jamk.fi

Firewood exporting from Central Finland to Europe

Focus on routing and estimation of costs

Nikolay Krupen

Bachelor’s thesis
May 2016
School of Technology, Communication and Transport
Degree Program in Logistics Engineering

Jyväskylän ammattikorkeakoulu
JAMK University of Applied Sciences

jamk.fi

Description

Author(s) Krupen, Nikolay	Type of publication Bachelor's thesis	Date May 2016
		Language of publication: EN
	Number of pages 85	Permission for web publication: x

Title of publication
Firewood exporting from Central Finland to Europe
Focus on routing and estimation of costs

Degree programme
Logistics Engineering

Supervisor(s)
Pakarinen, Risto
Vauhkonen, Petri

Assigned by
Honkonen, Juha

Abstract

The project was initiated by A-Firewood Finland Oy and it was connected to its potential entering the European market. Currently, the company is planning its future operations, and building the supply chain network is one of the most essential steps to be taken.

As logistic costs determine a significant share of the total expenditures for such voluminous cargo as firewood, a clear overview of them had to be presented. This was done by using the qualitative research approach. A literature review and analysis were conducted in order to understand the advantages of forest industry and to highlight the information essential for the study. Moreover, a description of the practical transportation arrangements was compiled from scientific and business articles and the information provided by authorities.

The collected data was used in the second main part of the project, which was devoted to transportation cost estimations to selected destinations in Europe, and it was complemented by freight rates given by shipping companies. The outcomes of this were the delivery costs to each destination. Based on this information, the destinations were compared to each other, the transportation risks were identified and suggestions for supply chain system improvement were proposed. It could be said that the project built a framework for the development of a transportation network of the company.

Keywords/tags
Wood processing, renewable energy, firewood, transport cost estimation, supply chain planning, export, road transportation, operations planning

Miscellaneous

Contents

Figures

Tables

Abbreviations

ACEA European Automobile Manufacturers Association

ADR European Agreement Concerning the International Transport of Dangerous Goods by Road

AETR European Agreement Concerning the Work of Crews of Vehicles Engaged in International Road Transport

ATRI American Transportation Research Institute

B2C Business-To-Customer

CEMT European Conference of Ministers of Transport

CEN European Committee for Standardization

DIN German Industrial Standards

DKK Danish crone (currency)

DSRC Dedicated short-range communications

EEA European Economic Area

EETS European Electronic Toll System

EMS European Modular System

EU European Union

EUR Euro (currency)

FEU Forty-Foot Equivalent Unit container

GNSS Global Navigation Satellite System

GSM-GPRS Global Standard for Mobile Communication - General Packet Radio Service

HGV Heavy Goods Vehicle

IFO Intermediate Fuel Oil

INCOTERMS	International Commercial Terms
ISO	International Organization for Standardization
LHV	Longer and Heavier Vehicle Combination
LSMGO	Low Sulphur Marine Gas Oil
LTL	Less-than-Truck-Load
SWOT	Strengths, Weaknesses, Opportunities and Threats analysis
TL	Truck Load
TS	Technical Standards
UK	United Kingdom
USA	United States of America
VAT	Value Added Tax
VED	Vehicle Excise Duty

1 Introduction

1.1 Overview

The importance of energy for the humanity cannot be underestimated: all aspects of human life, from heating in the personal households and running the automobiles to the manufacturing of goods in the factories need it. From the ancient times people have been thinking, from which source can they take it. The 21st century provides a wide variety of possible choices: in the world where nuclear technologies are available, generating and transmitting of energy is not a problem anymore.

However, it has not been that easy all the time. As late as less than two hundred years ago burning of coal was the most widespread solution for industrial facilities and the locomotives of trains. Many people did not like this material due to the smell and dust that were inevitable in the burning process. The occupation of a coal-burner was the dirtiest one and the ecological situation in industrial areas was terrible already at that period of time.

Fortunately, also a clean source of heating energy was available and it was utilized in almost every private building. The fireplace was a spot which acted as the center of the house: food was cooked on the stove, it gave the light and in the evenings the whole family gathered around it. Fed by firewood, the stove was an ideal solution, especially for rural areas, where the inhabitants were able to find the material by themselves. This had to be more complicated in the cities, but, most probably, the firewood supplies were centralized and available for all citizens.

Times have changed and, obviously, nowadays the role of firewood it not as essential as it used to be in the medieval times. However, it is still an important source of energy even though there is a tremendous variety of options in the market. It is clear that people in the countryside prefer it because of the warmth and coziness of an open fire, but more interesting is that firewood has its industrial implementation too. It has an image of an eco-friendly and sustainable fuel and suits perfectly for small and medium-size production facilities.

As every raw material, firewood has its own properties and a supply chain with subsequent advantages and problems. All these theoretical and practical are covered in the thesis report.

1.2 Company description

The research project was launched by a group of entrepreneurs that have decided to establish their own wood processing company called A-Firewood Finland Oy. As firewood is highly demanded in the European market now, the business idea is to cut the logs into smaller pieces, prepare them for transportation and export the ready-made high-quality firewood to the other European countries.

The chosen location for the manufacturing facility is Saarijärvi in Central Finland. As the project is only in a preliminary phase, the exact place for production premises has not been defined yet, but two potentially suitable ones has been found. Currently, the project initiators are working on legal matters related to the establishment of a new company, exploring different markets and planning the purchases, but the first real actions are expected to be taken at the beginning of 2017 at the latest. The project development will depend on several factors, including the future economic situation in Finland and the target countries and feasibility of wood exporting that was partially clarified by this report.

In order to make the exporting process as smooth as possible, the company that is new in the market should clarify all niceties in advance. Therefore, the related logistics assignments were tasked to JAMK students in order to reach optimal solutions.

1.3 Research aim, objectives, and limitations

The key research aim was to create a model of supply chain processes for firewood from Central Finland to the chosen destinations in Europe. The focal point of the thesis was an assessment of transportation costs, but associated issues such as analysis of the firewood material properties were also included in this paper.

Reaching the core aim enabled to achieve minor objectives, which are listed below.

- To form an overview of the industry and its global/local tendencies

- To define the supply chain problems that a newcomer to the market had to face
- To propose solutions to those problems

The research was focused on determining the costs of transportation. Therefore, other supply chain activities such as warehousing and planning were covered only theoretically or not covered at all. Moreover, after determining the core markets of A-Firewood, clarification of transportation costs to other destinations became unnecessary and, subsequently, they were excluded from the study. The research concentrated on the delivery of ready firewood, and this was why costs of such preliminary phases such as haulage of timber were not taken into account.

This document was written for the company and served its needs. However, the information collected and summarized in it can be utilized by everyone who is interested in firewood export or, in general, in the forest industry.

Due to the challenges such as difficulties in getting up-to-date quotes from the transportation companies without making real business offers and obsolete statistical information, this study cannot be accounted as fully accurate. Furthermore, the situation in the transportation industry can change very quickly due to the influence of external factors, thus facts and figures definitely need to be checked if this study is used for practical purposes. The last identified limitation is that a significant share of documents in Europe is published in the language of the country where the research was made or data was collected. The amount of information in English is still considerable, but missing the sources in local languages influenced the quality of the research about such target countries as Germany and Denmark.

1.4 Methods of research

Desk research was chosen as the most suitable method for this project. There was plenty of information available about the transportation system in Europe and about the supply chain of firewood. The sources of data varied from government reports and statistics to company presentations.

The research approach was qualitative, which means that it was focused on discovering existing data, its analysis and summarizing. Unstructured or semi-structured data collection techniques were used. Compared to the quantitative research method, no generation of data was done, except the quotes of shipping companies for their freight rates or usage of specialized online tools to estimate the market price for transportation services. Furthermore, in order to evaluate the results, to relate them to the development of the company's supply chain system and to assess its potential, a SWOT analysis was done.

Due to the nature of study, it was not reasonable to conduct surveys or interviews of people who were not fully involved in the industries of transportation or forestry. Even if a suitable candidate had been found, it would not have been certain that he or she could have added valuable information to this project because of the narrowness of the topic and sufficiency of the information in online sources. Therefore, such data collection techniques were included in the paper.

2 Wood as a product: physical and business features

2.1 Forest energy overview

The increasing usage of wood as a fuel is one of the most widely discussed topics in the energy industry nowadays. This issue attracts the attention of completely different parties, including authorities, consumers, energy producers and representatives of transportation and manufacturing companies. The reasons for such attention are, for instance, the possibility to decrease the consumption of traditional fossil fuels and to diversify the traditional energy market.

From an environmental point of view, forest biomass is a renewable source of energy that has a potential to reduce greenhouse gases emission in a long-term perspective. According to the "carbon neutrality" theory, the biomass extracted from the forest and burned in the energy generation process is replaced by new biomass growth in the forest, which re-absorbs the carbon emitted by the energy generation process. In this sense, the carbon emitted when generating energy from wood is perceived as staying in the atmosphere for a rather short time frame as Ferranti declares. (2014, 9.) By contrast, such carbon recovery timeframe for the fossil fuels is much longer. This was one of the reasons why the “2020 climate and energy package” including the initiatives of increasing the share of renewable energy to 20% of the gross domestic energy consumption and reducing greenhouse gas emissions by 20% with respect to 1990 levels by the year 2020, was undertaken by the EU authorities. Such government actions are one of the catalysts that could positively impact on the popularity of energy wood in Europe in the future.

As Eurostat statistics state, the consumption of renewable energy within the EU-28 almost doubled between 2004 and 2013. This very positive result was achieved because of the rapid development of various sources, including solar and wind energy, but the steady growth of biomass and wood consumption also played its role. In 2013, wood accounted for over 46% of EU-28’s gross inland energy consumption of renewables or 5.5 % of the total energy consumed in these countries. (Eurostat, 2015) In absolute numbers, the total energy wood consumption of the EU in 2012 was 337.2 million m^3, of which 168.6 were burned by households and the rest by biomass power plants. (Sokka, Koponen & Keränen 2012, 12)

The share of wood and wood waste in gross inland energy consumption varies extensively between the European countries. It ranges from over 20 % in Latvia and Finland down to less than 3 % in Cyprus and Malta, proving the trend that this fuel has the greatest popularity in the Scandinavian and Baltic countries. However, the share of wood energy used for the manufacturing needs is usually smaller. In concordance with the information from the Finnish Statistics Center, the amount of wood-based energy used for manufacturing in Finland in 2013 was 50 438 TJ (including forest chippings, firewood, sawdust, cutter shavings, industrial wood residue, wood pellets, briquettes, bark and other by-products from the wood processing industry) out of 521 075 TJ of the gross energy consumption, which makes a share of 9.7%. This fact shows that even in countries where forest energy plays a significant role, industrial facilities still prefer using traditional sources of energy. (Statistics Finland 2014.)

2.2 Types of wood energy sources

Before describing the sources of wood energy, two definitions must be given in order to use a proper terminology afterward; hence, forest fuel and wood fuel have to be distinguished. Forest fuel (fuelwood) is produced directly from forest wood or plantation wood through a mechanical process, also, the raw material has not previously had any other use. At the same time, wood fuels are defined by Krajnc as all types of biofuels originating from woody biomass, where the original composition of the wood is preserved and unaltered from its original form. (2015, 10)

There are five main types of a wood fuel defined by the EN ISO 17225-1 standard.

1. Firewood is cut and split, oven-ready fuelwood used in household wood burning appliances like stoves, fireplaces, and central heating systems. It usually has a uniform length, typically in the range of 200mm to 1000 mm.
2. Logwood usually has a uniform length, typically in the range of 200mm to 1000 mm).
3. Wooden chips are a chipped woody biomass in the form of pieces with a defined particle size produced by mechanical treatment with sharp tools such as knives. Wood chips have a sub-rectangular shape with a length of between 5 and 50 mm and a low thickness compared to other dimensions. Any type of woody biomass could be used for making wood chips. Chip-burning systems could be installed in combined heat and power plants or personal households.
4. Wood pellets are a densified biofuel made from pulverized woody biomass with or without additives, usually in cylindrical form, of various lengths. The particles are typically 5 to 40 mm long and have broken ends. In Europe, all pellets have to be uniform in shape and density and contain less than 10% of moisture. They also must not contain any recycled wood nor contaminants. The wood material is held together by lignin, a natural "glue" that is activated by heat when a wood material is put under pressure. Pellets have several advantages over logs including high energy output due to their low content of water and high density, lower volume for storing, less ash, and fewer required

deliveries. Pellets are just as cost efficient as logs because of the higher energy content, but pellet boilers are more expensive than log boilers. (Woodfuelresource 2016.)

5. Wood briquettes are densified biofuel made with or without additives in cubic or cylindrical units, produced by compressing pulverized biomass. They have very high heat output and density, and they do not require special stoves and have low moisture content.

As the customer is specializing on firewood, the study was mainly devoted to this type of the wood fuel. Nevertheless, the physical and chemical wood properties described in the next paragraph are valid for any wood energy source.

2.3 Wood as a fuel

The release of energy from the wood occurs during its combustion in the burning process. The main heat producing elements of wood are carbon and hydrogen, one burned kilogram of wood gives 32.8 MJ of energy from carbon and 142.1 MJ of energy from hydrogen. The main source of these two elements is lignin, which is a complicated component of polymeric phenolics. It has higher calorific value than the two other components of wood cells, cellulose, and hemicellulose, which are formed by long chains of carbohydrates. Altogether they form about 99% of the wood material; other organic components are so-called extractives, such as terpenes, fats, and phenols. Moreover, inorganic nitrogen and sulphur can be found in the wood; depending on the tree species, the content of the nitrogen can be 0.75% or higher in nitrogen-fixing trees such as alder. The share of sulphur is much lower, 0.05% is the highest. Compared to some other popular fuels, wood has relatively low heating value per dry weight due to a relatively low carbon content and high oxygen content. (Huhtinen 2006, 1-5.)

The most important physical wood properties are moisture content, density, heating value, particle size distribution, ash content and properties, chemical composition, the amount of volatiles and results of proximate and ultimate analysis. The key parameter here is moisture content: it significantly influences on the heating value, since the net heating value of the fuel decreases when water has to vaporise during the burning. The standard moisture content is 40%, but in can vary depending on many factors such as climatic conditions, time of the year, tree species, part of the stem and storage phase. The final result can balance from 15% in optimal Nordic conditions to 60%. Moisture content is usually specified as the percentage of the total weight of the sample (on a wet basis).

Wood density is a parameter that determines the weight of one metric unit of wood biomass. It can vary depending on: tree species, moisture content, and biomass type. Particle size is discussed more thoroughly in the next paragraph, but it can also range from sawdust-like particles to the whole pieces of wood.

Ash is the non-combustible mineral content of the fuel and predominantly consists of oxides of such as potassium, calcium, and magnesium. Some tree parts have very low ash contents, for instance, heartwood, and bark is a material with the highest concentration of it. The problem of ash in the burning process is that it can cause the formation of lumps of clinker or slagging, which may prevent the normal air flow in boilers or stoves. (Woodheat Solutions 2010, 7.)

Talking about the heating values, two definitions must be distinguished from one another. The calorific heating value is the amount of energy created when one kg of absolutely dry wood is burned and all water created in the burning process is condensed. At the same time, the effective heating value presumes that the wood is moist and that the water created in the burning process vaporizes. There are differences in both parameters between different tree species; in general, coniferous trees have higher heating values than deciduous or broadleaved species due to a higher content of lignin in their wood. Heating values could be given in MJ/kg or MJ/m^3, but expressing the energy in kWh or kcal is also common. For example, pine, which is the main product of A-Firewood Finland Oy, has the following calorific values: 19.3 MJ/kg or 7511 MJ/ m^3 or 5.37 kWh/kg or 4.6 kcal/kg. Moreover, it must be mentioned that different parts of the tree have different calorific values: pine stem without bark has a value of 19.31 MJ/kg and the same value for the whole tree with bark and crown is 19.52 MJ/kg.

3 Firewood: technical and commercial overview of the product

After the discussion about the general fuelwood features, the emphasis in this chapter would be aimed at firewood as a product. The features of its production, transportation, handling and trading are clarified thoroughly.

3.1 Firewood standards

The European Union commissioned the European Committee for Standardization (CEN) to develop standards for solid biofuels. Subsequently, the CEN established a Technical Committee 335 – Solid biofuels, which covers all types of woody biomass. Afterwards, a suite of interconnected technical standards (TS) was created, defining the terminology, specification, fuel quality assurance, sampling and the range of tests needed to quantify fuel properties. CEN/TS have displaced all other European national standards across the EU, such as DIN. New ISO standards (ISO/TC 238) are also based on them. (Kofman 2010, 2.)

Different groups of standards are responsible for the description of wood fuels, determination of its parameters and quality control. Overall, there are about 30 standards, and each of them specifies a certain biomass type, physical parameter or procedure, such as sampling or calculation of analyses. The properties stated by standards are divided into normative and informative: data from the first category has to be stated when selling the wood fuel, and informative properties can be used as a supplementary information.

Standard BS EN 14961-1:2010 defines the general requirements and lists what properties must be stated for each solid biofuel type. EN 14961 parts 2 to 6 then apply to an individual solid biofuel type and describe the specific classes of that fuel divided by quality classes.

The part 5 of the EN14961 standard determines the product standards for the non-industrial firewood. It is defined as a woody biomass with a particle size from 100 mm to 1000 mm and prepared by the method of cutting with sharp tools. Features that have to be normative for firewood, are origin, dimensions, moisture content and ash content. Density and net calorific value are informative and may be stated.

As mentioned before, the key feature for firewood is moisture content. It is assumed that the fuel is traded readily for combustion; selling wood that is not seasoned sufficiently and using a standard is also possible, but in this case the actual moisture content has to be clarified. The consequence of improper seasoning is pollution due to unburned gasses, the build-up of running soot in the chimney and the emission of fine dust. Dimensions are another important parameter as they show if firewood will fit into the burning chamber.

There are three classes of firewood: A1, A2 and B. Each of them have its own features and information about them that could be found in Appendix 1. (Kofman 2010, 4.)

