Leanness and Agility: Connection or Contradiction?

"An Exploratory Study Concerning the Integration of Lean and Agile"

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PREFACE

This thesis is the final, vital part of the Master of Science programme Supply Chain Management at Tilburg University, faculty of Economics and Business Administration. The topic is chosen on the basis of the elicited interests in lean and agile during the master programme.

My special thanks go to my supervisors, Dr. A.J.A.M. (Fons) Naus and Dr. J.A.C. (Job) de Haan. The supervision and support they gave truly facilitated the progression of the research. The co-operation is indeed much appreciated.

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ABSTRACT

As it becomes increasingly apparent that the competitions are actually between the supply chains, rather than individual companies, it is assumed that efforts should be made to gain insights into supply chain approaches which attempt to establish a total integrated supply chain. In answer to this need, this study aims to find out how to justify the integration of the lean and agile concepts, such that the benefits of both concepts can be combined to improve supply chain management.

The comparisons between lean and agile showed that the concepts share similar attributes, but the emphases might have been put differently. While some authors argue that lean and agile cannot co-exist, others suggest that lean and agile are mutually supportive. In order to clarify the discussions concerning the compatibilities and complementarities between the concepts, certain theoretical insights are developed regarding the integration of the concepts, also known as the leagile concept. The existing literature suggests that the leagile concept can be adequate when neither lean nor agile is capable to deal with certain market conditions. Also, this study distinguishes the lean oriented leagility from agile oriented leagility to emphasize that the leagile concept is not one-size-fits-all. Through reviewing the case studies relating to the conceptual application of the leagile concept, interesting insights have been obtained. In addition, a light is shed on different leagile approaches such as the Pareto distribution, decoupling point, and base, surge demand, agile corporate structure combined with lean manufacturing, and agile development combined with lean manufacturing.

In order to assess the integration of lean and agile, five interviews have been conducted with practitioners from different disciplines. The findings are utilized to build a matrix (figure 4.2), which is presented in chapter 4. The matrix distinguishes lean, agile, lean oriented leagility and agile oriented leagility to achieve operational excellence, customer intimacy, product availability and product leadership respectively. It is proposed that these four concepts can be adequate for companies with either efficiency or responsiveness focus, operating in a market with demand uncertainty ranging from low to high.
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1. INTRODUCTION

Supply chains are complex networks, in which suppliers, manufacturers, distributors, retailers and customers are involved. Also, it becomes increasingly apparent that the competitions are actually between the supply chains, rather than individual companies (Christopher and Towill, 2001). In other words, the performance of the total supply chain is more than the summed performances of individual companies within a supply chain. In order to boost the total supply chain performance, numerous concepts and methods have been developed in the past decades. Lean and agile are probably among the ones that received most attention.

Ever since the pioneering work of Toyota in the lean production approach, it has been receiving extensive attention from both researchers and practitioners. Lean thinking emphasizes the importance of identifying value, eliminating waste and generating flow (Womack and Jones, 1996). However, in situations where the demand is unstable and customer requirement for variety is high, agile manufacturing takes a significant step further in the argument that responsiveness is the vital enabler in modern supply chains (Harrison and Van Hoek, 2005). In the past decades, both lean and agile concepts have achieved interesting developments, and the application of the concepts is yet extended to software development and accounting. However, there is a tendency that lean and agile are oftentimes viewed in isolation (Naylor et al., 1999). In other words, the view is that first there was a need to adopt the lean concept and subsequently the companies should strive to become agile (Naylor et al., 1999). This approach might not be the best way to view lean and agile, since researchers have been suggesting that the choices should be based on the requirements of the market (Naylor et al., 1999; Mason-Jones et al., 2000; Goldsby et al., 2006) Hence, it is crucial to take different variables, such as the order qualifiers and order winners into consideration, such that the chosen concept will seamlessly match the type of operation, product, customer and market.

Given the assumption that lean and agile both have their distinctive capabilities to cope with the supply chain requirements, which means neither concept is superior to the other, recent studies suggest the integration of lean and agile, also known as the leagile concept, so that the benefits of both concepts can be utilized in the same supply chain.
1.1 Problem Indication

Although many authors share the opinion that lean and agile should be integrated into the leagile concept in order to level up the supply chain performance, there is no consistent reasoning regarding the integration. It seems that the two concepts have been freely promoted without sufficient development of frameworks and thus creating risks for companies trying to adopt the concepts. The preferred integration could also be attributed to the popularity of hybrids, in situations of not being able to choose a single concept. Moreover, the conceptual applications of the integration are limited to the sub-sets of the total supply chain, such as virtual group (Prince and Kay, 2003), order decoupling points (Nalor et al., 1999), or offshore crisis (Stratton and Warburtin, 2003). Also, the generalizability as well as the applicability of the results are harmed by major limitations such as analyzed industries and used methods. Therefore, a significant gap between academic literature and practice regarding this topic still exists.

1.2 Problem Statement

As mentioned in the problem indication, the application of the leagile concept is still immature, and a comprehensive overview of the concept and its applications barely exists. The absence of such an overview hinders the development and application of the leagile concept, as the ambiguity regarding the integration of lean and agile still remains. Also, such an overview is necessary, since it can provide more insight into lean, agile and leagile concepts respectively and therefore reduce the uncertainty amongst practitioners such that the successfulness of the adoption can be improved.

The scope of this research is however limited to the conceptual application in supply chain operations. This is due to the fact that the lean, agile and leagile concepts originate from the supply chain literature, and the popularity in this domain is expected to extend to other domains such as accounting and software engineering. Based on the analyses above, the problem statement is formulated as follows:

“How to justify integrating the lean and agile concepts, such that the benefits of both concepts can be combined to improve supply chain management?”
1.3 Research Questions

In order to appropriately address the problem statement above, several research questions are formulated. The depth of the research questions is built up gradually with the aim to achieve a thorough understanding of the concepts in general, and subsequently approaching the problem statement by linking the results and findings, in a way that new insights can be provided into the integration of the lean and agile concepts.

- What are the similarities and differences of the Lean and Agile concepts in the existing literature?
- What are the characteristics of the leagile concept?
- What are the key factors determining the necessities of the leagile concept?
- Which similarities and differences are discovered in the conceptual applications of the leagile concept?

The first research question focuses on the similarities and differences between lean and agile in the existing literature. The comparison is necessary to gain more insight into the building blocks and capabilities and limitations of the concepts, and provides a solid foundation of the research.

The second research question highlights the characteristics of the leagile concept, as well as the development of the concept, in order to gain understanding into the need to integrate lean and agile in the same supply chain. Additionally, the discussion about the characteristics of the concept will clarify the added value of the leagile supply chain.

The third research question discusses the key factors determining the necessities of the leagile concept. Although there might be many such factors, the focus will be on the strategic factors, which are critical in promoting the integration.

The final research question underlines the similarities and differences observed in the conceptual applications of the concept. The comparison should provide a strong base to minimize the ambiguities regarding the concept, and helps the development of a solid framework.
1.4 Methodology
The nature of the study is mainly exploratory, due to the fact that topic is relatively new and few studies have been conducted. The data will be collected through literature review. Firstly, scientific papers will be searched in the database. Secondly, case studies and an interview will be used to assess the theoretical insights collected through literature review. Finally, the implications found through literature review, case studies and interviews will be integrated to provide a comprehensive conclusion concerning this topic.

1.5 Structure of the Thesis
In chapter 2, the lean and agile concepts will be elaborated from a supply chain perspective, including an extensive comparison to show the key similarities and differences between the concepts. In chapter 3, the integration of lean and agile concepts will be discussed along with the possible approaches. Additionally, industrial case studies will be analyzed to judge the effectiveness of the integration. In chapter 4, the findings from the literature review will be tested through various interviews with practitioners in the supply chain environment. In chapter 5, a comprehensive conclusion will be presented based on the results of the literature review and the interview, combined with the limitations of the results and the directions for future applications.
2. LEANNESS AND AGILITY FROM A SUPPLY CHAIN PERSPECTIVE

Due to the intense global competition in the 1980s, supply chain management has become the subject of increasing interest (Bowersox et al., 2008). At that time, the supply chain concepts were mainly intra-organizational and aimed to integrate the internal business functions within a firm (Dubois et al., 2004). As supply chain management continuously evolves, the focus is yet extended beyond the boundaries of individual firms, as company performance is no longer solely determined by internal processes, and the collaboration with upstream production and downstream distribution is becoming increasingly crucial nowadays (Cagliano et al., 2004).

Two supply chain concepts advocating the integration of the total supply chain are lean and agile. Lean manufacturing was developed by Toyota after a visit to the manufacturing facilities of Ford in the US (Womack et al., 1990). As American industries lost ground to their Japanese competitors due to the successfulness of lean manufacturing (Yusuf and Adeleye, 2002), the agile concept was introduced to regain competitive advantage amongst American manufacturers (Brown and Bessant, 2003). While it is likely that both lean and agile are successful concepts, the relationships between the concepts appear to be unclear to most people. In order to shed light on these relationships, this chapter will elaborate on both the lean and agile concepts, by discussing their core values as well as the frameworks in which they have a place. In addition, the strategic priorities and the characteristics of the concepts will be compared to find out whether the concepts could be integrated to benefit supply chain management.

2.1 Leanness

After World War II, the Japanese manufacturers were facing certain shortages in material, financial, and human resources, which raised the need for a modern manufacturing concept (Womack et al., 1990). The visit of Toyota delegation at the Ford manufacturing facilities in the US made Kiichiro Toyoda, the chairman of Toyota Motor Company at the time realize that American car manufacturers had a more efficient manufacturing concept, which can easily outperform their Japanese counterparts (Womack et al., 1990). The reasoning above has led to the development of a process-oriented manufacturing system in Japan, known as the Toyota Production System (TPS) or lean manufacturing.
Lean manufacturing is a multi-dimensional approach, which embraces an array of management practices such as cellular manufacturing, equipment maintenance, demand, setup time and quality control (Womack et al., 1990). The aim of the approach was to combine these management practices to yield a streamlined system producing high quality products, at the required pace of the customers, with a minimized rate of wastes (Shah and Ward, 2002). Lean appeared to be a successful concept as it creates competitive advantages for firms, operating in different industries of the global market. Womack et al. (1990) suggest that the achievement of the lean concept mainly resulted from a detailed knowledge of the customers and the markets, as well as strong buyer-supplier relationships. Theoretically, lean manufacturing is able to achieve the same outcome by using half the human effort, half the manufacturing spaces, half the investment and half the engineering hours to develop a new product in half of the time, comparing to mass production method (Melton, 2005).

