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THE IMPACT OF IMPLEMENTING OPTIMIZED SUPPLY CHAIN MODEL ON COMPANY'S ENVIRONMENTAL SUSTAINABILITY. A CASE STUDY OF ESTONIAN PRODUCTION ESTABLISHMENT.

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I declare that I have compiled the paper independently and all works, important standpoints and data by other authors have been properly referenced and the same paper has not been previously being presented for grading. The document length is 12519 words from the introduction to the end of conclusion.

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ABSTRACT

Energy consumption in logistics and especially in road freight transportation, is steadily increasing and along with the greenhouse gas emissions which have a negative impact on the environment. In order to improve environmental sustainability of logistics, a change in the actors' behavior and policies is needed since the development of technology alone is not sufficient. The following thesis paper addresses energy efficiency improvements in supply chain comparing transportation of full loads and partial at the first step of research, comparing current single route delivery model and optimized combined route model in relation to CO2 emission and cost of delivery using the example of one Estonian-based production company.

Research is aimed at establishing the optimal supply chain model in terms of minimization of CO2 emission and cost of transportation. For this purpose, a specific case of an Estonian-based production company was chosen. Quantitative method of research was used to analyze the data. Two step research was conducted, the first step was aimed at analyzing current supply chain model and developing alternative CO2 emission and cost efficient model; second step was aimed at highlighting the benefits that will occur in case an optimized supply chain will be implemented, in which the opinion of specialists in the field of logistics, gathered via deep survey, establish an attitude towards environmental sustainability among Estonian business owners. Content analysis of information gathered through surveys was conducted in order to highlight the most important aspects and general opinion. As a result, an optimized supply chain model was developed and compared in terms of numbers with the current model. Both monetary and non-monetary benefits were analyzed and presented in the final part of the research. Experts point out that as competition in the logistics field is high, time and price are the most crucial aspects that define the direction of development.

The thesis is in English and contains 86 pages of text, 4 chapters, 26 figures.

Key words: sustainable supply chain, delivery model, road freight transportation, CO2 emission, routing.

INTRODUCTION

In the supply chain field, sustainable supply chain is one of most relevant topics. Protecting the environment in every possible way is the only path to saving the planet. Large companies all over the world are making steps towards sustainable business, integrating recycling programs, reducing waste, limiting CO2 emission. When it comes to supply chain, there are four ways of transportation: by sea, air, road or train. All of these ways have their strengths and weaknesses in terms of time and price, as well as all of them produce different levels of CO2 emission. In this research only road transportation will be analyzed as the routes are around Central Europe, Scandinavia and Baltics, which implies truck deliveries in 90% of cases due to lower prices and faster deliveries. This topic was chosen because of its importance and relevance of the environmental sustainability in supply chain; moreover, there is not much information on the sustainable supply chain system in Estonia, which is a motivating factor to receive more data, analyze and give recommendations on how to optimize the current supply chain management system in Estonia. Additionally, in 2015 Sulphur Directive 2012/33/EU was initiated in order to reduce Sulphur emission from vessels in the Baltic Sea along with the North Sea and English Channels (SECA). This directive has an impact on alternative transportation systems, as increase of fuel cost and additional surcharges make inland transportation more cost efficient, hence the share of it increased. Researching inland transportation sustainability becomes more relevant than ever. As the expected next step towards environmental sustainability will be adoption of a similar directive aimed at inland transport in the nearest future, that will influence the whole infrastructure. Current market situation connected with the COVID-19 pandemic and rapid fall of oil prices makes the future of the supply chain field unpredictable which requires extra attention and analysis.

The research is based on the pursuit of energy efficiency in logistics as a means to environmental sustainability in order to reduce energy consumption. The starting point for this research is to focus on the example of one company in cargo transportation within the traditional logistics system boundaries. The goal is to calculate the emission and cost of the current supply chain model and offer an alternative two step model, with creating groupage cargo as a first step and optimized routes as a second step. Calculating emission and cost for both current and alternative models and analyzing results. On the basis of the analysis a conclusion will be reached on the most efficient supply chain model, and the numbers will also be provided in order to back it up. Finally, this work highlights the benefits of adopting an optimized supply chain model that includes monetary and non-monetary, that take into account attitude towards environmental sustainability on the Estonian market, which is displayed through the analysis of surveys among specialists in the logistics field.

The main objectives of the research are:

1. Define the proven optimal supply chain model for Company X through comparison of cost and CO2 emission produced by using current and optimized supply chain model.

2. Identify monetary and non-monetary benefits of implementing optimized supply chain model.

3. Reflect current attitude towards sustainable supply chain among Estonian logistics specialists.

The research hypothesis is: "Reduction of monthly cost and CO2 emission is possible to achieve through implementing optimized supply chain model only".

Research questions:

1. What is the current transportation cost and CO2 emission of Company X using the current supply chain model?

2. What changes in cost and CO2 emission occur if Company X implements an optimized supply chain model?

3. What are the benefits of implementing an optimized supply chain model for Company X?

Quantitative research method was chosen for the research. Quantitative method was relevant in working with data provided by Company X, on monthly deliveries and destinations. The block of information received from company X was six-month supply chain history, from June to December 2019, with monthly deliveries in cubic meters to 15 most common European destinations. The loads in cubic meters were converted to tons and divided to full and partial loads.

The fuel consumption was calculated according to the vehicle type and mileage of each route. The CO_2 emission on each route was calculated by using the most accurate method (McKinnon and Pieck, 2011), according to the fuel consumption and fuel coefficient. The cost of delivery to each destination was calculated according to the cost of the vehicle, insurance, salary of the driver, amortization of the vehicle and fuel cost. In the end both costs and CO_2 emission were multiplied by the number of full and partial loads delivered by each route, to figure out overall emission and cost. The same calculation was made for alternative routes in order to receive similar data for comparative analysis.

The body of the thesis consists of four chapters. Chapter One covers the theoretical framework of the thesis, from development of the supply chain concept to latest trends and most broadly used models, one of which was used to create optimized supply chain model described in Chapter Three. Chapter Two includes justification of chosen method of research, data collection and calculation process description; justification of survey content and chosen respondents along with description of content analysis process. Chapter Three describes the current supply chain model and the CO_2 emission that it produces and provides information on the cost of each route. It gives a comparative analysis on the usage of combined loads and partial loads. Additionally, it describes an alternative supply chain model that uses combined routes, provides calculation on the CO_2 emission of the optimized system and costs of each route, and, finally, analyses the outcome of the current and optimized model. Chapter Four is dedicated to highlighting and summarizing the monetary and non-monetary benefits from implementing an optimized supply chain, along with the current attitude towards environmental sustainability among Estonian logistics specialists, which is reinforced by the analysis of surveys conducted among specialists in the logistics field. Content analysis of the survey outcome gave the author an understanding of the current attitude among Estonian logistics specialists towards environmental sustainability and establish general opinion on the ways to improve the current situation.

1. THEORETICAL FRAMEWORK

Modern supply chain represents all steps that are made to turn raw material into the end product, including delivering it from supplier to the place of production and on to the client. Supply chain management is a complex concept that covers and coordinates all these processes (Lummus and Vokurka, 1999).

Nowadays supply chain management not only grew to a separate area of business, but is threatening to become so broad, that it will lose its focus. On account of logistics, purchasing and production becoming the scope of supply chain management, it is now responsible for 70-80 percent of costs in a number of industries. Current order will most likely lead to supply chain management becoming an independent third party between the company and its suppliers (Ballou, 2007). As the author is looking into possible ways of developing a supply chain system, modern trends are among the areas of interest. Digitalization is one of the current trends in supply chain management, which along with all the benefits, brings the potential threat of "death of supply chain" due to the tendency to include robotics and artificial intelligence to automate labor-intensive tasks and processes (Lyall et al. 2018). In time it may lead to an overall exclusion of third party involvement and moving from automatic purchasing and invoicing to drones and autonomous vehicles making the deliveries. The only aspect where individuals cannot be excluded is analyzing and development, creating, sharing and using information still involves human aspect (Schniederjans et al.2020). In any case, digitalization is working for the benefit of supply chain managers with regard to assisting in routine actions, making time for analysis and development (Wilkesmann and Wilkesmann, 2018).

The best way to describe the supply chain trend according to the study by McKinsey and Company is: "... By the year 2020, 80 percent of the goods in the world will be manufactured in a country different from where they are consumed compared with 20 percent now".

Environmental sustainability in the supply chain field and the ways to reach it is the overall goal of this research. As the supply chain is moving towards globalization, the question of cross border cooperation and coordination is now on the table; information sharing via advanced technologies and the financial strategy aimed not at cost reduction but on revenue generation. Building a trustful and systematic approach of cooperation of cross border units will become the key success factor (Ballou, 2007). In this case the three pillars of Corporate Social Responsibility- Social, Economic and Environmental sustainability will become essential. If the economic aspect has always been under scrutiny, the importance of environmental sustainability only recently started drawing attention, and its social aspect was previously underestimated. Paying more attention to humans' higher needs is the germinating tendency that originates from studies on benefits and damage to health depending on changes in gross national product (Norris, 2006) and a comprehensive sustainability index "gross social feel-good", which combines indexes on safety, health, comfort and environment (Tsuda and Takaoka, 2006). However, social sustainability is a variable which is hard to measure, as it contains too many indicators (Labuschagne and Brent, 2006). It defines the current situation of the social sustainability aspect, which is possible to research and analyze, but is complicated to incorporate into real business processes (Hutchins and Sutherland, 2008). In the present research economic sustainability will be reviewed with the aim of providing a strong foundation for building environmental sustainability as a necessary aspect of a strong economic position. In the context of aiming to reach an acceptable level of environmental sustainability, the question of funding arises. Ways of receiving additional profits from solving environmental issues concern researchers that understand the importance of business perspective for a practical implementation of theories (Guide et al.2003). Value remaining in products at the end of primary lifecycle can be extracted through remanufacturing (Fleischmann et al.1997). The lifecycle of a number of products is becoming shorter, especially electronics, which can become a source of additional profit after recycling or at least can finance the utilization of products that cannot be remanufactured (Bhattacharjee and Cruz, 2015). The challenge of supply chain management is to meet customer's expectations, i.e. a fast, flexible and consistent delivery system with a low cost. At the same time, the last decade was marked by a raising awareness regarding the negative environmental impact of industry (Hutchins and Sutherland, 2008). The worldwide trend was supported by European Commission by preparing a sustainable development strategy which is constantly updated along with the wide range of policies (Commission E, 2009). The definition of sustainable supply was formulated by Seuring and Müller (2008):

> "The management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e., economic, environmental and social, into account which are derived from customer and stakeholder requirements."

The paper adopts this definition. One of the ways of making supply chain management sustainable in all three dimensions is to consider it as a closed system responsible for the whole life cycle of the product, from used product to recycled and turned into usable again (Fleischmann et al. 1997). This product life cycle is called Closed- Loop Supply Chain and is argued to be the most effective from the side of sustainability (Guide and Van Wassenhove, 2002).

In pursuit of finding the right answers to the research questions, the author had to consider different options of reaching environmental sustainability. There are some practical tools that the industry may use to reach environmental sustainability. In 2008 the European Commission presented a directive that must increase the amount of renewable energy sources used by 20% and 10% of biofuels in 2020. Besides the use biofuels can decrease GHG emission from transport, this energy source can be grown and used in the same country which will additionally lower its cost and open new market opportunities, most importantly it may decrease dependency on oil industry (Markevicius et al. 2010). Specialists are constantly looking for ways to reduce emission; electric trucks are another solution to the increasing air pollution. Electric delivery trucks are a relatively fresh invention that might become competitive after solving the battery charging issue. Disappointing report on the European Union survey (Vermie, 2002) on the effectiveness of electric delivery trucks was done by Jeeninga et al. (2002), concluding that vehicles performed below expectations in the terms of speed, distance and reliability. The research conducted by Davis and Figliozzi (2013) evaluated use of electric delivery trucks in four dimensions: vehicle cost, power consumption and range, estimated fleet size, energy required to ride at normal truck speed. Authors concluded that due to higher purchase cost and inefficiency in routing constraints, cost savings on reduced operational costs must be very high, to make use of electric trucks efficient. Additionally, the electric truck fleet must be bigger, due to their shorter range. Positive impact on the environment is doubtless, as the road transport is ranked as the largest source of air pollution especially in large cities (D’Angiola et al., 2010). Dealing with the financial aspect for broader usage of electric delivery trucks is only a matter of time.

Now the efficiency- increasing systems of supply chain management will be considered. In order to answer the research question and develop an optimized supply chain model, the author used the existing efficiency increasing system described below as a pattern. Delivering goods from manufacturers to customers is the main goal of a logistics system. Decreasing cost of the service became an issue during the last few years. Making a delivery from one supplier to a customer is called ‘direct shipment system’, perfectly suitable for large loads, goods that need to be isolated or when the schedule is tight. In case one of these criteria is not fulfilled an alternative system is used, suitable for multiple suppliers situated in one region. Hub and spoke system implies collecting cargo from all suppliers in one central warehouse, with future consolidation and redistribution to the customers. The system requires close attention to routing to stay effective (Liu et al. 2013).

The strong side of the system is improving customer service through faster deliveries, the weak side is that in practice suppliers and customers are rarely situated close enough for the system to be fully effective. Cross docking system reaches the same goals using different ways. Its main goal is to reduce the warehousing costs by sending goods right after they arrive to the warehouse, without a need for long-term storage. Cross docking system gives the opportunity to send arrived cargo fully or redistribute it according to the route. In case it is managed effectively the period of receiving and shipping decreases to its minimum (Apte and Viswanathan, 2000). Vehicle routing problem questions on the counterweight not warehousing, but transportation efficiency. The system is used to create an optimal route for one vehicle to carry a limited amount of weight. In the end the optimal set of routes is minimizing the total distance and the number of vehicles used, which allows to reduce the cost (Baker and Ayechew, 2003). The system may be applied in cases with longer distances, where returning to the warehouse is economically unjustified. An interesting issue of cross docking combined with vehicle routing problem was raised by research of Wen et al. (2009), all of the best qualities are combined in this case. Minimum amount of time in storage is reducing costs and predetermining time of pickups and deliveries, while composing optimal routes increases quality as well as time of service performance. In case the amount of actions needed to consolidate and deliver will be properly managed, a mixed system might offer high quality solutions within a short time period, according to the research. The inventory routing problem like all of the previously mentioned systems addresses the needs of a customer to receive goods at a certain time. But it is aimed at raising the service value through lowering customer's storage costs and supplier delivery costs. In case when a single product type is constantly delivered to a set of customers, storing the product in a central location brings benefit for both suppliers and customers (Campbell et al. 1998). Certain amount of clients and precise delivery schedule is needed for this system to be economically justified from the supplier side.

Current situation and trends on the Estonian logistics market have a crucial meaning for the practical side of current research. Estonian logistics infrastructure is relatively developed. Mostly due to geographic positioning, routes between Russian Federation and Europe lay through Estonia (Hilmola and Henttu, 2015) not to mention routes from Europe's mainland countries to Scandinavia. Some of the loads are going through short sea freights. According to Eurostat (information updated in March, 2020) Baltic Sea is in third place with 21% of all European Union short sea shipping tonnages, right after Mediterranean Sea and the North Sea. The tonnages of transport supporting the short sea shipping along with independent road transport is rising each year. Estonian Government is investing in developing a convenient digital crossing border system between European Union and Russian Federation, so that the road transport flow can continue growing. Due to convenient border-crossing procedures, Estonia has a leading position in transit from Russian Federation to European States. Consistent development led to 1.8% growth over the period (Statistics Estonia, 2014) in railway block train services. Even during the crisis of 2008 the industry had minor losses, because of the unique service the country provides is constantly being developed. The lowest decrease in transit volumes among the countries of the Gulf of Finland was detected in Estonia (Hilmola and Henttu, 2015). In Estonia the transport industry accounts for 8% of employment and is considered to be a promising industry for investments.

For this paper the author chose vehicle routing problem as a model to build the research, mainly because it is aimed at determining the best routing strategy for a single vehicle or a fleet of vehicles that deliver supplies to various geographical locations (Epaminondas et al. 2020). The decision was made on the basis of data received from Company X. Length of routes do not imply hub and spoke system and the absence of information of Company X's customers' needs doesn't allow the use of cross docking system. Vehicle routing was the best solution based on the acquired information and demands.

2. METHODOLOGY

In this chapter the author of the thesis is explaining the chosen research method used to answer research questions “What is the current transportation cost and CO2 emission of Company X using current supply chain model?”, “What changes in cost and CO2 emission occur if Company X implements optimized supply chain model?” and “What are the benefits of optimized supply chain model for Company X?”. Additionally, the author will present research design, data collection process, data source, methods of calculation and process of analysis.

In order to analyze the current delivery system of Company X and develop an alternative system the author used the quantitative research method. The research method will be substantiated in order to prove its suitability for answering the formulated research questions.

Experimental qualitative research, where subjects are measured before and after optimization in order to establish causality, was the most appropriate solution. Since the research questions are clearly defined, objective answers are expected. The data and all followed calculations are presented in tables and charts. The concept of the research may be used more widely, outside the researched establishment.

Author received a block of statistical data from Company X, on the amount of monthly loads sent from Estonia to 15 most common destinations during a six-month period. Author requested Company X to provide data only on inland transportation, with the starting point in Estonia. The 15 European and Scandinavian destinations were given as most popular, due to situated saw mills and branches, and appropriate for truck deliveries, due to mileage and time efficiency. The data was divided into loads sent with each transportation, cost and CO2 emission was calculated according to the distance and fuel consumption. The first step of the research was to establish the numerical benefit of creating a groupage cargo within the current supply chain model. For this purpose, loads were divided into full and partial and analyzed separately.

After conducting calculations on current routes, the author designed and calculated the same block of data for an alternative routing model, based on a vehicle routing problem (Baker and Ayechew, 2003). The model was chosen as most efficient for the given destinations and amount of cargo. Due to a limited access to information on storage and customers demand, the author developed the optimal way of achieving reduction of CO2 emission in order to obtain environmental sustainability. Additionally, cost reduction was chosen as a persuasive factor for possible implementation of the previously mentioned developments to practice. The two blocks of data were compared in the dimensions of CO2 emission and cost per each route. The difference was calculated and shown through numbers and charts.

All of the research calculations were necessary for reaching the final results in monthly CO2 emission and cost of delivery. Average rate and standard deviation were calculated via Excel for a clear statistical picture. Intermediate assumptions and argumentation were presented at every step of the calculation process. Tables with results of the calculations are presented in Appendices. The monthly costs and CO2 emission of two delivery models were compared through comparison tables and charts. The results of the analysis were revealed and commented by the author.

The third research question addressed the benefits of implementing an optimized supply chain model. Within this question the author considered it important to reflect the current attitude towards environmental sustainability on the Estonian logistics market, in order to emphasize the relevance of the research and distinguishing possible obstacles on the way to its practical implementation. For this purpose, a deep survey among logistics specialists was carried out. Author chose specialists according to their experience, relevance to specifically inland transportation and belonging to medium sized establishments that represent the majority of Estonian logistics market. Four of the specialists are working in different logistics establishments based in Estonia. One specialist is working in Company X and was responsible for reflecting the company's opinion on the researched topic. All of the interviewees have more than five years of experience in the field of logistics. One of the interviewees was female, one was a business owner and one represented Company X. This selection was made for the purity of research.

Survey consisted of 20 questions formulated on the basis of three blocks:

1. First block of questions was designed to reveal the experience of interviewees.

2. Second block was responsible for understating the system and the amount of loads at interviewees' current work place.

3. Third block was aimed at finding out the attitude towards environmental sustainability among specialists of the related area.

The questions were sent to interviewees and answered by them in writing.

Content analysis along with detection of patterns was used to process data, gathered through the survey, in order to examine patterns in received answers in a replicable and systematic manner.

The author was looking for information on current logistics practices in Estonia and understanding of attitude towards the environmental sustainability issues among logistics specialists.

The author managed to formulate a joint opinion of specialists on the current level of attention to environmental sustainability and possibility of implementing optimized transportation models in order to decrease the level of pollution in future, and the conditions under which the optimization will become possible.

3. ANALYSIS

Company X provided information on their monthly loads of supplies and ready goods in cubic meters delivered during the six-month period from June to December 2019 to 15 destinations located in the Baltics, Scandinavia and Europe. They stated that the average amount of truckload sent is 80 cubic meters, in case when the load is partial it is sent immediately in a separate truck due to timing matters. The information of truck fuel consumption was included in the data. All the calculations made by the author of this research were based on the statistics provided by Company X.

3.1 Analysis of current supply chain model of Company X

As the author figured out during the research, Company X currently does not have any specific supply chain model. The deliveries are made according to the supplying needs of clients and production branches. The whole current delivery system is aimed first of all at time saving. It was decided to make an intermediate research step to the current supply chain by analyzing the benefit of creating groupage cargo from the partial loads formed every month in order to reduce cost and CO2 emission. For this purpose, full and partial loads are analyzed separately.

3.1.1 Main transportation destinations

The first question of the research is aimed at calculating cost and CO2 emission for the current supply chain model. The starting point for calculating both factors is to process the current delivery routes.

Company X is delivering supplies that are necessary for production and ready goods from Estonia to 15 most common European destinations on a monthly basis. In this research, the author has analyzed data on the routes and truck loads from the period of six months. Most popular are the deliveries made around Estonia- 1250 full truck loads in six months. Due to the fact that Company X's office and saw mills are based around Estonia while the production and other suppliers are based in other Estonian destinations, deliveries throughout Estonia on the average are 179 full truckloads per month. The country's closest neighbors Latvia and Lithuania are in second and third places with 168 full truckloads and 103 full truckloads in six months. Company X has a combined subsidiary for all Baltic States, which leads to constant deliveries between those states. Finland and Sweden in six month have 51 full truckloads and 32 truckloads. Route calculation for both Finland and Sweden is different from other destinations, as sea freight mileage was eliminated from the overall mileage. For Finland approximately 80 km of mileage is eliminated from route calculation. The same applies for Denmark and Norway, sea freight mileage approximately 379 km is eliminated from the overall calculation for these destinations. Popular destinations are Poland with 53 full truckloads and Netherlands with 59 full truckloads per six months. Poland is one of most common destinations also because main routes to European states lay through Poland as it is seen on Figure 1.