The length and diameter of at least 85% of firewood should be kept in the specified property class. There are some remarks about both of these two parameters: diameter classes D2 and D5 are recommended as ignition wood and the length should stay within the boundaries of 2 cm from the stated value. The “smooth and even” cut-off surface that is mandatory for the A1 class firewood could be achieved by using a chainsaw. Moreover, the moisture content on both wet and dry basis has to be stated; it should not be less than 12 w-% on a wet basis (M) or 13.64 w-% on a dry basis (U).

In addition, in the case of exporting firewood to Great Britain, the goods must be accompanied by a Plant Passport in order to confirm that they meet the landing requirements specified for the UK. Regulated firewood that is bark-free (with the exception of conifer material from pine wood nematode demarcated areas and plane from other EU member states) does not need to be accompanied by a Plant Passport. (Forestry Commission 2015, 8.)

3.2 Production of firewood

The process of industrial firewood production consists of six stages: felling, forwarding, chopping/splitting, drying, distribution, and transportation. Its supply chain model is represented in the diagram below.

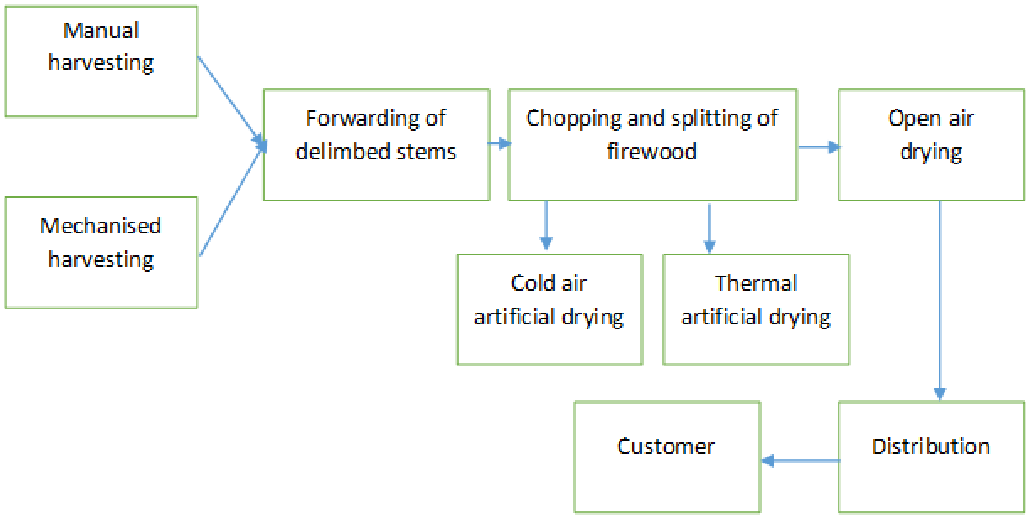


Figure 1. Visual representation of a firewood production process

In Eleftheriadis view (2012, 2), a cost of felling is almost the same for both manual and mechanized harvesting. The second step, delimbing of stems increases the harvesting cost, but in this case, more favorable conditions for a low-cost forwarding of stems are created. Two significant factors that influence on the cost and productivity of cross-cutting and splitting operations are the stems' diameter and the type of machinery which is used in these processes. Talking about drying, open air drying has better cost efficiency than the artificial one, so oven drying is recommended in cases when air drying is not possible or there are strict technical product requirements. The normal moisture content in freshly sawn wood is about 50%, so drying is inevitable in the process of firewood preparation.

There is a direct relation between harvested quantities and the cost per unit for split, dried and packed firewood. According to the economies of the scale principle, large quantities enable savings mainly by decreasing the delivery cost and because of more efficient use of machinery. This correspondence can be seen in the diagram below. (Raitila, 2008)

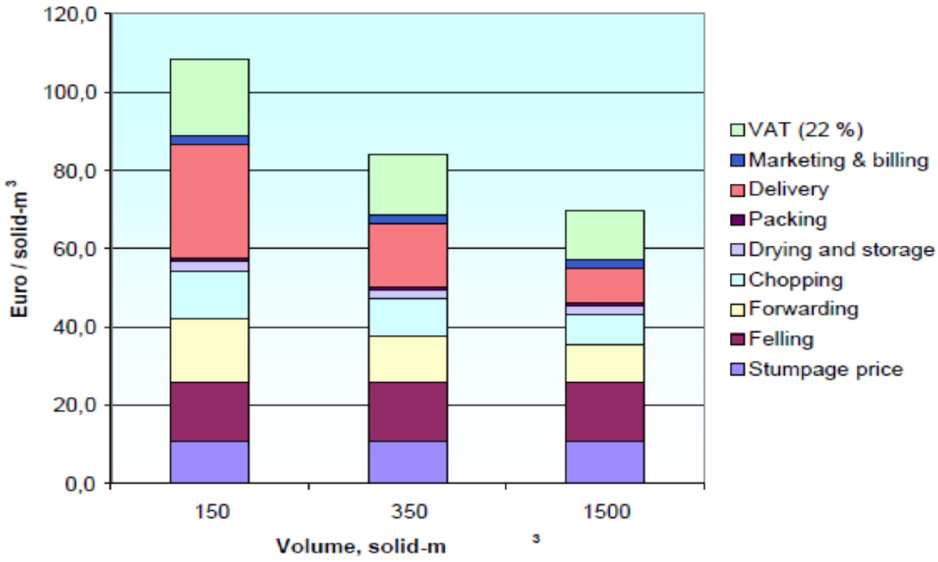


Figure 2. Relation between quantities and costs of produced firewood

3.3 Description of the firewood supply chain

Responsible for more than 20% of the overall firewood production cost, the transportation is divided into two significant parts: delivery to the processing operation and the second-stage transport of wood fuel product to the end user. The gains in this area could be achieved in various ways, including the maximization of load density and using the transport more efficiently. An example of the firewood transport chain can be found on the flowchart below. (Visser 2010, 26.)

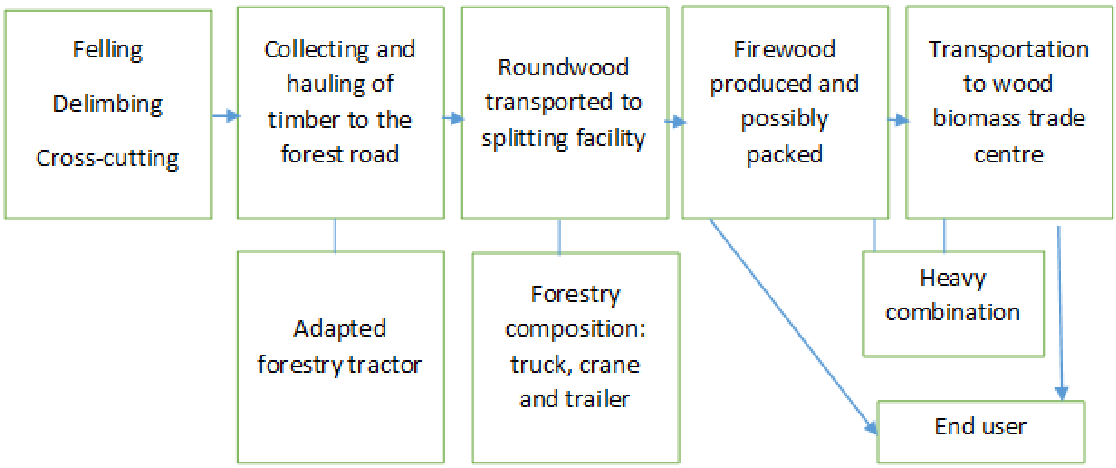


Figure 3. Visual representation of a firewood supply chain model

There are several requirements to the firewood transportation system. For instance, it should be designed to be as optimized as possible, especially where haul distances are long. This includes having voluminous and robust purpose-built trucks which would be able to take loads of sufficient density so that the gross vehicle mass would be reached and the payload would be maximized. This is especially important if the moisture content of firewood is high.

As the study was aimed at the transportation of already prepared material, issues related to the delivery to the processing stage such as loading of logs to the trailer were not covered. Instead, long-distance transportation was studied.

As the EFORWOOD research reveals, (Le, Bajric, Vötter, Berg, Anderson & Roux 2011, 8) in 2004 wood products represented less than 5% of the total tonnage shipped in Europe. However, the share varied a lot from country to country: in Scandinavia and other major producers of energy and industrial wood this share was generally bigger, for example, in Sweden forest products and timber accounted for about 25% of the national land transport.

Different modes of transport could be used for a long-distance delivery of wood products, but in Europe, the most common ones are road, rail and inland waterways. The proportion of them varies in each country, but generally inland waterways play a significant role only in Germany (14% in ton-kilometre in 2007), and rail transport is more important in Germany and Sweden than, for example, in France and The UK. (ibid., 9.)

Usually, the choice of transport is determined by the distance that the wood products have to be transported. The average distances for wood products are 17 km for a road, 60 km for rail and 94 km for inland waterways. Short distances are usually covered by road; in other cases, alternative transport modes are considered. Compared to other products, the distance of an average delivery of wood products is slightly longer than the same parameter for other commodities; this trend is clearly visible in the diagram below, where the transportation statistics of all groups of products (so-called NST25) and wood cargo are matched. (ibid., 12.)

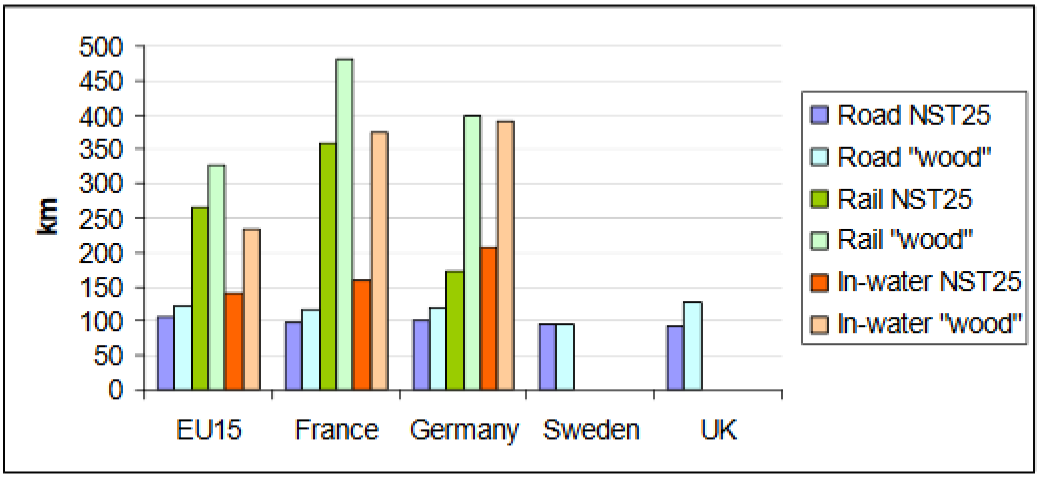


Figure 4. Comparison of average transport distances of wood and other products

3.4 Firewood prices

The Slovenian Biomass Trade Centre has researched the market prices of firewood in several European countries in 2014. The rates have changed since then, but it is still reasonable to consider these values presented in Figure 5. The given prices include VAT and transportation costs and refer to the retail on the local level. M, in this case, stands for the moisture content and L means the average firewood length. (Prislan, Krajnc, Jemec & Piškur 2014, 3.)

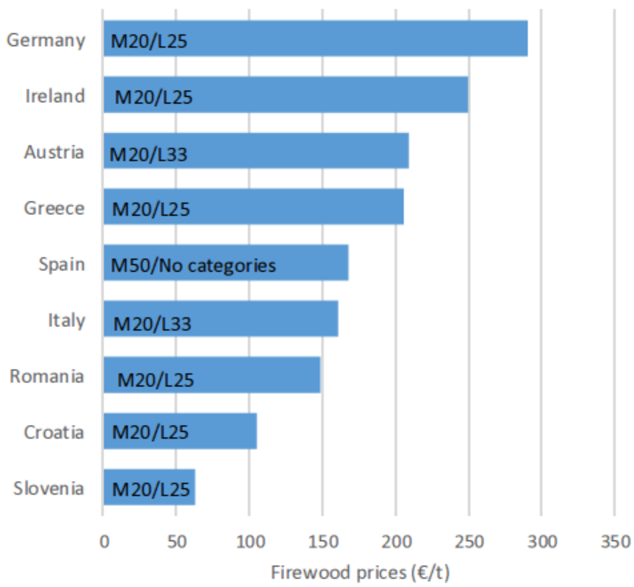


Figure 5. Overview of firewood consumer prices in Europe

As can be seen, the prices for firewood vary significantly by country. In Germany, the market price in 2014 was 290.27 EUR per ton and this was the highest rate among the considered countries.

As Hugos (2003, 56) states, the pricing strategy of a company should depend on its cost structure. If a company has flexibility to vary the size of its workforce and productive capacity and the cost of carrying inventory is high, it should adjust the demand during the peak season. In the case of a smaller degree of flexibility and lower inventory carrying costs, a low-season demand should be stimulated.

4 Transportation, taxation and exporting procedures

This chapter covers general issues related to the taxation and organization of exporting process of firewood from Finland to Europe.

4.1 Regulation of truck dimensions

The choice of correct vehicle for the transportation determines both variable and fixed costs of the delivery process. First, fuel costs depend on the burn rate of the vehicle and maintenance ones are mainly dependent on its age; also, capital cost of the truck, insurance fee, and some other fixed costs are directly formed by the truck type. However, even if the vehicle suits to business needs, it must comply with existing regulations.

Weight and dimensions of heavy commercial vehicles are established by the Directive (EU) 2015/719; road safety and condition of the infrastructure are the main reasons, explaining the limitation of these parameters. Moreover, the Directive ensures free circulation of vehicles, which comply with the limits from performing international transport operations within their territories, and aims on avoiding the national operators to benefit from undue advantages over their competitors because of the local regulations. (A 29.4.2009/719.)

In the overwhelming majority of the countries, the vehicle height is limited by 4 meters and width could not exceed 2.55 meters. Length and weight limitations depend on the vehicle type: lorry or trailer should not be longer than 12 meters, for road trains and articulated vehicles the limits are 18.75 meters and 16.5 meters respectively. The maximum weight depends primarily on the number of axles, but, generally, it cannot exceed 10 tons for a non-drive axle and 11.5 tons for a drive axle.

The maximum permissible vehicle parameters are unified in the most of the European countries. However, there are significant exceptions: for instance, in some states the maximum height is simply not defined. Sweden is one of those countries; moreover, the length of the lorry or trailer there could be twice as big as in continental Europe and can reach 24 meters. There is a great number of niceties in the regulation of maximum permissible weight, so each specific case should be checked separately.

European regulation related to this topic could be changed in the future because of the precedent of European Modular System implementation in Sweden and Finland. EMS entails these two countries the use of longer and heavier vehicle combinations (LHVs). In short, EMS consists of the longest semi-trailer, with a maximum length of 13.6 m, and the longest load-carrier, with a maximum length of 7.82 m, allowed in the EU. This results in vehicle combination’s length of 25.25 m. Therefore, by using LHVs’, the volume of three EU combinations can be transported by two EMS combinations. The project initiators state that the use of LHV’s has a positive effect on the economy and environment, while not affecting traffic safety negatively. (Åkerman & Johnsson 2007, 2.)

4.2 Driving time regulations and AETR agreement

The Regulation (EC) No 561/2006 is responsible for controlling the driving times and the rest periods and related to all drivers, who are performing road haulage and passenger transport operations. The area of regulation is diverse and includes all types of journeys, so it does not take distance, type of driver’s employment or national/multinational status of the voyage into account. The need for such regulations is explained by avoiding distortion of competition, improving road safety and ensuring drivers' good working conditions. The regulations are valid on the territory of all

EU and AETR countries, Iceland, Norway and Liechtenstein; therefore, the only exception is Switzerland. (A 15.3.2006/561.)

Tachographs, which are tracking the driving time, must be installed in every vehicle with permissible mass greater than 3.5 tons including any trailer or semi-trailer or passenger vehicles, adapted to carry at least nine people including the driver. Regulations must be followed even if the vehicle is not loaded; the control is carried out via checking tachograph records by appointed services at the roadside and at the premises of undertakings.

The list of the key AETR rules could be found below.

- Daily driving period shall not exceed 9 hours, with an exemption of twice a week when it can be extended to 10 hours.
- Total weekly driving time may not exceed 56 hours and the total fortnightly driving time may not exceed 90 hours.
- Daily rest period shall be at least 11 hours, with an exception of going down to 9 hours maximum three times a week. Daily rest can be split into 3 hours rest followed by 9-hour rest to make a total of 12 hours daily rest
- Weekly rest is 45 continuous hours, which can be reduced every second week to 24 hours. Compensation arrangements apply for reduced weekly rest period. Weekly rest is to be taken after six days of working, except for coach drivers engaged in a single occasional service of international transport of passengers who may postpone their weekly rest period after 12 days in order to facilitate coach holidays.
- Breaks of at least 45 minutes (separable into 15 minutes followed by 30 minutes) should be taken after 4.5 hours at the latest. (ibid., 6-7.)

4.3 Other road transportation limitations

Among key limitations in road transport other than weight, dimensions and driving time regulations could be highlighted cabotage, rules of dangerous goods carriage and speed limits.

Cabotage is defined as a carriage of goods for hire or reward by a non-resident haulier on a temporary basis. Historically such operations were restricted to some extent; even nowadays, the cabotage in air transport industry is generally prohibited with certain exceptions such as operations inside the EU. Reasons for such prohibitions are economic protectionism, national security or public safety. However, the situation on the road transportation market is different and the limitations related to cabotage are usually minimized.

Cabotage rules inside the European Union are set in force by the Regulation (EC) No 1072/2009. After increasing the volumes of freight transportation in Europe some decades ago, especially the intra-EU flows, the need in the liberalization of national markets has become clearly visible. For any company, establishing in every country where it wants to operate just on a temporary basis can be a challenge and avoidance of such operations will cause inefficiency problems due to the empty mileage. (A 21.10.2009/1072.)

Therefore, the article 1 of the Council Regulation 3118/93 has been created. According to it, “any road haulage carrier who is holder of the Community authorization (provided for in Council Regulation 881/92), is entitled to operate national road haulage services for hire and reward in another Member State without having a registered office or other establishment therein, provided these services are performed on a temporary basis”. (A 25.10.1993/3118.) In 2009, this regulation was adjusted and some uncertainties related to the local interpretation of the rules were removed.