2.1.1 Value Identification and Waste Removal
The lean concept can be interpreted as a set of managerial practices focusing on the elimination of waste along the value chain, within and across companies (Womack et al., 1990; Holweg, 2007). Womack and Jones (1996) suggest that the basic principles of lean consist of the identification and creation of value, the elimination of waste and the generation of flow. Hence, the starting point to become lean is identifying value and defining the value proposition for the customers (Melton, 2005). Given the importance of discovering value and wastes, it is necessary to understand how this should be established.

Monden (1993) categorizes the processes into value adding, non-value adding and necessary but not value adding. Hines and Rich (1997) refer to value-adding processes as the conversion of raw materials, or semi-finished products, into end products. The non-value adding processes, however, refer to unnecessary actions, which should be avoided. The necessary but not value adding processes are wasteful but necessary in the current design, which requires major changes in the process design in order to remove them. Hines and Rich (1997) also identify the following types of wastes, which are commonly accepted in the TPS: overproduction, waiting, transport, unnecessary motion, inappropriate processing, unnecessary inventory, and defects (Figure 2.1).
Overproduction is typified as the most serious waste since it hinders a smooth flow of goods within the supply chain, and is likely to harm the productivity and product quality (Hines and Rich, 1997). Also, the waste of overproduction might trigger other types of waste, such as inventory and subsequently the defects. For instance, too much stock causes unnecessary storage and lead time. Consequently, less time and effort are left to detect the defects. In addition, overproduction appears to create unnecessary pressures on production rate, which might harm the productivity.

Waste of waiting occurs when goods are not moving or being processed, which is typically caused by the inefficient use of time. Waiting time can be reduced by optimizing the flow in the manufacturing processes. If it is not possible to fully eliminate the waste of waiting, TPS suggests that waiting time for workers should be used for other activities such as training and maintenance rather than producing unnecessary goods (Hines and Rich, 1997).

The waste of transport may appear to be similar to the waste of unnecessary motion. However, the waste of transport only applies to the unnecessary movement of the goods, whereas the waste of unnecessary motion refers to the ergonomics of production (Hines and Rich, 1997). In an extreme view, every single movement of the goods can be regarded as a waste of transport. The aim is therefore to minimize rather than eliminate the movement. Additionally, the excessive movement might damage and deteriorate the goods. Also, when the goods are excessively in transit, the managers might lose the overview of the inventory.
The waste of unnecessary motion concerns the movement of the employees, such as stretching, bend, and pick up, while it can be avoided (Hines and Rich, 1997). These unnecessary movements can harm the fitness and health condition of the employees, and lead to poor productivity, which should therefore be eliminated. TPS suggests that excessive motion can be prevented by redesigning the processes with the involvement of shop floor workers.

The waste of inappropriate processing refers to situations when over-complex solutions are applied to relatively simple processes (Hines and Rich, 1997), such as using complex tools and machines instead of simple ones when not needed. Using an overly complex tool may encourage overproduction to justify the investment. Subsequently, it might cause other wastes such as waiting and transport. The ideal is therefore using the simplest possible tool to produce required quality and quantity, located within the reach of preceding and upcoming procedures (Hines and Rich, 1997).

As mentioned before, the waste of unnecessary inventory is likely to be triggered by overproduction and waiting. It might increase the lead time and space, and subsequently hinder the identification of problems (Hines and Rich, 1997). Since a significant amount of problems are hidden in the inventory, the simplest way to minimize these hidden problems is to reduce the inventory.

Defects are the most obvious waste, since defects result in scrap and rework can raise the costs and lead time significantly. According to the Toyota philosophy, the defects should therefore be eliminated by utilizing employee involvement and kaizen activities (Hines and Rich, 1997).

It is clear that wastes do not contribute to value-adding. Hence, when the wastes occur, the quality and the efficiency of the supply chain will be jeopardized. Following this threat, a systematic identification of the value and wastes should be established by using techniques such as value stream mapping. Value stream mapping is a set of actions required to bring a product through the manufacturing processes, from raw materials to the end consumer (Rother and Shook, 1999). Both information and material flow within the supply chain will be considered by value stream mapping in order to identify all types
of waste in the value stream and take actions to eliminate those wastes (Rother and Shook, 1999). Also, value stream mapping provides the possibility to work on the big picture, rather than individual processes. Thus, value stream mapping creates a strong foundation for the main processes and consequently facilitates more thoughtful decisions to continuously improve the value stream (McDonald et al. 2002). Hines and Rich (1997) highlighted seven value mapping tools in an empirical study. The authors found out that all seven value mapping tools have distinguishing capabilities to cope with distinctive types of wastes, and suggest combining different tools into a toolkit. The composition of the toolkit, however, should be based on the situation and environment, and the target is to identify all possible wastes and make processes valuable for the customer.

2.1.2 Lean Framework

As mentioned before, identifying value and wastes is the starting point to become lean, and the ultimate goal is to level up the performance along the value chain in a way that is preferred by the customers. Thus, it is necessary to gain more insight into the lean practices, which are designed to achieve the ultimate goal.

Empirical studies tend to focus on the connection between lean implementations and performance. However, most studies only focus on a single aspect (Hackman and Wageman, 1995; Samson and Terziovski, 1999), or two aspects (Flynn et al., 1995; McKone et al., 2001) of lean. An exception is from Cua et al. (2001), who considered the effects of just-in-time (JIT), total quality management (TQM) and total preventive maintenance (TPM) on operational performance. Shah and Ward (2003) add the fourth bundle, human resource management (HRM) to investigate the simultaneous and synergistic effects of the bundles on operational performance (Figure 2.2). This is based on the notion of MacDuffie (1995) and Osterman (1994) that HRM is a critical factor of performance improvement. It is also underpinned by the assumption that TQM, JIT, TPM and HRM have similar goals of continuous improvement and waste reduction. By combining these bundles, a comprehensive and consistent set of practices can therefore be formed. Additionally, researchers stress that the combination of the lean techniques levels up the performance because of the relationships between the practices (Schroeder and Flynn, 2001).
TQM can be defined as a manufacturing program aimed at continuously improving and sustaining quality products and processes by capitalizing on the involvement of management, workforce, suppliers and customer, in order to meet or exceed customer expectations (Dean and Bowen, 1994; Powell, 1995; Cua et al., 2001). TQM is an essential bundle within the lean framework, based on the assumption that the TQM practices are necessary to eliminate defects. Also, the continuous improvement, also known as kaizen, is the fundamental principle of the lean concept to meet the changing customer expectations. According to Cua et al. (2001), the total quality management framework is set up with the following 3 subsets of manufacturing practices: 1) cross-functional product design and systematic process management; 2) the involvement of customers, suppliers and employees; 3) management commitment and well-established strategy.
JIT refers to a manufacturing program with the primary goal of continuously reducing, and ultimately eliminating, all forms of waste along the value chain (Sugimori et al., 1977; Cua et al., 2001). Two major forms of waste, inventory and waiting, can be addressed by the JIT practices such as set-up time reduction, pull system production, JIT delivery by supplier, daily schedule adherence, strategic planning, functional equipment layout, committed leadership, cross-functional training, and employee involvement (Cua et al., 2001). Shah and Ward (2007) proposed and tested 10 dimensions to measure the lean performance, and six of these dimensions are derived from the JIT practices. This confirms the importance of the JIT bundle within the lean concept.

TPM is a manufacturing program designed primarily to maximize equipment effectiveness throughout its entire life through the participation and motivation of the entire workforce (Nakajima, 1988; Cua et al., 2001). The TPM bundle is characterized by autonomous and planned maintenance, equipment technology, strategic planning, committed leadership, cross-functional training and employee involvement (Cua et al., 2001).

It is interesting to observe that Cua et al. (2001) only considered TQM, JIT and TPM. However, the authors repeatedly mentioned practices such as employee involvement, leadership and cross-functional training. This might justify the choice of Shah and Ward (2003) by classifying HRM as a separate bundle to the framework. Also, by categorizing HRM practices into a separate bundle, the framework provides the ability to isolate the effects amongst different bundles, and therefore increases the reliability of the results. According to various authors, the HRM practices are focused on the employee involvement, respect achieved through decentralized authority and organizational layer reduction, communication between workers and management, multi-functional training, team work and collaborations (Dal Pont et al., 2008; Kenney and Florida, 1993).

While it might seem intuitive that each of the bundles contributes to the performance gain, the findings from empirical studies are not consistent. Cua et al. (2001) found that each of the bundles can have significant positive effects on the measured performance. Also, the results support the compatibility of the practices from different bundles, and suggest that a higher level of manufacturing performance can be obtained when the practices are
jointly implemented. As Cua et al. (2001) used four classical performance dimensions: cost efficiency, quality, on-time delivery, and volume flexibility, the results provide interesting insight into the effects of different configurations on particular performance dimensions. For instance, on-time delivery and cost efficiency are positively associated with a great number of practices in the performance bundles, while quality and especially volume flexibility show less positive associations.

Dal Pont et al. (2008), suggest that JIT and TQM have a positive significant and direct effect on operational performance, whilst HRM has a positive, significant and mediated effect on operational performance. The positive direct effects of JIT and TQM on the operational performance confirm their roles as pillars in the lean house. However, it is interesting that the positive effects of HRM on operational performance are mediated by JIT and TQM, this might suggest that some of the HRM practices should be implemented in an early phase in order to maximize the effect of JIT and TQM. For instance, JIT implementation requires training programs for the employees. If the training programs can be completed before the JIT implementation starts, failures might be notably reduced, resulting in a higher effectiveness of the JIT practices.

