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Identifying Wastes in Supply Chain Coordination

Master of Science Thesis in Master Degree Program Quality and Operations Management

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CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden, 2012
Report No. E2012:003

MASTER'S THESIS E 2012:003

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Chalmers Reproservice
Göteborg, Sweden 2012

Abstract

A supply chain is a very wide concept, which contains several issues and aspects when it comes to management. Lean is a common approach applied to several environment settings, such as manufacturing and service operations. Applying lean to manage supply chains is also a popular study field, attracted many industrial practices and academic researches with various applications.

In this thesis, the author also would like to merge lean approach into supply chain management, but with a new perspective. The central of lean is to improve through relentless waste elimination; and the importance of the coordination in a supply chain has been recognized, a key success factor in superior supply chain performances. However, there seems no research exploring the possibility of linking these two areas, adapting the thinking of lean to manage the coordination in supply chains. In this case, the thesis works as a pilot study in developing a framework of methodology to identify wastes associated with the coordination in a supply chain for further improvements. With better coordination in a supply chain, the efficiency and effectiveness of supply chain performance is expected to improve.

Key words: Supply Chain, Lean, Supply Chain Coordination, Lean Wastes

Acknowledgement

The thesis work took a large amount of time and effort to accomplish, with the supports of a group of people; without these people the thesis would not be completed. Here I would like to send my thanks to the persons facilitating the thesis research. First, the supervise team, both from the university and the industry, Magnus Persson and Maximilian Pasche at Chalmers, Emma Westerberg and Mohammad Bakht Shirin Armin; thank you all for the guidance in the thesis research, which is inspiring. Especially to Emma, thank you for the patience and experience sharing during the entire supervision period. I learned a lot by seeing your way of working. Also, thank all the interviewees and people who participated information sharing and data gathering for the thesis research. Especially Mika Partala, thank you for the generous help and arrangement in performing the case study.

Special thanks to my dear beloved family and friends, without your supports, I could hardly finish the education at Chalmers. It is a life time experience to spend three and a half years in Sweden. Thank you all my family in Taiwan, supporting my decision in studying aborad; thank you for the love and care even we were away from each other. Thank you, Eivor Niklasson and Henrik Balke for being my spiritual mentors and carrying me through the toughest time with encouragments. I am so grateful to meet you when the life value is different from person to person and I can look after you. Thank you, Tarik Olevic for your selfless infromation sharing and helps; you are the coolest. Thank you all for sharing my tears and laughers, turining a beautiful page of my life.

Göteborg, January, 2012

Ting-Chen Su

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1. Introduction

In this chapter, the general information of the thesis research would be introduced. First the background provides the initiation of the thesis research and following with the purpose, the sub-purposes for the thesis research were defined. In the end, the delimitation in the thesis research would be presented.

1.1.Background

Supply Chains have been an influential leverage for the world leading enterprises to outperform their competitors; the researches have indicated that companies excel in supply chain operations winning almost every measure of financial success (Accenture, 2003 & Krivda, 2005). *''A supply chain is all the activities associated with transform the production resources from the raw materials to the final product delivered to the end customer ''*

(Schniederjans *et* al., 2010).

The composition of a supply chain comprises various units, organizations, facilities, departments and so on, devoting joint efforts to fulfill the customer requirements. Since the operations in a supply chain involve several different units, especially legally independent organizations, the coordination in a supply chain is a key successful factor, which aligns the different units working coherently towards the mutual objective. To improve the supply chain performance, the coordination in a supply chain should be improved. With the coordination across a supply chain, the efficiency and effectiveness of the chain are expected to increase (Sandberg & Bildsten, 2011).

On the other hand, as one of the most common approaches applied for making improvements, Lean has been activated in various industries for decades, especially in automotive industry; the word itself implies lightweight, in the sense of speed and agility. Initiated from the production system of the world's currently biggest automaker and one of the leading enterprises, Toyota Motor Company (TMC), Toyota Production System (TPS) is famous for its efficiency, quality, and consistency in the product and production process (Liker, 2004 & CBSNews, 2011). In describing the features of TPS, lean refers to the business capability of accomplishing more with less, which contains world-class practices (Sayer & Williams, 2007 & Tapping, 2008).

Since its birth, lean has been evolved noticeably from originally a manufacturing method to a more comprehensive concept joining with philosophies, methods, and tools. For which, the center thinking is through relentless waste elimination to achieve continuous improvement. Today in sum, *''lean is a systematic approach that focuses the entire enterprise on continuously improving quality, cost, delivery, and safety by seeking to eliminate waste, create flow, and increase the velocity of the system's ability to meet customer demanc*

MainStream (Plenert, 2007).

Combining lean and the supply chain together, the similarity and new opportunity reveal. Both of them emphasize on customer focus, delivering the customers only what they want. The customer requirements are the mutual objectives should be coordinated in a supply chain (Schniederjans *et* al., 2010). The coordination in a supply chain plays a critical role in achieving the success in a supply chain, since poor coordination results in poor supply chain performances (Ballou *et* al., 2000). In this case, applying lean to improve the coordination in a supply chain provides a new opportunity to reach the world-class supply chain performance; eliminating wastes in inadequate coordination in the supply chain to improve the supply chain performance.

1.2.Purpose

The purpose of the thesis is to develop a methodology for identifying wastes associating with the coordination in a supply chain, and giving suggestions for improvement.

1.3.Sub-Purpose

In order to achieve the purpose of the thesis, three following sub-purposes were developed ensuring the thesis purpose would be answered comprehensively. By answering the sub-purposes the flow of thesis report is naturally composed.

1. What are the wastes associating with the coordination in a supply chain?

A supply chain contains several different activities to perform the supply chain, and waste refers to something unwanted during the process. As wastes involving in a supply chain present with various formats which correlate with different types of issues, the wastes concerning in the thesis should be recognized before they are able to be identified. In this sub-purpose, what wastes are regarding to the coordination in a supply chain would firstly be answered.

2. How can the waste associating the coordination in a supply chain be identified?

As mentioned, wastes involving in a supply chain present with various formats and correlate with different types of issues. It requires different methods and criteria to look into in order to identify the different types of wastes involving in a supply chain. So in this sub-purpose, the method for identifying the wastes associating with the coordination in a supply chain would be presented.

3. How can the coordination in a supply chain be enhanced?

The ultimate goal for waste identification in the coordination in a supply chain from a lean perspective is to improve its performance. The last sub-purpose in the thesis is to provide improvement suggestions to enhance the coordination in a supply chain.

1.4.Delimitation

A supply chain is very complex system, and involving many units and activities, and SCM contains several phases from product development, production, and aftersales services so on, involving various issues, such as partnership, marketing strategy, and contracting etc. Due to the restricted time, effort, and resources, the case study performed in the thesis research was limited to only the first tier supply chain, from the first tier supplier of the central business to the case company and the intermediate in between. Also, the product development process, aftersales market, and long term planning and partnerships development are beyond the scope of discussion. The thesis research only concerns about the issues in the coordination in a supply chain while execution.

2. Theoretical framework

To fulfill the purpose of the thesis, a series of literature reviews were conducted during the research period, which provide the fundamental knowledge to perform the thesis research. In this chapter the result of the literature review would be presented. Beginning with supply chain, the composition of the supply chain would first be introduced, continuing with the topics in supply chain management (SCM). After that the knowledge of lean, lean thinking, just-in-time, and pull system would be provided. In the end of the chapter, different types of wastes from both lean and SCM are presented.

2.1.Supply Chain

A supply chain is ''*all the activities associated with transformation and the flow of goods and services with the involving information flow, from the state of raw materials to the final customers*" (Ballou *et* al., 2000). For which the goes only one direction from the upstream the downstream; on the other hand, information flow goes both directions (See, Figure 2-1). In a supply chain, these two flows go hand in hand, could hadly isolate each other (Plenert , 2007).

The composition of a supply chain, it begins with the central business which could be manufacturing or service operations; then extends to the other partners. Together with the central business, these partners are referred as supply chain actors in the theses. A supply chain actor could be a company, a plant, or a facility and each actor plays different role in the supply chain. Extending from the central business, the upstream partners are the suppliers, which could be providers of raw materials, components, equipment, technology, human resources, transportation services, and so on; on the other side, the downstream customers could be the wholesalers, retailers, or distribution centers, and so on, both business and individual customers (Christopher, 2011; & Schniederjans *et* al., 2010).

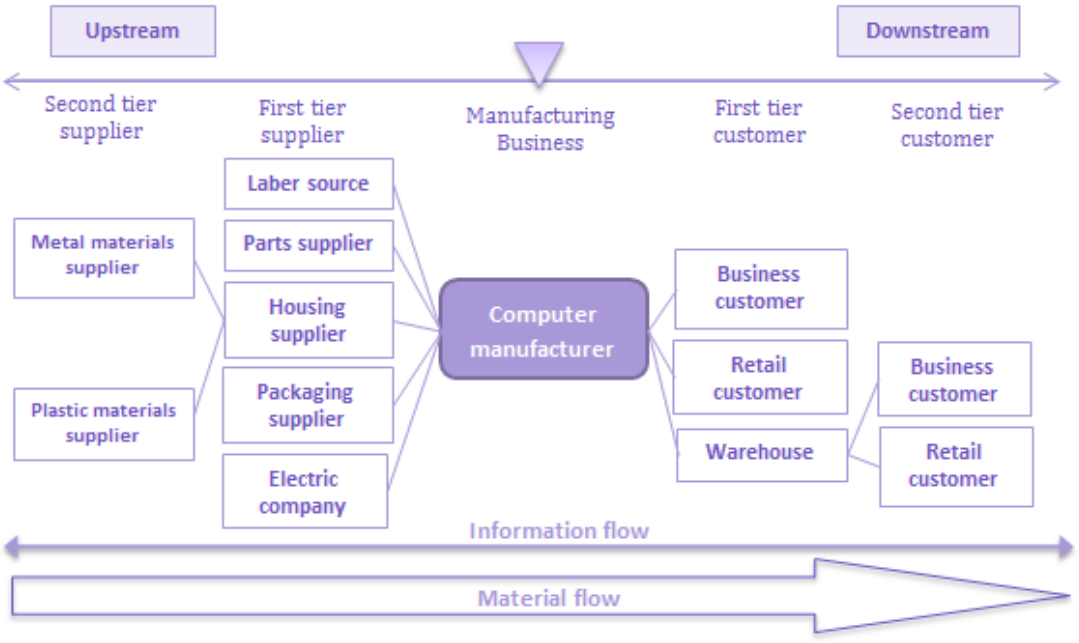

Figure 2-1 Example of a supply chain in computer manufacturing business, adapted from (Schniederjans *et* al., 2010)

To illustrate the relations of these actors in the supply chain, the suppliers and customers are classified into tiers (See, Figure 2-1). For example the suppliers provide resources directly to the central business are the first tier suppliers; they are closet to the central business. And their suppliers, the suppliers of the first tier suppliers, are called the second tier suppliers accordingly. The same rule applies to the customer side, the direct customers of the central business are the first tier customers and their customers of the first tier customers are the second tier of customers. By looking into the material flow, the flow of materials goes from one actor to another; the first tier suppliers and customers direct link to the central business. And the second tier suppliers link with the first tier ones, so as to the customer side. Yet in the real life, a second tier actor could be the first one at the same time; thus, instead of a "chain", a supply chain is actually rather than a network providing the product to satisfy the ultimate customers' requirements (Christopher , 1985).

2.1.1. Supply Chain Processes and Activities

Three fundamental processes or stages in a supply chain actor are procurement, production, and distribution. An actor purchases required resources, provides with operations, and then deliver the product, a good or service, to its downstream customer. In general, a supply chain is composed by the operations of these three basic processes in each actor, connecting together in fulfilling the requirement of the end customer (Thomas & Griffin, 1996).

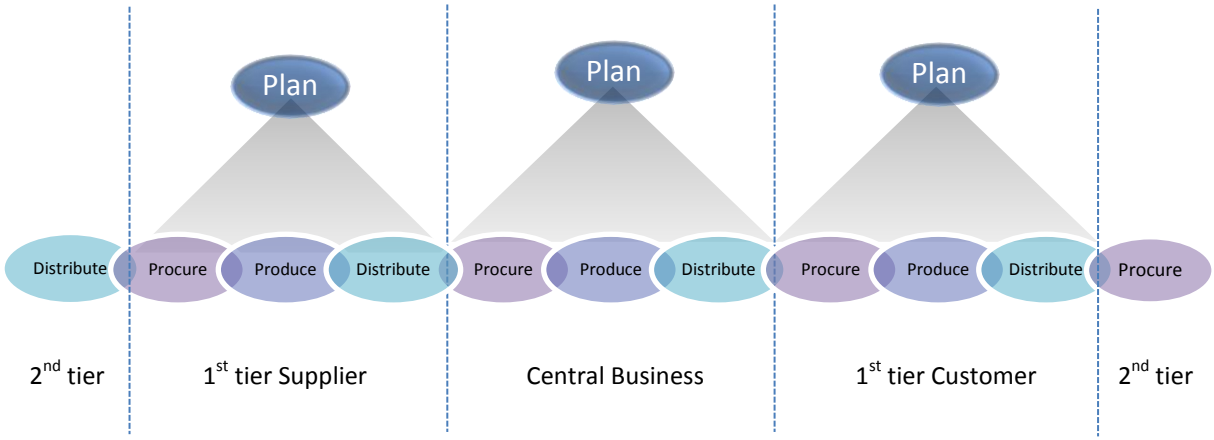

Figure 2-2 Composition of three basic processes in a supply chain, adapted from SCOR model, SCC (2010)

Besides these three fundamental stages, the operations of a supply chain could be further divided into different sub-processes and supply chain activities. A supply chain activity *may be a process, operational unit, or human resource acts with computer, human, biological, or other systems in the supply chain* (Whang, 1995). In the operations of a supply chain, a process or sub-process could be further divided into one or several activities. Supply chain activities could be the actions directly contribute to the output of the operation process, such as machining, manufacturing, and sub-assembly in manufacturing activities. Also there are some activities acting with the management purposes for other activities interacting together, such as production planning and scheduling, order processing, supply chain strategies, contracting, and so on (Malone *et* al., 1994).

2.2.Supply Chain Management

The initiation of SCM concept could be traced back before 1960s, and the use of the term, SCM, emerged in the 1980s and since then it has increasingly caught the world's attention. In the 1990's, SCM gained its popularity in both researches and practices; abundant of studies were published associating with SCM, and the world leading companies, such as Dell, Nokia, and Zara, applied it as the powerful leverage to outperform their competitors (Accenture, 2003; Huan *et* al., 2004; Schniederjans *et* al., 2010; & Mentzer, *et* al., 2001).