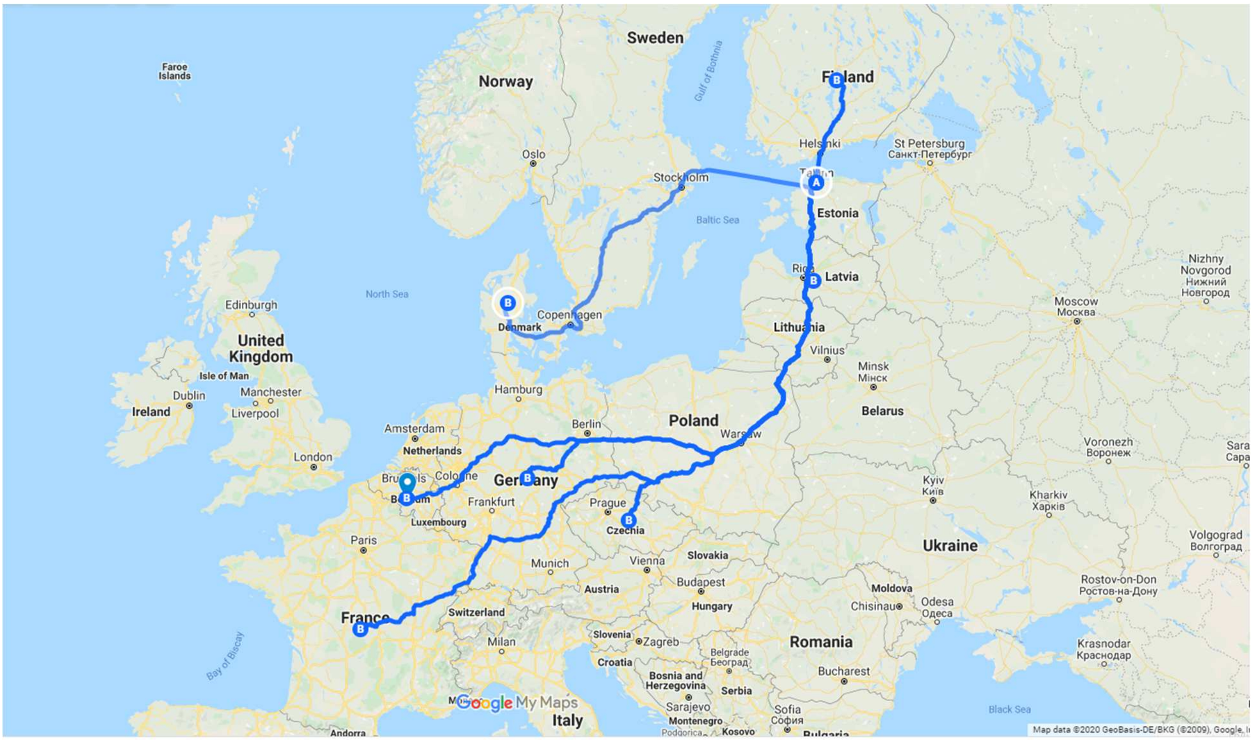

Figure 1. Delivery routes of Company X from Estonia to Belgium, Czech Republic, Denmark, Finland, France, Germany, Latvia

Source: Author's calculations based on data from Appendix 1

Route to the Netherlands has one of the longest mileage 2145 km and on the average has only eight full truckloads per month. France and Germany are almost on the same level, 24 and 26 full truckloads in six months. France has the second longest route - 2575 km, that will make an impact on pricing and CO2 emission. Deliveries to Czech Republic constitute 35 full truckloads per six months and an average of five loads per month. Some of the least popular directions are Belgium and Denmark with 12 and 17 full truck loads within the six-month period. Route to Belgium is one of the longest 2294 km. Deliveries to Norway have an average of less than one per month, length of the route is relatively short considering sea freight to Sweden of approximately 379 km as it is shown on Map 2. Full truckloads to Slovakia have almost the same amount of four in the six-month period. The most uncommon destination is Spain with one full truckload in six months and the longest route of 3836 km as it is shown on Figure 2.

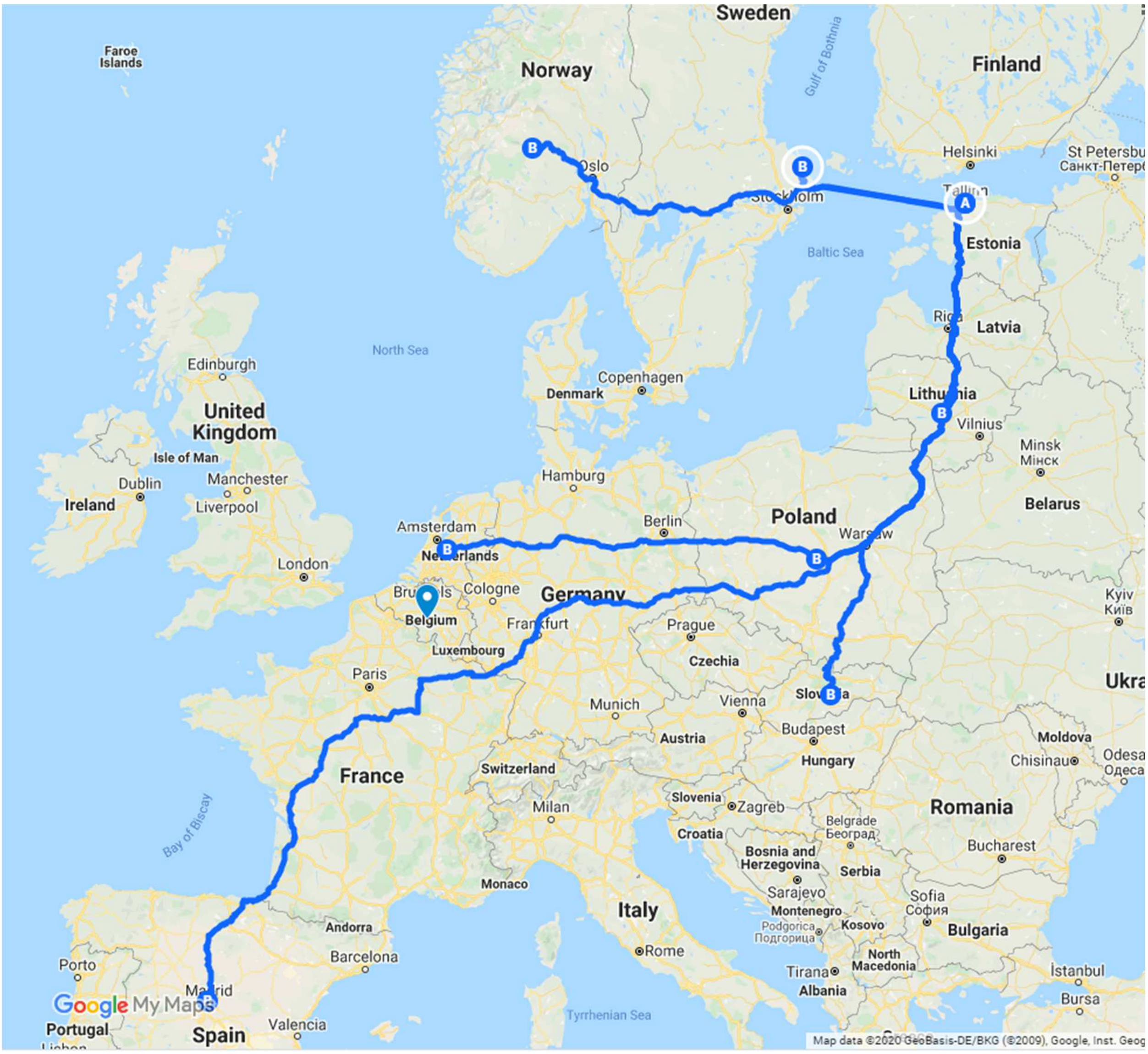

Figure 2. Delivery routes of Company X from Estonia to Lithuania, Netherlands, Norway, Poland, Slovakia, Spain, Sweden

Source: Author's calculations based on data from Appendix 1

3.1.2 Correlation of full and partial truckloads during the month and over the period

Loads delivered each month and during the whole period are highly relevant, as they show the frequency of deliveries to each destination. Number of deliveries affects the overall cost and CO2 emission, which are the main research topics of the supply chain in Company X.

As the amount of data on monthly truck loads to 15 destinations was quite large, it was decided to divide it to full loads and partial loads, for calculations to be clear and illustrative, for future adjustments.

Appendix 2 shows the monthly amount of full truckloads sent to 15 destinations from Estonia. Appendix 2 shows partial truckloads in percent which were sent each month from Estonia to 15 destinations.

As it is shown on Figure 3, the major amount of full truckloads was sent around Estonia, the peak fell on September with 257 loads, the minimum index was recorded in December 83 full loads.

Slovakia, Spain and Norway recorded the smallest number of full truckloads sent during the six-month period, one for each. The only truck load sent for Slovakia was during October, the same for Norway, for Spain during November. Both Spain and Slovakia do not have branches or production units of Company X, that is the main reason why deliveries there are rare.

Latvia shows a steady amount of deliveries from 17 to 31 each month, reaching the maximum level in September and the minimum level in December. Lithuania shows the same picture, with the amount of deliveries from 6 to 22, reaching the maximum amount again in September and the minimum in December.

Poland, Finland and Netherlands have relatively the same amount of full truckloads sent during the six-month period, but Poland had the steady amount of deliveries each month except December with two fixed peaks in July and September, Netherlands had a peak that was twice larger than normal amount of truckloads in July and other months showed steady correlation between five and eight full truckloads each month. Finland’s full truck load curve is jumping up and down each month except October and November when loads reached their maximum of ten per month, just before the rapid fall in December (Figure 3).

Czech Republic and Sweden have similar full truckload indexes. Both showed the maximum amount of full loads sent during Autumn months of October and November, but the difference is that Czech Republic kept the index high until December and Sweden showed a fall to four full loads in December.

France and Germany with 20 and 23 full truck loads sent during the six-month period, show their maximum during the same month of October, but Germany shows a steady number of loads during the whole period while France shows low indexes in the first half of the period and a sudden jump in the second half of the period.

Figure 3 shows relatively the same index of full truckloads sent to Belgium and Denmark, 10 and 14 during the six-month period. Both of them showed growth of indexes during autumn months and zero loads during December.

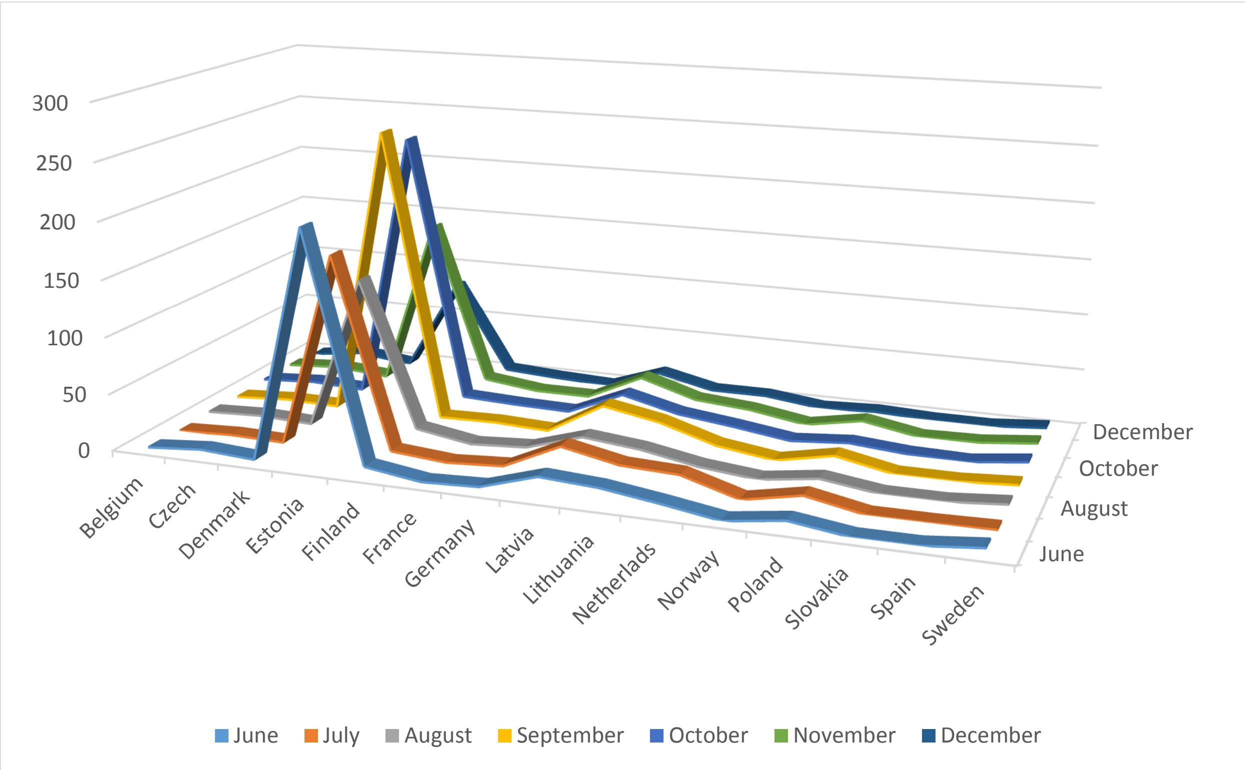

Figure 3. The correlation of full loads delivered by Company X to 15 destinations from June 2019 to December 2019

Source: Author’s calculations based on data from Appendix 2

When it comes to partial loads, Figure 4 shows data scatter, that is sometimes related to the amount of full loads during the six-month period. For example, Poland and Lithuania show a large number of partial loads and the amount of full loads to these destinations is also high. France demonstrates the highest index of partial loads among other destinations, but the amount of full loads is relatively small. Estonia and Latvia have a high index of full loads and a high index of partial loads; Germany has a high index of partial loads and low index of full loads.

The smallest index of both full and partial loads according to Figure 3 and Figure 4 shows Spain, other destinations show similar correlation during the six-month period. All the partial loads are sent separately according to the schedule of Company X.

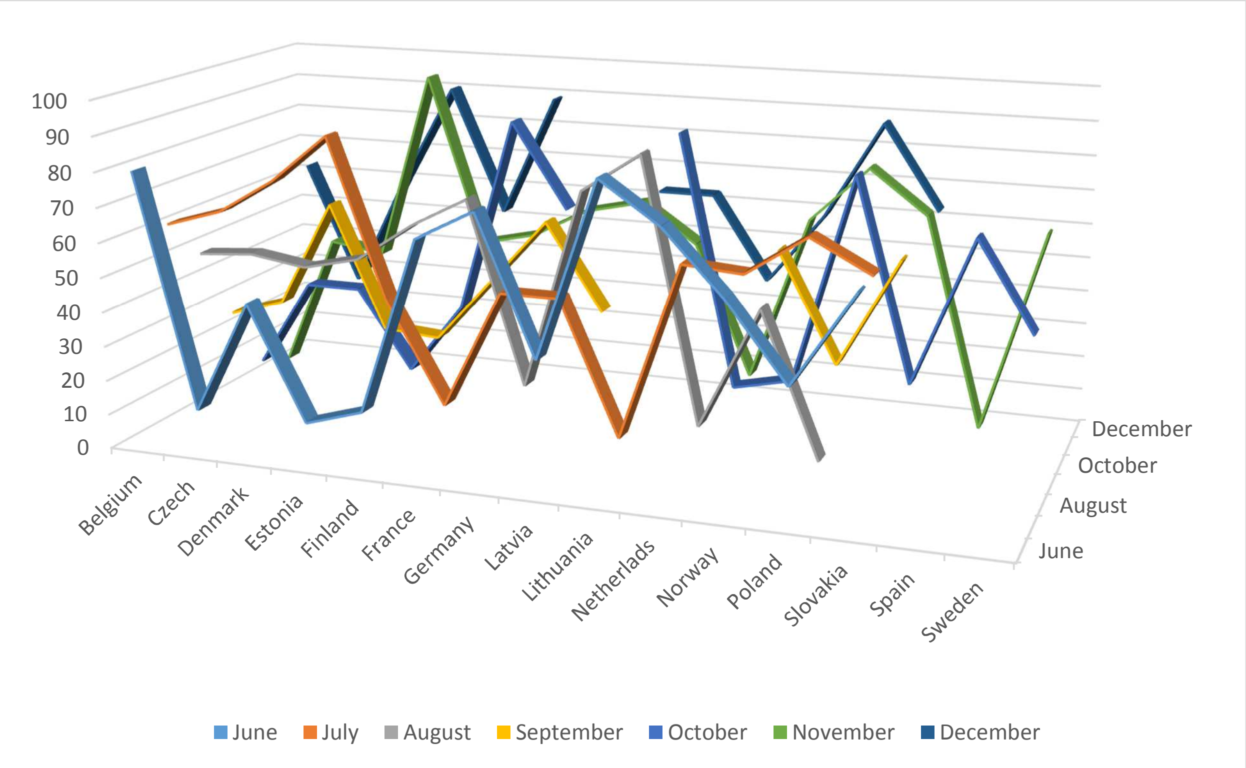

Figure 4. The correlation of partial loads delivered by Company X to 15 destinations from June 2019 to December 2019

Source: Author’s calculations based on data from Appendix 2

3.1.3 Calculation and analysis of fuel consumption for current routes

Fuel consumption affects both of the main aspects of this research, i.e. cost and CO_2 emission. Only by calculating the amount of fuel used the information on emission can be received.

Data received from Company X included the information on the fuel consumption of their trucks, which was needed to calculate fuel consumed on each route. According to the data, the truck fuel consumption varies from 35 to 40 liters per 100 kilometers, depending on the mark, type and year of issue. As it was unknown which truck served which destination, it was decided to calculate the average amount of fuel consumption of one truck. According to the calculations, the average amount is 37.5 liters per 100 kilometers.

Appendix 3 demonstrates the results of the calculations.

The maximum amount of litres was spent on destination to Spain 1438,5 L according to Figure 5. The minimum amount shows Finland and Sweden, considering the current numbers reflect inland transportation only and do not reflect the part of the route done by sea, including time, price, CO_2 emission, fuel consumption of ferry. As Estonia is a small country, distances are relatively short as well, which would be further compensated by frequency of deliveries.

A relatively large amount of fuel is used on routes to Belgium, France and Netherlands. From 966 L to 804 L of fuel used on each trip to the above-mentioned destinations.

Czech Republic, Germany and Slovakia according to Figure 5 show a medium-high amount of fuel used to reach one destination, which varies from 487 L to 595 L. Lower indexes are shown by Poland 425 L to reach one destination and Denmark 375 L to reach one destination. Norway according to Chart 3 has an index of 278 L, but again calculations for both Denmark and Norway do not include sea freight and all the costs and emissions that accompany sea freight. Estonia's closest neighbours are expectedly at the last places on fuel consumption, as both are closely located. Indexes are 139 L for Latvia and 199 L for Lithuania.

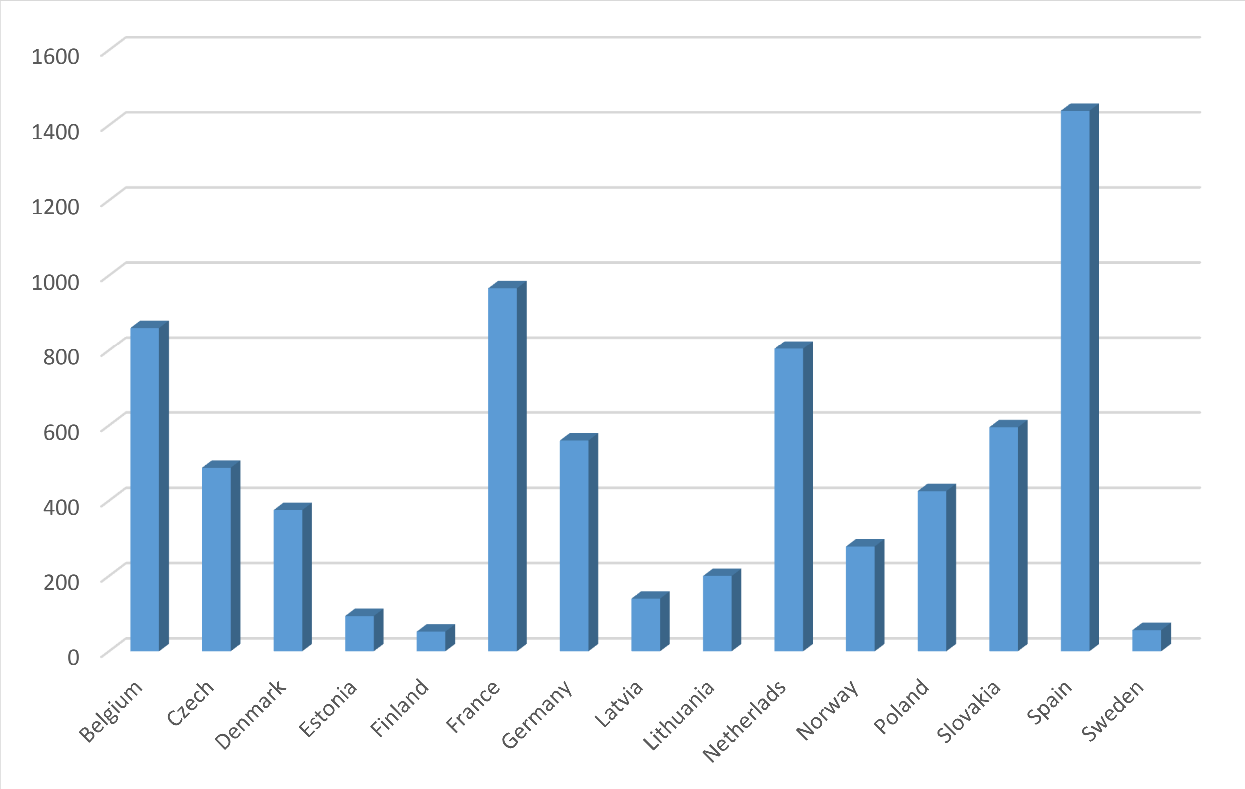

Figure 5. Fuel consumption in liters per each of the 15 routes with the starting point in Estonia

Source: Author's calculations based on data from Appendix 3

The calculations above are made in order to conduct further calculations to figure out what are the CO2 emissions per each of 15 most common routes, with the starting point in Estonia. The amount of fuel used to reach each destination shows the level of pollution that is caused by every delivery even on such relatively short routes like the ones within European Union.