Amongst all empirical studies considered in this section, Shah and Ward (2003) are the only authors who combine all four bundles into one study (Figure 2.2). The authors find that each of the individual bundles significantly contributes to performance. This was quite remarkable since such a result had never been reported before. However, the fact that authors attribute the positive contribution of all lean practices to the synergistic effects might be a bit weak. Firstly, the lean bundles explain only 23% of the variation in operational performance when the effects of industry are controlled for, which means the framework lacks robustness. Secondly, differences in results and findings could be attributed to the quality of data and the amount of industries included in the dataset. Cua et al. (2001) use a dataset consisting of 163 samples across 3 industries (electronics, machinery and transport parts). Dal Pont et al.’s (2008) dataset is from the same industries but consists of 266 samples. Shah and Ward (2003), however, use a dataset from 20 industries that counts 1748 samples. The differences in the used dataset may
limit the appropriateness of comparison. Nevertheless, the study of Shah and Ward (2003) provides an interesting framework as a starting point for future studies.

2.2 Agility
Due to the successful adoption of lean manufacturing by Japanese firms in major industrial markets such as automobile, machine tools and electronics, American industries lost ground to their Japanese competitors (Yusuf and Adeleye, 2002). This increased the need for a new manufacturing approach in order to regain the competitive advantages of American firms. As a result, the agile concept was introduced to make a significant step ahead of the best practices at that time, such as lean manufacturing (Kiperska-Moron and De Haan, 2010). Also, companies were forced to look beyond the cost and quality advantage to cope with market volatility (Yusuf et al., 2004). In response to the changing needs of customers, the agile concept was developed, encompassing terminologies such as flexibility, speed, responsiveness and quality. Agile manufacturing can be defined as the capability of surviving and prospering in a competitive environment of continuous and unpredictable change by reacting quickly and effectively to changing markets, driven by customer-designed products and services (Gunasekaran, 1999; Cho et al., 1996). Harrison and Van Hoek (2005) add that the speed capability is massively emphasized by the agile concept, and the required level cannot be obtained by using previously known tools and techniques. The assumption is that responding quickly and at the right time is not enough to deal with today’s market instability. Therefore, being lean and responsive might not be sufficient in industries such as personal computer and apparel, characterized by uncertain demand and high volatility (Kiperska-Moron and De Haan, 2010).

2.2.1 Flexibility
While lean and agile share the same target, which is creating value and improving performance, the emphasis is put differently. More specifically, the agile concept calls for a higher level of flexibility to adapt to the dynamic environments, rather than reducing costs. Tan (1998) suggests that flexibility refers to adaptability and versatility, and agility emphasized the speed that a system needs to adapt. Therefore, flexibility seems to be a
necessary precondition for agility. Additionally, the contingency theory suggests that there is no universal way to manage or organize companies, and the management style should be based on the situational constraints which the organizations are facing (Sherehiy et al., 2007). Hence, the organization’s flexibility to adapt to the environment determines the success of the company in a dynamically changing environment.

According to Upton (1994), flexibility is the ability to change or react with minimal negative repercussions for time, effort, cost or performance. Swamidass and Newell (1987) add that environmental uncertainty is one of the major reasons for a company to seek flexibility. Based on this, it can be suggested that flexibility is closely related to uncertainty and variability. This relationship is demonstrated by Correa (1994). The author links flexibility, uncertainty and variability in the context of managing unplanned change, by proposing flexibility as a solution to deal with the effects of unplanned changes, while uncertainty and variability are attributes of the unplanned change. Elkins et al. (2004) mentioned that agile manufacturing systems share the ability to reallocate production capacities to products that have higher demand than expected, and ensure fast new product launches, while the production ability for products with lower demand is retained. Additionally, the authors state that agile manufacturing systems might be attractive for the automotive companies because of the ability to rapidly and cost-effectively reset and reuse the manufacturing equipment in response to changing product demand, which is beyond the capability of traditional flexible manufacturing systems (FMS). This is due to the fact that FMS requires significant additional costs and time to adapt to unplanned products (Elkins et al., 2004). Therefore, it seems that the agile concept takes even a step further than the FMS in which the flexibility is been promoted.

2.2.1 Agile Framework

Most of the literature on agile manufacturing and related issues either focuses on the strategies or techniques, rather than developing a framework through an integrated view (Gunasekaran, 1999). Realizing the importance of a framework for further research and application, Gunasekaran (1999) attempted to develop a conceptual model for the agile concept, along four key dimensions including strategies, technology, people and system issues. Yusuf et al. (1999) define the core concepts of agile manufacturing as virtual
enterprise, core competence management, capability for reconfiguration, and knowledge enterprises. Meade and Sarkis (1999) developed a decision methodology and structure for manufacturing and organizational agility improvement, capturing dimensions such as mastering change and uncertainty, enriching the customer, leveraging the impact of people and information, and cooperating to enhance competitiveness. Another framework originates from Christopher (2000). The author characterizes the agile concept as market sensitive, virtual, process integration and network based. Based on these characteristics, Agarwal et al. (2007) further develop the framework and define the dimensions market sensitivity and responsiveness, information driven virtual integration, process integration and performance management, and network based centralized and collaboration planning.

![Agile Framework](image_url)

**Figure 2.3: Agile framework (Agarwal et al., 2007)**

Although different authors use various dimensions to establish a framework for the agile concept, certain similarities can be observed amongst these frameworks. Firstly, the importance of technologies and information systems is emphasized. Secondly, information sharing and supply chain collaborations are necessary to sense the market and improve the responsiveness. Thirdly, process integrations are essential to level up the
performance. Finally, the customers have a central role in the agile concept. The four dimensional model (figure 2.3) of Christopher (2000) will be further elaborated in this section as it appears to be superior to other frameworks. This assumption is based on the fact that this model is frequently used by numerous authors (Christopher and Towill, 2001; Christopher, 2004; Harrison and Van Hoek, 2005; Agarwal et al., 2006; Agarwal et al., 2007) in their studies, and therefore more robust and further developed comparing to other frameworks.

According to Christopher (2000), the most important characteristic of an agile supply chain is market sensitivity. Market sensitive means that the supply chain is capable of reading and responding to real demand (Christopher, 2000). This can be achieved by switching from forecast-driven to demand-driven. A demand driven supply chain has the ability to hear the voice of the market by using efficient consumer response (ECR) and other information technologies, to sense the demand directly from point-of-sale, and subsequently respond adequately to it. The forecast driven organizations, however, make forecasts and convert these forecasts into inventory because they are not able to acquire data on actual customer requirement. These forecasts truly limit the market sensitiveness of the supply chain since the forecasts are based on historical data rather than real-time data. Agarwal and Shankar (2002) point out that the extent of the market sensitiveness is influenced by the level of collaboration amongst supply chain partners and the ability of using information technology tools. The definition of Christopher (2000) suggests also that market sensitivity is pointless without the ability to respond. An agile supply chain should therefore utilize the captured demand data as the basis of daily productions and operations. Agarwal et al. (2007) suggest three practices to improve the market sensitivity and responsiveness including providing daily point-of-sale feedback, listening to consumers and capturing emerging trends.

Yusuf et al. (1999) suggest that a virtual supply chain provides the possibility to harness and coordinate the resources and skills spread across different organizations, for manufacturing either simple or complex products very rapidly, and based on customer requirements. In comparison with the traditional supply chain, a virtual supply chain is information based rather than inventory based (Christopher, 2000; Agarwal et al., 2007).
A virtual supply chain is therefore created by using the information technology to share data between buyers and suppliers (Christopher, 2000). This is due to the fact that information is an essential part of a modern supply chain. Additionally, all supply chain partners should have access to the same information at the same time, to ensure adequate collaboration between supply chain partners (Christopher, 2002). Also, informational driven virtual integration is essential from the strategic point of view as it improves the responsiveness to market instabilities. There are three management practices proposed by Christopher et al. (2004) and Agarwal et al. (2007) to promote the virtual integration, including shared information on real demand, collaborative planning and end-to-end visibility. Sharing information on real demand is necessary to adapt operations to changing demand. Collaborative planning ensures the successfulness of operations through resource and skill sharing amongst partners. End-to-end visibility, in turn, contributes to collaborative planning, since it provides each supply chain member with the ability to be aware of vital information, such as requirements, challenges and successes.

Agarwal et al. (2007) suggest that shared information between supply chain partners is achieved by process integration. Process integration refers to collaborative working, information sharing, joint product development and common systems (Christopher, 2000). This form of process integration is beyond companies’ boundaries and without delays caused by buffers in process phases (Christopher et al., 2004). Agarwal et al. (2007) state that supply chain efficiencies can only be fully acquired if top management is committed to integration. The authors highlight co-managed inventory, collaborative product design and synchronous supply as three main practices to promote process integration and performance management. Co-management inventory refers to collaborative management of supply chain stocks by all supply chain partners. Collaborative product design is achieved by joint design, utilizing the trends information from point of sale amongst all supply chain partners. Synchronous supply involves the constant and consistent supply all the way through the supply chain in the way that the supply chain activities are simultaneously taking place. These three practices contribute independently to process integration and performance management, and the ultimate goal is adapting rapidly to the changing demand.
Christopher (2000) suggests that today’s business environment is characterized by network competitions, which means that the performance of the whole supply chain outweighs the performance of individual organizations. The era of network competition requires therefore, a supply chain, which is network based and being able to leverage the competencies and strengths of network partners. Similar to other dimensions of the framework, the final goal is to achieve greater responsiveness to market requirements (Christopher, 2000). Consistently, Agarwal et al. (2007) provide three management practices to strive for centralized and collaborative planning, including leverage partners’ capabilities, focus on core competencies and act as network orchestrator. Leverage partners strength is essential in determining the success of the supply chain, since it enables the supply chain partners to focus on their core competencies, and in turn, increases the strength of individual partners. Acting as a network orchestration contributes to the success of the dimension through a positive impact on the performance of the other two practices. It allows organizations to benefit from leveraging partners’ strengths as well as enabling the focus on core competencies among individual supply chain partners.

2.3 Lean and Agile Compared

Previously in this chapter, the characteristics of lean and agile are discussed to gain insight into the concepts. It seems that lean and agile share similar attributes, but the emphases may have been put differently. Cagliano et al. (2004) found, via an empirical study consisting of 284 European samples that lean agile show comparable performance and the performance differences between them are not statistically significant. Naylor et al. (1999) compare the strategic priorities of lean and agile from a supply chain end-customer perspective, by using the total value metric, including lead time, service, costs and quality. As shown in table 2.1, both concepts exhibit equal importance on lead time and quality, whereas the difference is in the varying emphasis on service and costs.
Table 2.1 A comparison of value metrics of lean and agile (Naim and Gosling, 2010; Naylor et al., 1999)

Mason-Jones et al. (2000) used the same performance indicators in a market qualifiers and market winners setting to compare the lean and agile supply chain. Table 2.2 suggests that the lean concept utilizes the cost advantage as market winner whereas the agile concept uses the service level advantage. Christopher and Towill (2001) state that this switching focus in market qualifiers and market winners is a natural development, since the market has been through a 15-20 years transition, from product driven to market orientated to market driven and finally reached the customer driven stage.

