MASTER

Defining purchasing strategy differentiation in long-haul freight transport
a FMCG company business case

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Defining purchasing strategy
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business case

by

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*Confidential* The Company
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Abstract
This Master’s thesis concerns the analysis of European transport outsourcing and possible performance improvements within The Company. Currently all lanes are purchased based on a single strategy although the management trade-off between quality and costs show specific lane challenges. New influential levers on cost and quality were identified; these levers were used to develop four strategies based on geographical lane characteristics.
Management Summary

In a FMCG company European FTL transportation is tendered on an annual basis. In deciding which Logistics Service Provider to contract, the company uses the balance between Quality and Costs of the proposed service as a management trade-off. However, the FMCG Company does not monitor the Quality part of the equation and insight in the Costs drivers is limited. Despite the fact that these combined variables determine the overall transport performance. This thesis focused on measuring transport performance. And using transport performance to answer the question of how purchasing strategy can optimise transport performance; hence the following research question was formulated:

*How is the Company transport purchasing process influencing transport performance and how can this be optimised?*

The scope of this research project was limited to long-haul transport and data from the Company’s 2011 European Transport Tender. This tender contained long-haul freight transport data on two of the company divisions which added up to 263 lanes, outbound 21 factories to 49 delivery points, with a total value of € XX.X million for 30,000 FTL. In these business units inventories are mainly kept at Sales Units, meaning factories apply direct shipment supply chain methodology.

In buying logistics services the general tendency is to use price as the main and single decision variable, although this can result in sub-optimal purchasing performance. Financial costs are not the only part considered as logistics costs and "generally do not provide all required information about logistics performance". Next to negotiations on price a buyer should manage supplier relationships in such a way that a climate is created where suppliers actively supporting the company’s overall business strategy and value proposition, are continuously challenged to improve their added value and integrate in the company’s business processes to boost productivity.

In this thesis we identified the Cost-Quality efficient frontier, representing transport performance, where a logistics service outsourcing company can relatively position itself to, in assessing the room and direction for improvement. In approaching this efficient frontier one has to define what the base quality level of the logistic service outsourced should be. Based on the position relative to the efficient frontier and base quality level we identified three different scenarios and corresponding approaches, where aiming for both improved quality and cost levels has proven to be suboptimal.

Transport tariffs are for 66% exogenous and in general leave about 1-3% profit margin for the Logistics Service Provider (LSP). In a highly competitive market, such as the EU freight transport market, LSP’s struggle to find (financial) room for improvement and innovation. Although transport margins are slim and transport costs are evident we show that there are more cost levers that can be taken into account in defining a logistics service strategy; transport tariffs increase where the risk on empty mileage increases. Our analysis shows that this risk can be predicted by the alignment of the company’s transport network balance and the market transport balance. Aligned networks, i.e. network (im)balances that are in the same direction, show increased transport tariffs versus disparate network (im)balances. The wages between the different countries, the amount of trucks (volume) on a lane and the maximum transit time have been proven not to significantly impact transport rates.
The dataset available to us did not allow us to determine the exact cost position relative to the efficient frontier. Due to limited quality KPI measures in place neither we were able to determine the exact quality position. However we were able to identify the base quality levels and the levers on costs per lane. Current purchasing practise contains one strategy for all lanes, neglecting differences in geographic lane attributes. Using these new insights we constructed a new strategy framework which differentiates on lane specific geographical attributes. Figure A presents this lane differentiation purchasing strategy. On the x-axes the network alignment between company’s network and market network and on the y-axes the challenge on quality on a lane. Each quadrant clusters a group of lanes which require their own strategy:

- High quality challenge and advantageous network alignment; we recommend to use smaller LSP’s who are sensitive for opportunities closing their routing network and a long term relation to secure quality levels in difficult markets.
- Low quality challenge and advantageous network alignment; in general a more matured market where a pure cost driven strategy like reverse auctions will bring the best results.
- Low quality challenge and disadvantageous network alignment; in this situation securing capacity is the main goal possibly to be combined with a cost driven strategy. In general larger LSP’s are able to secure capacity best due to their large network; a longer relationship is not required in this competitive situation.
- High quality challenge and disadvantageous network alignment; this is the most difficult scenario where a longer term relation is required to be able to invest in quality and capacity, in general larger LSP’s are able to provide this service best.