3.1.4 Calculation and analysis of CO2 emission for each route

All calculations in the previous chapters were made in order to see the amount of CO2 emission, which is one of the main questions of the research, that is produced during one trip to a given destination. According to "Guidelines for Measuring and Managing CO2 Emission from Freight Transport Operations" and other similar guidelines on CO2 calculation methods the most accurate way of calculating CO2 emission is by using the energy-based approach, multiplying fuel consumption by CO2 emission factor. In case of inland transport, i.e. trucks, the fuel used is diesel. CO2 emission factor for diesel is 2.9 (Guidelines for Measuring and Managing CO2 Emission from Freight Transport Operations, 2011).

Based on the formula calculations presented in Appendix 4 were made, that show the CO2 emission for each of the 15 destination with the starting point is Estonia. The indexes show the amount of CO2 emission would be made with one truck during one-way trip. Figure 6 demonstrates various CO2 emissions for different routes. As the CO2 emission depends on the fuel consumption and the fuel consumption depends on the length of the route, indexes are interdependent with indexes in Figure 5, that show the correlation of fuel consumption depending on the destination.

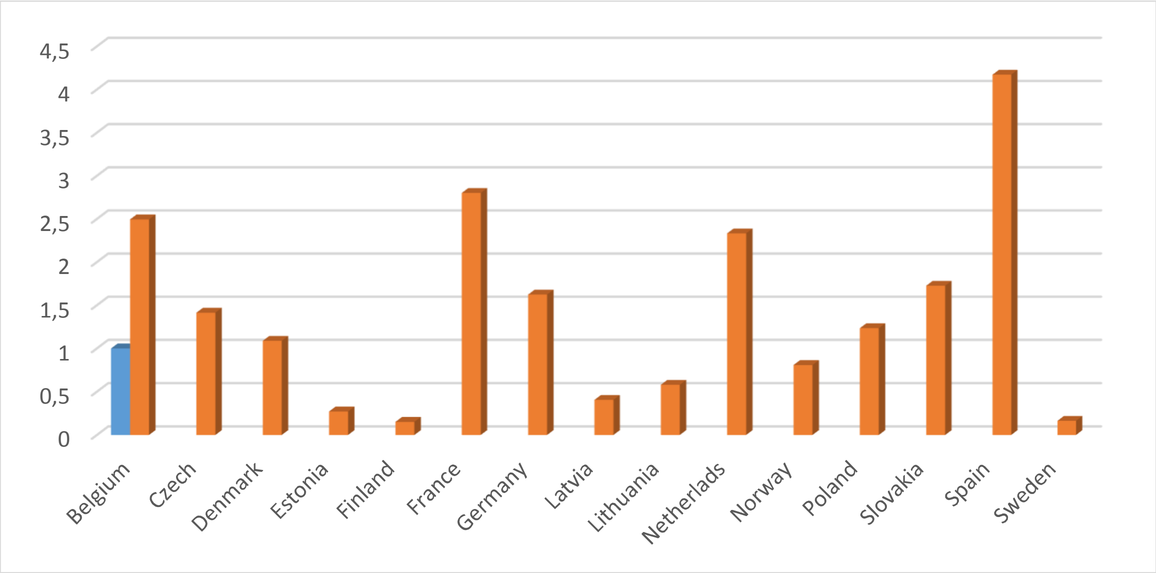

Figure 6. Correlation of CO2 emission depending on the length of each of the 15 routes with the starting point in Estonia

Source: Author's calculations based on data from Appendix 4

The longest routes to Spain, France and Belgium are responsible for producing the largest amount of CO2 emission. Reaching closer to Estonia destinations, like Latvia, Lithuania, Finland and Sweden are responsible for producing less CO2 emission, but only if the frequency of deliveries is not taken into consideration. Czech Republic, Poland, Slovakia and Germany are having medium index of CO2 emission, which is expected as it correlates with the fuel consumption for these routes (Figure 6).

Using the results of calculations made in this chapter, it is possible to make further calculations on full and combined truckloads and amount of CO2 emission that will be produced, depending on the load of the truck.

3.1.5 Calculation and analysis of CO_2 emitted by delivering full and partial load

The author decided to make an intermediate change to the current supply chain model. As Company X is currently sending partial loads according to the schedule, without forming full loads in order to reduce CO_2 emission and cost. In these circumstances, the CO_2 emission level is higher, as the vehicle is making the same transportation, with the same fuel consumption but is only partially loaded. The logical step would be calculating and analyzing possible benefits in emission and cost of forming groupage cargo. The percent of CO_2 emission produced by delivering partial load as groupage cargo and CO_2 emission produced by sending it separately are analyzed in this paragraph.

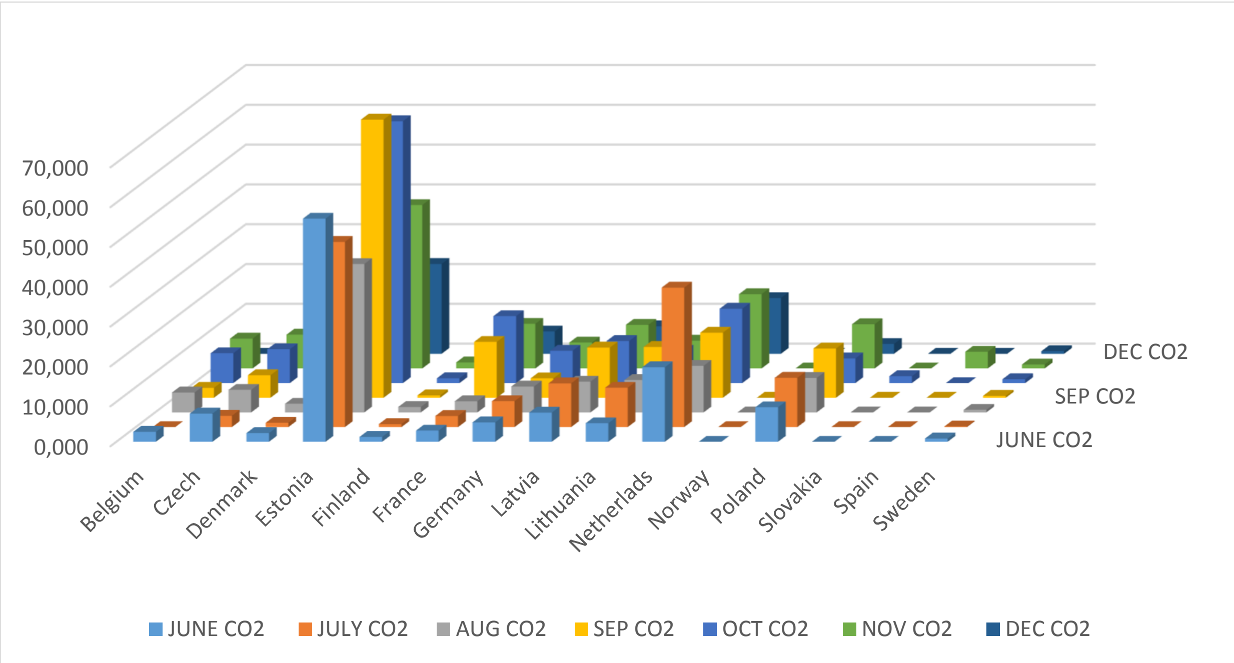

Figure 7. CO_2 emitted from delivering full loads to 15 destinations with the starting point in Estonia over the six- month period

Source: Author’s calculations based on data from Appendix 5

In order to record and analyze the difference of emission of full load delivery and partial load delivery the combined table was created (Appendix 5). The indexes of CO_2 emission for partial loads are next to the indexes of CO_2 emission for full loads for the same destination for comparison. In cases when partial loads are delivered separately the level of emitted CO_2 is the same as from the delivering the full load. In the context of environmental sustainability, it is an unnecessary pollution that might be reduced by forming groupage cargo.

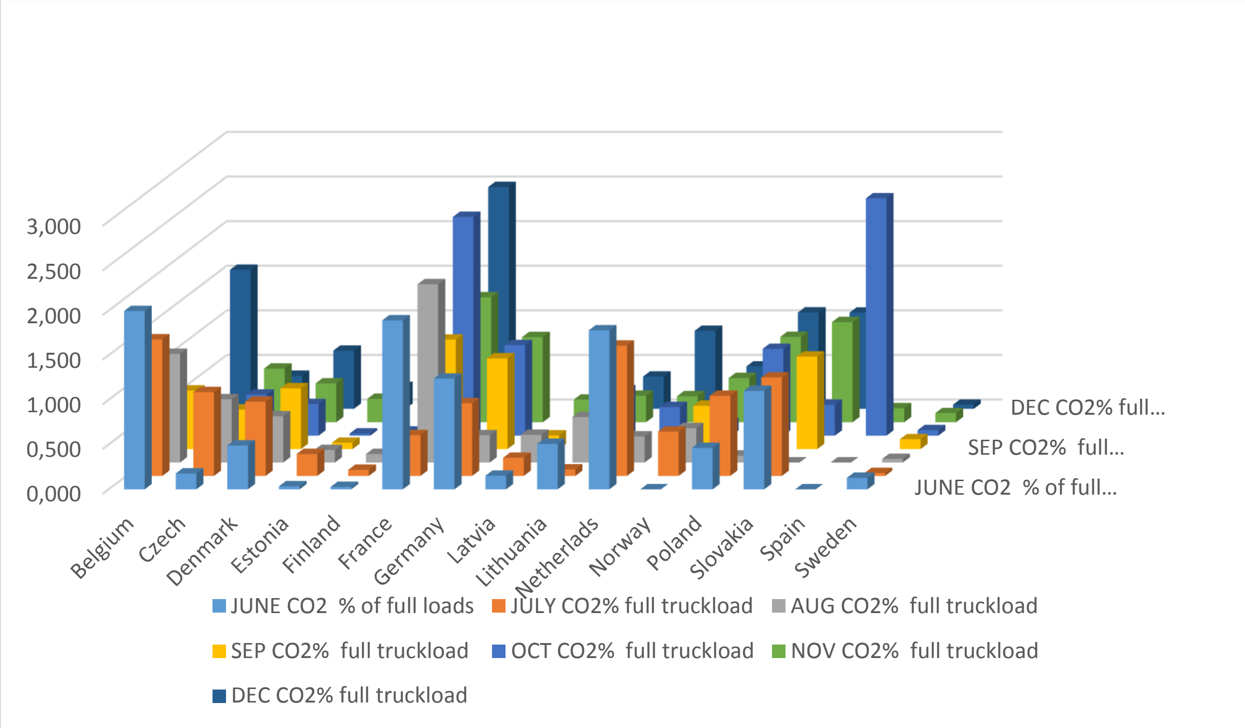

Figure 8. CO2 emitted from delivering partial loads to 15 destinations with the starting point in Estonia over the six- month period

Source: Author's calculations based on data from Appendix 5

Figure 7 demonstrates monthly CO2 emitted over the chosen period by delivering full loads. Figure 8 has the same data on the partial loads. In case sending groupage cargo will become a usual practice for Company X, the numbers on Figure 8 will reduce almost twice (Appendix 5). Reaching this goal may be less time inefficient in case the whole supply chain model will be optimized, according to the vehicle routing problem, which is the next step of this research.

3.1.6 Calculation and analysis of cost formed by delivering full and partial load

The first research question requires calculating cost of delivery using each of the 15 routes with the starting point in Estonia that were used by Company X in 2019. To figure out the optimal way of truck delivery from Estonia to main destinations, calculation of the cost is one of the key factors. Appendix 6 demonstrates the outcome of the cost calculation of one delivery using each of the 15 routes.

As expected, the longest routes have the highest cost, like Spain, France and Netherlands. Finland and Sweden have the lowest costs; however one should not forget that sea freight charge is not considered in the calculations. Figure 9 demonstrates the correlation between costs for deliveries to different destinations with the starting point in Estonia.

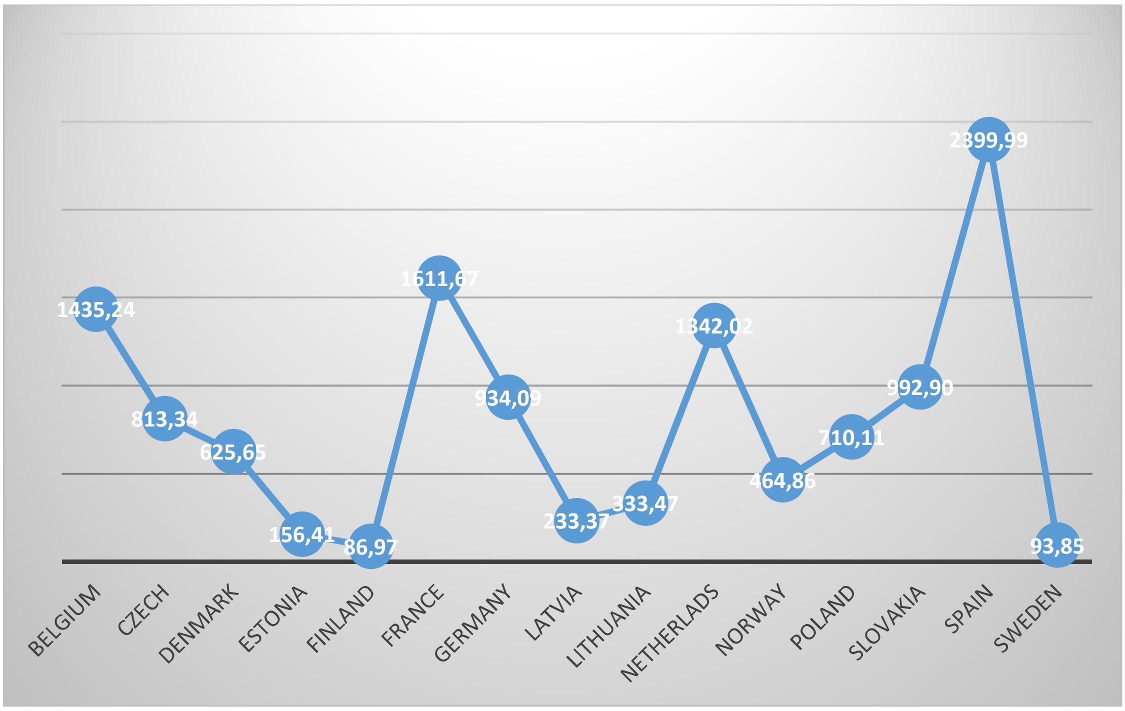

Figure 9. Correlation of cost depending on the distance of each of the 15 routes with the starting point in Estonia

Source: Author's calculations based on data from Appendix 6

As mentioned above, Company X is sending cargo according to schedule, partial loads that are left each month were sent by a separate delivery, instead of forming a groupage cargo. Within these conditions, the costs are higher along with the CO_2 emission rate, since the vehicle is making the same transportation, but it is only partially loaded. The percentage of the cost generated by delivering partial load as groupage cargo and cost generated by sending it separately are analyzed in this paragraph.

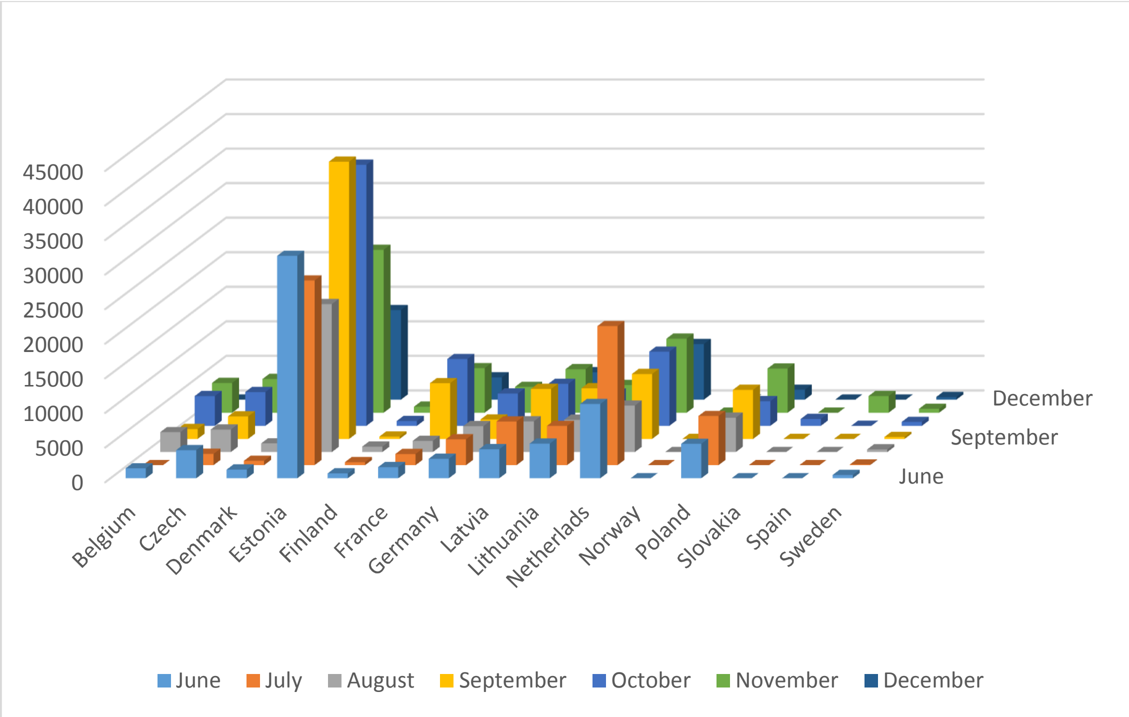

Figure 10. Cost of delivering full loads to 15 destinations with the starting point in Estonia over the six- month period

Source: Author's calculations based on data from Appendix 7

The overall cost of delivery of full loads correlation over the six-month period is demonstrated on Figure 10. As expected, the cost depends on the mileage of the route and the frequency of deliveries, and consequently, the amount of loads. Figure 11 shows the same data for the partial loads. In cases when they are delivered separately, the cost is the same as for the full load, which is inefficient from the financial side.

Appendix 7 shows the total amount of monthly costs for partial deliveries for each route. The second index in the table presented in Appendix 7 for comparison is cost of full truck load delivery to each destination. According to the data, forming groupage cargo will be a reasonable move for Company X in order to reduce costs. Overall tendency shows the large difference in cost between partial loads are sent as groupage cargo and when they are sent separately.

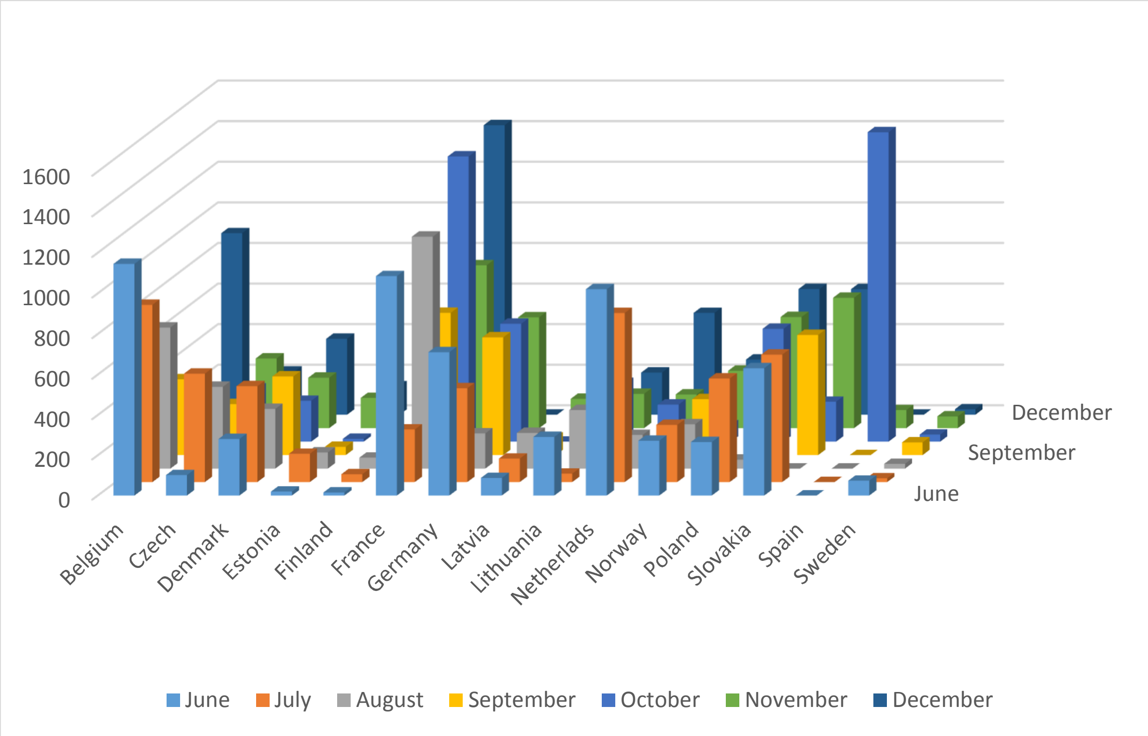

Figure 11. Cost of delivering partial loads to 15 destinations with the starting point in Estonia over the six- month period

Source: Author's calculations based on data from Appendix 7

From the data received from Company X and calculated by the author, it is clear that both CO2 emission and costs are much lower if partial loads are sent as groupage cargo. The numbers convincingly prove that from a financial point of view and in terms of environmental sustainability groupage cargo deliveries are the most efficient. However, it does have one weak aspect, which is time. Creating groupage cargo takes time that Company X is not interested in wasting. This is where the second phase of the research will offer the solution. Creating combined routes will provide the opportunity to create groupage cargo and minimize the time loss.