Table 2.2: Market winners – market qualifiers matrix for lean versus agile supply chain (Mason-Jones et al. 2000)

Additionally, Naylor et al. (1999) highlight the key characteristics of lean and agile as supply chain strategies, based on literature and industrial case studies. The authors claim that the characteristics highlighted in table 2.3 are prerequisites for the lean and agile concepts, and the importance of the characteristics is labeled as essential, desirable and arbitrary respectively.

As shown in table 2.3, the lean and agile concepts attribute equal importance to the use of market knowledge, supply chain integration and lead time compression. The use of market knowledge is needed to accurately sense the customer requirements, and resulting in a more responsive supply chain (Naim and Gosling, 2010). Also the integration of the supply chain is equally emphasized in both concepts in order to meet the requirements of customers, either through a long-term relationship or virtual networks (Naim and Gosling, 2010). Stalk Jr. and Webber (1993) suggest that lead time reduction has been a major
order winner. Lean promotes the elimination of all seven wastes, including the wasted time and therefore the ability to shorten the lead time. Similarly, agile tries to decrease the lead time by leveraging information flow and material flow throughout the supply chains (Naylor et al., 1999).

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Lean</th>
<th>Agile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of Market Knowledge</td>
<td>O O O</td>
<td>O O O</td>
</tr>
<tr>
<td>Virtual Corporation/Value Stream/Integrated Supply Chain</td>
<td>O O O</td>
<td>O O O</td>
</tr>
<tr>
<td>Lead Time Compression</td>
<td>O O O</td>
<td>O O O</td>
</tr>
<tr>
<td>Eliminate Wastes</td>
<td>O O O</td>
<td>O O</td>
</tr>
<tr>
<td>Rapid Configuration</td>
<td>O O O</td>
<td>O O O</td>
</tr>
<tr>
<td>Robustness</td>
<td>O O O</td>
<td>O O O</td>
</tr>
<tr>
<td>Smooth Demand/Level Scheduling</td>
<td>O O O</td>
<td>O</td>
</tr>
</tbody>
</table>

O O O = essential; O O = desirable; O = arbitrary.
Table 2.3: Rating the importance of different characteristics of lean and agile (Naylor et al., 1999).

The characteristics of similar importance include eliminate wastes and rapid configuration. Lean is aimed to create the maximum value for the customers by eliminating wastes. A lean supply chain is flexible to a certain extent, but since the flexibility is not a pre-condition to become lean, lean might be inferior to agile in terms of flexibility (Naylor et al., 1999; Naim and Gosling, 2010). In contrast, the agile concept advocates a higher level of rapid reconfiguration to increase flexibility. An agile supply chain will therefore eliminate as much waste as possible, but since eliminating waste is of lower priority than being flexible, agile might be more wasteful than lean (Naylor et al., 1999; Naim and Gosling, 2010). This finding is also consistent with the cost focus of lean and the service level focus of agile, depicted in table 2.1 and 2.2.

Characteristics of different importance are robustness and demand smoothing. Various authors (Fisher, 1997; Christopher and Towill, 2002; Lee 2002) point out that the lean concept is not always capable to manage internal processes and/or external relationships. This is based on the assumption that lean performs best in an environment characterized by high volume and predictable demand. When the volume is low and demand is volatile, the customer requirements will become more unpredictable, and the supplier capabilities and innovations will be more difficult to control (Cox and Chicksand, 2005). Also,
Cooney (2002) states that lean practices such as JIT cannot be sustained unless production leveling is possible. Therefore, the lean concept might be incapable of dealing with the volatilities in volume and product variety. It is also seems that lean is less robust, and calls for demand variation reduction by standardizing, simplifying and optimizing the processes along the supply chain (Naylor et al., 1999). Agile, instead, calls for flexibility and adaptability, to cope with the volatilities in the market.

Bhatia (2004) provides another interesting comparison between lean and agile based on the attributes such as products, demand, product life cycle, product variety, customer drivers, profit margin, average forecast error and forecast approach (table 2.4)

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Lean</th>
<th>Agile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Products</td>
<td>Functional</td>
<td>Innovative</td>
</tr>
<tr>
<td>Demand</td>
<td>Predictable</td>
<td>Unpredictable</td>
</tr>
<tr>
<td>Product Life Cycle</td>
<td>Long</td>
<td>Short</td>
</tr>
<tr>
<td>Customer Drivers</td>
<td>Cost</td>
<td>Assortment</td>
</tr>
<tr>
<td>Profit Margin</td>
<td>5% - 15%</td>
<td>20% - 60%</td>
</tr>
<tr>
<td>Average Forecast Error</td>
<td>5% - 10%</td>
<td>30% - 40%</td>
</tr>
<tr>
<td>Forecast Approach</td>
<td>Calculative</td>
<td>Consultative</td>
</tr>
</tbody>
</table>

Table 2.4: A Comparison between Lean and Agile (Bhatia, 2004)

The author suggests that lean is more appropriate for functional products while agile is more suitable for innovative products. Fisher (1997) argued that functional products satisfy the basic needs of the customers, and therefore do not change significantly over time. This might suggest that the life cycle of functional products is relatively long, and the demand is more stable and predictable. This might result in a lower level of forecast error. However, the stability in demand might attract competitors to enter the market and cause a lower profit margin. The lower profit margin is based on the assumption that the price is used as a major tool to differentiate, since functional products are oftentimes homogeneous and standardized. Given that cost is the major order winner for functional products, it is understandable that lean could be an appropriate concept to manufacture and distribute the products, as it can provide maximum value to the customers through efficiency maximizations along the supply chain. In order to avoid low margins,
companies utilized innovations in fashion or technology to differentiate from competitors and provide customers extra incentives to buy their products (Fisher, 1997). However, innovations are continuous rather than a one-time event (Smith, 1993), or else it will be imitated by the competitors, again resulting in lower profit margins. This contributes to the shorter life cycles and greater product varieties of innovative products. Consequently, it drives up the demand unpredictability and forecast error. In order to cope with the higher market instabilities and forecast errors, companies are required to sense the market trends and provide rapid responses to it. Thus, the agile concept might provide a solution for companies with innovative products by being flexible and responsive throughout a synchronized supply chain.

2.3.1 Lean and Agile Cannot Co-Exist?

Due to the differences in characteristics and priorities, several authors find that the two concepts cannot co-exist. Richards (1996) claims that the flexibility promoted by the agile concept cannot be achieved under lean production, since lean calls for simplification and standardization. Similarly, Harrison (1997) expressed doubt whether agile and lean are compatible as agile requires more resources than lean does. Goldsby et al. (2006) found in a simulation that lean is only able to achieve the lowest cost combined with the highest service when the market is stable and predictable. The authors also suggest that lean and agile are regarded as opposing concepts.

Kisperska-Moron and De Haan (2010) point out that the lean concept, with its focus on standardization to improve efficiency, can discourage innovation, differentiation and complex learning, and is therefore contradictory to the agile concept that utilizes innovation and differentiation as order winners to benefit from changing demand and requirements. Vazquez-Bustelo et al. (2007) state that lean subordinates responsiveness to cost and efficiency while agile focuses on flexibility and responsiveness. Narasimham et al. (2006) found in an empirical study that agile plants beat lean plants on almost all measured performance dimensions, except for cost efficiency. Thus, trade-offs should be made when choosing for an appropriate supply chain approach. Inman et al. (2010) suggest that higher inventory levels could be necessary to maintain the higher service level required by agile plants, whereas lower inventory levels are required for cost-
efficient lean plants. The necessary trade-offs might imply that two concepts cannot co-exist, although they address certain similar competitive priorities.

2.3.2 Lean and Agile are Complementary?

Katayama and Benett (1999) describe lean as an overarching concept that is compatible with any production system. It means that the lean concept should be compatible and complementary with the agile concept (Krishnamurthy and Yauch, 2007; Naylor et al., 1999). In addition, various authors stress that the integration of lean and agile will result in benefits that cannot be achieved when the concepts are adopted in isolation (Inman et al., 2010; Krishnamurthy and Yauch, 2007). Inman et al. (2010) also suggest that many elements cited as necessary for the agile concept are similar to the elements of lean, including flexible setup, setup-time minimization, cross-trained employees, relationships with suppliers, quality assurance, and reduced lead time and costs. For instance, flexible setup is part of the TPM bundle; setup-time minimization and supplier relationships are covered in the JIT bundle; cross-trained employees is emphasized in the HRM bundle; and quality assurance is highlighted in the TQM bundle. Reducing lead time and costs in particular, are the fundamentals of the lean concept, along with the quality assurance. Therefore, it seems that the two concepts could be complementary.

2.3.3 Agile is based on Lean?

Various authors claim that agile is based on the elements of existing systems and practices that are already in use (Gunasekaran et al., 2008; Vazque-Bustelo et al., 2007). Some other authors even suggest that agile manufacturing is the natural development from the lean concept (Gunasekaran et al., 2008; Gunansekaran, 1999). Gunasekaran et al. (2008) also state that the agile concept is not only based on responsiveness and flexibility, but also on the cost and quality of goods and services, which are emphasized in the lean concept. Sakris (2001) argues that agile manufacturing equals lean manufacturing combined with flexible manufacturing systems. Goldman and Nagel (1993) state that agile manufacturing utilizes the flexible production technologies along with lessons learned from lean production, such as TPM and JIT. Hormozi (2001) claims that agile might be the last step in the development from mass production to agile, which means that a range of companies adopted lean first before they became agile. Narasimhan et al.
(2006) suggest that the pursuit of agility might presume leanness, and Inman et al. (2010) found in an empirical study based on a broad sample of larger U.S. manufacturers that JIT-purchasing, a major element of lean manufacturing, is antecedent to agile manufacturing. This empirical finding partially supports the claim (Narasimhan et al., 2006) that leanness is a precursor to agility from a performance perspective. However, Inman et al. (2010) found that the relationship between JIT-production and agile manufacturing was non-significant. Based on the above logic, it seems that lean and agile have a lot in common, although they emphasize different elements.