The main restraint in cabotage within the EU is a number of operations within a time limit: as the article 8 of the Regulation states, “every haulier is entitled to perform up to three cabotage operations within a seven days period starting the day after the unloading of the international transport”. (ibid., 4.)

ADR is a Europe-wide classification of dangerous goods, which also could be applied to the transport of goods by rail. It divides the substances into UN classes (for instance, explosives, gases or flammable liquids) and defines the rules for their transportation, packaging, and labelling. Speaking of speed limits, they vary in each European country and the maximum permitted speed always has to be clarified in advance.

4.4 INCOTERMS rules

INCOTERMS are uniform, internationally recognized foreign trade terms that refer to the type of agreement for the purchase and shipping of goods internationally. They were created in 1936 by the International Chamber of Commerce; the most recent version of these rules is INCOTERMS 2010. Each rule has a three-letter abbreviation and defines respective obligations, costs and risks involved in the delivery of goods from the Seller to the Buyer; moreover, the right of ownership in each stage of the journey is clarified. However, there are major limitations: INCOTERMS rules do not constitute a contract, supersede the law governing the contract or take the responsibility for credit terms, currency or price to be paid. INCOTERMS always have to be accompanied by a named place of destination and a reference to the rules.

There are 11 rules in INCOTERMS 2010, compared to 13 in the previous version. They could be grouped based on two principles. First, there are several rules that could be used only in the sea and inland waterways transportation (FAS, FOB, CFR, and CIF); other rules do not have such limitation. Secondly, there are four categories determined by the first letter of the rule. There is only one “E” rule (EXW) and, according to it, the seller’s obligation is limited to placing the goods at the disposal of the buyer at the seller’s premises or another named place. “F” rules (FCA, FAS, and FOB) limit the seller’s obligation to place the goods at the disposal of the buyer at the seller’s premises or another named place. “C” rules (CPT, CIP, CFR, CIF) state that the seller arranges for transportation, but does not bear the risk of loss or damage to the goods or any additional costs due to events occurring after the shipment. Finally “D” rules (DDP, DAT, DAP) demand the seller to bear all necessary expenses and risks involved in transporting the goods to the named place of destination. (Nordea 2011.) The visualized representation of INCOTERMS 2010 can be found in Appendix 2. (livingstonintl.com 2016)

4.5 Taxation

4.5.1 Trade legislation and Value Added Tax

In this chapter is analysed, how the exporting of firewood from Finland to Europe has to be done from a legal point of view and which taxes have to be paid throughout the process.

According to the European legislation, (A 28.11.2006/112.) it is possible to import and export the goods inside the EU freely. The government of any country may not limit quantities of imports/exports nor restrict trade in any other way. Moreover, the transit of goods through any European country could not be limited.

There are several exceptions to this principle. One of them is related to the definition of harmonized rules; the product can circulate within EU freely only if it complies with them. Otherwise, restrictions can be used for sanctions such as limiting quantities of sales. The aim of the harmonized rules is the protection of consumers, public health, and the environment.

In the “Wood and articles of wood, wood charcoal” product category there are three non-harmonized subcategories of products, which are bamboo charcoal, wood charcoal and clothes hangers of wood. As we can see, there is no firewood, so it can be accounted as a harmonized product.

Moreover, there are mutual recognition rules. They state that if the product is sold to the final customer, there might be an obligation to use a given language for your products depending on the country of destination. As A-Firewood is going to sell some of its products directly to consumers, this has to be taken into account. (ibid., 26-78)

As Finnish Customs website states, for goods traded between EU countries, no customs declarations need to be submitted. For the purpose of foreign trade statistics, however, Intrastat declarations have to be submitted for the goods if the annual value of the exports exceeds 500 000 euros. (Finnish Customs Administrations, 2011)

Value Added Tax (VAT) is the tax that is chargeable on all of the company’s sales and purchases unless exports to the countries outside the European Union. There are two important reasons for A-Firewood to consider VAT: the company should include the tax into the final consumer price; furthermore, as a customer of freight forwarding companies, A-Firewood should pay itself the tax for the transportation and other services.

In order to sell products, A-Firewood has to register with the tax authorities in Finland, which is the location where the business is established. Furthermore, it must charge VAT from the customers and to account for this to the tax authorities. There is also an option of VAT deduction, which presumes that only the difference between the sales and purchases of A-Firewood has to be taxed. In Finland, the VAT tax return is done every year, quarter or month depending on the business turnover. A yearly VAT tax return is possible if the business turnover is EUR 25000 or less a year, and a quarterly VAT tax return is possible if the business turnover is EUR 50000 or less a year. (Annacondia 2015, 3.)

If the annual turnover of A-Firewood would be less than EUR 8500, it can apply for an exempt from VAT as a small enterprise, and this figure is a so-called threshold for Finland. If the total value of all taxable sales of A-Firewood in the year falls below this limit, the company would be exempt from VAT and could have the right not to charge VAT. If the case of the voluntary registration it must charge VAT, though. (ibid., 4.)

A-Firewood must supply its customers with a paper or electronic invoice; at least the state-given VAT identification number and the amount of VAT amount being charged have to be displayed there.

In each EU country, there are three VAT rates: a standard, reduced and super-reduced one. Reduced rates apply to the limited amount of supplies and the taxation of some supplies can be super-reduced, which consists of zero-rated or exempt-rated products. There is a difference between these definitions: for zero-rated sales it is still possible to deduct all the VAT that was paid on purchases directly related to this sale and for exempt sales such deduction is not possible. In most cases, a standard rate should be applied to firewood, but there are some exceptions with the reduced applicable rate, such as Belgium, Germany or Portugal. VAT rates for firewood in the EU are shown in the table below. Even though the company is registered in Finland

and the material has a Finnish origin, the VAT has to be paid in accordance with the location of the final customer.

Switzerland and Norway are not parts of the European Union, but their belonging to the EEA community equalizes the exporting procedures to them with other EU countries. The VAT rates for these two countries are also included in the table.

Table 1. VAT rates for firewood in Europe

Country and VAT rate for the firewood, %			
Belgium	6	Luxembourg	8
Bulgaria	20	Hungary	27
Czech Republic	15	Malta	18
Denmark	25	Netherlands	21
Germany	7	Austria	13
Estonia	20	Poland	8
Ireland	13,5	Portugal	6
Greece	23	Romania	20
Spain	21	Slovenia	22
France	10	Slovakia	20
Croatia	25	Finland	24
Italy	10	Sweden	25
Cyprus	19	United Kingdom	20
Latvia	21	Switzerland	8
Lithuania	21	Norway	25

Article 50 of the VAT Directive states that “B2C intra-Community transport of goods (goods departing from one Member State and arriving in another) is taxed at the place of departure”. However, the decisive circumstance, in this case, is whether the buyer used the VAT number. If no VAT number was used, the intra-Community transport was taxed in the country of departure. However, if the service buyer used the VAT number of another Member country (for instance, German customer used German transportation company and subsequently German VAT number), the rate of this country had to be used. (A 28.11.2006/112.)

The taxation of transportation services is a complicated matter due to many possible situations related to the background of the service provider and buyer and differences in taxation of private individuals and commercial customers. All situations relevant for A-Firewood could be modelled and merged into one table. Procurement of shipping services from local shipping companies is taxed according to this rate. The table is put into Appendix 3. (VAT Appeals and Communications Branch 2008.)

Transport of goods from one Member State to another via non-EU territory is also considered as intra-Community. In this way, transport from Finland to Sweden via Norway is intra-Community. Moreover, if the transportation includes several legs, each of them would be assumed as intra-Community; so, the truck transportation from Jyväskylä to Helsinki or Kotka would have this status if the fact of its further delivery to the UK could be proofed afterward.

Direct transport services from Finland to countries outside the Community and correspondingly, from outside the Community to Finland, are exempt from tax. Therefore, the transportation services from Finland to Norway and Switzerland would have tax-exempt status. In addition to this, any directly connected internal transports within Finland are exempted as well.

Ancillary services are taxed in the place where they are actually rendered. However, if the service buyer utilizes a VAT number issued in one of the Member States, the tax rate of this country has to be used. Ancillary services related to the transportation to so-called third countries are exempt from tax. In order to proof the direct connection of such services with the country outside EU, an adequate documentation such as an export certificate or freight documentation has to be provided (Vero.fi).

Moreover, ancillary services provided in port areas and airports to meet the direct needs of ships or airplanes are zero-rated. This includes harbour pilotage, mooring and unmooring, stevedoring, landing, stowing, loading, re-stowing, carnage, tonnage dues, cargo dues and towage. The zero-rating does not apply to the additional services, for instance, breaking down of containers, packing or storage for more than five days.

4.5.2 Transport taxes

The taxation of cargo hauliers in Europe is a complicated issue: the system varies a lot from country to country and the tax legislation changes quite often. Nevertheless, in order to perform trucking operations in accordance with the law and to estimate costs, the haulier has to clarify all possible taxes, tolls and charges in advance.

Currently, each member of EU and EEA have its own set of policies related to the taxation of transport. They are defined by social, cultural and economic reasons. Some taxes have a similar basis for all countries (for instance, fuel excise duties) and some are specific and could be identified only in one or several member countries. Certain tax categories also have to be paid by passenger car drivers, some are tailored specifically for a cargo transport.

The most common reasons of changing the tax percentages or introducing the new ones are related to the environment: there is a trend of tightening such regulations from year to year. However, there might be a different cause of changes; among the examples are coverage of road damage costs, promotion of alternative fuel supplies, encouraging or discouraging particular types of vehicle or commercial interest.

Among the fiscal instruments applied to the use of road transport in the European Union countries are vehicle purchase taxes (VAT and others), circulation taxes (annual registration tax), scrappage incentives, fuel duties (VAT and others), and road use charges, which include road or bridge tolls, Eurovignette fees, weight-distance taxes and urban road pricing.

4.5.2.1 Fuel excise tax

This is an indirect tax included into the cost of truck fuel, generally diesel. The tax is calculated on a volume basis, it is directly related to the haulier’s activity and, therefore, it can be counted as a variable cost. A current version of the fuel tax legislation in EU was adopted in 2003 by the energy taxation Directive 2003/96/EC. Only the minimum fuel excise level was defined by the Directive; this is the reason why the fuel duties vary substantially across the EU. (A 27.10.2003/96.)

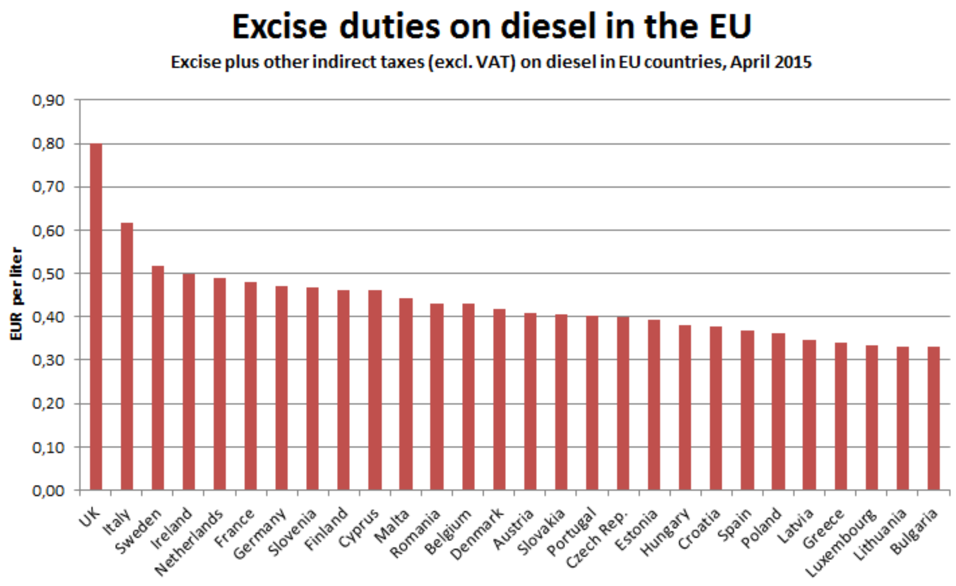


Figure 6. Excise taxation of diesel fuel in European countries

The most recent diesel duties, taken into use in 2015, can be seen in the diagram above. The minimum level, determined by the EU Directive, is 359 EUR per 1000 litres of diesel; in some countries, such as Lithuania, Romania, Greece and Bulgaria, the tax is set closely to the minimum boundary level. There may be economic reasons, but, for instance, the comparably low fuel tax rate in Luxembourg could be explained by the soft tax policy of this state. On the opposite, fuel taxes in such countries as the United Kingdom and Italy could be twice as high as the minimum tax rate.

The excise taxes are different for leaded and unleaded fuel and they are generally higher for the leaded one. However, the unleaded diesel dominates on the market nowadays; therefore, primarily the excise rate for this fuel should be taken into account. Moreover, the taxation of biodiesels, newly introduced to the market, differs from the traditional diesel; usually, the tax rate decreases in proportion to the share of biofuels that producers blend into the motor fuels released for consumption.

In addition to the fuel excise rate, the VAT has to be paid. In the case of diesel, no reduced tax levels can be used; therefore, hauliers pay full VAT amounts with every purchase of fuel depending on country.

4.5.2.2 Road user charging

The collection of road usage fees could be done either on the time or distance basis. They are charged in a different way: so-called Eurovignettes, stored since 2008 in the electronic format, are used for time-based payments and for the distance-based charging manual tolling or distance-based electronic tolling systems with a Global Navigation Satellite System (GNSS) or a Dedicated Short Range Communication (DSRC) function are implemented. The tolling is regulated by two pieces of European legislation: the "Eurovignette Directive" 1999/62/EC, amended by the Directive 2006/38/EC, and the Directive 2011/76/EC. These directives clarify the rules of money charging and set the maximum level for time-based charges. Due to the legislation flexibility, the road user charging system significantly varies throughout the European Union. (A 17.05.2006/38.)

Eurovignettes used to be employed in nine European countries: Belgium, Bulgaria, Denmark, Netherlands, Hungary, Lithuania, Luxembourg, Romania, and Sweden. However, during several years, the replacement process was continuing and currently this system is valid only in four countries: Denmark, Luxembourg, the Netherlands, and Sweden. The process of abolishing this system is ongoing; for example, Eurovignettes.eu portal states that Belgium has decided to no longer levy the Eurovignette for the Belgian territory as of April 1st, 2016 and to replace it by a kilometre-based toll. (eurovignettes.eu 2016)

The Eurovignette rates are updated every year; they depend on the emission group and amount of axles of the HGV. Trucks with the gross weight more than 12 tons are obliged to use vignettes. They are valid in any country of implementation, so if the truck is going through several Eurovignette countries, only one valid Eurovignette is needed. The service is distributed through the organization named AGES.

Distance-based charges, justified by the Directive 2004/52/EC, are a different way to collect taxes by the government. At the moment, the situation with these taxes is tentative in many countries, because the decisions about introducing them or changing the rate levels still have to be made. However, in some states such as Germany, the system is working well for the several years. The following technologies are used in order to track the chargeable operations: GNSS, GSM-GPRS, and DSRC. The user can pay the tax simply by subscribing to a single contract with a European Electronic

Toll System (EETS) provider; however, currently vehicles require multiple in-vehicle units in order to operate in different countries. (A 29.4.2004/52.)

While Germany, Switzerland and Slovenia have the toll rates valid for all roads in the country, such countries as Italy, France, Spain, Poland and Slovakia apply different charges per vehicle-kilometre for different sections of the toll road network. They are gathered while passing the physical barrier on the road and are paid either to the government or to the private owners of the road infrastructure. In some states, the road tolls could be combined with the time-based or traditional distance-based charges; most often in such cases, they are collected for entering the bridge, tunnel or another piece of infrastructure with a high investment cost (for example, Oresund bridge in Denmark). This topic and its relevance for A-Firewood will be covered more precisely afterward.

4.5.2.3 Ownership/registration duties

The taxation on the ownership of commercial vehicles depends on various factors in different EU countries. The most common criteria are weight and number of axles, but, in addition, among them could be exhaust emissions, noise, fuel consumption, axles suspension or payload. Duty could be determined by one or several parameters. This tax has to be paid on a yearly basis; on contrast, the vehicle acquisition tax (or registration) is a one-time payment. The registration tax represents a very small share of the vehicle's operating costs oppositely to the vehicle excise duties, which can be substantial.

VED are regulated by the EU Council Directive 2006/38/EC, which determines the minimum obligatory duty levels across the EU. In addition, the Directive stipulates lower minimum duty levels for the vehicles equipped with air suspension since it is assumed that their impact on the road infrastructure is lighter.

As vehicles, which belong to A-Firewood, are registered in Finland, both of these duties have to be paid in accordance with the Finnish tax rates. If the company will use the external transportation service, these taxes should be included in an invoice. The estimation of costs could be done based on parameters of the chosen truck and was calculated in the following chapters.

In addition, the CEMT license has to be obtained by the freight if the company or trucks are registered outside the EU or the ETA. The license is not a vehicle-specific, but it could be used by not more than one vehicle at one time. CEMT permits the company to run road transport operations for a maximum of three laden trips, after which the vehicle must return to its registration state. Moreover, for the transport operations including loading or unloading outside the EEA, a third-country permit should be purchased. Both permits are valid until the end of the calendar year and could be issued by Trafi. (A 1252/2002.)

5 Freight transport costs and practical delivery arrangements

This chapter covers methods used for the estimation of transportation costs related to exporting of firewood from Central Finland to Europe. The calculation model is the same for all locations. Due to the impossibility to receive pricing quotes from shipping companies, the results are based on statistics, transport calculations and assumptions. For those reasons and market volatility, it is not recommended to rely solely on them for making managerial decisions.