The scope of SCM is rather broad from the strategic level to the operational level, and spread through different business functions in a company such as product design, marketing and sales, manufacturing, customer service, to product disposal, and so on. (Mentzer, *et* al., 2001; & Chopra & Meindl, 2007) One definition of SCM is ''*the systemic, strategic approach to coordinate the business functions of a company together as well as to across the supply chain, for the purpose of improving the long-term performance of the supply chain and the involving companies* ''

(Mentzer, et al., 2001).

In the past, companies used to focus on the most effective decision making in a single facility, and these sub-optimizations may result in a poor overall performance (Thomas & Griffin, 1996; & Zimmer, 2002). Because of the increasingly demanded customer requirements and intensified global competition, companies tend to outsource their non-core operations in searching for new competitive advantages. Facilitating by the advanced information technology (IT) development, companies enable to work closer to each other. Companies increasingly recognize themselves as a part of the supply chain, and the competition has moved from between companies to between supply chains. Accordingly today the focus in SCM is to coordinate the involving companies in a supply chain working jointly towards the mutual goals. Such goals might be cost minimization, profit maximization, responsivness or stabilization in the supply chain (Schniederjans *et* al., 2010; & Simatupang *et* al., 2002).

2.2.1. Coordination in Managing a Supply Chain

A supply chain is a complex system, containing various activities which are correlating with each other, spreading through different business functions, and organizations; the dependencies between supply chain activities are the prerequisite for coordination (Productivity Press, 2006; & Soroor, *et* al., 2009). The purpose of coordination in a supply chain is to align all the activities working jointly as a unified system then stimulate the overall supply chain performance (Arshinder *et* al., 2008). Several literatures have stated that coordination in a supply chain is a key factor for a successful supply chain. Poor coordination in supply chains could lead to dysfunctional supply chain activities as to poor performances, such as low capacity ultilization, excess inventory, high total cost, low customer satifaction, irresponsive order fulfillment, and so on (Arshinder *et* al., 2008; Ballou *et* al., 2000; & Simatupang *et* al., 2002).

The need for coordination in supply chains has been recognized; yet there is no clear definition in the theory. The most commonly adopted definition of the coordination in the supply chain is from Malone *et* al. (1994), *''coordination can be seen as the process of managing dependencies among activities.*'' In managing a supply chain the dependencies of supply chain activities should be managed (Arshinder *et* al., 2008).

2.2.2. Three Dimensions of Coordination

The management of supply chain activities, some may only involve a single business function and others may involve different functions and even actors. Three dimensions of coordination are indicated in Ballou *et* al. (2000), for the success of SCM, namely intra-functional, inter-functional, and inter-organizational coordination accordingly (See, Figure 2-3).

In an organization, the division of responsibilities and working processes is often according to the dependency of supply chain activities, for which the activities in a supply chain function is likely to have the same authority in management and control. However the resource is constraint in both operations and management, there are trade-offs between the operations of supply chain activities, especially within the same function. For example, there is a trade-off between the costs of inventory and transportation activities in procurement of a supply chain actor. Here intra-functional coordination is required to evaluate and balance the trade-offs in optimizing the outcome of the function. But since the power of management and control is likely to be same centrol, from the same authority, intra-functional coordination is rather easy to achieve (Soroor *et* al., 2009; Arshinder *et* al., 2008; & Ballou *et* al., 2000).

Figure 2-3 Three dimensions coordination in supply chain management (Source: Ballou *et* al., 2000)

Furthermore, there are also activities involving more than one function in a supply chian, such as supplier selection of an actor. In order to select the right supplier with requisite capabilities, and fruther develop the suitable purchasing strategy, the reuqirements for product development should be conveyed to the phurchasing function. When it comes to performing such an ativity like this, inter-functional coordination is desirable (Ballou *et* al., 2000).

The last but not the least, inter-organizational coordination. As mentioned previously, a more and more competitive business environment increases the opportunity of companies working together as a system. Under this circumstance, an inherent nature of potential conflicts existing between companies should be resolved. Conflicts between supply chain actors may due to different objectives and perceptions, disagreements in performance measures and incentives, or ambiguous authority, responsibility, and roles (Arshinder *et* al., 2008; Albrecht, 2010; & Soroor *et* al., 2009). Finally, in SCM coordination across supply chain actors without organizational boundaries is emphasized, ''*integrated planning, coordination, and control over all inter-organizational processes and activities in the supply chain*'' (Stock *et* al., 2010). And the focus of coordination in SCM has moved from intra-organizational to the inter-organizational and even inter-organiozational one (Ballou *et* al., 2000).

2.2.3. Coordination Mechanism

In succeeding in coordinating a supply chain across activities, functions, and even organizations, implementation of proper coordination mechanisms is essential, for both internal uses among business functions in a supply chain actor or the enteral links with the suppliers and the customers. The suitable utilization of coordination mechanisms is expected to increase efficiency and effectiveness in the operations the actors and the supply chain (Sandberg & Bildsten, 2011).

Some coordination mechanisms implemented in the operations of a supply chain from commonly mentioned by several researchers, connecting business functions and supply chain actors. The core concept of SCM is to align all the actors behaved as a unified system towards the mutual objectives. From this perspective, the mutual objective for the supply chain, resolving the potential conflicts between actors or functional managers, is vital. The common objective with the focus of optimizing the overall results of the supply chain, also bring benefits to the individual actors. Expressing in concrete formats, the mutual goals are often performed with the contracts and agreements among actors, which provide the standards for the actors regarding to their responsibilities, duties, and tasks (Porteus & Whang, 1991; & Whang, 1995).

Ensuring certain performances are achieved by responsible units, actor, process, or individual personnel, performance metrics are applied as a coordination mechanism, to illustrate the expectations from the other units or the direct management. The established measures functions as an objective and direct units to work in a way reaching the performance as possible. The measures could be either internal or external uses. For the external use between actors, the formal contract or agreement are likely applied (Soroor *et* al., 2009).

Another critical factor is regarding the issues in infromation exhanges. In managing a supply chain, the information flow is the power; the operations in the material flow are perfromed in the manner designated and controlled by the infromation flow (Productivity Press, 2006; & Dibenedetto, 2007). In this factor two different criteria, information technology (IT), and information sharing. Information sharing could be defined as the act to dismminate common understadeing among the involved parties, functions, actors, organmizations and so on, which play a big role if the supply chian actors would like to work togther with the long-term relationships (Simatupang *et* al., 2002). Shared information provides the visibility of the operations in supply chain processes, such as customer demand, product-related data, costs-related data, process-related data, and performance metrics so on (Soroor, *et* al., 2009). Besides, the public information for coordination in operations; information sharing in some previate data of the actor brings in positive results for the supply chain. For exmaple, the customer sharing the demand data with the supplier enables the supplier to schedule and ulilize the resources more effecicnty (Soroor, *et* al., 2009).

Information sharing or transparancey is encourged in developing a seamless supply chain, which requires the free flow of information among processes, functions, actors, and even organizations (Stamm, 2003). Implementation of Information Technology (IT) systems enabls the transformation efficiency and the quality of infromation exchanges, the accuacy, which resloved the potential human factors in processing the wrong data. For exmaple, one of the commonly used IT systems is electronic data interchange (EDI) messages. In conclude, with suitable IT system in supply chain coordination bringing positive result for the information flow; and in the end, supply chain performance is stimulated (Soroor, *et* al., 2009).

2.3.Lean

Initiating from the Japanese automotive manufacturer, Toyota Motor Company (TMC), lean is also used synonymously with the Toyota Production System (TPS). Established in the 1930s by Sakichi Toyoda, TMC is famous for its efficiency and quality, the consistency in the product and process (Liker, 2004). In 1988, a group of researchers at Massachusetts Institute of Technology (MIT) led by Dr. James P. Womack found out Toyota required less effort, time, and resources to design, make, and services their products, also there were less defects and employee injuries within the process. Later on, lean was used to describing the circumstances observed in Toyota; implying the production system of TMC was lightweight and responsive (Sayer & Williams, 2007).

The origination of TPS was in a server industrial environment in Japan after the World Word II, and TMC faced strong competition from the American automotive manufacturers. In order to keep up and be competitive, in the next a few decades a variety of solutions to particular limitations were generated in TPS by a key engineer in TMC, Taiichi Ohno, who was also known as the father of TPS (Murman *et* al., 2002). Some prominent solutions till applied today and also by numerous different companies; these terminologies are often tied up with lean, such as pull system, kanban, and Just-In-Time (JIT); but lean is more (Trent, 2008; Plenert, 2006; & Tapping, 2008).

Since the outperformance of TPS was noticed in 1988, lean has attracted numerous researchers in investigation and evolved considerably. Nowadays lean contains many dimensions from philosophy, management framework to methodology and tools, with numerous of the world's leading companies applications (Sayer & Williams, 2007). Lean is both a science and practice, which could be defined as *''a systematic approach that focuses the entire enterprise on continuously improving quality, cost, delivery, and safety by seeking to eliminate waste, create flow, and increase the velocity of the system's ability to meet customer demand''*

MainStream Management (Plenert, 2006).

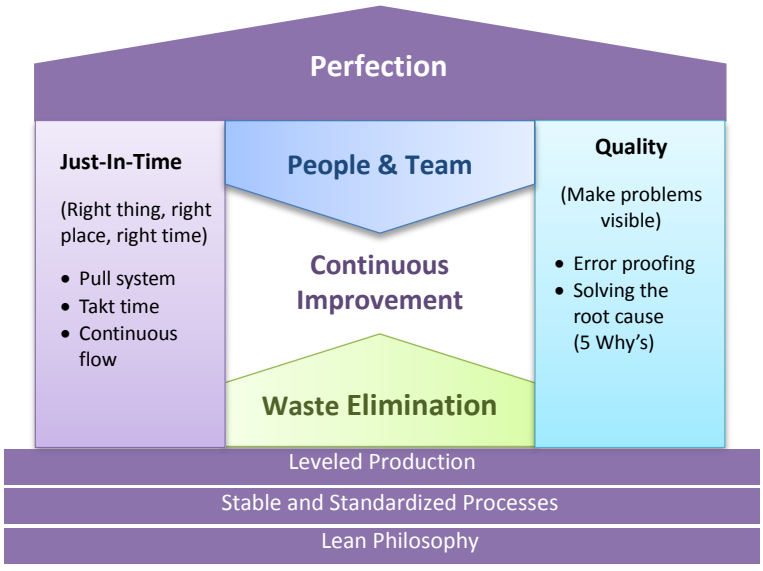

Figure 2-4 House model of lean, adapted from TPS model in Liker (2004)

2.3.1. Lean Thinking

In Figure 2-4, the house model presents the foundations building up Toyota Production System (TPS); these are also main concepts of lean, the thinking, strategy, and approach. The world is always changing, so the improvement should always be made. From the model, it is known that the core of *Lean Thinking* is to improve continuously through wastes elimination and people's involvement. The common approaches applied in lean include adopting just-in-time (JIT) strategy with pull system to eliminate wastes, and involving everybody to uncover the problem in the process and increase the quality. More information regarding to JIT strategy and pull system could be found in the following sections, 2.3.2 Just-In-Time and 2.3.3 Pull System.

Agreed among several researchers the primary target of lean is the relentless elimination of wastes (Dibenedetto, 2007; Murman *et* al., 2002; Plenert, 2006; & Trent, 2008). The main spirit in lean thinking is to *do more and more with less and less while bring customers with exactly what they want* (Womack & Jones, 2003). So there would be no wastes produced. *Kaizen* is a Japanese word referring to a problem solving process for the ongoing improvement based on knowledge, 'learning by doing'. The process of improvement in learning by doing highlights the importance of listening to everyone's voice, not just from the experts and the managers but also the operators, and promoting cross-functional teams in the working environment for joint learning. Also providing education to personnel enables them requiring enough knowledge (Murman *et* al., 2002; & Larkin, 2006).

Moreover, some other philosophies or disciplines are used as the foundation when applying lean. The most underground base is the development of lean culture, the commitment to be lean. In the operations the stable and standardized processes are underlined. With standardized processes and procedures in operations when there is any problem, it would be revealed. This corresponds to the right pillar that uncovering the problems and solving the root cause to enhance the quality. Another purpose of standardization is to be the bases for improvements. Furthermore, for more efficiency, leveled production makes the production resources allocation and utilization easier to be managed, and visualization facilitates the convenience and effectives in operations. From these mentioned above, it is found that quality and efficiency are the features promoting in lean (Liker, 2004).

2.3.2. Just-In-Time

One of the most commonly terms attached with lean is just-in-time (JIT) strategy for materials control. JIT indicates that the required materials and resources for operations arrive 'just in time' when they are needed; the right item arrives with the right amount, in the right time, and the right place. Originated from a manufacturing environment, it referred to production materials should arrive at a manufacturing unit when they are required. Hence, no extra resources are wasted in keeping the materials or idled in waiting for others. But what is more, the application has been extended to operations in a supply chain, JIT materials supply and JIT delivery.

It is hardly to implement JIT internally without external support from the involving the suppliers to supplement their products and services in a coherent manner. JIT in supply chain management (SCM) seeks for long term relationships with reliable suppliers for the better overall long term objective, which a single actor could hardly achieve itself. The desired characteristics of the suppliers to develop a long term relationship are about the quality of the supplied products, capabilities of the suppliers for joint development, and the attitude of joint efforts in problem solving and improved continuously (Schniederjans *et* al., 2010). Also, the performance of JIT in a supply chain heavily depends on the supplier's capabilities in providing goods steadily and with flexibility when it is needed. In JIT, the production and material supplies tend to be small lot size but continuously; but at the same time, the supply chain also would like to be responsive to the customer demands or deviations. It turns out with shortest lead time with limited inventory level. In this case, responsiveness in timely communication and capability in stable supply and attitude towards problem solving are the valued features of the suppliers in JIT strategy.

In functioning JIT strategy, a couple of approaches or techniques accompanied with the strategy to strengthen the entire system, including production takt time, a cycle time set-up to provide downstream operations steadily with a continuous flow, and customer pull (Murman, et al., 2002).

2.3.3. Pull System

In contrast to the traditional make-to-stock (MTS), production push, pull system is applied accompanying with just-in-time (JIT) approach. Pull is not equal to make-to-order (MTO), it indicates in the production or other operations environments that ''no one in the upstream should produce a good or service until the downstream customer ask for it'' (Womack & Jones, 2003). This statement in lean thinking extends the scope and lean applications more than just for manufacturing but also including service operations. Also the concept of 'the customer' is not just limited to the end customers, the consumers, which are emphasized by both some researchers in Lean and SCM. They declared that since the end customers are the ones pay for the product, good or service, the assessment of wastes and improvement areas should be based on their conceptions. Nevertheless, in Total Quality Management (TQM) proclaimed that ''the next process is the customer''. Especially, in an internal operations setting, there is no real customer involved. The downstream process should be treated as the actual customer that the requirements should be fulfilled. This interpretation is progressively acknowledged in researches and practices (Baudin, 2004).