### 2.4 Implications

After comparing the lean and agile concepts, it became evident that various authors share the opinion that lean and agile are related, and the assumption that agile is based on lean might confirm the possible compatibilities and complementarities between the concepts. However, Inman et al. (2010) suggest that lean and agile appear to be complementary only in supply chain settings, rather than individual manufacturing firms, unless the firm exhibits a large extent of vertical integration, characterized by multi-units that act as a supply chain. This may support the point of view that lean and agile may not be able to co-exist, though the specific distinction between the supply chain and single manufacturing plants has not been made by many authors.

The reasoning above may suggest that actually two major streams can be distinguished in the existing literature: 1) lean and agile cannot co-exist, which means that lean and agile will cancel out each other’s effectiveness when integrated in the same supply chain; 2) lean and agile are mutually supportive, which means that a synergetic effect can be achieved by integrating the concepts. Since it is necessary to minimize this ambiguity for future research and applications, the compatibility issues will be addressed in the upcoming chapter.
3. INTEGRATION OF LEAN AND AGILE

In the previous chapter, the characteristics of the lean and agile concepts were discussed. Through a side-by-side comparison, two major streams of findings are distinguished in the existing literature. While some authors highlight the strategic difference between lean and agile and thus suggest that they cannot co-exist, others claim that the concepts exhibit significant similarities and can therefore be integrated to achieve synergetic effects. In order to minimize the ambiguity concerning the compatibilities and complementarities between the concepts, this chapter will develop theoretical insights concerning the integration issues. Additionally, a number of case studies will be analyzed to examine these two streams of opinions discussed in the previous chapter.

3.1 Supply Chain Structures and Decoupling Points

Prior to the discussion concerning the integration of lean and agile, the typical supply chain structures and decoupling points need to be addressed. This is necessary because the integration issues in the existing literature are frequently based on the supply chain structures and decoupling points. Hence, the integration approaches may become easier to understand when the structures and decoupling point issues are clarified first.

Figure 3.1 visualizes the typical supply chain structures with decoupling points serving as a stock keeping point for the particular strategy. The order decoupling points separate the part of the supply chain that uses forecast and stock to buffer against the variability in the demand, and the part of the supply chain that responds directly to the customer demand (Naylor et al., 1999).

Figure 3.1: supply chain strategies and order decoupling point. (Naylor et al., 1999)
When the order decoupling point is placed in the upstream part of the supply chain, the strategy is customer driven, and an order decoupling point in the downstream represents a forecast driven strategy. By varying the position of the order decoupling point, five different supply chain structures can be distinguished: buy-to-order, make-to-order, assemble-to-order, make-to-stock and ship-to-stock.

3.2 Leagility

Naylor et al. (1997) were the first to use the term leagile for the hybrid combination of the lean and agile concepts. This blending strategy has been set forth by Naylor et al. (1999), and Christopher and Towill (2001). Naylor et al. (1999) argue that the appropriate concept, either lean or agile, in the supply chain will depend upon the requirements of the customer. The authors visualize the application of the concepts in figure 3.2, with the dimensions linked to the demand for variability in production and demand for variety of products. The figure, consisting of four quadrants, suggests that the lean concept in the bottom-left quadrant tends to be appropriate for settings characterized by low variability in production and low variety of products, whereas the agile concept in the top-right quadrant is likely to cope with high variability in production and high variety of products. Beside the similarity and difference between lean and agile in applications, the authors claim that the top-left and bottom-right quadrants provide interesting implications. Consequently, the authors stress that these two quadrants can be operationalized by the integration of the lean and agile concepts, in a way that captures the best of both worlds.

![Figure 3.2: Application based on demand for variety of products and variability in production (Naylor et al. 1999)](image-url)
3.3 Existing Leagile Approaches

Christopher and Towill (2001) indicate that there are numerous common elements between lean and agile, and argue that the concepts can be brought together to provide cost and service benefits for the customers. Subsequently, the authors conceive three approaches to establish the ‘marriage’ between leanness and agility. The first approach (figure 3.3) is based on the Pareto Rule, suggesting that 80% of the total revenue is generated by 20% of the total product line. This provides interesting opportunities to distinguish the management strategy for the 20% and the 80% of the products respectively. The authors stress that the lean concept can be applied to the top 20% of the products, oftentimes in a make to stock setting, characterized by its predictable volume and fast-moving nature. The remaining 80% slow-movers manufactured in a make-to-order setting, are typically less predictable and hence will require agility to manage. Goldsby et al. (2006) claim that it is common for manufacturing plants to have production lines designed for the efficient processing of fast-moving products as well as production lines dedicated to cope with the volatility of slow-moving products. Christopher and Towill (2001) mentioned that this approach is suitable for environments characterized by a high level of product variety, and when the demand of fast-movers and slow-movers are not in proportion.

![Figure 3.3: The Pareto Distribution Approach (Christopher and Towill, 2001)](image_url)
The second approach (figure 3.4) regarding the integration of both concepts relies on the creation of a decoupling point combined with form postponement (Christopher and Towill, 2001). According to Bowersox et al. (2008), form postponement is meant to delay the final customizations and assemblies until exact customer specifications are fully known. This can help manufacturing firms to increase responsiveness without sacrificing efficiency, and thus combine the benefits of lean and agile. When postponement is utilized, the demand in supply chain upstream from the decoupling point will become more stable and the product variety can be reduced. The idea is to apply the lean concept to the upstream parts of the supply chain to produce generic and semi-finished products in a typical make-to-stock setting, whereas the agile concept can be applied to the final customizations in the downstream in a make- or assembly-to-order setting, characterized by a more volatile demand and a higher degree of product variety. This approach is also highlighted by Naylor et al. (1999). Through a PC supply chain example, the authors demonstrated how leanness and agility can be integrated to cope with demand volatility and product variety without losing cost benefits in the supply chain upstream. Christopher and Towill (2001) argue that this approach requires a supply chain that has the possibility of modular production or intermediate inventory, such that the customization and distribution can be postponed.

Figure 3.4: The Decoupling Point Approach (Christopher and Towill, 2001)

The third hybrid approach (figure 3.5) entails the separation of base and surge demand patterns. Goldsby et al. (2006) stress that this approach involves having temporary capacity to cope with demand spikes. The idea is to utilize the lean concept for the production of base stock in a make to stock setting, to maintain efficiency in the
operations. This is because the base demand can be estimated on the basis of historical demand. Surge demand, however, appears to be less predictable. Hence, the production of surge stock requires the flexibility and responsiveness of the agile concept (Christopher and Towill, 2001). The authors also suggest that the separation of base demand and surge demand can be achieved either by separation in space or in time. The separation in space provides the possibility to manufacture the base stock in low cost countries, while surge demand should be met by manufacturing locally near to the market. The separation in time, on the other hand, involves using slack periods to manufacture base stock in a way that the production capacity is smoothly utilized. The authors also state that this third hybrid approach is based on the premise that base demand can be accurately forecasted, and the production capacity allows to manufacture the surge stock locally in small batches.

![Figure 3.5: Base and Surge Demand Approach (Christopher and Towill, 2001)](image)

### 3.4 Potential Leagile Approaches

The approaches discussed in the previous section attempt to combine lean and agile, though most approaches tend to suggest that a supply chain should be divided into a lean part and an agile part. However, this strategy might limit the flexibility in applications, when companies prefer to adopt the integration alongside the entire supply chain by adding specific elements of either lean or agile to their existing strategy. Looking at the figures 2.2 and 2.4 in chapter 2, it is likely that other possibilities do exist, such as combining the elements of the concepts to establish an integration.
### 3.4.1 Agile Oriented Leagility

Christopher (2000) pointed out that the virtual supply chain emphasized in the agile concept is information based. Also, the author argued that an efficient consumer response (ECR) system and other information systems are deployed to collect the voice of the market and to respond rapidly to it. This may suggest that technologies and equipments are essential for the agile concept to realize flexibility and responsiveness. However, it seems that the agile concept does not explicitly emphasize the reliability of the technology and information systems. Following this possible deficiency of agile and the importance of reliable equipments and information systems for the concept, the TPM bundle of lean might accommodate agile to reduce the down time of the systems and keep the equipments effective. Shah and Ward (2003) stated that the practices of TPM attempt to maximize equipment effectiveness by deploying planned predictive and preventive maintenance of the equipment. Thus, it can be assumed that the maintenance addressed by the TPM practices can help the agile concept to increase equipment reliability and effectiveness such that the responsiveness of the agile concept will be secured (figure 3.6).

![Figure 3.6: Potential Leagile Approaches: Incorporating TPM or HRM to increase Agility](image-url)
Christopher (2000) argued that complexity should be reduced to enhance agility, and one of the complexities is caused by the organization structure and management processes. The author suggests that the reduction of complexity can be achieved by developing a human resource strategy that leads to multi skilled workers and multi functional working. This human resource strategy is addressed in the HRM bundle of lean, which encompasses practices such as decentralized authority, multi-functional training, and team work and collaboration (Dal Pont et al., 2008). Hence, it is likely that by incorporating the human resource management practices into the agile concept, the organizational complexity can be reduced, resulting in an enhanced state of organizational agility (figure 3.6).

It is evident that these two leagile approaches are agile oriented. The proposed lean elements can help the agile concept to become more responsive and efficient, and thus resulting in higher profit margins. The first approach is likely to be adequate for agile environments with a high level of automation and information technology integration, while the second approach tends to be appropriate for labor intensive agile environments. However, there are situations where a lean focus may be required to provide cost benefits to the customers while the flexibility and responsiveness of the agile concept can be supportive to further decrease the wastes such as overproduction, inventory and waiting.

### 3.4.2 Lean Oriented Leagility

Given that the core of lean is to maximize the value for the customer by eliminating wastes, various agile elements might be helpful to further improve the efficiency and responsiveness of the lean concepts. For instance, the virtual supply chain of agile can help lean supply chain to become leaner. Agarwal et al. (2007) mentioned that the information driven virtual supply chain emphasizes real-demand information sharing, collaborative planning and end-to-end visibility. As the virtual supply chain of agile provides the possibility to address customer demand at all stages of production (Prince and Kay, 2003), the products can be manufactured on the basis of market information collected through daily point-of-sale feedback and ECR, or the customer’s specifications, and thus decrease the chance that products will become obsolete. In other words, the virtual supply chain can help a lean supply chain to manage processes based on the real
demand and final customer specification in a way that wastes such as inventory and overproduction can be reduced (figure 3.8).