5.1 Transportation costs analysis

There are many factors that have to be taken into consideration when analysing the internal and external costs of a transport network: its size, the intensity of operations, the technology in use, features of transported products and the internal and external costs of individual components of the system. The key definition in transportation modelling is node: this is a place of origin or destination of goods, for instance, a clustering of manufacturing plants, warehouses, logistics centres and/or freight terminals located in shipper and receiver areas. The movement of freight units between nodes is possible because of the infrastructure and the quality of this movement depends on the volume of demand, the efficiency and effectiveness of the services, and the physical scale of the hardware. (Janic 2007.)

Talking about the road transportation, there are three steps in the movement of loads from shippers to receivers carried out by the same truck: collection in the origin zones; line-hauling from the border of the origin to the border of the destination zone; and distribution within the destination zones. (ibid., 34) Each sub-process causes internal and external costs: the first category is paid directly by the operator for cargo movement and external costs is a burden that network imposes on society.

Internal costs are determined by such processes as collection, distribution, line hauling and transhipment of units and they include the cost of ownership, insurance, maintenance and repair, labor, energy, taxes and various tolls and fees. As these costs lay on the shoulders of an exporter, they have to be analysed thoroughly in order to understand the freight rates.

The expenditures of road freight transport could be or could be not under the influence of the trucking company. Market and other conditions, determining parameters such as fuel and spare parts prices, insurance fee, taxes, road tolls, in most cases could not be affected by the company. On the contrary, costs related to shipped quantities and service quality are managed by the company itself, depend on the realization of technical and human potential and impact on such parameters as a coefficient of fleet utilization, average speed, a coefficient of available time utilization, average distance of the loaded truck run. (Kulovic 2004, 321.)

The factors increasing costs volatility are product characteristics, truck configuration, geographical characteristics, company size and driving characteristics. Moreover, such issues as truck utilization rate, empty running, and possibilities for back-haul, service availability and managerial decisions influence on costs significantly. In order to create a clear cost model, the influence of truck fleet operational parameters has to be assessed and modelled.

Traditionally, freight transportation costs are divided as fixed, variable and labor; however, sometimes labor costs are included in the category of fixed ones. The proportion of costs varies in accordance with the factors mentioned above, but the key expenditures are always fuel, tires, spare parts and lubrication as variable costs and interest, depreciation and overhead costs as fixed ones. (ibid., 322-323)

From the customer perspective, the cost is usually the most important aspect of trucking services. Nevertheless, speed, security, and reliability are also among the required factors most often. For a freight forwarder, following these factors means the increase in variable costs, which could be balanced by improvement into the truck utilization rate. The common reason of bigger share of fixed costs than expected is inadequate management and operational practices, but the reasons also could be related to the poor condition of the vehicles and infrastructure.

Another relevant transportation mode is maritime transportation. The traditional cost distribution in this industry is different compared to the road transportation. Expenditures are divided into three categories: capital, which are related to the acquisition of vessel; operating, including crewing, maintenance, storing and insurance, and voyage, associated with the particular ship employment and including bunkers, port and canal charges, pilotage, port fees and loading and discharging expenses. (ICS 2015) The third category is especially interesting for the charterers: the freight rate, given to them, is often dependent on voyage costs.

Such term as Bunker Adjustment Surcharge directly influences on freight rates: this is a charge used by the shippers to mitigate the impact of fluctuations in the price of the ship's fuel. The bunker clause, often used in contracting, states that the fluctuations in bunker costs are shared between consigner and consignee. So, typically, the market prices for maritime fuels (such as IFO 380 or LSMGO) provided by a trustworthy source (for example, Bunkerworld Rotterdam) are revised on a monthly basis and the customer price for one metric ton of fuel changes with every fluctuation of them.

5.2 Truck transportation costs distribution

The information from the reports issued by American Transportation Research Institute and Finnish Statistics Centre will be used as a basis for writing this chapter. Reasons for that choice are relevancy of the papers, the appropriate research methodology and need in comparison the American and European markets.

The main finding of the ATRI report is that while marginal cost points have variability from year to year, the proportion between cost categories is remaining stable over years, except the situations caused by the macroeconomic fluctuations such as oil prices shrinking or increasing. Fuel price is determining about one-third of the freight transportation costs, so every significant change of it influences on proportions between all other costs. This is clearly shown by the proportion of fuel costs versus overall expenditures for the time span since 2008 to 2013 in the USA: after the downfall of the oil market at the end of 2008, the share of fuel price decreased by 10% compared to the peak values. Relative shares of other cost items remained the same or increased. In Finland, the average share of fuel costs is smaller and, on average, comprises only about one-fifth of overall expenditures. However, the share of fuel cost increases together with the vehicle size: it varies between 7% for vans and 24% for the heavy combinations. (Torrey & Murray 2014, 21.)

Driver wages are an another substantial cost item. The percentage tends to vary depending on the country and it is usually smaller in developing states rather than in the developed ones. In many countries including Finland, the labor cost is dependent on the union agreements and wage rates set by them. Generally, this cost is increasing in the process of time, but its share is quite stable. Statistics tells that in the USA labor costs form from 26% to 30% of the total expenditures; in Finland the share is even higher and direct costs together with the indirect ones comprise about 45% from all expenses. For vans, this parameter can reach 65%.

Third biggest expenditure item is truck purchase payments or the vehicle lease. This cost is typically fixed, except the cases when motor carriers purchase additional trucks and trailers in response to capacity constraints in high-demand times. It includes the actual equipment depreciation and interest to be paid. In percentage values, the typical purchase payments in the USA lay between 10% and 18% of the overall costs and from 12% to 16% in Finland. The average tractor and semitrailer combination depreciation rate together with the interest for Finland is 10,97% from the total cost or 16.28% from the fuel and labor cost.

Other significant vehicle-based costs are tires, maintenance and repair and insurance. They could be estimated as percentages based on other costs. Finnish Statistics Centre provides the relative share of each of these costs for each vehicle type. Maintenance cost is directly dependent on the labor one, and in 2010, the share of it for the semitrailer combinations including spare parts, lubrication, and AdBlue component was **15,67%** from the overall labor cost. Tires and their adjustment can be derived from the fuel cost and, according to the same report, they comprise **13,6%** from it. On opposite to these costs which are variable, insurance is a fixed cost and its share (including transport, equipment, and driving ones) was **6,82%** from the cost of labor, fuel, tires, and maintenance. These numbers are used in the subsequent calculations.

In order to compare the calculated freight rate with the current market values, VAT, operating margin and profit should be added. VAT varies depending on the country where the transportation service is obtained. Operating margin and profit are used by service providers to adjust the revenues; their values obviously vary, but the rates used in calculations below are 5% for the operating margin and 20% for the profit.

There are three operating sectors of freight transport: Less-than-Truck-Load (LTL), specialized transport and Truck Load (TL). The first sector has the biggest operating costs for the several number of reasons: frequent pick-up and delivery operations in congested urban areas, causing higher fuel and maintenance costs; increased overhead costs caused by handing big numbers of smaller shipments; a need for multiple terminals located near urban areas and the subsequent need for more equipment.

Specialized cargo has the second biggest operating cost and Truck Load is the most economical one. According to statistics, in 2013 average total marginal costs of LTL in the USA were 9% bigger than the same parameter of the specialized cargo and 13% bigger than of the TL. A-Firewood is going to use only TL, so this operating sector should be referred when making the estimations.

It must be mentioned that transportation costs compound the biggest share of the supply chain costs, but it does not exceed even 50%. Warehousing, inventory holding, order processing, management, and planning costs also must be taken into account when planning the supply chain system and their distribution can be found in the diagram below. (Kille & Schwemmerin 2014)

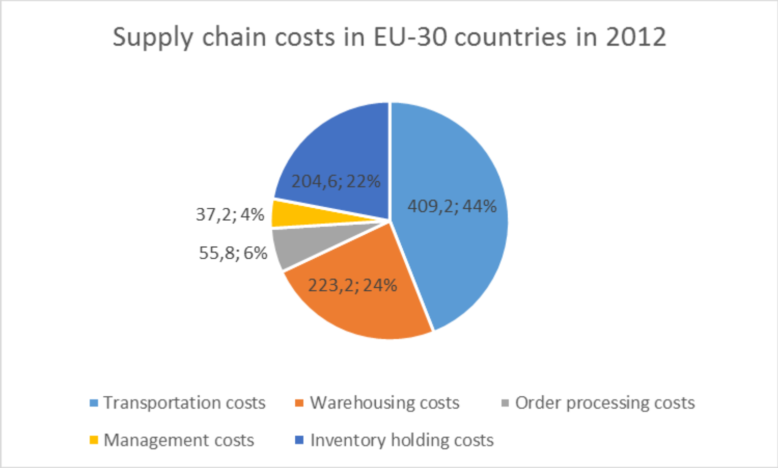


Figure 7. Distribution of supply chain costs

5.3 Transportation costs adjustment

There are many ways to model the costs of freight transportation. It could be done either on an empirical or statistical basis, but in both cases, the quality of modelling directly depends on the input data and the amount of parameters taken into consideration.

The most appropriate way of cost modelling for A-Firewood lays somewhere in between: the up-to-date information has to be used, but in case of inability to find the relevant data, the appropriate statistics should be added. Moreover, the existing theoretical model has to be taken into consideration and compared with the research outcomes. For this purposes, the model created by Mirsad Kulovic was selected: based on truck fleet operational parameters, it enables to estimate the fixed and variable costs taking the capacity and efficiency parameters into account.

The model assesses costs per unit of transportation work, measured in ton-kilometre. The following factors are considered: vehicle capacity and utilization, fleet availability and utilization, path utilization, speed and travelled distance. Four parameters X, Y, Z, and F are established in order to analyse transport costs as a function of truck fleet operational parameters and characteristics group of similar operational parameters. X value represents the influence of elements which are related to the average carrying capacity of truck fleet and its utilization; it could be calculated as $1/(e*q)$, where e is a coefficient of vehicle capacity utilization and q is its capacity in tons. Y is responsible for time utilization and comparison of available operating time with the time under repair. The formula for Y is 1/(a*p), where a is the coefficient of vehicle fleet utilization and p is the coefficient of time utilization. The first parameter uses days as the unit of time measurement and the second one is calculated on a hourly basis. (Kulovic 2004, 2.)

Z parameter shows the influence of path utilization, determined by the ratio between loaded and unloaded distance travelled, and average vehicle speed. There is a significant number of factors impacting on Z: demand pattern, backhaul opportunities, a condition of the infrastructure and issues with the availability situation on the market. In its simplest version, Z could be calculated as 1/(b*s), where s is the average speed and b is the coefficient of path utilization. Finally, F represents the influence of time lost during the operation and is affected by management decisions and the quality of cargo handling services. It could be simply calculated by dividing time lost on the average length of a loaded truck run. (ibid., 3).

After calculation the parameters, they could be used to find the total transportation cost. Kulovic proposes the following formula:

TTC=X*(Y*fixed costs*(Z+F)+Z*variable costs)

The key problem is collection of the valid data: a lot of measurements must be done to find precise coefficients. However, they can be estimated in order to create the overview of expenditures. The model assumes that fixed and variable costs are already known, so its aim is to adjust them and to bring the expenditures closer to reality.

5.4 Choosing of the proper vehicle

The decision, which vehicle model should be used for the firewood distribution has to be based on various factors. It obviously has to be determined by the product: sacked firewood is a loose product and its density necessitates the usage of comparably voluminous trucks in order to perform operations efficiently. Cargo is going to be palletized, so there must be an opportunity to load and to unload pallets. Another considered factors are dimensions and weight restrictions: regulations of every state, through which the vehicle is going, should be complied. Different stages of the wood supply chain, shown in the Figure 3, require using various vehicles; as the study concentrates on the final stage of distribution process and delivery the product to the final customer, selection of vehicle only for this operation was done.

There are many transportation options available, but the most rational one is to use a 32-ton GSW semitrailer. Its capacity is good enough and, at the same time, the weight and dimensions are not restricted anywhere; moreover, the vehicle design enables to use the tractor unit and trailer separately. As ACEA states, the fuel consumption of such semitrailers needed to transport a certain amount of cargo is 9.4, 4.1, 2.9, 1.9 and 1.4 times smaller than for 3.5-ton, 7.5-ton, 12-ton, 18-ton and 26-ton trucks respectively. Longer and heavier combinations may carry more pallets at once and have better fuel consumption per ton, but they are currently restricted in continental Europe except Finland and Sweden. (Larsson 2009, 7.)

The semitrailer described below is common on European roads and its parameters are in accordance with the Directive 96/53 EC. It has five axles and the payload of 25000 kg. The total length is 16.5 meters, of which 4.5 meters is the maximum distance from the front of the tractor to the fifth wheel and 12 meters from the fifth wheel to the end of the semitrailer. The maximum front overhang of the semitrailer is 2.04 meters, which gives a length of 13.6 meters for a semitrailer with a flat front. The tractor wheelbase 3.6m and the semitrailer wheelbase 7.5m were chosen for the reasons of better traction: a longer semitrailer wheelbase gives a higher kingpin load and more load on driven axles. According to the directive 97/27, a wheelbase could be up to 8.115 meters; however, such long wheelbase would cause an overload on the driving axle in the case of even load distribution.

The axle distance of the semitrailer is 1.31 meters. The distance from the front axle to the fifth wheel is 3.14 meters. Empty vehicle weights 7 tons and the maximum mass of cargo loaded is 25 tons, so the overall weight of fully-loaded combination is 32 tons. The useful volume is 92 cubic meters.

In Nylund's and Erkkilä's view (2005,17), the fuel consumption of full-loaded semitrailer on a highway is slightly bigger than 35 liters per 100 km. Taking factors of slowdowns, driving through urban areas and congestion into consideration, the number can be increased up to 38 liters, which is a reasonable value for the fuel cost calculations.

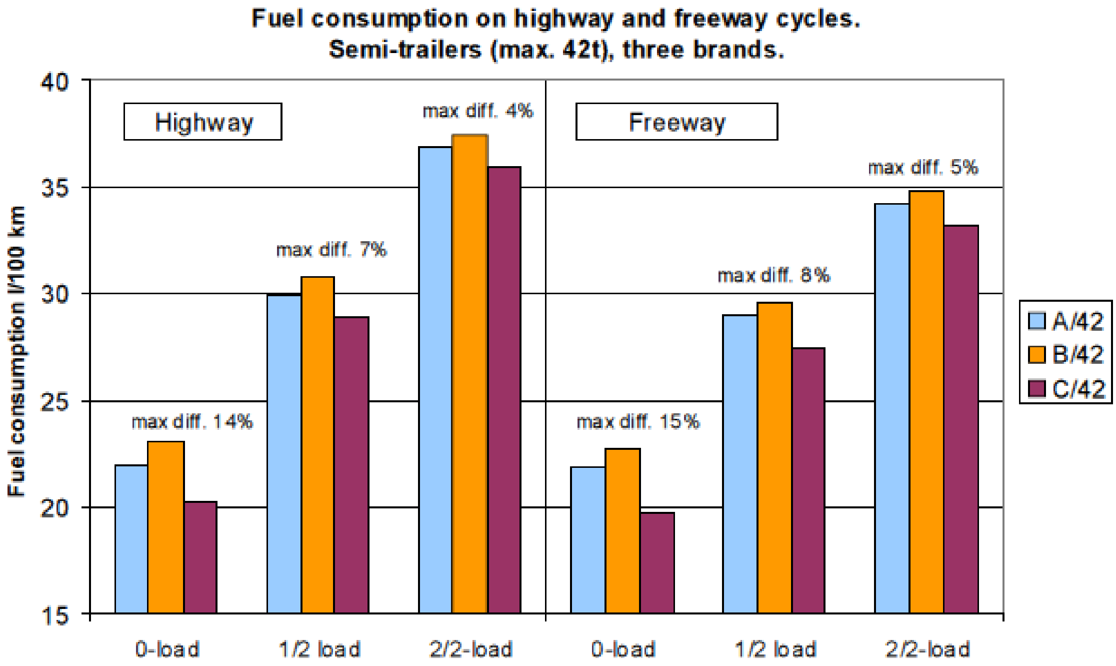


Figure 8. Analysis of fuel consumption rates of semitrailers

Firewood is packed in 40-liter sacks, stacked on pallets. The planned weight of one pallet is intended to be 1000 kg. As the main constraint in the transportation of firewood is volume, there is a question of how many sacks could fit on one pallet.

It was assumed, that the origin of firewood is birch and it has the normal moisture content of 20%. The basic wood density, in this case, is 610 kg/m^3. Density of the chopped firewood is twice lower, according to FAO, so the value is 305 kg/m^3. Therefore, one pallet will fit 3.28 m^3 of firewood or 82 40-liter sacks. Taking the size of pallets and needed space into account, 25 pallets or 2050 sacks can be loaded to the semitrailer in total. The example of such loading arrangement can be found in the picture below. (drova.lv 2016)

Figure 9. Example of palletized firewood packed in 40-liter bags

The website mascus.fi was used to estimate the normal market price for the type of semitrailer needed. According to it, the Schmitz Cargobull semitrailer manufactured in 2011 is sold for 13500 EUR excluding VAT. The normal annual depreciation of the appropriate semitrailer is 10 years, so this vehicle still has the approximate lifespan of five years left. Assumed that the depreciation rate is 20%, which is normal for such equipment, we can find that the depreciation factor is 0.134, so the annual depreciation can be calculated based on that and to be 1809 EUR. In this case, the salvage value is 33% or 4455 EUR. Assumed the weighted interest rate to be 7%, the annual interest is 127 EUR, which together with the annual depreciation compounds the fixed cost of 1936 EUR or 5.3 EUR/day**.** However, the cost of tires must be subtracted from the depreciation: if assumed that the cost of one tire is 230 EUR and the number of tires needed is 10, the annual depreciation without tires cost is 1476 EUR or **4.04 EUR/day**.

5.5 Rules of shipping the vehicle combination by ferry

International truck transportation from Finland if often related to the need to transport vehicles by sea as Ro-Ro cargo. In this chapter, the main details related to such operations are covered in the example of FinnLink service between Naantali and Kapellskär, provided by Finnlines.

The sea freight of Ro-Ro is comprised of several factors: meter-pricing, vehicle fee including the driver ticket, tonnage and port fees, VAT of 24% and additional charges for oversized loads, dangerous goods or electrical connection. The information that has to be provided to the shipping company is: name of freight payer, unit length and its registration number, number of drivers, need for electrical connection, presence of dangerous cargo and oversized components.