3.2 Analysis of optimized supply chain model of Company X

Routes of the current supply chain model of Company X are created according to the time saving strategy. Every route is done separately in most cases with full truckload, according to the information received from Company X. In case the amount of cargo left by the end of the month does not create a full truckload, it is sent as a partial load in a half-empty truck. This delivery system is aimed at saving time, as Company X is not a logistics company, they subcontract logistics services and firstly try to fulfill their supplying needs. With the limited information received from Company X, an alternative delivery system was created and calculated with the goal of reducing CO2 emissions and the cost of delivery. In order to answer the second research question optimized supply chain model was created taking into account vehicle routing problem's principles, that were chosen as the most appropriate to follow in creating optimized supply chain model, according to the needs of Company X and the data provided to the author (Baker and Ayechew, 2003).

3.2.1 Description and justification of alternative routing system

The central objective of the current research is to offer an optimized supply chain model to replace the current one, which was proven to be less efficient in the previous paragraph model. Author chose to optimize the routing system. Optimized routes were created according to the maps, mileage and amount of cargo. The only routes that were left separate are within Estonia and Finland, as both destinations are so close, there is no need in combining them with other destinations.

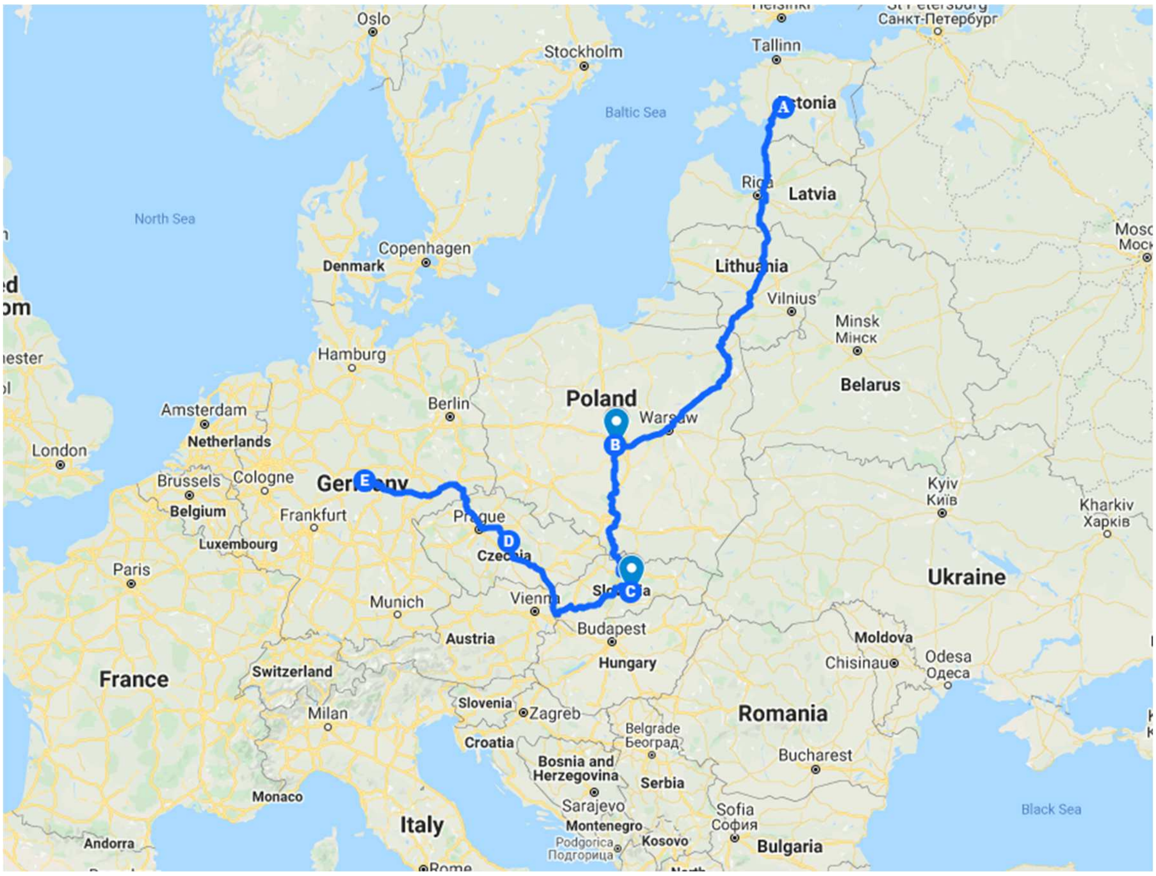

Figure 12. Combined route from Estonia to Germany with transitional stops in Poland, Slovakia and Czech Republic

Source: Author's calculations based on data from Appendix 8

Figure 12 demonstrates the optimized route from starting point in Estonia to Poland-, Slovakia-, Czech Republic with the end point in Germany. Only Germany being the final destination is mentioned for brevity but all of the above-mentioned destinations will be included in one route. Map 4 shows the optimized route with a starting point in Estonia and next stops in Sweden, Norway and with the end point in Denmark. This route includes two sea freights, from Estonia to Sweden and from Norway to Denmark. As in the previous calculation (see above), the sea freight was eliminated from calculation, since the amount of CO2 emission and costs in this research is calculated for inland transportation (truck deliveries) only. In future paragraphs this route will be named ‘Denmark’ for brevity.

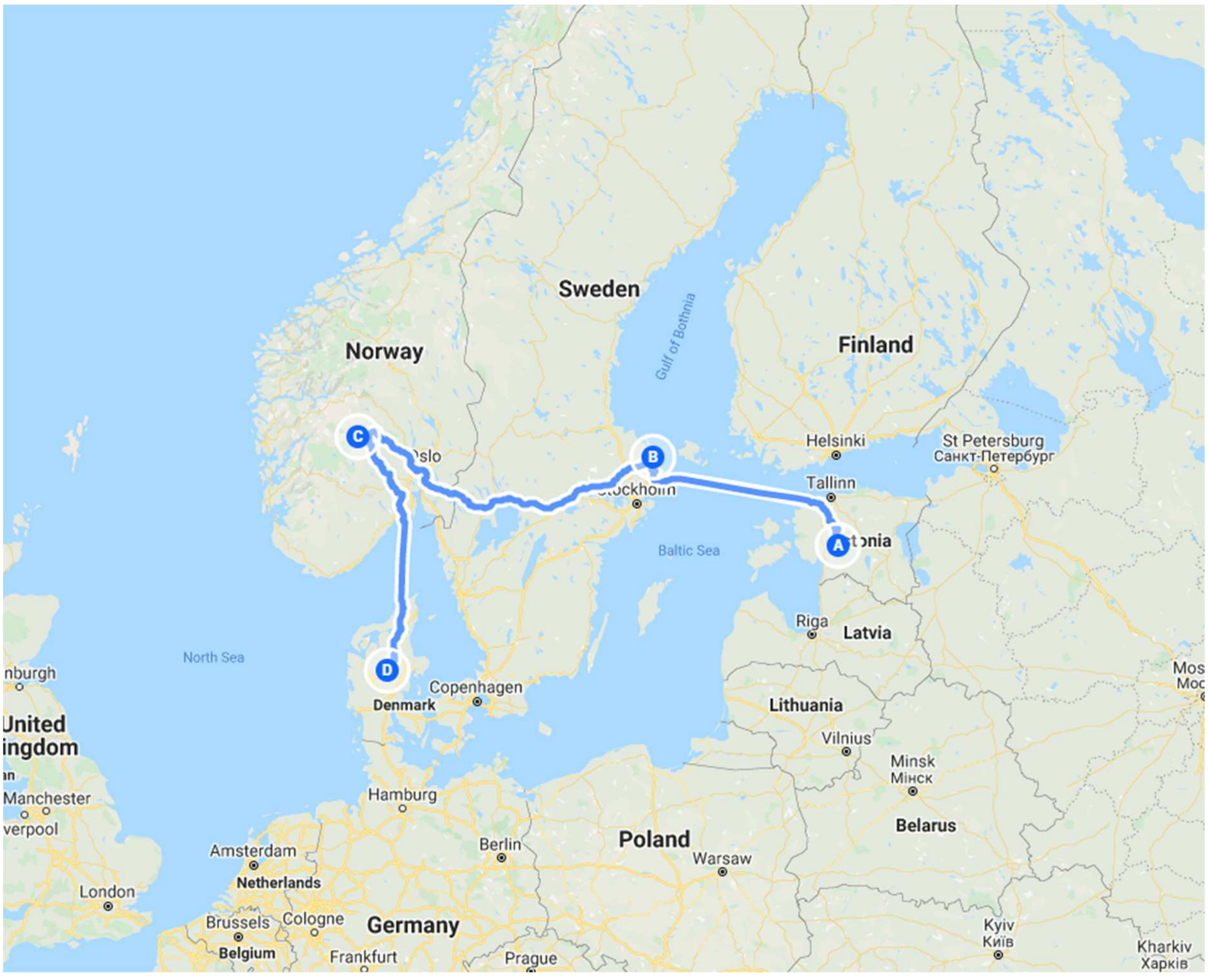

Figure 12. Combined route from Estonia to Denmark with transitional stops in Sweden and Norway

Source: Author’s calculations based on data from Appendix 8

Figure 13 shows a relatively short optimized route with the starting point in Estonia with the intermediate point Latvia and the end point in Lithuania. The monthly amount of cargo to both Latvia and Lithuania is large, deliveries that use the alternative route will be constant.

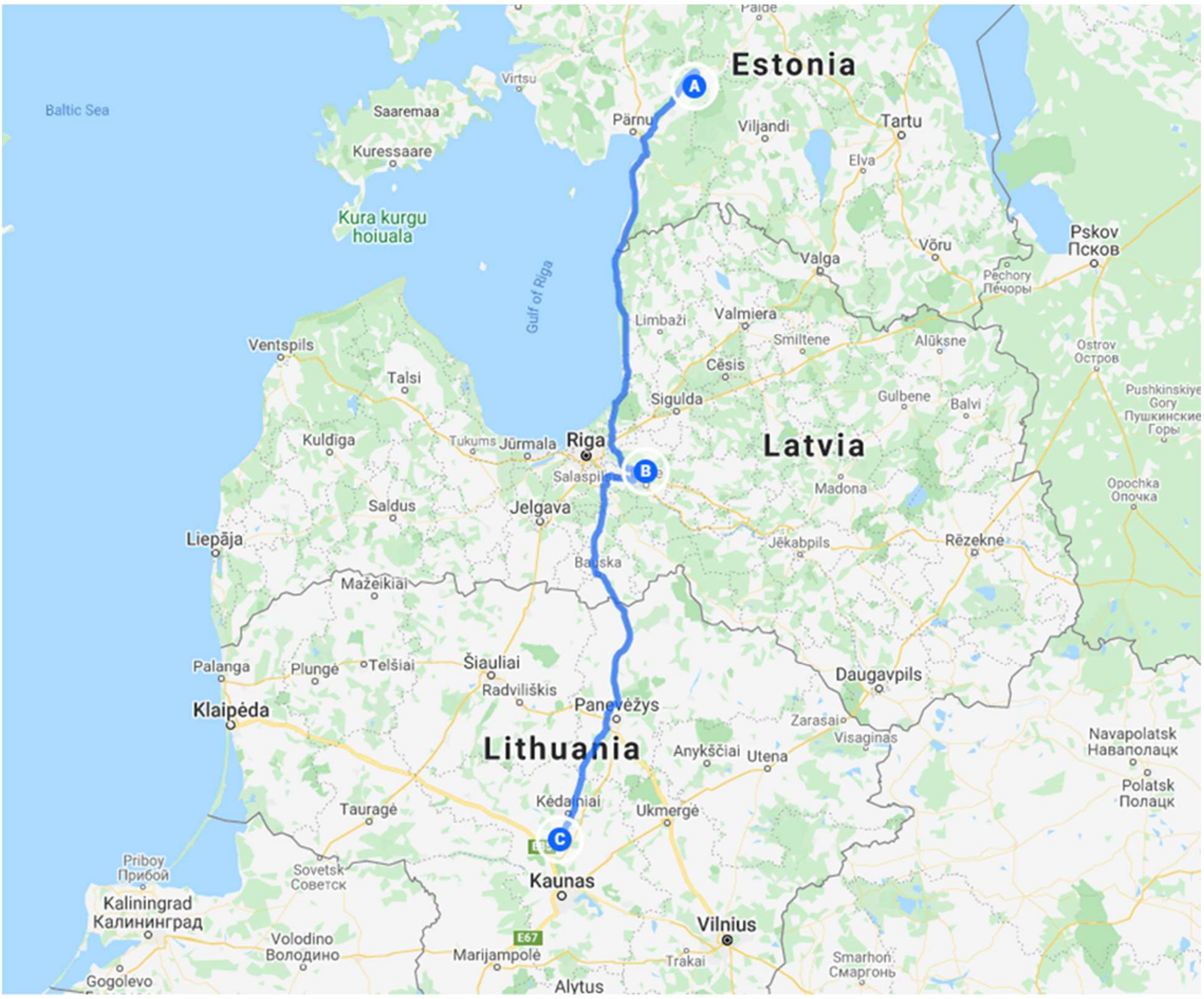

Figure 13. Combined route from Estonia to Lithuania with transitional stop in Latvia

Source: Author’s calculations based on data from Appendix 8

The final optimized route is demonstrated on Figure 14 is also the longest one. With the starting point in Estonia with stops in Netherlands-, Belgium-, France- and the end point in Spain. Again, the new destination will be called ‘Spain’ for brevity, but will include all above-mentioned destinations.

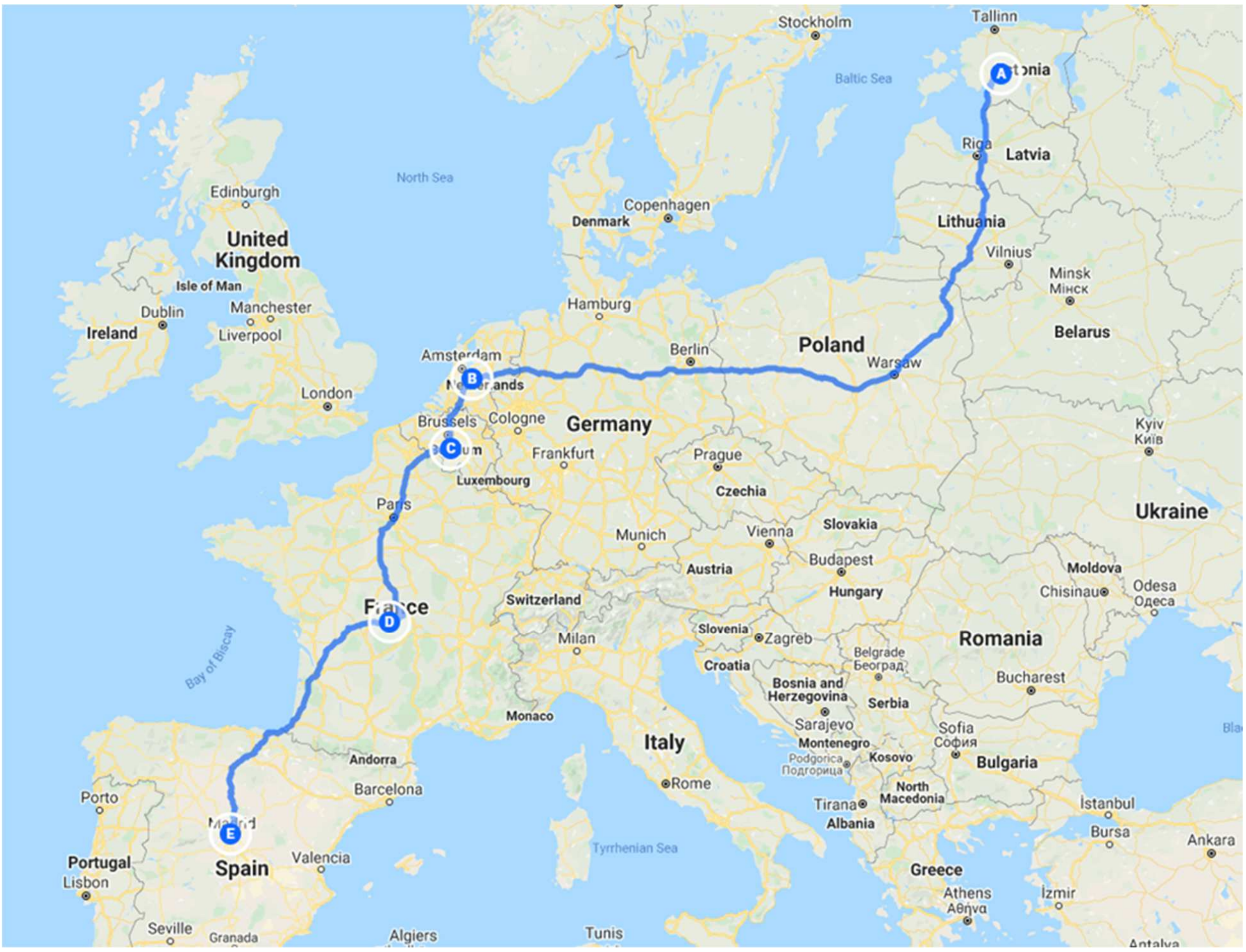

Figure 14. Combined route from Estonia to Spain with transitional stops in Netherlands, Belgium and France

Source: Author's calculations based on data from Appendix 8

Using the vehicle routing problem and operating with the limited amount of data received from Company X alternative routing system was created taking into account supplying needs of Company X, current delivery system (current routes), amount of cargo delivered monthly. The optimized system was aimed at combining routes according to the destinations in order to decrease the amount of deliveries and fuel consumption, which will lead to reduction of CO2 emission and costs.

3.2.2 Correlation of truckloads sent using optimized routes during the six- month period

The amount of cargo sent to each of the alternative routes, making the amount of loads to be of crucial importance in the context of answering the research question. The amount of loads shows the frequency of deliveries using each route and is directly affecting the overall CO2 emission produced over the analyzed period and the cost of deliveries.

The amount of loads sent to each of the new destinations that were named by the end points of each route, is much higher, due to combining cargo being sent via different routes. As done in the previous paragraph, the loads were divided into full and partial for convenience. Lithuania demonstrates the largest amount of cargo sent. The same picture was demonstrated in the analysis of the current delivery system, in which both Latvia and Lithuania showed a large amount of cargo sent. The amount of cargo sent around Estonia stayed the same as the route was not changed. According to the data, Estonia has the largest amount of cargo sent, even considering combined routes. Fluctuations of cargo sent using German route was between 9.76 and 21.44, with the peak in November and drop at the end of half-year in December (Appendix 8). Denmark's destination shows the largest loads during the autumn months and minimum during July. According to the data in Appendix 8, the amount of cargo sent to Spain fluctuates from 9.33 to 18.71 each month. As the destinations were combined, loads grew according to monthly deliveries.

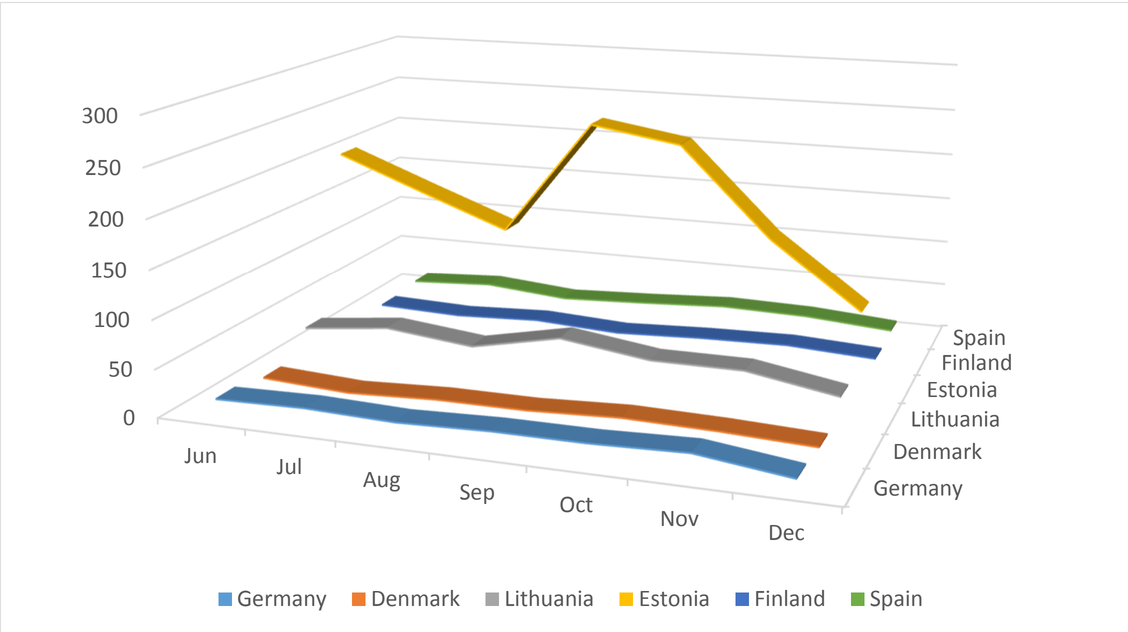

Figure 15. The correlation of full loads delivered by Company X using combined routes from June 2019 to December 2019

Source: Author's calculations based on data from Appendix 8

Correlation of full and partial truckloads of combined routes is demonstrated on Figure 15 and Figure 16. Estonia shows the largest amount of full loads, Lithuania and Germany are on the second and third place according to Figure 15. The fluctuation of amounts of partial loads is less chaotic due to combined loads being delivered to different destinations that creates more opportunities for creating a full load.

