CHALMERS
UNIVERSITY OF TECHNOLOGY

The Effects of Consolidation on Volvo Group's LCL Transportation Network

Master's thesis in Supply Chain Management

Sasan Pezeshki
Fan Wang

Department of Technology Management and Economics
CHALMERS UNIVERSITY OF TECHNOLOGY
Division of Service Management and Logistics
Gothenburg, Sweden 2016
Report No. E2016:085

MASTER'S THESIS E2016:085

The Effects of Consolidation on Volvo Group's LCL Transportation Network

SASAN PEZESHKI FAN WANG

Supervisor & Examiner: Gunnar Stefansson

CHALMERS
UNIVERSITY OF TECHNOLOGY

Department of Technology Management and Economics
Division of Service Management and Logistics
Chalmers University of Technology
Gothenburg, Sweden 2016

The effects of consolidation on Volvo Group's LCL shipments

SASAN PEZESHKI
FAN WANG

SUPERVISOR: GUNNAR STEFANSSON

© Sasan Pezeshki & Fan Wang, 2016

Master's Thesis E2016:085

Department of Technology Management and Economics
Division of Service Management and Logistics
Chalmers University of Technology
SE-412 96 Göteborg, Sweden
Telephone: + 46 (0)31-772 1000

ABSTRACT

The purpose of this thesis was to map out the current less-than-container load (LCL) flow of Volvo Group and to investigate the effects that consolidation of the LCL shipments would have on the company's transportation network. In order to map out the company's current LCL transportation network, data was collected from 12 LCL logistics service providers that had been used by the Volvo Group during 2015. The geographical spread of the LCL shipment varied from region to region. Asia-Pacific (APAC) was the region with the largest portion of the LCL shipments during the year based on the number of shipments. 62 percent of the consignments were shipped intra-APAC during 2015, and the shipments from all of the three regions (APAC, EMEA and Americas) to APAC accounted for 75% of the total number of consignments globally. During the year, the Volvo Group had LCL shipments originating from 34 different countries.

Base on a total cost of ownership model, multiple criteria were considered in order to evaluate potential scenarios developed during the project. Five categories representing different costs related to a purchase were chosen in order to evaluate the scenarios from different perspectives. The chosen categories are cost, management, quality, service and communication. Within each category a number of assessment parameters that would have an impact on the total cost of that specific category were identified.

In order to identify consolidation opportunities for the Volvo Group's LCL transportation network, seven potential LCL transportation scenarios were constructed. Five of them included consolidation, both buyers' consolidation and standard consolidation, and the other two scenarios were designed in order to identify the effects of consolidation. Each scenario was then assessed based on the aforementioned parameters. The conclusion from the analysis is that each scenario has its strengths and weaknesses. Having a door-to-door setup with a reduced number of logistics service providers will decrease the level of management needed and improve the quality of the LCL transportation network. A transport solution where Volvo Group procures the LCL transports in different transport legs will lead to the lowest transport cost. If the company's aim is to get the best service level then a door-to-door solution with multiple logistics service providers will be the most feasible setup. In order to make the business-to-business communication more efficient as well as gaining a better tracking and tracing solution, the Volvo Group should manage minor and major flows differently. The transports in the major lanes should be procured in different transport legs and the transports in the minor lanes should be purchased door-to-door from a limited number of logistics service providers.

Keywords: *Less-than-container Load, Consolidation, Buyer's Consolidation, Logistics Service Provider, Total Cost of Ownership, Procurement, Supplier Base Reduction, Weight Criterion Method.*

ACKNOWLEDGEMENTS

This project was conducted at Volvo Logistics offices in Arendal, Gothenburg. During this project, we have been in contact with various employees of the company that all have been very collaborative. We would like to thank all of them for their insightful opinions and ideas. We would also like to show our gratitude towards the logistics service providers for participating in interviews and providing answers to all our questions.

Especially, we would like to direct our appreciation to our supervisors at the Volvo Group, Helena Carlsson and Mario Van den Bussche, for their guidance and support regarding different issues throughout this project. We would also like to thank Gunnar Stefansson, our supervisor at Chalmers University of Technology, for his time, inspiration and all the good input during this project.

Gothenburg, May 2016
Sasan Pezeshki & Fan Wang

TABLE OF CONTENT

TABLE OF FIGURES

TABLE OF TABLES

LIST OF ABBREVIATIONS

LCL: Less-than-container Load

FCL: Full Container Load

LTL: Less-than-truck Load

CFS: Container Freight Station

B/L: Bill of Lading

EDI: Electronic Data Interchange

APAC: Asia-Pacific

EMEA: Europe, the Middle East and Africa

OEM: Original Equipment Manufacturer

TCO: Total Cost of Ownership

3PL: Third-party Logistics

RFI: Request for Information

RFQ: Request for Quotation

PCT: Pre-carriage Transportation

MCT: Main-carriage Transportation

OCT: On-carriage Transportation

1 INTRODUCTION

The introduction chapter presents a background of the thesis and a brief description of the Volvo Group. Subsequently, the purpose of the thesis and research questions that need to be answered in order to fulfill the purpose are given. This is followed by the limitations of the thesis as well as the outline of the report.

1.1 Background

Supply chain management continues to evolve, expand and globalize at an almost ungraspable pace. Adapting and integrating new decision support tools and technologies regarding the internet, new machinery and equipment, infrastructure changes and business analytics are challenges that supply chain managers are confronted with daily in every industry (Liang, et al., 2015). One of the most fundamental processes in a company's supply chain is freight transportation. The process is essential in order to move finished products from factories to customers, raw material from sources to factories and semi-finished goods between plants. The process is also one that accounts for a large share of a company's logistics expenditure, usually between one-third and two-thirds of the total amount (Hosseini, et al., 2014). The economic impacts that logistics have on countries and their societies are also substantial, in 2011 these activities accounted for 8,5% of the US gross domestic product (GDP) and the numbers in Europe are almost the same (Grant et al., 2015).

The various activities associated with logistics and transportation do also have an impact on the environment and its sustainability. These issues have gained more and more attention and been causing growing concern for businesses on a global scale (Grant et al., 2015). The transport sector has a greenhouse gas footprint of approximately 5,5% of the total global greenhouse gas emissions (Hosseini, et al., 2014). Growth of container shipping over the past 30 years due to globalization is one of the biggest sources for this development. Increasing sustainability regarding ocean freight transportation can be reached by reducing the amount of emissions from shipping activities, both in ports and in deep seas. Shipping fewer containers, increasing container utilization, shipping containers more efficiently, slow steaming and switching fuels to lower sulfur diesel can contribute to a reduction of emissions (Grant et al., 2015).

One way of achieving a reduction both in emissions and in shipping costs is to increase container utilization. McKinnon (2012) argues that the pressure to minimize shipping costs gives firms strong incentives to maximize fills and further identifies higher utilization degree as one of the most attractive sustainable distribution measures for companies. There is however almost no data regarding container utilization, nor on weight nor on volume, of deep-sea containers at a macro level (Grant et al., 2015). One possible reason for this might be that most of the measurements of freight at macro level are in terms of weight rather than volume (McKinnon et al., 2012).

Not fully utilizing the containers or vehicles is not something that companies do intentionally and it is not, in most cases, a result of poor management. McKinnon (2010) identifies the main causes that hinder the transport management to fully utilize the company's unit loads and classifies them in five categories:

- Market-related, such as fluctuations in demand.
- Regulatory constraints, e.g. health and safety regulations.
- Inter-functional constraints resulting from poor coordination and not aligned department goals.
- Infrastructural hinders such as limited capacity of facilities.
- Equipment-related constraints, e.g. incompatibility of resources.

By studying the constraining factors in figure 1-1, McKinnon (2010) finds that companies are making perfectly rational trade-offs between transport efficiency and other corporate goals that hinders the effectiveness of the transport network. The other corporate goals, such as minimizing inventory throughout the supply chain, minimizing staffing costs by optimizing productivity at loading bays and creating agile supply chains in order to handle fluctuations in a better way, can lead to a lower total logistics costs even if it leads to lower unit load utilization.

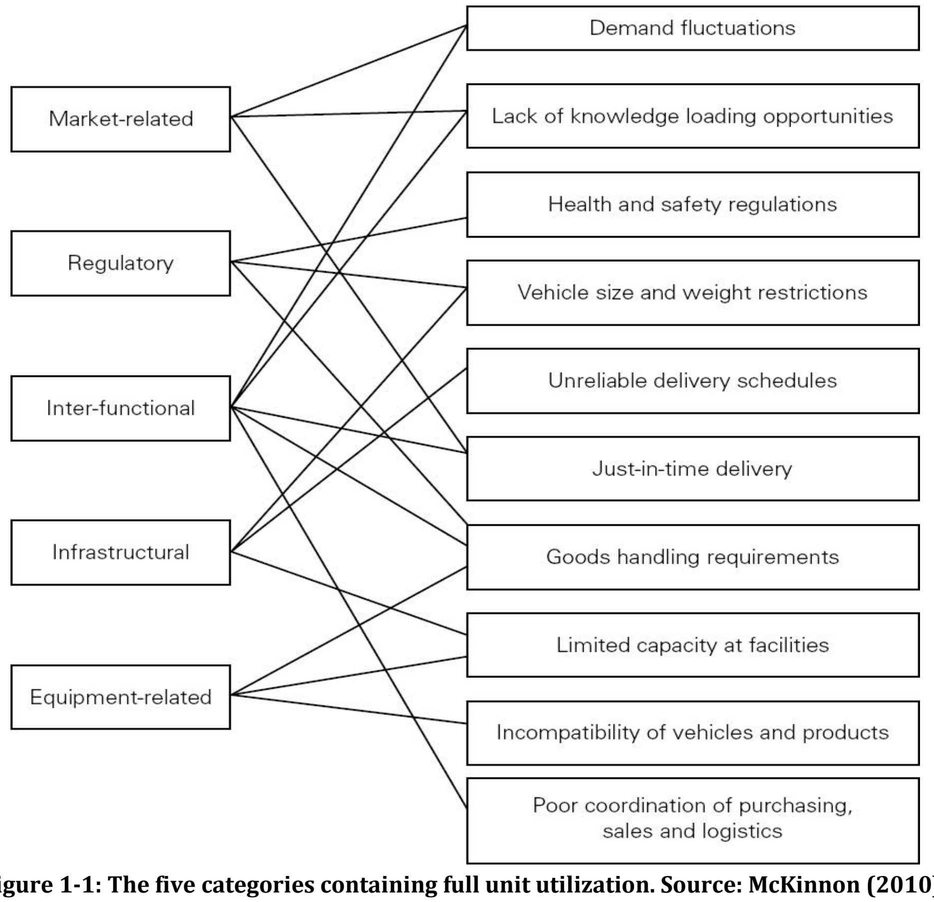


Figure 1-1: The five categories containing full unit utilization. Source: McKinnon (2010).

A logistics strategy that can help increase the unit load utilization through combining two or more shipments is volume consolidation. Consolidation can be performed internally at an original equipment manufacturer's (OEM's) facility or by a transportation company during the transportation (Lumsden, 2007). Consolidation is also a crucial strategy for cost reduction in LCL and LTL transports. Chopra & Meindl (2010) are of the opinion that larger firms have an advantage in the LCL segment because of the high fixed cost for setting up consolidation centers.

1.2 Volvo Group

Volvo Group is one of the biggest companies in Sweden and one of the world's leading manufacturers of trucks, marine and industrial engines, buses and construction equipment. The company does also provide complete solutions for financing and service. Volvo Group is a global company with customers in over 190 markets, production facilities in 19 countries and about 100,000 employees throughout the world. The company is listed on Nasdaq Stockholm, and has net sales of SEK 313 billion (Volvo Group, 2016). The company has earlier aimed for an acquisition-driven growth; this has resulted in Volvo Group, on the truck side, acquiring Mack Trucks, Renault Trucks and UD Trucks. The company has also created a joint venture with Eicher Motors and a strategic alliance with DFCV, where Volvo Group owns 45% of the company, in China.

These acquisitions and collaborations are expected to provide economies of scale in product development, production, distribution and service. This has led to the company's next phase where the aim is to reorganize the company in order to take out overlaps, reduce structural costs and increase efficiency as well as profitability (Volvo Group, 2016). Within this reorganization the transport organization were centralized into logistics services. The approach to levels of engagement, optimization and IT solutions varied in the previous organizations and now the company is striving to formulate a common vision forward regarding the transport strategies.

1.3 Purpose and research questions

The purpose of this thesis is to map out the current less-than-container load (LCL) flow of Volvo Group and to investigate the effects that consolidation of the LCL shipments would have on Volvo Group's transportation network. In order to fulfill the purpose of the thesis, three research questions presented below must be answered. Reasoning for their feasibility and importance are also given.

1. How does the Volvo Group's current less-than-container load transportation network look like?

Multiple forwarders are currently used to handle Volvo Group's LCL shipments, and there is no clear data regarding all of the shipments available in-house. Therefore, it is hard to have a holistic overview of Volvo Group's existing LCL transportation network. Understanding the Volvo Group's LCL transportation network is the first step of this project. This is not only a requirement from Volvo Group but also a necessity for further analysis. In order to answer this question, there is a need for data collection from the forwarders used by the company during 2015.

2. What are the internal customers' requirements on the less-than-container load shipments?

After understanding the current LCL transportation network, there is a need for understanding the internal customers' requirements regarding the network. What are the important factors that need to be considered when creating a transport solution for the shipments? In order to identify the customer requirements, a literature study is conducted and a list of important parameters will be found. Through interviews and discussion with internal stakeholders, the parameters that are considered most important for the Volvo Group will be chosen in order to assess the potential LCL transportation scenarios.

3. What are potential feasible consolidation scenarios for Volvo Group's LCL shipments? How would the customers' requirements be influenced by the different scenarios?

The last research question aims to find and evaluate potential solutions for the Volvo Group's LCL transportation network. A number of different scenarios for the network will, based on the findings in the literature review and insights from interviews held with employees within different departments, be designed. The constructed scenarios will then be assessed according to the parameters considered most important by the internal stakeholders.

1.4 Limitations

The scope of this thesis is restricted by a number of different limitations. One limitation is that only data from 2015 is regarded when mapping out the Volvo Group's current LCL transportation network. It would have been interesting to look on data for the previous years as well in order to get a picture of how the shipments have been developing over time. There is no possibility for the researchers to detect any big fluctuations that might have been specific for year 2015 because of the limited time that data has been collected for. Another limitation of this project is that less-than-truck load shipments are not regarded.

Today, there are three transport processes taking place within the Volvo Group; Transport Parts, Transport Materials, and Transport Products. There is no LCL transports related to Transport Products. This process is hence not regarded when formulating the assessment parameters and constructing the scenarios.

1.5 Report outline

The first chapter mainly presents the background of the thesis and an initial description of Volvo Group. It also contains the purpose, research questions and limitations of the thesis. In chapter two, the relevant theoretical background used in the analysis and discussion is given. It starts by introducing supply chain management, performance measurements, and the total cost of ownership model, as well as describing sourcing strategies from a total cost of ownership perspective. Thereafter, a few important logistics concepts are presented. Chapter three describes how the research process is designed and conducted. The methods used for data collection and data analysis, as well as data accuracy are also introduced in this chapter. The current situation of Volvo Group’s LCL transport is mapped out in chapter four. The data collected from literature review, interviews, questionnaire and organizational documents is presented in this chapter as well. Chapter five starts with describing alternative scenarios for the Volvo Group’s LCL transportation network followed by parameter assessment according to the Weight Criterion method and scenarios assessment. Chapter 6 will answer the research questions separately along with other relevant findings gained from the whole thesis project. The last chapter discusses the key findings from the project as well as the contribution of the project, and provides suggestions for further research.

2 THEORETICAL FRAMEWORK

This chapter aims to present the relevant theories and models that are used as tools to conduct the analysis for answering the second and third research questions. It starts by introducing supply chain management as a concept, performance measurements, and the total cost of ownership model as well as describing sourcing strategies from a total cost perspective. Thereafter, a few important logistics concepts are presented.

2.1 Supply chain management

Chopra and Meindl (2006) state that a supply chain consists of not only manufacturers and suppliers but also warehouses, retailers, transporters and even the final customers, in order to fulfill a customer demand. To be more specific, a supply chain encompasses all functions related to receiving and accomplishing a customer request, as well as new product development, marketing, operations, distribution, finance and customer service. Similarly, Christopher (2005) considers a supply chain as a network of interrelated organizations that through upstream and downstream connections generates value to the final consumers. As depicted in figure 2-1, a supply chain usually exists within a complex network where divergent and convergent flows of material, information and money are handled. A supply chain can be deemed as an intra-organizational supply chain from a broad perspective while it can be described as inter-organizational when considered from a narrow perspective. However, the most critical prerequisite of a supply chain is the tight cooperation among different activities, e.g. marketing, production, procurement, logistics and financial (Stadtler et al., 2015). Hence, Stadtler et al. (2015) continue with defining supply chain management as "the task of integrating organizational units along a supply chain and coordinating material, information and financial flows in order to fulfill ultimate customer demands with the aim of improving the competitiveness of a supply chain as a whole".

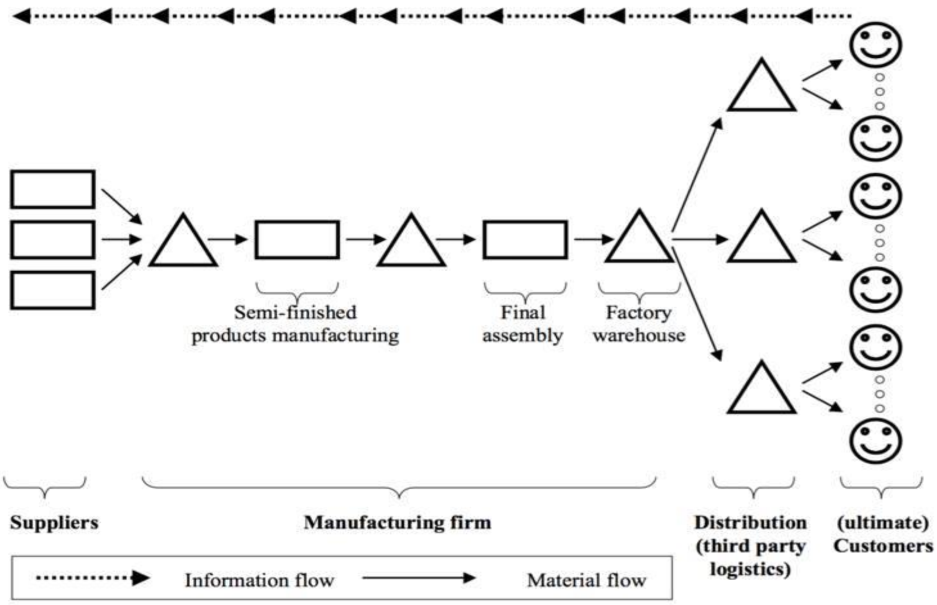


Figure 2-1: An example of Supply Chain Network. Source: Stadtler et al. (2015).

Stadtler et al. (2015) point out that all members' objective within a supply chain is to increase competitive advantages through their joint efforts. In other words, the competitiveness of a company's products or services relies on the performance of the whole supply chain, rather than the company itself. Therefore, it is the competition between different supply chains instead of single companies. Stadtler et al. (2015) also highlight that a closer integration of members in a supply chain and a better coordination of material, information and financial flows are two primary ways for a supply chain to increase its competitiveness. Likewise, Martin (2005) describes supply chain as a system consisting of processes or functions whose aim is to reduce supply chain costs and improve customer service. Hence, it is common to see that companies are keeping exploring ways to decrease logistics cost in order to make the whole supply chain more profitable.

2.1.1 Performance measurements

If a company wants to establish a clear picture of how its supply chain is performing there is a need to measure its performance. Neely et al. (1995) defines performance measurements as "the process of quantifying the efficiency and effectiveness of actions". In order to do the actual quantification a performance measurement system is needed, this system was defined by Skjøtt-Larsen et al. (2007) as "the concrete tool designed to quantify performance". The first step of improving and controlling any process is to measure its performance in order to understand it. Improving the performance of a supply chain management is a continuous processes and that necessitates logical performance measurement systems (Anand & Grover, 2015). The performance measurement system has an important role and multiple functions in a supply chain (Anand & Grover, 2015):

- It helps translate supply chain strategies intro operational objectives.
- It acts as a deviation identifier and gives managers the ability to detect and react to deviations.
- Performance goals can be communicated throughout the company.
- It can clarify the responsibilities and objectives of the different actors within the supply chain.
- The system can support future strategic decisions.
- It can also highlight how the different processes within the supply chain are interconnected to each other and increase the understanding of the network.

Performance measurements can be divided in four major categories; time, quality, cost and supporting metrics. The measured parameter in the different categories can further have a resource or output point of view. Some supply chain measurement with a resource perspective can be:

- Total costs of the used resources.
- Costs associates with distribution, e.g. transportation and handling costs.

- Costs that are associated with holding inventory; costs associated with making investments in the inventory, inventory obsolescence, costs associated with work-in-process such as tied up capital.
- Return on investment; which is a measurement of the company's profitability, usually a ration between net profit and total assets.

Supply chain performance measures with an output perspective can be:

- Total revenue
- Profit; total revenue minus the expenses
- Vehicle utilization; target utilization achievement which indicates to what extent a target has been achieved
- The number of complaints from the customers
- On-time deliveries
- Lead time

The choice of what to measure is based on what kind of information that is important for the company. The measurements could be internal within the company, between companies and together with other companies. Measurements within the company are internal measurements of processes, e.g. the order fulfillment process, and internal measurements of functions, e.g. warehousing, transportation, distribution. Measurements between companies, suppliers and customers, are related to supplier performances and lead-times between companies. A company can also have measurements in alliance with other companies and the purpose of such measurements is to measure the performance of the entire supply chain and to share costs and profits.

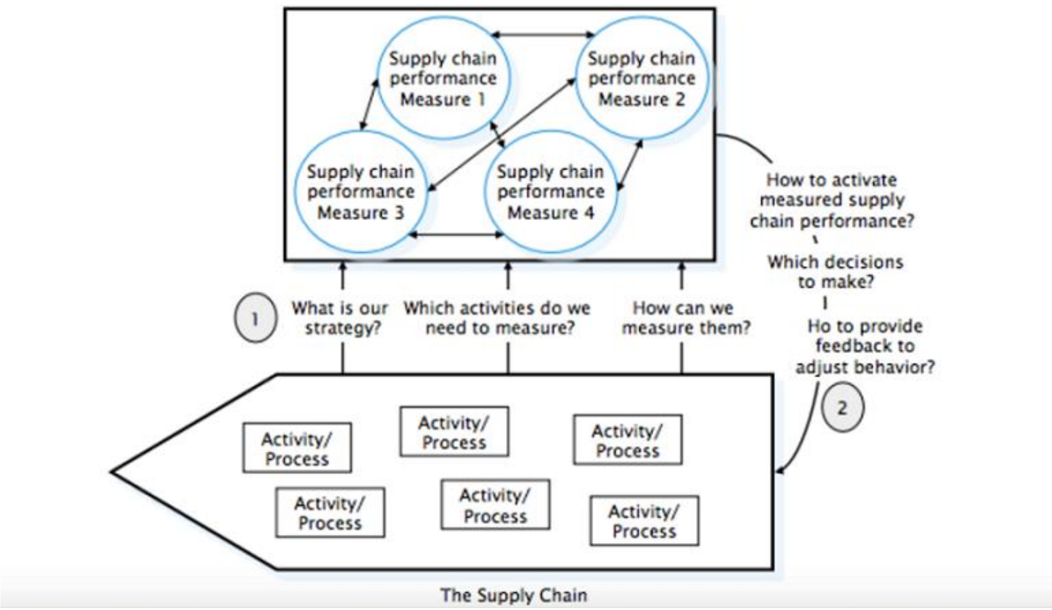


Figure 2-2: An example of a measuring systems design. Source: lecture material.

Figure 2-2 shows how a measurement system is set up; in the first step the company needs to look at its strategy in order to find out the activities or processes that needs to be measured to reach the targets. After the right activities and measurements are found, there is a need to decide how to measure them. A few supply chain performance measurements can be identified based on the findings in the first step. In the second step the measurements are collected and decisions can be taken based on the results in order to adjust the activity or process in question.

2.1.2 Total cost of ownership

A way of understanding the real cost and performance of a procured service or product is to analyze it from a total cost of ownership (TCO) perspective. This tool is a rather complex approach which requires the buyer to determine all of the costs that are important and significant during the procurement, procession, use and disposition of the acquired good or service (Ellram, 1995).

Ellram (1995) found out four primary uses of the TCO model based on a case study in which 11 organizations from various industries participated. The case study firms used TCO in supplier selection, evaluation, and measurement of the suppliers' current performance in order to initiate major process changes. The organizations which implemented TCO analysis to initiate changes did take a very broad and systematic approach instead of solely focusing on purchasing-related issues and the performances of potential suppliers. These organizations' strategic and/or make-or-buy decisions were supported by the TCO analysis (Ellram, 1995). The constituents of TCO can be divided into five major categories, see figure 2-3.

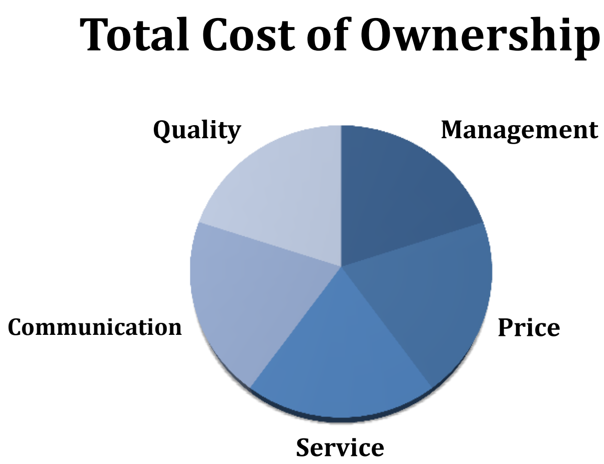


Figure 2-3: Constituents of TCO

2.1.3 Sourcing strategy and the total cost perspective

The decision whether to use single sourcing or multiple sourcing is an important strategic decision for all companies (Kirytopoulos et al., 2010). To what extent that uncertainty of supply disruption can be mitigated is also closely dependent on the sourcing strategy (Christopher et al., 2005). Furthermore, this decision can impact customer-supplier relationships. This can consequently influence the costs and benefits of acquiring suppliers' resources and competences to improve and innovate existing practices or products (Skjøtt-Larsen et al., 2007).

When purchasing customized or specialized products or services, it is more possible to reap the benefits of single sourcing. High-involvement relationships must be established when using a single sourcing strategy, which requires not only mutual dependency and trust but also time and resources. The benefits of this kind of close relationship include lower risk of supply disruption, more chances to utilize supplier's capabilities, cost reductions from improved production processes and physical flows, higher service level, and more flexibility. Another important advantage is the increased bargaining power in price negotiation due to the supplier base reduction and volume consolidation. For buyers, one disadvantage of a high-involvement relationship is high investments related to coordination, adaptation and handling. The risk of relying on only one supplier cannot be ignored. Multiple sourcing, on the other hand, is a better option with commodity type products or common services and can help a buyer get a lower component prices through competitive bidding among suppliers. Comparatively low-involvement relationships are built between buyers and suppliers, either short term or long term. Major advantages that can be gained from multiple sourcing encompass decreased transaction uncertainty, higher technological flexibility and reduced component prices. The disadvantages of multiple sourcing originate mainly from the low-involvement relationship. As a result of this type of relationship, a high level of supplier commitment and loyalty are difficult to achieve and benefits are therefore hard to gain from suppliers' capabilities and know-how. Having several suppliers simultaneously will generate higher management costs. (Skjøtt-Larsen et al., 2007)

From a total cost perspective, the direct component price is usually lower when using multiple sourcing while direct purchasing costs might increase. This is because the orders are assigned to different suppliers, which generates different transaction costs. The total cost of multiple sourcing might increase for some reasons, e.g. the initial investment is high since many suppliers are involved and adaptation costs increase the total cost when integrating internal resources with suppliers'. Meanwhile, by selecting the most appropriate suppliers for specific tasks, it is possible to achieve a lower total cost. (Lindquist and Yhlen, 2011)

When it comes to single sourcing, several benefits can be gained from a high-involvement relationship, as aforementioned. These benefits can reduce the total cost significantly. Håkansson and Wootz (1984) introduce two scenarios where single sourcing outperforms multiple sourcing from a total cost perspective due to a closer customer-supplier relationship. The first scenario is when indirect costs related to the purchase are higher than the direct component price. In this case, a high-involvement relationship can help reduce the indirect costs related to the purchase. In the second scenario, when the indirect costs are lower than the component costs, the total cost is possible to decrease by making suppliers compete against each other to get lower component costs.

2.2 Logistics

The traditional understanding of logistics is that it is a practice aiming to do the right things in the right way. Shapiro and Heskett (1985) describe logistics as "those activities that relate to receiving the right product or service in the right quantity, in the right quality, in the right place, at the right time, delivering to the right customer and doing this at the right cost". Jonsson and Mattson (2005) hold the view that the objective of logistics is to control the material flow and therefore they regard logistics as "the planning, organization, and control of all activities in the material flow, from raw material until final consumption and reverse flows of the manufactured product, with the aim of satisfying the customer's and other interested party's needs and wishes". Lumsden (2007) continues with providing a more extensive interpretation of logistics, in which logistics is deemed as part of the supply chain that encompasses the movement of people and/or materials, and activities related to managing the right individual in the right quantity to the right place at the right time and cost. It aims to fulfill all of the stakeholder's requirement, especially the customers' and it includes all activities in the flow of materials, resources, information, financial assets and reverse flows, in terms of planning, organization and control as well as encompassing operative responsibilities that includes administration, operation, purchase, constructive duties and detailed design.

The efficiency of logistics activities can be described from three interrelated dimensions: service, costs and tied-up capital. It is vital to avoid sub-optimization when trying to improve the logistical efficiency from one aspect. This is also called the "logistical goal mix" which aims to reach a balance among different goals, as shown in figure 2-4. To exemplify, a company might take some measures such as decreasing the number of shipments by consolidation to lower the transport costs. These measures do, on the other hand, require the company to keep a high inventory level and wait for larger shipping volumes. As a result of this, the company would have higher tied-up capital and worse customer service due to decreased shipping frequency. (Lumsden, 2007)

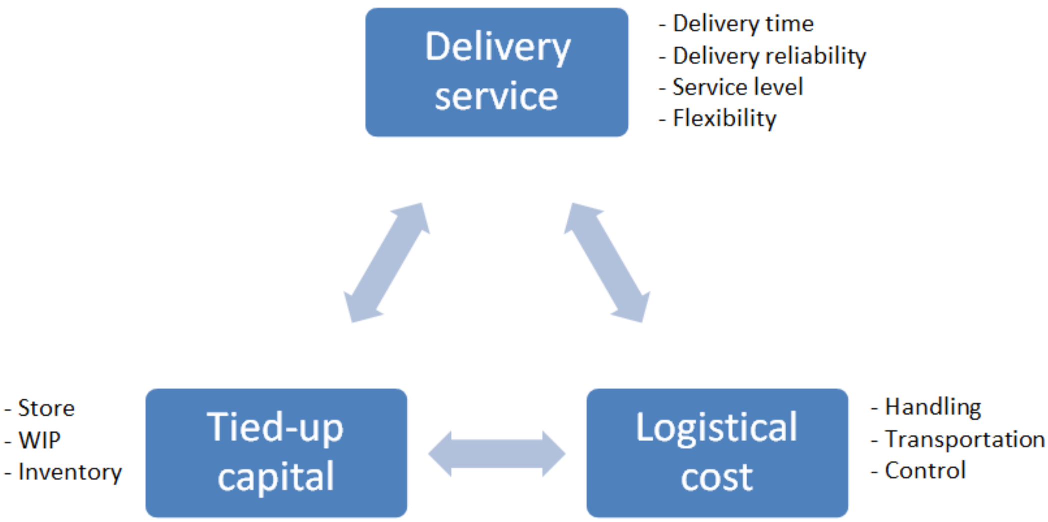


Figure 2-4: The logistical goal mix. Source: Lumsden (2007).

2.2.1 Third-party logistics

Nowadays, manufacturing companies are keen on gaining competitive advantages and differentiating themselves from their competitors. As a result of this, the attention put on the company's distribution function has increased. The reason behind this is that products of different companies are becoming more and more homogeneous and the delivery performance of the company critical for its success. The role that transportation companies and forwarding companies plays in a transportation chain has changed significantly, from providing merely isolated physical deliveries to offering complete logistical solutions which include not only physical distribution but also transportation planning and storing. (Lumsden, 2007)

According to Berglund et al. (1999), the term third-party logistics (3PL) refers to "activities carried out by a logistics service provider on behalf of a shipper, consisting of at least management and execution of transportation and warehouse" while additional activities can be added as well, e.g. inventory management, tracking and tracing, secondary assembly and installation of products. Zhang and Okoroafo (2015) argue that a 3PL provider can provide advanced logistics services including transportation, warehousing, freight consolidation and distribution, cross-docking, and logistics information systems. Lumsden (2007) agrees with the former interpretation, but goes further with explaining 3PL from a different perspective; flow control. A transport comprises two flows: a physical flow of freight delivery and an information flow used to control the physical flow. Usually, a 3PL provider is responsible for the complete control of both flows. In other occasions, the manufacturing companies probably do not want to handle all logistics activities by themselves, but still expect to control the flows. In this case 3PLs can be an excellent solution. They have the expertise to implement appropriate IT systems and the manufacturers can have complete control of all flows without being involved in the physical flow.

2.3 Sea transport

Sea transport is deemed as a cost-efficient freight transport mode, especially for heavy and bulky products where short lead times are not required (OECD, 2010). The factors contributing to its great economic performance include larger loading capacity of vessels compared to other transport modes and free ocean routes (Lumsden, 2007). The low operating costs of ships, due to large capacity and low energy consumption of ships as well as the limited manpower required does further improve the cost-efficiency of this freight mode (Rodrigue et al., 2006). The continuous development towards larger and more specialized vessels has made the price of sea transportation lower and lower over time (Lumsden, 2007). Although many advantages can be gained from sea transport, its drawbacks cannot be ignored. Comparing with other means of transport, the speed of sea transport, around 26 km/h in average, is relatively slow and leads to long lead-times. Safe and reliable as sea transport is, maritime routes are sometimes hindered by extreme weather conditions.