2.4.Different Types of Wastes

Waste is something contrary to value, and value creation for the customers is both emphasized in SCM and Lean. By applying lean in managing a supply chain, value creation could be enhanced through wastes elimination. Eliminating unnecessary wastes during the process, both within the operations of a supply chain actor, and between the interfaces of supply chain actors, creates higher value for the customers as to the supply chain. The competitive advantages of the supply chain and the involveing actors are accordingly ensured (Barker & Naim, 2004; & Plenert , 2007). Next wastes could be identified in the operations of a supply chain and the descirption of different categorizations would be provided in the following sections.

2.4.1. Traditional Wastes in Lean

There are seven types of wastes recognized in Toyota Production System (TPS), a production setting with the orientation of a single manufacturing facility; and due to its setting, the recognized wastes are from a physical perspective. These wastes are classified into seven categories, namely overproduction, waiting, motion, transportation, over processing, and inventory. Moreover, many lean literatures state one more category of wastes, untapped employee creativity. Involving everyone is one of the emphases in lean thinking; no one else but them is clearer about where should be improved in their daily work. Without fully used their expertise it is a waste (Tapping, 2008; & Liker, 2004). As supply chain activities also include production processes in actors, these wastes involved in the production should also be identified and eliminated from the supply chain. The description of the seven plus one types of wastes in lean, please refer to Table 2-1.

Table 2-1 Eight types of wastes in lean, adapted from Morgan (2009) and Tapping & Shuker (2003)

Wastes Category	Description
Overproduction	The biggest enemy in lean since it is the source of the other sex categories of wastes. Overproduction represents providing a product or a service prior to it is required, the extra production would cost extra production materials and operation resources. ''It is better to have idle production capacity than overproduction. (Trent, 2008)''
Excess inventory	Excess inventory is often a result of overproduction, which represents the surplus of products in the working process. The surplus product may become obsolete and take extra resources in production and preservation.
Waiting time	Waiting time represents the idle time stops in the working flow; this type of wastes is rather easy to identify and even improve.
Unnecessary transportation	Unnecessary transportation represents moving materials and output unnecessarily, which include moving surplus materials or operation resources for temporary locating and stocking.
Extra motion	Extra motion represents any motion that is not necessary to the successful completion of an operation; this may result from poor organization layout, ineffective equipment, and other human factors so on.
Over processing	Over processing represents unnecessary processing steps to fulfill customer requirements, which is the most difficult type of wastes to uncover.
Defect and error	Defect and error represents defective work in meeting customer requirements requires putting extra resource for correction or reworks.
Untapped employee creativity	Untapped creativity of employees represents without fully utilizing the creativity from each employee in making improvement, another category of wastes stated by many lean researchers.

2.4.2. Wastes in Supply Chain Management

Besides the seven plus one types of wastes recognized in lean, more types of wastes could be identified, when it comes to supply chain management (SCM) (Trent, 2008). Information flow is the other key flow besides the physical material flow, also the effort of management and control is required in SCM. The description of the other types of wastes in SCM, please refer to Table 2-2.

Table 2-2 More types of wastes in SCM, adapted from Trent (2008)

Waste Category	Description
Digital waste	This type of wastes refers to redundant or unnecessary data requiring extra resources to collect, manage, transmit, or restore without tactical or strategic reason.
Duplication of effort	This is easy to happen in lager organizations, in which each operating location has its own process or ways of working even dealing with the same operations.
Overdesigning	The wastes refer to the product design that the engineers and marketers tend to insert as many functions/features as possible to a product regardless if customers' requests.
Excessive overhead	The wastes refer to the over design in organization or supply chain structure that cause extra layers and process requiring extra cost and time in delivering the result.
Poor planning	The wastes refer to the misalignment in supply chain information resulting in the unbalance of supply and demand or extra efforts for information exchanges.
Poor measurement	The measurement reflects the objectives an organization would like to achieve and measuring the wrong attributes not just consuming extra resources, it also leads the managers and employees focus on the wrong issues.

3. Methodology

In this chapter, how the thesis research was conducted would be introduced. First, the design and procedure in conducting the thesis research would be presented. Then, the details of data collection approaches and sources would be described next. In the end of this chapter, the reliability and validity of the thesis research would be discussed.

3.1.Research Design

To fulfill the purpose of the thesis, methodology development, the thesis research adopted the case study as the research strategy. The case study is one of the most common strategies applied in conducting social science researches; some other strategies are for examples, the experiment and the survey. Depending on the types of research purposes, the preference in selecting the research strategy would be varied; many social scientists convince this is the only appropriate strategy when it comes to the exploratory investigation. Also, the case study strategy is especially valid in answering ''how'' questions regarding to contemporary events (Yin, 2002). In this this research, the author would like to explore how the wastes associating with the coordination in a supply chain could be identified, by investigating a real case, the coordination in part of a supply chain.

The design of the thesis research is to develop the methodology based on literature researches but involve the empirical evidence at the same time, to support the theoretical finding with the empirical data. The empirical circumstance was considered during the developing period; also the outcome of the methodology would be validated and refined through performing a case study. The defining case to perform the case study would also evolve with the theoretical finding during the research period, in optimizing the outcome of the thesis research, combining both the theoretical and empirical study.

3.2.Research Framework

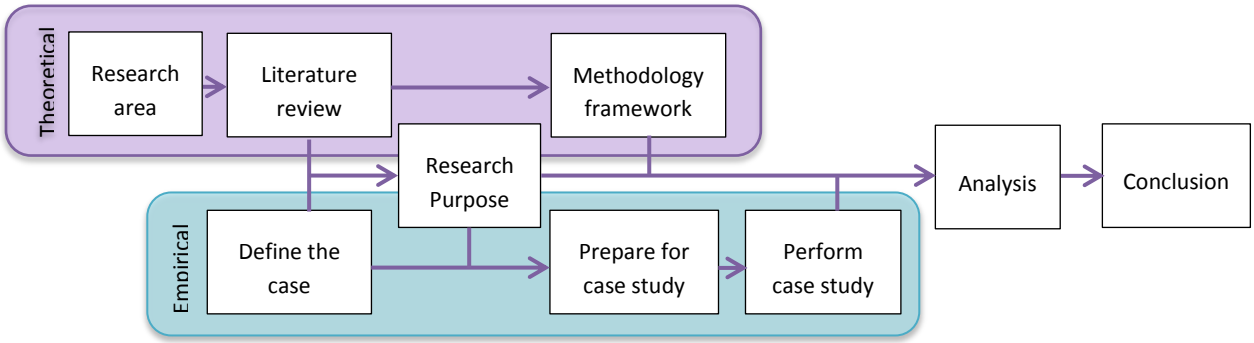

Figure 3-1 Framework of the thesis research procedure

The thesis framework of the research could be seen in Figure 3-1, which shows the procedure of conducting the thesis research. Aligning with the research design, developing the methodology with a theoretical basis and validating the methodology with empirical data, the theoretical and empirical study ran parallel during the research period. At the end the conclusion of the research would be generated through combining and analyzing the findings from both of the studies.

At the beginning of the research period, a large amount of literature researches was conducted in the research areas of Supply Chain and Lean from published journal article and books, in acquiring enough knowledge background and formulating the purpose of the research. Both Lean and Supply Chain are well developed research areas, evolving over time in fitting the content of contemporary global development and different environment settings. So the challenge at the beginning of the research was to combine supply chain and lean, two popular research areas containing broad research topics; identifying the similarity and research opportunities of supply chain and lean, to create the purpose of the thesis research, but prevent the duplication of previous research works at the same time.

After the primary research concept framed with case study as the research design, the study of empirical case selection started to be performed through a number of empirical data collection methods which would be present in 3.3 Data Collection. The process of defining the case for detailed data collection initiated with the case company, a final truck assembly manufacturer in the truck manufacturing industry; and the scope of investigation was set on the first tier supply chains of the case company under the consideration of the available time and effort with the trade-off between research depth and width. The final decision of formulated case to perform the case study design is the engine supply chain from the first tier supplier to the case company. The collected data from the empirical study would be presented in Chapter4, Result.

Refining the research purpose through a series of theoretical and empirical study, the research purpose was finalized to develop a methodology based on a theoretical perspective and validate the methodology through an empirical case. In the case study, the current state of supply chain activities and the requirements for supply chain coordination in the in the case would be investigated as the method to identify waste and improvement areas associating with the coordination in the supply chain. In comparison the developed methodology framework and the performed case, the analysis of methodology development for waste identification in supply chain coordination and improvement suggestions in enhancing the coordination in supply chains would be given. Also, at the end of this report, a conclusion of the thesis research would be provided.

3.3.Data Collection

During the period of the thesis research, several different means for data collection were applied, which encompass both theoretical and empirical date. The main leverage for theoretical data collection is through literature reviews, which provide required knowledge in conducting the thesis research. A case study was performed to support achieving the research purpose with empirical data. One of the principles of data collection in case studies is to use multiple sources of evidence to increase the convincingness and accuracy of finding or conclusion. There are six most commonly used sources of evidence for data collection in case studies addressed in Yin (2002); among them, four were applied to collect the emprical data in the thesis research, namely documentations, archived records, direct observation, and interviews.

The sources of secondary data collection from the internal materials of the involving companies in the case study, documents and archived records, provide stated details of information, which enables to corroborate information from other sources. Also with the stated information, these sources provide stable data which could be reviewed repeatedly. The first-hand information of empirical data could be gathered through direct observations during the visit of the case study site. Direct observations allow the investigator to collect data in real time, and provide contextual information of the covering event. And from interviews, the insightful information interpreted through the eyes of specific interviewees is acquired. This source of evidence could also provide shortcuts to identify the prior situation and other sources of evidence (Yin, 2002). More detailed description of the sourcing channel in different data collection approaches, and the applications in the thesis would be introduced in the following sections.

3.3.1. Literature Reviews

During the research period, a lot of literatures were continuously reviewed, to provide the fundamental knowledge for the thesis research. The source of literatures includes published books, e-books, journal articles, periodical reports, and so on, through the searching channel of Chalmers library database and public searching engine, Google Scholar. Many literatures were acquired from Emerald Library, Science Direct, JSTOR, books24x7, and so on, which could be accessed through the website of Chalmers library.

At the beginning of the research period, the literature review focused on the general knowledge of lean and supply chain to reveal the correspondence and get the inspiration of the research direction. The key words used for searching for literatures includes supply chain, supply chain management (SCM), lean, lean thinking, lean tool, and lean SCM and so on. After the research purpose was formed, more literatures were further reviewed with more specific searching key words, such as supply chain coordination, supply chain activities, coordination mechanisms, just-in-time, pull, waste elimination, wastes in supply chains, and so on. The in-depth literature reviews provides sufficient knowledge to guide the empirical study and generate the analysis in the thesis. The result of literature reviews was presented in Chapter 2, Theoretical framework.

3.3.2. Documentations and Archived Records

Secondary data gathering for the empirical study was proceed through reviewing the hand-out materials acquired during visiting of operation sites in the case study, and the internal materials of the cooperated companies in the thesis research, including the consultant company, case company, and the supplier involving in the case. Reviewing the empirical materials of documentations and archived records regarding to the case, some facts of the supply chain and information of the involving companies in the case were gathered; this facilitates the works of defining the supply chain and performing data collection for the case study.

3.3.3. Direct Observations

One of the data collection approaches used for collecting first-hand empirical data in the thesis research is direct observations, visiting the operations sites of the case to observe and record real time information. Three times study visits had been performed during the thesis research period; with different areas of interests, the investigations were also corresponding to different purposes. During the visits, several questions were also asked to inquire the required data; also notes were taken as the main recording method for relevant information, assisting with photographing under the limited permission of involving companies. A summary of information regarding to the performed visits could be found in Table 3-1.

Table 3-1 Information of study visits, including tour guide, area, and performing date

Guide and Organization	Area	Date
Tour guide in case company	Operations of the case company	2011-05-19
Logistic Engineering Consultant, Case Company	Truck assembly plant of the case company	2011-08-26
Packaging Engineer, Supplier	Engine assembly factory of the supplier & distribution center of the carrier	2011-11-03

At the beginning of thesis research period, the first-time study visit was performed in the operations site of the case company, to get the background information of the operations in the case company in targeting and defining the supply chain for the case study. The information of the operations in the case company was provided by tour guide explaining the functions and operations in different the facilities, with the emphasis on the central business, final truck assembly, in the case company.

After the general information of first tier supply chains in the central business being gathered, the second-time study visit was conducted in the case company, to acquire the information regarding to the operations of material supplies for the central business. An employee from the case company, the logistics engineering consultant, provided personal guide and internal insight, answering the questions and providing information regarding to the specific case.

The last-time study visit was to collect data and perform the case study, which took place in the supplier's operations site of the final production facility and the nearby distribution center of the carrier at the same day. During the study visit, several questions were asked to the personnel involving in the operations for information inquiry regarding to the case. A case study template was created, with information inquiry questions and record sheet, as the preparation of the detailed case study data collection (Appendix A). The entire process was accompanied with a personal guide, the packaging engineer of the supplier, introducing the right informants, and providing explanations and interpretations of relevant information regarding to the case, when needed.

3.3.4. Interviews

The most commonly used empirical data collection approach in the thesis research is to perform semi-constructive interviews, to acquire quick pictures of the background information, professional advices for research direction, and real time information for the case study. An interview template was created and applied during the research period, as the protocol to perform interviews and keep the performed interview records in a more systematic way (Appendix B). During the interviews, notes were taken as the recording method. The transcription of the interview reports were further sent to the interviewees ensuring the validation of information gathering; further contacts to the interviewees via emails or phone calls for information clarification were preceded if needed. An information summary of performed interviews could be found in Table 3-2.

Table 3-2 Information of interviews, including purpose, interviewee, and performing date

Purpose	Interviewee	Organization	Date
Background information for the case study	Traffic Manager	3PL Company	2011-06-07
	Process Manager	Case Company	2011-06-29
	Inbound Logistics Process Manager	Case Company	2011-07-07
	Logistic Engineering Consultant	Case Company	2011-08-26
Focus in the case study	Lean SCM Researcher	University	2011-10-17
	Lean Production Specialist	Consultant Company	2011-10-27
Data collection for the case study	Distribution Center Manager	Carrier	2011-11-03
	Production Planning Manager	Supplier	2011-11-07
	Transport Manager	Supplier	2011-11-07
	Customer Contact	Supplier	2011-11-07

At the beginning of the thesis research, the purpose of interviews was defining the chain for case study. With the background information of the supply chain of case, the target for the case study was able to select. The interviews for the background information involved interviewees from the case company and third-party-logistics (3PL) company, with the areas in distribution arrangement of material supply to the case company in 3PL company, planning procedure from ordering to delivery of central business, truck assembly, relevant information of first tier suppliers of the case company, and operations of arrival materials supplied in the case company.