Departures are organized twice per day to both directions: at 11:00 and 22:45 from Naantali and at 09:15 and 21:45 from Kapellskär. Freight rates are generally lower for the morning departures.

Semitrailers, special loads, dangerous goods units or other units that require stevedoring must be cleared and ready to load 1,5 hours before the scheduled departure. All units must be equipped with the appropriate lashing points. If weather conditions require the securing of loads, vehicles not equipped with the necessary lashing points cannot be shipped. Semi-trailer should have two securing points per side and a towing coupling at the front of the towing vehicle that is sufficient for two lashings. The maximum vehicle height is 4.8 meters and width should be no more than 6.5 meters.

In addition, in Naantali, the surveillance system requires a free-of-charge vehicle permit that is connected to license plate number. It could be obtained from the harbor authorities. (Finnlines 2016)

5.6 Vehicle taxes to be paid in the country of registration

As the chosen vehicle is registered in Finland, it has to follow Finnish tax regulations. In this country, the power tax for vehicles is based on the total weight and number of axles. The daily rates in cents for 100 kg can be found in the table below provided by ACEA.

Table 2. Power tax rates for heavy vehicles in Finland

Number of axles	Without trailer	With semitrailer	With trailer
2	0.6 for weight less or equal 12 tons		
	1,3	2,2	2,1
3	0,8	1,3	1,4
4	0,7	1,2	1,3
5 or more	0,6	1	1,2

As can be seen, the rate for the chosen 5-axle tractor with a semitrailer is 1 cent per 0.1 tons per day. Therefore, the annual tax is 32000*365/100 = **1168 EUR.**

CEMT tax has to be paid to Trafi only for the trucks going outside the EEA, so, for the chosen destinations including Norway, A-Firewood is not obliged to pay it. Nevertheless, the rate is **50 EUR** per truck.

There are no time or distance-based charges in Finland. The fuel excise duty is 0.506 EUR/litre and the average diesel price for the moment of 26.04.2016 is 1.132 EUR/litre.

5.7 Labor costs

In Finland, the minimum wage is not defined officially but is determined by agreements between labor unions and government. Salaries in transportation industry have to be in compliance with the document called “Kuorma-autoalan työehtosopimus”, adopted by the Automotive and Transportation Industry Labor Union and Automotive Industry Employers’ Union. The document is valid from 01.02.2014 until 31.01.2017.

The recommended wage for drivers is determined by several parameters such as truck type, experience, national or international status of the operation, evening, night or holiday working hours and type of cargo. Moreover, rates are constantly updated and the most recent ones are in validity from 01.12.2015. Hourly rates for the semitrailer drivers with different experience can be found in the table below.

Table 3. Hourly salary rates for semitrailer drivers in Finland

Experience, years	Hourly wage, EUR
less than 4	13,28
from 4 to 8	13,44
from 8 to 12	13,89
more than 12	14,17

The waiting time is remunerated according to the given rates. In case if the operation is international, the rate increases by 8%. For the work from 6 pm until 10 pm additional 15% from the basic rate should be paid and 20% for the work from 10 pm until 6 am. The rate increase for working on holidays is 100%; in the case of working more than 12 hours per day, the overtime rate of 50% should be applied. Carrying dangerous or radioactive substances increase the rate on 5%. In addition, the daily accommodation and lunch cost for drivers operating in Europe is 56.4 EUR and 32.8 EUR inside Finland. Moreover, according to SKAL, the indirect labor costs in Finland, such as social taxes, holiday, and sickness payments vary from 65% to 73% from the basic salary. The 70% rate is used for finding the total employee cost. (Autoliikenteen Työnantajaliitto ry & AKT ry 2014.)

For practical labor cost calculations it was assumed that a driver has six years of experience, so his basic hourly wage with international increase added reached **14.52 EUR** or **13.44 EUR** without it.

6 Transportation cost calculations for A-Firewood

6.1 Transportation costs modelling

The first step of the costs estimation process was routing. This process determined the variable costs: on this stage was accounted, how many kilometres the route length was, how much time the haulage would take and which places would be chosen for driving and overnight breaks.

The fuel and labor costs were based on this parameters. In order to calculate fuel costs, the average vehicle fuel consumption rate was multiplied by the distance to be driven in each country and its average fuel price was cleared from VAT. The calculation of labor costs was more complicated: the time driven was multiplied by the hourly wage rate, but the final number should also have included the indirect labor costs, allowances, and premiums. Tires, lubrication, and maintenance are independent variable costs, but in the calculations it was assumed that they were dependent on fuel and labor costs respectively. Moreover, voyage costs had to be added to the variable costs too.

Fixed costs included depreciation and interest, vehicle excise taxes and insurance. VAT, operating margin, and profit were calculated based on the obtained results. The calculation for each route was done in a unified form, which allowed to compare the total distance cost and cost per ton-kilometre easily. The last parameter was adjusted according to Kulovic model by the vehicle utilization rate of 90% and two operating options: driving with a full load on the way back and empty driving, which would result in 50% path utilization rate.

Five countries with the biggest market potential were chosen for the transportation costs estimation procedure; they were Norway, Denmark, Germany, the Netherlands and the United Kingdom. The outcomes of the estimations below also could be used for expenditure clarification for some other European countries, such as Sweden and France.

6.2 Transportation of firewood to Norway

A-Firewood is planning to cover mainly the northern areas of Norway with the firewood supply. Three primary destinations are Narvik, Hammerfest, and Tromsø and they were used for the expenditures calculation.

There are no time or kilometre-based charges in Norway. The distance charges still existed some years ago (ITF states, that in 2008 the rate was 1.57 EUR/km), but now they are abolished. However, there is a significant number of tolled roads, ferries and bridges in this country. As can be seen in the picture below, the overwhelming majority of such places is located in the southern parts of the country: the only chargeable ferry in the A-Firewood area of interest is Bognes-Skarberget, but there will be no need to use it. All chargeable routes can be found in the picture below. (Sixt 2016)

Figure 10. Chargeable road network in Norway

The weight and dimensions restrictions for a tractor and semitrailer combination in Norway are the following: height is not defined, width is 2.55 meters, length is 17.5 meters, weight per non-drive axle is 10 tons and 11.5 tons per drive axle; maximum weight of a 5-axle vehicle with axle spacing of 1.31 meters is 43 tons. Because of the weight limitations, a EMS combinations could not be used in this country.

The first route that has to be planned is from Saarijärvi to Hammerfest. Its length is 1131 km, of which 818 km are in the Finnish territory and 313 km in Norwegian. There are no road tolls or charges to be paid throughout the whole distance.

The time of the trip was calculated by using the ViaMichelin tool and it was based on speed limits used on all segments of the distance. It takes two driving days to reach Hammerfest if the journey is done on average speed. The routing and labor costs can be seen in the table below. On the second day the driver exceeds the limit of nine driving hours per day; however, this is permitted if done not more than two days per seek. The daily cost includes the basic rate, indirect rate, accommodation and lunch allowances and an international premium of 8%. Evening, night and holiday premiums are not included. The tables below serve the role of an example how planning and calculations were done and this is shown by the Saarijärvi-Hammerfest lane.

Table 4. Route planning on the example of Saarijärvi-Hammerfest lane

POA	POD	Time driven per day	Distance driven	Daily cost, EUR
Saarijarvi	Oulu	4:20	289 km	
Break		5:05		
Oulu	Sieppijärvi	9:15	608 km	
Overnight break				244,14
Sieppijärvi	Enontekiö	3:25	783 km	
Break		4:10		
Enontekiö	Stokkedalsveien	8:25	1032 km	
Break (15 min)		8:40		
Stokkedalsveien	Hammerfest	10:35	1131 km	318,05

Table 5. Journey cost calculation on the example of the Saarijärvi-Hammerfest lane

Lane	Saarijärvi-Hammerfest		VAT (if applicable)
Distance, km		1131	
	of which in Finland	818	
	of which in Norway	313	
Fuel consumption, l per 100 km		38	
VAT in Finland		24%	
VAT in Norway		25%	
Fuel price in Finland, EUR/l		1,13	
Fuel price in Norway, EUR/l		1,43	
Fuel cost in Finland, EUR		283,77	68,10
Fuel cost in Norway, EUR		135,78	33,95
Total fuel cost, EUR		419,55	102,05
Total labour cost, EUR		488,14	
Maintenance cost, EUR		61,69	14,80
Tires and lubrication cost, EUR		46,02	11,04
Fees and charges related to trip, EUR		0,00	
Depreciation and interest cost, EUR		6,52	1,56
Excise vehicle tax, EUR		6,40	
Insurance cost, EUR		52,75	
Operating margin, EUR		56,90	
Total variable and labour cost, EUR		1015,39	
Total fixed cost, EUR		122,57	
Total journey cost, EUR		1137,96	129,46
Price with profit added, EUR		1422,45	
Price with profit and VAT added, EUR		1763,84	
Cost in cents per tkm, path utilization 100%		4,47	
Cost in cents per tkm, path utilization 50%		8,94	

The second potential destination in Norway for A-Firewood export is Tromsø. It is located closer to Saarijärvi than Hammerfest, so the travel time and expenditures for this trip are slightly smaller. The Finnish part of the route is almost the same as in the first case and the overnight break is planned to be taken in Sieppijärvi too. The route is free from any toll roads, bridges or ferries. The route planning and cost modelling for this lane can be found in Appendix 4.

The route to the third destination, which is Narvik, goes through the Swedish territory; that is why the Eurovignette charge has to be paid. In 2016, the daily fee is 8 EUR, regardless of the emission group of the vehicle or its number of axles. The purchasing of Eurovignette for one day is more economical than buying it for one month or one year: the truck has to stay at least 156 days in Sweden before the annual option would become reasonable. The cost per ton-kilometre to Narvik is higher than to Hammerfest or Tromsø despite the shorter distance. This can be explained by the need of the obligatory Eurovignette payment and higher fuel prices in Sweden than in Finland or Norway. Moreover, as the overnight stay is planned in the Swedish village Morjärv, the international operation premium and increased lunch and accommodation payments have to be paid to the driver for both days. The route planning and cost modelling for this lane can be found in Appendix 5.

6.3 Transportation of firewood to Denmark

The second main export destination for A-Firewood is Denmark. There is a trend in this country of developing the renewable energy sector; together with the relative proximity to Finland, this makes this country a good potential market. The cities of Herning and Kolding were chosen as delivery locations by A-Firewood because of the presence of a big amount of potential customers there.

Two types of charges are implemented in Denmark. First, this is one of the Eurovignette countries; therefore, cargo vehicles are charged on the time basis. Moreover, two bridges in the country are tolled: Storebaelt bridge, connecting Zealand with Funen, and Oresund bridge between Malmö and Copenhagen. Altogether, the charge for the car and trailer combination is 1136 DKK or **152.62 EUR**.

All maximum permitted dimensions and weights in Denmark are tighter than in Sweden, through which the transportation is done; therefore, only they were taken into account. The biggest possible height is 4 meters, width is 2.55 meters, length is 16.5 meters, weight per non-drive axle is 10 tons and 11.5 tons per drive axle; maximum weight of a 5-axle vehicle is 42 tons.

Transportation to Denmark includes the shipping of the cargo vehicle from Finland to Sweden. There are several companies operating in this market: most of them transport both passengers and cargo. One option is to use the Wasaline service between Vaasa and Umeå, but in this case, the distance to be traveled increases significantly, so it would be more reasonable to carry the goods to Turku area and then have them delivered to Stockholm area. There are two companies providing such service: Silja Line and Finnlines. The ferry of Silja Line links Turku and Stockholm; Finnlines connects Naantali and Kapellskär by so-called FinnLink ferry service.

Vehicle transportation freight rates were given by customer service departments of both companies, taking dimensions and weight into consideration. The one-way transportation of the loaded combination by Silja Lines would cost **1140.5 EUR**; in the case of the unloaded vehicle, the charge would decrease up to **932.6 EUR**. Finnlines were not able to give the exact freight rate due to its dependency on a certain voyage, but they estimated that on average transporting the loaded combination with given dimensions would cost from 700 EUR to 800 EUR excluding VAT. This was a more beneficial price than the offer from Silja Lines even if the upper limit of **800 EUR** would be taken as a reference value. Therefore, using the FinnLink service was more beneficial in our case. The issues related to this connection are described thoroughly in the Chapter 5.5.

It is possible to reach Kolding in two driving days, but for that the driver has to drive 9:15 hours during the second day. The morning Finnlink departure from Naantali at 11:00 means that the driver should leave Saarijärvi 3 am; therefore, he would earn a night driving premium. However, he would not receive a salary for the time on the ferry, since for that the voyage has to last at least 24 hours. The ferry arrives at 18:15, so he would drive additional three hours in the evening time. These bonuses were taken into account in calculations. Route planning and cost modelling for this lane can be found in Appendix 6.

The route to Herning is almost the same as in the first case, but the driver would have to drive additional 40 minutes after Kolding, so the total time driven during the second day is 9:55 hours. This is very close to the daily limit of 10 hours, so the driver has to be very professional and punctual to complete the journey on time. Otherwise, the additional driving day increases the expenditures. On the positive side, the route consists mostly of high-speed highways without entering the urban areas, so the factor of congestion and traffic jams slowing down the driving process is minimized. Route planning and cost modelling for this lane can be found in Appendix 7.

6.4 Transportation of firewood to Germany

Three regions in Germany were considered by A-Firewood as interesting from a market point of view: Ruhr area, Bremen and Eastern parts of the country. Germany has a significant demand for renewable energy and it could be fulfilled by A-Firewood, despite that the local supply is strong. Therefore, the cities of Dortmund, Bremen and Leipzig could be assumed as possible destinations and transportation costs from Finland to these places should be estimated.

Germany is the country where a distance-based vehicle tax is implemented. The payment process is automated and could be done online on the website www.toll-collect.de. The rates are set by German Federal Trunk Road Toll Act and include the infrastructure costs and costs due to the air pollution caused by the vehicle. The charge is determined by the emission class and number of axles; for a 5-axle Euro 5 vehicle, the rate would be **15.6 EUR** per 100 kilometers. Moreover, passing through two tunnels in the north of Germany (Herren Tunnel near Lubeck on 104 highway and Warnow Tunnel near Rostock on 105 highway) is chargeable and costs **1.50 EUR** and **4.60 EUR** accordingly.

Limited dimensions on German roads are the same as in Denmark: 4 meters, 2.55 meters and 16.5 meters for height, width and length of the vehicle. Weight per drive and non-drive axles are also standard (11.5 and 10 tons), but the maximum permitted weight of a 5-axle combination is 40 tons.

The most reasonable option to carry a vehicle to Germany from Finland is to use a Ro-Ro service of a shipping company. There are currently to big players on the market: Transfennica and Finnlines. Finnlines has a bigger number of departures from Finland to Germany (about 16 voyages per week), more than half of which are from Helsinki, which is also the cheapest option. Other ports of departure are Hanko, Kotka, Turku, and Uusikaupunki. The ports of arrival in Germany are Rostock and Travemünde. Ships from Helsinki to Travemünde depart every day; the frequency of the ones to Rostock is three times per week.

Freight rates given by Finnlines for the transportation of the semitrailer are the following: 1936 EUR including VAT for the Helsinki-Travemünde lane and 1748 EUR for the Helsinki-Rostock lane. The price is valid for a loaded vehicle; in the case of an empty one, a 500 EUR discount can be given. Moreover, the final rate depend on the bunker surcharge, which is updated every 7th day of the month.

However, it is more reasonable to disconnect the trailer from the tractor unit and to send it without a driver. In this case, the shipping cost would be smaller and there would be no need to pay additional labor costs to the driver for time on the vessel or daily allowances. In addition, due to the trade misbalance, there is no shortage of trailers in Finland, so the price for such service would not be high.

For every particular final destination in Germany, it had to be decided, whether Rostock or Travemünde port of arrival should be used. Due to more frequent connections and much shorter sailing time, Travemünde was a slightly more preferable option from the reliability point of view, but lower freight rates of Helsinki-Rostock lane also were ought to be taken into account.

For the delivery of cargo to Dortmund, the port of Travemünde was chosen. Distance charge for this trip is **80.9 EUR**. The approximate cost of delivery just a loaded trailer is expected to be around **1700 EUR** including VAT; the price for the unloaded one is 500 EUR less and this figure was essential for simulating the 50% utilization rate. Ships arrive at 21:30, so evening and night premiums had to be taken into account. In addition, as the working time in Germany is less than 10 hours, the employee received 16.10 EUR as meal allowance. Route planning and cost modelling for this lane can be found in Appendix 8.

It is invalid to compare the adjusted cost of the transportation to Germany to the same parameter for such destination as Norway due to the significant distance traveled by sea. Nevertheless, it was useful to compare final destinations between each other.

Another destination in Germany was Bremen. It is located at the ports even closer than Dortmund and there would be no need to stop during the journey. Travemünde is located closer to Bremen than Rostock, so it was chosen again as a port of arrival. Distance charge for this trip is **31.2 EUR**. Moreover, according to the Finnish legislation, any shift shorter than 4:45 hours is counted as a full 4:45 hours working time, and this rule had to be applied when calculating the labor cost for the second day. Route planning and cost modelling for this lane can be found in Appendix 9.

Leipzig was chosen as a location in East Germany. This city is located closer to Rostock than to Travemünde, so together with lower freight rates it made possible to prefer this port of arrival. On the way from Rostock to Leipzig there is no need to stop for a break; at the same time, the duration of driving from Travemünde exceeds five hours. A **4.60 EUR** fee has to be paid on the exit from Warnow tunnel in Rostock;

moreover, **59.1 EUR** have to be paid as a distance charge. Ferries from Helsinki to Rostock arrive at 10:00 in the morning, so no driving time in Germany would be under the evening or night premium. However, the departure time in Finland is at 22:30, consequently, they had to be applied to this leg. Route planning and cost modelling for this lane can be found in Appendix 10.