Figure A Lane differentiation purchasing strategy
Conclusion
With the lane differentiation purchasing strategy we were able to assess the Company’s lane overview and positioned each lane, represented by a dot, in the above figure. Although the quality challenge cut-off point is not fixed we can conclude that using a pure cost based strategy would result in suboptimal tender outcome for this lane database. The vast majority of the lanes are positioned in one of the other three strategy quadrants and should be addressed accordingly in achieving the best logistics performance. Finally we recommend The Company to improve quality KPI measurement in order to monitor current quality levels and correctly utilise the Lane differentiation purchasing strategy. For consistency purposes the strategy has to be tested on The Company and other companies’ lanes.
Preface

This Master’s thesis is the result of my graduation project carried out within the Sourcing and Supplier Development department in The Company. This project represents the partial fulfilment of the study Industrial Engineering and Management Sciences at Eindhoven University of Technology.

As a graduate student in Operations, Management and Logistics, more specifically the research field of logistics services outsourcing in the supply chain, during this project I have discovered new levers in transport tariffs and management trade-off in transportation outsourcing. Next to newly gained insights this thesis helped me to develop a strategy that uses geographical differences in Europe to optimize purchasing.

I would like to thank several people that helped me throughout this master thesis project. First of all, I would like to thank Rob Broekmeulen, for all the time he invested in guiding me during the research project. I want to express my thanks for his comments and the many open discussions we enjoyed together. These discussions significantly contributed in framing all different aspects of the challenge in the world of logistics outsourcing. Secondly I would like to thank Matthew Reindorp, for utilising his financial background in the discussions and his clarifying view on several aspects of this thesis.

I would like to thank my company supervisor for the opportunity to write my master thesis at The Company. She played a significant role in teaching the daily practise of purchasing. Next to that her manager and Director provided me great support and inspiring input during the execution of my research project at The Company. Also I would like to thank the Intern for her efforts in improving the visual support within this report.

Special thanks go out to my dear family and friends for their confidence and their support during my study, whether this was study or leisure related. Finally, I want thank my housemate Bas for his patience and confidence in me finalising my Masters on time.

Jort van Rijnswou

Utrecht, April 2012
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Abbreviations

3PL 3rd Party Logistics
4PL 4th Party Logistics
CBU Country Business Unit
EU European Union
ECB European Central Bank
EMELA Europe, Middle East and Latin America
FTL Full Truck Load
LSP Logistic Service Provider
LTL Less than a full Truck Load
SC Supply Chain
SSD Sourcing and Supplier Development
SP Supply Point (i.e. factory)
SU Sales Unit

Short explanations

Full cabotage: is transport performed within a country or between countries by carrier registered in a different country than the transport is performed.

Direct shipment: is a supply chain strategy that reduces warehouse space dedicated for produced goods in a factory close to none. In this case produce has to be shipped directly to the next factory or consumer warehouse.

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1. Introduction

This document is the report of the master thesis project titled Defining purchasing strategy differentiation in long-haul freight transport: a FMCG Company business case, concluding the MSc. Operations Management and Logistics program in Eindhoven University of Technology, executed within the sub-group of Operations Planning, Accounting and Control. This research project was carried out at the Global Operations department of The Company in the Netherlands. The first chapter will bring you in the area of Transport purchasing and The Company. First we will start with introducing the company that provided the business case, in paragraph 2 we will go more into detail on the Company business units where this project focuses on. After which chapter 2 will introduce the problem situation of this thesis.

1.1. The Company Group
The Company group is a multi-brand health and nutrition company. *Confidential*

1.2. The Company
This Master thesis will be executed at the operations department of The Company. The two businesses account respectively for XX% and X% of the group’s 2010 turnover and grew significantly with X.X% respectively X% (The Company Full Year results 2010, 2011). These relatively new business units do not represent the major share of the Company group turnover, but they are the main drivers of growth for the group. The other business units are supplying more matured markets with stable products and therefore are mainly focussing on cost reduction and innovation. Whereas the business units where this research took place, are operating in a fast growing market and expand at a high pace by entering new markets.

As The Company is listed on the stock exchange the investment taken to acquire *Confidential* has to be returned by freeing operational cash, resulting in the different strategies between the Company divisions (The company’s Operations Communication Forum, April – August 2011). After the acquisition of *Confidential*, The Company were greatly fragmented while being built up from different companies, each containing numerous brands. During recent years these brands and companies have been consolidated and processes have been aligned. Nevertheless there is still a significant need for standardisation and optimisation of the current business processes.