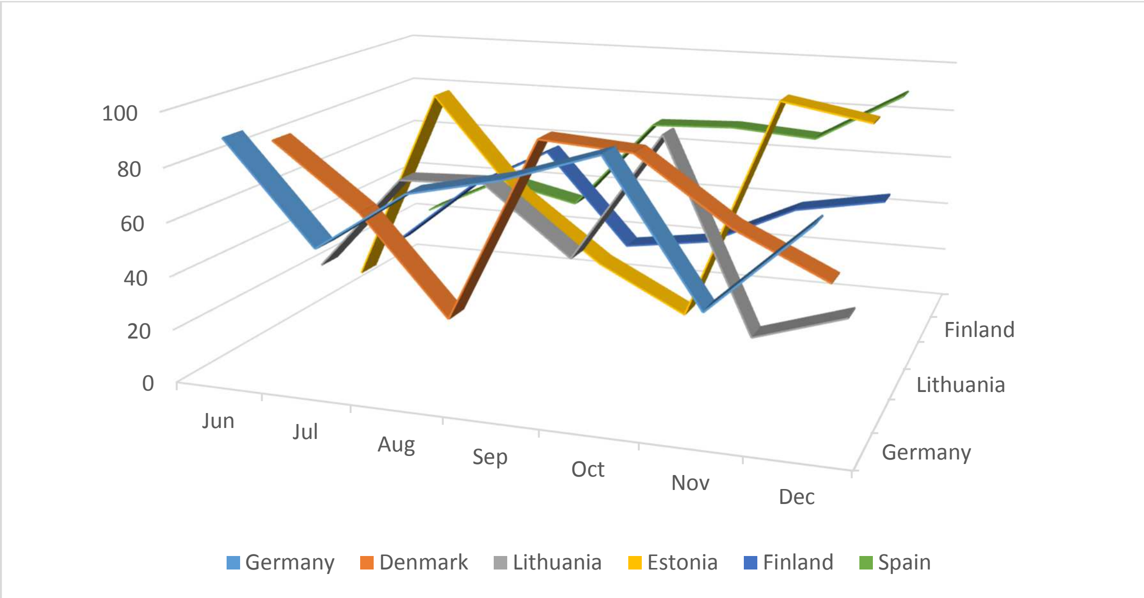

Figure 16. The correlation of partial loads (in percent of full loads) delivered by Company X using combined routes from June 2019 to December 2019

Source: Author's calculations based on data from Appendix 8

3.2.3 Calculation and analysis of fuel consumption for optimized routes

The fuel consumption directly affects both CO2 emission and cost. The optimized supply chain model must be more efficient in both of these dimensions. In order to answer the second research question fuel consumption is calculated according to the new mileage.

All calculations in this paragraph were made using the same data as in paragraph 3.1.3., since the same vehicles with the same fuel consumption per 100 km are used here as well; the only variable that has changed is mileage. Due to routing optimization, the mileage has grown for each of the alternative routes.

The calculated fuel consumption values of combined routes are presented in Appendix 9.

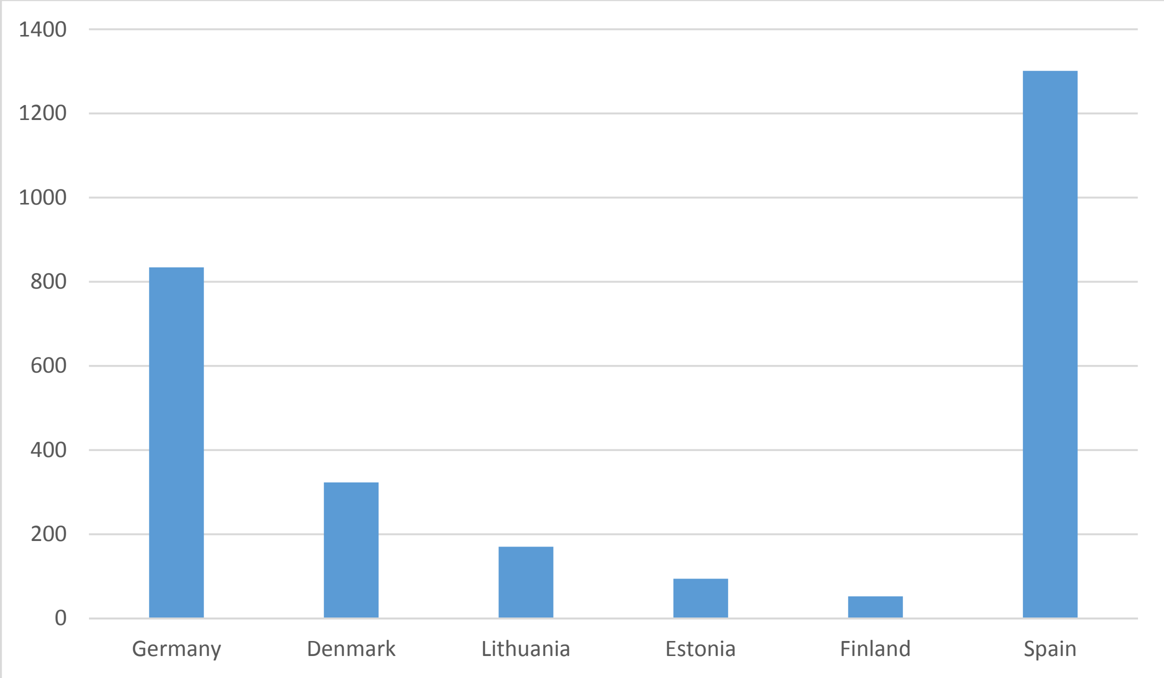

Figure 17. Fuel consumption in litres per each of the combined route with the starting point in Estonia

Source: Author's calculations based on data from Appendix 9

As expected, the largest fuel consumption is detected in the routes with the largest mileage, Spain and Germany according to Figure 17. Additionally, these destinations now have two stops, which is adding mileage as well. Finland and Denmark have a smaller mileage, due to the fact that the sea freight was not counted in the calculations for both the current delivery system and the optimized one. Compared to the amount of fuel consumed using the current routes, the amount of fuel decreased.

3.2.4 Calculation and analysis of CO2 emission for each optimized route; full and partial loads

Second research question requires calculating CO2 emission coefficients for each of the combined routes in order to proceed with further analysis.

Using the fuel consumption calculated in the previous paragraph, the CO2 emission for the combined routes was calculated. Same method that was used in paragraph 3.1.4 was used to calculate CO2 emission coefficients per one route for combined routes.

Received numbers are presented in Appendix 10.

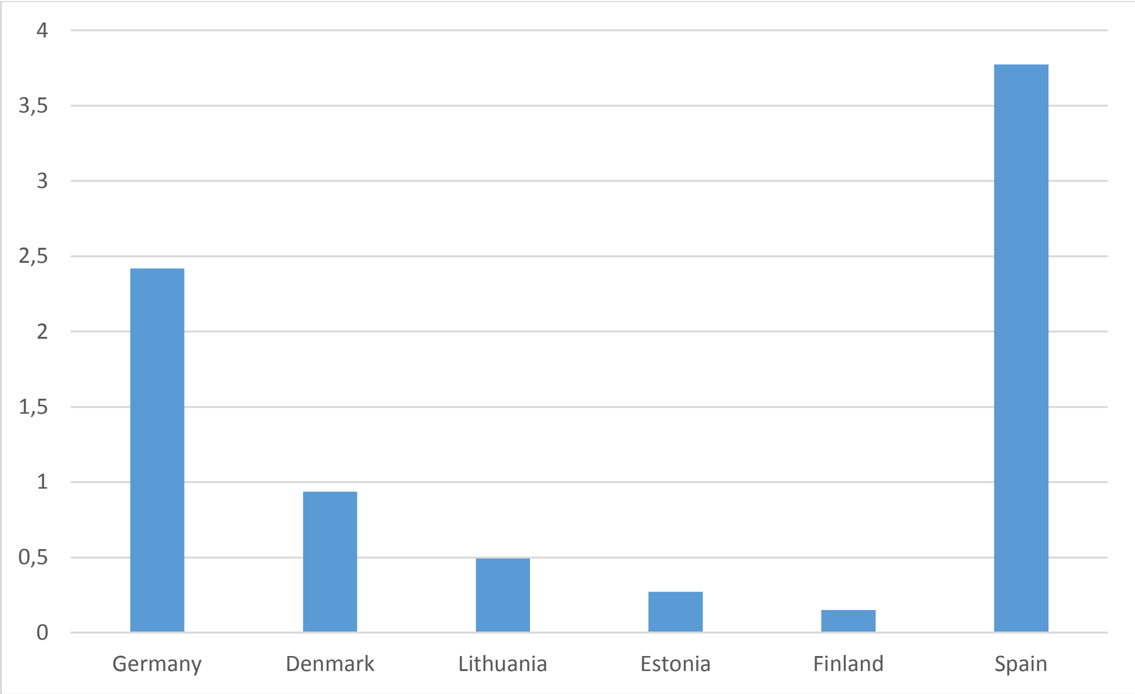

Figure 18. Correlation of CO2 emission depending on the fuel consumed using each of the combined route with the starting point in Estonia

Source: Author's calculations based on data from Appendix 10

As it is demonstrated in Figure 18, the correlation between CO2 emission is high. The largest coefficients are shown in Spain and Germany, which is expected as these routes are the longest and have the largest fuel consumption. Estonian and Finnish route CO2 coefficient includes only emission produced by inland transportation, as sea freight was not included in the calculation. CO2 emission for these destinations is relatively low.

In Appendix 10 the monthly amount of CO2 emission of full truckloads for each of the combined routes is presented. The CO2 emission was calculated from the CO2 emission coefficient for each route multiplied by the number of loads. The correlation is shown in Figure 19 where the highest emission is detected in Spain and Germany and the lowest emission is detected in Finland. Since the sea freight emission was not included in the calculation and the distance from Estonia is small, the CO2 emission is expectedly low. Also the route to Finland was not changed due to its small distance. Largest fluctuation is noticed in Spain due to a large difference in monthly full loads.

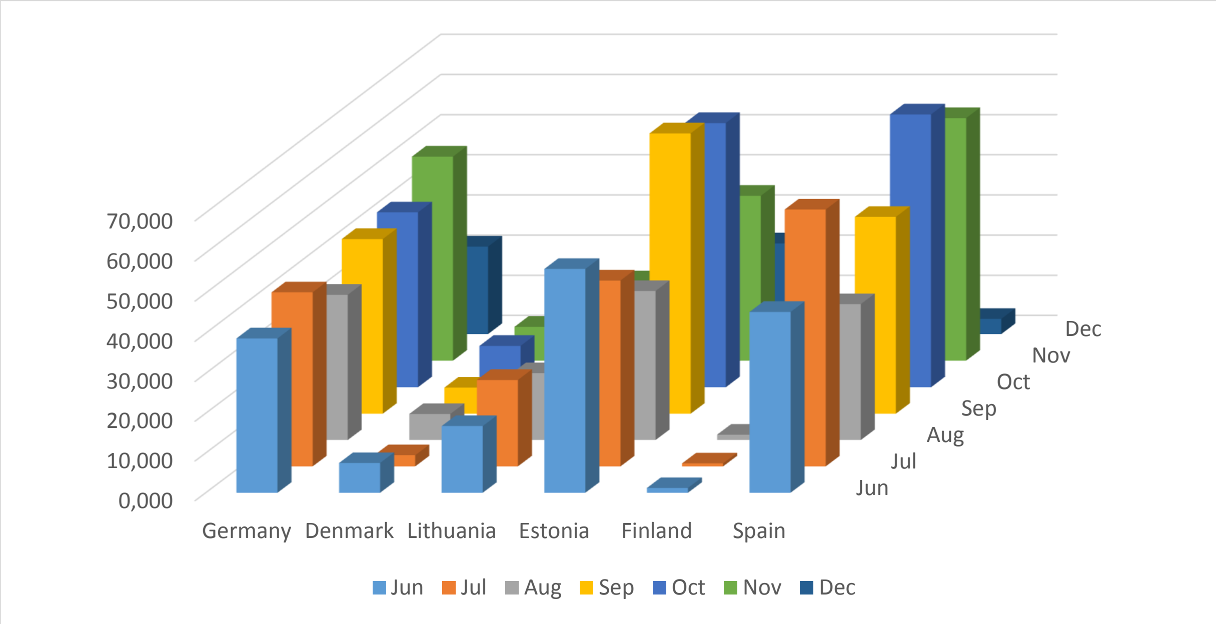

Figure 19. CO2 emitted by delivering full loads using optimized routes over the six- month period

Source: Author's calculations based on data from Appendix 10

In Appendix 10 calculated CO2 emission of partial loads for combined routes is presented. Spain is showing the highest monthly emission due to the long distance, Germany is in second place, due to the distance and large amount of partial loads every month. All of the other routes show low CO2 emission and fluctuation during the six- month period (Figure 20).

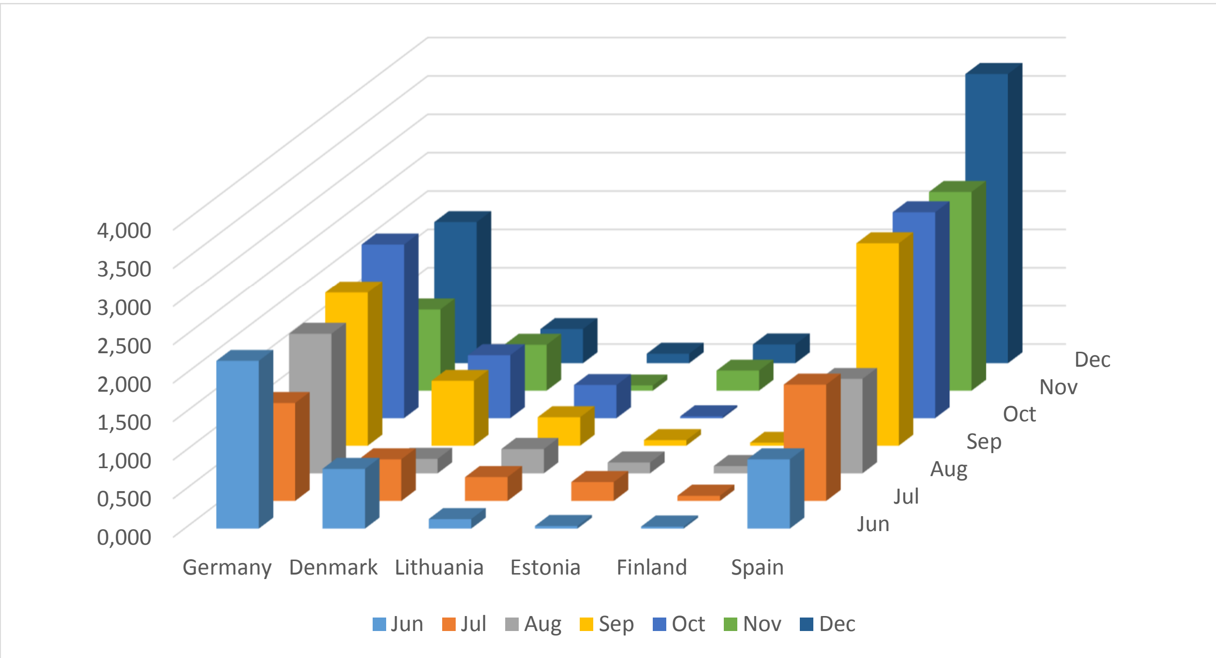

Figure 20. CO2 emitted by delivering partial loads using optimized routes over the six- month period

Source: Author's calculations based on data from Appendix 1

3.2.5 Comparative analysis of CO2 emission produced by using current routes and optimized routes

From the received data on CO2 emission and monthly loads, Appendix 11 was created to compare monthly CO2 emission of current routes and optimized. The numbers decisively prove that using combined routes, which include from two to four stops in key destinations are more effective in terms of lowering the CO2 emission. Figure 21 shows more than 50% difference in emission for all the routes, except those that were not optimized, i.e. Estonia and Finland. For routes with larger mileage like Spain the gap grows to 60%. The same picture can be seen in CO2 emission data gathered in July, August, September, October and November. In December the amount of CO2 emission is lower on almost every route, due to the reduction of the number of loads by the end of half year, but still the fluctuation of emission stays the same as during other months.

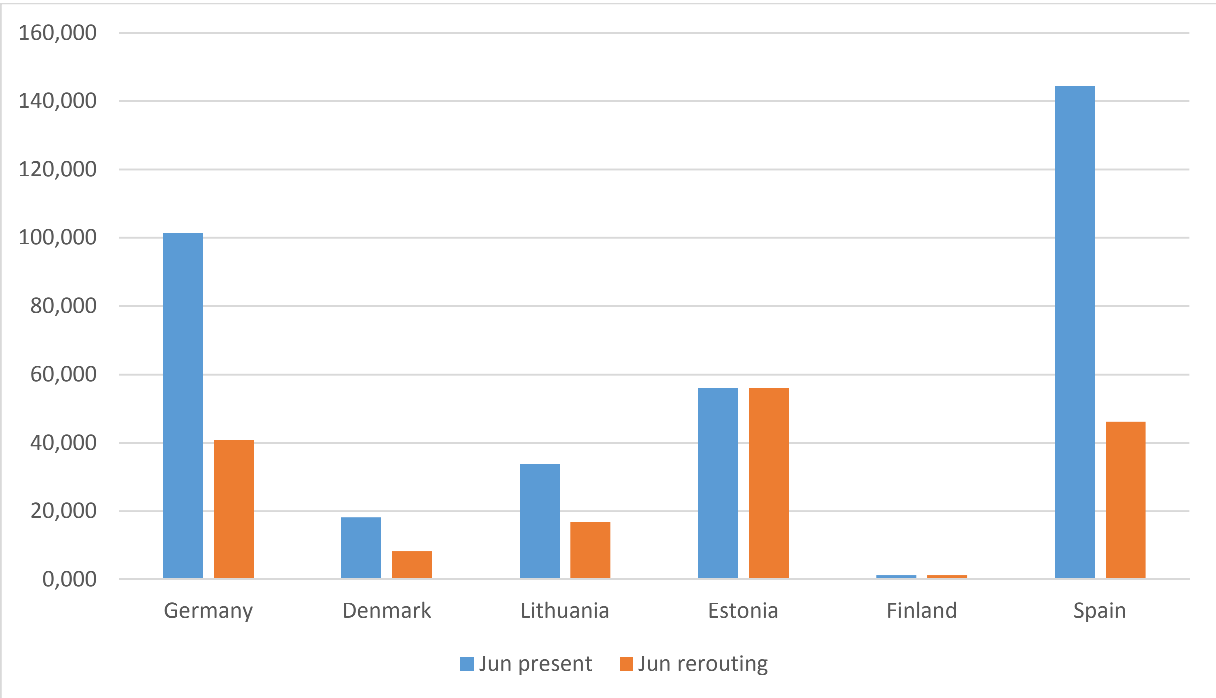

Figure 21. Comparison of CO2 emission produced by using current route and optimized on the example of deliveries executed in June

Source: Author's calculations based on data from Appendix 11

From Appendix 11 and Figure 21 the overall CO2 emission win can be calculated. CO2 emission for six month deliveries using the current delivery system produced 2604.57 tonnes CO –emissions and in case optimized routing system will be implemented the CO2 emission will reduce to

1193.75 tonnes CO. The 2.2 difference proves efficiency of calculated routing optimization strategy.

3.2.6 Calculation and analysis of cost of each optimized route

The cost per each optimized route is a part of the research question. Proving that the optimized supply chain model is more cost efficient, which in turn proves the research hypothesis.

The same method of cost calculation as described in paragraph 3.1.6. was used to calculate the total cost of one ride using each optimized route. All of the original costs stayed the same, but the fuel consumption, salary, insurance and amortization changed due to the change of routes. The total costs of combined routes are presented in Appendix 12. Cost correlation is shown in Figure 22, expectedly the longest route is responsible for the highest cost. Close destinations like Lithuania have a relatively low cost. For destinations like Finland and Denmark sea freight cost was not included in the calculation as this research is focused on inland transportation only.

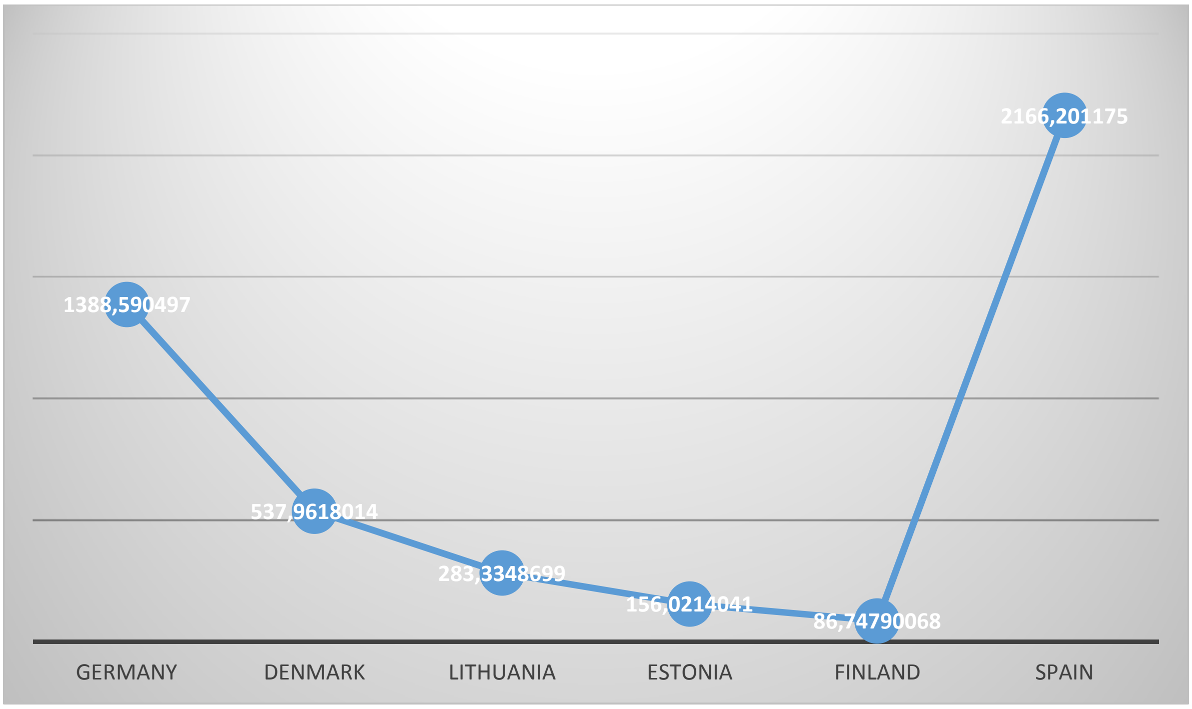

Figure 22. Correlation of cost of delivery in EUR depending on the distance of each of the combined routes

Source: Author’s calculations based on data from Appendix 12

In Appendix 12 costs per one delivery of current routes and combined are compared. The correlation of costs is presented in Figure 23. For the routes that were optimized, Spain, Germany, Lithuania and Denmark more than 50% difference was noticed. For longer routes like Spain and Germany 70% and 60% difference in total cost per one delivery was detected. The numbers show a potential financial benefit from routing optimization.