6.5 Transportation of firewood to the Netherlands

The Netherlands is located close to Germany and is known as a significant European industrial and commercial centre. Its territory is comparably small, thus it would be reasonable to compare the transportation costs to all corners of the country. Three destinations were chosen by A-Firewood: Rotterdam, which is the busiest port in Europe and a big cluster of the chemical industry, Eindhoven and Maastricht, also known as major innovation centres.

The Netherlands is one of the Eurovignette countries. Moreover, there are two tolled tunnels: Kil Tunnel near Dordrecht and Westerschelde Tunnel in South Beveland. German distance-based charges also have to be taken into account. Dimensions and weight-per-axle requirements in the Netherlands are the same as in Germany, but the maximum permitted weight of a five-axle combination varies and is equal to 50 tons.

The gate to The Netherlands from Finland is the port of Travemünde: located closer to the border than Rostock, it would require driving only several hours to any city in the area that is interesting for A-Firewood. Same freight rates and assumptions as in the previous chapter could be applied to this connection. The only reason of different transportation cost per ton-kilometer between all three destinations is a distance; due to this factor, fuel and labor costs and road tolls in Germany slightly varied. Route planning and cost modelling for these lanes can be found in Appendices 11, 12 and 13.

6.6 Transportation of firewood to Great Britain

The fifth key market for A-Firewood is the United Kingdom. The company was planning to export its products primarily to three areas: London surroundings, Wales and the north of England. Three cities, chosen as destinations, were Ipswich, Swansea, and Leeds.

A specific HGV Levy charge is implemented in the country and it has to be paid before entering the UK. The rate depends on total mass, a number of axles and vehicle type; the rate for the used combination will be 10 GBP or **12,73 EUR** per day. In addition, toll roads and bridges are spread all over the England and Wales and expenditures related to them also had to be taken into account when calculating costs. (Sixt 2016)

Figure 11. Chargeable road network in Great Britain

Maximum vehicle height in the UK is not defined; width and length of an articulated vehicle cannot be more than 2.55 meters and 16.5 meters relatively. The normal maximum weight of an articulated vehicle is 40 tons; the weight of 44 tons is allowed for 6-axle vehicles only in some cases.

One option to carry goods to Great Britain is a maritime Ro-Ro transportation. Finnlines use two ports in the UK: Tilbury and Kingston-Upon-Hull and ships depart from Helsinki, Rauma, and Kotka. The cheapest option is Helsinki; also, the frequency of departures is the same as from Kotka (one per week to both ports of arrival) and is more reliable than from Rauma, which sends only one ship per week to Hull. The shipping price of the loaded combination is **2852 EUR** including VAT and it is the same for reaching both ports of arrival from Helsinki. Transportation of the empty vehicle back to Helsinki costs **2492 EUR**; the rate was volatile because of the bunker surcharge fluctuations.

In order to determine, which port had to be chosen for each destination in the UK, distances were compared. It became clear, that using Tilbury was more suitable for southern English areas and Wales; at the same time, northern cities such as Leeds, Newcastle, and Manchester would better be served by Kingston-Upon-Hull.

Table 6. Distances from British ports to local destination

Destination	Tilbury	Kingston-Upon-Hull
Ipswich, distance in km	104	344
Swansea, distance in km	335	441
Leeds, distance in km	336	97

On these lanes the same principle should be used as in the previous cases: tractor unit leaves the trailer in Vuosaari, it is transported by the vessel and is picked by another tractor in Great Britain. Even though it takes only a few hours to deliver the cargo from Tilbury to Ipswich and from Leeds to Hull, the labor expense would still be for as 4:45 hours. Evening premium of four hours also has to be paid to drivers as departures from Vuosaari usually take place at 22:00. Route planning and cost modelling for all three lanes could be found in Appendix 14.

Another way to carry goods between these countries are container shipments. The feeder service is provided by many operators and containers are mainly shipped between the ports of Vuosaari and Teesport or Bristol. There are various companies operating on that lines; the most notorious ones are CMA CGM, MSC, and Containerships.

According to the freight rate given by CMA CGM, transporting one FEU unit to Bristol would cost about 900 EUR. Together with additional charges (terminal handling charges, port fee, and documentation charges), the cost would be approximately 1150 EUR. According to the previous calculations, the delivery of such container from Saarijärvi to Vuosaari would cost about 230 EUR, depending on the truck type used, an experience of the driver and timeframes of the operation.

The cost of the delivery from the port of Bristol to three chosen locations was estimated by the same model as previously. It must be noted that the labor cost of trucking from Bristol to any of the three destination would be the same, since all journeys did not exceed 4:45 hours. The estimated expenditures can be found in the table below.

Table 7. Estimation of container shipping costs from Finland to the UK

Container shipping from Bristol	Destination		
	Ipswich	Swansea	Leeds
Total variable and labour cost, EUR	1608,38	1545,80	1608,38
Total fixed cost, EUR	178,82	169,32	178,82
Total journey cost, EUR	1787,20	1715,12	1787,20
Price with profit and VAT added, EUR	2659,36	2552,09	2659,36
Cost in cents per tkm, path utilization 100%	15,90	19,03	15,90

The volume of one FEU container is 67.7 m^3. As the calculated capacity of one pallet is 3,28 m^3, 19 pallets or 19 tons of cargo could fit into one container. Using the port of Bristol is be beneficial if the market is located in Wales or southwestern parts of England. For Yorkshire and Scotland, different possibilities such as Teesport as a port of arrival have to be assumed. As can be seen, the container shipping option is more cost-efficient than the usage of semitrailers.

7 Conclusion

7.1 Utilization of obtained results

The research revealed several outcomes related to the distribution of firewood around Europe. First, it became clear that there are many costing factors in this process and some of them are critical for the entire operation. Both labor and fuel costs have a great share of the overall expenses and the company should put as much effort as possible to optimize them. For example, this could be done by purchasing the fuel in countries with the lower price for it whenever possible. Moreover, implementation of some reasonable logistics solutions planned ahead (for example, shipping the trailer without tractor unit and driver on board) is a way to cut expenditures. Issues related to the maritime transportation have to be clarified especially precisely: this industry has plenty of specific niceties and inability to comply them would most probably lead to the increase in costs.

Finding the cost per ton-kilometre is a good approach to assess the transportation expenses and to compare the suitability of various destinations, but it is relevant only if the journey distances are relatively similar and the same transportation modes are used. The situation when transportation on a longer distance has a lower transportation cost per kilometre than on a shorter one is common, but in this case this is not always a positive sign. The more important parameter is a cost per ton or cubic meter: this clearly shows the reasonability of the transportation to the certain area and the ratio between logistics costs and the expected revenue. During the calculation of costs, general theoretical assumptions related to the distribution of transportation expenditures were proved. Even though in some cases it varied due to a large proportion of ferry transportation costs, the reliability of research method was justified.

Transportation costs from Finland to five European countries were analysed in this report. In each of them, customer prices for firewood are different, and a deeper market research has to be done in order to answer a question of reasonability to transport firewood to these destinations. The summarized theory gave a great support to the analysis as it became possible to determine the impact of each cost factor and to find out the influence of the product origin to transportation arrangements. The obtained results can be merged into one table.

Table 8. Compilation of estimated costs

Lane	Type	Distance, km	Journey cost, EUR	Customer price, EUR	Cost per tkm, 100%	Cost per ton	Share from the profit
Saarijärvi-Hammerfest	Truck	1131	1137,96	1763,84	4,47	45,52	15,70%
Saarijärvi-Tromsø	Truck	1064	1101,92	1707,98	5,75	44,08	15,20%
Saarijärvi-Narvik	Truck	988	1129,52	1750,75	5,08	45,18	15,58%
Saarijärvi-Kolding	Truck	1354	2550,44	3953,18	8,37	102,02	35,18%
Saarijärvi-Herning	Truck	1430	2606,87	4040,65	8,10	104,27	35,96%
Saarijärvi-Dortmund	Truck	845	2418,30	3748,37	12,72	96,73	33,36%
Saarijärvi-Bremen	Truck	524	2116,60	3280,73	17,95	84,66	29,19%
Saarijärvi-Leipzig	Truck	705	2037,76	3158,53	12,85	81,51	28,11%
Saarijärvi-Rotterdam	Truck	904	2351,86	3623,85	11,56	94,07	32,44%
Saarijärvi-Maastricht	Truck	902	2362,86	3662,43	11,64	94,51	32,59%
Saarijärvi-Ipswich	Truck	430	2768,01	4290,41	28,61	110,72	38,18%
Saarijärvi-Swansea	Truck	661	2941,84	4559,85	19,78	117,67	40,58%
Saarijärvi-Leeds	Truck	423	3455,35	4284,63	29,04	138,21	47,66%
Saarijärvi-Ipswich	Container	660	1794,19	2242,73	15,90	94,43	32,56%
Saarijärvi-Swansea	Container	530	1724,93	2156,16	19,03	90,79	31,31%
Saarijärvi-Leeds	Container	660	1794,19	2242,73	15,90	94,43	32,56%

Some assumptions could be done already now, and it became clear that the most determining factor is geography. The minimum overall cost and cost per ton-kilometre would cause the transportation to the northern parts of Norway. Together with possibly high customer prices, it makes this country one of the most favourable importers of A-Firewood products. The same could be said about the north of Sweden: as no ferry transportation is needed to deliver the cargo to, for example, Kiruna, the transportation process to these areas is simple and smooth. One more reason of concentrating on a Swedish market is that 60-ton vehicle combinations are permitted in this country, which would decrease the cost per ton-kilometre even more.

The cost of delivery to Denmark, Germany, and the Netherlands is approximately the same. As the firewood market is fulfilled in this part of Europe, especially in Germany, there has to be raised a question: is it economically efficient to deliver such cargo from Finland and to compete with local suppliers? High transportation costs are unavoidable because of the voluminous nature of the cargo and need to use maritime transportation services due to the remoteness of Finland. In Germany, there are high consumer prices for firewood (about 290 EUR per ton in 2014), but even in this case, the delivery costs would reach about 30% from the revenue.

Talking about the United Kingdom, it is also hard to say that exporting firewood to this country is a better option compared to selling it in the northern parts of Scandinavia. However, dispatching the product in containers would have a less cost per ton than using Ro-Ro vehicles and this opportunity could be tried by A-Firewood. Container handling and customer delivery procedures should be planned well, but, in general, exporting to this market looks beneficial.

The transportation cost was calculated in two ways: with and without adding the profit margin and VAT. The first figure is suitable for understanding the market situation and for comparing the prices that freight forwarders could quote for such service. On the contrary, a cost cleared from VAT and profit margin models a scenario, wherein A-Firewood organizes the transportation by themselves. A management decision of possible outsourcing the transportation service based on these two approaches has to be made.

7.2 SWOT analysis and recommendations

A simple SWOT analysis was created to visualize the main internal and external factors influencing on commercial and supply chain perspectives of A-Firewood as a market newcomer.

Table 9. SWOT analysis of A-Firewood operations

Strengths	Weaknesses
Branding the product as a high-quality firewood	Difficulties in reaching the continental Europe; maritime transport has to be used
Good possibility to access the Northern Scandinavia region	The product nature as of a low-density breakbulk cargo
Product nature does not require special transport conditions	Tough competition with local suppliers
	Traditional door-to-door delivery pattern
Opportunities	**Threats**
Global trends towards sustainability and renewable fuels	Oil prices fluctuations; changes in road user charging policy
Domination of import over export in Finnish maritime sector	Changing of trade regulations and quality standards
Finding the customer niche	Human factor risks
Utilization of EMS vehicles for Sweden	Transportation risks, e.g. congestion and accidents
Usage of favorable Incoterms rules	Changing of the import vs. export balance

Described strengths and weaknesses are mainly internal and consist of issues, arising from the company's business strategy. There are positive and negative moments in marketing, delivery and product strategies, which were clarified after an interview with A-Firewood representative, theoretical research and the analysis of company's supply chain. Most of the highlighted points were mentioned in the previous chapter. One weakness that could be easily missed is the need in using the door-to-door delivery pattern: except the wholesale deliveries to the wood biomass trade centers, usually in a firewood trade the order size is small and could be hardly optimized.

Opportunities and threats could be classified by the following parameters: impact, probability, and timeframe. The example of a minor opportunity, which still could be beneficial is the implementation of 60-ton EMS combinations for delivery of firewood to the northern areas of Sweden: due to the economy of scales, this would be more efficient than to utilize standard semitrailers. A visible and significant opportunity that could be proved by the information from Finnish Centre of Statistics is the imbalance between the export and import of trailers and containers by sea: for instance, the import exceeded export in about 4 million tons in 2014. This led to a big amount of empty units in Finnish ports and easiness of acquiring or leasing them. However, this is also a potential threat if the situation would change within the next couple of years. Finally, an opportunity that could be a result of successful negotiations is agreeing about using the INCOTERMS rule that is beneficial for A-Firewood. If DAT term instead of DDP would be negotiated, A-Firewood becomes to be responsible for delivery the cargo only to the terminal, where it would be picked by the buyers. Various distribution models could be created for A-Firewood using different INCOTERMS rules, but all of them except DDP give the company a certain degree of flexibility.

Threats must be identified and considered wisely and in accordance to their risk to the business. Modelling the delivery process helped a lot to understand their impact on company's operations. The instability of transportation market is a major one directly influencing on the cost of distribution: for example, rises and drops of oil prices always affect at such modes as road and sea-going transportation dramatically. Taxation of road users could be one more example of the instability: new road tolls or charges could be introduced rapidly in every country or the charging model could be changed. Human and congestion risks factors are especially visible on the example of Saarijärvi-Kolding lane: the driving time is so tightly planned and close to the daily limit, that the possibility of driver's mistake or an unexpected traffic jam could not be neglected, as it would instantly rise up the cost of the journey. Moreover, the fuel consumption increases in traffic congestion conditions compared to highway and freeway driving.

7.3 Further research opportunities

This paper described just a preliminary plan of firewood deliveries abroad. After selecting the customers, export procedures should be clarified on a more specific level. The relation between different lot sizes and a cost per ton has to be studied; also, after negotiations it would be possible to compare different delivery terms and to assess the suitability of each of them.

The thorough analysis of risks and measuring their consequences is another step to be done. It should be clear for the company, how much money would it lose in each negative scenario and how probable force majeure situations are. The risks planning is ought to be executed on different levels: from a short-term modelling to understanding the impact of macroeconomic events.

Five markets were chosen for this research, but the area of A-Firewood interest is not limited by them. After estimating the transportation costs to another European countries such as Sweden, France or Switzerland and setting customer prices, the destinations could be ranked according to their market attractiveness. This information could be used to plan the production volumes in the future.

7.4 Personal discussion

Objectives that I set before starting to work on this project were fulfilled. Information about a practical arrangement of firewood deliveries is comparably easy-to-find, but, in this report, it is collected and summarized to the needs of A-Firewood. Together with the transport cost estimations, it compounds a ready package for creating the supply chain of a newly established company in the industry of firewood. Obtained results could be used as a manual when planning the operations; moreover, calculation models in Excel format submitted to the company could be employed for clarifying transportation costs to other destinations. However, there is barely greater significance to the results: the created cost estimation model shows the approximate expenditures for the transportation via chosen lane, but more precise analysis of cost factors and their better adjustment with the firewood industry has to be done in order to obtain outcomes that are truly reliable. Some factors that influence on the cost, such as the smaller fuel consumption of the truck not loaded fully, were not taken into account as their estimation would add the complexity to already sophisticated calculations. One more issue is fixed expenses such as equipment cost or insurance cost: in many cases, they are negotiable and it is hardly possible to rely on any estimations of such expenditures; it is much easier to clarify variable and labor costs. Finally, shipping costs were not analysed and just quoted from shipping service providers.

Some obstacles occurred during the thesis writing process, but, in general, it went according to the plan and without noticeable problems. As A-Firewood is not a real company yet, I could not send shipping quotes on their behalf, or to use a company email address. Most of the freight forwarding companies request a customer's tax number before sending a commercial offer and to disclose any information related to the freight rates, so after getting several rejections I made a decision to use a cost estimation method rather than to obtain transportation prices directly from the service providers. Luckily, maritime shipping companies were able to calculate freight rates without such formalities.

The wood processing industry was completely new for me and one of the most important outcomes of this thesis is that I got a great acquaintance with it in general and specifically with such product as firewood. Obtained knowledge about wood properties and the market of renewable fuels would be beneficial in many economic sectors, from pulp & paper production to power generation business.

In this paper, I tried to make as a practical and useful overview of topics related to the firewood export abroad as possible. However, the business model of A-Firewood is not completely clear even for the project initiators, thus some important aspects of this process could be missed. In addition, as told before, there are too many variables in the process of transportation costs calculation to achieve a precise result; hence, this is always an estimation, which, as the author hopes, still will be appreciated by readers and A-Firewood.

References

ACEA Tax Guide 2015. 2015. PDF document on ACEA' website. Accessed on 3 May 2016.

Åkerman, I. & Johnson, R. 2007. *European Modular System for road freight transport – experiences and possibilities.* Stockholm: *TFK*. Accessed on 13 April 2016.

Alakangas, E. & Virkunen, M. 2007. Biomass fuel supply chains for solid biofuels. *VTT*. Accessed on 3 April 2016.

Annacondia, F. 2015. VAT Registration Thresholds in Europe*. International VAT Monitor.* Accessed on 1 May 2016.

Austrian Standards Institute. 2014. *Solid biofuels — Fuel specifications and classes. Part 5: Graded firewood (ISO 17225-5:2014)*. Wien: Author. Accessed on 15 March 2016.

Autoliikenteen Työnantajaliitto ry & AKT ry. 2014. *Kuorma-autoalan työehtosopimus.* [Labor agreement of trucking industry]. Helsinki: Author. Accessed on 4 May 2016.

British Department of Transport. 2014.*HGV Levy Payment Guide*. London: Author. Accessed on 30 April 2016.

Eleftheriadis, I. 2012. Costs of wood biomass production from forests. CRES. Accessed on 6 April 2016.

European Comission. 2012. *Road Transport: a change of gear.* Luxembourg: Author. Accessed on 2 April 2016.

European Parliament. 1993. *Council regulation (EEC) No 3118/93.* Brussels: Author. Accessed on 28 March 2016.