The time-consuming processes of loading and unloading, which may require several days of handling goods in ports, influence the performance of sea transport negatively (Rodrigue et al., 2006). Another challenge of maritime transport is port congestion. According to Rajamanickam and Ramadurai (2015), port congestion has been experienced by many major ports, such as; Navi Mumbai Port, Vishakhapatnam Port, Los Angeles Port, Long Beach Port and Manila Port. This is the result of continuous growth in international trade and the limited capacity of some port facilities. Hoppin (2006) argues that the ocean transport system is becoming increasingly fragile due to port congestion, and suggests shippers to use alternative ports when some ports are getting close to their maximum capacity. For shippers, this could dramatically lower the cost of port congestion by reducing late deliveries and decreasing the possibility of stock-outs. The arguments provided above result in that sea transport might not be an appropriate choice when transport distances are short or when fast deliveries are required by customers (Rodrigue et al., 2006).

2.3.1 Container shipping

Container shipping comprises two main means: full container load (FCL) shipping and less-than-container load (LCL) shipping (Xiao, 2011). Hoppin (2006) describes FCL as "a customer purchases the use of an entire 20-foot or 40-foot container" while LCL as "multiple shipments are combined into a single ocean container". According to Hong and Liu (2013), the shipper and receiver in FCL shipping are both one unit, and therefore FCL shipping is deemed as a "door-to-door" service. On the other hand, the transport mode of LCL shipping can be described as "customer-freight station-field-field-fright station-customer". In this shipping mode, consignor and consignee are normally several units, which implies that the transport links involved in LCL shipping are more than those in FCL shipping. It is more economical to deliver smaller shipments via LCL shipping comparing with FCL shipping. The drawback is that transit time of LCL shipping is 15% to 20% longer than FCL shipping and more delays in delivery are expected as a result of shipment consolidation and deconsolidation (Hoppin, 2006). Hence, many shippers still prefer to purchase FCL service even when their consignments are far from a full container load (Hoppin, 2006).

The operational processes of LCL shipping and FCL shipping are illustrated below, see figure 2-5. For example, to move a full container from the Far East to the North American Midwest requires ten steps (Lewis, 1994):

- Delivering the empty container to the shipper
- Picking up the full container and transporting it to the local port
- Storage at the port for a short period of time
- Loading into the right position on the vessel based on the weight of the container and the unloading sequence
- Transportation by vessel
- Discharging the container from the vessel
- Loading the container on a train

- Unloading the container from the train and loading it on a local drayage vehicle
- Delivery of the container to the receiver by the drayage vehicle
- Picking up and repositioning of the empty container

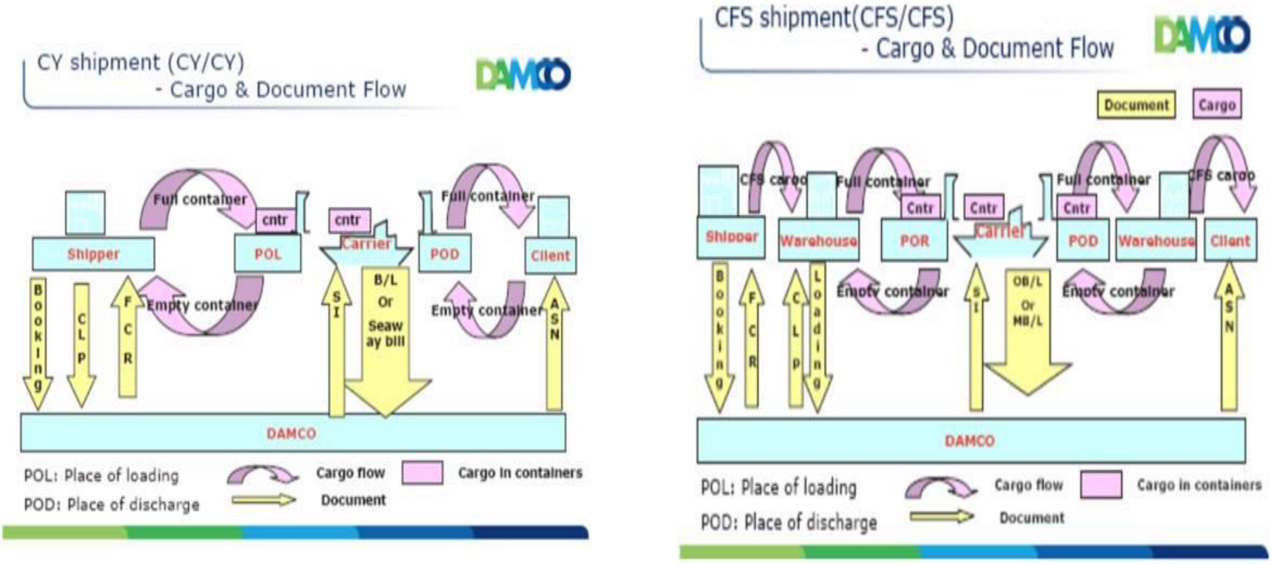


Figure 2-5: FCL and LCL operational processes. Source: Hong and Liu (2013).

Compared to FCL shipping, some steps are performed differently in LCL shipping. Small consignments are first conveyed to a nearby Container Freight Station (CFS) by trucks and then consolidated in containers, after which the container are stored at the port until delivered by ships. After arriving at the receiving port, the container is moved to another CFS in which the consignments are split for the last delivery to the final customers. During the whole process, information related to each step is recorded in a computer database, allowing shipper, carrier, forwarder and customer to track and trace the container location and freight payment status. (Lewis, 1994)

For freight forwarders, it is of great importance to consolidate shipments, especially when providing LCL services. Different shippers' freight are consolidated and then distributed in the same standardized containers when using LCL shipping (Notteboom and Ebrary, 2011). Therefore, freight forwarders aim to make the best decisions regarding how to consolidate shipments from several shippers and how to pick up appropriate shipping routes along the transport links that are available in their networks. In practice, it is usually very difficult and complex to make these decisions. To exemplify, if there is a direct link between the origin and destination of a shipment, then it may be a good choice to go with the liner service. However, shipments sometimes have to be delivered to some ports before sending to the final destinations when the direct links are unavailable or considering from an economical perspective. In other cases, different forwards may share some orders and work together (Notteboom and Ebrary, 2011).

2.3.2 Bill of lading

Bill of lading has been the most important commercial document in international carriage of goods by sea for a long time. The bill of lading has evolved a lot since its introduction and does include more information today in order to support the procedural and practical needs of international trade (Schmitz, 2011). The document itself is a symbol of the goods and possessing the bill of lading gives the holder control over the goods during its transit (Schmitthoff, 2007). Schmitz (2011) explains the bill of lading as a document that is signed and issued by or on behalf of the carrier of goods by sea to the person that has contracted the carrier for the transportation of goods. The bill enables the receiver of the goods or his/her agent to claim delivery of the goods in the port of destination. The bill of lading does further set out the terms of the transportation and also proves that there is a transportation contract between the owner of the ship which the goods are carried on and the party who has delivered the goods to the ship owner for transportation.

Though the circumstances in reality are often more complicated, one challenge, in the simplest case, can be to identify the parties. The goods can be carried on a ship chartered from the ship owner, and then the carrier can either be the ship owner or the charterer of the vessel. Another situation where identification can be troublesome is when the person shipping the goods is acting as an agent of another party (Schmitz, 2011). Even if the bill of lading has been used for a long time and served the commercial community well, there are still some subjects related to the document that causes concerns in the industry. Issuing several sets of bill of lading and physically transferring them from the exporting country to the importing country can be problematic, costly and inefficient. There is also a risk that the arrival of the bill of lading is later than the goods, meaning that the lawful delivery of the goods may be delayed (Schmitz, 2011). Several potential solutions replacing the bill of lading such as setting up a central registry system and simplifying the bill have been considered. The most successful solution is to replace the paper bill of lading with a computer-to-computer messaging system or an “electronic bill of lading”. Replacing various written documents with electronic data interchange (EDI) in order to save money and improve the efficiency of document handling is becoming more and more common in the industry.

EDI can be used to exchange digital documents between two trading partners. The ultimate goal of the systems is to achieve a fully integrated electronic trading process through the creation of a multi-user system where carriers, shippers, banks and other parties are linked (Schmitz, 2011). All of the functions of the paper bill of lading, even the possibility of trading the goods while in transit, are accommodated by the EDI (Livermore & Euarjai, 1997). The information printed on the bill is typed into the carrier’s computer and a “private key” is provided to the shipper so that they can have access to the information and control the cargo while in transport (Schmitz, 2011). The “private key” can be traded in order to transfer the ownership of the goods. The actual key is in practice cancelled and a new key is issued to the buyer of the goods. However, there are still some challenges that need to be overcome, especially when it comes to some legal categories and definitions that sometimes seem overstretched.

The benefits of adopting EDI could be revolutionizing for a company's document handling procedures, accepting a certain degree of legal uncertainty before new laws that fits the new technology is in place can be worth it (Schmitz, 2011).

2.3.3 Incoterms

The globalization taking place under the late 19th century and early 20th century has led to an increase in the volumes and complexity of global sales as goods are being sold in larger quantities, in a greater variety and between more countries. A drawback of this development is the possibility for misunderstandings and disputes when sale contracts are not adequately drafted. Incoterms are rules created by the International Chamber of Commerce (ICC) in 1936 in order to standardize and clearly define each trade partner's obligations towards each other to mitigate the risk of legal complications.

This globally accepted contractual standard has been updated over the years and the latest version of the Incoterms was published in 2010. This version, consisting of 11 rules, takes into account the spread of customs-free zones, the increased amount of electronic communication when conducting business and the growing concerns of security flaws in the movement of goods. (Ramberg, 2010)

The 11 Incoterm rules from 2010 are divided into two distinct classes. The first class can be applied to any mode or modes of transportation. The second class is applied to sea and inland waterway transportation; this means that both the point of delivery and the place where the goods are carried to the buyer are ports (Ramberg, 2010). The different rules can be found in table 2-1.

Table 2-1: Chart over the 2010 Incoterms

Rules for any type of transport	
EXW	EX WORKS
FCA	FREE CARRIER
CPT	CARRIAGE PAID TO
CIP	CARRIAGE AND INSURANCE PAID TO
DAT	DELIVERED AT TERMINAL
DAP	DELIVERED AT PLACE
DDP	DELIVERED DUTY PAID
Rules for sea and inland waterway transport	
FAS	FREE ALONGSIDE SHIP
FOB	FREE ON BOARD
CFR	COST AND FREIGHT
CIF	COST INSURANCE AND FRIEGHT

The differences between the rules are who is responsible for each task during the transportation, the costs of transportation and risks during the transport and delivery of goods. The allocation of how the costs are divided between buyer and seller when using different Incoterms can be seen in Appendix C.

2.3.4 Customs

There are lots of risks linked to customs; the World Customs Organization (WCO) defines risks as “the potential for non-compliance with customs laws”. Truel (2012) divides the customs risks into three major categories;

- Operational: Interruptions and delays in the production or project, loss of sales, increase in inventory costs and penalties related with late deliveries.
- Financial: Recalculation of duty and taxes, different financial penalties, interest rate of financial penalties.
- Reputation: Negative press coverage, loss of customers, negative impact on credit rating and loss of trust from shareholders.

Truel (2012) does further stress the importance of customs management as a strategic asset and the benefits of embedding it into wider business planning, reasoning behind this being that sources of customs risks are found in almost all business functions.

The transaction costs regarding international trade are higher compared to the costs for domestic transactions. Obvious charges such as taxes and tariffs is one reason for this but costs related to the paperwork involved in customs clearance and dealing with delays are also important elements (Verwaal & Donkers, 2003). Obstfeld and Rogoff (2001) showed that customs-related transaction costs play a more important role in a setting where the international trade costs are significant. This is usually the case for international transactions, resulting in that customs-related transaction costs becomes an important part of the transaction costs for international trade. Verwaal and Donkers (2003) are of the opinion that since there are economies of scale involved in transaction costs, larger firms should have an advantage compared to smaller firms, when it comes to customs related transaction costs. Cecchini et al. (1988) make an empirical analysis through surveying 500 companies and find out that the costs of customs procedures were 30-45% higher for firms with fewer than 250 employees compared to firms with more than 250 employees. Verwaal and Donkers (2003) further find out that when the average transaction size respectively transaction frequency increases by 1%, the average customs-related transaction costs decreases by 0,74% respectively 0,54%.

Goods brought into the territory of EU are subject to control by the customs. The movement of the goods within the EU is however not under the customs control and the entry of the goods takes place only at the outer border of the EU.

In order for the goods to be released into free circulation within the EU market they must be declared on the standards EU customs document, the Single Administrative Document (SAD) (Verwaal & Donkers, 2003). The SAD contains, in one set of forms, the control, country, transport, fiscal and statistical data that is required for the customs procedures. On the other hand if the goods are to be exported outside the territory of the EU, then they are placed under an export procedure (Verwaal & Donkers, 2003). Within the EU, the normal customs procedure is to file an export or import declaration for each export or import transaction. This can however be reduced by using simplified customs procedure and gives the firm the possibility of combining several transactions into one single declaration (Verwaal & Donkers, 2003). One example is that firms, when certain conditions are met, can declare import and export transactions on a monthly basis. This means that the firm can drastically lower the time it takes to collect the data, prepare the documentation and processes the declaration in the business information system.

2.3.5 Comparison between air freight and sea freight

When it comes to international shipping, a decision regarding whether to go with air freight or sea freight should be made carefully. With the increasing demand on rapid and safe delivery, air freight is becoming more and more popular (Lumsden, 2007). The excellent performance of air freight in terms of speed and reliability provides shippers the opportunity to dramatically reduce their inventory costs which comprises origin inventory costs, in-transit inventory costs and safety stock costs (Lewis, 1994). As aforementioned, sea freight might be influenced by port congestions or extreme weather conditions, so delays are very common and acceptable. Another sever problem is that sea freight usually has weekly schedules, and therefore missing one ocean liner means that the shipment has to wait for at least one week. On the other hand, although air freight might be influenced by poor weather conditions as well, many airlines have daily schedules which can significantly diminish the cost of shipment delays (Lewis, 1994).

Comparing with ocean shipping, two major drawbacks of air freight that are usually criticized include the relatively higher transport costs and worse environmental impacts. However, the truth is that sea freight might be cheaper than air freight in some occasions. When using air freight, chargeable weight of a shipment is calculated by combining its size and weight (Lewis, 1994). Comparatively, the size of a shipment mainly determines the cost of sea freight, e.g. the price of LCL shipping is usually based on cubic meter. Therefore, shipping by sea is more possible to be cheaper when the shipment is heavy and large (Lewis, 1994). In other words, air freight might be cheaper when shipping light consignments. It is noteworthy that even the shipping cost of air freight is mostly more expensive, the warehousing costs at airports are usually much cheaper than those at seaports (Lewis, 1994). From a perspective of environmental impacts, air transport consumes large quantities of non-renewable fossil fuel and generates more emissions than other modes of freight transport (Graham et al., 2014). Conversely, sea transport is considered as a clean form of transportation which is both eco-friendly and fuel-efficient (OECD, 2010)

2.4 Consolidation

According to Ülkü (2009), shipment consolidation is a logistics strategy that allows larger volumes to be transported on the same vehicle to the same destination by consolidating two or more orders or shipments. Some primary benefits of implementing this logistics strategy are economies of scale and decrease in the transportation cost per item, per order or per unit weight. An example of shipment consolidation has been described by Ülkü (2009). As shown in figure 2-6, a forwarder highlighted that by consolidating different shipments to one, it would be possible to achieve a 62 percent saving of shipping cost. Another benefit of consolidation is related to transportation service. Transit times could be shorter and more consistent, which leads to reduction in safety or in-transit inventory and consequently results in less tied-up capital, faster deliveries, earlier payments and more flexible cash flow (Masters, 1980). One of the objectives of implementing a consolidation strategy is to get a higher load factor, but it does not mean that building full truckload is necessary. Many carriers implement a consolidation strategy without aiming for 100 percent vehicle utilization, in order to make operations more agile and flexible (Ülkü, 2009).

Shipped separately		
Item	**Weight (lbs)**	**Shipping Cost ($)**
Dress	2.5	68.40
Coach Bag	4.5	86.99
DVDs	6.0	90.63
Receiver	24.6	179.60
Total		***425.62***

After Consolidation (One package)	
37.6 lbs	***$161.19***

Figure 2-6: Example of cost savings from shipment consolidation. Source: Ülkü (2009)

Vehicle, inventory and terminal consolidation are three major consolidation methods that are being used in logistics (Hall, 1987). Vehicle consolidation refers to collecting several small shipments and consolidating them into one truck. The aim of inventory consolidation is to find out the optimal number, type and location of stocking points. Terminal consolidation is a logistics strategy in which goods are aggregated and stored in a facility, loaded into vehicles, and then sent to different receivers. From a material flow perspective, Lumsden (2007) elaborates the consolidation function of terminals. Different suppliers' shipments are gathered into a nearby terminal first by low capacity transport modes due to the low shipping volumes, after which these shipments are consolidated in the terminal and subsequently delivered by high capacity transport modes. The reason lies in the longer transport distance and higher shipping volumes of the outbound flow from the terminal. The shipments are then unloaded and split into smaller units at the second terminal and finally transported to the final customers (Lumsden, 2007).

Figure 2-7 describes some distribution system configurations where shipment consolidation can have a positive effect (Ülkü, 2009). In system 1a, a shipper's orders with the same destination can be delivered after consolidation performed by the shipper. System 2b, shows shipments from different consignors that are consolidated at a make-bulk terminal and transported to a break-bulk terminal, after which shipments are spread out in smaller units to the consignees.

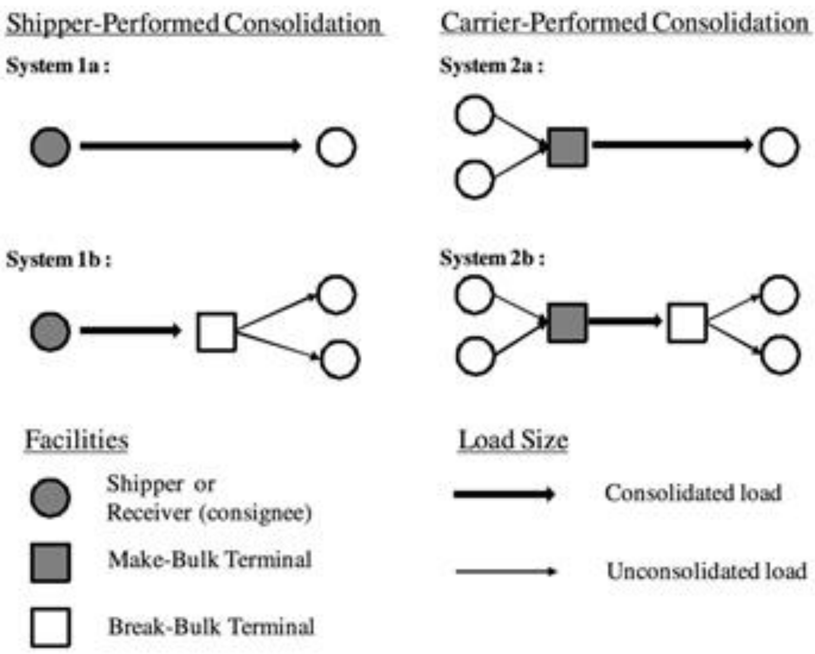


Figure 2-7: Examples of distribution system configurations in relation to shipment consolidation.

2.4.1 Terminals

Terminals are facilities where freight is assembled or dispersed. They can also be deemed as points of interchanges between different modes of transport or the same mode of transport (Rodrigue et al., 2006). According to Lumsden (2007), the performance of a transport can be seen as perfect when freight is transferred directly from the supplier to the customer without any intermediaries. However, this ideal scenario could hardly be successful in reality due to the mismatch between size of the shipment and the loading capacity of the external modes of transport in terms of volume or weight. Direct deliveries, might therefore result in a low average vehicle utilization and consequently higher costs. Terminals are designed and used to deal with the problems present when using door-to-door transports. Apart from consolidation, Lumsden (2007) identifies several additional functions of terminals including transshipment, coordination, sorting, kitting, sequencing, and commercialization and storing. Some of these functions are explained in the following page.

- **Transshipment**: Goods are transshipped between two transport mods within a short period of time, e.g. from vessels to trucks.
- **Coordination**: Different means of transport arrive at the terminal at different times. For the purpose of making the terminal an efficient node, it is therefore necessary to coordinate vehicles in an appropriate way, e.g. to adjust the arrival times and departures for different vehicles.
- **Storing**: From the perspective of material flow, goods are stopped in the terminal and then different functions can be performed. Goods can be stored in the warehouse for a short period of time or longer times, which is decided by customers' requirements.

2.4.2 Cross-docking

Cross-docking is defined by Kinnear (1997) as "receiving product from a supplier or manufacturer for several end destinations and consolidating the product with other suppliers' product for common final delivery destinations". According to Van Belle et al. (2012), cross-docking is a logistics strategy aiming to transfer incoming shipments directly to outbound vehicles, with little or no storage in between. Apte and Viswanathan (2000) describe cross-docking as a warehousing strategy which enables the movement of products from the receiving dock to the shipping dock, with a minimum dwell time and little handling and storage in between.

Traditionally, goods are received in a distribution center first and then stored, after which they will be picked up from the storage area and sent to the customer when an order has arrived. Four main functions of warehousing can be found from this process, including receiving, storage, order picking and shipping (Van Belle et al., 2012). Among these four functions, storage and order picking are usually more costly than the others due to high inventory holding costs and high labor costs. However, the storage and order picking functions of a warehouse can be reduce with the help of cross-docking while still keep its receiving and shipping functions by transferring shipments directly from inbound vehicles to outbound vehicles (Bartholdi and Gue, 2004).

Figure 2-8 below describes the process flow at a typical cross-dock. Specifically, after the inbound vehicles arrive at the cross-dock facility and are unloaded, the goods are moved to the outbound area directly for loading process or stored in a temporary storage area to be consolidated and loaded later (Agustina et al., 2014).

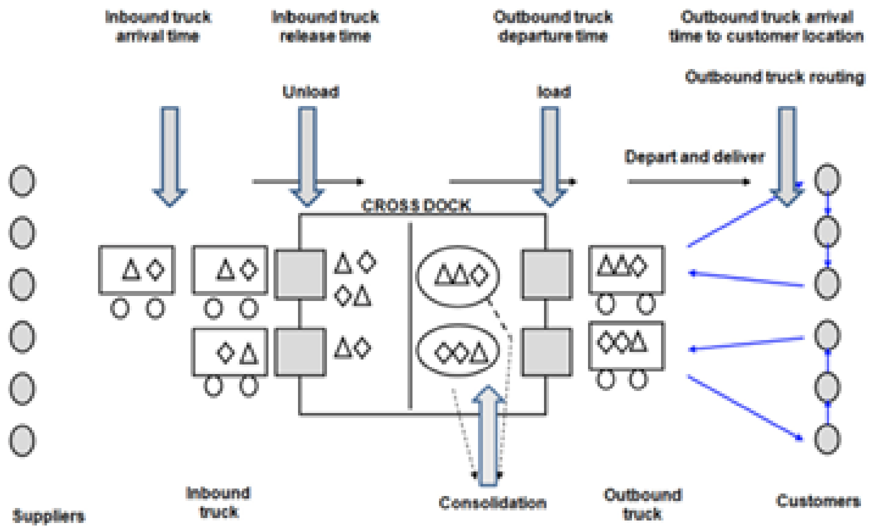


Figure 2-8: Process flow at a typical cross-dock. Source: Agustina, Lee and Piplani (2014).

Cook et al. (2005) state that by implementing cross-docking it is possible to deliver goods faster and more frequently with smaller shipping volumes. This is aligned with the objectives of a lean supply chain as well. Compared with traditional distribution center, Van Belle et al. (2012) identifies several benefits of cross-docking including cost reduction regarding warehousing costs, inventory-holding costs, handling costs and labor costs, shorter delivery time, improved customer service, reduction of storage space, faster inventory turnover, fewer overstocks and less risk of loss and damage. Van Belle et al. (2012) also state some other advantages of using cross-docking by comparing it with point-to-point deliveries, e.g. reduced transportation costs, consolidation of shipments, higher resource utilization and improved match between actual demand and shipment volumes. On the other hand, cross-docking also has some disadvantages. Apte and Viswanathan (2000) consider cross-docking as information handling system as well as a material handling system, which depends heavily on the use of expensive and sophisticated IT systems in order to coordinate both the information flow and the physical product flow.

Based on a comparison with traditional distribution, Apte and Viswanathan (2000) summarize some influential factors when deciding whether it is suitable to implement cross-docking or not. Two of the most important factors are the product demand rate and the unit stock-out cost. As depicted in figure 2-9, when the unit stock-out costs are low and the product demand rate is stable and constant, it is fairly appropriate to use cross-docking. When the unit stock-out costs are high and the product demand rate is unstable or fluctuating, traditional distribution is more preferred. Apart from these two scenarios, the performance of related systems and planning tools plays an important role in the suitability of cross-docking, i.e. whether the number of stock-outs can be maintained to an acceptable level. Van Belle et al. (2012) agree with Apte and Viswanathan (2000) and goes further by embracing more factors, e.g. it is more beneficial to use cross-docking when suppliers or customers are farther from the cross-docking facilities, when the demand of products is increasing while there is a significant decrease in inventory space and costs, when the timing of arrival and departure are matched appropriately, and etc.

		Product demand rate	
		Stable and constant	Unstable or fluctuating
Unit stock-out costs	High	Cross-docking can be implemented with proper systems and planning tools	Traditional distribution preferred
	Low	Cross-docking preferred	Cross-docking can be implemented with proper systems and planning tools

Figure 2-9: Suitability of cross-docking. Source: Van Belle, Valckenaers and Cattrysse (2012).

3 METHODOLOGY

This chapter starts with describing the research process and research strategy of this thesis, followed by the methods related to data collection including literature review, interviews, questionnaire and organizational documents. Thereafter, the methods in relation to data collection are described. In the last section of this chapter, the accuracy of this thesis is discussed.

3.1 Research process

As depicted in figure 3-1, the thesis consists of three main stages; data collection, analysis and conclusions, where six key activities have been conducted in sequence according to the process flow. These activities are interrelated and some relevant information is presented on the right-hand-side of figure 3-1. General discussions with Volvo Group were the starting point of this thesis, in order for the researchers to fully understand the problem that should be solved during this project. This thesis was initiated and predefined by the Volvo Group, it is therefore of great importance to understand their demand. After the problem was defined, several data collection activities such as literature study, interviews and questionnaire were initialized to collect the necessary data, which in turn brought the researcher a better understanding of the subject studied. The gathered data were subsequently arranged, sorted and analyzed, after which the current state of the LCL transportation network was mapped out and several potential assessment parameters were generated. In the analysis stage, alternative scenarios were constructed by the researchers based on their learning's from the data collection stage. The weight criterion method was used to evaluate the importance of each criterion and then used to analyze different scenarios. The analysis of the different scenarios was made by employees of the company in during a workshop led by the researchers.

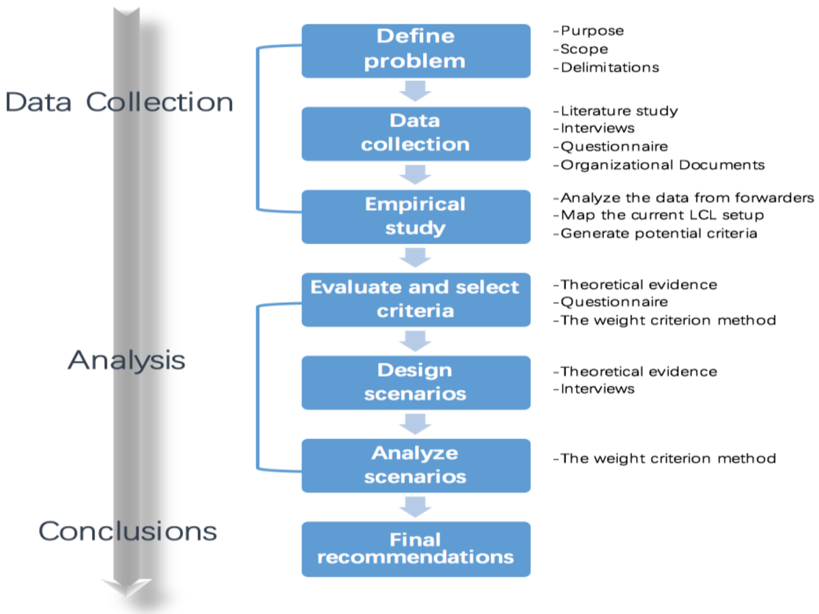


Figure 3-1: The research process.

3.2 Research strategy

Choosing an appropriate research strategy is of great importance since it influences the way a research performs in terms of data collection and data analysis. Research strategies can be classified into two main groups: qualitative and quantitative, which are either implemented separately or applied together (Bryman, 2002). Quantitative research requires investigators to count and measure data in order to conduct a precise analysis of the target concepts or hypothesis (Ryen, 2004). Data gained from quantitative research are usually numerical or can be translated into numbers (Gillham, 2010). With the help of this type of data, researchers can understand and describe the current situation but not the underlying reasons which results in the current situation (Seymour, 1992). Qualitative research, on the other hand, can help researcher to understand and describe complex situations, as well as provide researchers a holistic picture of a situation. Qualitative data includes quotations from people regarding their experiences, opinions and attitudes, observations of people's behaviors and descriptions of happenings and relationships between people (Seymour, 1992).

This thesis was based on a mixture of quantitative and qualitative research. This was in accordance with the purpose of the thesis and decided with nature of the research questions in mind. In order to answer the research questions, the researchers did not only need to gather quantitative data to map the current LCL transportation network, but also gather qualitative data to understand the customer's demand regarding these transports. This made it possible for the researchers to come up with alternative scenarios and evaluate them according to a number of pre-weighed parameters. Without having a mixed strategy for the research this would not be possible.

3.3 Data collection method

When collecting data for a study, the researcher should be aware of the two existing types of data; primary and secondary. Primary data are data collected specifically for the research in question, for the first time and are thus original (Kothari, 2004). There are several ways of collecting primary data: observation methods, interviews, questionnaires, through mechanical devices and so on.

Data that have been collected by someone else and passed through the statistical processes are on the other hand called secondary data (Kothari, 2004). The researcher must be careful when using secondary data, there is a possibility that the secondary data are unsuitable and inadequate in the context of the problem that the researcher wants to study (Kothari, 2004). Before the researchers use secondary data in their research they must make sure that the data possess the following characteristics (Kothari, 2004):

- Reliability of data: in order for the researcher to make sure that the data is reliable a couple of questions should be answered: I) who collected the data? II) Where was the data collected from? III) Which methods were used in order to collect the data? IV)

Could the complier of the data be biased in any way? V) What level of accuracy was desired when the data was collected?

- Suitability of data: the data that was suitable for one purpose might not be suitable in another setting. The researcher must carefully consider what different terms and units used when collecting the data from the primary source means. He or she must also consider what the purpose of the first data collection was and if that can make the data unsuitable in some way.

- Adequacy of data: the level of data accuracy should be found adequate for the purpose of the study. The data should also be related to an area which is not narrower or wider that the present study.

During this project, primary data were gathered from interviews with both Volvo Group and forwarding companies such as DHL, DSV, DB Schenker and Geodis Wilson. Primary data were also collected through a questionnaire. Secondary data on the other hand were collected through a literature study in the beginning of the project but also from different forwarders responsible for the Volvo Group's LCL shipments during 2015. The secondary data collected from the forwarders were deemed as reliable since they were collected by the forwarding companies' IT systems which the invoices are based on. The researchers are of the opinion that a high level of accuracy was desired when these data were collected by the forwarders and there is no reason for it to be biased.

3.3.1 Literature review

The purpose of doing a literature review was to have a good understanding of the research topic and what other researchers have already done in the field. Data collected from the literature study were viewed as a complement to the interviews and sometimes in order to understand the topics discussed in the interviews. The knowledge gathered by the researchers during this stage was also used when constructing the different scenarios and assessment parameters. The literature review was mainly conducted through the Chalmers library databases, based on the keywords related to the research topic. The most relevant books, scientific journal articles and reports were selected and studied, which also generated new keywords of more specific areas. The primary keywords that have been used are; logistics, consolidation and sea transport. Regarding the area of sea transport, for example, some new keywords were added such as port, incoterm, customs, and LCL shipping.

3.3.2 Interviews

One way of gathering data based on asking questions, either orally or in writing, is through interviews. Davidsson and Patel (2003) describe interviews as a meeting set up by the interviewer in order to get answers from the interviewee. The benefits with interviews are that they are flexible and offer a good insight into the interviewee's experiences, opinions and attitudes (Creswell & Clark, 2011). There are also some drawbacks with this kind of data gathering, one being that interviews require resources as time and space (Hilsson, 2004). Another drawback with interviews is that people tend to change their behaviors and opinions under observation (Davidsson & Patel, 2003). One way of mitigating the risk of getting unreliable data from the interview is to make sure that the interviewee is motivated. This can be done through explaining the purpose of the interview and if possible relating the purpose to the interviewee's goals and ambitions (Davidsson & Patel, 2003).

Two important parameters to consider when collecting data through interviews are the level of standardization and the level of structure. Level of standardization is the freedom that the interviewer has regarding how and in which sequence the questions are being formulated and asked. The level of structuring, on the other hand, is the level of freedom that the interviewee has in the interpretation of the questions based on his or her experiences and attitude (Davidsson & Patel, 2003). These parameters can be altered based on which kind of information the interviewer wants to get from the interviews. A non-structured interview offers a higher degree of flexibility but this flexibility results in incomparability between two interviews. Analysis of unstructured interviews is also harder and more time-consuming (Kothari, 2004). A high level of standardization and structure should be used if a quantitative analysis is to be made for the gathered data. In interviews where a qualitative analysis is to be conducted based on the gathered data, a low level of standardization and structure are preferred.