Similarly, process integrations promoted by the agile concept can make a lean supply chain more responsive and efficient. Christopher (2000) relates process integration to collaborative working, information sharing, joint product development and common systems. Christopher et al. (2004) suggest that this cross-organizational integration can eliminate delays caused by buffers in process phases. Also, the practices such as co-managed inventory, collaborative product design and synchronous supply can help lean supply chains to decrease supply chain stocks and synchronize supply chain processes, such that wastes like waiting and inventory are minimized while the responsiveness is increased.

3.5 Case Study
In order to find out to what extent the hybrid approaches are applicable for companies to deal with the flexibility and efficiency issues across industries, a number of case studies will be analyzed in the upcoming paragraphs.
Feagin et al. (1991) point out that case study is an ideal methodology to set up a holistic, in-depth investigation. Tellis (1997) argues that case study is known as a triangulated research methodology. Amongst various triangulations, including data, investigator, theory and methodology, case study is characterized by the data triangulation, as multiple sources of data are used. Additionally, due to the fact that various case studies from different authors will be analyzed, investigator triangulation can be achieved as well. Moreover, by using multiple sources, the construct validity, as well as the internal and external validity can be improved (Ying, 1994). However, Tellis (1997) stresses that case studies tend to be selective by their nature and might therefore harm the external validity and generalizability of the results.

3.5.1 Case Study A: Leagile Corporate Infrastructure

Krishnamurthy and Yauch (2007) analyzed a manufacturer in the high-tech industry to determine whether the leagile concept can be applied to a multi-business-unit corporation headquartered in the US. The corporation has multiple production facilities throughout the world and offers standard and custom-engineered products in a business-to-business setting. The agile focus of the corporation is characterized by its decentralized structure, as well as extensive upward, downward and lateral communication to increase market sensitivity and responsiveness. Additionally, the corporation has adopted lean concepts throughout its production facilities, including various lean tools such as value stream mapping and Poke Yoke. Since the corporation combines both lean and agile characteristics within its organizational boundary, it is likely to confirm that the leagile concepts can be applied to a multi-business-unit corporation. Also, the authors found that there is a fixed decoupling point placed between headquarters and sales & service group, which separates the agile part of the corporation from the lean part of the corporation.

This construction is quite exceptional since the integration of lean and agile is not established within the supply chain or manufacturing facilities. Instead, the company has a leagile oriented organizational structure, with the sales & service group serving as the central nerve that seeks market opportunities, and divides the manufacturing tasks amongst lean production units.
3.5.2 Case Study B: Leagile Polish Distributor

Kisperska-Moron and De Haan (2010) investigated a Polish distributor in the laundry, cleaning and paper product market, which acts as a supply chain integrator. The distributor aimed to become the preferred partner for both multi-national producers and local retailers by providing high services at low costs. The Polish distributor was forced to adopt the agile concept during the initial stage of fierce competition to win customer orders, since the priority of upstream producers was to be first in the market with new product varieties as well as having distributors to allocate the products to the customers faster than other competitors. When the market was stabilized after several years and the distributor became the sole distributor for manufacturers and retail stores, the distributor’s strategy shifted towards the lean concept. This is because efficiency became more essential than speed for the distributor to make a profit. The authors found that the Polish distributor still uses the elements of agile even though they had switched the focus to get the operations leaner. For instance, the distributor continuously tries to improve the coordination and integration to become agile, while significant efforts were made to make the processes more efficient and valuable to the customers. Also, the distributor did not pursue agility at any cost. Instead, they try to combine the efficiency and market sensitivity to conquer the market segment.

This case study provides yet other implications concerning the integration of lean and agile, since the Polish distributor did not aim to establish the integration. However, the market forced the distributor to switch the focus from speed to efficiency. As the agile practices were adopted in an earlier stage, the useful aspects were retained when shifting towards the lean concept and resulting in an effective strategy by combining the core values of the concepts.

3.5.3 Case Study C: Leagile Global PC Supply Chain

Naylor et al. (1997) studied a PC manufacturer, which is characterized by a large and complex supply chain, including both company owned and independent supply chain members. The supply chain consists of five major echelons, ranging from an extensive amount of component vendors through different sub-assembly plants to the final assembly. The finished goods are transported to the distribution center and finally
reaching the end-users through authorized dealers. In order to reduce the manufacturing lead time, the company implemented JIT in the early 1980s. Subsequently, the company integrated the material planning processes of all plants by establishing a centralized planning through an electronic data interchange (EDI) system. The leagility is achieved by positioning a decoupling point at the finished goods echelon. The location of the decoupling point is based on the lead time required by the end-users, and the forecast difficulties caused by a short product life cycle.

This structure of integration seems to be a show case for the second hybrid approach suggested by Christopher and Towill (2001). The supply chain upstream from the decoupling point adopted the lean concept in a make-to-stock setting to increase efficiency, whereas the downstream part of the supply chain from the decoupling point adopted the agile concept in an assemble-to-order setting to cope with product variety, demand variability and short lead time. However, due to the short product life cycle, the supply chain might still face stock-related risks. Therefore, an accurate forecast of the demand is essential to achieve efficiency and responsiveness at the same time. If the forecasted demand is lower than the real demand, the responsiveness in the agile downstream will be jeopardized. Vice versa, if the forecasted demand is higher than the real demand, overstock will occur in the lean upstream and resulting in a lower efficiency.

3.5.4 Case Study D: Leagility in Dutch Poultry Supply Chain
Van der Vorst et al. (2001) examined the applicability of the leagile concept for the Dutch poultry supply, which is characterized by an inflexible production environment and a high level of demand uncertainty. As the Dutch poultry supply was confronted with increasing demand on the one hand and governmental regulations on the other hand, it became necessary to increase process flexibility and cost efficiency. During the initial phase, lean was regarded as an appropriate concept to adopt since the order winner was the cost, while quality, lead time and service level were the order qualifiers. However, the supply chain might also benefit from the agile concept due to the demand instabilities caused by the promotional activities initiated by the retailers, and a short lead time required by the customers. The reasoning above lead to the implementation of material
decoupling points to postpone the customer specific labeling and packaging processes, and information decoupling points to make the actual demand visible in an earlier stage.

Similar to the previous case study in the PC supply chain, the lean concept is applied to the upstream from the decoupling point and the agile concept for the downstream. However, the company faced some problems related to the location of the decoupling points due to the perishability of the poultry products and information sharing difficulties amongst supply chain partners. The authors argue that the specific characteristics of the food industry might restrict the applicability of the leagile concepts. For instance, the quality requirement is of utmost importance in the food industry, and may subsequently limit the flexibility of the processes. This is likely to suggest that leagility is not a universal concept, and the applicability should be based on the characteristics of processes and on business priorities.

3.5.5 Case Study E: Parallel Lean and Agile Supply Chain at an US Carpet maker

Johansson et al. (1993) point out that becoming lean through eliminating wastes might restrain performance enhancement. The authors provided an example in the carpet industry, by which a large extent of process re-engineering is required rather than only being lean. Although the lean concept reduces the lead time by 75% from 16 weeks to about 4 weeks, it was still not able to satisfy the required lead time of 1 week. This forced the carpet maker to redesign the processes such that the production is completed within 3 days. Through technology innovations, process re-engineering along with streamlined material flow, the required lead time is achieved while cost benefit is provided to the customers.

The carpet maker found through a Pareto Curve based product analysis that the agile concept can be applied to the top 10% product range guaranteed by one-week delivery, which counts for 52% of the volume. The remaining products can be provided by adopting the lean concept as the same one-week guarantee is not applicable for this product range. This integrated supply chain structure is similar to the first hybrid approach suggested by Christopher and Towill (2001). Although the authors argued that
management strategies are different for the 80% and 20% product ranges, the underlying reasoning is the same.

3.5.6 Case Study F: Leagile Fashion Supply Chain by Zara

Christopher (1998) stressed that Zara’s world leading supply chain exhibits certain leagile characteristics. Based in La Coruna, Spain, Zara is one of the fastest growing and most dynamic apparel companies in the world. The key of its success is the supply chain strategy characterized by low stock, high efficiency and high responsiveness. Zara tries to sense the international fashion trends and customer lifestyle by utilizing the information collected from various sources, consisting of company’s stores and websites as well as competitor’s stores, university campuses, clubs and fashion shows. Subcontractors all over the world are arranged to complete labor intensive processes while labeling and packaging processes are delayed until the final specifications are fully known. On top of that, the products are tested before the finalization of the production runs, such that the failure rate is reduced to around 1%, in comparison to the industry average of 10%.

Zara’s supply chain strategy is an interesting example of the third hybrid approach mentioned by Christopher and Towill (2001). As the production is kept at a slightly lower level below the expected sales, economies of scale can be achieved while overstock is avoided. Zara deals with base and surge demand by separation in space. Base demand is produced by lower-cost subcontractors to improve cost efficiency, and the spare capacity of the supply chain is utilized when needed, to manufacture surge demand, such that fast response can be provided to the demand peaks.

3.6 Implications

In this chapter, the integration of lean and agile, also known as the leagile concept, is discussed. Bases on the theoretical insights, it seems that the integration can enable the companies to benefit from the advantages of both concepts. Additionally, a number of approaches are introduced on the basis of the differences between lean and agile. The existing approaches tend to suggest that lean should be applied to one part of the supply chain whereas agile should be adopted by another part of the supply chain. However, this chapter also shed light on approaches that combine the elements of lean and agile into
one single concept, which might be applicable to the individual enterprises. Also, these approaches provide an alternative for organizations and supply chains, which prefer to be either lean or agile, although the elements of the rivalry concept might allow them to become leaner and more agile.

In order to find out whether the integration is applicable to different industry settings, six case studies are analyzed. It is interesting to observe that all six case studies support the leagile concept, though the structure of the approaches differs from one case to another. The case studies suggest that lean and agile are compatible and complementary. On one hand, lean is likely to fit industries with stable markets, smooth demand and functional products. Lean is able to shape a highly efficient supply chain when the aforementioned requirements are met. However, lean does not necessarily lead to sustainable competitive advantage, as it can compromise flexibility. On the other hand, agile tends to be appropriate in product-based industries with unstable markets, volatile demand and innovative products with short life cycles. Also, agile is often regarded as a serious alternative to lean when flexibility and market responsiveness need to be improved. Similarly, adopting agile does not guarantee a world’s leading supply chain, as an agile supply chain might be wasteful and thus less efficient.