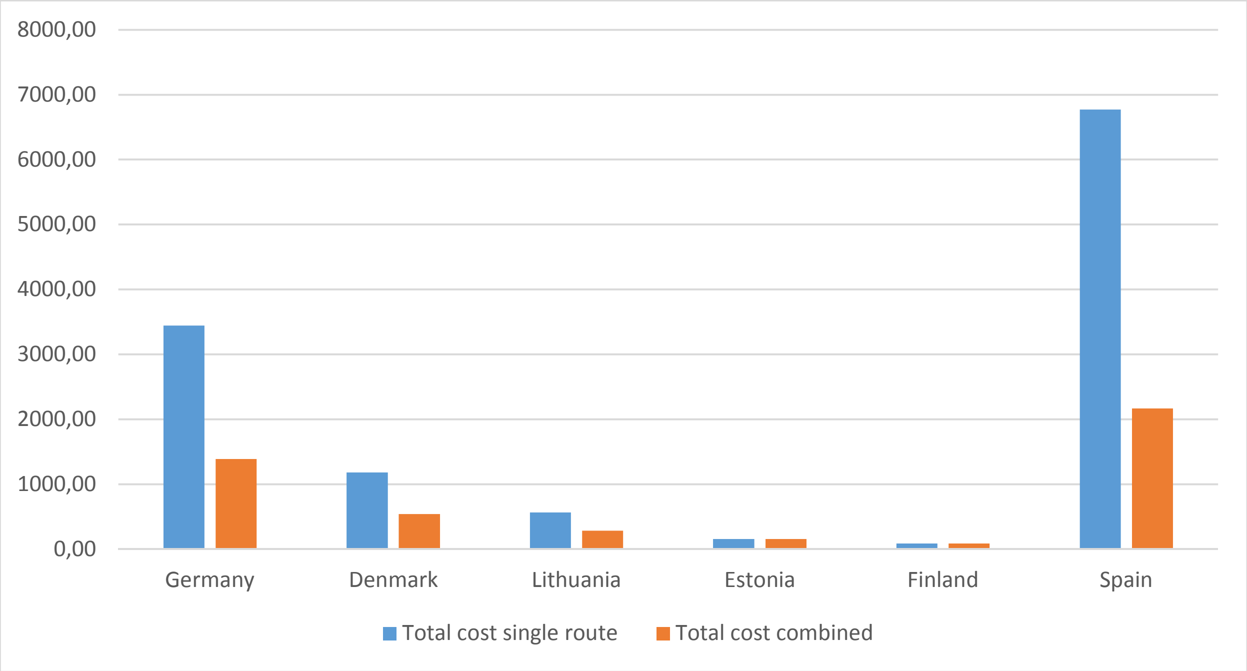

Figure 23. Comparison of cost of delivery in EUR using current routes and optimized routes
Source: Author's calculations based on data from Appendix 12

3.2.7 Comparative analysis of cost of delivery by using current and optimized routes

From the received calculations, a comparative table in Appendix 12 was created. Monthly costs on each route are shown, depending on the number of loads each month and length of the route (number of stops). The monthly cost correlation is presented in Figure 24 using the example of deliveries executed in June, more than 50% difference in costs was detected on every route that was optimized. For longer routes like Spain and Germany the difference grows to 60%. The same difference in costs is presented in the chart for July, August, September, October and November, with the difference in number of loads, which changes total costs per month. In December the costs expectedly fall to their minimum, as the number of loads by the end of the half-year gets to its lowest, but the difference in costs stays the same as during other months.

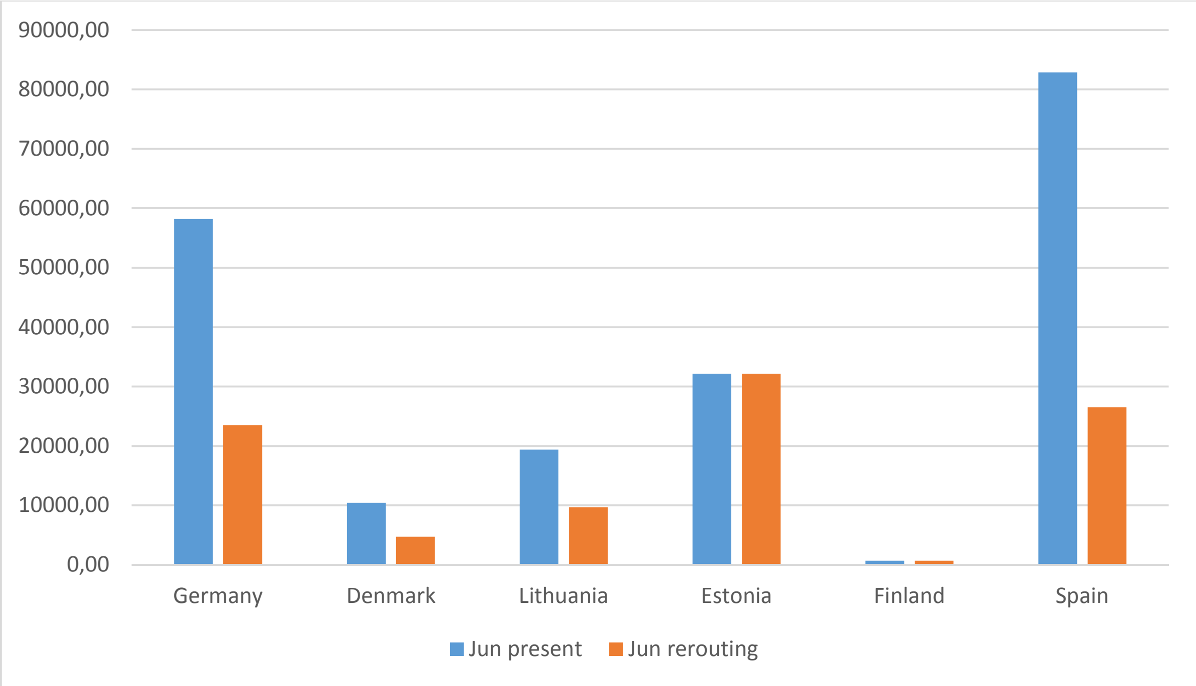

Figure 24. Comparison of cost in EUR of delivery using current and optimized on the example of deliveries executed in June

Source: Author's calculations based on data from Appendix 12

Based on the estimated data presented in this chapter, the overall benefit from routing optimization is clear. The total cost of deliveries during the six-month period using the current delivery system is 1 494 692.83 EUR. According to the calculations of the costs of optimized routes total delivery cost of Company X will be 685 059.20 EUR. 2.1 difference is detected in the total costs of deliveries. Optimization of routes gives benefit in terms of lowering the CO2 emission and from financial side, which is proven in numbers

4. BENEFITS OF IMPLEMENTING OPTIMIZED SUPPLY CHAIN MODEL

Since benefit is a subjective concept, it can be evaluated according to different criteria, depending on the goals of the research. In the present research the author considers it to be significant to estimate monetary and non-monetary benefit, which includes reduction of CO2 emission and establishing a green image of Company X in case the optimized supply chain model will be implemented.

1. Financial stability is important to every business. Optimization in different parts of operations has become the norm nowadays. In case optimization includes cost reduction, it becomes more justified and attractive for business owners. In this case routing optimization brings significant cost reduction.

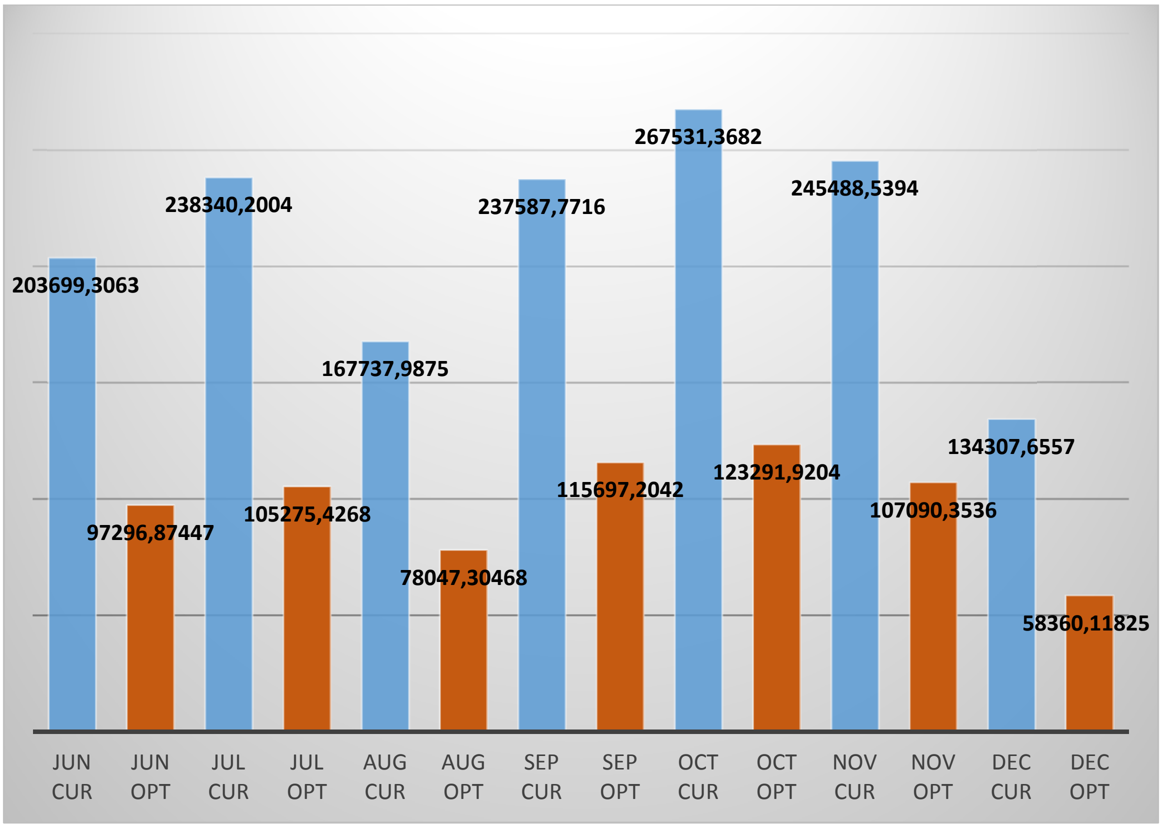

Figure 25. Monthly delivery costs in EUR formed by using current and optimized supply chain model during the period from June to December 2019

Source: Author's calculations based on data from Appendix 12

Figure 25 visualizes the total monthly costs of deliveries of Company X formed by using the current supply chain model and potential costs in case the optimized supply chain model will be implemented. The rapid fall of the cost is noticeable every month; the difference becomes more significant as more cargo is delivered. For the current supply chain model the average cost is 213 527.5 with the standard deviation of 38 525.05. Compared to the potential average cost of the optimized supply chain model 97 865.6 with the standard deviation of 17 112.14 the author notices more than twice the difference in the average rate and decrease in the standard deviation rate, that together with other factors means that the second block of data is not only more financially attractive but also more congeneric. Creating combined routes will potentially bring lower monthly delivery costs and reduction of fluctuation of monthly cost over the period. In case monthly costs will be more steady, it will be easier to forecast the cost fluctuation for the next period.

Financial benefit is the factor that might change the current attitude towards environmental sustainability issues in Estonia. According to the information gathered during the interviews, three out of five respondents do not consider reduction of CO2 emission relevant and only two of the respondents understand the importance of the issue. All of the respondents suppose that the reduction of CO2 emission will also mean cost reduction, which will make the implementation of the former possible. In other words, cost reduction is not only a highly important positive factor, but also serves as a motivator to make Company X and other logistic companies adopt the optimized supply chain model.

2. To evaluate non-monetary benefits of implementing the optimized supply chain model the first step is to estimate the overall CO2 emission reduction.

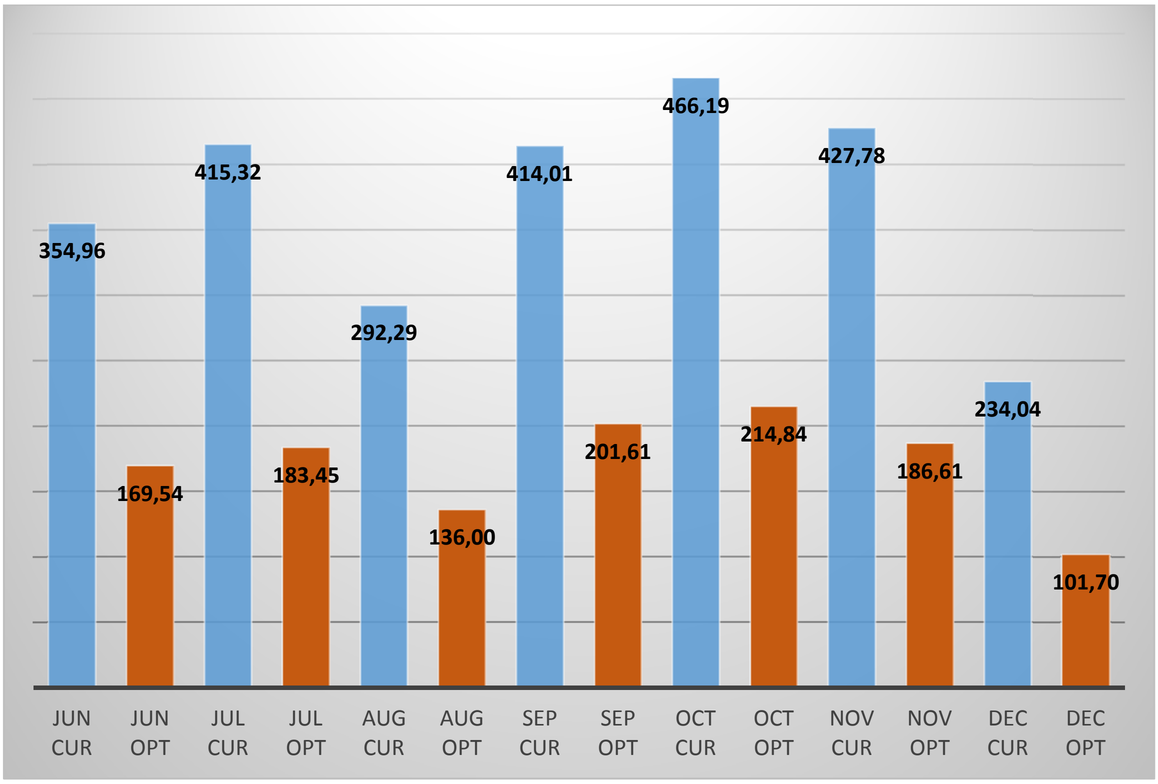

Figure 26. Monthly CO2 emission produced by using current and optimized supply chain model during the period from June to December 2019

Source: Author's calculations based on data from Appendix 11

In terms of CO2 emission, the 2.2-time potential difference is detected. The amount of emissions is fluctuating according to the number of monthly deliveries, but the overall tendency stays the same during the whole six-month period. Average rate of emission produced by using the current supply chain model is 372.08 with the standard deviation rate of 67.13. In case the optimized supply chain model will be used, a potential average rate falls to 170.57, with the standard deviation rate of 29.81. Rapid decrease in the average emission rate is a strong argument for implementing the optimized system and the smaller standard deviation rate indicates the second block of data being more congeneric. T use of combined routes for deliveries in a six-month period will potentially produce less emission and provide smaller fluctuation of emission rate during the period.

3. Besides reduction of pollution, optimization of the supply chain model will potentially create a green image for the company, or positively add to the existing image of an environmentally responsible establishment. Company X has successfully implemented recycling programmes and is trying to reduce emission by delivering maximum loads. All the steps in achieving green image may bring an additional benefit like potential increase of selling prices, that can become possible if the company operates responsibly. Recent research in customer behaviour shows that clients are willing to pay more in case business adds something valuable to the society (Bathmanathan and Hironaka, 2016). Additionally, green image is something that might sway customers to choose a certain good or service over others, hence it may bring extra profit.

4. Integrating green attributes, initiatives and practices into a corporate brand improves its image in the eyes of customers that is linked to environmental commitments and concerns, thus gaining it a competitive advantage. With the oncoming economic crisis initiated by COVID- 19 pandemic gaining a competitive advantage is crucial for businesses.

5. Being green is slowly becoming not a choice but a necessity. With the Sulphur Directive 2012/33/EU (SECA) limiting sulphur emission from vessels as a first step towards integrating more limitations to the supply chain field. The common knowledge of the overall pollution from transportation of all kinds makes the author believe that in the nearest future companies will be obligated to limit their CO2 emission and other pollution factors.

6. Organisations spend vital resources like money, time and people to build a strong corporate image, in case this image is green, it becomes more attractive for consumers and strong in the eyes of shareholders. The concept of Green corporate image originates from a Green Branding phenomena. Green branding or in other words sustainable branding are those brands, the business practices of which are considered environmentally friendly by consumers (Bathmanathan and Hironaka, 2016). Number of researches detect a positive correlation between customer satisfaction and Corporate image, client's loyalty and company performance (Javier et. al., 2014).

7. The companies who operate in a sustainable way have an advantage over those that do not. Number of government agencies, commercial businesses and non-profit organizations are in need of businesses that intend to cooperate with them in order to meet specific green standards. In many

cases businesses try to meet these requirements to get a profitable contract, even though the government still hasn't mandated all the standards.

Reflecting the attitude towards environmental sustainability on the Estonian logistics market is an important aspect for the practical implementation of the researched optimization method. According to the survey, all of the respondents have more than five years of experience in the related area. The first respondent has 20 years of experience in logistics, the third has 15 years of experience, the fourth - six years and the fifth - 15 years. The second respondent has a four-year experience as a logistics analyst in Company X, but has all in all 11 years of experience in the related field. Only one respondent has an education in logistics. Others have legal, journalistic and engineering education. Respondents 4 and 5 has been working for only one company; respondents 3 and 1 have changed three companies, respondent 2 has been working as a logistics analyst in only one company. There is a difference in position between respondents 5 and 3- 4 and 1. The first ones are a head of department and a business owner, i.e. have controlling positions and second ones are logistic specialists, with their specific area of responsibility. Respondent 2 is the only logistics analyst. All of the interviews specialize or were specializing in road freight. The most common delivery destinations from Estonia are Central Europe (Poland, Germany), Netherlands, Nordic countries (Finland, Sweden, Norway), Republic of Belarus and Russian Federation. The number of truckloads sent by the respondent’s firms vary from 24 to 300 a month. Larger companies have approximately between 100 to 300 loads a month, smaller companies have less. The average percentage of truckload according to the answers varies from 90% to 100%, it’s important to remember that the majority of the respondents are working in logistics companies that practice groupage cargo deliveries.

All of the respondents stated that time of delivery is a highly important aspect of the service for their clients. Price is another crucial aspect, according to the survey results. Market competition makes logistic companies look for all possible ways to reduce time of delivery and cost, even though in some cases these factors are mutually exclusive. Preparing groupage cargo for delivery takes from 1 to 3 days according to the respondents. The additional time added to overall delivery time is a sensitive issue, when it plays a leading role in client’s decision making process.

Concerning the question of current ways of optimization, two of the respondents answered that creating maximum loads is their way of optimization, one stated that optimization is made through creating optimal routing, third answered with an advanced packaging system that reduces time and labour hours on loading and unloading. Respondent from Company X stated that the current optimization is focused on fixing prices via long term contacts with subcontractors. Two out of five respondents do not have either knowledge or opinion on a sustainable supply chain. Three out of five respondents personally are very concerned about environmental sustainability and understand the damage to the environment that transportation causes. Four out of five respondents admitted that in their company's level of CO2 emission is not taken into account. The same pattern is detected with the issue of finding possible ways of implementing a sustainable delivery system, four out five respondents do not consider this possibility. With the similar question about the optimized delivery system being offered to the company, the majority of respondents mark that it may be considered only in case time and cost will not increase. By common opinion sustainable ways of transportation are considered costlier and more time consuming, because of this reputation they are often not even considered. An opposite reaction was detected when the survey question concerning the implementation of a sustainable supply chain included cost reduction. All of the respondents were willing to consider this possibility, as soon as the pricing pressure was eliminated. Four out of five respondents answered negatively to the question about the supervisor's opinion about the company's green image and willingness to pay more in order to strengthen their public image. Fifth respondent who is working for Company X, states that supervisors are highly interested in public image and are willing to invest in it. The reasons for low interest towards green image are different, one is conservatism and the belief in the current supply chain model, others are focused on profit, third concerned with the wellbeing of their employees. The joint opinion is detected when the same question is asked about clients. All of the respondents believe that clients are only concerned with time and price, and hardly would be willing to pay more to obtain a green image.

The overall tendency shows a low level of awareness regarding the sustainable supply chain. The highly competitive Estonian logistics market makes specialists think of cost and time efficiency first. The only way to raise interest towards optimization is to add cost reduction to the new model. In this case, even conservative business owners are most likely to consider this option.

CONCLUSION

The main objectives of the thesis were:

1. Define the proven optimal supply chain model for Company X through comparison of cost and CO_2 emission produced by using current and optimized supply chain model.
2. Identify monetary and non-monetary benefits of implementing optimized supply chain model.
3. Reflect current attitude towards sustainable supply chain among Estonian logistics specialists.

Author managed to reach the goals of the research and confirm the research hypothesis: "Reduction of monthly cost and CO_2 emission is possible to achieve through implementing optimized supply chain model only.", according to the data obtained.

Current supply chain model of Company X with 15 routes starting in Estonia and ending in various location of Central Europe and Scandinavia is inefficient both in CO_2 emission and cost of delivery. The company is currently delivering maximum loads according in a time saving strategy, neither forming groupage cargo, nor creating combined routes for multiple destinations.

Author has managed to developed optimized supply chain model on the basis of principals of vehicle routing problem by the following actions:

1. 15 current routes were combined to five, according to the map.
2. The delivered loads were redistributed according to the new routes.
3. CO_2 emission and cost of delivery of current and optimized supply chain model were calculated for further comparison and analysis.

According to the analysis results, the use of current supply chain model with 15 separate routes produced 2.2- times more CO_2 emission than optimized supply chain model. Almost the same rate is detected comparing cost of delivery. Usage of optimized supply chain model with 5 routes provides 2.1- time cost reduction.