During the whole thesis process, several Volvo Group employees who work with logistics purchasing, transportation network optimization, logistics development and supplier management as well as some of the Volvo Group's forwarders were interviewed. This enabled the researchers to take different perspectives into account and gain a better understanding of the situation. All of these interviews were semi-structured and the researcher tried to have face-to-face meetings when possible. The researchers tried to gain understanding of the fields that the interviewees worked in order to see how it would influence the LCL transportation network. This did also mean that the interviewees were more motivated since the purpose of the interview was related to their work. An explanation of the thesis's purpose as well as why their insights are important for the thesis were given at the beginning of the interviews. The interviews had a low level of standardization and were more like a discussion between the interviewer and the interviewees. Table 2, shows which departments the interviewees that has been interviewed during this project belongs to.

Table 3-1: Table over the interviewees and which department they belong to.

External interviewees	
C_1	Forwarder 1
C_2	Forwarder 2
C_3	Forwarder 3
C_4	Forwarder 4

Internal interviewees	
I_1	Logistics purchasing
I_2	Logistics purchasing
I_3	Logistics purchasing
I_4	Logistics purchasing
I_5	Logistics purchasing
I_6	Development and project execution
I_7	Development and project execution
I_8	Logistics operations
I_9	Supplier management
I_{10}	Transport network optimization
I_{11}	Transport network optimization

3.3.3 Questionnaire

One of the most common ways of collecting data is through questionnaires (Anderson 2006). The method is used by governments, private and public organizations, researchers and private individuals (Kothari, 2004). A questionnaire can be done in different ways but the method is often associated with a set of questions that are sent to chosen individuals who then answer the questions and return the questionnaire to the researcher (Anderson, 2006). The questions can also be answered under guidance; in this case the questions are being answered in a face-to-face meeting where the researcher conducting the study asks the questions and fills out the questionnaire. The main benefit of this method is that the researcher can explain potential ambiguities (Anderson, 2006).

The benefits of collecting data through questionnaires are many and the most important ones are presented below (Kothari, 2004):

- The method is cost effective and does not require a lot of resources even when the respondents are geographically widely spread.
- The respondents are not under time pressure and have adequate time to answer the questions.
- Since the method is cost effective large samples can be taken, resulting in more reliable and dependable data.
- The method is not biased from the interviewer.

There are of course some drawbacks of using this method for gathering data, Kothari (2004) identifies some of them:

- The usage of the questionnaire is limited to the cases where the respondents are educated and cooperative.

- This method is quite slow and getting answers from all of the respondents may take some time.
- The researcher does lose control over the questionnaire when it is sent to the respondents.
- The method offers a low degree of flexibility since it is hard to change a question when the questionnaire is sent away.

A good way of mitigating some of the risks concerning questionnaires is to perform a pilot study or pilot survey. By testing the questionnaire on a smaller scale where the respondents are experts showcases the weaknesses of the survey and gives the researchers a chance to improve the questionnaire (Kothari, 2004). Another action that the researchers can take in order to get accurate results from the questionnaire is to make sure that the respondents are well motivated and often, the missive is the only opportunity for the researcher to do so (Davidsson & Patel, 2003). It is also important that the respondents easily can identify if the questionnaire is confidential or anonymous. If a questionnaire is anonymous then it is impossible to identify the respondents. In the cases where the questionnaire is confidential it is possible for the researchers to identify the respondents but the information cannot be further spread (Davidsson & Patel, 2003).

In this project, the questionnaires were sent by email since the chosen respondents are geographically widely spread. The questionnaire was also decided to be confidential; the underlying reason for this was that respondents might hide their real thoughts if their names are disclosed. Having a confidential questionnaire can therefore help the researchers get more reliable and dependable data. In order to mitigate risks of misunderstandings regarding the questions in the questionnaire, the researchers conducted a pilot survey where two employees of the Volvo Group were consulted. With the help of the pilot survey, mistakes were modified and unclear terms were explained more clearly in order to avoid potential ambiguities. The purpose of conducting the survey was also explained thoroughly in the missive to further motivate the respondents to provide valid and reliable answers.

In total, 35 questions were included in the questionnaire and the respondent was asked to evaluate the importance level of parameters in pairs. Figure 3-2 shows a question from the questionnaire, the purpose of this question is to identify whether the respondents think that transport price is more important than the costs of bill of lading or vice versa. Transport Price should be selected if the respondent is of the opinion that Transport Price is more important than B/L cost. When one parameter is considered equally important as the other one, then the option equally important should be chosen. The whole questionnaire can be found in Appendix D.

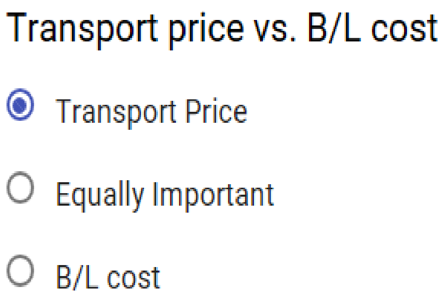


Figure 3-2. Example of a question from the questionnaire.

3.3.4 Workshop

Workshops are occasions when people come together in order to pool experiences and find solutions for a problem. The workshop is dependent on that the participants, who collectively have more knowledge and experience regarding the subject compared to the facilitator, exchanges ideas in order to solve the problem in question. A successful workshop has an end-product that has been constructed during the session by the participants. It can also be beneficial to have the workshop away from the participants' normal settings in order for them to seriously work on the problem in question (Moynihan et al., 2004).

Maynihan et al., list some examples of what can be done in a workshop:

- The participants can analyze a problem or project
- The participants can make a plan of action
- The participants can learn a new skill
- The participants can acquire new competencies which makes them more inclined to changes
- The workshop can serve as a team-building exercise for the participants

How the workshop is designed depends on several variables; the objective, the available time, geographical location of the participants and the budget disposed for the workshop. As above-mentioned, workshops are often concerned with the participants solving a problem or learning new competencies. These situations might require some practice or information before the workshop and one approach is to divide the workshop into two stages. The facilitator can decide to send out the information that needs to be processed and inform the participants about the skills that needs to be practiced in advance. This results in that less amount of time is needed at the actual workshop. (Moynihan et al., 2004)

The researchers did during this project conduct a workshop in order to start a discussion around the subject and get the opinions of the employees. The aim of the workshop was to analyze how the different assessment parameters would be influenced by the constructed scenarios. This would together with findings from the literature review decide the feasibility of the different scenarios.

The researchers booked two workshops with six Volvo Group in the company's offices in Arendal, Gothenburg. Some of the participants joined the workshops through Skype due to the geographical spread, some of the participants working in Asia and some in Belgium. All of the participants received a presentation together with a document, explaining all of the assessment parameters and scenarios before the meeting. It was requested from them to decide how well a scenario would fulfill an assessment parameter. This would later be discussed during the workshop. The reasoning behind this being that the discussion at the workshops would be more yielding if all of the participants were well accustomed to the subject. The first workshop started by the researcher giving a short presentation of the research and the findings to the date, after that each category were discussed by the participants.

3.3.5 Organizational documents

In the beginning of the thesis, the researchers were informed that several forwarders were involved in Volvo Group's LCL shipments in 2015. Volvo Group's Internet Portal for Transport Contract Management System, Volta, was then used to find out all relevant transport contracts for LCL shipments. Based on the contracts, 12 forwarders were identified and necessary data were requested from the forwarders by emails, phone calls and visits.
Acquiring all related data was complicated since the contact persons were in different countries with different time zones. Some forwarders did also have problems with their IT systems and the data gathered from different forwarders did not always have the same format.
All of the forwarders were not able to provide all of the needed data; this resulted in that the researchers made some assumptions in order to have all data. The assumptions made by the researchers can be seen in Appendix A.

3.4 Data analysis method

In this section of the report the methods that were used in order to analyze the collected data are presented. The scenario creation process is explained together with how the assessment parameters were identified and weighed by the researchers.

3.4.1 Scenario creation

In order to identify consolidation opportunities for the Volvo Group's LCL transportation network, a number of potential LCL transportation scenarios were constructed by the researchers during this thesis. For the purpose of obtaining viable scenarios, the scenarios were designed based on findings in the literature review, insights from interviews held with employees in different departments, analysis of the gathered data and extensive discussions between the researchers. The feasibility of the constructed scenarios was then checked with internal stakeholders, their feedbacks further helped the research team develop the constructed scenarios.

3.4.2 Assessment of the scenarios

The factors considered to assess the different scenarios developed during this project were deduced from a total cost of ownership model. Five categories representing different costs related to a purchase were chosen in order to evaluate the scenarios from different perspectives. Within each category a number of different performance indicators that would have an impact on the total cost of that specific category were identified. The researchers did however, in consent with internal stakeholders, choose the most important factors from each category. The reason why a holistic TCO assessment of the different scenarios was not done was primarily the available time for this project but also the fact that a lot of the factors would not be influenced by the constructed scenarios.

The different factors were then weighed against each other based on importance from Volvo's point of view. This was done through the Weight Criterion Method. In order to identify which factors that were considered more important than the others a questionnaire was sent out to various people within the Volvo Group. The respondents had different experience levels and hold positions in various departments of the company, see table 3-1 for the departments. This was decided by the researchers in order to obtain the opinions of people from different departments that might have different objectives and goals.

Table 3-2: Distribution of respondents of the questionnaire.

Department
Logistics Purchasing
Supplier Management
Transport Network Optimization
Logistics Development
Logistics Operations

The result from the questionnaire was then analyzed in order to find out which assessment parameter that the majority considered most important within each category. This was used as an input when constructing the matrix in the Weight Criterion Method.

3.4.3 The weight criterion method

When evaluating alternative scenarios according to different criteria, the weight criterion method has been proved helpful. Analysts are required to compare criteria carefully and thoroughly, for the purpose of making the evaluation of the alternatives as objective as possible. This method performs especially well when the majority of the criteria are soft parameters which are hard to rank. This method has been used to solve problems related to the transport sector by several researchers such as; Bask and Vepsäläinen (1998), Lindau et al. (1993) and Woxenius (1998).

The weight criterion method is described by Woxenius (1998) in six steps. The first step is to define the current evaluation situation and to avoid using outdated references which cannot match the actual problem. The following step is to list the most relevant demands and criteria. Subsequently, several alternative scenarios that can fulfill the demands are generated and prepared to be analyzed further. After that, the chosen criteria are weighed through pairwise comparison.

Table 3-3: Example of the weight criterion matrix. Source: Woxenius (1998).

	Criteria							
	A	**B**	**C**	**D**	**E**	**Corr**	**P_i**	**k_i ($p_i/\Sigma p_i$)**
A	-0	2 (AB)	2 (AC)	0	1	1	6	0.24
	B	-2	2	1	1	3	5	0.20
		C	-4	0	0	5	1	0.04
			D	-1	2 (DE)	7	8	0.32
				E	-4	9	5	0.20
						Σ:	**25**	**1.00**

A specially designed weight criterion matrix should be used in this critical step, as shown in table 3-2. To exemplify, the number 2 is given to the cell AB, meaning that parameter A is more important than B. In cell AD, the number 0 is placed since D is more important than A. When two criteria are equally important, the number 1 is put in the corresponding cell such as cell AE, BD and BE. Following the same procedure, all criteria are weighed in pairs. Regarding the column Corr., odd numbers are given as correction factors. Subsequently, the evaluator should sum up each column and replace the plus sign of the sum to a minus sign, which explains where the negative numbers such as the numbers in the cell AA, BB, CC, DD and EE come from. For instance, the number in the cell EE is calculated in equation (1). After that, every row including the Corr. number is summed up. The row sums are then placed in the column $P_i$separately. The number in the cell DP_i, for example, is explained in equation (2). The sum of the column P_i, $\sum P_i$, is then used to calculate k_i, as shown in equation (3). $\sum k_i$ should equal 1.00 if the matrix is filled out correctly.

$$EE = -(AE + BE + CE + DE) = -(1 + 1 + 0 + 2) = -4 \quad (1)$$

$$DP_i = DD + DE + DCorr = -1 + 2 + 7 = 8 \quad (2)$$

$$k_i = \frac{P_i}{\sum P_i} \quad (3)$$

Table 3-4: Example of the evaluation matrix. Source: Woxenius (1998).

Criteria	K_i	Alternative 1		Alternative 2		Alternative …		Alternative n	
		fulfil-ment	k_i*fulf. ment	Fulfil-ment	k_i*fulf. ment	fulfil-ment	k_i*fulf. ment	fulfil-ment	k_i*fulf. ment
A	0.24	3	0.72	2	0.48	3	0.72	2	0.48
B	0.20	2	0.40	3	0.60	2	0.40	2	0.40
C	0.04	2	0.08	3	0.12	1	0.04	3	0.12
…	0.32	2	0.64	2	0.64	2	0.64	1	0.32
n	0.20	1	0.20	1	0.20	0	0.00	1	0.20
Σ	**1.00**	**10**	**2.04**	**11**	**2.04**	**9**	**1.80**	**9**	**1.52**

After that, a new matrix is introduced for the analysis of alternative scenarios, where all criteria are used to get the fulfillment degree. As an example depicted in table 3-4, the grading system is:

3 The scenario fulfills the criterion well.
2 The scenario can fulfill the criterion to some extent.
1 The scenario has a very low possibility to fulfill the criterion.
0 The scenario is impossible to fulfill the criterion.

Subsequently, the k_i ∗fulfilment is calculated for each scenario by multiplying k_i by fulfilment point and the columns are added up. It is also important to note that the grading system can be designed in other ways, i.e. a more detailed evaluation can be gained when more levels are encompassed in the system. Finally, it is evident to see to what extent each scenario can fulfill the criteria and the sum of k_i∗fulfilment is used to make the final decision.

3.5 Pareto's principle

Vilfredo Pareto, an Italian economist, created a mathematical formula in order to showcase the unequal distribution of wealth in his country in 1906 (Reh, 2005). Pareto could show that 20 percent of the people owned 80 percent of the wealth; he did also discover later that the same partitioning was applicable to other phenomena in life, one example being that 80% of the peas were produced by 20 percent of the peapod (Lipovetsky, 2009). Dr. Joseph Juran who is one of the pioneers in quality management did in the 1930s recognize this distribution as a universal principle (Juran, 1974). Juran called this the "vital few and trivial many", and did in his initial work identify that 20 percent of the defects caused 80 percent of the problems. The 80-20 rule, a common name for the Pareto principle can be applied to almost everything from management to the physical world. The principle means that a small percentage of the causes, 20 percent, are responsible for a large percentage, 80 percent, of the effect, figure 3-3 (Lipovetsky, 2009).

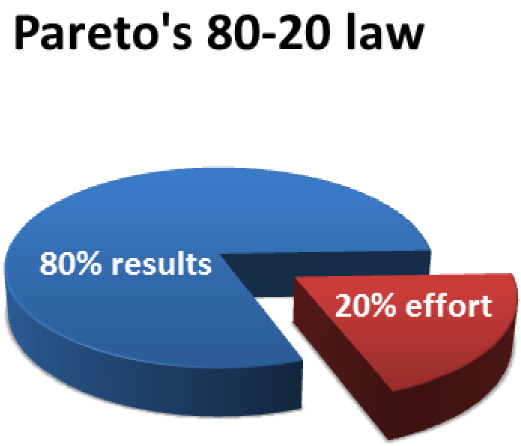


Figure 3-3: Pareto's 80-20 law.

Juran was of the opinion that this principle could have great benefits for managers and advocated using this principle to focus on the main 20 percent of effort that provided 80 percent of the benefits. The value and strength of the principle is that it can remind managers to concentrate on the small percentage of causes that is responsible for the lion share of the outcome. (Juran, 1974)

3.6 Data accuracy

An important aspect to consider regarding research results is how valid the obtained knowledge is and how true the results of the research are. This can be measured through a reliability and validity analysis of the report (Ghauri & Grnhaug, 2010). The conducted research's ability to measure what it was intended to measure is defined as the validity of the research (Saunders et al., 2000). Reliability on the other hand refers to the stability of the measurements (Ghauri & GrÖnhaug, 2010).

Bryman and Bell (2011) divide the validity of a qualitative study into two criterion; internal and external. External validity assesses if the results of the research can be generalized, something that is hard to achieve when the research methodology is a qualitative one. The reasoning behind this is that case studies are often used when conducting a qualitative research and that the sample sizes associated with this methodology are small. Internal validity is defined as the level of alignment between the results of the study and the observations that the researchers makes during the study. For a quantitative study the validity of the study is divided into four criterion (Bryman & Bell, 2011):

- **Concurrent validity** is an evaluation on how well two different measurements that measures the same thing have a relationship consistent with each other.
- **Construct validity** is concerning the hypothesis used in the study and how well they are construed from relevant theories.

- **Face validity** is the level to which a specific measure seems to measure what it was intended to measure; one way of doing this is by asking the stakeholders if this is the case.
- **Convergent validity** is a comparison between a measurement of a concept and other measurements of the same concept derived through other approaches.

For a qualitative research the validity can also be divided into external and internal validity (Bryman & Bell, 2011). External validity is an indication of how well the study can be replicated. Internal validity on the other hand refers to the discrepancy between the observers, where there is more than one, regarding the observations made during the study. Bryman and Bell (2011) divides the reliability of a quantitative research into three categories:

- **Stability** is how much a measure fluctuates over time.
- **Internal reliability** is a consistency measurement on the indicators that makes up the scale used.
- **Inter-observer consistency** is a measurement on to which degree measurements on the same quantity varies if taken by different observers.

4 EMPIRICAL FINDINGS

This chapter aims at answering the first research question. It starts by describing the current situation of Volvo Group's LCL transport, and then presents the data gathered from the literature review, interviews, questionnaire and organizational documents.

4.1 Business processes

Currently, there are three transport processes taking place within Volvo Group; Transport Parts, Transport Materials, and Transport Products. Transport Parts is a process that is being used when shipping products related to the aftermarket from, in most of the cases, distribution centers around the world. Shipments going to the factories and distribution centers from suppliers and cross docks around the world are classified as Transport Material. Transport Products is the process for transporting finished products to customers and dealers around the world. There are no LCL transports related to Transport Products in this thesis.

4.2 Current state of the LCL setup

Volvo Group’s LCL transports are handled by a number of different forwarders. The forwarders are responsible for certain geographical areas and certain business processes. In total, 12 forwarders were used during 2015 to handle the LCL shipments of the company, see table 4-1 for the name of carriers, which geographical area they were responsible for and the relevant business processes. The data used for the table below is collected from Volta.

Table 4-1: Table over forwarders, their geographical area and business process.

Carrier	Geographical Area	Business Process
Blue Water Shipping	Gent to Greenland	TP
Ceva Logistics	EMEA to APAC APAC to APAC	TM
DBSchenker	APAC to Worldwide Sweden & USA to EMEA	TP TM
DHL Global Forwarding	Global to Global	TM & TP
Eculine	Gent to Worldwide	TP
Fracht Forwarding	USA to Worldwide	TM
Geodis Wilson	APAC to APAC Global to Global	TM & TP TM
Yusen Logistics	Japan to APAC	TP
Kuehne + Nagel	Gothenburg to Qingdao	TM
Nippon Express	USA to Japan	TM
Panalpina	France to Panama	TP
Toll Global Forwarding	Germany & Sweden to Global	TM

An early step in the research was to collect data from the above-mentioned forwarders. Data regarding consignee, consignor, country and city of origin, destination country and city, weight of the shipment, volume of the shipment and price of the shipment were requested from the forwarders on a shipment level. However, the researchers were not able to collect all of the required data from every logistics service provider due to the fact that the forwarders' information technology systems differed and the data collected by the forwarders differed from company to company. As a result of this, the researchers made some assumptions in order to obtain complete and reliable data. The forwarders that were not able to provide all of the requested data are listed in table 4-2 and the assumptions can be seen in Appendix A.

Table 4-2: Table over missing data.

Forwarder	Not Provided Data
DHL Global Forwarding	Transport prices for shipments between North America and South America. Shipment data between 2015/10 and 2015/12 for North America and South America.
Yusen Logistics	Only provided transport prices for the latest six months
DBSchenker	Only provided the volumes of the shipments

4.2.1 Current share of the forwarders

The 12 forwarders mentioned in chapter 4.1 are each responsible for a part of Volvo Group's total global LCL shipments. The percentage that each forwarder is responsible for varies. In order to identify the current state of the Volvo Group's LCL shipments, there is a need to visualize the share that the companies performing the transportation are responsible for. There are several ways to showcase the forwarders and their shares of the total LCL shipments. It can be done based on spend, number of shipments, volume of the shipments, weight of the shipments and the pay-weight of the shipments. The researchers did, in agreement with internal stakeholders, decide to visualize the data based on pay-weight of the shipments, number of the shipments and spend. The reasoning behind this is that pay-weight gives a good overview of the weight and volume of the shipments, which is important when analyzing consolidation possibilities. The number of shipments is also of importance since more shipments can provide more consolidation opportunities. One can clearly find out the areas and lanes where Volvo Group has the biggest cost-saving potentials by analyzing the LCL shipments based on spend. Therefore, it is also very crucial to take spend into account. Having these figures next to each other does also provide some additional benefits since it provides some information regarding the nature of the shipments that the different forwarders are responsible for.

Starting by showing the forwarders' shares of the total LCL shipments based on spend, see figure 4-1, one can quickly identify that one forwarder, Company A, is responsible for more than 50 percent of the total spend. The three biggest logistics service providers based on spend, Company A, Company B and Company C, are together responsible for shipments that equals to more than 80 percent of the total LCL shipment spend of Volvo Group.

Share of Spend Amongst Forwarders

Figure 4-1: The share of the forwarders based on spends.

Company A is also, to the most evident degree, the biggest logistics service provider when it comes to number of LCL shipment globally. The company is responsible for almost 65 percent of Volvo Group's total LCL shipments, see figure 4-2.

Number of Shipments Amongst Forwarders

Figure 4-2: The share of the forwarders based on the number of shipments.

It is interesting to point out that the transportation supplied by Company C equaled to approximately 11 percent of the total spends but did only correspond to approximately five percent of the number of shipments.

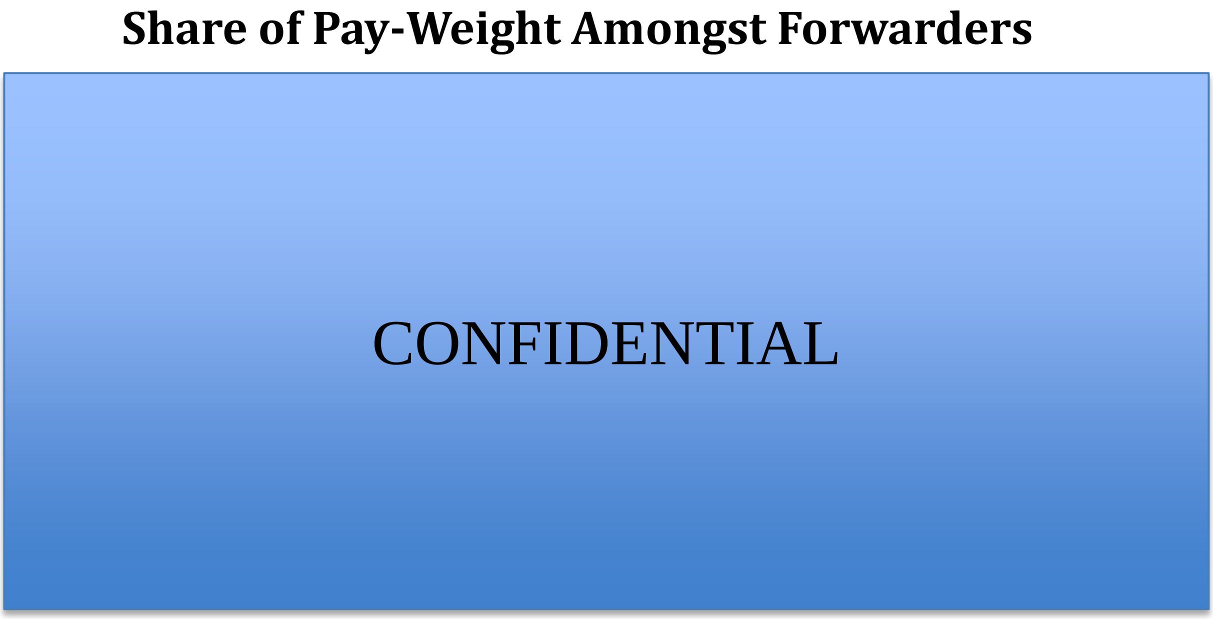


Figure 4-3: The share of the forwarders based on pay-weight.

The distribution of the pay-weight going through different forwarders can be seen in figure 4-3. Volvo Group's transports are paid based on the pay-weight; the unit is the largest number of the weight or volume multiplied by thousand of a shipment.

4.3 Major transportation flows

Volvo Group's transports are divided into three major regions in order to get a better geographical overview over where the LCL transportations took place during 2015:

- Asia Pacific (APAC) which includes East Asia, South Asia, Southeast Asia and Oceania.
- Europe, Middle East and Africa (EMEA)
- Americas which includes North America, South America and Central America

In order to identify the regions where the largest share of the LCL transports are taking place there is a need to visualize the flows between the major regions based on spend, number of shipments and pay-weight. The three measurements will together provide a good geographical overview over Volvo Group's LCL shipments. Figure 4-4 shows the flows between the above-mentioned regions. The thickness of the lines represents the number of shipments; a thicker line equals more shipments. Figure 4-5, 4-6 and 4-7 shows the sizes from different perspectives.

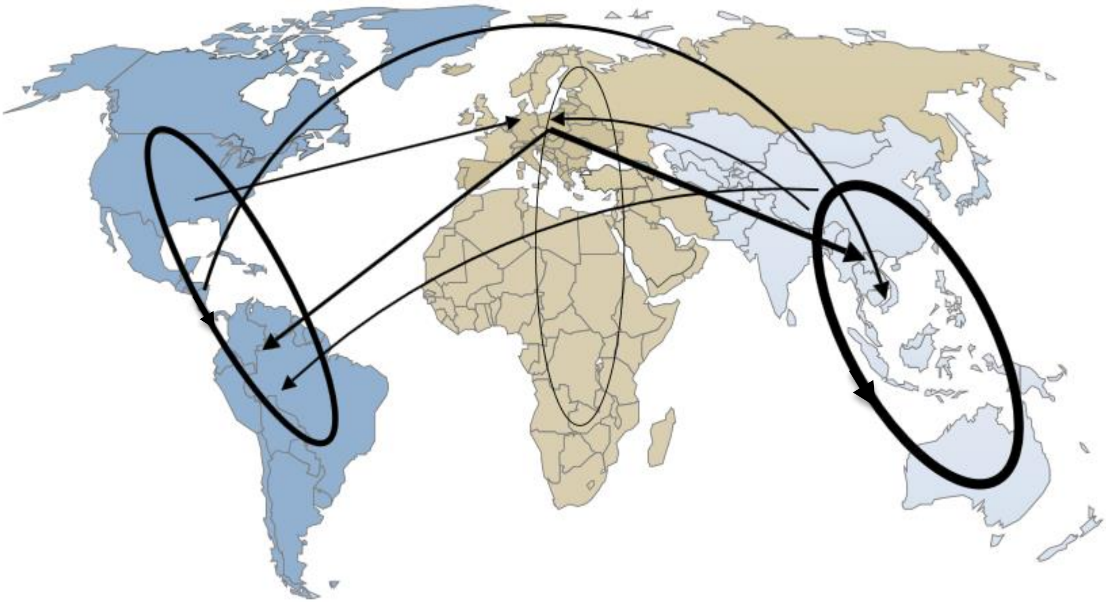


Figure 4-4: LCL flows during 2015.

By studying figure 4-5, it is obvious that the region where the Volvo Group did spend the largest amount of money, in 2015, is intra-APAC. The price of those shipments accounted for almost half of the total LCL spends of the company globally. Shipments from all of the three regions going to APAC accounted for 64 percent of the total spend, which means that the region is by far the biggest destination region for LCL shipments.

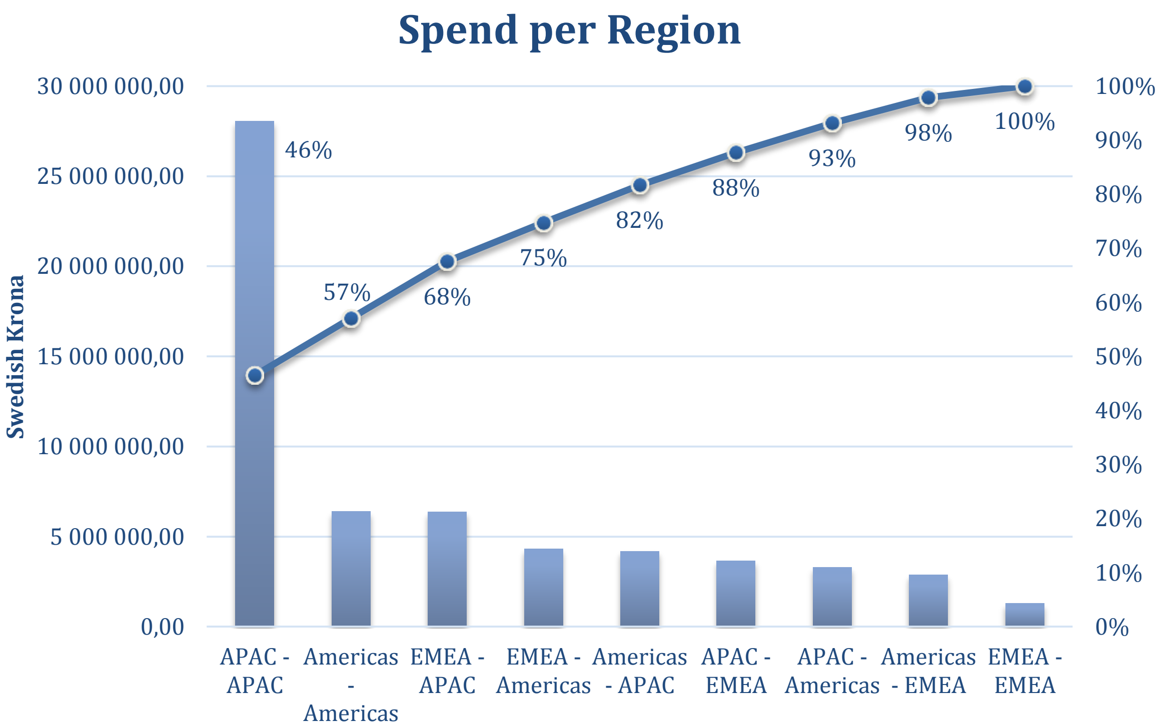


Figure 4-5: LCL spend per region during 2015.

Looking on the geographical spread of the LCL shipment, figure 4-6, based on the number of shipments, will further highlight the importance of APAC regarding the LCL shipments. 62 percent of the consignments was shipped intra-APAC during 2015, and the shipments from all of the three regions to APAC accounted for 75% of the total number of consignments globally. Another region of interest is the Americas and primarily shipments intra-Americas. They accounted for 11 percent of the total spend and 9 percent of the number of shipments during 2015.

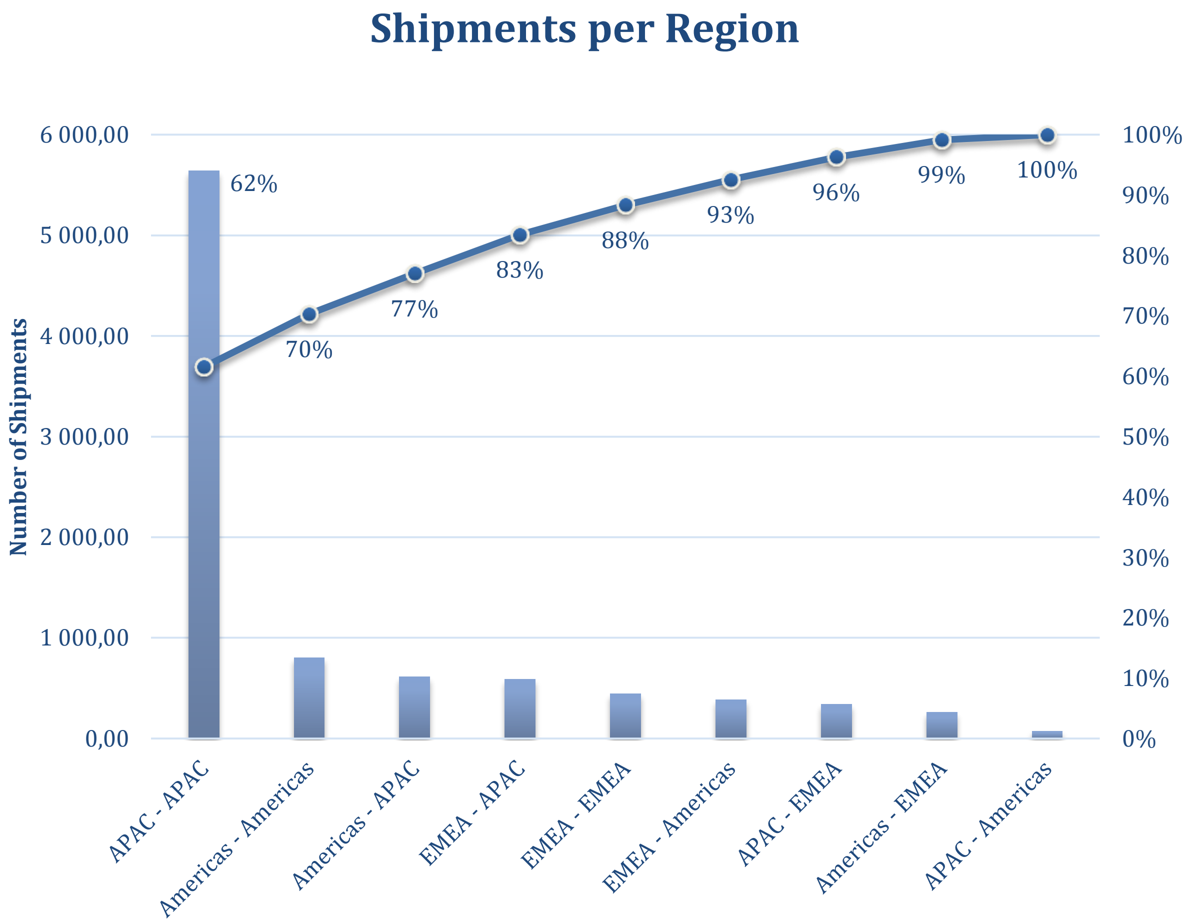


Figure 4-6: Number of LCL shipments per region during 2015.