Later on, two interviews were performed separately with an academic researcher and an industrial participant, to acquire research advices also as the preparation before performing the case study. These two interviews provided the insights from both the academic and industrial perspective of how could the case study being performed, which facilitated the methodology development in fulfilling the research purpose. In the end of the research period, four other interviews were conducted for the case study. The interviews involved personnel from the supplier and carrier side to gather relevant information regarding to the case. The questions performed in the interviews are attached in the end of the report accordingly, (Appendix C).

3.4.Reliability and Validity

The evaluation of the research quality could be judged by several tests, such as credibility, conformability, and so on; depending on the different research designs applied in the research, the criteria for quality test would be diverse. For the case study design, the research design applied in the thesis research, reliability and validity are the two main criteria used for establishing the quality of social research (Yin, 2002). Three types of validities are common criteria used in the case study, namely construct, internal, and external validity (Yin, 2002). Following the reliability and validity of data collection in the case study and research design would be discussed to develop the quality of the quality of the thesis research.

3.4.1. Reliability

The objective to develop the reliability of a study is that if later investigators follow the same procedure conducting the research, the same findings and conclusion are expected. So, the goal of reliability is to minimize the errors and biases in a study (Yin, 2002). In qualitative research, the reliability could be enhanced by recording the interviews, documenting the research process and presenting the result of data collection (Ryen, 2004). During the thesis research period, the first hand empirical data collections, interviews and direct observations notes were taken as the recording method. The developed data collection templates, interview template and case study record sheet, facilitates the data collection and storage were processed in a systematic way. The interview template and data collection recording sheet could be found in Appendix A and C, accordingly Also, after performing the data collection, the interview and case study reports were generated and sent to the respondents, ensuring the accuracy of acquired information.

3.4.2. Construct Validity

Construct validity is built when correct measures are established for the study; and it could be enhanced by three ways, use multiple sourced of evidence, establish chain of evidence, and have key informants review draft case study report in data collection (Yin, 2002). In this thesis research, several sources of evidence were applied as the empirical data collection approaches, which include documentations, archived records, direct observations, and interviews. With diverse data collection approach, over-reliance of a single source of data resulting in subjective judgments from investigator could be prevented. Also, with the planning reports reviewed by thesis supervisors, and documenting the data collection results the construct validity of the case study was ensured.

3.4.3. Internal and External Validity

Internal validity refers to establish the casual relationship, whereby the pattern of certain conditions leads to the other condition is shown. According to Yin (2002), internal validity is applicable to the explanatory and causal study only. In this case, internal validity of the case study in the thesis research would not be discussed here. External validity concerns if the finding of the empirical study could be generalizable to the other case study (Yin, 2002). One of the most common criticisms about case studies is about the generality of the result in the other circumstances. The purpose of the thesis research is to develop the methodology in identifying wastes in the coordination in a supply chain, and the case study was applied to validate the developed methodology. The methodology was developed in a more general level, methodology framework, to increase its generality in applying to the other cases.

4. Results

In the thesis research, a case study was conducted as the social study design to fulfill the research purpose with empirical data. In this chapter, the result of the empirical data collection would be presented. Starting with a case company, the operations and the first tier supply chains of the central business in the case company would first be introduced; continuing with the result of waste identification in supply chain coordination interviews. In the end of this chapter, the case study result of a part of the supply chain, engine supplies from a first tier engine supplier to the case company in final truck assembly business, would be presented.

4.1.Pre-study of the Supply Chain

The pre-study of operations in the case company, relevant information of first tier suppliers in the central business, and the arrangement of materials supplies were acquired. This provides background information for case selection, and some would be further applied to the case study. With the understanding of operations in the central business and supply chain set-up in engine supplies of the case company, the requirements for engine supplies in the case study could be generated.

4.1.1. Central Business –Final Truck Assembly

A study visit was performed in the case company to understand the operations involved the case company and the main functions in its business. Three business functions include in the case company's operations, namely, production, assembly, and packaging. In production, the fame members of trucks are produced from a single raw material, steel. Depending on the usage, internal use or external supply, the finished products would go to one of the two other functions, packaging or assembly. For those products supporting external customers, worldwide truck assembly plants, they would be packed and stored in the packaging function before their delivery. On the other hand, for the products for internal use, they would continue their journey in the assembly function, final truck assembly, which is the central business in the case company and contains three pre-assembly processes and one main assembly process in total (See, Figure 4-1).

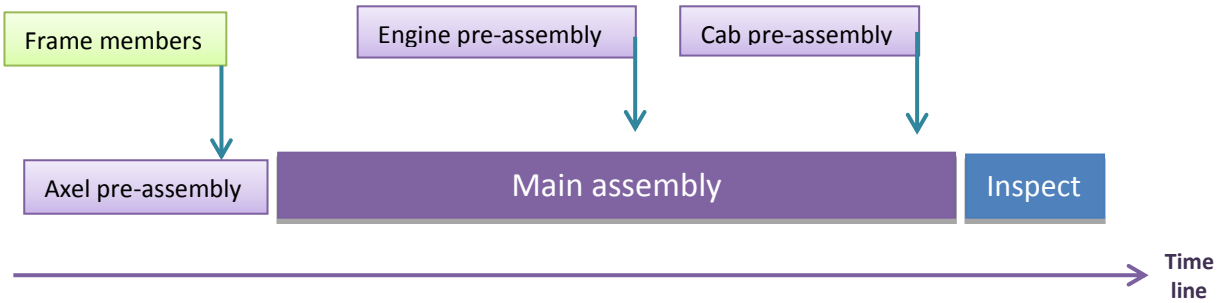

Figure 4-1 Procedure of the central business, final truck assembly processes in the case company

In the central business, truck assembly processes follow pull system with a specific takt time. A truck would only be built when there is a really truck order from the customers, and the construction of a truck is based on the specifications from real customer orders. As a truck is a complex and highly customized product, the specifications of a truck are rather detailed, encompassing abundant of information. Specifications of a truck order from the customer include the description of main components, such as chassis length, engine volume, the cab color, the texture of the car seats, and so on and would be broken down to the bill of material (BOM) level. Since every truck has its features and the variant components are exclusive, the operations and supplies of these variant components would correspond to a specific truck during the entire truck assembly processes. The variant components, for examples, are engine, tires, and gearbox and so on.

The general procedure of truck assembly in the case company could be seen as Figure 4-1. The entire processes cover axle, engine, and cab pre-assembly processes, and the main assembly, and each process contains two parallel assembly lines. The beginning of the truck assembly starts with axle pre-assembly process. Axles are painted and ready for being installed when they are delivered from the supplier; and in the axel pre-assembly process, axles would be attached with other items such as the suspension and brake cylinder, and then docked together with the riveted frame members produced in the production function. The finished products in this process would later on enter in the main assembly process and become the main body of the truck, chassis. The chassis then would grow into a finish truck after go through the whole main assembly process with various components and parts are added in between, which include the finished products from engine and cab pre-assembly process. And the code of specifying the variant components in truck assembly is corresponding to the specific chassis number.

In the engine pre-assembly process, engines and transmissions are matched together and the completed product would later on join the main assembly lines. And almost in the end of the main assembly lines, the completed products from the cab pre-assembly lines would join the main assembly process. In cab pre-assembly process, the cabs supplied from the supplier are attached with some small items, such as stairs, air intake and so on. Then the complete cab would be installed on the truck body and constructed as a finished truck in the main assembly lines. When a truck is completed in main assembly, it goes into the procedure of final inspection for which the station is located at the end of the main assembly lines; and at the station the finished truck would be tested and started for the first time before it is ready to leave the plant and deliver to the customers.

The operations of the central business adopt pull system and operations of the pre-assembly processes are pulled by the demands of main assembly. At the end of each station in pre-assembly and assembly processes, there are electronic boards showing information such as remaining time for on-hand task supposed to completion, back orders and the remaining units to operate for the current shift and so on.

4.1.2. First Tier Suppliers of Central Business

After the procedure and features of the central business understood from, several interviews were further conducted to recognize the first tier supply chain of the central business, the connections between the first tier suppliers and the case company, and the main components with direct influences on the central business. From the interviews, a general picture of the operations in products supplies was also captured. With this background information, the target for performing detailed data collection in the case study was able to be selected.

There are more than five hundreds first tier suppliers providing materials, parts, and components worldwide to the case company in accomplishing its central business. The distribution of products supplies is arranged by a single third-party-logistics (3PL) service provider. The 3PL company is responsible for finding freight transportation service providers and negotiating the prices of the service with them. Moreover, the 3PL company also designs the transportation networks for the case company. So when it comes to contracting a flow of transportation in product supplies, four parties are involved, namely the 3PL company, case company, the freight transportation company, and the product supplier. After the contract set, each actor has its own duty to fulfill in the operations of the supply chain and it is the suppliers' duty to book the transportation for products delivery.

Three types of ordering receiving methods from the case company could be distinguished among these more than five hundreds of first tier suppliers. The first type of suppliers is the ones provide variant products with specifications based on the real customer orders, and receive the orders from the case company on a daily basis with corresponding chassis number. This type of supplier also receives the production planning of truck assembly in case company automatically through the synchronized information systems for the better planning of production capacity; they include the suppliers of major components, such as axles, engines, gearboxes, cabs, tires, fuel tanks and so on. The second type of suppliers contains the majority involving in the central business. They are the suppliers providing standard products and receive batch sizes orders from the case company by calls or electronic data interchange (EDI) massages. The case company places demands to these suppliers according to its order planning schedule and the suppliers would provide the products in decided lead times. The last type is a nearby supplier locating next to the case company and provides small parts such as screws to the case company. They adopt Kanban system in product supplies, whenever the case company requires new products supply the signal would be sent to the nearby supplier and the products would be replenished in a very short time.

4.1.3. Engine Supply for Central Business

After the operations and the composition of first tier supply chain in central business were understood, the engine supply was selected as the investigation target, considering the importance and complexity of engine supplies. Engine is recognized as one of the major components and variant products, exclusive to each truck. The engine order is pulled by truck assembly schedule of the case company, directed by the operations in the central business. At the same time, as each engine is exclusive designated with a chassis number; operations in the central business cannot proceed as scheduled, if the engine supply is late or incomplete. Most of the engines used in the central business are supplied from an engine producer in Sweden, which the case company has a close relationship with. Considering the time restriction and resources accessibility for the thesis research, the target chain for the case study to investigate the coordination in supply chain activities was decided to be engine supplies from the Swedish supplier to the case company.

A study visit and some interviews are performed to gather the information about to the operations of engines supply to the case company. Engines arrive at the case company with full truck loaded, which means each run of engines supply arrive at the case company is delivered by a truck with trailer loaded in its full capacity. The truck would leave the engines outsides a warehouse where the engines would be unloaded and stored before their usages in engine pre-assembly. The location of the warehouse links with the engine pre-assembly lines and two parallel parking spaces with the size of a trailer are outside the warehouse. In this case when the truck delivers the engine with the full truck loaded, the truck trailer would be left there; and the operators from the case company could unload the engines one by one with fork lifter according to the requiring time. But the engines loaded on the truck body should be unloaded as soon as possible after the truck arrives so the truck could leave the case company in time.

According to the interview with logistics engineering consultant in the case comapny, the supplies of the variant components for truck assembly, including engines, follow just-in-time (JIT) delivery in supporting the pull system applied in thecase company. Also engines are rather expensive componenets, the amount of storaging engines in the case company is constrained, so both the storage areas and the parking spaces for loaded trailers are limited. Additionally in the JIT engine supply, engiens are assigned with the requiring time, which is the time for engines should arrive at the case comapy instead of the time they are used. From the logistics engineering consultant point of view, this is also due to the fact that the supplier is not always reliable so the case company controls its engines supply base on the designated time that they should arrive.

During the study visit it was noticed that inside the warehouse, there were a coulple piles of engines standing with the categorization of which pre-assembly lines the engine would go to. Further each engine was attached with a paper, which is called the engine ID, with barcodes and numbers illustrating the identity of the engine. From the the engine ID, the name of case company and supplier, the requiring date of the engine, the assembly line for which the engine would be used, as well as the chassis number indicating the assembly sequence are stated. The engines were piled in a way as the orders as they were in engine pre-assembly lines. From the interviews it is known that each engine is unique and ensuring the engines enter the engine pre-assembly lines with the right sequences and remaining in the truck assembly processes are essential for the case comapny. So with engine IDs, the fork lift driver would be able to unload, pile the engines, and deliver them to the assembly line with the right sequence.

4.2.Wastes in Supply Chain Coordination

Two interviews were conducted regarding to what waste is in the coordination in supply chain activities, from both industrial and academic point of views. These two interviews provide valuable information for thesis research in high lightening the focus areas of information gathering for the investigation of waste in coordination in supply chain activities as to the target chain.

4.2.1. Academic View of Wastes in Supply Chain Coordination

From the interview with academic researcher in the area of Lean SCM, in managing the operations of a supply chain, the emphasis is focused on the overall outcome of the chain; by creating and achieving the mutual objectives for the supply chain, the optimization of the overall outcome is likely to be reached. However, there are many different units involved in a supply chain, such as organizations, business functions and operation processes so on, with various focuses. Especially when there is more than one legally independent organization performing a supply chain, diverse interests or even conflicts may occur. If an actor is more concentrated on growing its own interest to maximize its benefit in the supply chain, instead of growing together as the whole system, the other actors' interests would be trade-offed. And this individual actor's persuasion of optimizing the certain performance is easily leads to the sub-optimization in the supply chain. The similar situation also exists among business functions and processes within the same company; these functions, departments, or processes have diverse management focuses. If any one of them emphasizes on specific performances which are not aligned with the overall objectives, it creates wastes in the operations of the supply chain. So the sub-optimizations of the supply chain units, actors, functions and so on, are regarded as wastes regarding to the coordination in supply chain activities.

In theory, a supply chain is carried out with a series of activities in operations to fulfill end customers' requirements. During this process, there are various requirements derived for different operations. As wastes could be interpreted as anything without contributing to what the end customers wants, the requirements for operations involving in a supply chain are based on the common objective, end customers' requirements; and the downstream requirements should be fulfilled by the upstream operations. From this point of view, wastes in the coordination in supply chain activities could be seen as failing in requirements transformation from the downstream to the upstream. A simple approach to identify wastes is to examine if the objectives of the requirements for operations chain are aligned in the supply or not; if they are misaligned, there are wastes.

The information of downstream operations' requirements for the upstream operations could be acquired from the performance metrics measured by the management. The measures of an operations process towards others indicates of which performance the process focuses on. The same indication could be applied to the self-assessment of operations performances in a process. The measures imply what are the criteria the management of a process would like operations to achieve. In investigating the sub-optimizations caused by diverse management focuses, performance measures are a good way to look into. The operations are leaded by the performance measure of the management, by comparing the management focuses between different units in the supply chain, the coherence or misalignment of the objectives and mutual goals could be identified. Thus is there sub-optimization involved the supply chain could be assessed.