The intermediate research of current supply chain model on the benefit of forming groupage cargo instead of delivering partial loads in half empty vehicle shows from 1.63 to 2.85 monthly difference in CO_2 emission, depending on the number of truckloads delivered during specific month. The difference in monthly cost of delivery in case partial loads will be sent as groupage cargo varies from 2.03 to 3.23, depending on the amount of cargo delivered during the month.
The implementation of optimized supply chain model reduces the amount of partial loads due to optimized cargo distribution according to the new routing system that includes from two to four stops.

Author divided potential benefits of implementing optimized supply chain model to monetary and non-monetary. The 2.1- time reduction of monthly cost of delivery represents a strong monetary benefit, that may motivate businesses to implement sustainable supply chain model. The number of benefits that cannot be calculated are named non-monetary. The most convincing point is the 2.2 CO_2 emission reduction that will follow implementation of optimized supply chain model. The fact that huge negative impact on environment can be decreased is a strong benefit by itself, but may additionally bring other benefits. Green image may potentially bring competitive advantage that becomes especially crucial considering the unstable market situation caused by COVID-19 pandemic. The consumers are willing to pay more in case businesses that offer service or product add value to the society, which means opportunity for potential price increase. Consumer’s loyalty increases in case business has a Green image, to say more numbers of governmental agencies, non- profit organizations and commercial establishments only cooperate with businesses that meet specific green standards. Finally, operating in a sustainable way may become a necessity in the nearest future, as emission limitation Directives are already being introduced by European Union.

Author proved that reduction of CO_2 emission is possible only by implementing sustainable supply chain model, i.e. level of environmental sustainability can be increased without significant financial injections. According to the results of the research use of combined routes can bring a significant reduction in cost of delivery, that most definitely can become a motivating factor of implementing developed during the research supply chain model. The survey aimed at establishing current attitude towards environmental sustainability on the Estonian logistics market, revealed low interest to the issue along with the low motivation to implement sustainable ways of transportation. The only condition of implementing sustainable ways of transportation was cost reduction. Author considers this tendency expected, due to high competition on the market and common practices on obtaining competitive advantage that focus on price reduction. Benefits that Green image and sustainable operating may bring price and turnover increase, due to customer's loyalty and willingness to pay more to sustainable businesses. On author's opinion these benefits can only be available to large companies at the moment. Small and medium sized establishments do not have the finances, analytical and developing volumes to construct a Green image that will bring monetary benefit, as this is a complex long- term process. Small and medium sized companies are focused on profits and short- term development plans. Implementation of sustainable supply chain elements in production and logistics establishments along with the cost reduction that it brings is possible and might attract interest of business owners. Obtaining positive Green image can be promoted as additional benefit.

Author considers sustainable supply model developed during this research applicable to production establishment and logistics companies in Estonia, Baltics, Scandinavia and Europe. The elements of the model may be altered according to the specific requirements of certain establishment. The obtained data on the cost of delivery and CO2 reduction can become a strong motivating factor of more businesses starting to become Green. Current situation on the logistics market shows that these optimizations are required. Following benefits of Green image may become available for the companies that will start to operate in a sustainable way. Current economic situation is motivating to work on competitive advantage. The Directives that most likely will be introduced in the nearest future, will change environmental sustainability from an option to necessity. In this case proposed in this research optimization will become vital.

In case additional information will be received from Company X, more sophisticated supply chain models can be developed and analysed, like cargo bundling. The further analysis is possible with the one- year data on amount of monthly loads delivered to various locations received from Company X. The deep statistical timeline analysis on the monthly loads.

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APPENDICES

Appendix 1. Monthly loads sent

Start	End	Jun	Jul	Aug	Sep	Oct	Nov	Dec	6 months
Estonia	Estonia	8245	6876	5500,5	10290,5	9683,5	6078,5	3356	**50030**
	Latvia	735	1100	790,5	1255	1040	1105	705	**6730,5**
	Lithuania	635	685	595	880	595	500,5	265	**4155,5**
	Netherlads	350,5	625	205	280	325,5	325	255	**2366**
	Poland	295	429	282,5	411,5	231,5	391	115	**2155,5**
	Finland	327	218	385	170	332	418,5	221	**2071,5**
	Czech	205	106,5	180	172,5	253	257	250,5	**1424,5**
	Sweden	231,5	48	170	147	255	265	171,5	**1288**
	Germany	150,5	180	167,5	145	225	183,5	0	**1051,5**
	France	67	46,5	68,5	217,5	275	180	115,5	**970**
	Denmark	98	70,5	99	145	173	96	24	**705,5**
	Belgium	72	24,5	99,5	50,5	122,5	121	25	**515**
	Norway	23,5	24,5	19	24	47	24,5	23,5	**186**
	Slovakia	25,5	25,5	0	24	48	26	25	**174**
	Spain	0	0	0	0	25,5	41,5	0	**67**

Table 1. Monthly deliveries in tonnes to 15 destinations fulfilled by Company X during the period from June to December 2019

Appendix 2. Monthly full and partial loads sent

Start	End	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Estonia	Belgium	1	0	2	1	3	3	0
	Czech	5	2	4	4	6	6	6
	Denmark	2	1	2	3	4	2	0
	Estonia	206	171	137	257	242	151	83
	Finland	8	5	9	4	8	10	5
	France	1	1	1	5	6	4	2
	Germany	3	4	4	3	5	4	0
	Latvia	18	27	19	31	26	27	17
	Lithuania	15	17	14	22	14	12	6
	Netherlads	8	15	5	7	8	8	6
	Norway	0	0	0	0	1	0	0
	Poland	7	10	7	10	5	9	2
	Slovakia	0	0	0	0	1	0	0
	Spain	0	0	0	0	0	1	0
	Sweden	5	1	4	3	6	6	4

Table 3. Monthly full loads deliveries to 15 destinations fulfilled by Company X during the period from June to December 2019

Start	End	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Estonia	Belgium	80	61,25	48,75	26,25	6,25	2,5	62,5
	Czech	12,5	66,25	50	31,25	32,5	42,5	26,25
	Denmark	45	76,25	47,5	62,5	32,5	40	60
	Estonia	12,5	90	51,25	26,25	8,75	96,25	90
	Finland	17,5	45	62,5	25	30	46,25	52,5
	France	67,5	16,25	71,25	43,75	87,5	50	88,75
	Germany	76,25	50	18,75	62,5	62,5	58,75	0
	Latvia	37,5	50	76,25	37,5	0	62,5	62,5
	Lithuania	87,5	12,5	87,5	0	87,5	51,25	62,5
	Netherlads	76,25	62,5	12,5	0	13,75	12,5	37,5
	Norway	58,75	61,25	47,5	60	17,5	61,25	58,75
	Poland	37,5	72,5	6,25	28,75	78,75	77,5	87,5
	Slovakia	63,75	63,75	0	60	20	65	62,5
	Spain	0	0	0	0	63,75	3,75	0
	Sweden	78,75	20	25	67,5	37,5	62,5	28,75

Table 4. Monthly partial loads deliveries (in % of full load) to 15 destinations fulfilled by Company X during the period from June to December 2019

Appendix 3. Mileage

Start	End	Mileage/km	Sea Freight/km
Estonia	Belgium	2294	
	Czech	1300	
	Denmark	1000	379 to Stockholm by sea
	Estonia	250	
	Finland	139	80 by sea
	France	2576	
	Germany	1493	
	Latvia	373	
	Lithuania	533	
	Netherlads	2145	
	Norway	743	379 to Stockholm by sea
	Poland	1135	
	Slovakia	1587	
	Spain	3836	
	Sweden	150	379 to Stockholm by sea

Table 5. Mileage in kilometers of each of the 15 routes of deliveries currently used by Company X

Start	**End**	**Liters**
Estonia	Belgium	860,25
	Czech	487,5
	Denmark	375
	Estonia	93,75
	Finland	52,125
	France	966
	Germany	559,875
	Latvia	139,875
	Lithuania	199,875
	Netherlads	804,375
	Norway	278,625
	Poland	425,625
	Slovakia	595,125
	Spain	1438,5
	Sweden	56,25

Table 6. Fuel consumed (in liters) delivering cargo by each of the 15 routes currently used by Company X

Appendix 4. CO2 emission coefficients

Start	End	Tonnes CO - emissions
Estonia	Belgium	2,49473
	Czech	1,41375
	Denmark	1,0875
	Estonia	0,27188
	Finland	0,15116
	France	2,8014
	Germany	1,62364
	Latvia	0,40564
	Lithuania	0,57964
	Netherlads	2,33269
	Norway	0,80801
	Poland	1,23431
	Slovakia	1,72586
	Spain	4,17165
	Sweden	0,16313

Table 7. CO2 emission calculated on the basis of fuel consumed delivering cargo by each of the 15 routes used by Company X

Appendix 5. Difference in CO2 emission of delivering full and partial loads

Start	End	JUNE part	JUNE full	JULY par	JULY full	AUG part	AUG full	SEP part	SEP full	OCT part	OCT full	NOV part	NOV full	DEC part	DEC full
Estonia	Belgium	2.00	2.49	1.53	2.49	1.22	2.49	0.65	2.49	0.16	2.49	0.06	2.49	1.56	2.49
	Czech	0.18	1.41	0.94	1.41	0.71	1.41	0.44	1.41	0.46	1.41	0.60	1.41	0.37	1.41
	Denmark	0.49	1.09	0.83	1.09	0.52	1.09	0.68	1.09	0.35	1.09	0.44	1.09	0.65	1.09
	Estonia	0.03	0.27	0.24	0.27	0.14	0.27	0.07	0.27	0.02	0.27	0.26	0.27	0.24	0.27
	Finland	0.03	0.15	0.07	0.15	0.09	0.15	0.04	0.15	0.05	0.15	0.07	0.15	0.08	0.15
	France	1.89	2.80	0.46	2.80	2.00	2.80	1.23	2.80	2.45	2.80	1.40	2.80	2.49	2.80
	Germany	1.24	1.62	0.81	1.62	0.30	1.62	1.01	1.62	1.01	1.62	0.95	1.62	0.00	0.00
	Latvia	0.15	0.41	0.20	0.41	0.31	0.41	0.15	0.41	0.00	0.00	0.25	0.41	0.25	0.41
	Lithuania	0.51	0.58	0.07	0.58	0.51	0.58	0.00	0.00	0.51	0.58	0.30	0.58	0.36	0.58
	Netherlad	1.78	2.33	1.46	2.33	0.29	2.33	0.00	0.00	0.32	2.33	0.29	2.33	0.87	2.33
	Norway	0.00	0.00	0.49	0.81	0.38	0.81	0.48	0.81	0.14	0.81	0.49	0.81	0.47	0.81
	Poland	0.46	1.23	0.89	1.23	0.08	1.23	0.35	1.23	0.97	1.23	0.96	1.23	1.08	1.23
	Slovakia	1.10	1.73	1.10	1.73	0.00	0.00	1.04	1.73	0.35	1.73	1.12	1.73	1.08	1.73
	Spain	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.66	4.17	0.16	4.17	0.00	0.00
	Sweden	0.13	0.16	0.03	0.16	0.04	0.16	0.11	0.16	0.06	0.16	0.10	0.16	0.05	0.16
	Full/ 6 mo	**9.98**	**16.29**	**9.13**	**17.09**	**6.58**	**15.37**	**6.26**	**14.18**	**9.51**	**20.86**	**7.46**	**21.27**	**9.56**	**15.47**

Table 8. Comparison of level of CO2 emitted from delivering full loads and partial loads using 15 routes over the six- month period

Appendix 6. Cost of delivery

End	Distance	Days 800km/h*8h	Salary 2100 brutto/30*da	Insuranse 1700 eur year/365 days* days	Amortization 10% year/365* days	Fuel consumption* price
Belgium	2294	3,58	250,91	16,69	98,20	1065,85
Czech	1300	2,03	142,19	9,46	55,65	604,01
Denmark	1000	1,56	109,38	7,28	42,81	464,63
Estonia	250	0,39	27,34	1,82	10,70	116,16
Finland	139	0,22	15,20	1,01	5,95	64,58
France	2576	4,03	281,75	18,75	110,27	1196,87
Germany	1493	2,33	163,30	10,87	63,91	693,69
Latvia	373	0,58	40,80	2,71	15,97	173,31
Lithuania	533	0,83	58,30	3,88	22,82	247,65
Netherlad	2145	3,35	234,61	15,61	91,82	996,62
Norway	743	1,16	81,27	5,41	31,81	345,22
Poland	1135	1,77	124,14	8,26	48,59	527,35
Slovakia	1587	2,48	173,58	11,55	67,94	737,36
Spain	3836	5,99	419,56	27,92	164,21	1782,30
Sweden	150	0,23	16,41	1,09	6,42	69,69

Table 9. Calculation of cost in EUR of delivery using each of the 15 routes

Start	End	Total
Estonia	Belgium	1435,24
	Czech	813,34
	Denmark	625,65
	Estonia	156,41
	Finland	86,97
	France	1611,67
	Germany	934,09
	Latvia	233,37
	Lithuania	333,47
	Netherlads	1342,02
	Norway	464,86
	Poland	710,11
	Slovakia	992,90
	Spain	2399,99
	Sweden	93,85

Table 10. Total cost in EUR of delivery using each of the 15 routes

Appendix 7. Comparison of cost of delivery: full and partial truckload

Start	End	JUNE part	JUNE full	JULY par	JULY full	AUG part	AUG full	SEP part	SEP full	OCT part	OCT full	NOV part	NOV full	DEC part	DEC full
Estonia	Belgium	1145.32	1431.65	876.89	1431.65	697.93	1431.65	375.81	1431.65	89.48	1431.65	35.79	1431.65	894.78	1431.65
	Czech	101.41	811.31	537.49	811.31	405.66	811.31	253.53	811.31	263.68	811.31	344.81	811.31	212.97	811.31
	Denmark	280.84	624.09	475.87	624.09	296.44	624.09	390.05	624.09	202.83	624.09	249.63	624.09	374.45	624.09
	Estonia	19.50	156.02	140.42	156.02	79.96	156.02	40.96	156.02	13.65	156.02	150.17	156.02	140.42	156.02
	Finland	15.18	86.75	39.04	86.75	54.22	86.75	21.69	86.75	26.02	86.75	40.12	86.75	45.54	86.75
	France	1085.16	1607.64	261.24	1607.64	1145.45	1607.64	703.34	1607.64	1406.69	1607.64	803.82	1607.64	1426.78	1607.64
	Germany	710.47	931.76	465.88	931.76	174.70	931.76	582.35	931.76	582.35	931.76	547.41	931.76	0.00	931.76
	Latvia	87.29	232.78	116.39	232.78	177.50	232.78	87.29	232.78	0.00	232.78	145.49	232.78	145.49	232.78
	Lithuania	291.06	332.64	41.58	332.64	291.06	332.64	0.00	332.64	291.06	332.64	170.48	332.64	207.90	332.64
	Netherlad	1020.73	1338.66	836.66	1338.66	167.33	1338.66	0.00	1338.66	184.07	1338.66	167.33	1338.66	502.00	1338.66
	Norway	272.42	463.70	284.01	463.70	220.26	463.70	278.22	463.70	81.15	463.70	284.01	463.70	272.42	463.70
	Poland	265.63	708.34	513.54	708.34	44.27	708.34	203.65	708.34	557.82	708.34	548.96	708.34	619.80	708.34
	Slovakia	631.40	990.42	631.40	990.42	0.00	990.42	594.25	990.42	198.08	990.42	643.78	990.42	619.01	990.42
	Spain	0.00	2393.99	0.00	2393.99	0.00	2393.99	0.00	2393.99	1526.17	2393.99	89.77	2393.99	0.00	2393.99
	Sweden	73.72	93.61	18.72	93.61	23.40	93.61	63.19	93.61	35.10	93.61	58.51	93.61	26.91	93.61
	Total	6000.13	12203.37	5239.14	12203.37	3778.18	12203.37	3594.34	12203.37	5458.14	12203.37	4280.09	12203.37	5488.48	12203.37

Table 11. Comparison of costs in EUR generated by delivering full loads and partial loads using 15 current routes over the six- month period

Appendix 8. Monthly full and partial loads sent using combined routes

Start	End	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Estonia	Germany	676	741	630	753	757.5	857.5	390.5	4805.5
	Denmark	353	143	288	316	475	385.5	219	2179.5
	Lithuania	1370	1785	1385.5	2135	1635	1605.5	970	10886
	Estonia	8245	6876	5500.5	10290.5	9683.5	6078.5	3356	50030
	Finland	327	218	385	170	332	418.5	221	2071.5
	Spain	489.5	696	373	548	748.5	667.5	395.5	3918
	Total	11460.5	10459	8562	14212.5	13631.5	10013	5552	

Table 12. Monthly cargo in tonnes delivered by Company X using combined routes during the period from June to December 2019

Start	End	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Estonia	Germany	16	18	15	18	18	21	9
	Denmark	8	3	7	7	11	9	5
	Lithuania	34	44	34	53	40	40	24
	Estonia	206	171	137	257	242	151	83
	Finland	8	5	9	4	8	10	5
	Spain	12	17	9	13	18	16	9

Table 13. Monthly full loads delivered by Company X using combined routes during the period from June to December 2019

Start	End	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Estonia	Germany	90	52,5	75	82,5	93,75	43,75	76,25
	Denmark	82,5	57,5	20	90	87,5	63,75	47,5
	Lithuania	25	62,5	63,75	37,5	87,5	13,75	25
	Estonia	12,5	90	51,25	26,25	8,75	96,25	90
	Finland	17,5	45	62,5	25	30	46,25	52,5
	Spain	23,75	40	32,5	70	71,25	68,75	88,75

Table 14. Monthly partial loads (in % of full loads) delivered by Company X using combined routes during the period from June to December 2019

Appendix 9. Fuel consumption calculation for combined routes

Start	End	Km	
Estonia	Germany	2225	
	Denmark	862	559 km by sea
	Lithuania	454	
	Estonia	250	
	Finland	139	80 by sea
	Spain	3471	

Table 15. Mileage of combined routes in kilometers

Start	End	Liters
Estonia	Germany	834.375
	Denmark	323.25
	Lithuania	170.25
	Estonia	93.75
	Finland	52.125
	Spain	1301.63

Table 16. Fuel consumed (in liters) delivering cargo by each of the optimized route

Appendix 10. CO2 emission per each of the combined route

Start	End	Tonnes CO - emissions
Estonia	Germany	2.4196875
	Denmark	0.937425
	Lithuania	0.493725
	Estonia	0.271875
	Finland	0.1511625
	Spain	3.7747125

Table 17. CO2 emission coefficient of each of the combined route

Start	**End**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**6 months**
Estoni a	Germany	38.715	43.554	36.295	43.554	43.554	50.813	21.777	278.264
	Denmark	7.499	2.812	6.562	6.562	10.312	8.437	4.687	46.871
	Lithuani a	16.787	21.724	16.787	26.167	19.749	19.749	11.849	132.812
	Estonia	56.006	46.491	37.247	69.872	65.794	41.053	22.566	339.028
	Finland	1.209	0.756	1.360	0.605	1.209	1.512	0.756	7.407
	Spain	45.297	64.170	33.972	49.071	67.945	60.395	3.775	324.625
	Total	165.513	179.50 7	132.22 4	195.83 2	208.56 3	181.95 9	65.410	

Table 18. Potential CO2 emission of delivering full loads using optimized routes

Start	**End**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**6 months**
Estonia	Germany	2.178	1.270	1.815	1.996	2.268	1.059	1.845	12.431
	Denmark	0.773	0.539	0.187	0.844	0.820	0.598	0.445	4.207
	Lithuania	0.123	0.309	0.315	0.370	0.432	0.068	0.123	1.740
	Estonia	0.034	0.245	0.139	0.072	0.024	0.262	0.245	1.020
	Finland	0.026	0.068	0.094	0.038	0.045	0.070	0.079	0.421
	Spain	0.896	1.510	1.227	2.642	2.689	2.595	3.775	15.335
	Total	4.031	3.941	3.778	5.962	6.279	4.651	6.512	

Table 19. Potential CO2 emission of delivering partial loads using optimized routes

Appendix 11. Comparison of CO2 potentially emitted delivering monthly loads using current routes and combined routes

Start	End	Jun prese	Jun rerou	Jul preser	Jul rerout	Aug pres	Aug rero	Sep prese	Sep rerou	Oct preser	Oct rerout	Nov prese	Nov rerou	Dec prese	Dec rerout
Estonia	Germany	101.359	40.893	111.105	44.825	94.462	38.110	112.904	45.551	113.579	45.823	128.573	51.872	58.551	23.622
	Denmark	18.167	8.273	7.360	3.351	14.822	6.749	16.263	7.406	24.446	11.132	19.840	9.034	11.271	5.132
	Lithuania	33.746	16.910	43.968	22.032	34.127	17.101	52.589	26.353	40.273	20.181	39.546	19.817	23.893	11.973
	Estonia	56.040	56.040	46.735	46.735	37.386	37.386	69.943	69.943	65.818	65.818	41.315	41.315	22.810	22.810
	Finland	1.236	1.236	0.824	0.824	1.455	1.455	0.642	0.642	1.255	1.255	1.582	1.582	0.835	0.835
	Spain	144.408	46.193	205.328	65.680	110.039	35.199	161.666	51.714	220.816	70.634	196.920	62.991	116.677	37.322
	Total	354.956	169.545	415.320	183.448	292.292	136.001	414.008	201.608	466.187	214.842	427.776	186.610	234.038	101.695

Table 20. Comparison of CO2 potentially emitted delivering monthly loads by using current routes and combined routes

Appendix 12. Comparison of cost per current and combined route

Start	End	Total cost
Estonia	Germany	1388.59
	Denmark	537.962
	Lithuania	283.335
	Estonia	156.021
	Finland	86.7479
	Spain	2166.2

Table 21. Total cost of delivery in EUR using each of the combined route

Start	End	Total cost single route	Total cost optimized route
Estonia	Germany	3441.83	1388.59
	Denmark	1181.39	537.96
	Lithuania	565.42	283.33
	Estonia	156.02	156.02
	Finland	86.75	86.75
	Spain	6771.95	2166.20

Table 22. Comparison of potential total costs in EUR per one delivery using current routes and combined route

Start	End	Jun present	Jun rerouting	Jul present	Jul rerouting	Aug present	Aug routi	Sep present	Sep routi	Oct present	Oct routi	Nov presen	Nov rerouti	Dec presen	Dec rerout
Estonia	Germany	58166.96	23467.18	63759.94	25723.64	54208.86	21870.30	64792.49	26140.22	65179.70	26296.43	73784.28	29767.91	33600.89	13556.11
	Denmark	10425.80	4747.51	4223.48	1923.21	8506.04	3873.32	9333.01	4249.90	14029.05	6388.30	11385.69	5184.61	6468.13	2945.34
	Lithuania	19365.69	9704.22	25231.94	12643.82	19584.79	9814.01	30179.38	15123.00	23111.61	11581.31	22694.61	11372.35	13711.47	6870.87
	Estonia	32159.91	32159.91	26820.08	26820.08	21454.89	21454.89	40138.46	40138.46	37770.83	37770.83	23709.40	23709.40	13090.20	13090.20
	Finland	709.16	709.16	472.78	472.78	834.95	834.95	368.68	368.68	720.01	720.01	907.60	907.60	479.28	479.28
	Spain	82871.78	26508.89	117831.98	37691.90	63148.46	20199.83	92775.76	29676.96	126720.17	40535.04	113006.97	36148.48	66957.69	21418.31
	Total	203699.31	97296.87	238340.20	105275.43	167737.99	78047.30	237587.77	115697.20	267531.37	123291.92	245488.54	107090.35	134307.66	58360.12

Table 23. Comparison of potential total costs in EUR over the six- month period for delivering loads using current routes and combined routes

Appendix 13. Survey questions

1. State your name, age and place of work?
2. What is your experience in the logistics field?
3. How many years have you been working on your current job?
4. What is your area of responsibility at a workplace?
5. What is the average amount of monthly loads in your establishment?
6. What are the main delivery destinations?
7. What type of deliveries your company specializes on?
8. What is your personal specialization?
9. What is the average truckload in percent?
10. How important is time of delivery for clients?
11. How important is price of delivery for clients?
12. How much time does it take to prepare a groupage cargo for transportation?
13. What ways of optimization are currently used in your company?
14. What is your opinion on sustainable supply chain?
15. Do you take into account CO2 emission in route building and load formation?
16. Do you consider sustainable ways of transportation? If no, please explain why?
17. In case you would be offered to optimize delivery system taking into account environmental sustainability, would you consider this possibility? Why?
18. In case optimization of delivery system with the environmental sustainability taken into account would also include reduction of cost, would you be interested in it?
19. How do the supervisors in your company refer to modern trend on environmental protection? Would they be willing to pay more in order to upgrade their public image?
20. How do your clients refer to modern trend on environmental protection? Would they be willing to pay more in order to upgrade their public image?