The last measurement that is of interest when looking at the geographical spread of the LCL shipment is the pay-weight of the shipments during 2015. The major flows based on the pay-weight are the same as for number of shipments and spend, see figure 4-7, Intra-APAC being the largest regional flow accounting for 50 percent of the total pay-weight transported during 2015. The pay-weight of all of the consignments shipped to APAC from the three regions accounted for 75 percent of the total pay-weight of the LCL shipments during 2015.

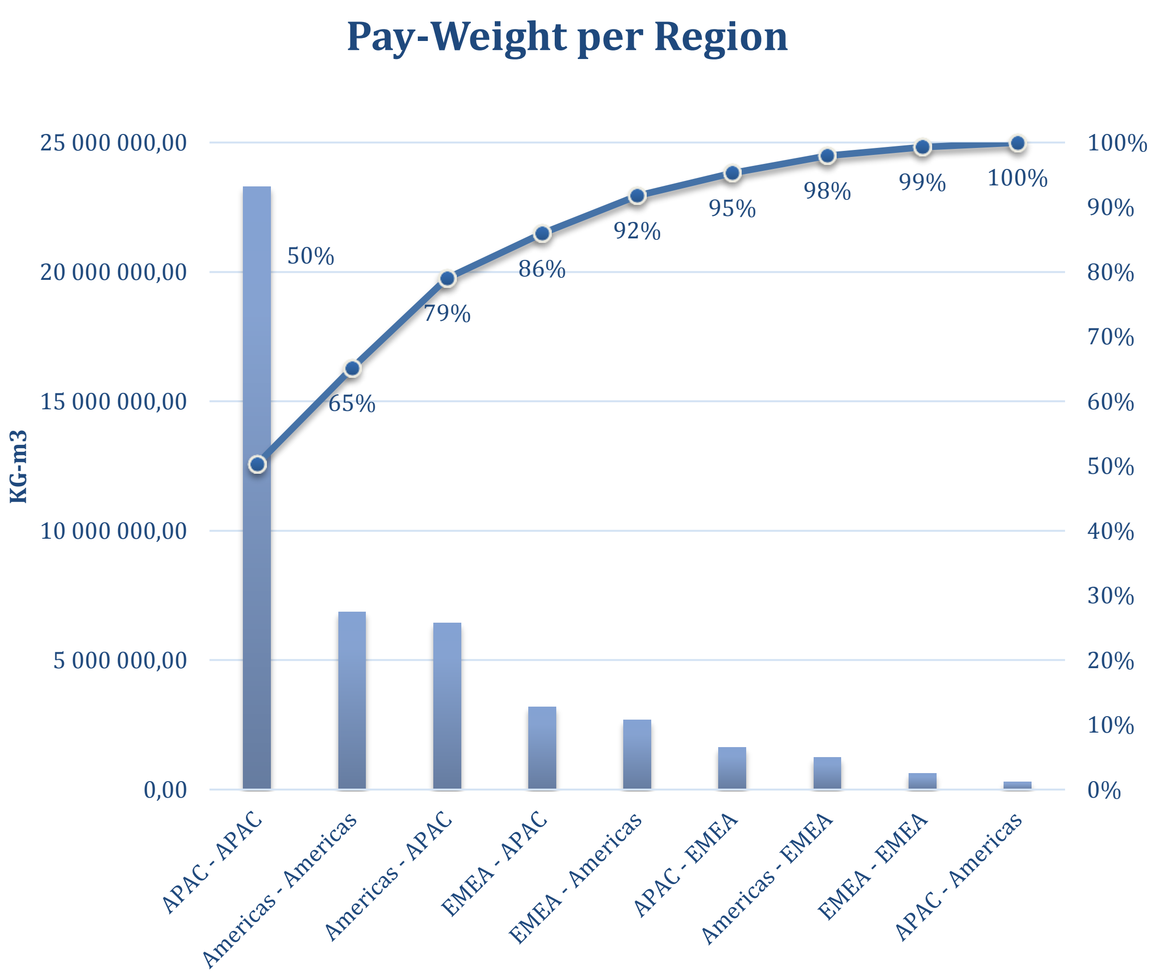


Figure 4-7: LCL shipments based on Pay-weight per region during 2015.

4.3.1 Countries of origin

During 2015, the Volvo Group had LCL shipments originating from 34 different countries. The number of shipments originating from these countries varied widely, e.g. the countries with the least amount of shipments had one single LCL shipment during 2015. The cost of the transports, the pay-weight of the shipments, the number of shipments and the geographical spread of all the countries and can be seen in figure 4-8, figure 4-9, figure 4-10 and figure 4-11 respectively.

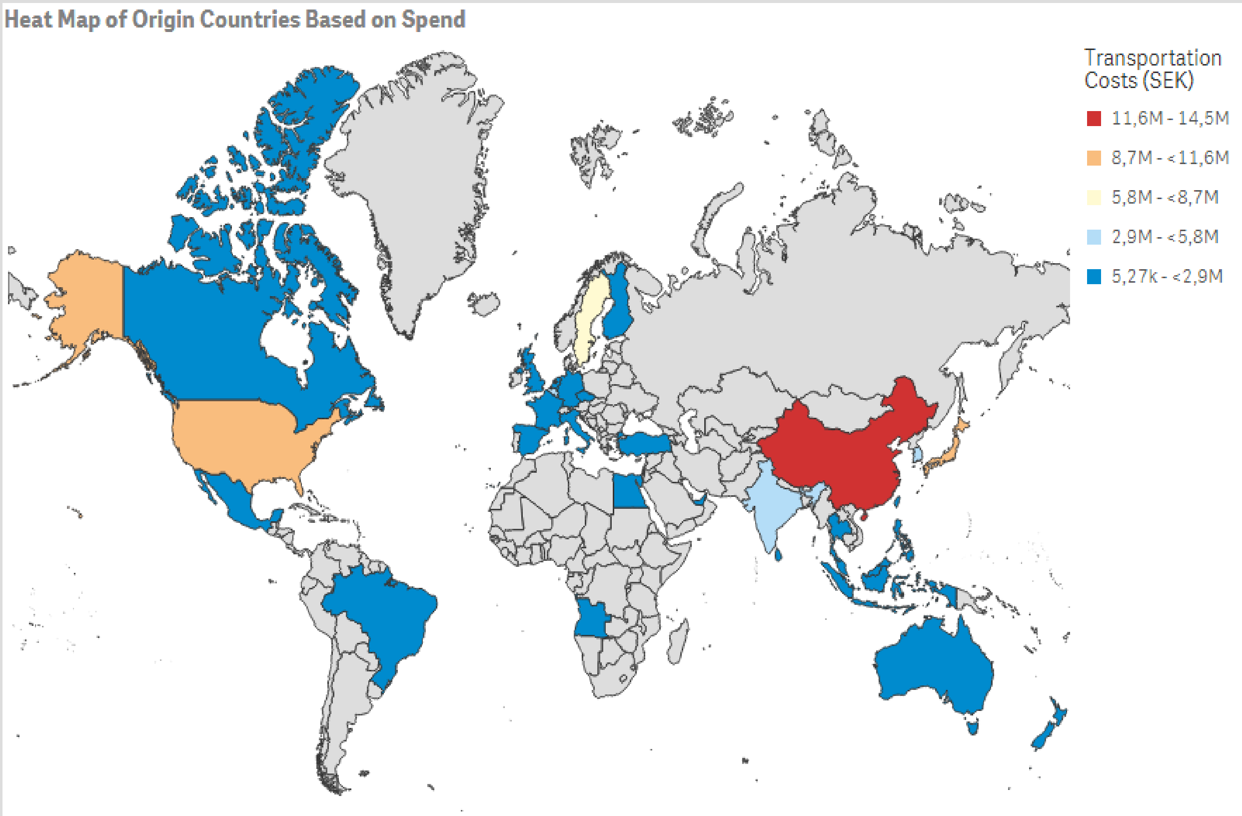


Figure 4-8: Heat map of origin countries based on spend.

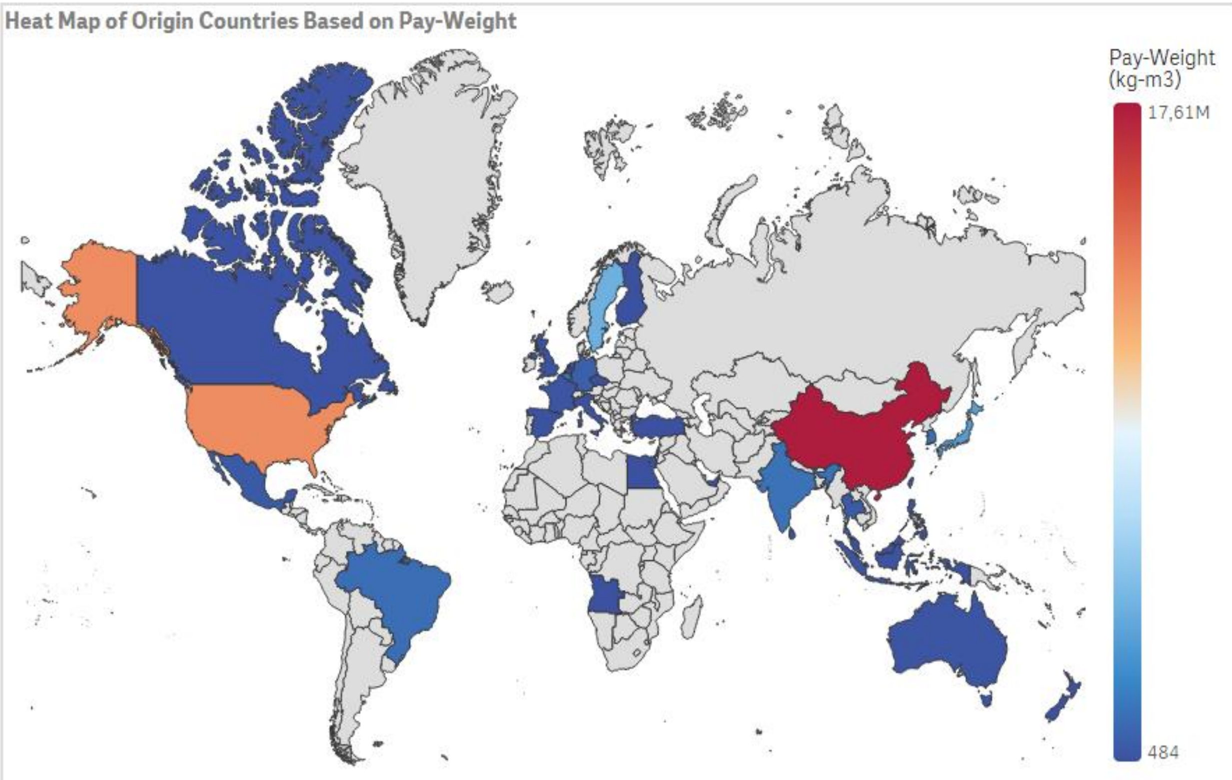


Figure 4-9: Heat map of origin countries based on Pay-Weight.

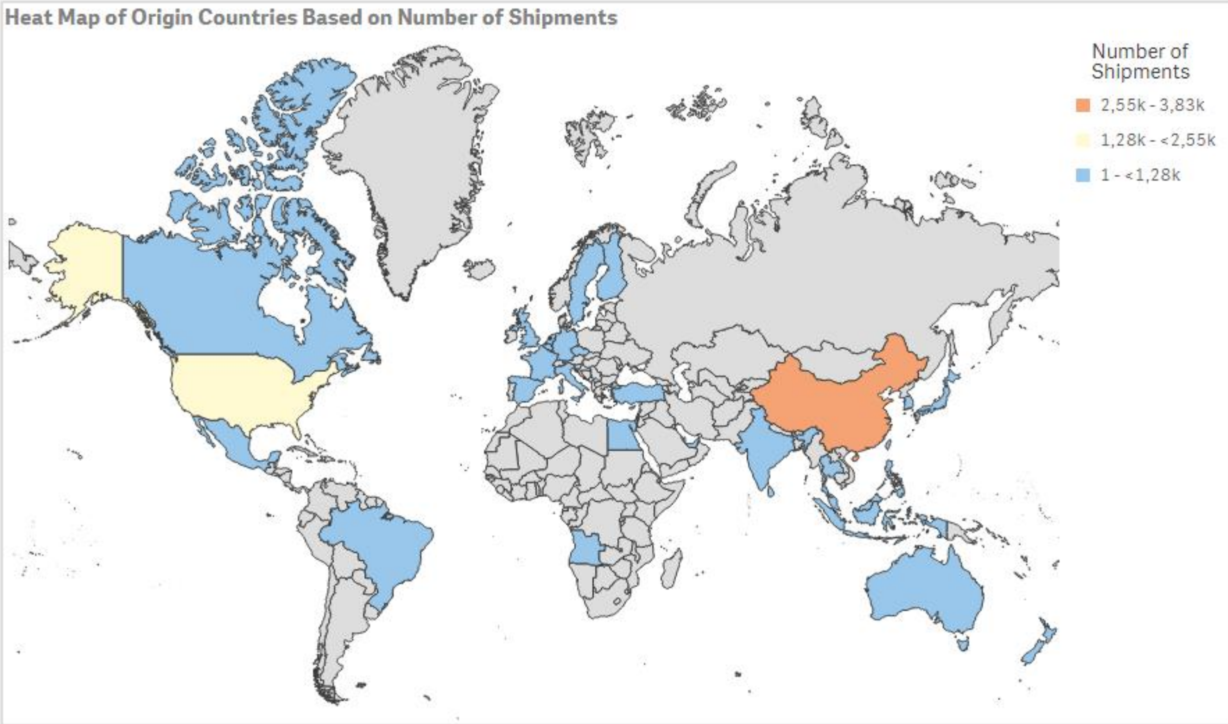


Figure 4-10: Heat map of origin countries based on number of shipments.

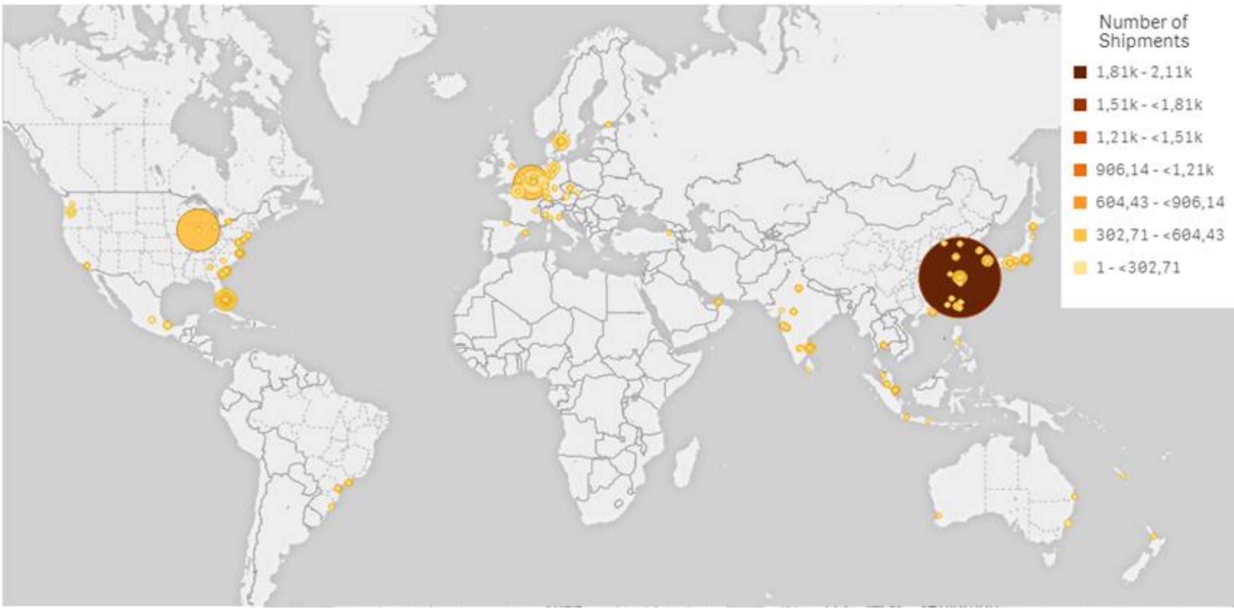


Figure 4-11: Countries of origin based on the number of shipment.

As shown in figure 4-11, the biggest percentages of the origin countries are located in APAC and EMEA, each having 15 countries with at least one LCL shipments during 2015. However, there is a difference in the number of shipment originating from these areas, also clearly shown by the size of the circles in the figure above. The 15 countries with at least one consignment located in APAC was the origin country for approximately 66 percent of the total number of LCL shipments during 2015 compared to the 15 countries in EMEA which accounted for approximately 15 percent. The four countries with at least one consignment during 2015 in Americas accounted for approximately 19 percent of the total LCL shipments during the year.

Figure 4-12 shows the countries where most of the LCL consignments originated from, the seven countries in the figure accounts for more than 80 percent of the Volvo Group's total LCL shipments during 2015. The country with the highest number of shipments, China, had almost twice as many shipments as the country with the second highest number of shipments, USA. It is also interesting to point out that 40 percent of the total number of shipments during the year originated from China.

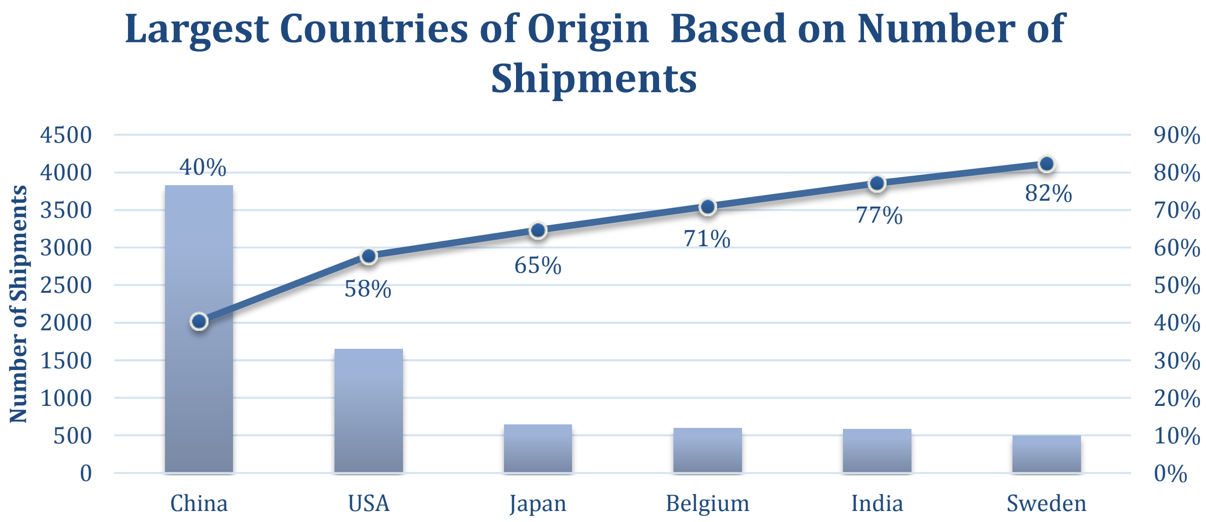


Figure 4-12: The countries that accounted for 80 % of the total number of LCL shipments.

The shipments from China are mostly concentrated around the eastern part of the country with Shanghai as the single biggest node of Volvo Group's LCL transportation network. Figure 4-13 shows the distribution of the shipments originating from China, Japan, India and Thailand on a city level.

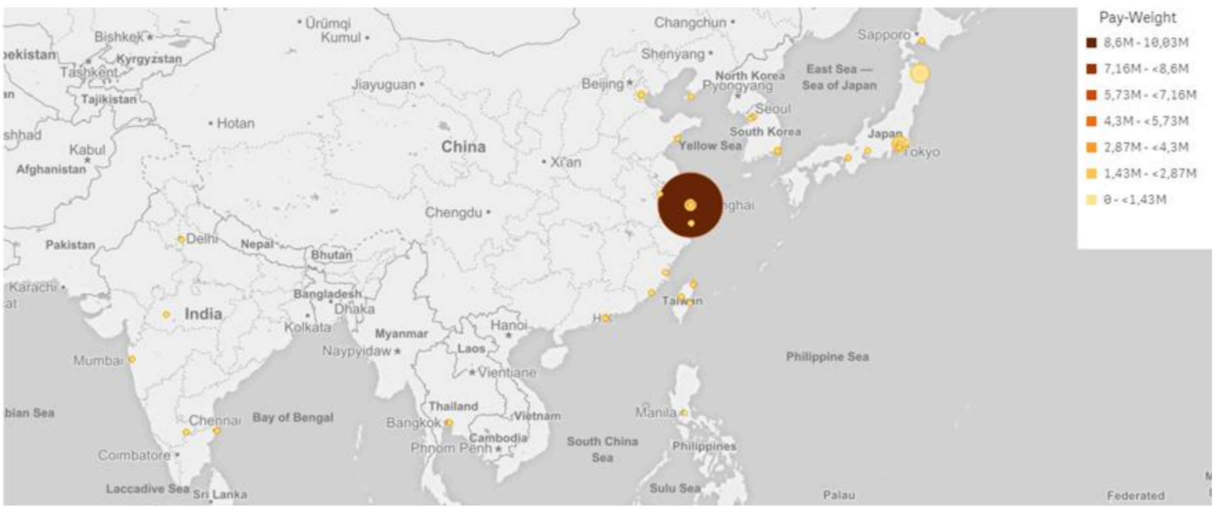


Figure 4-13: Overview over the shipments originating from China, Japan, India and Thailand.

Looking on the countries where the biggest shares of the LCL transports originated from during 2015, based on spend, a few vital countries can quickly be identified. Figure 4-14 shows the seven countries, 20.5 percent, which accounted for 83 percent of the total LCL transportation spend during 2015. It is Interesting to point out that the three countries accounting for the biggest part of the total spend had approximately the same percentage of the total cost, around 20 percent separately. China, where 40 percent of the shipments originated from, did only account for approximately 20 percent of the total spend.

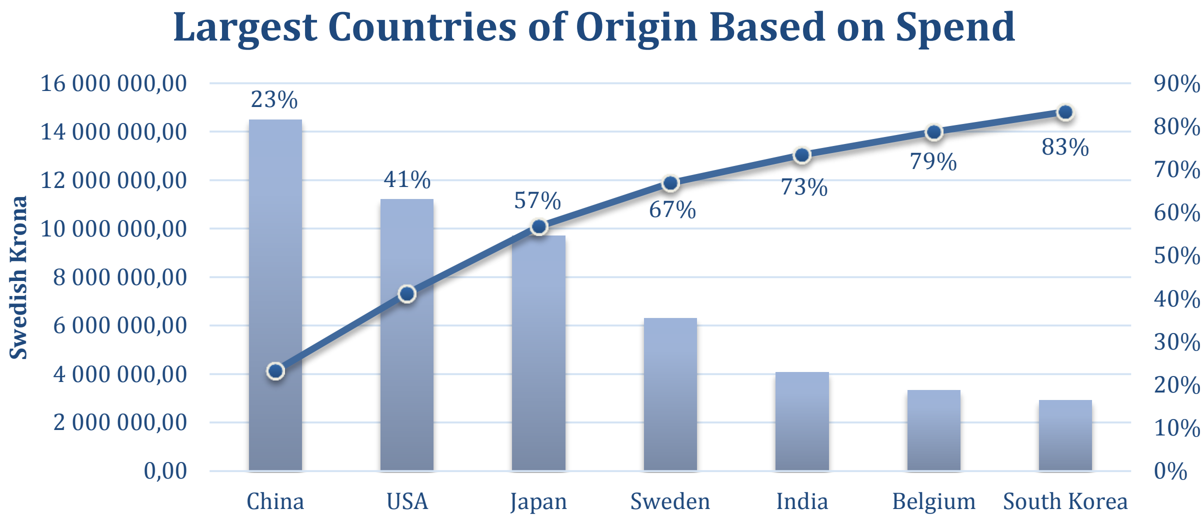


Figure 4-14: The countries that accounted for 80 % of the total LCL transportation spend.

The spread of the LCL pay-weight distribution amongst the origin countries can be seen in figure 4-15. Here only four countries account for 82 percent of the total LCL shipment pay-weight during 2015; China and USA are by far bigger than Sweden and Japan.

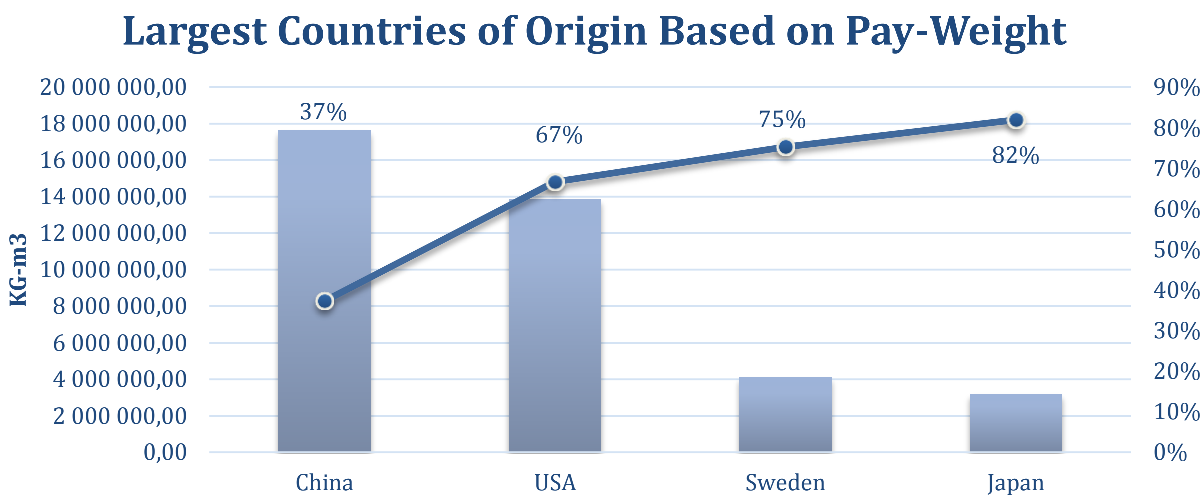


Figure 4-15: The countries that accounted for 80 % of the total Pay-weight of LCL shipments.

4.3.2 Major lanes

Volvo Group's LCL transports were further analyzed on a country to country level to provide a good understanding of the situation during 2015. During the year, 9168 LCL shipments were transported through 255 lanes. A lane refers to a transportation relationship between a specific origin country and a specific destination country. The lanes that accounted for a spend equal to at least one percent of the total LCL spends during 2015 can be seen in figure 4-16.

These 26 lanes accounts for almost 70 percent of the total spend, see Appendix B for the additional 15 lanes that together with these lanes equals for 80 percent of the total LCL spends. The lane between China and Thailand consumed 13 percent of the total spend during 2015, more than twice as much as China and India, the second biggest one. The nine biggest lanes based on price accounted for almost 50 percent of the total spend.

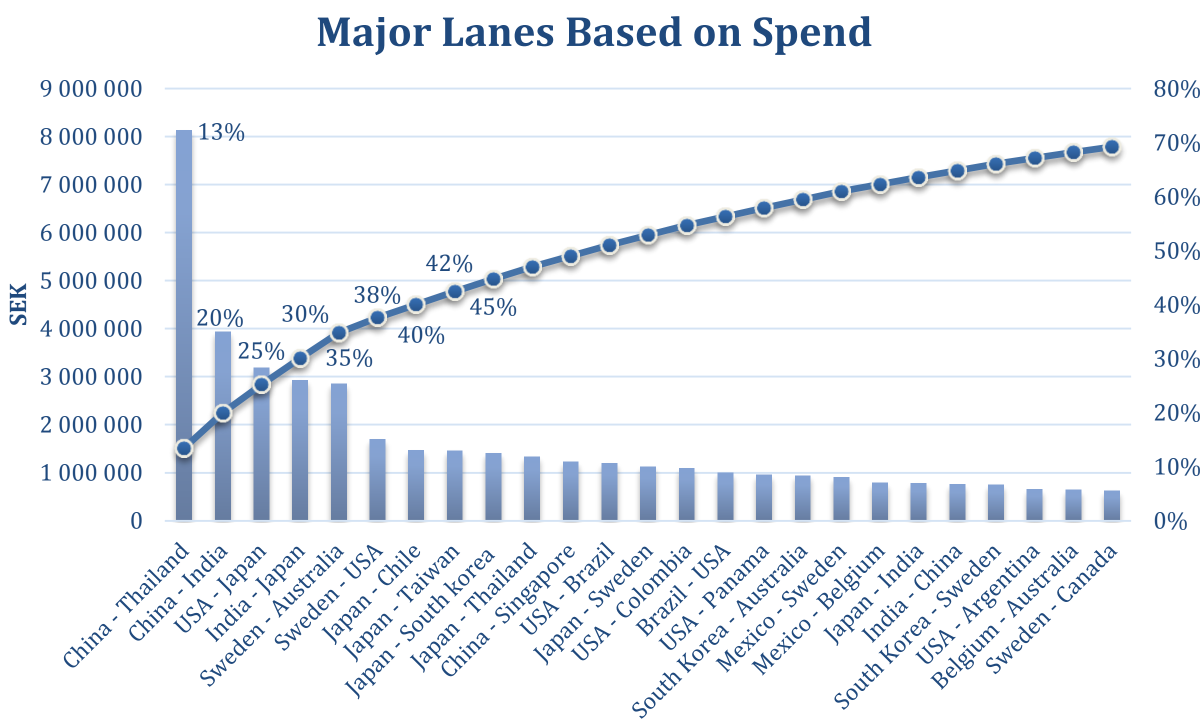


Figure 4-16: The LCL spends during 2015 on a country to country level.

The number of shipments on a lane level can be seen in figure 4-17, in difference with the LCL spends above there were only 16 lanes during 2015 who contributed to more than one percent of the total number of shipments. The other 16 lanes that together with the 16 lanes seen in figure 4-17 accounting for 80 percent of the total number of shipments can be seen in Appendix B. There is otherwise not much difference between the lanes when it comes to spend and number of shipments. One interesting finding is that the shipments from Sweden accounts for a large share of the costs compared to the number of shipments.

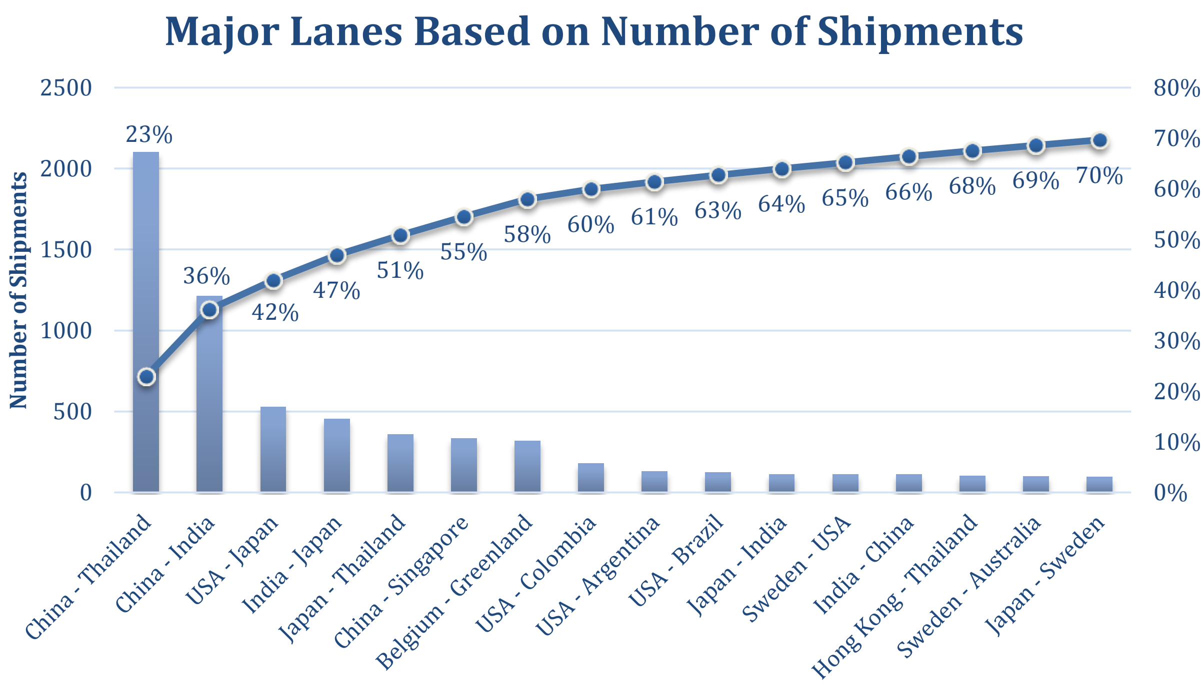


Figure 4-17: Number of LCL shipments during 2015 on a country to country level.

The major LCL lanes based on pay-weight can be seen in figure 4-18. Here only 13 lanes contribute to at least one percent of the total LCL pay-weight during 2015. The other 10 lanes that together with these 13 lanes account for 80 percent of the total LCL pay-weights during 2015 can be seen in Appendix B. The three biggest lanes, based on pay-weight, accounted for almost 50 percent of the total LCL pay-weight during 2015.