Given the benefits of the hybrid approaches to combine the advantages of multiple concepts, the integration of lean and agile might provide a solution for supply chains seeking both efficiency and responsiveness. In situations where modular product designs are achievable along with the postponement of final assembly and customization, leagility can enable companies to achieve mass customization, in a way that standardized components are put together in unique combinations. It is however essential that companies are able to accurately predict the demand in the supply chain upstream such that the responsiveness in the supply chain downstream will not be jeopardized. Vice versa, the supply chain downstream should maintain responsiveness and thus not compromise the efficiency of the supply chain upstream. The bottom line is that the applicability should be determined by the supply chain characteristics and business priorities. Therefore, it is possible that neither lean, agile nor leagile is appropriate for some unique business environments.
It is however questionable whether the results from the case studies are generalizable. The doubt is twofold. Firstly, all authors tend to support the integration, and opposing findings can hardly be found. This could be caused by the authors’ bias. In other words, because leagile is a revolutionary concept in the eye of the authors, they might want to promote it, and therefore failed to discover the limitations of the concept. Secondly, as the concept is quite new, the existing studies are aimed to gain insights into the topic, and therefore they are oftentimes qualitative in nature. As mentioned before, case studies tend to be selective and might limit the generalizability of the results (Tellis, 1997). Hence, quantitative studies might be required to measure the effects of leagile and provide hard evidence to test the feasibility of the concept. Despite the need for quantitative research, this study is also qualitative in nature. However, several interviews will be conducted in the next chapter to test the results obtained from the case studies.
4. INTERVIEWS

The case studies analyzed in the previous chapter suggest that lean and agile can be integrated to help companies benefit from the advantages of both concepts. This chapter will try to test the theoretical findings by discussing them with five practitioners. Also, it is expected that the interviews can provide new insights into the lean and agile integration.

4.1 Methodology

The interviews conducted with the practitioners are semi-structured. The objective of the interview is to bring certain experience concerning lean, agile and leagile to the surface, and adapt the subsequent questions to what the interviewee says. Firstly, the potential interviewees are contacted to provide the details of the topic and assess the qualifications of the interviewees. This is based on the predefined information and questions. Secondly, the interviewees are selected on the basis of their knowledge and experience about the topic. Finally, an interview is conducted with the selected interviewees, mostly without predefined questions. This is due to the fact that the interviewees’ experiences differ from one to another. Hence, it is assumed that the best strategy is to let them talk freely about the topic, and adapt the subsequent questions to their talks such that additional information can be obtained.

4.2 Operations Manager

The first interview is conducted with the operations manager of an automobile manufacturer in China. Founded in 1995, the company produces passenger and commercial vehicles based on Mitsubishi developed platforms. Since the company is targeting at the lower-end of the automobile market, increasing efficiency is their major focus. The company adopted lean in 1996, consisting of kanban and just-in-time practices. Also because of the clustering of supply chain partners in the same industrial area, they were able to further reduce the stock holding time from 4 hours to 2 hours. As the company realized that being lean may not be enough to grow in the dynamic Chinese automobile market, they introduced the 3A: agility, adaptability and alignment. The agile practices consist of collecting market information and incorporating it into model designs. Additionally, the company encouraged the suppliers to implement an integrated ERP
system, which allows the supply chain partners to share their real-time requirements and stock information, to shorten the time to market.

The operations manager repeatedly mentioned that being lean is the company’s main focus, since the cost is the major order winner in the lower-end automobile market. However, he is convinced that their company needs to be responsive in China’s ever growing automobile market. Hence, the current strategy is to remain lean, and gradually add the agile elements over time to speed up production processes and new product introductions based on the market requirements.

4.3 R&D Project Team Leader

The second interview is conducted with the R&D project team leader in the printing and digital document management industry. The company operated in an innovative industry with a relatively stable demand. Back in the 90s, the company intended to adopt the lean concept. However, they were afraid that cutting costs will limit the company’s capability to grow. As a result, they decided to adopt lean six sigma. As mentioned by the team leader, lean six sigma is a methodology which combines the original definition of six sigma – improving quality with lean features by measuring and eliminating defects. He argued that the fundamental difference between lean and lean six sigma is that the latter strives to grow and not just eliminate the wastes in existing processes.

In 2006, the company introduced Agile Scrum at the R&D department. The methodology is aimed to manage multidisciplinary product development throughout different stages. The team leader found that the agile practices and flatter organizational structure within the R&D department are well-matched. In cross-functional and self organizing teams, the department tried to achieve daily build, daily automatic testing and frequent deliveries. As a result, it allows the company to deliver products based on the customer’s specification within a shorter time frame.

The team leader believes that the combination of the agility in R&D and lean six sigma in operations can help the company to gain competitive advantages. Especially during the R&D stage, the iterative style of development provides the possibility to evaluate the temporary deliveries with the customers. Subsequently, the feedbacks and specification
changes after each evaluation can be incorporated into the next delivery. Also, frequent evaluations helped the company to gain customer’s trust, and thus make the customers more willing to accept the delays during the production stage.

4.4 Senior ERP Consultant

The third interview is conducted with a senior ERP consultant specialized in production planning and materials management. During his career at a manufacturer in the electronics industry, the consultant participated in a lean implementation project. His task was to design a new production planning system based on the materials requirement planning (MRP) system. It appeared to be weird for MRP to be used for the production planning in a lean environment, since MRP is based on the push strategy from the mass production while lean is a typical (sequential) pull strategy and more responsive to the actual demand. Therefore, it was questionable whether the company’s lean vision was based on the original lean concept. In the end, the consultant decided to implement a decentralized planning methodology alongside the MRP, to shorten the planning time-window, such that the changes can be incorporated into the daily production planning. The consultant mentioned that the MRP system cannot be replaced since it is required to share information with long lead time suppliers.

Also, the consultant confirmed the usefulness of a leagile approach. He suggested that the decentralized planning by lean might still not be capable to deal with orders for which an extreme short lead time is required, especially when manufacturing innovative or high-tech products. This is because the suppliers might not be able to deliver the complex materials and sub-assemblies within a required time frame. Thus, it might require the suppliers to increase stock. Another solution might involve supply chain partners to manufacture in a parallel and synchronized setting, though this requires a sophisticated information system, which allows the supply chain partners to share the real time information.
4.5 Product Manager

The fourth interview is conducted with the product manager in a company operating in the chemical industry. At the production site in the Netherlands the company manufactures an entire range of pre-decoration products (mineral fillers, mineral equalizers, wood repair etc.) which find their way to consumer markets across Europe. In this industry, production is typically make-to-stock oriented, as a result of a stable demand. The product manager believes that lean and agile can co-exist, by making use of the best of both worlds and combining them in a hybrid framework. However, the type of industry, market characteristics and speed of changes occurring, are key aspects which need to be taken into account when implementing such a system.

However, the product manager thinks that the leagile concept is not applicable for their company because of the traditional type of industry in which they are operating. He suggested that the lean concept might be more adequate, as the technological advancement and changes in the industry are often driven by legislation, such as the regulations on volatile organic compounds (VOC), which influences the entire supply chain. Hence, being efficient and providing maximum value to the customers is their major focus.

4.6 Key Account Manager

The fifth interview is conducted with the key account manager of a customer driven third party logistics (3PL) services provider in China. The account manager mentioned that their key accounts mainly are manufacturers and trading companies in the region, which export massively to the foreign markets. As sea freight cargo shipping takes a considerable amount of time, the customers often require a fast response of the service provider. Otherwise, the 3PL will lose their customers to the competitors. Thus, the company always reserves extra capacity, to guarantee the shortest handling and shipping time. The account manager suggested that their customers are willing to pay higher prices to shorten the time to market as much as possible. Thus, being efficient by decreasing spare capacities is not an option.
When proposing to establish a leagile structure by distinguishing the key accounts from the regular or one-time customers, the account manager was quite interested in it. However, he mentioned that the Chinese way of doing business differs from the Western business practices. As most Chinese companies prefer a long-term relationship, the customer base of the 3PL service provider mainly consists of loyal customers. Also, he believes that providing less responsive services to regular and one-time customers might make it harder to retain the customers in this highly competitive market. Hence, the strategy of the company is providing leading services to all customers such that mutual trust will be built over time. The gained trust can subsequently increase the customers’ loyalty, and willingness to pay premium prices, and thus compensate the possible loss caused by overcapacity.

4.7 Implications

In this chapter, five interviews are conducted to assess the applicability of the leagile concept across industries. The interviews confirm the applicability of the concept as well as the assumption that neither lean, agile nor leagile is a universal concept.

Additionally, the second interview provides new insights into the integration approaches. The company attempted to combine agile development with lean six sigma operations to establish a leagile structure. Such a concept also confirms that agile has been receiving attention outside the supply chain management. Based on this approach, a new integration strategy is developed.

As visualized in figure 4.1, the decoupling point is placed between the product development and manufacturing. Agile development allows companies to evaluate the temporary deliveries with the customers and incorporate feedback and changes into the upcoming deliveries. In this way, the company is able to develop a product based on the
changing specifications and needs of the customers. After the prototype is accepted by the customers, the product can be manufactured through lean manufacturing. Since the uncertainties are eliminated in the development stage, lean manufacturing is adequate through efficiency enhancement. In addition, certain flexibility in workforces, enterprise structures and information systems might be required to support the integration. This approach is expected to be applicable to an engineering-to-order setting, though the company still needs to balance the flexibility and efficiency amongst the workforce, enterprise structure and information systems to maximize the profit margins.