Appendix 14. Answers of respondent 1

Question 1.- State your name, age, education and place of work?

Answer- My name is Vadim Damaskin. I am 49 years old. I don't have a logistics education, was studying in TTU and have a higher technical education. I am working in Technomar Adrem.

Question 2.- What is your experience in the logistics field?

Answer- I am working in the field of logistics over 20 years. Changed 3 places of work over this period.

Question 3.- How many years have you been working on your current job?

Answer- On the current place I've been working for almost 8 years.

Question 4.- What is your area of responsibility at a workplace?

Answer- I mostly specialize in sea freight and air freight deliveries. Main transportation destinations that I am responsible for is USA, Canada, China, Mexico, Israel. As you can understand deliveries to such far situated destinations are mostly done by sea, urgent ones are done by air. Before I was specializing on inland transportation, mostly from Russian Federation, Republic of Belarus and Ukraine.

Question 5.- What is the average amount of monthly loads in your establishment?

Answer- During the month we send approximately 200-300 trucks to different destinations.

Question 6.- What are the main delivery destinations?

Answer- The cargo is mostly delivered to European destinations and Scandinavia. Also China, USA, Canada, Israel, Mexico, Hong Kong and Singapore.

Question 7.- What type of deliveries your company specializes on?

Answer- Mainly our company specializes on inland transportation via trucks, it is about 70% of our turnover. 30% is container sea freight, that is my current area of responsibility.

Question 8.- What is the average truckload in percent?

Answer- In most cases we try to load up to 90% of the vehicle. Of course it depends on the destination, type of cargo and urgency. So percentage may change.

Question 9.- How important is time of the delivery for clients?

Appendix 14 continued

Answer- Time is highly relevant for our clients. One of the main factors on what they decision either to work with us or not depends on. I guess in Estonia every logistics company is trying to reduce time of delivery as much as they can.

Question 10.- How important is price of the delivery for clients?

Answer- Price in another highly important factor from the client's perspective. I can't even say what is more relevant- time or price. I would have to say 50/50. In Estonian highly competitive logistics market every company is trying to offer lowest prices.

Question 11.- How much time does it take to prepare a groupage cargo for transportation?

Answer- To collect a groupage cargo ready for transportation it takes us from 2 to 3 days, depending on the character of the cargo and our current clients.

Question 12.- What ways of optimization are currently used in your company?

Answer- Our usual optimization system is to create maximally suitable route and at the same time not to forget about speed. We always try to consider both of these factors and keep them in balance.

Question 13.- What is your opinion on sustainable supply chain?

Answer- I don't have a specific opinion on this subject. I know that some of the large companies make it a part of their agenda, but our company is currently not focusing on it.

Question 14.- Do you take into account CO2 emission in route building and load formation?

Answer- Sustainable supply chain topic is currently not on table in our company. All I can say that we use only EUR-5 vehicles for transportation.

Question 15.- Do you consider sustainable ways of transportation? If no, please explain why?

Answer- At the moment we are not considering sustainable ways of transportation. My supervisors believe that it will lead to additional costs and in the conditions of Estonian market we are not able to afford that.

Question 16.- In case you would be offered to optimize delivery system taking into account environmental sustainability, would you consider this possibility? Why?

Appendix 14 continued

Answer- I would have to say no. I totally understand how it sounds, but company's current financial situation doesn't leave any place for maneuver. As I mentioned, company's supervisors set specific goals, that are mostly aimed at fulfilling client's needs in the shortest terms and with lowest price. Finding new clients is another goal on the agenda. That leaves no time to think about optimization from the side of saving the Earth.

Question 17.- In case optimization of delivery system with the environmental sustainability taken into account would also include reduction of cost, would you be interested in it?

Answer- Of course it would, but only in case it wouldn't influence delivery terms. Now I can't imagine how these 2 factors can be combined, without damage to 1 of them.

Question 18.- How do the supervisors in your company refer to modern trend on environmental protection? Would they be willing to pay more in order to upgrade their public image?

Answer- My supervisors believe in current delivery system. They have been working this way for more than 20 years. It's hard to start changing something. Especially for conservative people that they are. But I believe world's tendency will reach us sooner or later and they would be forced to start paying attention to environmental suitability.

Question 19.- How do your clients refer to modern trend on environmental protection? Would they be willing to pay more in order to upgrade their public image?

Answer- Our clients think of the profit first. So if upgrading image will bring profit, they will be interested. But it concerns only big clients, that can afford building long term strategies and work on their image in the long run. As for the small clients I don't believe that they will be willing and able to pay more, to receive some benefit in the far future. It's just the question of survival in small business.

Appendix 15. Answers of respondent 2

Question 1.- State your name, age and place of work?

Answer- Anatolii, 29 years, currently work at Company X.

Question 2.- How many years of working experience do you have? In what fields?

Answer- All in all working experience is 11 years in different fields. 4 last years in Logistics.

Question 3.- What is your position in the Company X?

Answer- I'm a Logistics Analyst.

Question 4.- How many years have you been working on your current job?

Answer- I'm here for 2 years now and not planning to change anything.

Question 5.- What is your area of responsibility at a workplace?

Answer- My main task is to analyze sales and logistics activities for next 18 months. So basically forecasting based on the previous data. Determining strengths and weaknesses of delivery system and giving recommendations.

Question 6.- What is the average amount of monthly loads in your establishment?

Answer- The average amount of monthly loads varies from 60 to 100, considering that our business is seasonal. Usually sales are in first and second quarter are higher than in third and fourth.

Question 7.- What are the main delivery destinations?

Answer- Our main destinations from the starting point in Estonia is first of all around the country, then Latvia, Lithuania, Finland and Poland.

Question 8.- What type of deliveries your company specializes on?

Answer- To close locations like Latvia and Poland of course its road freight. There's no point in using trains from financial point of view. From Estonia I have to say it's mostly truck deliveries, with the use of short sea shipping to Finland and Sweden, with few exceptions. From other company locations around Europe it's mostly a mix of road freight and sea freight.

Question 9.- What is your personal specialization?

Answer- I personally specialize in Logistics and Supply Chain Management analytics.

Appendix 15 continued

Question 10.- What is the average truckload in percent?

Answer- We are always trying to load maximum. I understand that usual truckload is around 80%, but as we have subcontractors who provide separate trucks for our needs we are able to increase the amount of load to close to 100%.

Question 11.- How important is time of the delivery?

Answer- Crucial because of type of the business, clients are expecting delivery to be on time, because materials are planned to be used according to the schedule.

Question 12.- How important is price of the delivery?

Answer- Due to high competition on the market and low marginality of the business price of delivery service is important and effects operational income.

Question 13.- What ways of optimization are currently used in your company?

Answer- Annual agreements are signed with transport company, it gives opportunity to have stabilize prices during the year.

Question 14.- What is your opinion on sustainable supply chain?

Answer- Sustainably is part of the company's strategy. Thus, all Company X suppliers are aware of standards, safety rules, trainings are conducted with third party, audits are done annually to make sure that suppliers are following norms agreed by Company X. Company which I work for conducts business responsibly, creates trends for the industry and other companies.

Question 15.- Do you take into account CO2 emission in route building and load formation?

Answer- Of course, CO2 emission are considered for choosing default routes. Moreover, annually we are checking company's CO2 emission and try to minimize it.

Question 16.- Do you consider sustainable ways of transportation? If no, please explain why?

Answer- In Estonia there are no sustainable ways of transportation which might serve company's needs. But in Germany e-trucks were used as a test, company keeps an eye on it.

Question 17.- In case you would be offered to optimize delivery system taking into account environmental sustainability, would you consider this possibility? Why?

Appendix 15 continued

Answer- We are always open for new solutions, especially from people outside of organization. Moreover, sustainability is one of strategic goals of the company.

Question 18.- In case optimization of delivery system with the environmental sustainability taken into account would also include reduction of cost, would you be interested in it?

Answer- We are facing financial crisis now, of course, cost reduction is one of the tactical goals for the company for next 6 months.

Question 19.- In your opinion how do the supervisors in your company refer to modern trend on environmental protection? Would they be willing to pay more in order to upgrade their public image?

Answer- Company X has invested recently in sustainability, renewable materials are used in production, company fights to replace disposable plastic with biomaterials. Company is ready to invest into creating public awareness about its sustainability and environmental protection actions.

Question 19.- In your opinion how do your clients refer to modern trend on environmental protection? Would they be willing to pay more in order to upgrade their public image?

Answer- It depends on clients and markets, where they operate. For example, Nordic countries are ready to invest in more sustainable solutions, Finland promotes usage of biodegradable materials instead of disposable plastic. Finnish government stimulates usage of timber in construction, concrete buildings are huge source of CO2 emission. Unfortunately, not states are ready to support their companies in building environmentally friendly business.

Appendix 16. Answers of respondent 3

Question 1.- State your name, age, education and place of work?

Answer- My name is Andrei, I'm 38 years old and work at Hackmann Logistics. I have a legal education.

Question 2.- What is your experience in the logistics field?

Answer- A lot, all in all over 15 years.

Question 3.- How many years have you been working on your current job?

Answer- I'm now the owner of Logistics company for about 3 years.

Question 4.- What is your area of responsibility at a workplace?

Answer- I'm responsible for everything. Mostly dealing with clients and supervise everyday work, that include orders, deliveries and cargo clearance.

Question 5.- What is the average amount of monthly loads in your establishment?

Answer- As the company is still in the beginning of its path we have from 20 to 30 loads per month. But we are planning to increase this number at least by 10-15% by the end of the year.

Question 6.- What are the main delivery destinations?

Answer- Currently we specialize on transportation to Scandinavia, mostly Norway and Denmark. In plans adding Netherlands and Germany to the main destinations, we are working on it.

Question 7.- What type of deliveries your company specializes on?

Answer- We specialize on road deliveries, to be precise we use curtain-sided truck 24 tons.

Question 8.- What is the average truckload in percent?

Answer- 100%. I know it sounds hard to perform, but we always try to do our best. The company is still reaching its peak and we try to minimize cost in order to offer best prices and stay competitive.

Question 9.- How important is time of the delivery for clients?

Answer- Time is highly important.

Appendix 16 continued

Question 10.- How important is price of the delivery for clients?

Answer- The price plays the major role. This business is very competitive, only by reducing prices we can win the clients.

Question 11.- How much time does it take to prepare a groupage cargo for transportation?

Answer- From 2 to 3 days.

Question 12.- What ways of optimization are currently used in your company?

Answer- We always try to load are trucks to the maximum. I guess this is our main way of optimization for now.

Question 13.- What is your opinion on sustainable supply chain?

Answer- I haven’t really been thinking about it. But I am aware of the global policy regarding this matter. In future it will concern every business, including ours.

Question 14.- Do you take into account CO2 emission in route building and load formation?

Answer- No, we are not.

Question 15.- Do you consider sustainable ways of transportation? If no, please explain why?

Answer- I don’t consider it our main field of activity. Trying to build new business from scratch takes all the effort. I’m thinking of my employees and how responsible it is to provide them with jobs and salaries. Making future plans to increase the turnover and win new clients and of course expand.

Question 16.- In case you would be offered to optimize delivery system taking into account environmental sustainability, would you consider this possibility? Why?

Answer- I believe sustainable supply chain will most definitely result in growth of costs. In the current market situation, I personally can’t allow that to happen. It will either take all the profit or scare away the clients.

Question 17.- In case optimization of delivery system with the environmental sustainability taken into account would also include reduction of cost, would you be interested in it?

Appendix 16 continued

Answer- In this case I will definitely consider it. I like the idea and understand its importance for the world in the long run.

Question 18.- How do the supervisors in your company refer to modern trend on environmental protection? Would they be willing to pay more in order to upgrade their public image?

Answer- In my case I'm my own supervisor. And if I could afford it I would be happy to upgrade my image. But now I have to use other ways to do that.

Question 19.- How do your clients refer to modern trend on environmental protection? Would they be willing to pay more in order to upgrade their public image?

Answer- They are aware of it. But in Estonia there are different rules of the game. A bit old-school I have to say. A lot is done over personal relationships, just like in Russian Federation. And I have to follow those rules. Paying for image is still not a part of our agenda.

Appendix 17. Answers of respondent 4

Question 1.- State your name, age, education and place of work?

Answer- I'm Veera Mironenko, 34 years old. Was studying in Eesti Ettevõtluskõrgkool Mainor at the faculty of journalism. Working at Tallship OU.

Question 2.- What is your experience in the logistics field?

Answer- It's actually my first job in logistics. So all in all 6 years.

Question 3.- How many years have you been working on your current job?

Answer- Again, 6 years in the same establishment.

Question 4.- What is your area of responsibility at a workplace?

Answer- I am responsible for road transportation, including multimodal shift, oversized cargo delivery and sometimes groupage cargo.

Question 5.- What is the average amount of monthly loads in your establishment?

Answer- I can say for sure only concerning my department. We send +/- 200 loads each month.

Question 6.- What are the main delivery destinations?

Answer- First of all from Russia to Europe and back. One of our most popular destinations. Then its Asia, USA, European states, Kazakhstan, Republic of Belarus and Turkey. For transportation to some of these destinations I have to work with cooperation with my colleagues from sea freight department, as you understand.

Question 7.- What type of deliveries your company specializes on?

Answer- The main specialty of our company is vessel chartering. That brings 60% of our profits. I specialize in projects shifts, multimodal shifts, in one-word road transportation.

Question 8.- What is the average truckload in percent?

Answer- I'd have to say from 90% to 100%, surely it depends on the character of the cargo, our current order and time limits.

Question 9.- How important is time of the delivery for clients?

Answer- Again it depends on the type of cargo, but in most cases time is essential factor.

Appendix 17 continued

Question 10.- How important is price of the delivery for clients?

Answer- I would say highly important, every single clients wants to deliver as cheap as possible, some want to get transportation for free.

Question 11.- How much time does it take to prepare a groupage cargo for transportation?

Answer- It depends on destination. When we prepare delivery to popular destinations like Russia, it takes about 2-3 days. From Tallinn to European states even faster, today we receive order, tomorrow truck is on its way, but again not in all cases, depends on the country of issue.

Question 12.- What ways of optimization are currently used in your company?

Answer- If we have any specific ways of optimization, I'm not aware of them. I can say that we try to load the truck to the fullest, but I'm not the one who's responsible for routing.

Question 13.- What is your opinion on sustainable supply chain?

Answer- My personal opinion is that transportation is responsible for huge part of world's pollution. Air pollution with enormous gas emission, fuel and oils in sea and rivers. That makes me angry.

Question 14.- Do you take into account CO2 emission in route building and load formation?

Answer- Unfortunately, I have to admit that we don't.

Question 15.- Do you consider sustainable ways of transportation? If no, please explain why?

Answer- In case we will start to use sustainable ways of transportation the company will go bankrupt and I'm not the only one who has such opinion. Most of my colleagues and specialist from other establishments share it.

Question 16.- In case you would be offered to optimize delivery system taking into account environmental sustainability, would you consider this possibility? Why?

Answer- Sure we would. What I don't know is how these estimations would end, but we are interested in reducing pollution and the least we can do is try to pay some attention to the matter.

Question 17.- In case optimization of delivery system with the environmental sustainability taken into account would also include reduction of cost, would you be interested in it?

Appendix 17 continued

Answer- I can't imagine how this can be possible, but the answer is yes! I personally would be happy if such un option would be found.

Question 18.- How do the supervisors in your company refer to modern trend on environmental protection? Would they be willing to pay more in order to upgrade their public image?

Answer- My supervisors are first of all interested in profits. That doesn't mean they are bad people, but with this market situation they have to be callous, as they are responsible for wellbeing of 40 employees. I don't believe that they look at company's image from this angle, most likely they try to offer high quality service with the lowest price and maintain friendly relationships with our main clients.

Question 19.- How do your clients refer to modern trend on environmental protection? Would they be willing to pay more in order to upgrade their public image?

Answer- I'm sure there's very few of those who would be able to do that. From my personal experience all of the clients are only concerned with the prices.

Appendix 18. Answers of respondent 5

Question 1.- State your name, age, education and place of work?

Answer- My name is Oleg Kulikov, 34 years old. I studied at Eesti Ettevõtluskõrgkool Mainor at logistics faculty. Work at Sinnitta AS.

Question 2.- What is your experience in the logistics field?

Answer- I've had a long way. In logistics for about 13 years.

Question 3.- How many years have you been working on your current job?

Answer- I've been at my current position for 10 years now.

Question 4.- What is your area of responsibility at a workplace?

Answer- I'm responsible for cargo transportation from our European suppliers to warehouse in Estonia. Then for deliveries to our clients. And additionally I'm in charge of warehousing.

Question 5.- What is the average amount of monthly loads in your establishment?

Answer- Approximate amount of cargo sent is from 40 to 50 tons a month.

Question 6.- What are the main delivery destinations?

Answer- Deliveries in most case go to Russia and Europe, sometime Baltic states and Scandinavia as well.

Question 7.- What type of deliveries your company specializes on?

Answer- We use road transport for most of the cases. It is our usual practice. In cases of urgent deliveries, it's air freight.

Question 8.- What is the average truckload in percent?

Answer- We use the services of subcontractors, have 2-3 permanent partners. For our needs groupage cargo is the best answer. I believe we load about 5-10% of the truck each delivery.

Question 9.- How important is time of the delivery for clients?

Answer- 90% of our clients are will to get their goods as soon as possible, so time is very important!

Question 10.- How important is price of the delivery for clients?

Appendix 18 continued

Answer- For the company, as a wholesaler, the price of delivery impacts the end price of the product. To stay competitive on the market we try to reduce prices in all possible ways. So yes, price is very important.

Question 11.- How much time does it take to prepare a groupage cargo for transportation?

Answer- The specifics of our work is that we receive cargo from suppliers all week long, and forming own deliver because of that takes longer time. Usually it takes 1-2 days.

Question 12.- What ways of optimization are currently used in your company?

Answer- We group cargo this way, that by receiving it in the end point warehouse, it doesn't take long to check it and send forward to clients. This way we significantly save time.

Question 13.- What is your opinion on sustainable supply chain?

Answer- Without any doubt, logistics infrastructure significantly affects environment, especially when it comes to gas emission. I hope that soon enough fuel trucks will be replaced by electric vehicles, that will reduce air pollution a lot.

Question 14.- Do you take into account CO2 emission in route building and load formation?

Answer- We don't.

Question 15.- Do you consider sustainable ways of transportation? If no, please explain why?

Answer- In highly competitive market of spare part wholesale, we fight for lower prices every day. The only way to stay interesting for clients. For us speed and price of delivery are more important aspects, than global environmental issues.

Question 16.- In case you would be offered to optimize delivery system taking into account environmental sustainability, would you consider this possibility? Why?

Answer- In case it wouldn't influence time of transportation too, we would consider it. Nobody wants to pollute environment without any necessity. We are doing it because don't see other option for the moment.

Question 17.- In case optimization of delivery system with the environmental sustainability taken into account would also include reduction of cost, would you be interested in it?

Answer- We would be more than interested! But we would have to look at the situation

Appendix 18 continued

on complex, considering speed and quality of the delivery.

Question 18.- How do the supervisors in your company refer to modern trend on environmental protection? Would they be willing to pay more in order to upgrade their public image?

Answer- Unfortunately no, I don’t believe that my supervisors will be willing to pay more, without knowing what it will bring them.

Question 19.- How do your clients refer to modern trend on environmental protection? Would they be willing to pay more in order to upgrade their public image?

Answer- From what I heard, clients are mostly concerned with their own needs, not the global ones. If the future benefit would be shown in numbers, I guess that can draw their attention.

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