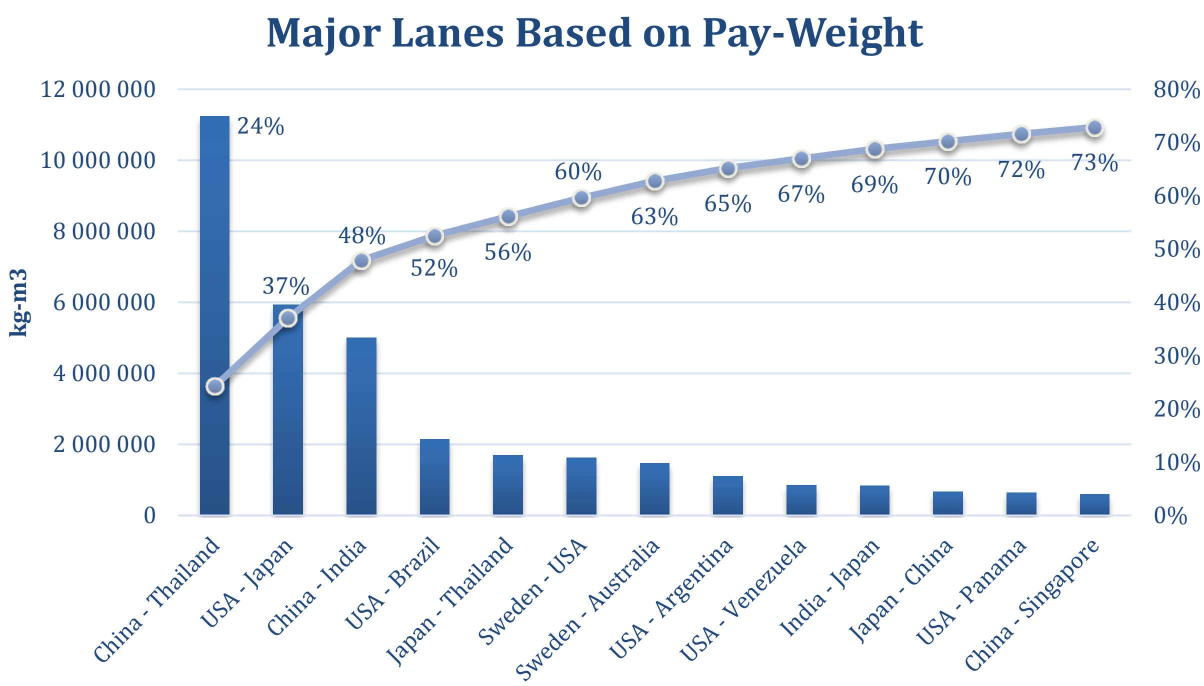


Figure 4-18: The major LCL lanes based on the pay-weight during 2015.

4.4 Weight of the shipments

An interesting finding from the data gathered during this project is the weight of the LCL shipments during 2015. The sizes of the shipments are of interest and can contribute to further understanding of the Volvo Group's LCL shipments. The average size of a LCL shipment during 2015 was 1670 kg, 4,8 m^3 with a pay-weight of 5052 kg-m^3. The 9168 shipments had a combined weight of approximately 15 500 tons but a large share of the consignments had a weight or pay-weight that equaled or was less than 100 kg and a volume less than 1 m^3. This share varies based on the measurement which one looks at the shipments through.

813 shipments which equals 8,9 percent of the total LCL shipments during 2015 had a pay-weight less than or equal to 100 kg-m^3 with an average pay-weight of 40 kg-m^3. When it comes to the weight of the shipments in kg, the share that had a weight below 100 kg is bigger. During the year, 2034 shipments, 22 percent of the total LCL shipments had an actual weight less than or equal to 100 kg. These consignments had an average weight of 38 kg and an average volume of 0,27 m^3. Not including shipments with an volume greater than 1 m3 there were 1975, 21,5 percent of the total LCL shipments with an weight less than or equal to 100 kg. See table 4-3 for an overview of the distribution.

Table 4-3: Distribution of the shipments with a weight or pay-weight below 100 kg or kg-m^3.

Number of Shipments	Measurement
813 Shipments	$\leq$ 100 kg-m^3
2034 Shipments	$\leq$ 100 kg
1975 Shipments	$\leq$ 100 kg and $\leq$ 1 m^3

4.5 Assessment parameters

Base on a total cost of ownership model, multiple criteria were considered in order to evaluate potential scenarios developed during the project. Five categories representing different costs related to a purchase were chosen in order to evaluate the scenarios from different perspectives. Within each category a number of different performance indicators that would have an impact on the total cost of that specific category were identified, see table 4-4. The most important and relevant factors in each category were then identified together with internal stakeholders.

Table 4-4: The selected criteria from different categories.

Cost	Management	Quality	Service	Communication
Transport price	Sourcing process	Lead-time deviation	Geographical coverage of logistics service providers	B2B communication
B/L cost	Network design and optimization	Environmental impact	Complaint handling	Deviations reports
Customs cost	Invoicing complexity	Invoicing quality	Fluctuation handling	Tracking & tracing
Lead-time	EDI		Lane adjustment flexibility	
	Operational management			

4.5.1 Criteria from literature study

As explained above some of the criteria were identified based on the literature study conducted in the initial part of the project and some from interviews held during the project. Below is an explanation of the different assessment parameters and why they are considered important. Those criteria acquired from literature study are:

- Transport price: refers to the freight rate of LCL shipment including both inland delivery, ocean delivery and delivery in the destination country, which is offered by forwarders and stated in contracts. This parameter is one of the most important criterion when it comes to purchasing transport services, since companies are constantly trying to lower the cost of their supply chains.

- Lead-time: refers to the time span between the creation of a delivery order and the final delivery of the order. Based on the literature study, it is found that lead-time has been used to evaluate the performance of a transport service by many researches. Evidently, short lead-time for the LCL shipments is also expected from the Volvo Group. Tied-up capital cost is closely related with lead-time so it is also included in this parameter. Tied-up capital contains any capital that cannot be used in the cash flow. It will increase if the delivery time is longer due to bad transport planning and unnecessary inventories.

- Sourcing process: This type of cost is generated from purchasing activities, i.e. the more complicated the process is, the more time and resources the procurement requires. Defining the needed service, RFI's, RFQ's, negotiating prices and the final contracting are steps that are resource intensive and which costs cannot be ignored. This is one of the parameters that could influence the final price of the transport.

- Network design and optimization: The transport network needs to be developed and optimized continuously. This process requires resources such as time but also know-how and expertise. The decisions, whether the customer or the transport provider is responsible for the development of the transport network and optimization of the logistics activities, therefore have significant impacts on the total transport cost.

- Electronic Data Interchange (EDI): This criterion mainly refers to the costs generated from booking processes. The complexity, transparency, and efficiency of the booking activities depend on the maturity level of an electronic data interchange system. A new EDI connection for the communication between buyer and supplier can be expensive to set up.

- Operational management: Includes costs resulted from coordinating shipments from different lanes when trying to consolidate shipments in a terminal. According to the literature study, coordination cost might increase when multiple forwarding firms are involved or shipment consolidation takes place in a logistics node.

- Environmental impact: This parameter is mainly considered from the perspective of energy consumption and pollution due to emissions in this project. This factor has been discussed and its importance highlighted by many researchers when discussing the quality of freight transport. It is an important factor since emission regulations might increase in the near future. This is also of importance since the Volvo Group is aiming to reduce emissions from products and production by at least 40 million tons of CO_2 by 2020 compared with 2013.

- B2B communication: Refers to all of the costs included in maintaining a relationship with a supplier. Maintaining a relationship between two companies requires resources, time of the employees. The cost of the relationship is influenced by the importance of the supplier for the company. This parameter can influence the total cost of ownership of a product or service and cannot be ignored when comparing two solutions.

- Tracking & tracing: This factor encompasses all costs related to tracking and tracing a shipment, which is both influenced by the customer and the forwarders. It is important for a company to have the ability to track and trace a shipment during transport. This gives the company the ability to anticipate events that can disrupt the supply chain so that they can be averted.

4.5.2 Criteria from interviews

Throughout this project a number of interviews have been held with employees within the Volvo Group. They have been working in different departments and had different experience levels. A number of important parameters that one needs to consider when comparing two different solutions have been identified from the interviews. Those criteria acquired from interviews are explained below:

- Customs cost: A parameter that have to some extent been ignored by the Volvo Group is customs. This has been identified as an area that holds a considerable opportunity for cost savings. However, the customs costs compared to the total logistics spend of the Volvo Group is rather low. Employees have during this project estimated a saving potential of about 10 percent of the customs costs with better planning. This is due to the large economies of scales that are present working with custom clearance.

- B/L cost: This parameter includes all of the costs regarded to bill of lading, which also have a potential to be reduced from appropriate consolidation of LCL shipment. The reasoning behind this being that there are economies of scale regarding B/L as well. Hence, B/L cost an important component of the total transport cost of LCL shipment and it is interesting to see how this parameter changes based on the solution.

- Invoicing complexity: Refers to all of the costs related to the invoicing process. For example, the way that an invoice is handled, either via email or EDI, affects the invoicing complexity to a great extent. During this project invoicing complexity has been identified as an area that requires attention since a complex invoicing solution might require a lot of resources to handle.

- Lead-time deviation: It describes the lead-time variation and fluctuation for the different LCL shipment and is one of the most important parameter of delivery performance. It is important for the Volvo Group to have lead-times that are constant and reliable in order to not endanger the operation in the production facilities. This is also important for the aftermarket since the end customers need to have their trucks running and not standing still waiting for a part to be delivered. An unplanned delay in shipment might result in a considerable increase in the total transport cost of the LCL shipment. Due to the fact that many ports are very congested nowadays, it is necessary to evaluate the risks of port congestion when considering lead-time deviation.

Previous problems related to port congestion has made the Volvo Group aware of this problem. It can however be hard to avoid port congestion since the ports are related and influence each other, e.g. problems in one port will influence ports nearby since containers are being rerouted. Having a transport network with a low level of flexibility can be troublesome if an important port in the network is congested.

- Invoicing quality: This factor describes the forwarder's invoicing quality, e.g. is the customer being invoiced according to the contract? Mistakes in the contract can be hard to find and time consuming to correct. It is also one factor that might influence the relationship between the supplier and buyer. So having invoices without any mistakes is important.

- Geographical coverage of logistics service providers: When evaluating different transport solutions, it is of great importance to compare the geographical coverage of logistics service providers since Volvo Group's is a global company with customers in every continent. A transport provider with a good geographical coverage could influence Volvo Group's transportation since they will have more frequent shipments and lower prices compared to a transport provider that are not in that market yet.

- Compliant handling: This parameter reflects a supplier's capability of handling Volvo Group's complaints. A supplier's feedback to a complaint influences its business relationship with Volvo Group. It also important to have a rigid complaint handling process so that issues that arise are solved and the network improved.

- Fluctuation handling: Fluctuation handling capacity of the transport providers and forwarders can from time to time be limited, especially when it comes to sea transportation. This is often due to macro trends and market situations worldwide. This parameter is used in order to assess the solution's ability to handle fluctuations in shipping volume.

- Lane adjustment flexibility: The Volvo Group is a global company with customers all over the world. It is hence hard to have a contract in place for every lane; a lane refers to a transport leg between two countries. This parameter refers to all of the costs related to adding lanes to a contract.

- Deviations reports: When a shipment is delayed, due to any reason, it is important that the Volvo Group receives information related to the delay. During this project a number of interviewees have stressed problems with deviation reports, some of the problems are related to forwarders not reporting delays and some to reports which are not satisfying. It is important to take the quality of deviations report into consideration when comparing two different solutions.

4.5.3 Result from questionnaire; weighing the assessment parameters

In order to use the parameters discussed in chapter 4.5.1 and 4.5.2 in assessment of the scenarios, there was a need for determining their importance levels. This was done through a questionnaire, see chapter 3.4.2. The result of the questionnaire is presented below, as shown in table 4-5. The percentage shows the distribution of the answers, based on their levels of importance. This was subsequently used as input when constructing the matrix in the Weight Criterion Method.

Table 4-5: Result from the questionnaire.

	COSTS	
Transport price	Equally important	B/L cost
100%	0%	0%
Transport price	**Equally important**	Lead-time
25%	**62.5%**	12.5%
Transport price	Equally important	Customs cost
100%	0%	0%
B/L cost	Equally important	**Customs cost**
12.5%	25%	**62.5%**
B/L cost	Equally important	**Lead-time**
0%	0%	**100%**
Customs cost	Equally important	**Lead-time**
0 %	0%	**100%**

	MANAGEMENT	
Sourcing process	**Equally important**	Network design and optimization
37.5%	**50%**	12.5%
Sourcing process	Equally important	**EDI**
28.6%	28.6%	**42.9%**
Sourcing process	**Equally important**	Invoicing complexity
42.9%	**57.1%**	0%
Sourcing process	Equally important	Operational Management
71.4%	0%	28.6%
Network design and optimization	Equally important	**Invoicing complexity**
33.3%	16.7%	**50%**
Network design and optimization	**Equally important**	Operational Management
28.6%	**57.1%**	14.3%

Network design and optimization	Equally important	**EDI**
28.6%	14.3%	**57.1%**
Invoicing complexity	**Equally important**	EDI
28.6%	**57.1%**	14.3%
Invoicing complexity	Equally important	Operational management
71.4%	14.3%	14.3%
EDI	Equally important	Operational management
57.1%	28.6%	14.3%

	QUALITY	
Lead-time deviation	Equally important	Invoicing quality
57.1%	42.9%	0%
Lead-time deviation	Equally important	Environmental impacts
71.4%	28.6%	0%
Environmental impacts	Equally important	**Invoicing quality**
28.6%	28.6%	**42.9%**

	SERVICE	
Geographical coverage of logistics service provider	Equally important	Compliant handling
62.5%	0%	37.5%
Geographical coverage of logistics service provider	Equally important	Lane adjustment flexibility
57.1%	0%	42.9%
Geographical coverage of logistics service provider	Equally important	**Fluctuation handling**
12.5%	25%	**62.5%**
Compliant handling	Equally important	**Fluctuation handling**
0%	37.5%	**62.5%**
Compliant handling	Equally important	Lane adjustment flexibility
50%	37.5%	12.5%
Fluctuation handling	Equally important	Lane adjustment flexibility
85.7%	14.3%	0%

	COMMUNICATION	
B2B communication costs	Equally important	**Deviation reports**
12.5%	12.5%	**75%**
Deviation reports	Equally important	Tracking & tracing
44.4%	33.3%	22.2%
B2B communication costs	Equally important	**Tracking & tracing**
25%	25%	**50%**

4.6 Buyer's consolidation

Buyer's consolidation is a distribution and logistics service, which is offered by many forwarders and carriers such as DSV, DB Schenker and DHL. The ultimate logic of this service is that when a customer purchases goods in a particular region from several suppliers, forwarders can bundle the customer's shipments into one shipment before the ocean delivery. As illustrated in figure 4-19, the customer has shipments from three different suppliers in the same country. In a standard consolidation process, these three shipments will be delivered to a consolidation center, then consolidated with other shipments into one container by a forwarder and prepared for further distribution. Within the whole logistics process, these three shipments are always charged separately. But in a buyer's consolidation setting, shipment 1, shipment 2 and shipment 3 will be consolidated into one shipment first and then consolidated with other shipments, see figure 4-20. Consequently, these 3 shipments are taken and charged as one shipment for the ocean delivery and inland transport. It important to point out that the operational differences between a buyer's consolidation setting and a traditional one can in some cases is non-existing. It is how the forwarder charges for the three shipments that is the biggest difference.

There are a lot of possibilities for potential cost savings since there is major economies of scale presented in logistics. Additional savings might be reaped from custom clearance and B/L if the shipments belong to the same legal entity. When the three shipments have the same destination, destination handling activities such as unloading could be simplified since only one truck is needed instead of three, which could reduce the environmental impacts and traffic at the consignee's facilities. What should be noticed is that a mature EDI system between the customer and the forwarder is preferred when implementing buyer's consolidation, in order for the forwarder to align the pick-up days of the customer's shipments.

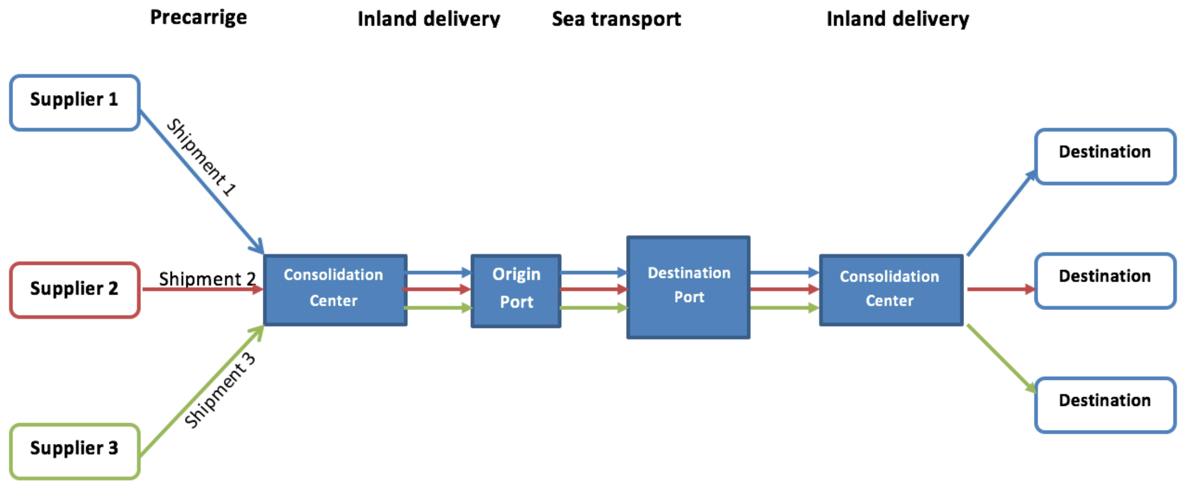


Figure 4-19: Standard consolidation process

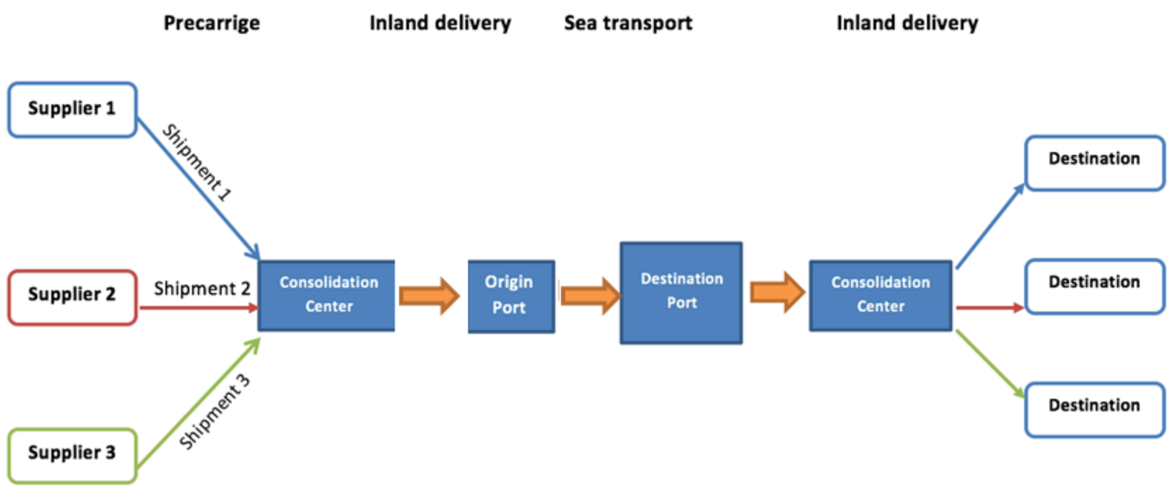


Figure 4-20: Buyer's consolidation process

5 ANALYSIS

This chapter aims at answering the third research question. It starts by describing the potential LCL transportation scenarios which can be viable for the Volvo Group in the future. In total, seven scenarios are explained with figures. This is followed by the importance of the different assessment parameters and is concluded by the analysis of the seven viable scenarios.

5.1 Potential LCL transportation scenarios

Totally seven scenarios for handling the Volvo Group's LCL transportations were constructed. Five of them involved consolidation, both buyers' consolidation and standard consolidation, and the other two scenarios were designed in order to identify the effects of having no consolidation. Air freight is not included in the last scenario, S4. One reason is that the scenario is constructed to reflect the Volvo Group's current LCL setup. By excluding air freight from the scenario its influences on the LCL transportation network can be found. Air freight is introduced based on findings from the literature study and interviews as well as the gathered data. The benefits of air freight are explained in chapter 2.3.5. From the interviews with I_7, C_1, C_2 and C_4, it was found that the break-point where air freight is less expensive than sea freight is around 100 kg. Based on the gathered data, 21.5% of the LCL shipments during 2015 had a weight less than 100 kg and a volume smaller than 1 $m^{3.}$ It is interesting and reasonable to take air freight into account and analyze its potential influences. Two perspectives were considered when constructing the scenarios; the network design and number of logistics service providers. The result of this was that there are four pairs of scenarios with the only difference being the number of logistics service providers. Below the scenarios and the underlying reason for their viability is explained:

Scenario S1:

S1-1: The first scenario is a door-to-door solution where the forwarder handles the flow from supplier or warehouse to the Volvo plant or dealer, see figure 5-1. The shipments below the point where air transportation is cheaper compared to sea transportation is sent by air and the shipments above the break point by sea. The number of logistics service providers is not reduced. This scenario was constructed since the amount that the Volvo Group spent on LCL transportation during 2015 is almost negligible compared to the total logistics spend. The amount of flow management required by this scenario is rather low; the forwarders can concentrate on their core competence and the total cost of the LCL transportations can be reduced. By not reducing the logistics service provider base, the company is able to create a competitive bidding situation and negotiate the best transport price for every lane.

S1-2: Scenario 1-2 is also a Door-to-Door solution where the forwarder handles the flow from supplier or warehouse to the Volvo plant or dealer, see figure 5-1. The shipments below the point where air transportation is cheaper compared to sea transportation is sent by air and the shipments above the break point by sea. The only difference compared to scenario S1-1 is that the logistics service provider base is reduced in this scenario. Beside the benefits explained above, the logistics service provider base reduction will have some benefits. The benefits will mainly be in management of the LCL transports and business to business communication regarding the transports. The disadvantage of the logistics service provider base reduction is that having fewer logistics service providers often means that it is harder to negotiate the best price for every lane since each logistics service provider is strong in particular areas.

Figure 5-1: Description of scenario S1-1 and S1-2

Scenario S2:

S2-1: In this scenario a distinction is made between the different flows. The rationale behind this is that since the different flows contribute to different share of the total spend they should not be treated in the same way; the larger flows should get more attention. Shipments in the biggest flows, major flows, should go through cross-docks in the areas when this is possible; there they will be consolidated with other shipments and sent to the destination by sea. The reasoning behind this is that the consolidation possibilities are largest in situations where the volumes are most stable. The largest flows are less influenced by fluctuations. This will only be done in areas where consolidation centers are already existing and in operation for the other flows since it is not feasible to set up an consolidation centers when the volumes and spend is so low. The minor flows are purchased door-to-door; the shipment below the breakpoint is sent by air and the shipments above the break point by sea. See figure 5-2 for an overview. By not reducing the logistics service provider base, the company is able to create a competitive bidding situation and negotiate the best transport price for every lane.

S2-2: The only difference between this scenario and S2-1 is the number of logistics service providers. In this scenario, a logistics service provider base reduction is made in the minor lanes, this in order to get some benefits regarding the management of the LCL transports and business to business communication concerning the transports. The disadvantage of the logistics service provider base reduction is that having fewer logistics service providers often means that it is harder to negotiate the best price for every lane since each logistics service provider is strong in particular areas.

Major flows, when possible:

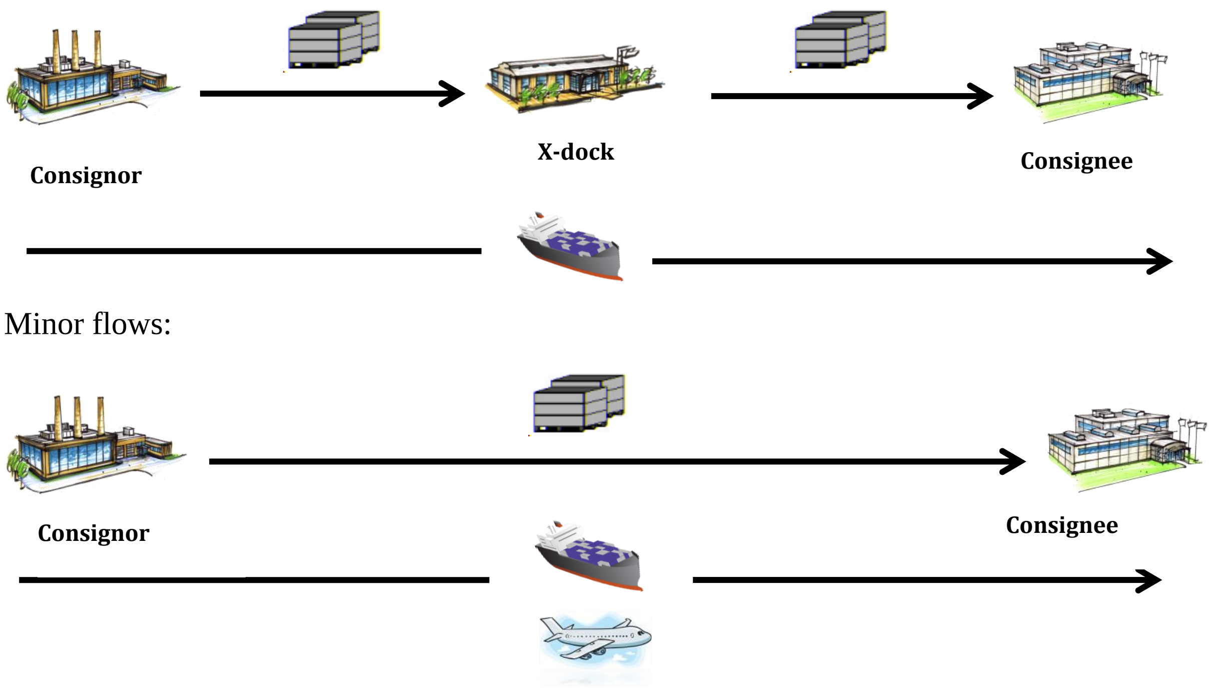


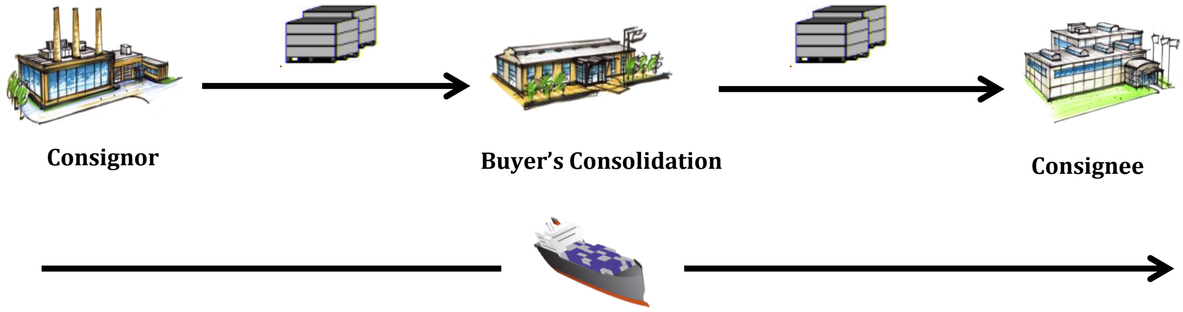
Figure 5-2: Description of scenario S1-1 and S2-2.

Scenario S3:

S3-1: Also in this scenario a distinction is made between the different flows. Again the same reasoning as above is viable since the different flows contribute to different shares of the total spend, they should not be treated in the same way; the larger flows should get more attention. A buyers' consolidation will be set up in the major flows, the reasoning for this solution being used only in the major flows is that stable volumes and shipments from different suppliers in the same country is needed. The minor flows are purchased door-to-door; the shipment below the breakpoint is sent by air and the shipments above the break point by sea. See figure 5-3 for an overview of this scenario. By not reducing the logistics service provider base, the company is able to create a competitive bidding situation and negotiate the best transport price for every lane.

S3-2: The only difference between this scenario and S3-1 is the number of logistics service providers. In this scenario a logistics service provider base reduction is made in the minor lanes, this in order to get some benefits regarding management of the LCL transports and business to business communication concerning the transports. The disadvantage of the logistics service provider base reduction is that having fewer logistics service providers often means that it is harder to negotiate the best price for every lane since each logistics service provider is strong in particular areas.

Major flows, when possible:



Minor flows:

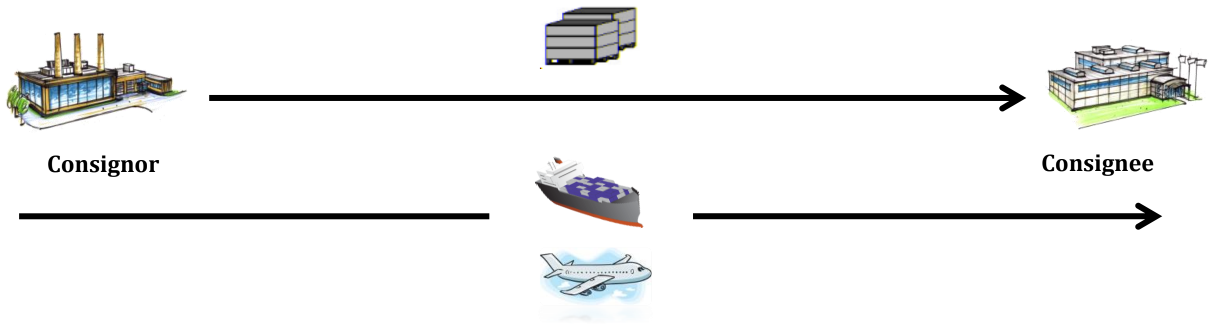


Figure 5-3: Description of scenario S3-1 and S3-2

Scenario S4:

S4: The last scenario is to force the flows through already existing cross-docks and to have door-to-door solutions when there are no cross-docks available. This is how the Volvo Group's LCL transports should be handled today in theory, but in reality it is mostly door-to-door solutions that are being used. It is not feasible to set up new cross-dock terminals for the LCL transports when the volumes and spend is so low. By not reducing the logistics service provider base, the company is able to create a competitive bidding situation and negotiate the best transport price for every lane.

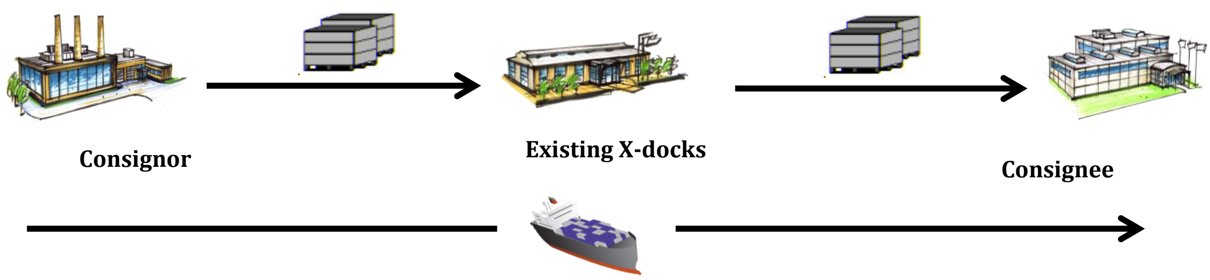


Figure 5-4: Description of scenario S4.

5.2 Parameter assessment; weight criterion method

The results of the questionnaire were used in order to define which of the assessment parameters that the Volvo Group considered most important in the five categories: cost, management, quality, service and communication. Each table below shows the importance of the assessment parameters in one category. The K_i number is an indication on how important the parameter is, where a higher number corresponds to a higher importance level.

Starting with the first category, cost, it is clear that transport price is the assessment parameter that is considered most important by the company, see table 5-1. This parameter is followed by lead-time and tied-up capital costs which are related to each other and considered almost as important. It is also clear that the costs related to the Bill of Lading are considered not to be of a high level of importance compared to the other parameters in this category.

Table 5-1: Weigh Criterion table, Costs.

	Transport price	B/L cost	Customs cost	Lead-time	Corr.	P_i	$k_i = \frac{P_i}{\sum P_i}$
Transport price	-0	2	2	1	1	6	***0.375***
	B/L cost	-2	0	0	3	1	***0.0625***
		Customs cost	-2	0	5	3	***0.1875***
			Lead-time	-1	7	6	***0.375***
					∑:	16	1.00

The results from the Weight Criterion method show that the most important assessment parameter regarding management is the EDI solution between the logistics service provider and the Volvo Group. This assessment parameter is followed by invoicing complexity which the respondents of the questionnaire found almost as important. The table, 5-2, does also show that the costs related to coordinating shipments from different lanes are not that important.

Table 5-2: Weigh Criterion table, management.

	Sourcing process	Network optimization	Invoicing complexity	EDI	Operational management	Corr.	P_i	$k_i = \frac{P_i}{\sum P_i}$
Sourcing process	-0	1	1	0	2	1	5	***0.20***
	Network optimization	-1	0	0	1	3	3	***0.12***
		Invoicing complexity	-1	1	2	5	7	***0.28***
			EDI	-1	2	7	8	***0.32***
				Operational management	-7	9	2	***0.08***
						∑:	25	1.00

Moving on to the next category, quality, the results from the questionnaire shows that having a stable lead-time is the most important assessment parameter when comparing the quality of two different transport solution, see table 5-3. An interesting finding from the questionnaire was that the least important parameter is the environmental impact of the transport solution. This is however understandable since the other parameters is a potential threat to the operation of the customers and production facilities.

Table 5-3: Weigh Criterion table, Quality.

Criteria						
	Lead-time deviation	Environmental impact	Invoicing quality	Corr.	P_i	$k_i = \frac{P_i}{\sum P_i}$
Lead-time deviation	-0	2	2	1	5	***0.56***
	Environmental impact	-2	0	3	1	***0.11***
		Invoicing quality	-2	5	3	***0.33***
				∑:	9	1.00

Table 5-4 shows the importance of the assessment parameters when it comes to service. It is clear that having a transport provider who can handle fluctuations in volume is the most important parameter. A good geographical coverage is also important. The costs related to adding new lanes to an existing contract are not considered important compared to the other parameters.

Table 5-4: Weigh Criterion table, Service.