European Parliament. 1993. *Council regulation (EEC) No 3118/93.* Brussels: Author. Accessed on 28 March 2016.

European Parliament. 2003. Council *Directive 2003/96/EC.* Brussels: Author. Accessed on 21 March 2016.

European Parliament. 2004. *Directive 2004/52/EC of the European Union and of the Council.* Brussels: Author. Accessed on 12 April 2016.

European Parliament. 2006. *Council regulation (EEC) No 2006/112/EC.* Brussels: Author. Accessed on 30 March 2016.

European Parliament. 2006. *Directive 2006/38/EC of the European Union and of the Council.* Brussels: Author. Accessed on 25 April 2016.

European Parliament. 2009. *Regulation (EC) No 1072/2009 of the European Parliament and of the Council.* Brussels: Author. Accessed on 27 March 2016.

European Parliament. 2015. *Directive (EU) 2015/719 of the European Union and of the Council.* Brussels: Author. Accessed on 25 March 2016.

Eurovignette - Home. 2016. Page on Eurovignette website. Accessed on 23 April 2016. Retrieved from https://www.eurovignettes.eu/portal/en/welcome?reset=true

Ferranti, F. 2014. Energy wood: A challenge for European forests. *European Forest Institute*. Accessed on 22 March 2016.

Finnlines. 2016.FinnLink Traffic Freight Guide. Helsinki: Author. Accessed on 28 April 2016.

Forestry Commission. 2015. *Importing firewood: requirements for landing regulated material into Great Britain*. Edinburgh: Author. Accessed on 11 May 2016.

Forestry statistics in detail. 2015. Page on Eurostat website. Accessed on 26 March 2016. Retrieved from http://ec.europa.eu/eurostat/statistics-explained/index.php/Forestry_statistics_in_detail#Wood_as_a_source_of_energy

Hugos, M. 2003. *Essentials of Supply Chain Management.* Hoboken: Wiley. Accessed on 10 March 2016.

Huhtinen, M. 2006. Wood biomass as a fuel. *5EURES Traning Sessions*. Accessed on 7 April 2016.

Hulen, B., Kauppila, J. & Chong, E. 2013. Road Haulage Charges and Taxes. *International Transport Forum.* Accessed on 10 April 2016.

ICS. 2015. Ship Operations and Management. London: ICS. Accessed on 13 April 2016.

Janic, M. 2007. Modelling the full costs of an intermodal and road freight transport network. *Elsevier,* 2, 33 – 44. Accessed on 29 March 2016.

Kille, C. & SchwemVinterbmer, M. 2014. *Top 100 in European Transport and Logistics Services 2013-2014*. Erlangen: Fraunhofer IIS. Accessed on 9 May 2016.

Kofman, P. 2005. *Wood for energy production, Irish Edition*. Dublin: COFORD. Accessed on 29 March 2016.

Kofman, P. 2010. *Preview of European standards for solid biofuels*. Dublin: COFORD. Accessed on 3 April 2016.

Krajic, N. 2015. *Wood Fuels Handbook*. Pristina: Food and Agriculture Organization of the United Nations. Accessed on 5 May 2016.

Krajnc, N., Jemec, T. & Rogelja, T. 2015. *Steps in setting up wood biomass production chains in protected areas.* BIOEUPARKS Project. Accessed on 2 May 2016.

Kulovic, M. 2004. Freight transport costs model based on truck fleet operational parameters. *Promet – Traffic – Traffico*, 1, 321 – 325. Accessed on 11 April 2016.

Larsson, S. 2009. Weight and dimensions of heavy commercial vehicles as established by Directive 96/53/EC and the European Modular System (EMS). *ACEA*. Accessed on 20 March 2016.

Le, E., Bajric, F., Vötter, D., Berg, S., Anderson, G. & Roux, S. 2011. *Identification of existing transport methods and alternative methods or new approaches with data about costs, labor input and energy consumption.* Joensuu: European Forest Institute. Accessed on 16 March 2016.

Nordea. 2011. *Incoterms 2010*. Kopenhagen: Author. Accessed on 7 May 2016.

Nylund, N. & Erkkilä, K. 2005. Heavy-duty truck emissions and fuel consumption simulating real-world driving in laboratory conditions. *VTT*. Accessed on 13 April 2016.

Official Statistics of Finland (OSF): Energy use in manufacturing [e-publication]. ISSN=1798-7776. 2014. Appendix table 1. Energy use in manufacturing by energy source 2014 . Helsinki: Statistics Finland. Accessed on 1 April 2016. Retrieved from http://www.stat.fi/til/tene/2014/tene_2014_2015-11-05_tau_001_en.html

Prislan, P., Krajnc, N., Jemec, T. & Piškur, M. 2014. *Monitoring of wood fuel prices in Slovenia, Austria, Italy, Croatia, Romania, Germany, Spain and Ireland*. Report. Biomass Trade Centre II. Accessed on 5 May 2016.

Raitila, J. 2008. Firewood production and business models. *VTT*. Accessed on 5 April 2016.

Renewable energy statistics. 2015. Page on Eurostat website. Accessed on 28 March 2016. Retrieved from http://ec.europa.eu/eurostat/statistics-explained/in-dex.php/Renewable_energy_statistics

Seely, A. 2016. VAT: European law on VAT rates. *House of Commons Library.* Accessed on 25 March 2016.

SKAL. 2009. *Ajoneuvojen kustannuslaskennan perusteet.* [Methods of calculating road transportation costs]. Helsinki: Author. Accessed on 26 April 2016.

Sokka, L., Koponen, K. & Keränen, J. 2015. Cascading use of wood in Finland – with comparison to selected EU countries. *VTT*. Accessed on 14 April 2016.

Solakivi, T., Ojala, L., Laari, S., Lorentz, H., Töyli, J., Malmsten, J. & Viherlehto, N. 2014. *Logistiikkaselvitys 2014* [Logistics clearance]. Turku: Juvenes Print. Accessed on 8 May 2016.

Tilastokeskus. 2010. *Kuorma-autoliikenteen kustannusindeksi 2010: Käyttäjän käsikirja.* [Cost index of truck transportation 2010: User's handbook]. Helsinki: Author. Accessed on 2 May 2016.

Torrey, W. & Murray, D. 2014. An Analysis of the Operational Costs of Trucking: 2014 Update. *ATRI*. Accessed on 16 April 2016.

Value added tax in international services. 2011. Page on Finnish Tax Administration's website. Accessed on 25 April 2016. Retrieved from https://www.vero.fi/en-

US/Precise_information/Value_added_tax/Value_added_tax_in_international_service%2814716%29

Vinterbäck, J & Porsö. 2011. *WP3 – Wood fuel price statistics in Europe – D 3.3.* Uppsala: Swedish University of Agricultural Sciences. Accessed on 8 April 2016.

Visser, R. 2010. Good Practice Guide: Production of wood fuel from forest landings. *EECA Business.* Accessed on 4 May 2016.

What is export? 2011. Page on Finnish Customs Administration's website. Accessed on 15 April 2016. Retrieved from http://www.tulli.fi/en/businesses/export/index.jsp

Woodfuelresource.org.uk. 2016. *Types of Wood Fuel*. Accessed on 28 March 2016. Retrieved from http://www.woodfuelresource.org.uk/types-of-wood-fuel.html

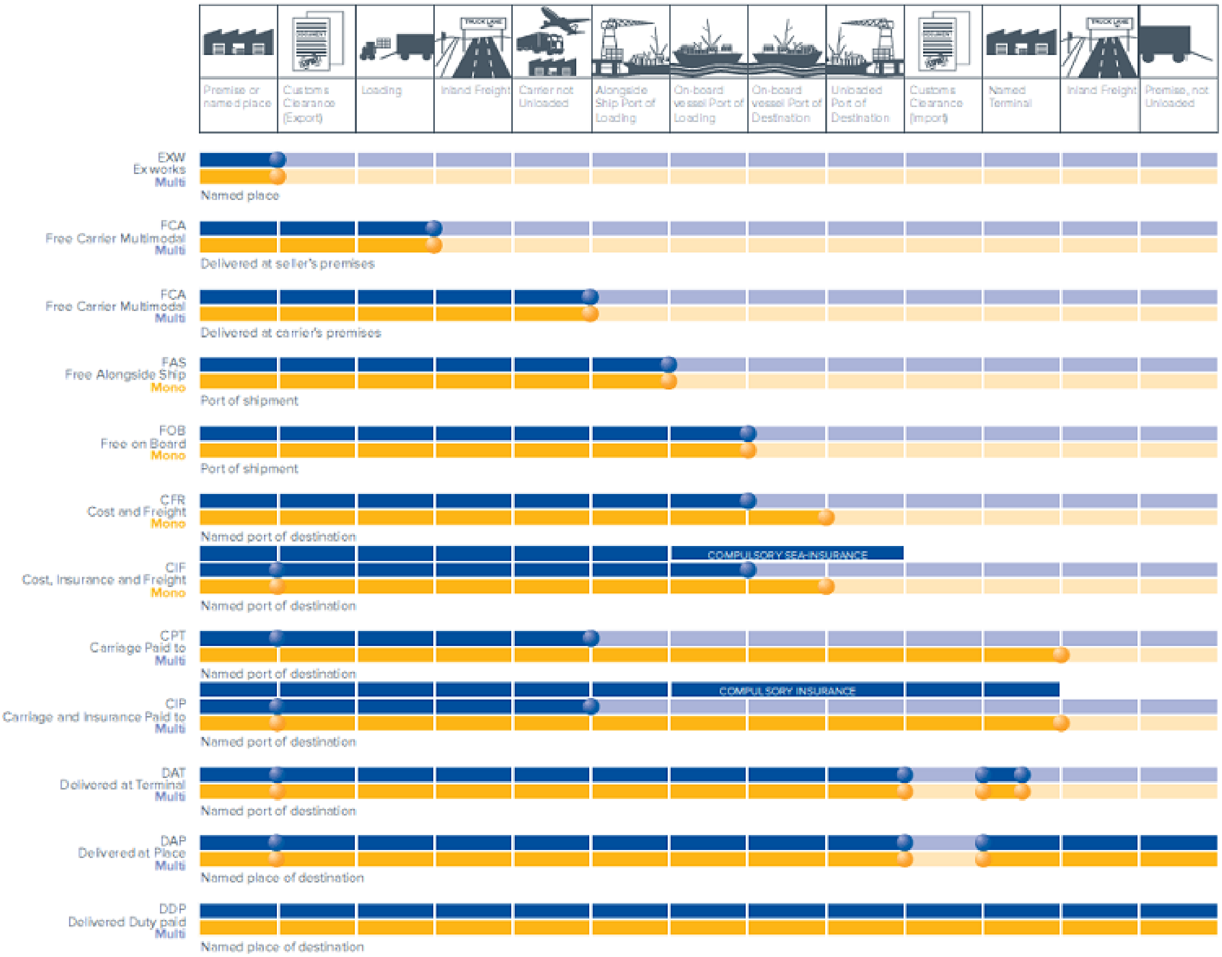
Woodheat Solutions. 2010. Summary of woodfuel standards. *Biomass Energy Centre*. Accessed on 2 April 2016.

Appendices

Appendix 1. Distinction of firewood by property classes

	Property class	Units	A1	A2	B
Normative	Origin and source		1.1.3 Stemwood 1.2.1 Chemically untreated wood residues	1.1.1 Whole trees without roots 1.1.3 Stemwood 1.1.4 Logging residues	1.1.1 Whole trees without roots 1.1.3 Stemwood 1.1.4 Logging residues
	Wood species [a]		To be stated		To be stated
	Diameter, D [b] See Figure 2.	cm	D2 ≤ 2 D5 2 ≤ D ≤ 5 D10 5 ≤ D ≤10 D15 10 ≤ D ≤15 D15+ ≥15 (actual value to be stated)		D15 ≤ 15 D15+ ≥15 (actual value to be stated
	Length, L [b, c] See Figure 2.	cm	L20 ≤ 20 L25 ≤ 25 L33 ≤ 33 L50 ≤ 50 L100 ≤ 100		L33 ≤ 33 L50 ≤ 50 L100 ≤ 100
	Moisture, M [b,f] EN 14774-1, EN 14774-2	w-% wet basis	M20 ≤ 20 M25 ≤ 25		M25 ≤ 25 M35 ≤ 35
	Moisture, U [b,f]	w-% dry basis	U25 ≤ 25 U33 ≤ 33		U33 ≤ 33 U54 ≤ 54
	Volume or weight	m^3 stacked or m^3 loose or kg	To be stated which volume or weight is used when retailed		
	Proportion of split volume	% of pieces	≥ 90 %	≥ 50 %	No requirements
	The cut-off surface		Even and smooth [e]	No requirements	No requirements
	Decay	% of pieces	No visible decay	≤ 5 %	If significant amount (more than 10 % of pieces) of decay exists it should be stated. In case of doubt particle density or net calorific value could be used as indicator.
Informative	Energy density, E [g]	kWh/m^3 loose or stacked kWh/kg	Recommended to be stated.		
	Drying		Recommended to be stated, if firewood is dried by natural seasoning by ambient air or artificially by hot air.		

Appendix 2. Visualized representation of the INCOTERMS rules



Appendix 3. Clarification of VAT charging for transportation services

Haulier	Customer	Circumpstances	VAT position
Person registered for VAT in Finland	Person registered for VAT in Finland	Intra-EU Transport	Haulier charges Finnish VAT.
Person registered for VAT in Finland	Not registered for VAT(e.g. private individual)	Intra-EU Transport from Finland	Haulier charges Finnish VAT because the transport begins in Finland
Person registered for VAT in Finland	Not registered for VAT(e.g. private individual)	Intra-EU Transport to Finland	Liable to VAT in the other Member State because that is where the transport begins. Finnish hauler register for VAT in the other Member State subject to the VAT rules in that other Member State.
Person registered for VAT in other EU Member State	Person registered for VAT in Finland	Intra-EU Transport to or from Finland	Haulier does not charge any VAT. Customer must account for Finnish VAT* under the reverse charge rule.
Person registered for VAT in other EU Member State	Not registered for VAT(e.g. private individual)	Intra-EU Transport from Finland	Liability to Finnish VAT arises because the transport begins in Finland. Haulier must register and charge customer Finnish VAT.
Person registered for VAT in other EU Member State	Not registered for VAT(e.g. private individual)	Intra-EU Transport to Finland	No liability to Finnish VAT. Haulier charges the customer VAT in the other Member Stat eat the rate applicable there because that is where the transport begins.
Person registered for VAT in Finland	Registered for VAT or private individual	Import of goods to Finland where another EU Member State is the final destination	Intra-Community transport service. However,if the value of the haulage is included in the amount subject to VAT at the point of entry, then the haulage service is zero-rated.
Person registered for VAT in other EU Member State	Registered for VAT or private individual	Import of goods into other EU Member States where Finland is the final destination	Intra-Community transport service. However,if the value of the haulage is included in the amount subject to VAT at the point of entry,then the haulage service is zero-rated.

Appendix 4. Route planning and cost modelling, Saarijärvi-Tromsø lane

POA	POD	Time driven per day	Distance driven	Daily cost, EUR
Saarijarvi	Oulu	4:20	289 km	
Break		5:05		
Oulu	Sieppijärvi	9:15	608 km	
Overnight break				244,14
Sieppijärvi	Norwegian border	4:20	910 km	
Break		5:05		
Norwegian border	Tromsø	7:35	1064 km	244,00

Lane	Saarijärvi-Tromsø		VAT (if applicable)
Distance, km		1064	
	of which in Finland	839	
	of which in Norway	225	
Fuel consumption, l per 100 km		38	
VAT in Finland		24%	
VAT in Norway		25%	
Fuel price in Finland, EUR/l		1,13	
Fuel price in Norway, EUR/l		1,43	
Fuel cost in Finland, EUR		291,05	69,85
Fuel cost in Norway, EUR		97,61	24,40
Total fuel cost, EUR		388,66	94,25
Total labour cost, EUR		488,14	
Maintenance cost, EUR		61,69	14,80
Tires and lubrication cost, EUR		42,63	10,23
Fees and charges related to trip, EUR		0,00	
Depreciation and interest cost, EUR		6,52	1,56
Excise vehicle tax, EUR		6,40	
Insurance cost, EUR		50,99	
Operating margin, EUR		56,90	
Total variable and labour cost, EUR		981,11	
Total fixed cost, EUR		120,81	
Total journey cost, EUR		1101,92	120,85
Price with profit added, EUR		1377,40	
Price with profit and VAT added, EUR		1707,98	
Cost in cents per tkm, path utilization 100%		5,75	
Cost in cents per tkm, path utilization 50%		11,51	

Appendix 5. Route planning and cost modelling, Saarijärvi-Narvik lane

POA	POD	Time driven per day	Distance driven	Daily cost, EUR
Saarijarvi	Oulu	4:20	289 km	
Break		5:05		
Oulu	Morjärv	8:15	537 km	
Overnight break				260,24
Morjärv	Kiruna	3:35	804 km	
Break		4:20		
Kiruna	Narvik	7:20	988 km	237,33

Lane	Saarijärvi-Narvik		VAT (if applicable)
Distance, km		988	
	of which in Finland	444	
	of which in Sweden	497	
	of which in Norway	47	
Fuel consumption, l per 100 km		38	
VAT in Finland		24%	
VAT in Sweden		25%	
VAT in Norway		25%	
Fuel price in Finland, EUR/l		1,13	
Fuel price in Sweden, EUR/l		1,47	
Fuel price in Norway, EUR/l		1,43	
Fuel cost in Finland, EUR		154,02	36,97
Fuel cost in Sweden, EUR		222,55	55,64
Fuel cost in Norway, EUR		20,39	5,10
Total fuel cost, EUR		396,97	97,70
Total labour cost, EUR		497,58	
Maintenance cost, EUR		62,88	15,09
Tires and lubrication cost, EUR		43,54	10,45
Fees and charges related to trip, EUR		6,40	1,60
Depreciation and interest cost, EUR		6,52	1,56
Excise vehicle tax, EUR		6,40	
Insurance cost, EUR		52,34	
Operating margin, EUR		56,90	
Total variable and labour cost, EUR		1007,36	
Total fixed cost, EUR		122,15	
Total journey cost, EUR		1129,52	126,41
Price with profit added, EUR		1411,90	
Price with profit and VAT added, EUR		1750,75	
Cost in cents per tkm, path utilization 100%		5,08	
Cost in cents per tkm, path utilization 50%		10,16	