Another aspect of wastes in the coordination in a supply chain to look into is alignment between the operation and its management. In order to perform the operations of a supply chain efficiently, the operation and the management must cooperate each other. The management goals should be accomplished by related operations; on the other hand, the operations require the support from the management in order to fulfill the tasks. If one of these two parties is misplaced, the supply chain performances could hardly achieve the optimized result. From this perspective, the waste in the coordination in supply chain activities could be identified by revealing the misalignment between the operations and management focus.

4.2.2. Industrial View of Wastes in Supply Chain Coordination

Also an interview regarding to wastes in the coordination in a supply chain was performed with an experienced industrial participant involving the research projects of the case company. Acquiring from the interview, wastes related to the seven traditional wastes in lean manufacturing are quite straight forward; they could be revealed by walking through the operations sites in the material of a supply chain. An affected and powerful tool commonly applied in the case company is Value Stream Mapping (VSM). But the real challenge in identifying the waste in another flow of a supply chain; wastes relating to information flow is rather hard to recognize. To identify the waste involving the information flow of a supply chain, one good point to look into is through exploring the gap between scheduling and performing time of the operations.

Some information about the targeted chain, engine supply from a Swedish producer to the case company, the specifications of engine orders are broken down to the Bill-of-Materials (BOM) level, and the flow of information contains a huge amount of data and information sharing and transparency between actors are essential. In the targeted chain, engine supplies adopt just-in-time (JIT) sequence supply, any deviation occurs in engine supplies, such as shortage, delay, and supply with incorrect sequence would disturb the operations and material flow in the central business. Nevertheless, in the reality disturbances exist and deviations occur sometimes, responsive in-time information exchanges could reduce the potential harm to the minimum level. Under this situation, the deviation handling is extra essential here; with proper planning and suitable information exchange mechanisms, the effect of subsequent waste resulting from deviations could be limited. However the integration of data interchanges with information systems among actors consumes lots of resources, which relies on the actors' capabilities to support integration and apply advance information technology (IT). This is a trade-off should be balanced in searching for efficiency.

During the interview, the interviewee mentioned ''*muda before muda is muda*'', which implies eliminating the factor resulting waste is the real waste should be eliminated. Identifying the source of the waste and further improving it are the leverage should be applied in wastes elimination and the case study. The feasibility of JIT sequence supply heavily depends on the supplier's capability of product supplies, with quality products and on time supply, and it also requires the cooperation from the other actors, for example in-time information and reliable production planning from the case company. The operations of sequencing are very expensive in and the application of JIT sequence supply requires a stable environment; unstable supply and product system would only cause even worse chaos and more wastes. From his point of view, inefficient or insufficient coordination mechanisms between the actors to stabilize the whole system are wastes relating to the coordination in a supply chain and should be looked at in the case study.

4.3.Operations in Engine Supply for Central Business

The target chain was set as the engine supply from a Swedish engine supplier to the case company. A series data gathering and discussion were carried on to understand the activities involving in the target chain and define the scope for conducting the case study. In the target chain, all the engines from the supplier to the case company are distributed by a designated carrier with trucks, for which the distribution center is close to the supplier. Further, considering the relevance of the case study to the research purpose, the scope of supply chain was defined from the last operation process of engine production in the supplier, engine final assembly, to the central business in the case company. There are only three actors involving in the daily operations of the defined chain, which are the supplier, the carrier, and the case company accordingly (See, Figure 4-2).

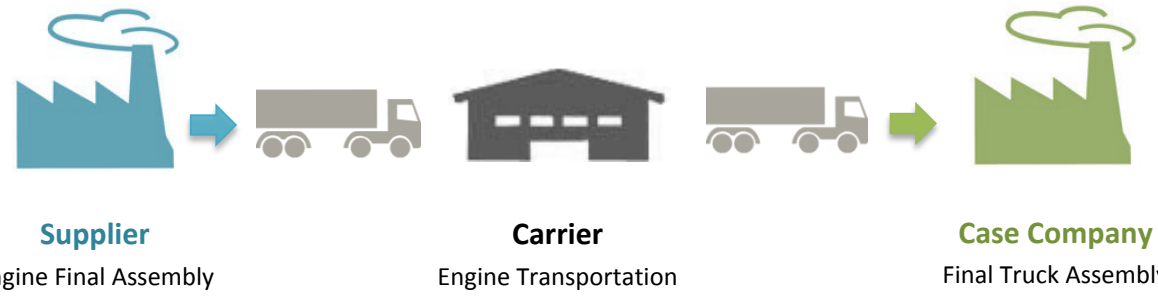

Figure 4-2 General process illustrating the scope of operations in the defined chain

A study visit was performed to investigate the operations involving the defined chain's material flow, which encompassed the upstream operations in supply chain activities before the engine delivery for the case company. The scope of the study visit included the supplier's factory where engines final assembly took place, and the distribution center of the carrier where the engines supplied to the case company would be dispatched. During the entire study visit, the investigation was accompanied with a supplier's employee providing with required information and interpretation for the case study. In the two following sections, the information gathered from the study visit would be introduced, and divided into the operations in the supplier and operations in the carrier.

4.3.1. Operations in Supplier's Engine Final Assembly Factory

The operations of engine final assembly process contain three types of engine assembly lines, producing engines with different volumes separately. Same as the other assemblies, at the end of engine final assembly lines, there were stations for final inspections, running tests for quality control. After the engines are ready, completing the final assembly and inspection, all the engines with different volumes from the different assembly lines would be combined together into the same flow and join in the next operations process, painting process, altogether. There were automated guided vehicles (AVGs) applied inside the factory, carrying the engines to the designated stations for next operations with specific routes. The general processes after engine final assembly until engine delivery to Carrier's distribution center could be seen in Figure 4-3.

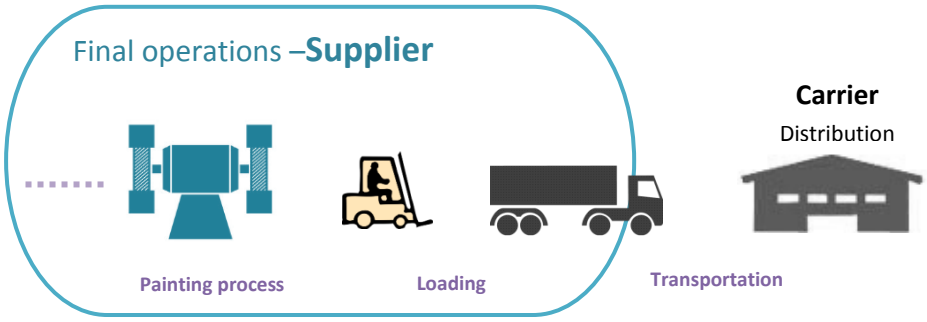

Figure 4-3 General process of final operations in supplier's engine final assembly process

After the final assembly and inspections the engines come into the painting process, in which the engines would be wrapped, painted, and unwrapped. Every engine entering in the process also carries with its identity papers, referring as ''engine card''. There are barcode and some massages on the engine card, which contains the important information about the specific engine. During the process, engine cards would be scanned and used in delivering critical information for operations. The operations in the painting process adopt first-in-first-out (FIFO) rule, the engines would be operated according to the order they entering in the process, besides in some occasions. For example, when there is an urgent engine supply should be caught up with the delivery schedule. An engine might attach with a specific paper note besides it engine card when it comes in the painting process, and this means the engine should be prioritized in operations. Also, sometimes the process director would come personally and deliver the message that the engines for a specific customer should be operated first.

In the painting process, engines would firstly been wrapped with some paper and plastic materials manually to protect some part of the engines without being painted. This operation is a standardized procedure, regardless the engine types and volumes, they would be wrapped in the same way. So no specific information it needed here. Also, since the engine card is very essential in carrying engine's information, it is crucial that the engine card is well covered by the plastic material in this operation. After that, the engines would be prepared for entering the painting machines. The operators could differentiate the engine types by observing their appearances. Then basing on the engine type, the operators scan the corresponding barcode from a brochure at the painting station, as a set-up for the painting machine. This information is processed by the computer program and sent to the machine automatically after when the barcode was scanned; and later on the engine could be painted by the machine automatically through the set-up. Two painting machines run in parallel for each engine only goes in one of them, one by one. When an engine is finished in the painting machine, the next engine would be transported by the automatic pallet to the machine. For the engine which is painted would pile in at the end of the station and wait for the color is dried.

When there is a pile and the painted engines are dried, the operators who were wrapping the engines would come to the end of the station to process further operations. Frist, parts of the cover materials would be removed from the engines, while the rest would continue to be on the engines and protect them during the transportation. Then the engine card would be scanned and the engine would be applied with two of its identical engine IDs, on the top and the side, which is the last operation in the painting process. After that engines would wait for forklifts distributing them to the storage area. The engine IDs were the same format as those discovered in the case company. Since engine IDs is applied, they would be used all the way to the case company in different occasions.

The next operation after painting process is forklift drivers distribute the engines from the painting station to the storage area. The forklift drivers sort and place the engines according to the flow that the engines would be transported to the customers, and the drivers are able to perform this operation is based on the information providing by the engines IDs. Additionally, there is a specific flow for the case company's engine supplies in the supplier's storage area. Outside the supplier's factory, there were a couple of parking lots, parking with the carrier's empty trailers. For those engines are for the case company, forklift drivers would directly load them on those trailers. Only when a trailer is full, forklift drivers would continue to load on the next one. According to the forklift divers, the carrier's employee would come with truck to the parking lots several times a day, and check if there is any trailer fully loaded. If yes, then the truck driver would pick up the trailer and transport it to the nearby distribution center, which belongs to the carrier. What is more, the entire operations apply FIFO rule. Following the engines would go to the carrier's distrbution center.

4.3.2. Operations in Carrier's Distribution Center

The main function of the carrier's distribution center in the defined chain is to collect the engines from the supplier and a few engines from the other foreign producer together, and supply the engines to the case company according to the delivery schedule. As every engine is exclusive, every of them have their own requiring time for the case company, engine deliveries from the distribution center to the case company are matching with truck runs. In general the engines from the supplier might stay one or two days in carrier's distribution center before the delivery, and the engines from the other foreign producer are around three to four days.

During the study visit, it was observed that before the truck arriving the carrier's distribution center with the engines from the supplier, the truck driver would call the person at the distribution center as the notice for upcoming delivery. When the truck was arrived, the truck driver left the loaded trailer on the ground directly, and picked up another empty trailer, then went away. The personnel at the distribution center continued unloading the engines from the trailer with forklift and piled them inside the warehouse. The engines were piled base on their volumes; two volumes of engines were piled in two areas of the warehouse separately. In this operation, the forklift driver could easily distinguish the engine volumes by the size of their appearances without specific information needed.

Then before the delivery day, the personnel at the distribution center would sort out the requiring engines from the two original piles differentiated by volumes, and located them in a separate area as the preparation for upcoming delivery. This preparation could smooth the loading operation, and ensure the presence of requiring engines. The engine deliveries from the distribution center to the case company are several times a day with a fixed time table. One supplier's employee would send the weekly delivery schedule, sequence list, to the one from the carrier by email. The sequence list states the engines' delivery order with their corresponding chassis numbers. By the time to sort out engines for daily delivery from the original piles, the person at the distribution center would compare the sequence list with the engines IDs to pick out the requiring engines via forklift. Furthermore, if any requiring engine is found missing after the daily delivery was sorted out, the person at the distribution center would contact the supplier's employee, to confirm the engine's status and inquire the further arrangement. The last personnel at the distribution would load the requiring engine on the truck and deliver the engines to the case company according to the schedule.

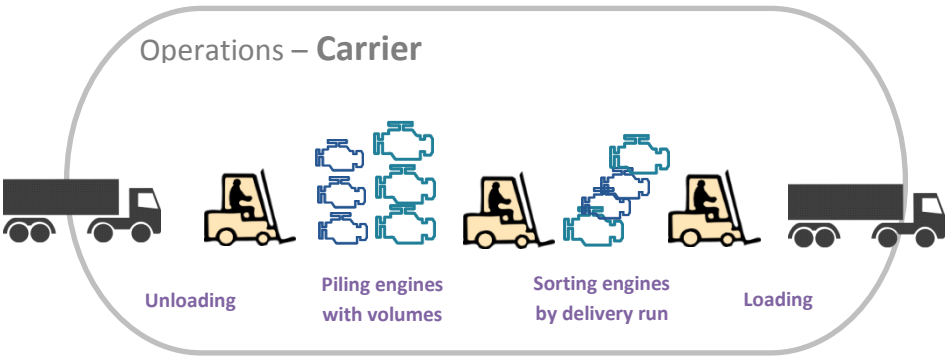

Figure 4-4 Process of engine operations in carrier's distribution center

4.4.Information exchanges in the Supply Chain

In order to perform physical operations in engine supply from the supplier to the case company, the coordination in the defined chain requires information exchanges between companies involved. The coordination in information exchanges includes the routine planning in operations, and personal contact in communication in stabilizing the material flow of engines supply.

In planning for the operations, the supply chain functions involving in the defined chain include the case company purchases engines according to its production needs from the supplier, the supplier produces the products and purchases transportation service from the carrier, and the carrier delivers the engines to the engines to the case company. Under this scope, the investigation of supply chain coordination in planning includes the order planning of engines from the case company to the supplier, the production and delivery planning of engines from supplier and later on transfer to transportation order and delivery planning to the carrier. Besides that, the communication between contact persons in the supplier, the carrier, and the case company, and coordination between the management of operations processes and organizational departments of the supplier, link the in-time information from different operations segments in the supply chain together. This type of information exchanges includes deviation handling and meeting in the defined chain which would be described in more details in 4.4.2 Communication and Management.

4.4.1. Planning for Engines from Ordering to Delivery

Several interviews were conducted including process managers in the case company, the personnel in production planning department of the supplier, and transportation managers from both the supplier and the carrier, to understand the general flow of information transmission and the mechanism applied. To illustrate the information flow of the defined chain, it could start with the case company having the production schedule for which the trucks should be assembled in the central operations in what sequence every day is designated. The order of requiring engines for the central operations would be placed to a system with the specifications of the engine, the requiring date, and following sequence applied in the process of central operations. The information would further be transferred to the supplier side through the connection of electronic information system with electronic data interchange (EDI) massage on a daily basis. Together with engines orders from other customers, the supplier has some time for production planning and preparing the materials before the real operations. Several parameters are applied in supplier's production planning, such as production capacity of diverse engine volumes, delivery leads time to the customers, and the urgency of engine demands from the customers so on.

In the defined chain it is supplier's duty to plan and book for the transportation for engine delivery from the carrier, which has the partnership with the 3PL company, to the case company. The booking and scheduling for engine delivery is based on the agreement involved the supplier, the carrier, the 3PL company, and the case company, these four parties in contracting. Besides contracting issues, the 3PL company does not engage in daily operations in the defined chain. Together with the planning for engine production, the delivery schedule is also generated from the production planning department in the supplier. The carrier receives the planning for engines delivery from its distribution center to the case company weekly. The carrier arranges the engines and loads them on the corresponding truck run basing on this planning. The information in the deliver planning contains the sequence of engines supposed to arrive at the case company.