Criteria							
	Geographical coverage of carrier	Compliant handling	Fluctuation handling	Lane adjustment flexibility	Corr.	P_i	$k_i = \frac{P_i}{\sum P_i}$
Geographical coverage of carrier	-0	2	0	2	1	5	***0.3125***
	Compliant handling	-2	0	2	3	3	***0.1875***
		Fluctuation handling	-0	2	5	7	***0.4375***
			Lane adjustment flexibility	-6	7	1	***0.0625***
					∑:	16	1.00

The last Weight Criterion table shows the most important assessment parameters regarding to the communication between the transport provider and Volvo group, see table 5-5. The respondents of the questionnaire were of the opinion that accurate deviation reports are more important than the costs related to business to business communications and the tracking and tracing of the shipments.

Table 5-5: Weigh Criterion table, communication.

Criteria						
	B2B communication	Deviation reports	Tracking & tracing	Corr.	P_i	$k_i = \frac{P_i}{\sum P_i}$
B2B communication	-0	0	0	1	1	***0.11***
	Deviation reports	-0	2	3	5	***0.56***
		Tracking & tracing	-2	5	3	***0.33***
				∑:	9	1.00

5.3 Scenario analysis

Each scenario was assessed based on the parameters that can be seen in chapter 4.5. The input from the two workshops conducted during this project together with findings in the literature and insights from empirical findings was the basis of the analysis. Each scenario was then graded based on the scale in table 5-6. Scenario S4, which is a representation of the LCL transportation network today, was chosen as a benchmark scenario and given the grade 2 in all of the assessment parameters. The influence of introducing air transportation in the LCL transportation network and a reduction of logistics service providers have also been considered when grading each scenario. The fact that the number of grades is limited results in that two scenarios might have the same grade in one assessment parameter without having the same performance. The differences between the performances of each scenario are however discussed in the subsections. Initiated changes that yet have not been implanted, e.g. the Volvo Group's new collaboration platform, Transporeon, was also regarded when grading the different scenarios.

Table 5-6: Grading system for the analysis.

Grade	Performance
4	The scenario can fulfill the parameter better than S4.
3	The scenario can fulfill the parameter somewhat better than S4.
2	The scenario fulfills the parameter equally well as S4.
1	The scenario fulfills the parameter somewhat worse than S4.
0	The scenario fulfills the parameter worse than S4.

Each section below will start by showing the overall score of each scenario in one category; cost, management, quality, service and communication. The underlying reasons for the scores are explained in the subsections following each section. Each subsection is concluded by the performance of the different scenarios in that specific assessment parameter.

5.3.1 Cost analysis

Transport cost is one of the most important aspects of a transportation solution. As table 5-7 shows, the different scenarios will influence the transportation cost differently. From the questionnaire it was concluded that the company regards the price of the transport and lead-time as the two most important factors. The price of the transportation is the lowest in scenario S2-1 and S2-2; where consolidation is done in cross-docking facilities procured separately by the Volvo group. However, scenario S2-1 is deemed to have a better performance regarding lead-time compared to S2-2. When it comes to lead-times, scenario S1-1 will have the best performance. This scenario does however lead to a high transportation price which results in a accumulated score of 1,56 in the cost category. Scenario S2-1 gets an overall score of 2,44 and is performing best in the cost category.

Table 5-7: Weight criterion score regarding cost.

Assessment parameter:		Transport price	B/L cost	Customs cost	Lead-time	∑:
	k_i :	*0,3750*	*0,0625*	*0,1875*	*0,3750*	1,0
S1-1	Performance:	0,0	1,0	0,0	4,0	6,0
	$k_i *$ Performance:	0,00	0,0625	0,0000	1,5000	**1,56**
S1-2	Performance:	0,0	1,0	0,0	3,0	4,0
	$k_i *$ Performance:	0,00	0,0625	0,0000	1,1250	**1,19**
S2-1	Performance:	2,0	3,0	2,0	3,0	12,0
	$k_i *$ Performance:	0,75	0,1875	0,3750	1,1250	**2,44**
S2-2	Performance:	2,0	3,0	2,0	2,0	10,0
	$k_i *$ Performance:	0,75	0,1875	0,3750	0,7500	**2,06**
S3-1	Performance:	1,0	3,0	2,0	3,0	10,0
	$k_i *$ Performance:	0,375	0,1875	0,3750	1,1250	**2,06**
S3-2	Performance:	1,0	3,0	2,0	2,0	8,0
	$k_i *$ Performance:	0,3750	0,1875	0,3750	0,7500	**1,69**
S4	Performance:	2,0	2,0	2,0	2,0	8,0
	$k_i *$ Performance:	0,7500	0,1250	0,3750	0,7500	**2,00**

5.3.1.1 Transport price

The transport price is the most important assessment parameter in the cost category according to the results from the questionnaire. It is important to explain the constituents of the transport price; pre-carriage (PCT), terminal handling costs, main-carriage (MCT) and on-carriage (OCT). The different scenarios will influence the price of the constituents differently.

Regarding pre-carriage, there is no possibility for the Volvo Group to get any consolidation effect in the LCL transportation network in scenario S1 and S3. Shipments from each material supplier need to be transported to a logistics service provider's cross-dock terminal and each shipment will be charged as a separate shipment. In scenario S2 on the other hand the company has a chance to consolidate the shipments during the pre-carriage if the same material supplier is supplying other Volvo entities, either through the same cross-docks or in the same city. In theory, there is also a possibility to consolidate the shipments' pre-carriage through a milk-run if the material suppliers are located close to each other. However, today there is no consolidation between the material suppliers located close to each other; this is hindered by the way the shipments are booked in Atlas. The system can book a dynamic milk-run but then Volvo has to pay for a full truck load.

The terminal handling costs between these three scenarios might differ to some extent. In scenario S1 and S2, the terminal handling costs is more or less equal to scenario S2 if the logistic service provider responsible for the shipment uses their own container freight station. In situations where the logistics service provider needs to use the terminal of another company, there will be additional terminal handling costs. The logic is the same in situations where logistics service providers need to consolidate Volvo's shipments through local LCL logistics service providers. The reason for why the local LCL logistics service providers are not used directly by Volvo is because they cannot offer door-to-door solutions. The terminal handling costs in scenario S2 should also be lower since the cross-docks are used for full-container load shipments as well, hence some benefits can be gained from economies of scale.

In the main-carriage and on-carriage, there will be consolidation possibilities in scenario S2 and S3. In scenario S1 each shipment will be charged separately by the forwarders, resulting in a higher transportation price compared to scenario S2 and scenario S3. In a buyer's consolidation setup the shipments will be consolidated and charged as one shipment for the main-carriage and the shipments could also be consolidated for the on-carriage in the case that they have the same destination. This is also the case if the consolidation is done in a cross-dock facility controlled by the Volvo Group.

The major drawback of scenario S1 when it comes to the transport prices is the minimum charges that exists today. The transport contracts between Volvo Group and the logistics service providers are divided into different components; OCT, MCT, PCT etc., all with a minimum charge. These results in that the logistics service providers add minimum on minimum for each transportation contract component, resulting in a transportation price that is unreasonably high. Scenario S2 and S3, mitigates the risk of this happening by consolidating the shipments after pre-carriage, this results in that the minimum charges for small shipments can be avoided. In scenario S2, there is a chance of mitigating the risk of high transport prices due to minimum charges because of the consolidation effect during the pre-carriage. A way to solve the problem of minimum charge is to have a real door-to-door contract with the logistics service providers. In this contract, a specific price for the door-to-door service of a country pair will be negotiated between the Volvo Group and the logistics service providers instead of adding together the minimum charges of different components.

Reducing the number of logistics service providers will influence the transport price, since all of the logistics service providers have their own specific geographical area of expertise. With multiple logistics service providers it is possible to receive the lowest transport price for each country pair. If a logistics service provider reduction is done, it might not be possible to get the lowest prices world-wide since the logistics service provider might need to outsource the transports in their geographical area of weakness to other providers, hence creating a situation of margin on margin. This will influence the transport prices in scenario S1 mostly since it is completely door-to-door solutions while door-to-door solutions will only be used for minor flows in scenario S2 and S3.

The conclusion of the above-mentioned reasoning, which was confirmed in the two workshops conducted in the company, is that the transport price will be the highest in scenario S1-1 and scenario S1-2. This is because that no consolidation benefits regarding price can be gained in the different transport legs by Volvo. A logistics service provider reduction will further influence the transport price negatively since it will create a situation of margin on margin. Buyer's consolidation setups (scenario S3-1 and S3-2) might result in consolidation effects in the MCT and OCT legs which results in a lower transport price. However, the sea transportation constituent a small part of the total transport price and that is why the benefits will be limited. Apart from the benefits that can be gained from scenario S3, scenario S2 will provide further benefits in the PCT leg and this scenario will result in the lowest transport price. The scores of the different scenarios can be seen in the table below, table 5-8.

Table 5-8: Weight criterion score regarding transport prices.

	S1—1	S1—2	S2—1	S2—2	S3—1	S3—2
Performance:	0	0	2	2	1	1

5.3.1.2 B/L cost

The costs of B/L can be influenced to a great extend if the shipments can be consolidated, but this cannot be done in all countries. Creating one B/L can cost between 500 and 1000 SEK, in a situation where the company has 10 shipments from different material suppliers going to the same destination, consolidating the B/L and creating one for all of the shipments will result in big savings for the company. The requirements on B/L differs from country to country, a consolidation effect cannot be achieved in our biggest country pair China - Thailand. The reason is that a house waybill is needed for each shipment, even if they are in the same container. In some other markets Volvo Group Logistics Services buys the products in the consolidation centers and sells them in the destination market in order to enable the consolidation of B/L. There is a need of identifying in which markets a B/L consolidation is allowed. Since 40 percent of all LCL shipments originated from China, the consolidation effect can only be received from the remaining 60 percent, probably even less since more countries have the same regulation.

In scenario S1, where more shipments will be transported by air, cost reduction from airway bill will be more significant compared to scenario S2 and S3. However, in scenario S1, there is no opportunity to influence the B/L cost through consolidation, a B/L document is needed for each shipment not transported by air. In scenario S2 and S3 it is possible to get some consolidation effect regarding B/L costs in the countries where this is allowed. Reducing the number of logistics service providers will not influence the B/L cost. The performances of the different scenarios are visualized in table 5-9.

Table 5-9: Weight criterion score regarding B/L costs.

	S1—1	S1—2	S2—1	S2—2	S3—1	S3—2
Performance:	1	1	3	3	3	3

5.3.1.3 Custom cost

The influences of different scenarios on customs costs are similar to the B/L costs explained above. Customs are related to the material invoices, if the material invoices can be consolidated then the customs declaration can be consolidated as well, which influences the costs of the customs clearance. In scenario S1 export and import customs clearance costs needs to be paid by shipment and no consolidation effect can be gained. In scenario S2 and S3, it is possible to get some consolidation effects in export and import customs clearance costs in some markets if the shipments are going to the same entity in the receiving country. The introduction of air transportation and a logistics service provider reduction will not influence customs cost. The performances of the different scenarios are presented in table 5-10.

Table 5-10: Weight criterion score regarding customs cost.

	S1−1	S1−2	S2−1	S2−2	S3−1	S3−2
Performance:	0	0	2	2	2	2

5.3.1.4 Lead-time

In general, the lead time in scenario S1 should be shorter compared to the other two scenarios. This depends on a few parameters; firstly the logistics service providers should be able to have more frequent departures per week than the Volvo Group on its own, unless referred to specific country lanes where the company has massive volumes by themselves. Another parameter that influence the lead-time is that the LCL logistics service provider might have cross-docks facilities closer to the material supplier compared to the Volvo Group, e.g. if there is a shipment from Barcelona, Spain to Shanghai, China then Volvo needs to transport the goods from the supplier to the cross-dock in Gent, Belgium but the logistics service provider might have a cross-dock in Barcelona, this means that they can offer a shorter lead-time.

The lead-time in scenario S3 will in general be longer than S1 since the cut-off dates needs to be aligned, resulting in additional waiting time for some shipments at the consolidation centers. The forwarders estimate the lead-times to be a few days longer in a buyer’s consolidation setup compared to a door-to-door setup. There is another situation in scenario S1 and S3 that might influence the lead-times negatively; if the logistics service provider cannot consolidate a full container they might use a transit port. This means that, an extra deconsolidation and consolidation needs to be performed, e.g. if the service provider have a shipment from Shanghai to Chennai, then they might bring the container to Singapore in order to deconsolidate the shipments and reconsolidate them with other shipments going to Chennai. The results of this will be longer lead-times. The same setup is used for the logistics service providers’ pre-carriage solutions; they use different cross-docks in order to utilize the containers as much as possible.

In scenario S2, where the cross-docks are purchased by the Volvo Group separately there is two consolidation steps each with a cut-off time. There is first a consolidation at the Volvo Group purchased cross-dock, in order for the consolidation to be done the goods needs to arrive at the facility before a specific cut-off time. The consolidated shipments are then transported to the cross-dock facility of a logistics service provider, to be consolidated with the shipments of other customers. The service provider does also require the goods to arrive at the facility a few days ahead of the vessel departure date, creating another cut-off time. In scenario S1 and S3, the first cut-off time does not exist. Based on experience within the company, the lead-times are approximately five days longer through Volvo Group's network compared to a door-to-door solution.

The reduction of logistics service providers will influence lead-times negatively, this is due to the fact that a single provider will not perform equally well in every geographical area. Creating situations where mot transit ports and transit cross-docks needs to be used in order to achieve high container utilization. The introduction of air transportation will influence this parameter to a great extent, since air transportation is much faster than sea transportation. The biggest lead-time reduction will be in scenario S1 since more shipments will be transported by air while air transportation will only be considered for the minor flows in scenario S2 and S3. The performances of the different scenarios are visualized in table 5-11.

Table 5-11: Weight criterion score regarding lead-time.

	S1—1	S1—2	S2—1	S2—2	S3—1	S3—2
Performance:	4	3	3	2	3	2

5.3.2 Management analysis

The least amount of management is needed in scenario S1-2; where the transports are procured door-to-door from a reduced number of logistics service providers, see table 5-12. This scenario gets an overall score of 3,28.

Table 5-12: Weight criterion score regarding management.

	Assessment parameter:	Sourcing process	Network optimization	Invoicing complexity	EDI	Operational management	Σ:
	k_i:	*0,20*	*0,12*	*0,28*	*0,32*	*0,08*	**1,00**
S1-1	Performance:	3,00	3,00	3,00	2,00	3,00	14,00
	k_i *Performance:	0,60	0,36	0,84	0,64	0,24	**2,68**
S1-2	Performance:	4,00	4,00	4,00	2,00	3,00	17,00
	k_i *performance:	0,80	0,48	1,12	0,64	0,24	**3,28**
S2-1	Performance	1,00	1,00	1,00	2,00	2,00	7,00
	k_i *performance:	0,20	0,12	0,28	0,64	0,16	**1,40**
S2-2	Performance	2,00	2,00	2,00	2,00	2,00	10,00
	k_i *performance:	0,40	0,24	0,56	0,64	0,16	**2,00**
S3-1	Performance	2,00	3,00	2,00	2,00	3,00	12,00
	k_i *performance:	0,40	0,36	0,56	0,64	0,24	**2,20**
S3-2	Performance	3,00	3,00	3,00	2,00	3,00	14,00
	k_i *performance:	0,60	0,36	0,84	0,64	0,24	**2,68**
S4	Performance	2,00	2,00	2,00	2,00	2,00	10,00
	k_i *performance:	0,40	0,24	0,56	0,64	0,16	**2,00**

One interesting fact is that EDI connections was the most important parameter in this category, since it is very costly and complex today. With the introduction of Transporeon, this will be a prerequisite for the logistics service providers to be a potential business partner; therefore all of the scenarios did receive the same grade. Scenario S2-1 which performs the best in the cost category does also require the most amount of management. Whereas S1-2 with the least amount of management required lead to the highest transportation cost.

5.3.2.1 Sourcing process

When it comes to sourcing process cost, scenario S1 is the least complex one. The request for quotation (RFQ) process is shorter for the first scenario. The evaluation process that comes after the RFQ is easier for the door-to-door solution if the pricing structure is easy. The sourcing process complexity is increased in S3, since volumes, pick-up dates and the performance of the system needs to be agreed upon. It is also harder and more complex to evaluate a network solution compared to a door-to-door solution. The sourcing process in S2 is the most complex one; the reasoning behind this is that the cross-docks are sourced separately from the PCT and OCT.

Reducing the number of logistics service providers will probably mean a lower sourcing cost since fewer contracts need to be written and maintained. This will influence scenario S1 mostly since the reduction of service providers will only be implemented for the minor flows in scenario S2 and S3. The performances of the different scenarios are presented in table 5-13.

Table 5-13: Weight criterion score regarding sourcing process.

	S1—1	S1—2	S2—1	S2—2	S3—1	S3—2
Performance:	3	4	1	2	2	3

5.3.2.2 Network design and optimization

In scenario S1, there is no need for the Volvo Group to optimize the network and very limited internal administration is needed since the company depends fully on the logistics service providers' capabilities, networks and administration. However, the pick-up dates needs to be stipulated for all three scenarios. The pick-up dates at the material suppliers needs to be decided upon and coordinated with the logistics service providers LCL flows, since the service providers might use special vessels and routes for their LCL flows. The need of network design and network optimization in scenario S3 is almost the same as S1 with one exception. Pick-up dates between different material suppliers in the same region needs to be coordinated in order for the logistics service provider to consolidate the shipments in a cross-dock facility, this require some effort from the company regarding optimization. Scenario S2 requires the most effort regarding network design and optimization. More internal administration is needed in this scenario as well, due to the fact that the company has to rely on its own capabilities and network optimization abilities.

By reducing the number of logistics service providers, it is possible for the Volvo Group to have closer relationships with a few logistics service providers. This will also make it easier for the company to get a holistic picture of the LCL transportation network. Another benefit of the close relationships with logistics service providers is that the Volvo Group will have more opportunities to utilize the logistics service providers' resources and expertise. As a result of it, there will be a better chance for the logistics service provider to develop the network and easier for Volvo Group to avoid sub-optimization. This will influence scenario S1 mostly since the reduction of service providers will only be adopted for the minor flows in scenario S2 and S3. The introduction of air transportation will not influence this parameter. The performances of the different scenarios can be seen in table 5-14.

Table 5-14: Weight criterion score regarding network design and optimization.

	S1−1	S1−2	S2−1	S2−2	S3−1	S3−2
Performance:	3	4	1	2	3	3

5.3.2.3 Invoicing complexity

When it comes to the invoicing complexity, Scenario S1 is the least complex scenario. The invoicing complexity depends on the rate structure meaning that a simple rate structure will lead to simple invoicing. The invoicing complexity is increased in scenario S2 and S3 since the different shipments will be invoiced separately before the consolidation in the PCT and as one after the consolidation in the MCT. In case that the consolidated shipments have the same destination they will be invoiced together in the OCT as well. This creates further complexity since the Volvo Group needs to connect the transport cost to each consignee because of the fact that the transportation costs are included in the cost of sales. So in a situation when 20 shipments are consolidated, the cost needs to be split to a shipment level. In the buyer's consolidation setups existing today, the invoices from the logistics service providers have not been separated on a shipment level after consolidation, creating extra amount of work for the company.

In scenario S2, the pre-carriage will be under one transportation contract and the cross-dock and main-carriage under another transportation contract, maybe with two different logistics service providers. This will increase the invoicing complexity since more invoices need to be accumulated and handled by the company. Another problem that can make the invoicing more complex in scenario S2 is that smaller logistics service providers might be used for the pre-carriage and it has previously been hard for some of them to send the transport invoices to the Volvo Group entity in the receiving country. This problem only exists when the collect (FCA) incoterm is being used, then the transportation price is paid by the consignee, if a prepaid incoterm is being used, then the cost is taken locally and the problem none existing.

With a reduction of logistics service providers, the invoicing complexity is expected to be reduced since the chance of achieving a good invoice structure is larger when dealing with fewer service providers instead of multiple. This will influence scenario S1 mostly since the reduction of service providers will only be adopted for the minor flows in scenario S2 and S3. The introduction of air transportation might result in an increase of invoking complexity since a new transport mode will be added in the invoice structure. The performances of the different scenarios are visualized in table 5-15.

Table 5-15: Weight criterion score regarding invoicing complexity.

	S1−1	S1−2	S2−1	S2−2	S3−1	S3−2
Performance:	3	4	1	2	2	3

5.3.2.4 EDI

The influences of this parameter on scenario S1, S2 and S3 are considered the same after the Volvo Group's new system, Transporeon, is implemented in the near future. Today, it is very complex for the Volvo Group to integrate each logistics service provider into the company's current EDI systems. Hence, no EDI setups exist with the LCL providers today. This problem will not exist in the near future since it will be a prerequisite for the logistics service providers to connect to Transporeon, they will otherwise not be a potential business partner.

By reducing the number of logistics service providers, the complexity of the EDI solution will decrease since fewer logistics service providers need to be integrated with Transporeon. The LCL providers are usually providing other type of services to the Volvo Group as well, which means that they need to connect to Transporeon anyway. The influence of a logistics service provider reduction is hence deemed to be small. The introduction of air transportation will not influence this parameter. The performances of the different scenarios are presented in table 5-16.

Table 5-16: Weight criterion score regarding EDI.

	S1−1	S1−2	S2−1	S2−2	S3−1	S3−2
Performance:	2	2	2	2	2	2

5.3.2.5 Operational management

The level of operational management needed is dependent on if Atlas is used or not. All of the forwarders that have been interviewed during this project are of the opinion that it is much easier to receive the transport booking through Atlas compared to receiving the bookings via e-mail from different Volvo entities throughout the world. If the logistics service providers are integrated to Atlas, then the level of operational management needed from the traffic department, in all of the scenarios, are almost the same. However, in scenario S2, multiple logistics service providers will probably be used for the different transport legs, this will increase the complexity of setting up the transport solution in Atlas. The reason behind this is that; in a door-to-door setup less master data is needed compared to a network setup.

Scenario S1 and S3 requires almost no operational management and coordination if Atlas is being used. Without Atlas then the operational management of S1 is less complex compared to S3 and S2, since the logistic service provider will handle the entire transportation chain. In scenario S3, some alignment between the different material suppliers might be necessary, this will increase the level of operational management needed. Scenario S2 is the most complex one from an operational management point of view since Volvo Group controls the pre-carriage and cross-dock operation. Hence, coordination between different shipments is necessary.

Reducing the number of logistics service provider will not influence the level of operational management needed in the different scenarios since almost no management is needed for the door-to-door setups. However, integrating multiple logistics service providers to atlas is more complex compared to adding a few to the system. The introduction of air transportation will not influence this parameter. The performances of the different scenarios are shown in table 5-17.

Table 5-17: Weight criterion score regarding operational management.

	S1−1	S1−2	S2−1	S2−2	S3−1	S3−2
Performance:	3	3	2	2	3	3

5.3.3 Quality analysis

The most important assessment parameter in the quality category is the lead-time deviation. As seen in table 5-18, the door-to-door solutions, scenario S1 and S3, will have a more stable lead time.

Table 5-18: Weight criterion method regarding quality.

Assessment parameter:		Lead-time deviation	Environmental impact	Invoicing quality	Σ:
	k_i:	*0,56*	*0,11*	*0,33*	*1,00*
S1-1	Performance:	3,00	0,00	3,00	6,00
	$k_i * $ performance:	1,68	0,00	0,99	**2,67**
S1-2	Fulfillment	3,00	0,00	4,00	7,00
	$k_i * $ performance:	1,68	0,00	1,32	**3,00**
S2-1	Fulfillment	2,00	1,00	1,00	4,00
	$k_i * $ performance:	1,12	0,1	0,33	**1,56**
S2-2	Fulfillment	2,00	1,00	2,00	5,00
	$k_i * $ performance:	1,12	0,11	0,66	**1,89**
S3-1	Fulfillment	3,00	1,00	2,00	6,00
	$k_i * $ performance:	1,68	0,11	0,66	**2,45**
S3-2	Fulfillment	3,00	1,00	3,00	7,00
	$k_i * $ performance:	1,68	0,11	0,99	**2,78**
S4	Fulfillment	2,00	2,00	2,00	6,00
	$k_i * $ performance:	1,12	0,22	0,66	**2,00**

However, scenario S1 and S3 does have a bigger environmental impact compared to the other scenarios. It can also be seen that the introduction of air transportation influence all of the scenarios negatively from an environmental point of view. Scenario S1-2 has the overall best performance in the quality category. However, scenario S3-2 do also perform really well in this category with the one exception that the invoice quality is deemed to be higher in scenario S1-2.

5.3.3.1 Lead-time deviation

Lead-times are influenced by a few factors; even if most of them are hard for the logistics service providers to influence, e.g. extreme weather conditions and port congestions, there might be difference between the different scenarios. In scenario S1, it is easier for the logistics service provider to reroute the shipments in order to mitigate the risk of port congestions compared to scenario S2 and S3. In a buyer's consolidation setup, scenario S3, the consolidation point might be contracted in advance and fixed to some extent. Rerouting the shipments to another port after the consolidation might be problematic and not efficient. In scenario S2, the cross-docking facilities are contracted separately, making it hard for the company to re-route the shipments to other facilities and ports. However, in all of the three scenarios, the facilities are still more or less pre-determined and rerouting shipments a complex operation. The ports that the different logistics service providers use are more or less the same as well, since they are decided by the sea carriers.

If the logistics service provider cannot consolidate a full container in scenario S1 and S3, they might use a transit port. This means that, an extra deconsolidation and consolidation needs to be performed. The same setup is used for the logistics service providers' pre-carriage solutions; they use different cross-docks in order to utilize the containers as much as possible. This situation creates more possibility for mistakes in the operations as well as opportunities for the shipments to be transported via congested ports, which might lead to more lead-time fluctuations.

Reducing the number of logistics service providers might influence the lead-time deviations negatively since different service providers might use different ports and transportation solution. However, the effect of this will probably be very limited because the same ports are being used by most of the service providers. The introduction of air transportation will influence lead-time deviations positively since this transport mode is more reliable than sea transportation. The reasoning behind this is that port congestions can be avoided and the more frequent departures, daily schedules of the airlines compared to the weekly schedules of the sea carriers, mitigates the effects of a missed departure. Air transportation will influence scenario S1 mostly since it is only used in the minor flows in scenario S2 and S3. The performances of the different scenarios are visualized in table 5-19.

Table 5-19: Weight criterion score regarding lead-time deviation.

	S1—1	S1—2	S2—1	S2—2	S3—1	S3—2
Performance:	3	3	2	2	3	3

5.3.3.2 Environmental impact

The environmental impact of the different scenarios differs, scenario S1 and S2 might have some beneficial environmental effects in the PCT leg while scenario S2 and S3 might be beneficial in the OCT leg. Scenario S1 have a lower environmental impact if the LCL logistics service provider have cross-dock facilities closer to the material supplier compared to the Volvo Group, e.g. if there is a shipment from Barcelona, Spain to Shanghai, China then Volvo needs to transport the goods from the supplier to the cross-dock in Gent, Belgium but the logistics service provider might have a cross-dock in Barcelona. Scenario S2 would also result in a reduction of environmental impact if the goods could be collected through a milk-run from the different material suppliers. Scenario S2 and S3 will be beneficial in the OCT leg, if the shipments have the same destination. Fewer vehicles can be used to do the inland delivery. In a door-to-door setup there might be a number of shipments going to the same consignee by a number of different trucks, depending on when the customs clearance is done. Consolidating the shipments and sending them out by one truck is beneficial, especially since road transportation contributes to more greenhouse gas emissions compared to sea.

Reducing the number of logistics service provider will not influence this parameter to a great extent. However, it can be argued that a reduced logistics service provider base will lead to the usage of more transit ports which impacts the environmental impact negatively. The introduction of air transportation will also influence the environmental impact of the network negatively since the transport mode generates more emissions than sea and road transportation. This will influence scenario S1 mostly since this transport mode is only used in the minor flows in scenario S2 and S3. The performances of the different scenarios can be seen in table 5-20.

Table 5-20: Weight criterion score regarding environmental impact.

	S1−1	S1−2	S2−1	S2−2	S3−1	S3−2
Performance:	0	0	1	1	1	1

5.3.3.3 Invoicing quality

Invoicing quality is highly dependent on invoicing complexity; a complex invoicing process will lead to more opportunities for mistakes. The rationale used in chapter 5.4.2.3 can be applied to invoicing quality as well. Scenario S1 is deemed to be the least complex scenario regarding invoicing complexity. The invoicing complexity is increased in scenario S2 and S3 since the different shipments will be invoiced separately before the consolidation in the PCT and as one after the consolidation in the MCT. A reduction of logistics service providers will increase the chance of having invoices with a better quality since it is easier to reach a good invoice structure when dealing with a few logistics service providers. A reduction of service providers will probably lead to a closer relationship, hence increasing the chance of continuously improving the invoice quality. The performances of the different scenarios are presented in table 5-21.

Table 5-21: Weight criterion score regarding invoicing quality.

	S1−1	S1−2	S2−1	S2−2	S3−1	S3−2
Performance:	3	4	1	2	2	3

5.3.4 Service analysis

The door-to-door solutions, scenario S1-1 and S3-1 has the best score in this category. They have exactly the same overall score. This category is more related with the number of logistics service providers. Within the same group of scenarios, e.g. S1-1 and S1-2, the differences are obvious but between the scenarios, S1, S2 and S3, with the same service provider base the performances do not differ much. This can be seen in table 5-22 below.

Table 5-22: Weight criterion score regarding service.

	Assessment parameter:	Geographical coverage	Compliant handling	Fluctuation handling	Lane adjustment	Σ:
	k_i:	*0,3125*	*0,1875*	*0,4375*	*0,0625*	**1,00**
S1-1	Performance:	2,0000	3,0000	2,0000	2,0000	9,00
	k_i * performance	0,6250	0,5625	0,8750	0,1250	**2,19**
S1-2	Performance:	0,0000	4,0000	1,0000	3,0000	8,00
	k_i * performance	0,0000	0,7500	0,4375	0,1875	**1,37**
S2-1	Performance:	2,0000	2,0000	2,0000	2,0000	8,00
	k_i * performance	0,6250	0,3750	0,8750	0,1250	**2,00**
S2-2	Performance:	1,0000	2,0000	2,0000	2,0000	7,00
	k_i * performance	0,3125	0,3750	0,8750	0,1250	**1,69**
S3-1	Performance:	2,0000	3,0000	2,0000	2,0000	9,00
	k_i * performance	0,6250	0,5625	0,8750	0,1250	**2,19**
S3-2	Performance:	1,0000	3,0000	2,0000	2,0000	8,00
	k_i * performance	0,3125	0,5625	0,8750	0,1250	**1,89**
S4	Performance:	2,0000	2,0000	2,0000	2,0000	8,00
	k_i * performance	0,6250	0,3750	0,8750	0,1250	**2,00**

5.3.4.1 Geographical coverage of the logistics service provider

As previously explained, no logistics service provider has an excellent network worldwide. They do all have their geographical area of weaknesses and strengths. All of the logistics service providers interviewed during this project has explained that they have an excellent network worldwide apart from Africa. This parameter will not be influenced by the three scenarios, only the reduction of logistics service providers will have an impact on this parameter. Reducing the number of service providers means that it is harder for Volvo Group to choose the best service provider in each market. This will influence scenario S1 mostly since more door-to-door solutions will be used. The performances of the different scenarios are described in table 5-23.

Table 5-23: Weight criterion score regarding geographical coverage of service providers.

	S1−1	S1−2	S2−1	S2−2	S3−1	S3−2
Performance:	2	0	2	1	2	1

5.3.4.2 Compliant handling

The complaint handling is also a parameter that largely depends on the number of logistics provider used. A reduction of logistics service providers might lead to a closer relationship between the Volvo Group and providers, which could result in the design of a better complaint handling process. It is also easier to develop a good setup with a few service providers compared to a number of different service providers. Since the reduction of logistics service providers will only be done in the minor flows in scenario S2 and S3, the benefits of a logistics service provider reduction will be most significant in scenario S1. However, there is one difference between scenario S1 and S3 compared to scenario S2. In scenario S1 and S3, the company does only have to deal with one logistics service provider since the different transportation legs are purchased from the same providers. In scenario S2, the PCT might be purchased from one provider and the cross-dock service from another one, this will create further complexity regarding to the complaint handling processes. There might be situations where problems arises in the interface between the two logistics service providers, then the complaint will be solved by three parties. The performances of the different scenarios are visualized in table 5-24.

Table 5-24: Weight criterion score regarding complaint handling process.

	S1−1	S1−2	S2−1	S2−2	S3−1	S3−2
Performance:	3	4	2	2	3	3

5.3.4.3 Fluctuation handling

In periods where transport capacity is limited, the different scenarios will have different implications. The reason behind this is the different nature of the relationships between the Volvo Group and sea carriers compared to the relationship between LCL service providers and sea carriers. The contracts between the Volvo group and sea carriers are usually longer, often yearly contracts. The LCL service providers on the other hand, are more inclined to switch between sea carriers in order to get the cheapest prices possible, this does often result in quarterly contracts between the parties. In situations where transport capacity is limited the sea carriers prefer more loyal customers and better paying cargo. Therefore, the network will be less influenced by limited sea capacity in scenario S2 compared to scenario S1 and S3.

Having multiple logistics service providers means that it is easier to handle fluctuations since the Volvo Group will not rely on a few logistics service providers' capacity. Therefore, reducing the number of logistics service providers will make it harder to handle fluctuation. This will influence scenario S1 mostly since door-to-door solutions will only be used in the minor flows in scenario S2 and S3. The performances of the different scenarios are presented in table 5-25.

Table 5-25: Weight criterion score regarding fluctuation handling.

	S1—1	S1—2	S2—1	S2—2	S3—1	S3—2
Performance:	2	1	2	2	2	2

5.3.4.4 Lane adjustment flexibility

This parameter will not be influenced by the different scenarios. With a reduction in the number of logistics service providers, the Volvo Group will have closer relationships with a few logistics service providers. One potential benefit of this could be an "open-book" setup including a worldwide contract, in which new country pairs with few shipments, does not need a specific transportation contract. This will increase the efficiency of adding new lanes that are not used so often. The performances of the different scenarios are shown in table 5-26.