Appendix 6. Route planning and cost modelling, Saarijärvi-Kolding lane

POA	POD	Time driven per day	Distance driven	Daily cost, EUR
Saarijarvi	Orivesi	2:45	173 km	
Break		3:30		
Orivesi	Naantali	6:40	386 km	
Clearing procedures		8:10		
Shipping (excl. from labour cost)		14:40		
Kapellskär	E4 / 53	17:35	576 km	
Overnight break				342,50
E4 / 53	E4 / Laganbron	4:25	949 km	
Break		5:10		
E4 / Laganbron	Odense	9:30	1329 km	
Break		10:15		
Odense	Kolding	10:45	1354 km	321,75

Lane	Saarijärvi-Kolding		VAT (if applicable)
Distance, km		1354	
	of which in Finland	386	
	of which in Sweden	725	
	of which in Denmark	243	
Fuel consumption, l per 100 km		38	
VAT in Finland		24%	
VAT in Sweden		25%	
VAT in Denmark		25%	
Fuel price in Finland, EUR/l		1,13	
Fuel price in Sweden, EUR/l		1,47	
Fuel price in Denmark, EUR/l		1,23	
Fuel cost in Finland, EUR		133,67	32,08
Fuel cost in Sweden, EUR		323,99	81,00
Fuel cost in Denmark, EUR		90,86	22,72
Total fuel cost, EUR		548,52	135,79
Total labour cost, EUR		664,25	
Maintenance cost, EUR		83,94	20,15
Tires and lubrication cost, EUR		60,16	14,44
Fees and charges related to trip, EUR		934,90	233,72
	of which are road taxes	12,80	3,20
	of which are ferry costs	800,00	192,00
	of which are tolls	122,10	30,52
Depreciation and interest cost, EUR		6,52	1,56
Excise vehicle tax, EUR		6,40	
Insurance cost, EUR		118,23	
Operating margin, EUR		127,52	
Total variable and labour cost, EUR		2291,77	
Total fixed cost, EUR		258,67	
Total journey cost, EUR		2550,44	405,67
Price with profit added, EUR		3188,05	
Price with profit and VAT added, EUR		3953,18	
Cost in cents per tkm, path utilization 100%		8,37	
Cost in cents per tkm, path utilization 50%		16,74	

Appendix 7. Route planning and cost modelling, Saarijärvi-Herning lane

POA	POD	Time driven per day	Distance driven	Daily cost, EUR
Saarijarvi	Orivesi	2:45	173 km	
Break		3:30		
Orivesi	Naantali	6:40	386 km	
Clearing procedures		8:10		
Shipping (excl. from labour cost)		14:40		
Kapellskär	E4 / 53	17:35	576 km	
Overnight break				342,50
E4 / 53	E4 / Laganbron	4:25	949 km	
Break		5:10		
E4 / Laganbron	Odense	9:30	1329 km	
Break		10:15		
Odense	Herning	11:25	1430 km	339,03

Lane	Saarijärvi-Herning		VAT (if applicable)
Distance, km		1430	
	of which in Finland	386	
	of which in Sweden	725	
	of which in Denmark	319	
Fuel consumption, l per 100 km		38	
VAT in Finland		24%	
VAT in Sweden		25%	
VAT in Denmark		25%	
Fuel price in Finland, EUR/l		1,13	
Fuel price in Sweden, EUR/l		1,47	
Fuel price in Denmark, EUR/l		1,23	
Fuel cost in Finland, EUR		133,67	32,08
Fuel cost in Sweden, EUR		323,99	81,00
Fuel cost in Denmark, EUR		119,28	29,82
Total fuel cost, EUR		576,94	142,90
Total labour cost, EUR		681,53	
Maintenance cost, EUR		86,13	20,67
Tires and lubrication cost, EUR		63,28	15,19
Fees and charges related to trip, EUR		934,90	233,72
	of which are road taxes	12,80	3,20
	of which are ferry costs	800,00	192,00
	of which are tolls	122,10	30,52
Depreciation and interest cost, EUR		6,52	1,56
Excise vehicle tax, EUR		6,40	
Insurance cost, EUR		120,85	
Operating margin, EUR		130,34	
Total variable and labour cost, EUR		2342,77	
Total fixed cost, EUR		264,11	
Total journey cost, EUR		2606,87	414,04
Price with profit added, EUR		3258,59	
Price with profit and VAT added, EUR		4040,65	
Cost in cents per tkm, path utilization 100%		8,10	
Cost in cents per tkm, path utilization 50%		16,20	

Appendix 8. Route planning and cost modelling, Saarijärvi-Dortmund lane

POA	POD	Time driven per day	Distance driven	Daily cost, EUR
Saarijarvi	Helsinki Harbour	4:10	326 km	129,32
Clearing procedures		5:40		
Shipping (excl. from labour cost)		28 h 30 mins		
Travemünde	Osnabrück	4:05	524 km	187,18
Break		4:50		
Osnabrück	Dortmund	6:10	845 km	

Lane	Saarijärvi-Dortmund		VAT (if applicable)
Distance, km		845	
	of which in Finland	326	
	of which in Germany	519	
Fuel consumption, l per 100 km		38	
VAT in Finland		24%	
VAT in Germany		19%	
Fuel price in Finland, EUR/l		1,13	
Fuel price in Germany, EUR/l		1,07	
Fuel cost in Finland, EUR		112,89	27,09
Fuel cost in Germany, EUR		177,33	33,69
Total fuel cost, EUR		290,22	60,79
Total labour cost, EUR		316,50	
Maintenance cost, EUR		40,00	9,60
Tires and lubrication cost, EUR		31,83	7,64
Fees and charges related to trip, EUR		1493,81	283,82
	of which are road taxes	65,24	12,40
	of which are ferry costs	1428,57	271,43
	of which are tolls	0,00	0,00
Depreciation and interest cost, EUR		6,52	1,56
Excise vehicle tax, EUR		6,40	
Insurance cost, EUR		112,10	
Operating margin, EUR		120,92	
Total variable and labour cost, EUR		2172,37	
Total fixed cost, EUR		245,94	
Total journey cost, EUR		2418,30	363,41
Price with profit added, EUR		3022,88	
Price with profit and VAT added, EUR		3748,37	
Cost in cents per tkm, path utilization 100%		12,72	
Cost in cents per tkm, path utilization 50%		21,23	

Appendix 9. Route planning and cost modelling, Saarijärvi-Bremen lane

POA	POD	Time driven per day	Distance driven	Daily cost, EUR
Saarijarvi	Helsinki Harbour	4:10	326 km	129,32
Clearing procedures		5:40		
Shipping (excl. from labour cost)		28 h 30 mins		
Travemünde	Bremen	2:15	524 km	139,92

Lane	Saarijärvi-Bremen		VAT (if applicable)
Distance, km		524	
	of which in Finland	326	
	of which in Germany	198	
Fuel consumption, l per 100 km		38	
VAT in Finland		24%	
VAT in Germany		19%	
Fuel price in Finland, EUR/l		1,13	
Fuel price in Germany, EUR/l		1,07	
Fuel cost in Finland, EUR		112,89	27,09
Fuel cost in Germany, EUR		67,65	12,85
Total fuel cost, EUR		180,54	39,95
Total labour cost, EUR		269,24	
Maintenance cost, EUR		34,02	8,17
Tires and lubrication cost, EUR		19,80	4,75
Fees and charges related to trip, EUR		1396,13	333,81
	of which are road taxes	25,16	4,78
	of which are ferry costs	1370,97	329,03
	of which are tolls	0,00	0,00
Depreciation and interest cost, EUR		6,52	1,56
Excise vehicle tax, EUR		6,40	
Insurance cost, EUR		98,12	
Operating margin, EUR		105,83	
Total variable and labour cost, EUR		1899,74	
Total fixed cost, EUR		216,87	
Total journey cost, EUR		2116,60	388,24
Price with profit added, EUR		2645,75	
Price with profit and VAT added, EUR		3280,73	
Cost in cents per tkm, path utilization 100%		17,95	
Cost in cents per tkm, path utilization 50%		29,12	

Appendix 10. Route planning and cost modelling, Saarijärvi-Leipzig lane

POA	POD	Time driven per day	Distance driven	Daily cost, EUR
Saarijarvi	Helsinki Harbour	4:10	326 km	129,32
Clearing procedures		5:40		
Shipping (excl. from labour cost)		28 h 30 mins		
Rostock	Leipzig	4:00	705 km	133,75

Lane	Saarijärvi-Leipzig		VAT (if applicable)
Distance, km		705	
	of which in Finland	326	
	of which in Germany	379	
Fuel consumption, l per 100 km		38	
VAT in Finland		24%	
VAT in Germany		19%	
Fuel price in Finland, EUR/l		1,13	
Fuel price in Germany, EUR/l		1,07	
Fuel cost in Finland, EUR		112,89	27,09
Fuel cost in Germany, EUR		129,50	24,60
Total fuel cost, EUR		242,39	51,70
Total labour cost, EUR		263,07	
Maintenance cost, EUR		33,24	7,98
Tires and lubrication cost, EUR		26,58	6,38
Fees and charges related to trip, EUR		1263,21	300,49
	of which are road taxes	49,66	9,44
	of which are ferry costs	1209,68	290,32
	of which are tolls	3,87	0,73
Depreciation and interest cost, EUR		6,52	1,56
Excise vehicle tax, EUR		6,40	
Insurance cost, EUR		94,46	
Operating margin, EUR		101,89	
Total variable and labour cost, EUR		1828,49	
Total fixed cost, EUR		209,27	
Total journey cost, EUR		2037,76	368,11
Price with profit added, EUR		2547,20	
Price with profit and VAT added, EUR		3158,53	
Cost in cents per tkm, path utilization 100%		12,85	
Cost in cents per tkm, path utilization 50%		20,65	

Appendix 11. Route planning and cost modelling, Saarijärvi-Rotterdam lane

POA	POD	Time driven per day	Distance driven	Daily cost, EUR
Saarijarvi	Helsinki Harbour	4:10	326 km	129,32
Clearing procedures		5:40		
Shipping (excl. from labour cost)		28 h 30 mins		
Travemünde	Deventer	4:20	761 km	202,36
Break		5:05		
Deventer	Rotterdam	6:45	904 km	

Lane	Saarijärvi-Rotterdam		VAT (if applicable)
Distance, km		904	
	of which in Finland	326	
	of which in Germany	374	
	of which in Netherlands	204	
Fuel consumption, l per 100 km		38	
VAT in Finland		24%	
VAT in Germany		25%	
VAT in Netherlands		21%	
Fuel price in Finland, EUR/l		1,13	
Fuel price in Germany, EUR/l		1,07	
Fuel price in Netherlands, EUR/l		1,21	
Fuel cost in Finland, EUR		112,89	27,09
Fuel cost in Germany, EUR		121,65	30,41
Fuel cost in Netherlands, EUR		77,52	16,28
Total fuel cost, EUR		312,07	73,79
Total labour cost, EUR		331,68	
Maintenance cost, EUR		24,40	27,57
Tires and lubrication cost, EUR		19,93	22,52
Fees and charges related to trip, EUR		1424,25	356,06
	of which are road taxes	46,68	11,67
	of which are ferry costs	1370,97	329,03
	of which are tolls	6,61	1,39
Depreciation and interest cost, EUR		6,52	1,56
Excise vehicle tax, EUR		6,40	
Insurance cost, EUR		109,02	
Operating margin, EUR		117,59	
Total variable and labour cost, EUR		2112,32	
Total fixed cost, EUR		239,53	
Total journey cost, EUR		2351,86	481,50
Price with profit added, EUR		2939,82	
Price with profit and VAT added, EUR		3645,38	
Cost in cents per tkm, path utilization 100%		11,56	
Cost in cents per tkm, path utilization 50%		19,19	

Appendix 12. Route planning and cost modelling, Saarijärvi-Eindhoven lane

POA	POD	Time driven per day	Distance driven	Daily cost, EUR
Saarijarvi	Helsinki Harbour	4:10	326 km	129,32
Clearing procedures		5:40		
Shipping (excl. from labour cost)		28 h 30 mins		
Travemünde	Gelsenkirchen	4:00	737 km	195,46
Break		4:45		
Gelsenkirchen	Eindhoven	6:30	872 km	

Lane	Saarijärvi-Eindhoven		VAT (if applicable)
Distance, km		872	
	of which in Finland	326	
	of which in Germany	491	
	of which in Netherlands	55	
Fuel consumption, l per 100 km		38	
VAT in Finland		24%	
VAT in Germany		25%	
VAT in Netherlands		21%	
Fuel price in Finland, EUR/l		1,13	
Fuel price in Germany, EUR/l		1,07	
Fuel price in Netherlands, EUR/l		1,21	
Fuel cost in Finland, EUR		112,89	27,09
Fuel cost in Germany, EUR		159,71	39,93
Fuel cost in Netherlands, EUR		20,9	4,39
Total fuel cost, EUR		293,50	71,41
Total labour cost, EUR		324,78	
Maintenance cost, EUR		23,89	27,00
Tires and lubrication cost, EUR		18,74	21,18
Fees and charges related to trip, EUR		1438,86	359,71
	of which are road taxes	61,28	15,32
	of which are ferry costs	1370,97	329,03
	of which are tolls	6,61	1,39
Depreciation and interest cost, EUR		6,52	1,56
Excise vehicle tax, EUR		6,40	
Insurance cost, EUR		108,38	
Operating margin, EUR		116,90	
Total variable and labour cost, EUR		2099,77	
Total fixed cost, EUR		238,20	
Total journey cost, EUR		2337,97	480,86
Price with profit added, EUR		2922,46	
Price with profit and VAT added, EUR		3623,85	
Cost in cents per tkm, path utilization 100%		11,92	
Cost in cents per tkm, path utilization 50%		19,76	

Appendix 13. Route planning and cost modelling, Saarijärvi-Maastricht lane

POA	POD	Time driven per day	Distance driven	Daily cost, EUR
Saarijarvi	Helsinki Harbour	4:10	326 km	129,32
Clearing procedures		5:40		
Shipping (excl. from labour cost)		28 h 30 mins		
Travemünde	Gelsenkirchen	4:00	737 km	205,11
Break		4:45		
Gelsenkirchen	Maastricht	6:50	902 km	

Lane	Saarijärvi-Maastricht		VAT (if applicable)
Distance, km		902	
	of which in Finland	326	
	of which in Germany	491	
	of which in Netherlands	85	
Fuel consumption, l per 100 km		38	
VAT in Finland		24%	
VAT in Germany		25%	
VAT in Netherlands		21%	
Fuel price in Finland, EUR/l		1,13	
Fuel price in Germany, EUR/l		1,07	
Fuel price in Netherlands, EUR/l		1,21	
Fuel cost in Finland, EUR		112,89	27,09
Fuel cost in Germany, EUR		159,71	39,93
Fuel cost in Netherlands, EUR		32,3	6,78
Total fuel cost, EUR		304,90	73,80
Total labour cost, EUR		334,43	
Maintenance cost, EUR		24,60	27,80
Tires and lubrication cost, EUR		19,47	22,00
Fees and charges related to trip, EUR		1438,86	359,71
	of which are road taxes	61,28	15,32
	of which are ferry costs	1370,97	329,03
	of which are tolls	6,61	1,39
Depreciation and interest cost, EUR		6,52	1,56
Excise vehicle tax, EUR		6,40	
Insurance cost, EUR		109,53	
Operating margin, EUR		118,14	
Total variable and labour cost, EUR		2122,27	
Total fixed cost, EUR		240,59	
Total journey cost, EUR		2362,86	484,88
Price with profit added, EUR		2953,57	
Price with profit and VAT added, EUR		3662,43	
Cost in cents per tkm, path utilization 100%		11,64	
Cost in cents per tkm, path utilization 50%		19,34	

Appendix 14. Route planning and cost modelling, Finland-UK lanes

Lane	Saarijärvi-Ipswich		Saarijärvi-Swansea		Saarijärvi-Leeds	
Distance, km		430		661		423
	of which in Finland	326	of which in Finland	326	of which in Finland	326
	of which the UK	104	of which the UK	335	of which the UK	97
Fuel consumption, l per 100 km		38		38		38
VAT in Finland		24%		24%		24%
VAT in the UK		20%		20%		20%
Fuel price in Finland, EUR/l		1,13		1,13		1,13
Fuel price in the UK, EUR/l		1,37		1,37		1,37
Fuel cost in Finland, EUR		112,89		112,89		112,89
Fuel cost in the UK, EUR		45,12		145,33		42,08
Total fuel cost, EUR		158,01		258,22		154,97
Total labour cost, EUR		263,73		304,46		263,73
Maintenance cost, EUR		33,33		38,47		33,33
Tires and lubrication cost, EUR		17,33		28,32		17,00
Fees and charges related to trip, EUR		1990,15		1990,15		1990,15
	of which are road taxes	12,73	of which are road taxes	12,73	of which are road taxes	12,73
	of which are ferry costs	1977,42	of which are ferry costs	1977,42	of which are ferry costs	1977,42
	of which are tolls	0,00	of which are tolls	0,00	of which are tolls	0,00
Depreciation and interest cost, EUR		19,55		19,55		19,55
Excise vehicle tax, EUR		19,20		19,20		19,20
Insurance cost, EUR		128,32		136,37		128,14
Operating margin, EUR		138,40		147,09		138,21
Total variable and labour cost, EUR		2462,54		2619,63		2459,17
Total fixed cost, EUR		305,47		322,22		305,11
Total journey cost, EUR		2768,01		2941,84		2764,28
VAT, EUR		530,09		554,01		529,41
Price with profit added, EUR		3460,01		3677,30		3455,35
Price with profit and VAT added, EUR		4290,41		4559,85		4284,63
Cost in cents per tkm, path utilization 100%		28,61		19,78		29,04
Cost in cents per tkm, path utilization 50%		48,95		34,18		49,68