In the distribution center, the carrier has access to the supplier's production system, inspecting the status of engines. If there is any engine missing by the time it supposed to be ready for delivery, the personnel at the distribution center would be able to look up the preparation of the engine and further confirm with the contact person in the supplier regarding to the proper solution for the missing engine.

4.4.2. Communication and Management

In this target chain, there are designated contact persons from each company, the case company, engine supplier, and the carrier, in transferring the information involved between companies and coordinating the operations in the defined chain. As mentioned in the previous section, if there is any missing engine in the carrier's distribution center by the time it is about to delivery, the contact person from the carrier would contact the on from the supplier. There is no direct contact or communication flow between the carrier and the case company. The communication in deviation handling involved in the defined chain relies on the contact person in the supplier to coordinate.

From the interview with the contact person in the supplier, the communication between her and the contact person in the case company is rather frequent, almost several times a day with phone calls. The communication between them goes both way and it is hard to define the only purpose of each contact because of the close relationship between the supplier and the case company in the cooperation of engines supply. The essential information of internal operations between these two companies should be aware by each other in responsiveness of corresponding to requiring changes, deviation handling. Issues for coordination include the disturbances involve in the operation sites which interrupt or may interrupt the scheduled material flow in engines supply, and the consequent problem solving connections.

From the interview with production planning department of the supplier, it is known that every morning there is an internal meeting involving process managers, department representatives, and together with the top management within the company. During the meeting the managers are able to share the information and operations conditions regarding to their representative responsibilities, and negotiate the cooperative adjustment or arrangement jointly. For example, the manager of the production planning department might broadcast the urgent engines demands from a specific customer, or recently high demands of engines in specific volume. The managers would further negotiate and coordinate the production priorities according to this information and disseminate the information down to their personnel at the operations sites. This meeting is also the channel for the contact person in the supplier to acquire the in plant information and use it for external contact, transmitting from the production planning manager after the meeting. Nevertheless if there is any incident happens during the middle of the day, the requiring coordination for the emergency would directly contact through the communication between responsible persons when it is needed.

5. Analysis

In this chapter, the analysis presents the findings built up with theoretical study and examined through the empirical study. First, the analysis of wastes regarding to the coordination in a supply chain are recognized as well as the method for identification would be presented. Following, the analysis of identifying the defined chain's requirements would be provided, as validating the developed method with empirical data in the case study. After that, the improvement suggestion of enhancing the coordination in a supply chain with a lean perspective would be discussed the end.

5.1.Recognize Wastes in Coordination in Supply Chain Activities

From the literature review it is know that a supply chain contains several different activities cooperating together to deliver the final product and satisfy the end customer needs (Schniederjans *et* al., 2010). Besides the original scope in lean manufacturing, operation and production activities in a manufacturing facility, the operations of a supply chain extend to the operations across facilities and comprise other transitional activities between the interfaces of supply chain actors. These activities are such as material releasing, transportation, receiving, and materials handling so on, connecting the flow of materials in different actors together as a supply chain. In facilitating different activities in a supply chain and coordinating them in a coherent and efficient way, other activities in planning, managing, and controlling the operations in a supply chain are also required. These activities are, for example, demand and supply planning, order processing, production planning and scheduling so on (Trent, 2008). In managing a supply chain, these activities are all included; and with the coordination in a supply chain enables all the activities across different actors working together.

In preforming the activities in a supply chain, two flows are accordingly composed, material and information flow. In order to accomplish the execution in a supply chain, material and information flow could hardly separate from each other (Schniederjans *et* al., 2010). To identify the waste in the activities in a supply chain, the investigation should encompass both flows, also the other activities in management and control during operations. Fourteen categories of wastes are identified from the traditional lean manufacturing theory and extended lean supply chain management. With the fourteen categories recognized in the literatures, the waste identification in coordination in supply chain activities would be more structured. In the following sections, which categories of wastes are correlating to supply chain activities would be first discussed. Then it continues with the analysis of the cause of wastes in the activities involving in a supply chain. In the end, what wastes are regarding to the coordination in a supply chain, reflecting on the research purpose would be illustrated.

5.1.1. Wastes in Supply Chain Activities

Fourteen types of wastes are introduced in 2.4 Different Types of Wastes, from both lean and supply chain management (SCM) perspectives. In the traditional lean theory, lean manufacturing, the recognized wastes in seven categories are material flow and physical operations orientated. To identify the seven types of wastes, overproduction, excess inventory, waiting time, unnecessary transportation, extra motion, over processing, and defect, a common way conducted in lean manufacturing is to investigate the operations comprising in the material flow and recognize the wastes. With the same notion, identifying wastes in the operations in a supply chain could be done by applying the same types of wastes and same approach in identification, by looking into the supply chain's material flow.

Besides these seven types of physical wastes, other types of wastes are recognized in Trent (2008), in managing a supply chain. In accomplished the execution in a supply chain, it requires the interactions between material and inforamtion flow. Wastes relating to the information flow of a supply chain could be processing, storing, and transforming information unnecessarily while the execution. Digital waste is the type of wastes referring to spending extra resources on holding unnecessary information or running information inefficiently in the infromation system, with too manty digital bits and bytes. This types of wastes influences the effectiveness and efficiency in information exchanges in a supply chain, so as to the information flow in running the supply chain activities. Adopting inappropriate mechanisms in information exchanges could be the reason for the ineffectiveness and inefficiency in the information flow of a supply chain, which might be the ressult of poor planning, another type of wastes recognized in managing a supply chain. Wastes of poor planning in supply chain activities include the misalignment in the of demand and supply information, which causes extra physical wastes in the operations in a supply chain, and adaopting inappropreiate mechanism which requires extra efforts for information exchanges in a supply chain (Trent, 2008).

In addition to the operations and information exchanges in a supply chain, other activties in a supply chain include the activties for management and control to ensure the supply chain performance being ideal. Performance measurements are applied to assess the supply chain performance and rearch the purpose of management and control; the performance measure reveals the objectives an organization or functional management woudle like to achieve. It also provides incentitives for the personnel to fulfill the certain criterion in performance, since the criterion which has been measured in performance is the one considerated by the managers when it comes to evaluation. In this case, the performance measures lead the other supply chain activities into a certain direction. Measuring the wrong attributes not only costs extra resources in ineffectives performance measurement, but more seversely result in the supply chain untis working towards the diverse objectives. If the design of the performance measures in a supply chian is poor, misalignments in mutual objectives between supply chain untis would occur. These are recognized as the wastes of poor measurement, another type of wastes in managing a supply chain, which should preveneted during the execution. Moreover, another waste type, untapped employee creativity, is acknowledged as without fully ultilizing the capability of employees, which comprises serveral different aspects. Applying to the execution of supply chain activities, untapped creativity in general concerns with the unused employees capability in making improvement in various supply chain activities. These are the types of wastes could be applied in the execution of supply chain activties from the fourteen categories.

Table 5-1 Eleven types of wastes associated with the supply chain activities

Correlation	Type of Wastes	
Material flow (7 physical wastes)	Overproduction	Extra motion
	Excess inventory	Over processing
	Waiting time	Defect and error
	Unnecessary transportation	
Information flow	Digital waste	
	Poor planning	
Management and control	Poor measurement	
	Untapped employee creativity	

Yet, other types of wastes, duplicated of effort, overdesigning, and excessive overhead have less correlation in the execution of a supply chain. From the theory, the main processes of supply chain activites while the execution could be devided into three stages, procurement, production, and distribution (Thomas & Griffin, 1996). From this illustration, the phase of production development and product design are beyond the scope of discussion when it comes to the operations in a supply chain. In this case, over-designing, referring to maketing and engineering functions insert product features without aligning to the customers' requests, is the waste category resulting in the product development phase (Trent, 2008). Duplicated of effort denotes the same operations in different operation sites in the same organization have different ways for operations, so it requires extra efforts to design, organize, and manage the operations. Excessive overhead indicates complex organizational structure containing more layers than necessary, for which it takes extra time and effort to process decision makings in a supply chain. These two waste categories relate to the issues in organizational structure and design, which are more strategic level instead of operational in supply chain management. For the reasons mentioned above, these three categories of wastes are not within the scope for wastes identification in supply chain activities.

Table 5-2 Three types of wastes associated with other fields in SCM

Type of Waste	Correlated Field in SCM
Duplication of effort	Organizational design
Overdesigning	Product development
Excessive overhead	Organizational structure

In sum, the fourteen types of wastes recognized in 2.4 Different Types of Wastes contain eleven waste types covering in the scope of wastes in supply chain activities. First the seven traditional wastes categorizing in lean manufacturing comprise the physical wastes in the material flow of operations. And digital wastes and poor planning represent two types of wastes might occur in the information flow of a supply chain. Poor measurement and untapped employee creativity emcompass issues in managing and controlling supply chain activities, which should not be negelected ensuring the postive result of supply chain performance and management. While the other three waste types, duplication of effort, overdesigning, and excessive overhead, are related with other issues in SCM, with less coorelation with the execution in supply chain activities.

5.1.2. Waste of Wastes in Supply Chain Activities

From the interview with the industrial lean expert regarding to the waste in the coordination in a supply chain, he mentioned ''muda before muda is the muda'' is the notion in wastes elimination. 'Muda' means 'waste' in Japanese. The description above indicates that the actual waste should be eliminated is the waste which causes other wastes, the cause of wastes. To eliminate the source of wastes is a more effective solution for problem solving and making improvements. Wastes in a supply chain could be many and present in various formats. These wastes are generally caused by some main reasons. For example, poor communication between supply chain actors results in extra buffers and physical wastes in the supply chain, sub-optimizations in supply chain units trade off fully utilizing the overall supply chain capability, and so on. To investigate where the real problem is, and eliminate the source of wastes, more solid solutions for wastes elimination and continuous improvement are likely to be achieved. From this viewpoint, the waste should be identified in the thesis research is focusing on the cause of wastes, or the problem area in supply chains.

Among the seven types of physical wastes in the material flow of a supply chain, overproduction is main reason that results in the other six types of wastes (Morgan, 2009; & Tapping & Shuker, 2003). Overproduction implies the product demand and supply are imblanced, poor planning in processing the information of demand and supply; and poor planning is the type of wastes associating with information flow of a supply chain. Several articles have highlightened the significance of managing the information of a supply chain (Productivity Press, 2006). The seven types of physical wastes occur in the operations of a supply chain's material flow, directed by the information flow with planning and scheduling, communication in management and control, and so on. Inadequate management in information flow of a supply chain enlarges the consequence of physical wastes. In this case, physical wastes could also be improved through the control of wastes in information flow of a supply chain.

However, it is rather hard to assess wastes in the information flow of a supply chain. Two types of wastes relate to the information flow of a supply chain, digital wastes in extra digital bits and bytes and poor planning. Poor planning includes imbalanced demand and supply in a supply chain, ineffective and efficient way of information exchanges, and lacking of transparency in information sharing. From the same interview, the industrial lean expert confirmed information flow is a very vital part in supply chain and for sure it would be very valuable to eliminate the wastes involved. The problem is the truck assembly industry is a complex business; especially they are built according to customized specifications. A huge amount of information exchanges in between, which relies on various information systems and other information exchange mechanisms in performing the supply chain activities and building up the truck. There are over fifty computer systems running at the same time to accomplish the central business in the case. It would be unlikely and unnecessary to understand the function of every system in order to identify the digital wastes. Also the investment in information systems and developing the coordination in information exchanges between supply chain actors is rather expensive. Under this circumstance, continuous improvement is not suitable for applying to wastes elimination in the information flow of the defined chain. From the reasons above, the digital wastes and the adequacy of coordination mechanisms would not be discussed in this case.

Furthermore, the cause of wastes in supply chain activities could be many. Besides the factors mentioned above; it is evidential that poor coordination is a reason for wastes involved in a supply chain. Several literatures have addressed the importance of the coordination in a supply chain; poor coordination leads to poor supply chain performance. Especially when the supply chain activities involving more than one organizational function or even organization, inter-functional and inter-organizational coordination are key successful factors in the performance of a supply chain (Arshinder *et* al., 2008; & Ballou, Gilbert, & Mukherj, 2000). Poor coordination in the supply chain results in more wastes in the supply chain and enlarges the consequence. So in identifying ''the muda before muda'' in a supply chain, the cause of wastes or problem areas, the coordination in a supply chain is definitely a key area for investigation. So, poor coordination between supply chain activities is the focus of wastes identification in this thesis research.

Table 5-3 Waste of wastes in supply chain activities, the correlation, and role in the thesis research

Source of wastes	Wastes	Investigation field	Role in the thesis research
Overproduction	Physical wastes	Material flow	Lead by the information flow
Poor planning	Overproduction	Information flow	Hard to asses in this case
Poor coordination	Poor performance	SCM and control	The focus of the thesis

5.1.3. Wastes in Poor Coordination in a Supply Chain

Coordination refers to manage the dependency between activities enables these activities work jointly toward mutual objectives (Malone *et* al., 1994). From this definition, there are some key words are high-lightened in the investigation of wastes in the coordination in a supply chain, namely management, dependency and mutual objectives. In performing a supply chain, various supply chain activities are required which involve different supply chain units, such as processes, department, actors, and so on. These supply chain activities such as operations, management, planning and control, they are correlated to each other. In order to manage a supply chain, the dependencies between supply chain activities should be coordinated, which should be perform in a way leading the supply chain towards the mutual objectives of involving units.

In supply chain management (SCM), poor measurement and untapped employee creativities are two types of wastes correlating to the issues of management and control. Wastes under the category of poor measurement include ineffective measurement in supply chain performance; and one of the biggest issues within is measuring the wrong attributes which do not align with the overall supply chain objective. The importance of mutual objectives could hardly be overstated in SCM, especially when a supply chain contains different functions and organizations, mutual objectives might not easily be defined, even achieved, because of the potential conflicts in self-interests (Whang, 1995). Misalignment in supply chain objectives indicates poor coordination in the supply chain. Since the performance measures represent the objectives which the management would like to achieve in operations, misaligned supply chain objectives is the waste should be identified in the coordination in supply chain activities from poor measurement.

Moreover, wastes of without fully utilizing employee's capabilities are under the category of untapped employee creativity. In order to be successful in supply chain activities, it requires the cooperation between personnel from different hierarchies responsible for various activities. In this case, the coordination between personnel from different activities, and the coordination between the personnel and their belonged management should be reached. So the managerial level could make decisions based on the real situation in operations; and the operations in different supply chain activities could be managed and performed in way towards the mutual objectives. Poor coordination between people from different hierarchies or activities makes it hard to align all the operations together, and make improvements by involving everyone's expertise. Misalignments between the operations in different supply chain activities and between managerial and operational levels wastes should be identified in poor coordination in supply chain activities.