Table 5-26: Weight criterion score regarding fluctuation handling

	S1—1	S1—2	S2—1	S2—2	S3—1	S3—2
Performance	2	3	2	2	2	2

5.3.5 Communication analysis

The most important assessment parameter in this category is deviation reports. The questionnaire showed that this parameter was considered almost twice as important as tracking and tracing and almost five times as important as the costs of business-to-business communication. As can be seen in table 5-27 below, scenario S2-2 provides a better opportunity for receiving deviation reports in time instead of realizing that a shipment is delayed when the goods has arrived too late at the destination.

The B2B communication is more related with the number of logistics service providers. Therefore, the reduction of logistics service providers will reduce the amount and complexity of business-to-business communication.

Table 5-27: Weight criterion score regarding communication.

Assessment parameters:		B2B communication	Deviation reports	Tracking & tracing	Σ:
	k_i	***0,11***	***0,56***	***0,33***	**1,00**
S1-1	Performance	2,00	1,00	3,00	6,00
	$k_i *$ performance:	0,22	0,56	0,99	**1,77**
S1-2	Performance	3,00	2,00	3,00	8,00
	$k_i *$ performance:	0,33	1,12	0,99	**2,44**
S2-1	Performance	2,00	2,00	2,00	6,00
	$k_i *$ performance:	0,22	1,12	0,66	**2,00**
S2-2	Performance	3,00	3,00	2,00	8,00
	$k_i *$ performance:	0,33	1,68	0,66	**2,67**
S3-1	Performance	2,00	1,00	3,00	6,00
	$k_i *$ performance:	0,22	0,56	0,99	**1,77**
S3-2	Performance	3,00	1,00	3,00	7,00
	$k_i *$ performance:	0,33	0,56	0,99	**1,88**
S4	Performance	2,00	2,00	2,00	6,00
	$k_i *$ performance:	0,22	1,12	0,66	**2,00**

5.3.5.1 B2B Communication

The costs of maintaining a relationship with the logistics service providers will only be considered based on the LCL network, the fact that some providers are supplying other services to Volvo Group is not regarded. The relationships costs between the scenarios are not that different. In all of the scenarios, relationships with a number of different logistics service providers need to be maintained. Reducing the number of logistics service providers will decrease the amount of communication and number of relationships needed. However, it can be argued that a reduced provider base leads to a closer and more expensive relationship. Scenario S1 will be affected more than the other scenarios since the number of service providers will only be reduced in the minor flows in Scenario S2 and S3. The performances of the different scenarios are visualized in table 5-28.

Table 5-28: Weight criterion score regarding B2B communication.

	S1−1	S1−2	S2−1	S2−2	S3−1	S3−2
Performance	2	3	2	3	2	3

5.3.5.2 Deviation reports

The deviation reports received in the different scenarios varies. Based on experience, Volvo Group does not receive deviation reports in door-to-door setups during the transportation. The problems and delays are discovered when the goods has arrived too late at the destination. A factor that decides how good the logistics service providers are at providing deviation reports is the distance between their control towers and exporting offices around the world. The exporting offices need to report deviations to the control towers who in their turn report the deviation to Volvo Group. The logistics service providers' reason for having a centralized control tower is invoice centralization, this gives them the opportunity to invoice all of the shipments from one office and control them from one office. The control tower function might not be needed in the future when Transporeon is implemented. Today, the deviation reports are more reliable through Volvo Group purchased networks, scenario S2. The door-to-door solution offers very little visibility.

A logistics service provider base reduction could provide a better opportunity to reach a common process with clear guidelines of how the deviation reports should be handled. The closer relationships with the providers could also create a situation where the deviation reports could be handled more systematically and the LCL transportation network continuously improved. The performances of the different scenarios can be seen in table 5-29.

Table 5-29: Weight criterion score regarding deviation reports.

	S1−1	S1−2	S2−1	S2−2	S3−1	S3−2
Performance	1	2	2	3	1	1

5.3.5.3 Tracking & tracing

Scenario S1 should provide the best opportunity for Volvo Group to track and trace the company's shipments. This since the logistics service providers are responsible for the entire transportation chain and should have all the data regarding specific shipments. All of the logistics service providers that have been interviewed during this project say that they are capable of providing real time tracking and tracing data to Volvo Group. The experiences within the company differ from what the logistics service providers tell. As explained in the chapter above, Volvo Group has very limited information about what is happening during a door-to-door transportation. The company gets information about a delay first after the goods have arrived late to the destination. The company's employees describe the tracking and tracing process in a door-to-door setup as a "black box". The distances and disconnection between the control towers and exporting offices explained above is one reason for this. The introduction of Transporeon will improve the tracking and tracing of the shipments as well since the company will receive information about the shipments continuously.

Scenario S3 will add a further level of complexity for the tracking and tracing, to the above explained situation since a number of shipments will be consolidated to one. In scenario S2, it will be more difficult for the Volvo Group to track and trace the shipments since different logistics service providers might be responsible for different transport legs. This means that the company has to rely on information from different parties, which could increase the level of complexity for the tracking and tracing.

Reducing the number of logistics service providers will make the tracking and tracing simpler, since it is easier to develop a good tracking and tracing setup when dealing with fewer service providers. The introduction of air transportation will simplify the tracking and tracing process since the in-transit time will be shorter. The underlying reason is that; it is more difficult to track and trace a shipment while it is in-transit. The performances of the different scenarios are visualized in table 5-30.

Table 5-30: Weight criterion score regarding tracking and tracing.

	S1−1	S1−2	S2−1	S2−2	S3−1	S3−2
Performance	3	3	2	2	3	3

5.4 Summary of scenario assessment

To summarize the analysis done in the previous chapter the results are presented in the radar diagram below, figure 5-5. Each scenario has its strengths and weaknesses. Scenario S1-2 is the best performing scenario in both the management and quality category. From a cost perspective, scenario S2-1 performs better than the other scenarios. Scenario S1-1 and S3-1 will provide the best service level and the least complex communication is achieved in scenario S2-2.

In order to have a hollistic picture and understanding of the different scenarios, their weaknesses must also be highlighted. Below the performance of each scenario in all of the categories will be visualized through radar diagrams. A summary of the reasons behind the grading of the scenarios will also be provided.

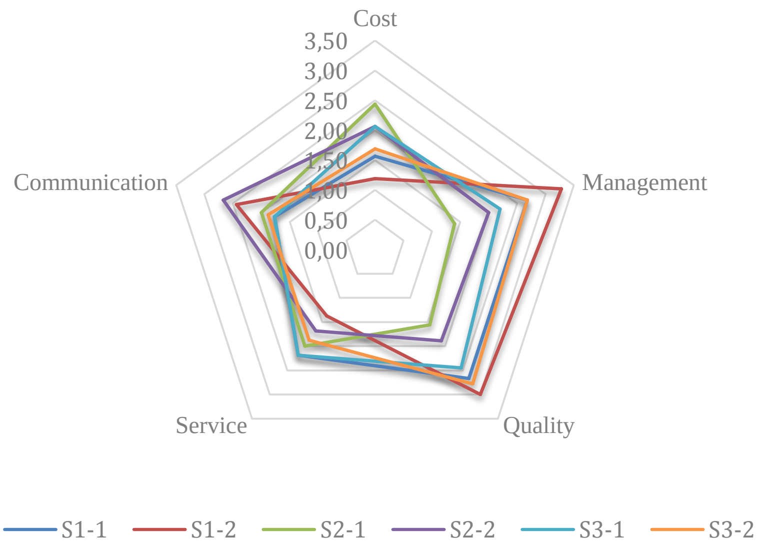


Figure 5-5: Radar diagram regarding the performance of different scenarios.

Alltough scenario S1-2 has the best performance in management and quality, its drawbacks in the cost and service category cannot be ignored, see figure 5-6. The main reason for why this scenario performs poorly in the cost category is due to the non-existing consolidation opportunities regarding shipments, B/L and customs costs. Since a reduction of logistics service providers is done in this scenario, there might be some limitation regarding the geographical coverage of the logistic service providers. The reasoning behind this is that every service provider has its geographical area of weaknes. Having door-to-door solutions means that the Volvo group will use the forwarders transportation network during the entire transportation. It is however concluded that the longer relationships that the Volvo Group have with the sea carriers will be benefitial in times where capacity is limited. Sea carriers tend to prirotize loyal customers and better paying cargo. Therefore, it is more difficult to handle fluctuations in a door-to-door setup compared to scenario S2.

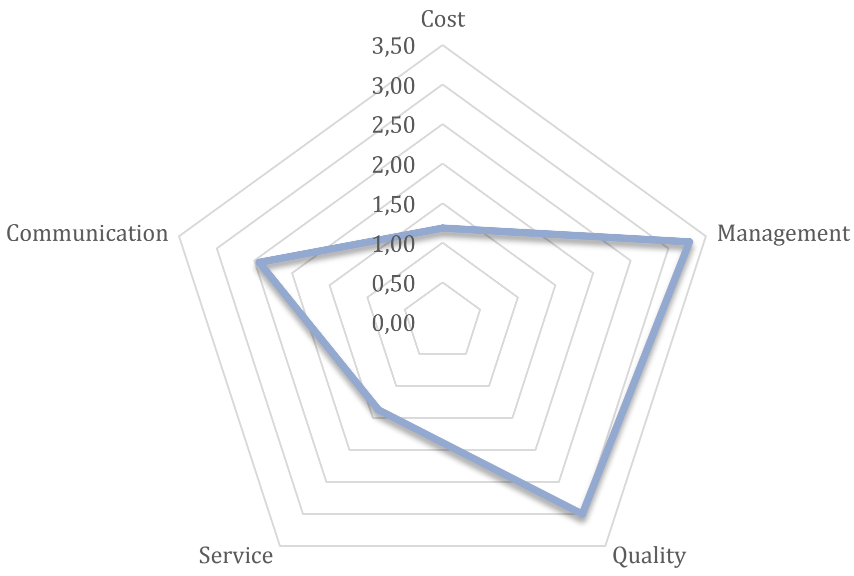


Figure 5-6: Radar diagram regarding the performance of scenario S1-2.

Scenario S2-1, figure 5-7, has the best overall performance in the cost category. The reason behind this is that the lowest price can be chosen for each transport leg, this scenario, together with S2-2, are the only scenarios that provide a possibility to gain benefits from pre-carriage consolidation. The drawbacks of this scenario are in the management and quality categories in which this scenario performs worst among the scenarios. The fact that the different transport legs as well as the cross-docks are purchased separately results in a more complex sourcing process. The invoicing complexity is also increased since different logistics service providers can be responsible for different legs. This scenario requires more internal administration as well, due to the fact that the company has to rely on its own capabilities and network optimization abilities.

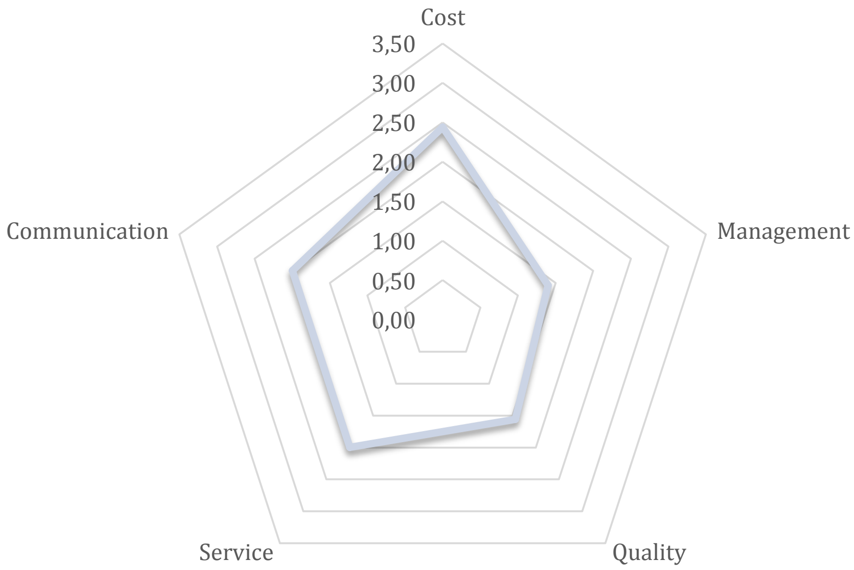


Figure 5-7: Radar diagram regarding the performance of scenario S2-1.

The cross-docking facilities are more or less pre-determined and rerouting shipments a complex operation in all of the scenarios. However, the separately contracted cross-docking facilities in scenario S2-1 makes it harder for the Volvo Group to re-route shipments to other facilities and ports in order to mitigate the risk of port congestion. This increases the chances of lead-time deviation. The high invoicing complexity does also lead to a decreased invoicing quality.

The difference between scenario S2-1 and S2-2 is the reduced number of logistics service providers in the latter one. This reduction results in an increased transportation cost and a lower service level, figure 5-8. However, there is benefits regarded to the management, quality and communication related to the LCL transportation network. This scenario is deemed to be the best solution in the communication category, since the deviation reports can be handled in a better way. Today, the deviation reports are more reliable through Volvo Group purchased networks, scenario S2-1 and S2-2 compared to door-to-door solutions that offers very little visibility. A logistics service provider base reduction will further provide a better opportunity to reach a common process with clear guidelines of how the deviation reports should be handled with the providers. The closer relationships with the providers could also create a situation where the deviation reports could be handled more systematically and the LCL transportation network continuously optimized.

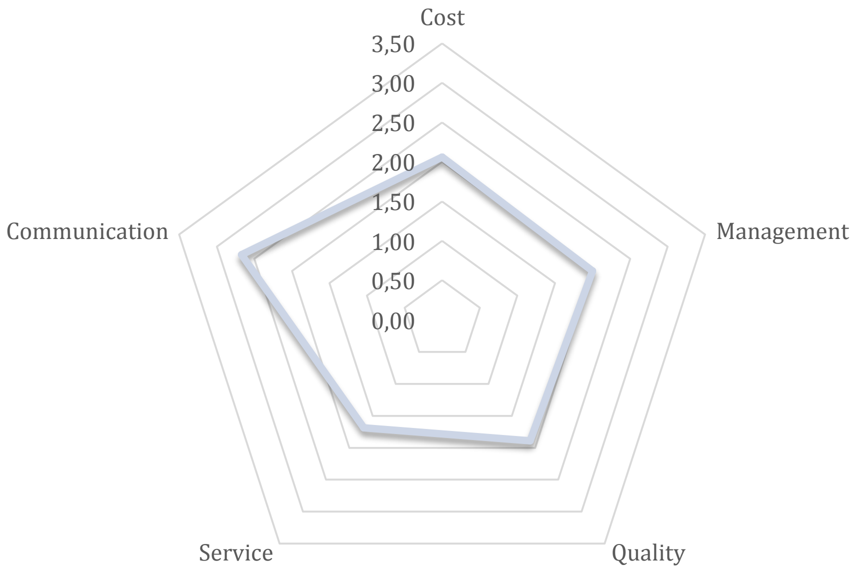


Figure 5-8: Radar diagram regarding the performance of scenario S2-2.

The most satisfying service level can be found in both scenario S1-1 and S3-1, see figure 5-9. It is interesting to note that these two scenarios also have similar performance in the communication and quality catergory. The underlying reason behind this is that a door-to-door setup is used in both of them, with the major difference being that buyer's consolidation is implemented in scenario S3-1. Therefore, scenario S3-1 performs better than scenario S1-1 from a cost perspecitve due to the consolidation possibilities in the main-carriage and on-carriage, these opportunities do not exist in scenario S1-1. Both of these scenarios have their weakness in the communication category, mainly due to the complexity of deviation reports in a door-to-door setup. Deviation reports are considered to be the most important assessment parameter in this category.

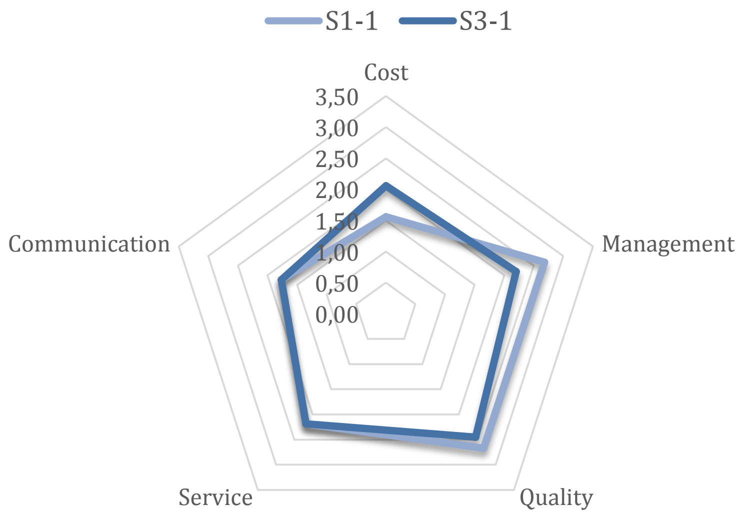


Figure 5-9: Radar diagram regarding the performance of scenario S1-1 and S3-1.

6 CONCLUSION

The purpose of this thesis was to map out the current less-than-container load (LCL) flow of Volvo Group and to investigate the effects that consolidation of the LCL shipments would have on the company's transportation network. In order to map out the company's current LCL transportation network, data was collected from the different LCL logistics service providers that had been used by the Volvo Group during 2015. Data regarding consignee, consignor, country and city of origin, destination country and city, weight of the shipment, volume of the shipment and price of the shipment were requested from the forwarders on a shipment level. Volvo Group's LCL transports are handled by 12 forwarders, each responsible for certain geographical areas and certain business processes. The geographical spread of the LCL shipment varied from region to region. Asia-Pacific (APAC) was the region with the largest portion of the LCL shipments during 2015 based on the number of shipments. 62 percent of the consignments were shipped intra-APAC during 2015, and the shipments from all of the three regions (APAC, EMEA and Americas) to APAC accounted for 75% of the total number of consignments globally. During the year, the Volvo Group had LCL shipments originating from 34 different countries.

Base on a total cost of ownership model, multiple criteria were considered in order to evaluate potential scenarios developed during the project. Five categories representing different costs related to a purchase were chosen in order to evaluate the scenarios from different perspectives. The chosen categories are cost, management, quality, service and communication. Within each category a number of assessment parameters that would have an impact on the total cost of that specific category were identified. The most important and relevant factors in each category were then identified together with internal stakeholders. In order to use the parameters to assess the scenarios, there was a need for determining their importance levels; this was done through a questionnaire. The results of the questionnaire were used in order to define which of the assessment parameters that the Volvo Group considered most important in the five categories.

In order to identify consolidation opportunities for the Volvo Group's LCL transportation network, seven potential LCL transportation scenarios were constructed by the researchers. Five of them included consolidation, both buyers' consolidation and standard consolidation and the other two scenarios were designed in order to identify the effects of consolidation. Two perspectives were considered when constructing the scenarios; the network design and the number of logistics service providers. The result of this was that there are three pairs of scenarios, S1, S2 and S3 with the only difference being the number of logistics service providers. Each scenario was then assessed based on the aforementioned parameters. The input from the two workshops conducted during this project together with findings in the literature and insights from empirical findings was the basis of the analysis. Each scenario has its strengths and weaknesses. Having a door-to-door setup with a reduced number of logistics service providers will decrease the level of management needed and improve the quality of the LCL transportation network. A transport solution where Volvo Group procures the LCL transports in different transport legs will lead to the lowest transport cost. If the company's aim is to get the best service level then a door-to-door solution with multiple logistics service providers will be the most feasible setup. In order to make the business-to-business communication more efficient as well as gaining a better tracking and tracing solution the Volvo Group should manage minor and major flows differently. The transports in the major lanes should be procured in different transport legs and the transports in the minor lanes should be purchased door-to-door from a limited number of logistics service providers.

7 DISCUSSION

As explained previously in this paper, all of the scenarios have their strengths and weaknesses. It is probably not feasible to use the same scenario for all of the LCL shipments although in some of the scenarios, different lanes are treated differently. Therefore, an interesting solution would be to combine different scenarios appropriately in order to benefit from their strengths and mitigate the effect of their weaknesses.

A combination that might be successful is to use a door-to-door setup purchased from a reduced number of service providers between countries where the number and volume of the LCL shipments are limited. This will lead to a higher transportation price but require a lower amount of management and communication as well as an increase in the quality of the network. Due to the limited spend in these flows, it is more valuable for the Volvo Group to gain benefits in the other categories even if it leads to a higher transportation price. In the flows where the Volvo Group has the highest volumes, a transport solution purchased in different legs might be the most beneficial setup. The rationale behind this is that the biggest possibilities for cost savings are in these flows. The more management needed might be less significant than the savings gained from the lower transportation prices. Between countries with medium amount of shipment volumes the Volvo Group should try to set up buyer's consolidation setups in order to gain consolidation benefits. This will also increase the amount of management needed but the savings from shipment, B/L and customs consolidation will be significant. Consolidating B/L documents and customs clearance costs are not allowed in certain markets, the benefits of shipment consolidation alone might not offset the extra level of management.

The next step that needs to be taken in order to improve the LCL transportation network is to identify which flows that are considered major and minor. An economical analyze in order to identify the breakpoint where door-to-door is a more feasible solution compared to consolidation in a Volvo Group purchased cross-dock between specific country pairs should be done.

REFERENCES

AB Volvo., 2016. 2015 Annual Report.

Anand, N. & Grover, N. (2015) Measuring retail supply chain performance: Theoretical model using key performance indicators (KPIs). *Benchmarking*, vol. 22, no.1, pp.135-166.

Agustina, D., Lee, C. & Piplani, R. (2014) Vehicle scheduling and routing at a cross docking center for food supply chains. *International Journal of Production Economics*, vol. 152, pp. 29-41.

Apte, U.M., & Viswanathan, S. (2000) Effective Cross Docking for Improving Distribution Efficiencies. *International Journal of Logistics Research and Applications: A Leading Journal of Supply Chain Management*, vol. 3, no. 3, pp. 291-302.

Anderson, J.D. (2006). Qualitative and Quantitative research. http://web20kmg.pbworks.com/w/file/fetch/82037432/QualitativeandQuantitativeEvaluationResearch.pdf (2016-04-28)

Bryman, A. & Bell, E. (2015) Business research methods (4th ed.). Oxford Univ. Press, Oxford.

Bartholdi, J. & Gue, K. (2004) The Best Shape for a Crossdock. *Transportation Science*, vol. 38, no. 2, pp. 235-244.

Bryman, A. (2002) Samhällsvetenskapliga metoder. Malmö: Liber AB.
Bask, A.H. & Vepsäläinen, P.J. (1998) Opening Markets for Logistics. I *Proceedings of the 10th NOFOMA Conference*, Helsinki, 9-10 June, pp. 404-417.

Berglund, M., van Laarhoven, P., Sharman, G., & Wandel, S. (1999) Third-party logistics: Is there a future?, *The International Journal of Logistics Management*, vol. 10, no. 1, pp. 59-70.

Chopra, S., & Meindl, P. (2010) Supply chain management: Strategy, planning, and operation (4th ed.). Upper Saddle River, New Jersey: Pearson Education, Inc.

Cecchini, P., Catinat, M. & Jacquemin, A. (1988) The European Challenge: 1992. Aldershot, Hants: Wildwood House.

Christopher, M. (2005) Logistics and supply chain management: creating value-added networks. Pearson education.

Cook, R.L., Gibson, B. & MacCurdy, D. (2005) A Lean Approach to Cross Docking. *Supply Chain Management Review*, vol. 9, no. 2, pp. 54.

Creswell, John W. & Clark, Plano. (2011) Designing and Conducting Mixed Methods Research (2nd ed.). Great Britain: Sage Publications.

Davidsson, B., & Patel, R. (2003) Forskningsmetodikens grunder. Lund: Studentlitteratur

Ellram, L.M. (1995) Total cost of ownership: an analysis approach for purchasing, *International Journal of Physical Distribution & Logistics Management*, vol. 25, no. 8, pp. 4-23.

Ghauri, P.N. & Grønhaug, K. (2010) Research methods in business studies (4th ed.). Pearson Education, Harlow.

Gillham, B. (2000) Case Study Research Methods. London: Continuum.

Grant, D.B., Trautrims, A., & Wong, C.Y. (2015) Sustainable logistics and supply chain management. London: Kogan Page.

Graham, W., Hall, C. & Vera Morales, M. (2014) The potential of future aircraft technology for noise and pollutant emissions reduction. *Transport Policy*, vol. 34, pp. 36-51.

Hillson, D. (2004) Effective Opportunity Management for Projects. New York: Marcel Dekker.

Hosseini, D.S., Shirazi, M.A., & Karimi, B. (2014) Cross-docking and milk run logistics in a consolidation network: A hybrid of harmony search and simulated annealing approach. *Journal of Manufacturing Systems*. vol. 33, no. 4, pp. 567-577.

Hoppin, D. (2006) How much does port congestion cost? Bottlenecks add costs that can scuttle any company's sourcing strategy, *Logistics Today*, vol. 47, no. 9, pp. 10.

Hong, X. & Liu, J. (2013) The energy-saving LCL model construction and calculation of foreign trade container shipping, *Energy Education Science and Technology Part A: Energy Science and Research*, vol. 31, no. 2, pp. 1013-1018.

Håkansson H. & Wootz B. (1984) Låga priser eller låga kostnader? *Swedish Purchasing Magazine*, No. 2.

Hall, R.W. (1987) Consolidation Strategy: Inventory, Vehicles And Terminals. *Journal of Business Logistics*, vol. 8, no. 2, pp. 57.

Jonsson, P. & Mattsson, S-A. (2005) Logistik: Läran om effektiva materialflöden (2nd ed.). Studentlitteratur, Lund.

Juran, J.M. (1974) Quality control handbook (3th ed.). McGraw-Hill, New York.

Kinnear E. (1997) Is there any magic in cross-docking?, *Supply Chain Management: An International Journal*, vol. 2, no. 2, pp. 49–52.

Kothari, C.R, (2004) Research methodology: methods & techniques (2nd ed.). New Age International (P) Ltd., Publishers, New Delhi.

Kirytopoulos K., Leopoulos V., Mavrotas G. & Voulgaridou D. (2010) Multiple sourcing strategies and order allocation: an ANP-AUGMECON meta-model. *Supply Chain Management: An International Journal*, vol. 15, no. 4, pp. 263–276.

Lumsden, K. (2007) Fundamentals of logistics. Compendium containing the chapters, 1-2.

Lipovetsky, S. (2009) Pareto 80/20 law: derivation via random partitioning. *International Journal of Mathematical Education in Science and Technology*, vol. 40, no. 2, pp. 271-277.

Lindquist, S. & Yhlen, Y. (2011) Sourcing of development components, Chalmers University of Technology, Göteborg.

Lewis, D. B. (1994) Freight mode choice: air transport versus ocean transport in the 1990's. Cambridge, MA: Massachusetts Institute of Technology, Flight Transportation Laboratory.

Lindau, R.A., Woxenius, J. & Lumsden K.R. (1993) Constraints experienced in a direct distribution system when safety mechanisms are removed. Department of transportation and logistics, Chalmers University of Technology, Göteborg.

Liang, Z., Chaovalitwongse, A.W. & Shi, L. (2015) Supply Chain Management and Logistics: Innovative Strategies and Practical Solutions. Boca Raton: CRC Press.

Livermore, J. & Euarjai, K. (1997) Electronic bills of lading: a progress report, *International Journal of Machine Learning and Cybernetics*, vol. 28, pp. 55.

Masters, J.M. (1980) The effects of freight consolidation on customer service. *Journal of Business Logistics*, vol. 2, no. 1, pp. 55-74.

McKinnon, A, Browne, M & Whiteing, A. (2012) Green Logistics: Improving the environmental sustainability of logistics (2nd edn.). Kogan Page, London.

McKinnon, A.C. (2010) Product-level carbon auditing of supply chains: Environmental imperative or wasteful distraction?, *International Journal of Physical Distribution & Logistics Management*, vol. 40, pp. 42-60.

McKinnon, A. (2012) The possible contribution of the shipper to the decarbonization of deep-sea container supply chains. I Proceedings of the 16th Annual Logistics Research Network (LRN) Conference, September, Cranfield University: Cranfield, UK.

Martin, C. (2005) Logistics and supply chain management: creating value-added networks. Edinburgh: Pearson Education.

Moynihan, M., Guilbert, J.J., Walker, B. & Walker, A. (2004) How to Run a Workshop. Networklearning.http://www.networklearning.org/index.php/library/how-to-run-a-workshop/82-how-to-run-a-workshop-pdf/file (2016-04-29)

Notteboom, T. (2011) Current issues in shipping, ports and logistics. University Press Antwerp, Brussels, Belgium. (Report)

Neely, A., Gregory, M. & Platts, K. (1995) Performance measurement system design: A literature review and research agenda. *International Journal of Operations & Production Management*, vol. 15, no. 4, pp. 80-116.

OECD. (2010) International maritime shipping - Environmental impacts of increased activity levels. *Globalisation, transport and the environment*, pp. 161-184.

Obstfeld, M. & Rogoff, K. (2000) The Six Major Puzzles in International Macroeconomics: Is There a Common Cause?, *NBER Macroeconomics Annual,* vol. 15, no. 1, pp. 339-390. CHANGE YEAR IN THE REPORT

Ryen A. (2004) Kvalitativ intervju- från vetenskapsteori till fältstudier: Malmö: Liber AB.

Rajamanickam, G.D. & Ramadurai, G. (2015) Simulation of truck congestion in Chennai port. Institute of Electrical and Electronics Engineers, pp.1904.

Reh, F.J. (2005) Pareto's Principle-The 80-20 Rule. *Business Credit*. vol. 107, no. 7.

Ramberg, J. (2011) ICC guide to incoterms 2010. Paris: ICC Publishing S.A.

Rodrigue, J., Comtois, C. & Slack, B. (2006) The geography of transport systems. London: Routledge.

Stadtler, H., Kilger, C., & Meyr, H. (2015) Supply Chain Management and Advanced Planning. Berlin, Heidelberg: Springer Berlin Heidelberg.

Shapiro, R.D. and Heskett, J.L. (1985) Logistics Strategy: Cases and Concepts. West Publishing Co., St Paul, MN.

Skjøtt-Larsen, T., Kotzab, H., Schary, P.B. & Mikkola, J.H. (2007) Managing the global supply chain (3rd ed.). Copenhagen Business School Press, Copenhagen.

Saunders, M., Lewis, P., & Thornhill, A. (2003) Research method for business students (3rd ed.). New York: Prentice Hall.

Seymour D. (1992) Marketing Research. Chicago: Probus Publishing Company.

Schmitz, T. (2011) The bill of lading as a document of title. *Journal of International Trade Law and Policy*, vol. 10, no. 3, pp. 255 - 280.

Schmitthoff, C. (2007) Schmitthoff's Export Trade: The Law and Practice of International Trade (11th ed.). Thomson/Sweet & Maxwell, London.

Truel, C. & Ebrary. (2012) A short guide to customs risk. Gower, Burlington, VT.

Ulku, M.A. (2009) Analysis of shipment consolidation in the logistics supply chain, ProQuest Dissertations Publishing.

Volvo Group. (2016) Volvo Group Global. http://www.volvogroup.com/GROUP/GLOBAL/ENGB/VOLVO%20GROUP/Pages/aboutus.aspx. (2016-04-27).

Verwaal, E. & Donkers, B. (2003) Customs-Related Transaction Costs, Firm Size and International Trade Intensity. *Small Business Economics*, vol. 21, no. 3, pp. 257-271.

Van Belle, J., Valckenaers, P., & Cattrysse, D. (2012) Cross-docking: State of the art. *Omega*, vol. 40, no. 6, pp. 827-846.

Woxenius, J. (1998) Development of small-scale Intermodal freight transportation in a systems context, Department of transportation and logistics, Chalmers University of Technology, Göteborg.

Xiao, Hong. (2011) Model and calculation for foreign trade container shipping mode. I *In Computer Science and Service System (CSSS), 2011 International Conference on*. 27-29 June 2011, Nanjing, pp. 2331 - 2334.

Zhang, H. & Okoroafo, S.C. (2015) Third-Party Logistics (3PL) and Supply Chain Performance in the Chinese Market: A Conceptual Framework. *Engineering Management Research*, vol. 4, no. 1, pp. 38.

APPENDIX A:

This section contains information and reasoning for all of the assumptions taken in order to obtain complete data from the forwarders.

Exchange rates:

Due to the fact that different currencies are used in the data collected from different forwarder, e.g. Swedish Krona, US Dollar, Japanese Yen and Indian Rupee, there was a need to convert all of the data to the same currency, Swedish Krona were chosen. The monthly average exchange rates for the different currencies against Swedish Krona were calculated in order to offset the rate fluctuation during the year. The exchange rates below are the ones that were used by the researcher:

1 USD = 8.4 SEK
1 JAY = 0.07 SEK
1 INR = 0.13 SEK

X-rates.com. (2016). *Exchange Rate Average (US Dollar, Swedish Krona) - X-Rates*. [online] Available at: http://www.x-rates.com/average/?from=USD&to=SEK&amount=1&year=2015 [Accessed 5 Apr. 2016].

Missing data from the forwarders:

JPYusen: Only able to collect the price of the transport for the last 6 months. This meant that an average cost per m^3 was calculated for the lanes with data available in order to calculate the price for the period with no data regarding prices:

Japan, Yokohama to Taiwan, Keelung

$$\frac{39\ 843\ USD}{6{,}355\ m^3} = 6269\ \frac{USD}{m^3}$$

$$\frac{39\ 843\ USD}{6{,}38\ m^3} = 6126\ \frac{USD}{m^3}$$

$$\frac{27\ 202\ USD}{4{,}316\ m^3} = 6302\ \frac{USD}{m^3}$$

Average:

$$\frac{6269 + 6126 + 6302}{3} = 6233\ \frac{USD}{m^3}$$

Japan, Yokohama to China, Shanghai

$$\frac{12\ 267\ USD}{1{,}804\ m^3} = 6800\ \frac{USD}{m^3}$$

$$\frac{12\ 111\ USD}{1{,}781\ m^3} = 6800\ \frac{USD}{m^3}$$

$$\frac{22\ 923\ USD}{3{,}371\ m^3} = 6800\ \frac{USD}{m^3}$$

$$\frac{13\ 272\ USD}{1{,}665\ m^3} = 7971\ \frac{USD}{m^3}$$

$$\frac{8\ 743\ USD}{1{,}082\ m^3} = 8080\ \frac{USD}{m^3}$$

Average:

$$\frac{6800 + 6800 + 6800 + 7971 + 8080}{5} = 7290\ \frac{USD}{m^3}$$

Japan, Yokohama to Hong Kong

$$\frac{35\ 210\ USD}{5{,}535\ m^3} = 6361\ \frac{USD}{m^3}$$

DBSchenker: The researchers were only able to get the volume of the DBSchenker shipment and not the weight of them. An average density of the 8682 shipments performed by the other forwarders was calculated in order to identify the average density of the LCL shipments.

$$\frac{15\ 126\ 415}{430\ 676} = 351{,}2\ \frac{kg}{m^3}$$

The average density, calculated above, was used to calculate the weight of the shipments performed by DBSchenker.

