transportation conditions of pharmaceutical supply chains.

The importance of integration and flexible product design have already been discussed in this study. The reason for including the storing and transportation factors is that easy transfer of materials, parts and products can influence the whole supply chain in all nodes and stages. Companies can gain money and time with competent and effective logistics management. Additionally, they may be able to provide a better service for customers and increase their satisfaction. To achieve this goal, the flow of goods entering and exiting the firms, as well as inside them should be controlled and kept even and steady.

Efficient management of a company's logistics force employees to enhance delivery times and service to clients. Another advantage of logistics management is increasing the transparency of supply chains. At different stages and nodes of supply chains, there are a lot of things happening and managers should be aware of them. With a proper design of databases to keep the record of historical events and evaluating real-time

situations, managers of supply chains can perform a better descriptive and predictive analysis to handle the current problems and prevent the future problems. This indicates the importance of controlling and monitoring the supply chains.

In addition, with better transparency, it is more likely to find the bottlenecks and problems of supply chains. Solving these problems can promote their efficiency and lower the costs. On the other hand, by increasing the quality of service, firms' current customers do not go away and they can attract more customers to pay for their products and services. With improved productivity and agility, companies can respond to the increasing demand that can generate better revenue for them.

In section 4.2, twelve barriers of achieving effective cold chains, that was mentioned by Joshi et al. (2009), have been stated. They are:

1. Inadequate knowledge of employees about new technology
2. Lack of appropriate cooperation between different nodes of supply chains
3. Job-related skills of employees
4. Costs of energy and expenses of buying, installation and maintenance of temperature control equipment
5. Absence of an appropriate system for evaluating quality and hygienic conditions of products
6. Existence of excessive numbers of nodes in the supply chain
7. Lacking standardization of processes, packaging, temperature, IT systems, Logistics, etc.
8. Responsiveness to the changes of regulations.
9. Lacking effective tracking system.
10. Considering the infrastructure of location of nodes and paths.
11. Commitment of senior managerial staff in integration.
12. Consumers’ appreciation of quality.

For barriers 1 and 3 – Inadequate knowledge about new technologies and Lack of occupational skills – agility factor of Employee training and knowledge sharing can be applied to overcome the problem. For the barriers, Lack of cooperation between different partners, Transparency and Trust development as well as Regular meetings with clients and suppliers are two agility factors to address the issue.

The fourth barrier – Costs of energy and facilities – can be handled by the factor of Joint Cost Reduction Program. The ninth barrier – Lacking effective tracking system – can be overcome by Integration of information systems in addition to the Efficient utilization of IT tools. On the other hand, the eleventh barrier – Commitment of management – can be faced with Commitment of different business partners as well as sharing competences. Moreover, the twelfth barrier – Consumers' appreciation of quality, can be encountered by taking customer wise measures to recognize the changes in customers' expectations. Proposing measures for customer satisfaction and product quality can also be applied to overcome the twelfth barrier.

However, for barriers 5, 6, 7, 8 and 10, there are no agility factors in the literature. Therefore, this study proposes five new agility factors to the existing literature. This include:

1. Development of a standard and appropriate system for measuring and evaluation of quality and hygienic conditions of products.
2. Removing redundant firms in the supply chain.
3. Standardization of processes, packaging, temperature, IT systems, logistics, etc.
4. Systematic and continuous monitoring of regulations in pharmaceutical industry.
5. Considering the infrastructure of the location of nodes and paths in the design stage of supply chains.

The first and fourth factors, belong to the group of Product Design agility factors. The second and third factors can be members of the group of Supply Chain Integration factors. Finally, the fifth factor should be part of the group of Storing and Transportation factors.

Table 2 in section 2.4, displays the agility factors of supply chains in the previous literature. One of the most important aspects of SCM is logistics management. At this point, the agility factors are grouped in three subgroups of Storing and Transportation factors, Product Design factors and Integration factors. Additional agility factors that are the contribution of this research have also been included that can be seen in table 4. As discussed earlier, factors 16, 17, 26, 27 and 33 are the contribution of this research.

***Table 4**. Agility factors of pharmaceutical supply chains*

AGILITY FACTORS	
Group A.	**Supply Chain Integration Factors**
1. Flexible organisational structure	
2. Commitment of different business partners to agile practices	
3. Joint production and inventory planning	
4. Joint cost reduction programs	
5. Process flexibility and integration	
6. Seamless flow of transactions between functional sections	
7. Considering environmental pressure in decision making	
8. Assessment and prioritizing of suppliers	
9. Sharing competences	
10. Employee training and knowledge sharing	
11. Transparency and trust development	
12. Regular meetings with clients and suppliers	
13. Credit based sales	
14. Integration of information systems	
15. Efficient utilization of IT tools	
16. Removing redundant firms in the supply chain	
17. Standardization of processes, packaging, temperature, IT systems, logistics, etc.	
Group B.	**Product Design Factors**
18. Market research	
19. Expanding and keeping customer relationships	
20. Customer wise measures to quickly recognize the changes in customer expectations and needs	
21. Proposing measures for customer satisfaction and product quality	
22. Joint development of products	
23. Fast introduction of new products	
24. Maximum utilisation of capabilities of Internet technology	
25. Delivery speed	
26. A standard system for measuring quality and hygienic conditions of products	
27. Continuous monitoring of regulations in pharmaceutical industry	
Group C.	**Storing and Transportation Factors**
28. Reliability of cold warehouses and vehicles	
29. Order fulfilment capacity	
30. Product variety	
31. Risk management	
32. Lighter packaging	
33. Considering the infrastructure of the location of nodes and paths of supply chain	

5.2 Managerial Implications

Over recent years, SCM is getting a favourite topic in management literature. Globalization of business, tough competition and frequent changes in legislation have made the management of pharmaceutical supply chains extremely complicated. Therefore, to remain in the competition and increase profitability, pharmaceutical firms should know how to deal with changes effectively. Moreover, because of having access to the Internet and social networks, customers' needs and expectations change frequently and companies should be agile enough to respond to these changes quickly.

This thesis provides useful managerial implication that can be applied by decision makers in pharmaceutical supply chains. Firstly, it increases the insight of managers about agility of pharmaceutical supply chains and its importance. Secondly, the list of agility factors in table 4, is a sound basis for supply chain professionals to develop an agile supply chain.

5.3 Future Research

There are some limitations in the methodology of this research, that can be a possibility for future research. The desk research process can restrict the range of agility factors that are currently based only on previous literature. Future studies can be done with action research methodology. Distributing questionnaires to managers of pharmaceutical supply chains and asking them for important agility factors or prioritizing them can be a good approach for future studies.

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