![Figure 4.2: Lean, Agile and Leagile Choices Based on the Company’s Focus and Demand Uncertainty](image)

The insights obtained from the interviews are utilized to build the matrix shown in figure 4.2. In this matrix, the horizontal axis represents the focus of the organization, consisting of lean efficiency and agile responsiveness, whereas the vertical axis represents the level of demand uncertainty, ranging from low to high. The matrix suggests that when demand uncertainty is high and the company’s focus is to gain efficiency, a lean oriented leagility can be utilized to ensure the product availability. The agile element within the approach is meant to prevent the company from becoming overly lean, as being overly lean might harm the availability of innovative products as well as the availability of existing products. In contrast, when the demand uncertainty is low, and the company’s focus is to become responsive, the adequate approach might be the agile oriented leagility. This approach requires the companies to incorporate the customers’ changing requirement into the product design and thus achieve product leadership.
The lean approach is regarded to be appropriate for efficiency focus and low demand uncertainty. This is based on the assumption that when demand is stable, the company can focus on the optimization of the existing activities based on relatively constant customer demand, and thus being capable of providing maximum value to the customers. It is expected that this approach allows companies to achieve operational excellence. In the reverse situation, when company prefers to be responsive in a highly uncertain market, the most suitable approach might be agile. This approach enables the company to increase the customer satisfaction and customer loyalty, such that customer intimacy is achieved. As a result, the wastes caused by being flexible and responsive, will be compensated by the higher prices, which the customers are willing to pay.
5. CONCLUSION

In this paper we argue that the integration of lean and agile is immature, and that a comprehensive overview of the concept and its applications are lacking. As it is assumed that such an overview might decrease the ambiguity concerning the integration, this study attempts to gain insights into the leagile concept by comparing the characteristics of the lean and agile concepts based on the findings from existing literature. We utilize and integrate the results of case studies and interviews to find out how to justify integrating both concepts, such that the benefits of both concepts can be combined to improve supply chain management.

After comparing the lean and agile concepts, it became evident that lean and agile share similar attributes, but the emphases might have been put differently. This is due to the difference in objectives amongst the concepts. Lean aims to increase efficiency and value to the customers while agile is designed to increase flexibility and responsiveness. As a result, the concepts vary on service (flexibility) and cost (efficiency), but they exhibit equal emphasis on lead time and quality. Based on the differences between the concepts, some authors argue that lean and agile cannot co-exist, which means that lean and agile will cancel out each other’s effectiveness when integrated in the same supply chain. However, other authors suggest that lean and agile are mutually supportive as the concepts share similar attributes, and the integration will enable the companies to achieve a synergetic effect.

In order to clarify the discussions concerning the compatibilities and complementarities between lean and agile, certain theoretical insights are developed regarding the integration of the concepts, also known as the leagile concept. The leagile concept has the characteristics of both lean and agile, operating jointly to provide maximum value to the customers through efficiency enhancement, as well as maximum service by being flexible and responsive to customer requirements.

The existing literature suggests that the leagile concept can be adequate when neither lean nor agile is capable to deal with certain market conditions. For instance, when demand for product variety is high and demand for production variability is low, as well as when
demand for product variety is low and demand for production variability is high. Also, this study distinguishes the lean oriented leagility from agile oriented leagility to emphasize that leagile is not a one-size-fits-all concept. It is assumed that companies might prefer to be either lean or agile due to the specific environment in which they operate, and certain elements of the rivalry concept can help them to become leaner and more agile at the same time.

Through reviewing the case studies relating to the application of the leagile concept, interesting insights have been obtained. All case studies suggest that lean and agile are compatible and complementary, thereby confirming that different leagile approaches allow the companies to benefit from the best of both concepts. These conceptual developments are often based on the existing approaches such as the Pareto distribution, decoupling point, and base and surge demand, except for one case study company, which attempts to combine agile in corporate structure with lean in manufacturing. The case studies confirm the assumption that leagile is not a universal concept, as the applicability, and the lean and agile elements within the concept are affected by the regulations, market conditions and business priorities.

![Figure 5.1: Lean, Agile and Leagile Choices Based on the Company’s Focus and Demand Uncertainty](image)

The above findings might imply that the integration of the lean and agile concepts can be justified, though the supply chain characteristics and business priorities should be considered to determine the applicability of the concept. In order to assess this assumption, five interviews are conducted with practitioners from different disciplines.
Although all practitioners showed interest in the leagile concept, two of them argued that the concept is not appropriate for their company. Again, it has been confirmed that leagile is not a universal concept, though it can be suitable in certain situations. In order to visualize this assumption, the findings are utilized to build a matrix (figure 5.1). The matrix distinguishes lean, agile, lean oriented leagility and agile oriented leagility to achieve operational excellence, customer intimacy, product availability and product leadership respectively. It is proposed that these four concepts can be adequate for companies with either efficiency or responsiveness focus, operating in a market with demand uncertainty ranging from low to high. Additionally, a new approach has resulted from one of the interviews, which suggests combining agile product development with lean manufacturing.

In sum, the results obtained from literature reviews, case studies and interviews justify the combination of lean and agile to the benefit of supply chain management. The motivation is threefold. Firstly, various case studies and interviews confirmed that the integration is preferable in certain situations, as it allows companies to benefit from the advantages of both concepts. Secondly, since the lean and agile concepts are assumed to be complementary, certain elements of the rivalry concept can help companies to pursue their objectives, and therefore make lean and agile supply chains leaner and more agile. Finally, competitions and changing market conditions require companies to continuously adapt their supply chain strategies. Thus, a hybrid concept such as leagile might be adequate to bridge the transformations either from lean to agile, or from agile to lean, by gradually adding the elements of the preferred strategy. Like every other concept, leagile is not universal. Hence, the applicability of the concept should be assessed on the basis of regulations, market conditions and business priorities. Moreover, insights originated from the leagile applications in software development suggest that the distinctions between lean and agile will start to blur when incorporating more and more aspects of one concept into another. The only thing that matters is whether the company delivers what customers want, within what time frame, and how much profit they can make together with the customers.
5.1 Discussion

Various cases studies and interviews indicated that both lean and agile concepts are often not fully implemented in different settings. In other words, a lot of companies only adopt certain elements of the concepts in their way to become either lean or agile. This could be attributed to the time and costs required to implement the entire concept. Also, it is possible that certain elements from the concept are found to be less applicable. As a result, the companies call themselves a lean or an agile organization, while they have not fully utilized the capabilities of the concepts. It is assumed that these developments could harm the reliability of the findings resulted from the applications, and contributing to the bias in judging the performance of lean and agile. It is therefore uncertain whether these results are sufficiently reliable to establish the comparisons between the concepts.

Additionally, lean is not only about improving efficiency and cutting costs. Melton (2004) point out that lean business also advocates speed issues through practices such as JIT and setup time reductions. Hence, the obtained financial benefit in a lean supply chain is not only obtained through cost-cuttings. Since the core of lean is providing maximum value to the customers, it can be assumed that customer accommodation through leveling up the flexibility and responsiveness are addressed by the lean concept to a certain extent. Therefore, it is recommended to look beyond the efficiency and cost cutting when evaluating the capabilities of lean.

Similarly, Youssef (1994) argues that agility should not be equated with speed and responsiveness as it also requires structural and infrastructural changes including technological advancement and joint improvement along the entire supply chain. It can therefore be assumed that these changes will help companies to increase efficiency. Also, Yusuf et al. (1999) stress that equating agile with speed and flexibility demonstrates a narrow understanding of the concept. Hence, practitioners should realize that agile goes far beyond speed and flexibility improvement.

Moreover, most leagile approaches attempt to integrate the efficiency of lean with the flexibility of agile. As indicated before, the capabilities of lean and agile go far beyond efficiency and flexibility respectively. Thus, academics and practitioners should ask
themselves whether this tunnel vision will yield maximum results when integrating the concepts.

5.2 Contribution

The contribution of this study can be interpreted from both the academic and practical perspectives. From the academic perspective, the study provides an overview of the lean, agile and leagile literature within the supply chain management. Through comparisons, similarities and differences between the concepts are discussed. Also, findings from different authors are contrasted to assess the compatibilities and complementarities between lean and agile. In addition, different leagile approaches are discussed through literature review, case study and interview. It is found that different forms of lean and agile integration can help companies to benefit from the advantages of both concepts. On top of that, the results obtained from the case studies and interviews are incorporated into a two-dimensional matrix, which links the concepts and value disciplines with the market demand and company focus. It is therefore assumed that this study will lead to improved insights into the lean, agile and leagile concepts respectively. As a result, a theoretical foundation and additional insights are provided for future research concerning the applications of the concepts.

From the practical perspective, this study sheds light on different approaches to establish a leagile supply chain. Additionally, the applications of lean, agile, lean-oriented leagile and agile-oriented leagile concepts are distinguished on the basis of the company focus and demand uncertainty. Thus, it is expected that the results can accommodate practitioners to assess the applicability of particular concepts in specific supply chain settings, and subsequently choosing the most adequate concept to improve supply chain processes and achieve competitive advantages.

5.3 Limitations and Future Research

This study, which is conducted to investigate the integration of the lean and agile concept, has several limitations. Firstly, it is uncertain whether the results from the case studies are generalizable. It is interesting to observe that all authors support the integration, and
opposing findings can hardly be found. This could be caused by the authors’ bias. In other words, because leagile is a revolutionary concept in the eye of the authors, they might want to promote it, and therefore failed to discover the limitations of the concept. Also, as the concept is quite new, the existing studies are aimed to gain insights into the topic, and therefore oftentimes qualitative in nature. Hence, quantitative studies might be required to isolate the effects of leagile and provide hard evidence to test the concept.

Secondly, the results derived from the interviews might have a lower external validity, which means that the results might not be generalizable to all supply chain settings. The external validity is threatened by the number of interviews conducted. Thus, more interviews might be required in the future to increase the external validity of the results. In addition, it is recommended to randomly select the interviewees across industries to further improve the external validity.

Thirdly, despite of data triangulations, such as data, theory and methodology, are applied into this study, the internal validity of the results cannot be assessed precisely. This is due to the nature of the study, which is qualitative. Hence, findings of this study should be tested through quantitative methods in subsequent studies.

Fourthly, this study suggests distinguishing the lean, agile, lean-oriented leagile and agile-oriented leagile, but no frameworks are provided for lean-oriented and agile-oriented leagile concepts. Therefore, future research should attempt to define a framework to test the applicability of the concepts.

Finally, this study suggests linking the lean, agile, lean-oriented leagile and agile-oriented leagile concepts to operational excellence, customer intimacy, product availability and product leadership respectively, but the relationships are not tested. Thus, the relationships between these value disciplines and the concepts provide an interesting direction for future research.
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