To conclude, the source and formats of wastes are various. In order to achieve high supply chain performance, the improvement should be made on the real problem, or the root cause. It is rather evidential coordination is a critical factor in running a supply chain, and poor coordination leads to poor supply chain performance. Therefore poor coordination is the waste criterion the thesis would like to identify. Be more specific, wastes in poor coordination in a supply chain are misaligned supply chain activities. In which, the misalignment could be between supply chain activities and within an activity, if the managers and the operators cooperate in the way, working as the same entity instead of performing individual tasks. Here, supply chain activities are more than only the operations in material flow; they also encompass planning, management, and control activities in accomplishing the supply chain. With misalignments, the full potential of the supply chain, working as a unified system, striving for the best performance, would hardly be achieved, or even problematic.

5.2. Method for Wastes Identification in Poor Coordination

From previous analysis, it is known that wastes involving in a supply chain could be many with the presence of different kinds of formats; in order to have a well performed supply chain, wastes involving in the coordination in supply chain activities should be eliminated (Barker & Naim, 2004). The wastes involving in the coordination in a supply chain could be wastes involving different types of supply chain activities, or the same type of activities but between different actors, processes, or departments. Three dimensions of coordination contain in supply chain management (SCM), namely intra-functional, inter-organizational, and inter-organizational coordination (Ballou et al., 2000). Applying to the management of supply chain activities, intra-functional coordination focus on the coordination in the same types of activities within an organization, for example the coordination in operation activities in the material flow of a supply chain actor. Inter-functional coordination refers to the coordination between different types of activities in an organization, which could be the coordination between planning, management, and operation activities in a supply chain actor. The last one, inter-organizational coordination is normally for the coordination in the same types of activities between organizations, which could be information exchanges between supply chain actors for planning and scheduling the operations. To identify wastes in poor coordination, the developing method should encompass different steps and different criteria to look into; so wastes presenting with different types of formats could be recognized.

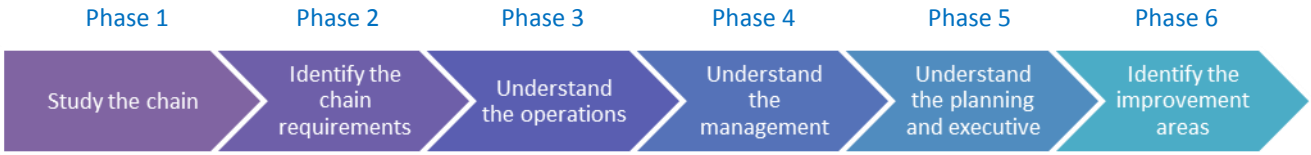

Figure 5-1 Methodology framework in identifying wastes in the coordination in a supply chain

A methodology framework was developed to identify wastes in the coordination in a supply chain, which contains six phases, illustrating the investigation steps of waste identification (See, Figure 5-1). From the interview with academic researcher in Lean SCM, the assessment of wastes in the original lean manufacturing theory is to identify what is unwanted by the customers during the operations; if an activity does not increase value to the customers and they are unwilling to pay for, it is regarded as a waste. However, when it comes to SCM, the execution of supply chain activities encompasses more than a single customer to satisfy. According to Christopher (2011), a supply chain is through the linkage of upstream and downstream processes and activities to satisfy the ultimate consumers. From this point of view, each downstream activity could be regarded as the upstream activity's customer, and the downstream customers' requirements should be fulfilled by the upstream activities. Moreover, these requirements should be aligned with the ultimate objective, satisfying the end customers while benefiting the involving units to create the maximum value of the entire system (Schniederjans *et* al., 2010). If the requirements of the downstream activities do not successfully transfer to the upstream activities, or the upstream activities do not perform in the way supporting the downstream activities' requirements, the overall objective would not be achieved. Misalignments in supply chain activities towards the overall objective are the wastes supposed to be identified in the thesis research, wastes in the coordination in a supply chain.

The developed methodology framework starts with a study in acquiring the basic information of the research target; for example, the operations and supply chain set-ups of the central business and involving units and personnel. This phase facilitates investigation in other phases, also is the foundation for the second phase, identify the chain requirements. In order to reach the ultimate objective, the requirements of supply chain activities should be successfully transferred among each other and coordinated in a supply chain. In this case, before the assessment of misalignments in the coordination in a supply chain, the requirements of supply chain activities should be identified first. According to the case study procedure in the thesis research, the identification of supply chain requirement was processed through a pre-study of the features and supply chain set-ups of the central business. Following with the investigation of different types of supply chain activities, operations, management, and planning, then identify misalignments in the coordination within the same types of supply chain activities and the misalignments between them.

5.2.1. Misalignments in Supply Chain Functions and across Organizations

Each type of supply chain activities represents a different function in the supply chain. Intra-functional coordination in the supply chain represents the coordination in the same types of supply chain activities. Waste identification in intra-functional coordination, identifying waste in the same types of supply chain activities, the smoothness of the operations involving a supply chain actor's material flow is one dimension to investigate on. The investigation of coordination wastes in material flow's operations is not searching for seven types of physical wastes in lean manufacturing, but the connection between operation activities. How are operations coordinated to deliver the final product to the customers? Is the current coordination effective so the material flow could go smoothly, and when there is a disturbance, can these activities be coordinated and to be responsive in minimizing the consequences? For this investigation, intra-functional coordination in the material flow, the operators' point of views is a very valuable source, to get the insight of actual situations.

Besides operations, a supply chain contains other activities in planning, and management and control. The planning and scheduling activities for different operations are interrelated, for which the coordination is needed to link the operations activities perform smoothly and achieve the supply chain objectives. To identify the wastes in the coordination of the planning activities could be done by investigating the rules for of planning and scheduling for different activities, whether they are aligned. Imbalanced demands and supplies lead to numerous physical wastes, which are recognized as a waste in poor planning (Trent, 2008). Moreover, by understanding the processes of information transformation and the interrelation between these plans and schedules, the disconnection between them or inefficiency in transformation may reveal. These are the wastes could be identified in poor coordination in supply chain planning and scheduling activities.

Furthermore, one emphasis in SCM is to coordinate the activities in a supply chain working together towards the mutual objectives (Simatupang *et* al., 2002). The objectives and management focuses of a supply chain unit, an organization or a department and so on, are implied by the performances it measures. The performance measurement indicates the objective a supply chain unit would like to achieve, which means the investigation of whether the mutual objective in the supply chain is aligned or not could be done by comparing the performance measures in different units. Misaligned objectives between supply chain units for sure are wastes should be identified in poor coordination in supply chain management and control.

Additionally, if the supply chain objectives are misaligned, it means ineffective performance measures are involved. Measuring the wrong attributes not only costs extra resources in measurements, but even worse leads the other supply chain activities towards different directions. These are the wastes presenting in poor measurement, also should be identified as wastes poor coordination in the supply chain management and control.

Since supply chains is an integral concept, viewing the entire chain as a system without organization boundaries, the investigation of poor intra-functional coordination should cross organizations; and the method in identifying poor coordination in the same types of supply chain activities, operations, management, and planning and executive, should be complete through the defined chain.

5.2.2. Misalignments in Inter-functional Coordination and Organizations

With different types of supply chain activities, operations, planning, and management and control, they associate with different functions in the supply chain. Also in performing a supply chain, its activities might contain several layers, from shop-floor operation, process management, functional management, to the cooperation between facilities, actors, and organizations, depending on the complexity of the supply chain activities involved. Since the activities are different, the requiring coordination is also varied in each supply chain (Arshinder *et* al., 2008). So when it comes to the coordination across functions in a supply chain, the investigation of potential waste in poor coordination would be more abstract and harder to describe with specific aspects as the method for waste identification. Some of the waste identification methods applied in previous section, intra-functional coordination, could also reveal some more wastes when it comes to inter-functional or inter-organization coordination. For example, planning and mutual objectives should be aligned and implemented through supply chain functions and layers in working as a whole system. If the planning does not reflect upon the actual operations' situation or does not have the same objective with management direction, then the system would not be aligned. So, poor planning and poor measurement should also be examined across functions and organization to investigate wastes in poor coordination in the entire system.

One aspect to look at misalignment in inter-functional coordination in the thesis is to investigate different perceptions of personnel involving in different functions and levels in the supply chain, especially between managerial and operational ones. With different roles and purposes play by each function in supply chain activities, there are various requirements in the supply chain. And with different duties and levels of positions, their expectations and perceptions of the improvement would not be the same. By investigating and comparing their perceptions and requirements in the supply chain, the misalignment or coherence in a supply chain between functions is revealed. If the shop-floor's reflection could be transferred to the higher management levels, or there is unused employee creativity in the supply chain. Also, by looking into how the duties in these positions connect with each other in the supply chain, what are the dependencies, and how much influence is engaged in, could also uncover any poor coordination should be improved in the supply chain.

5.3.Requirements for Activities in Defined Chain

The mechanism applied in identifying waste in the coordination in supply chain activities is to investigate whether the requirements of downstream activities are fulfilled by the upstream activities and aligning with the end customers' requirements. In order to identify the waste in the coordination in the defined chain, the requirements of the customers be identified. Since the defined chain is not a complete supply chain, and the thesis research focuses on the operational instead of strategic level in managing the supply chain, the marketing strategy of targeting customers is beyond the scope of discussion. In the section, the analysis of the chain requirements would base on the operations in the central business and the current supply chain set-up for the engine supplies in the case company, to identify the requirements for the supply chain activities in the defined chain.

5.3.1. Requirements from Central Business

The central business in the case company is in make-to-order (MOT) truck industry which adopts pull system in its operations. Every truck built by the case company is based upon the real customer order with specification. The operations and mainly components supplies with variances would only start when the truck orders have been placed, and the upstream activities are triggered by the demands of the downstream activities. For the defined chain, the engine demand is broken down to the bill-of-materials (BOM) level to the supplier, and the order of engine supply is designated with the corresponding chassis number applied in the central business. The correlation of the supplier and the case company is very tight, which contains an abundant of information exchanges in between to perform the operations in the central business. In this case, it requires efficient and effective mechanism for information exchanges, and enough transparency in information sharing.

Moreover, following the specific takt time, the flow of materials joins the operations in the central business continuously. And for the variant components such as the engines, they are exclusive with the corresponding chassis number, it is essential for the central business operating on the right products. To keep the operations in the central business running smoothly, the flow of materials for these variant components follows a specific sequence. So it is required for the engines entering the operations in the right sequence. Also, to ensure the right engine sequence and, most importantly, they being applied to the right products, an easy access of requiring information of engine identity in operations is highly valuable for the case company.

5.3.2. Requirements from Supply Chain Set-up

Corresponding to the operations in the central business, also because of the engine is a costly product, the current set-up of the defined chain adopts just-in-time (JIT) and sequence supply for the engines. So the inventory cost could be under control. The basic rule of JIT is to provide the materials base on the time when they are needed. In the defined chain, the availability of the engines directly influences on the operations in the central business. There is a fixed schedule for engine deliveries from the carrier to the case company, based on the requiring time of engines arriving at the case company. Accordingly, on time delivery is a requirement for engine supply.

Furthermore, from the interview with the supplier's traffic manager, sequencing is an expensive operation and rearranging would consume a lot of resources, so engine supplies in the right sequence is the request for dispatching. When it comes to JIT with sequence supply, the supply chain activities are tightly connecting with each other. If there is any deviation occurs in the system, the operations could not be performed as scheduled, since the continuous material flow would be disturbed. However, as the operations in truck assembly industry are with high technical complexity, the occurrence of disturbances could hardly be avoided. Efficient problem solving mechanism is especially important under this circumstance; and responsiveness in deviation handling and information exchanges enables the involving actors having sufficient time and information to plan for the alternatives. The requirements for the activities from the central business and its supply chain set-up in the defined chain please refer to Table 5-4.

Table 5-4 Requirements for activities in the defined chain

1.	Efficient and effective information exchange mechanisms
2.	Enough information transparency
3.	Right engine sequence in operations
4.	Easy access of requiring information of engine in operations
5.	On time delivery
6.	Engine supplies in the right sequence
7.	Responsive deviation handling

5.4.Enhance Supply Chain Coordination with Lean

The reason for identifying wastes relating to the coordination in the supply chain is to be able to find improvement areas and solutions to improve supply chain performance. As supply chain is not a static concept, it evolved when the time goes (Krivda, 2005). The coordination in the supply chain should be examined over time as well. From the interviews regarding to waste in supply chain coordination, the reasons for poor coordination resulting in wastes in supply chain activities could be many, such as no comment goals or misaligned in processes, functions, and organizations, the higher hierarchies do not aware the lower level's operations, and so on.

Performing a supply chain require the coordination with several different aspects, to improve the coordination in the supply chain, the involvement of the personnel is essential. The same emphasis as lean, listening to everyone's voice is one of the emphases in lean thinking (Liker, 2004). Employees are very valuable asset for every company; personnel in each position have their insights of the operations involving their work. By talking with them, the ideas of improvement suggestions are naturally exposed. Combing with operators' knowledge and insights of the work, more effective decision makings in improvement could be reached. After all, they are also the executors when it comes to implementation. Involving people from different functions and levels in making improvement, misalignment in inter-functional coordination could be eliminated.

Moreover, the importance of mutual objectives in the supply chain could hardly be overstressed, and clear agreements specify and characterize the concrete actions to reach the objectives. With clear agreements the mutual objectives would be clear and able to align between different supply chain units and involving different levels. With transferring the massage through the supply chain entirely with different levels, the operations in the supply chain would have the standards to follow as to linking with each other smoothly. However, normally they are different functions responsible for negotiating the agreements and practicing them. Under this circumstance the fulfillment of agreements in operations should especially be aware in management.

Yet, sub-optimization in the processes is a big enemy in SCM, and sub-optimization in many cases is because of lacking enough information in decision making. Information transparency is an emphasis in the coordination in a supply chain with close relationships. Information sharing between involving actors facilitates breaking the organizational boundaries in the supply chain. Sharing some critical private information between actors enables the efficiency and effectiveness in performing the supply chain. For example, if the customer provides not only the order quantity but also the demand information in operations to the supplier, the supplier could utilize its production resources in a more efficient way (Soroor, *et* al., 2009). The quality and efficiency of information exchanges could be improved by implementing IT, or standardizing the procedure as mechanisms for information exchanges. And standardization is one of the foundations and an important leverage in continues improvement in lean, which makes the problems revealed (Liker, 2004).

6. Conclusion

As a popular competitive leverage for worldwide companies, various researches and applications have been devoted in the field of supply chains; and nowadays lean is commonly applied to different fields in supply chains. The thesis applies lean in the supply chain back to the core of its thinking, continuous improvement through waste elimination. Moreover, in order to enlarge the effectiveness of implementing lean in improving supply chain performances, the thesis is aiming at shooting the cause or real problem of non-ideal performances in waste identification. For the coordination in a supply chain is a key success factor, the purpose of the thesis is to develop a methodology in identifying wastes in supply chain coordination.