DHL Global Forwarding: Data was only provided for the January 2015 to October 2015 for the shipments between North America and South America. This meant that assumptions regarding number of shipments, weights, volumes, pay-weights and prices were made for November 2015 and December 2015. The researchers calculated the average number of shipments, weights, volumes, pay-weight and price per month during the period of December 2014 and October 2015, which was further used to calculate the needed information on a shipment level. How the calculations were done for each country can be seen below:

Argentina:

Number of shipment per month:

$$\frac{85\ shipments}{11\ months} = 7{,}7\ \approx 8$$

Average weight (kg) of shipments per month:

$$\frac{54\ 977}{11} = 4998$$

Average volume (m3) of shipments per month:

$$\frac{222{,}5}{11} = 20{,}2$$

Average pay-weight (kg-m3) of shipments per month:

$$\frac{222\ 508}{11} = 20\ 228$$

Average spends (SEK) for shipments per month:

$$\frac{442\ 431}{11} = 40221$$

Brazil:

Number of shipment per month:

$$\frac{7\ \text{shipments}}{11\ \text{months}} = 0{,}63$$

This results in 1 shipment totally for November and December.

Average weight (kg) of shipments per month:

$$\frac{3148}{11} = 286{,}2$$

Average volume (m3) of shipments per month:

$$\frac{11{,}64}{11} = 1{,}05$$

Average pay-weight (kg-m3) of shipments per month:

$$\frac{11\ 643}{11} = 1058$$

Average spends (SEK) for shipments per month:

Prices to Brazil are missing.

Colombia:

Number of shipment per month:

$$\frac{153\ \text{shipments}}{11\ \text{months}} = 13{,}9\ \approx 14$$

Average weight (kg) of shipments per month:

$$\frac{65\ 904}{11} = 5991$$

Average volume (m3) of shipments per month:

$$\frac{257{,}1}{11} = 23{,}4$$

Average pay-weight (kg-m3) of shipments per month:

$$\frac{257\ 107}{11} = 23\ 373$$

Average spends (SEK) for shipments per month:

$$\frac{922\ 056}{11} = 83\ 823$$

Ecuador:

Number of shipment per month:

$$\frac{46 \text{ shipments}}{11 \text{ months}} = 4{,}18 \approx 4$$

Average weight (kg) of shipments per month:

$$\frac{77\ 917}{11} = 7\ 083$$

Average volume (m3) of shipments per month:

$$\frac{176{,}9}{11} = 16$$

Average pay-weight (kg-m3) of shipments per month:

$$\frac{178\ 172}{11} = 16\ 197$$

Average spends (SEK) for shipments per month:

$$\frac{446\ 642}{11} = 38\ 785$$

Guatemala:

Number of shipment per month:

$$\frac{7 \text{ shipments}}{11 \text{ months}} = 0{,}63$$

This results in 1 shipment totally for November and December.

Average weight (kg) of shipments per month:

$$\frac{822}{11} = 74{,}7$$

Average volume (m3) of shipments per month:

$$\frac{4{,}01}{11} = 0{,}36$$

Average pay-weight (kg-m3) of shipments per month:

$$\frac{4039}{11} = 367$$

Average spends (SEK) for shipments per month:

$$\frac{19\ 784}{11} = 1798$$

Nicaragua:

There was one shipment to Nicaragua during the 11 month period, the probability of a shipment to the country during November and December is only 18%. Hence there is no shipment added for the period in question.

Panama:

Number of shipment per month:

$$\frac{49\ shipments}{11\ months} = 4{,}45$$

This results in 2 shipments totally for November and December.

Average weight (kg) of shipments per month:

$$\frac{197\ 919}{11} = 17\ 992$$

Average volume (m3) of shipments per month:

$$\frac{532}{11} = 48$$

Average pay-weight (kg-m3) of shipments per month:

$$\frac{532\ 629}{11} = 48\ 420$$

Average spends (SEK) for shipments per month:

$$\frac{807\ 472}{11} = 73\ 406$$

Paraguay:

Number of shipment per month:

$$\frac{11\text{ shipments}}{11\text{ months}} = 1$$

Average weight (kg) of shipments per month:

$$\frac{8\ 508}{11} = 773$$

Average volume (m3) of shipments per month:

$$\frac{39}{11} = 3{,}5$$

Average pay-weight (kg-m3) of shipments per month:

$$\frac{39\,503}{11} = 3\,592$$

Average spends (SEK) for shipments per month:

$$\frac{55\,763}{11} = 5\,069$$

Uruguay:

There were two shipments to Uruguay during the 11 month period, the probability of a shipment to the country during November and December is only 36%. Hence there is no shipment added for the period in question.

Transport prices: The researchers were not able to get information regarding the transport prices of the transports performed by DHL, between North America and South America. The transport prices were calculated for each country based on the transport contract found in Volta. How the calculations were done for each country can be seen below:

Paraguay:

Origin charges:

95 USD (Handling fee)

28 USD (AES fee)

Ocean freight charges:

118 USD $*$ Volume of the shipment (m^3) (minimum 118 USD)

Other fees:

10 USD per shipment (B/L Security fee)

Transport Price:

Origin charges + Ocean freight charges + Other fees

Argentina:

Origin charges:

$95\ USD\ (Handling\ fee)$

$28\ USD\ (AES\ fee)$

Ocean freight charges:

$62\ USD * Volume\ of\ the\ shipment\ (m^3)\ (minimum\ 62\ USD)$

$2\ USD\ per\ shipment\ (ISPS)$

Other fees:

$10\ USD\ per\ shipment\ (B/L\ Security\ fee)$

$20\ USD\ * Volume\ of\ the\ shipment\ (m^3)\ (DG\ fee, minimum\ 20\ USD)$
$95\ USD\ per\ B/L\ \ (Destination\ handling\ fee)$
$35\ US$
$* Volume\ of\ the\ shipment\ (m^3)\ (Deconsolidation\ fee, minimum\ 100\ USD)$
$6\ USD\ * Volume\ of\ the\ shipment\ (m^3)\ (AGP\ fee, minimum\ 10\ USD)$

Transport Price:

$Origin\ charges + Ocean\ freight\ charges + Other\ fees$

Ecuador:

Origin charges:

$95\ USD\ (Handling\ fee)$
$28\ USD\ (AES\ fee)$

Ocean freight charges and surcharges:

$67\ USD * Volume\ of\ the\ shipment\ (m^3)\ (minimum\ 67\ USD)$
$2\ USD\ per\ shipment\ (ISPS)$

Destination charges:

$10\ USD\ per\ shipment\ (B/L\ \ Security\ fee)$
$20\ USD$
$* Volume\ of\ the\ shipment\ (m^3)\ (Terminal\ handling\ fee, minimum\ 90\ USD)$
$65\ USD$
$* Volume\ of\ the\ shipment\ (m^3)\ (Inland\ delivery\ fee, minimum\ 150\ USD)$
$70\ USD\ per\ shipment\ (Handling\ management\ fee)$
$50\ USD\ per\ shipment\ (Documentation\ fee)$
$10\ USD$
$* Volume\ of\ the\ shipment\ (m^3)\ (ISPS\ destination, minimum\ 40\ USD)$
$8\ USD$
$* Volume\ of\ the\ shipment\ (m^3)\ (LCL\ terminal\ handling\ fee, minimum\ 35\ USD)$
$90\ USD\ per\ shipment\ (Management\ fee)$

Transport Price:

$Origin\ charges + Ocean\ freight\ charges\ and\ surcharges +$
$Destination\ charges$

Guatemala:

Origin charges:

$95\ USD\ (Handling\ fee)$
$28\ USD\ (AES\ fee)$

Ocean freight charges:

$74\ USD * Volume\ of\ the\ shipment\ (m^3)\ (minimum\ 74\ USD)$
$2\ USD\ per\ shipment\ (ISPS)$

Other fees:

$10\ USD\ per\ shipment\ (B/L\ \ Security\ fee)$

$10\ USD$
$*\ Volume\ of\ the\ shipment\ (m^3)\ (Destination\ THC, minimum\ 10\ USD)$
$35\ USD\ per\ shipment (Destination\ handling\ fee)$
$85\ USD$
$*\ Volume\ of\ the\ shipment\ (m^3)\ (Inland\ delivery\ fee, minimum\ 85\ USD)$

Transport Price:

$Origin\ charges + Ocean\ freight\ charges + Other\ fees$

Nicaragua:

Origin charges:

$95\ USD\ (Handling\ fee)$
$28\ USD\ (AES\ fee)$

Ocean freight charges:

$92\ USD * Volume\ of\ the\ shipment\ (m^3)\ (minimum\ 92\ USD)$
$2\ USD\ per\ shipment\ (ISPS)$

Other fees:

$2\ USD\ per\ shipment\ (B/L\ \ Security\ fee)$
$50\ USD$
$*\ Volume\ of\ the\ shipment\ (m^3)\ (Destination\ THC, minimum\ 50\ USD)$
$95\ USD\ per\ shipment\ (Destination\ handling\ fee)$
$130\ USD$
$*\ Volume\ of\ the\ shipment\ (m^3)\ (Inland\ delivery\ fee, minimum\ 130\ USD)$

Transport Price:

$Origin\ charges + Ocean\ freight\ charges + Other\ fees$

Panama:

Origin charges:

$95\ USD\ (Handling\ fee)$
$28\ USD\ (AES\ fee)$

Ocean freight charges:

$85\ USD * Volume\ of\ the\ shipment\ (m^3)\ (minimum\ 85\ USD)$
$2\ USD\ per\ shipment\ (ISPS)$

Other fees:

$10\ USD\ per\ shipment\ (B/L\ \ Security\ fee)$
$7\ USD$
$*\ Volume\ of\ the\ shipment\ (m^3)\ (Destination\ THC, minimum\ 14\ USD)$
$12\ USD$
$*\ Volume\ of\ the\ shipment\ (m^3)\ (Documentation\ fee, minimum\ 35\ USD)$
$9\ USD$
$*\ Volume\ of\ the\ shipment\ (m^3)\ (Administration\ fee, minimum\ 25\ USD)$

$12\ USD$
$* Volume\ of\ the\ shipment\ (m^3)\ (Unstuffing\ fee, minimum\ 25\ USD)$
$24.50\ \ USD\ per\ shipment\ (Coload\ fee)$
$38\ USD$
$* Volume\ of\ the\ shipment\ (m^3)\ (Inland\ delivery\ fee, minimum\ 110\ USD)$

Transport Price:

$$Origin\ charges + Ocean\ freight\ charges + Other\ fees$$

Uruguay:

Origin charges:

$95\ USD\ (Handling\ fee)$
$28\ USD\ (AES\ fee)$

Ocean freight charges:

$62\ USD * Weight\ of\ the\ shipment\ (kg)\ (minimum\ 62\ USD)$
$2\ USD\ per\ shipment\ (ISPS)$

Other fees:

$10\ USD\ per\ shipment\ (B/L\ \ Security\ fee)$

$$35\ USD\ * \frac{Weight\ of\ the\ shipment\ (kg)}{Volume\ of\ the\ shipment\ (m^3)}$$

$(Destination\ handling\ fee, minimum\ 150\ USD, maximum\ 220\ USD)$
$85\ USD\ per\ B/L\ \ (Ocean\ arrival\ charges, plus\ VAT)$
$75\ USD\ per\ HB/L\ \ (Handling\ DGF)$

Transport Price:

$$Origin\ charges + Ocean\ freight\ charges + Other\ fees$$

Colombia:

Origin charges:

$95\ USD\ (Handling\ fee)$
$28\ USD\ (AES\ fee)$

Ocean freight charges:

$80\ USD * Volume\ of\ the\ shipment\ (m^3)\ (minimum\ 80\ USD)$
$2\ USD\ per\ shipment\ (ISPS)$

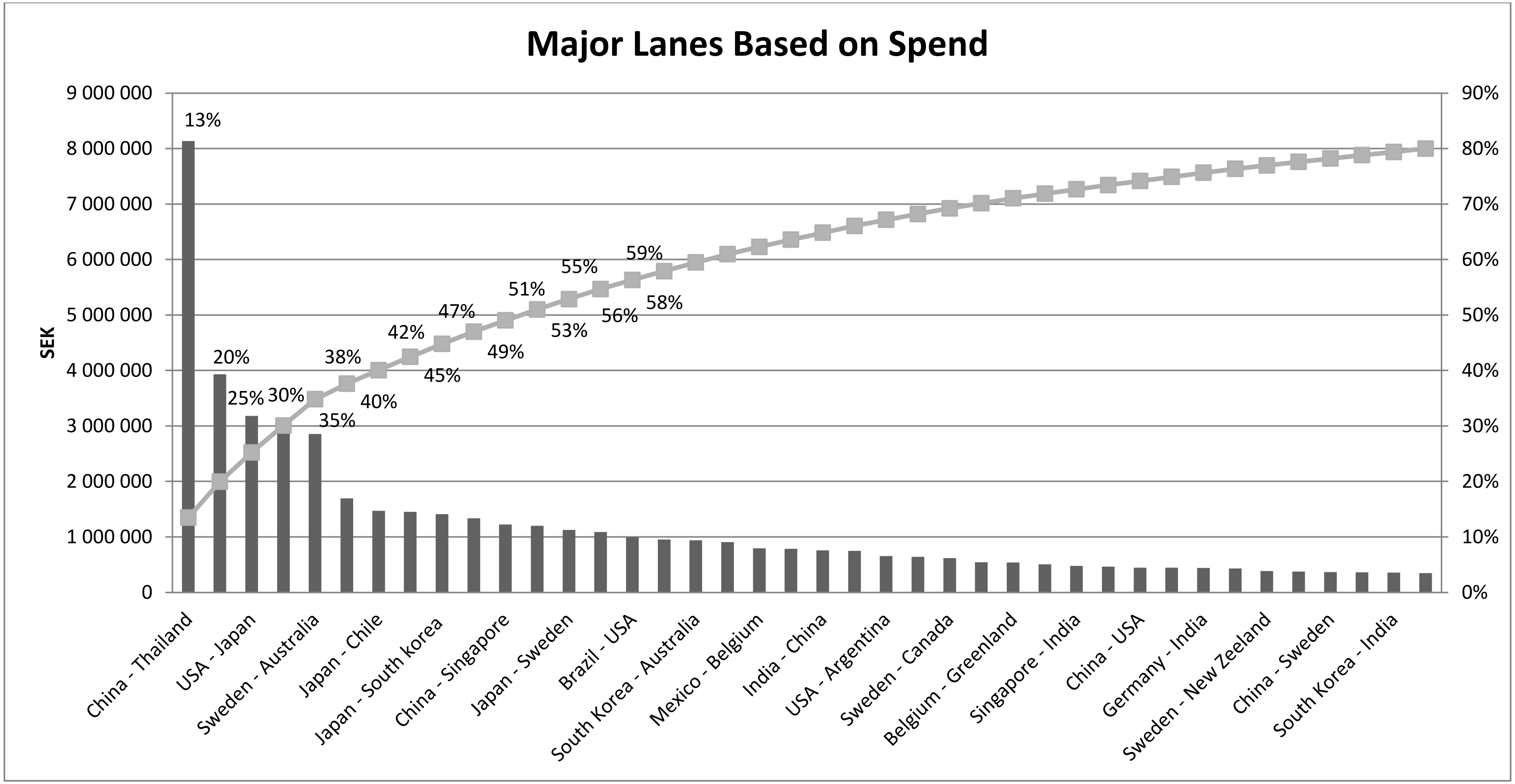
Other fees:

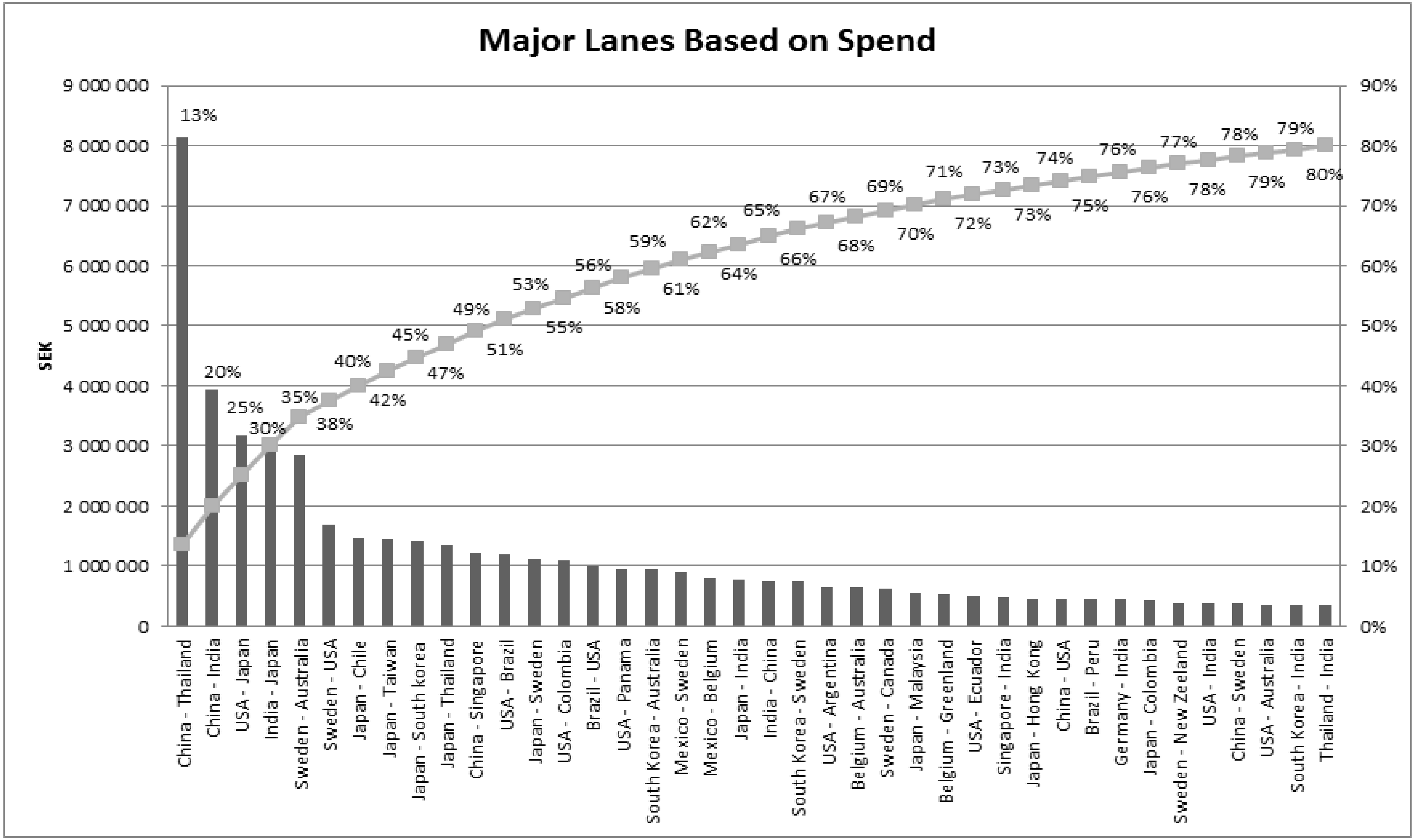
$70\ USD\ per\ shipment\ (B/L\ \ Security\ fee)$
$100\ USD\ per\ shipment\ (Destination\ handling\ fee)$
$18\ USD\ per\ shipment\ (CFS\ fee)$
$300\ USD\ per\ shipment\ (Inland\ delivery\ fee)$

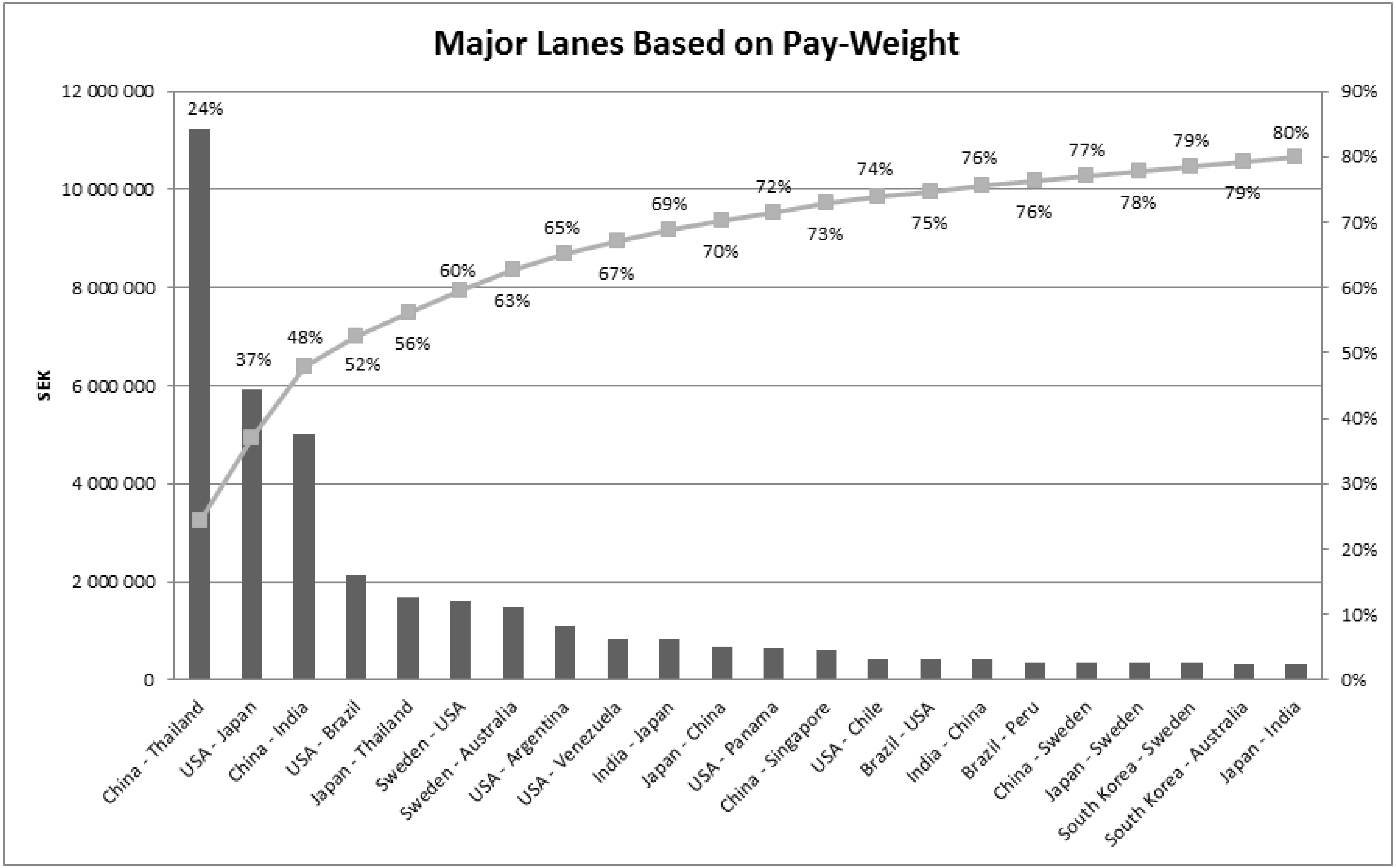
Transport Price:

$$Origin\ charges + Ocean\ freight\ charges + Other\ fees$$

APPENDIX B


Major Lanes Based on Spend
SEK
9 000 000
8 000 000
7 000 000
6 000 000
5 000 000
4 000 000
3 000 000
2 000 000
1 000 000
0
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
13%
20%
25%
30%
35%
38%
40%
42%
45%
47%
49%
51%
53%
55%
56%
58%
59%
China - Thailand
USA - Japan
Sweden - Australia
Japan - Chile
Japan - South korea
China - Singapore
Japan - Sweden
Brazil - USA
South Korea - Australia
Mexico - Belgium
India - China
USA - Argentina
Sweden - Canada
Belgium - Greenland
Singapore - India
China - USA
Germany - India
Sweden - New Zeeland
China - Sweden
South Korea - India


Major Lanes Based on Spend
SEK
9 000 000
8 000 000
7 000 000
6 000 000
5 000 000
4 000 000
3 000 000
2 000 000
1 000 000
0
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
13% 20% 25% 30% 35% 38% 40% 42% 45% 47% 49% 51% 53% 55% 56% 58% 59% 61% 62% 64% 65% 66% 67% 68% 69% 70% 71% 72% 73% 73% 74% 75% 76% 76% 77% 78% 78% 79% 79% 80%
China - Thailand
China - India
USA - Japan
India - Japan
Sweden - Australia
Sweden - USA
Japan - Chile
Japan - Taiwan
Japan - South korea
Japan - Thailand
China - Singapore
USA - Brazil
Japan - Sweden
USA - Colombia
Brazil - USA
USA - Panama
South Korea - Australia
Mexico - Sweden
Mexico - Belgium
Japan - India
India - China
South Korea - Sweden
USA - Argentina
Belgium - Australia
Sweden - Canada
Japan - Malaysia
Belgium - Greenland
USA - Ecuador
Singapore - India
Japan - Hong Kong
China - USA
Brazil - Peru
Germany - India
Japan - Colombia
Sweden - New Zeeland
USA - India
China - Sweden
USA - Australia
South Korea - India
Thailand - India


Major Lanes Based on Pay-Weight
SEK
12 000 000
10 000 000
8 000 000
6 000 000
4 000 000
2 000 000
0
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
24%
37%
48%
52%
56%
60%
63%
65%
67%
69%
70%
72%
73%
74%
75%
76%
76%
77%
78%
79%
79%
80%
China - Thailand
USA - Japan
China - India
USA - Brazil
Japan - Thailand
Sweden - USA
Sweden - Australia
USA - Argentina
USA - Venezuela
India - Japan
Japan - China
USA - Panama
China - Singapore
USA - Chile
Brazil - USA
India - China
Brazil - Peru
China - Sweden
Japan - Sweden
South Korea - Sweden
South Korea - Australia
Japan - India

APPENDIX C

COSTS | RISK | INSURANCE

All modes of transport | Sea and inland waterways

DESCRIPTION	COSTS	RISK	INSURANCE	FREIGHT/RISK	MORE DETAILS
EXW Ex Works	SELLER / BUYER	SELLER / BUYER	SELLER / BUYER	**Freight** Seller's premises. **Risk** Seller's premises.	Seller is only responsible for making the goods available at the seller's premises. The buyer bears the full risk from there to the destination.
FCA Free Carrier	SELLER / BUYER	SELLER / BUYER	SELLER / BUYER	**Freight** Freight handler. **Risk** Freight handler.	Seller is responsible for delivery to the custody of the carrier, which is provided by the buyer. Risk is transferred as soon as loading has taken place.
CPT Carriage Paid to	SELLER / BUYER	SELLER / BUYER	SELLER / BUYER	**Freight** Destination. **Risk** First freight handler.	Seller delivers the goods to the carrier at an agreed place of delivery and pays for transport to the named destination. Risk is transferred at the place of delivery, whereas seller pays for transport to the destination.
CIP Carriage and Insurance Paid to	SELLER / BUYER	SELLER / BUYER	SELLER / BUYER	**Freight** Destination. **Risk** First freight handler.	Seller delivers the goods to the carrier at an agreed place of delivery and pays for transport and insurance to the named destination. Risk is transferred at the place of delivery, whereas seller pays for transport and insurance to the destination.
DAT Delivered at Terminal	SELLER / BUYER	SELLER / BUYER	SELLER / BUYER	**Freight**: Destination. **Risk**: Destination.	Seller delivers the goods unloaded at a specified place inside the agreed terminal. Risk is transferred as soon as the goods have been unloaded.
DAP Delivered at Place	SELLER / BUYER	SELLER / BUYER	SELLER / BUYER	**Freight**: Place of destination. **Risk**: Arriving means of transport at destination.	Seller delivers the goods to the disposal of the buyer on the arriving means of transport at the agreed place. Seller assumes the risk until the goods are made ready for unloading from the arriving means of transport.
DDP Delivered Duty Paid	SELLER / BUYER	SELLER / BUYER	SELLER / BUYER	**Freight** Destination. **Risk** Destination.	Seller is responsible for bringing the goods to the destination, paying any duty and making the goods available to the buyer. Risk is transferred as soon as the buyer has access to the goods ready for unloading at the agreed destination.
FAS Free Alongside Ship	SELLER / BUYER	SELLER / BUYER	SELLER / BUYER	**Freight** Shipside in port of departure. **Risk** Shipside in port of departure.	Seller is responsible for delivery of the goods at the quay alongside the ship. From this point onwards, risk lies with the buyer.
FOB Free on Board	SELLER / BUYER	SELLER / BUYER	SELLER / BUYER	**Freight** On board ship. **Risk** On board ship.	Seller is responsible for delivery of the goods loaded on board the ship. Risk is transferred as soon as the goods have been set down inside the ship.
CFR Cost and Freight	SELLER / BUYER	SELLER / BUYER	SELLER / BUYER	**Freight** Port of destination. **Risk** On board ship.	Seller covers cost of freight, duty unpaid, to the named port of destination. Risk is transferred as soon as the goods have been set down inside the ship.
CIF Cost, Insurance and Freight	SELLER / BUYER	SELLER / BUYER	SELLER / BUYER	**Freight** Port of destination. **Risk** Port of destination.	Seller covers cost of insurance and freight, duty unpaid, to the named port of destination. Risk is transferred as soon as the goods have been set down inside the ship.

APPENDIX D – QUESTIONNAIRE

Weighing the assessment parameters

We are trying to compare different scenarios when it comes to LCL transports. These scenarios will be analyzed based on five different perspectives; cost, management, service, quality and communication, each consisting of several assessment parameters. The purpose of this survey is to weigh the different assessment parameters against each other.

The parameter that is considered most important by the person doing the survey should be chosen for each question. The option equally important should be chosen in the case where both options are considered equally important. This survey is confidential meaning that the researchers will be able to identify the respondents but the information will not be further spread.

Name of the respondent:

____

COSTS

This section is regarding costs associated with LCL transports.

Transport price vs. B/L cost
- o Transport Price
- o Equally Important
- o B/L cost

Transport price vs. Customs cost
- o Transport Price
- o Equally Important
- o Customs Cost

Transport price vs. Lead-time
- o Transport Price
- o Equally Important
- o Lead-time

B/L cost vs. Customs cost
- o B/L costs
- o Equally Important
- o Customs cost

B/L cost vs. Lead-time
- B/L costs
- Equally Important
- Lead-time

Customs costs vs. Lead-time
- Customs costs
- Equally Important
- Lead-time

MANAGEMENT

This section is related to the management and purchasing process costs related with LCL transports.

Sourcing process costs vs. Network design and optimization
Network design and optimization are costs related to network development and optimization.
- Sourcing process costs
- Equally important
- Network design and optimization

Sourcing process costs vs. Invoicing complexity
Invoicing complexity refers to all of the costs related to invoicing.
- Sourcing process costs
- Equally important
- Invoicing complexity

Sourcing process costs vs. EDI (booking and invoicing)
- Sourcing process costs
- Equally important
- EDI (booking and invoicing)

Sourcing process costs vs. Operational management
Organizational management refers to costs related to coordinating shipments from different lanes.
- Sourcing process costs
- Equally important
- Coordination

Logistics development costs vs. Invoicing complexity
- Logistics development costs
- Equally important
- Invoicing complexity

Logistics development costs vs. EDI (booking and invoicing)
- Logistics development costs
- Equally important
- EDI (booking and invoicing)

Logistics development costs vs. Operational management
- Logistics development costs
- Equally important
- Operational management

Invoicing complexity vs. EDI (booking and invoicing)
- Invoicing complexity
- Equally important
- EDI (booking and invoicing)

Invoicing complexity vs. Operational management
- Invoicing complexity
- Equally important
- Operational management

EDI (booking and invoicing) vs. Operational management
- EDI (booking and invoicing)
- Equally important
- Operational management

QUALITY

This section is related to the quality of the procured service regarding LCL transports.

Lead-time deviation vs. Environmental impacts
- Lead-time deviation
- Equally important
- Environmental impacts

Lead-time deviation vs. Invoicing quality
- Lead-time deviation
- Equally important
- Invoicing quality

Environmental impacts vs. Invoicing quality
- Environmental impacts
- Equally important
- Invoicing quality

SERVICE

This section is related to the service provided by the forwarders regarding LCL transports.

Geographical coverage of logistics service providers vs. Complaint handling
- Geographical coverage of logistics service providers
- Equally important
- Compliant handling

Geographical coverage of logistics service providers vs. Fluctuation handling
- Geographical coverage of logistics service providers
- Equally important
- Fluctuation handling

Geographical coverage of logistics service providers vs. Lane adjustment flexibility
All of the costs related to adding lanes to a contract.
- Geographical coverage of logistics service providers
- Equally important
- Lane adjustment flexibility

Complaint handling vs. Fluctuation handling
- Complaint handling
- Equally important
- Fluctuation handling

Complaint handling vs. Lane adjustment flexibility
- Complaint handling
- Equally important
- lane adjustment flexibility

Fluctuation handling vs. Lane adjustment flexibility
- Fluctuation handling
- Equally important
- Lane adjustment flexibility

COMMUNICATION
This section is related to the communication and relationship costs with the forwarders regarding LCL transports.

B2B communication costs vs. Deviation reports
B2B communication refers to all of the costs included in maintaining a relationship with a supplier.
- B2B communication costs
- Equally important
- Deviation reports

B2B communication costs vs. Tracking & Tracing
- B2B communication costs
- Equally important
- Tracking & Tracing

Deviation reports vs. Tracking & Tracing
- Deviation reports
- Equally important
- Tracking & Tracing