In this master thesis, a methodology framework is presented, illustrating the general procedure of waste identification (See, Figure 5-1). For each supply chain is unique, the developed framework stays in an overall level to increase the generality of applications. The mechanism behind the developed methodology in identifying wastes is to realize the supply chain requirements which are supposed to be aligned with the mutual objectives of the supply chain; then compare the current state of the supply chain with its requirements to recognize misalignments in supply chain coordination.

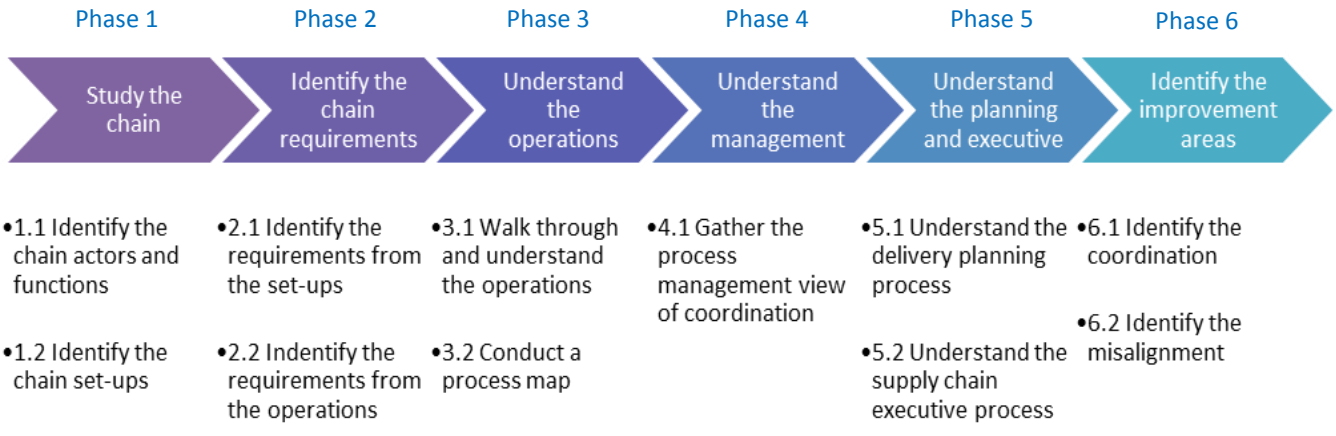

Figure 6-1 Framework and procedure applied to the case study in validating the methodology

The methodology framework was validated and refined after a case study (See, Figure 6-1). Through the case study, it is evidential that the improvement areas of the coordination in a supply chain could be found by applying the methodology. Similar implementations could be done in other supply chains with adjustments to the environment settings. Even the methodology framework is rather general. In this master thesis, the recognition of wastes associating with supply chain coordination is specified; both the potential presence formats, and the criteria used for identification are discussed in the analysis chapter of the report. With the details, further implementations of the methodology in identifying coordination wastes are supported.

To conclude, the importance of supply chains and the coordination are recognized; lean is an influential management approach. Even lean is commonly applied in managing the supply chain; somehow in nowadays research, the linkages between supply chain coordination and lean is rather still a few. This thesis research works as a pilot study to connect supply chain coordination and waste identification in lean; recognize what waste is regarding to the supply chain coordination, and develop a methodology framework in identifying the waste in coordination in a supply chain.

7. Recommendation for Further Research

For further researches, the development and validation of the methodology is mainly based on a single case, further researches could also be conducted in examining the generality of the methodology; to test if the developed methodology is restricted to specific industry and supply chain settings, and further refine and develop the methodology.

Further development on the methodology framework could extend to both directions. Before phase 1, study the chain, selecting a value stream which is most influential to the central business and very beneficial for the company to improve. Also, in lean manufacturing and other areas, value stream mapping (VSM) is the systematic approach commonly used in waste identification and elimination. The result of investigation would be presented in a graph format, the value stream maps, which illustrate the involving processes in a very efficient way. The further development of the methodology could so focus on how to adopt VSM approach to supply chain coordination, as well as to adapt the value stream map indicating the coordination in a supply chain.

Reference

Accenture. (2003). *Global Management Consulting, Technology and Outsourcing Service from Accenture.* Retrieved September 18, 2011, from Accenture.com: http://www.accenture.com/SiteCollectionDocuments/PDF/sce_meet_hiperf.pdf

Albrecht, M. (2010). *Supply Chain Coordination Mechanisms: New Approaches for Collaborative Planning.* London: Springer.

Arshinder, Kanda, A., & Deshmukh, S. (2008). Supply Chain Coordination: Perspectives, Empirical Studies and Research Directions. *International Journal of Production Economics*, 316-335.

Ballou, R. H., Gilbert, S. M., & Mukherj, A. (2000). New managerial challenges from supply chain opportunities. *Industrial Marketing Management*, 7-18.

Barker, R., & Naim, M. M. (2004). Housebuilding supply chains: remove waste – improve value. *International Journal of Logistics Management*, 51-64.

Baudin, M. (2004). *Lean logistics: the nuts and bolts of delivering materials and goods.* New York: Productivity Press.

Bell, E., & Bryman, A. (2011). *Business research methods.* Oxford Oxford University Press.

CBSNews. (2011, January 24). *Toyota Top Automaker Again: 8.42m Sold in 2010*. Retrieved August 19, 2011, from CBSNews.com: http://www.cbsnews.com/stories/2011/01/24/business/main7276718.shtml

Chopra, S., & Meindl, P. (2007). *Supply Chain Management: Strategy, Planning, and Operation.* New Jersey: Prentice Hall.

Christopher , M. (1985). *The Strategy of Distribution Management.* Gower Publishing Company.

Christopher, M. (2011). *Logistics & Supply Chain Management.* Harlow: Financial Times Prentice Hall.

Dibenedetto, B. (2007). Thinking lean -Technology can improve the performance of lean logistics in the supply chain. *The Journal of Commerce*, 21-22.

Huan, S. H., Sheoran, S. K., & Wang, G. (2004). A review and analysis of supply chain operations reference (SCOR) model. *Supply Chain Management: An International Journal*, 23-29.

Krivda, C. (2005). *Advertise on Businessweek.* Retrieved June 2011, from Businessweek: http://www.businessweek.com/adsections/2005/pdf/0515_supply.pdf

Larkin, J. (2006). Extending ''lean'' to supply chains. *Automotive Industries*, 7.

Liker, J. K. (2004). *The Toyota way :14 management principles from the world's greatest manufacturer.* New York: McGraw-Hill.

Malone, T. W., & Kevin Crowston, K. (1994). The Interdisciplinary Study of Coordination. *ACM Computing Surveys*, 87-119.

Mentzer, J. T., DeWitt, W., Keebler, J. S., Min, S., Nix, N. W., Smith, C. D., et al. (2001). Defining supply chain management. *Journal of Business Logistics*, 1-25.

Murman, E., Allen, T., Bozdogan, K., Cutcher-Gershenfeld, J., McManus, H., Nightingale, D., et al. (2002). *Lean enterprise value : insights from MIT's Lean Aerospace Initiative.* New York: Palgrave Macmillan.

Nash, M. A., & Poling, S. R. (2008). *Mapping the Total Value Stream: A Comprehensive Guide for Production and Transactional Processesby.* Productivity Press.

Plenert , G. (2007). *Reinventing Lean- Introducing Lean Management into the Supply Chain.* Burlington: Butterworth-Heinemann.

Porteus, E. L., & Whang, S. (1991). On manufacturing/marketing incentives. *Management Science*, 1166-1181 .

Productivity Press. (2006). *Lean Supply Chain: Collected Practices & Cases.* New York: Productivity Press.

Ryen, A. (2004). *Kvalitativ Intervju.* Malmö: Liber.

Sandberg, E., & Bildsten, L. (2011). Coordination and waste in industrialised housing. *Construction Innovation: Information, Process, Management*, 77-91.

Sayer, N. J., & Williams, B. (2007). *Lean For Dummies.* Indianapolis: John Wiley & Sons.

SCC. (2010). *Supply Chain Operations Reference (SCOR) model.* Supply Chain Council, Inc.

Schniederjans, M. J., Schniederjans, D. G., & Schniederjans, A. M. (2010). *Topics in Lean Supply Chain Management.* New Jersey: World Scientific.

Schniederjans, M. J., Schniederjans, D. G., & Schniederjans, A. M. (2010). *Topics in Lean Supply Chain Management.* Singapore: World Scientific Publishing Co. Pte. Ltd.

Simatupang, T. M., Wright, A. C., & Sridharan, R. (2002). The knowledge of coordination for supply chain integration. *Business Process Management Journal*, 289 - 308.

Soroor, J., Tarokh, M. J., & Shemshadi, A. (2009). Theoretical and Practical Study of Supply Chain Coordination. *Journal of Business & Industrial Marketing*, 131-142.

Stamm, D. J. (2003). Plan for lean success. *Industrial Engineering*, 24.

Stock, J. R., Boyer, S. L., & Harmon, T. (2010). Research Opportunities in Supply Chain Management. *Journal of the Academy of Marketing Science* , 32-41.

Tapping, D. (2008). *The Simply Lean Pocket Guide: Making Great Organizations Better Through Plan-Do-Check-Act (PDCA) Kaizen Activities .* MCS Media.

Tapping, D., & Shuker, T. (2003). *Value Stream Management for the Lean Office.* New York: Productivity Press .

Thomas, D. J., & Griffin, P. M. (1996). Coordinated supply chain management. *European Journal of Operational Research*, 1-5.

Trent, R. J. (2008). *End-to-End Lean Management: A Guide to Complete Supply Chain Improvement.* J. Ross Pub.

Whang, S. (1995). Coordination in operations: A taxonomy. *Journal of Operations Management*, 413-422.

Womack, J. P., & Jones, D. T. (2003). *Lean thinking: banish waste and create wealth in your corporation .* London: Simon & Schuster UK Ltd.

Wright, A. C., Sridharan, R., & Simatupang, T. M. (2002). The knowledge of coordination for supply chain integration. *Business Process Management Journal*, 289 - 308.

Wright, A. C., Sridharan, R., & Simatupang, T. M. (2002). The Knowledge of Coordination for Supply Chain Integration. *Business Process Management Journal*, 289 - 308.

Yin, R. K. (2002). *Case Study Research: Design and Methods.* California: Stage Publications Ltd.

Zimmer, K. (2002). Supply chain coordination with uncertian just-in-time delivery. *International Journal of Production Economics*, 1-15.

Appendix A –Template for Data Collection on Operation Sites

Questions for operators

1. What is the procedure of your work?
2. What information is needed to operate? How do you get this information?
3. Is there any difficulty in your work?
4. What improvement can be made to help your work?

Recording sheet

Time		Facility		Record person	
Contact					
Step No.	Q1. Description of the activities	Q2. Required information	Q2. Means	Q3, 4. Improvement suggestion	Notes

Appendix B –Interview Template

Date		Interviewer	
Location			
Interviewee:		Record Method:	
Company		Duty at Work	
Position			
Contact			
Questions			
Category			
Category			
Category			

Appendix C –Interview Questions

Appendix C-1 Interview Questions for Delivery Process

Date		Interviewer	
Location			
Interviewee: Traffic Manager		Record Method:	
Company		Duty at Work	
Position			
Contact			

Questions

Profile of Interviewee

1. Can you give us some introduction about the daily job, responsibility, and actors you interact with in your position?

Delivery Process

2. What is the standard process in handling the inbound logistics for the case company?

3. Can you describe the process of material supplies for the central business in general?
   a. Who is involved in the supply chain of the central business?
   b. What is the frequency of orders being placed?
   c. What methods do you use for placing the orders?
   d. What information is involved in placing an order?

Transportation tracking

4. Do you receive any feedback if the materials are transport? What information do you receive?

Further Contact

5. Can you refer us contact persons to know more about the supply chain?

Appendix C-2 Interview Questions for Ordering to Delivery Process

Date		Interviewer	
Location			
Interviewee: Process Manager Inbound Logistics Process Manager		Record Method:	
Company		Duty at Work	
Position			
Contact			

Questions

Profile of Interviewee

1. Can you give us some introduction about the daily job, responsibility, and actors you interact with in your position?

Ordering to Delivery Process

2. Please describe the planning of ordering to delivery process.
   e. What strategy do you use for planning orders?
   f. What methods do you for placing the orders to suppliers?
   g. What information is required in placing an order
   h. What is the lead time from the order to its delivered?

Supply Chain Performance

3. How is the performance of delivery precision in materials supplies for the central business?

Further Contact

4. Can you refer us contact persons to know more about the supply chain?

Appendix C-3 Interview Questions for Waste in Supply Chain Coordination

Date		Interviewer	
Location			
Interviewee: Lean SCM Researcher Lean Production Specialist		Record Method:	
Company		Duty at Work	
Position			
Contact			

Questions

Profile of Interviewee

1. Do you have the experience in a project or research work related to coordination among different supply chain actors in execution level?

Wastes in Supply Chain Coordination

2. In supply chain execution, where do you think coordination between actors is needed to achieve lean in a supply chain?

3. From your previous experience, what are the challenges in supply chain coordination involving different actors?

Improvement Area

4. What inefficiency exists in the coordination between actors during the supply chain execution?

5. What do you think the waste is in the coordination between supply chain actors during their execution?

6. Where do you think improvement could be made regarding to coordination between actors in supply chain execution?

Appendix C-4 Interview Questions for Production Planning

Date		Interviewer	
Location			
Interviewee: Production Planning Manager Customer Contact		Record Method:	
Company		Duty at Work	
Position			
Contact			

Questions

Profile of Interviewee

1. Can you describe the responsibility of your position associating with the chain? Where in this chain does your position have influence on and in what way?

Information and correlation

2. What is the information flow in scheduling the operations in this part of the chain?
    a. What information is need in scheduling this part of the chain? How do you get it?
    b. What is the rule or consideration in scheduling the operations?
    c. How long time ahead is the operations scheduled? In what frequency?
    d. How the information is transmitted to the operations?

3. What is the correlation between the schedule of the operations in this part of the chain and other operations? In what way the information of the schedule is transmitted to the other actors?

4. When there is deviation in fulfilling the schedule what is the corresponding adjustment in scheduling and the chain, and how is the information transmitted?

Problem and difficulty

5. Are you aware of the operations in this chain both in your company or other companies? If yes, what are they and what is expected from the operations?

6. In coordinating the planning and operations in your company with the others, where do you find it is difficult to perform your work?

7. Do you find any difficulty in the chain when the operations are carried out by more than one company? Where do you think the problem usually occurs and what problem it is?

Improvement area

8. Do you see potential improvement in the supply chain? If yes, where?