The Company concentrated the Global divisions operations at the Netherlands, where the division’s factories, warehouses and customers are situated in almost every country in the world. The Sourcing department at The Company was the department where this thesis was executed. The central sourcing team is responsible for the purchasing of direct and indirect materials, where logistic services can be considered as indirect materials or Other Goods and Services (OG&S). The Sourcing department comprises different roles, where the central Logistics Buyer, central Supply Chain and local Supply Chain are the roles that are involved in my position as a researcher. My position in the organisational chart can be viewed in Appendix 1, more details on the collaboration between these different roles can be found in paragraph 3.1.
2. Project definition
The second part of this Master thesis will focus on the research project itself. This chapter delineates the problem definition, the research questions and objectives formulated. This all is supported by a literature review. Concluding the chapter with the research approach and corresponding project plan.

2.1. Problem definition
Having pictured the background of the Company it naturally follows that higher management is pushing for more productivity and freeing up cash. As current transport purchasing practice is based on an annual tender this should be the main topic of research. In short this means; what are the effects of current purchasing strategy and how can they be improved? The latest transport strategy also aims for improved transport performance where “Service and Quality is key” (The company’s logistics purchasing strategy 2011), meaning that there are different ways in achieving efficient transport through a purchasing strategy. With this we formulated the following problem statements:

Which transport purchasing strategy can lead to improved transport performance?
How can transport performance be defined through analysing the current purchasing process?

2.2. Problem proposition
The Company’s latest transport strategy aims for improved transport performance where “Service and Quality is key” (the company’s logistics purchasing strategy 2011). However there is not enough knowledge and intelligence on transport performance available that enables The Company to improve besides pure price negotiations. The current transport purchasing system is based on transport tariffs and their payment terms as result from an annual tender and incidental feedback on service and quality from stakeholders. Although service and quality are key factors to improve they are not monitored and the relation to transport tariff is not clear. This problem definition leads to the following problem statement:

Investigate current levels of transport costs in relation to transport quality, effects of purchasing practise and how they relate to each other. Define transport performance and use the base levels and variables to create insight in how to improve transport purchasing.

In short the aim of this thesis is: Analysing transport performance of a large company to investigate the relations between buying behaviour and logistics performance.

Having said that, naturally the following research questions arise:

- **RQ1. What is the current level of Cost?**
- **RQ2. What is the current level of Quality?**
- **RQ3. What is the current purchasing practice?**
- **RQ4. How is The Company’s transport performance situated on the Cost-Quality efficient frontier?**
- **RQ5. How can transport quality be improved through purchasing processes?**
- **RQ6. How to differentiate strategies in transport service purchasing?**

These questions can be grouped into two parts:

1. The first part focuses on analysing the current process and the corresponding performance.
2. The second part focuses on how to improve the purchasing process and investigation of improvement opportunities.

Summarised into one question:

*How is the Company transport purchasing process influencing transport performance and how can this be optimised?*

### 2.3. Research scope

The scope of this thesis is the variables and factors that influence logistics performance and how these can be altered to change the purchasing process and affect the main variable: logistics performance. Figure 1 presents an overview of the identified variables that influence logistics performance. We identified these variables by browsing scientific literature presented by Google Scholar using “logistics performance”, “purchasing behaviour”, “logistics network” and “greenhouse gasses exhaustion” as search criteria. Deliberately left out of scope are variables that cannot be directly influenced by operational processes, for example: greenhouse gas exhaustion and innovation in carrier equipment and technology. These variables are important to monitor, but altering the single variables itself do not directly lead to changes in logistics operations. For example, governmental charges on high polluting modes of transport will in general not lead to a switch of modality, but only to higher operational costs (Hoen et al., 2010).

![Figure 1 Preliminary cause and effect diagram](image-url)
The overview in Figure 1 shows a first overview of variables and factors that can influence logistics performance. The scope of this master thesis was only on the variable “Purchasing behaviour” and its underlying factors influencing logistics performance. All variables in the above mentioned figure influencing “Purchasing behaviour” will be further investigated in Paragraph 2.4.

2.4. Literature review

Purchasing logistics is the activity involved in buying a service that: “has the mission to get the right materials to the right place at the right time” (Ghiani et al., 2004). Purchasing logistics in the industrial sector is in most companies considered as a service. In many industrial companies these services and other external costs are responsible for more than half of the costs of goods sold. This implies a significant effect of buying behaviour on the companies’ overall (financial) performance (van Weele, 2010).

2.4.1. Logistics performance measurement

Logistics performance measurement is defined as the relation between logistics costs and perceived logistics value, where logistics costs and value are determined by multiple factors. Factors like transport tariffs and fuel price are well known, however these factors are not solely responsible in determining logistics performance. According to Beamon (1999) different views on what should constitute logistics performance make it difficult for many firms to practise Supply Chain Management in logistics. To overcome this problem they need a comprehensive overview of their supply chain activities and full appreciation of the impact of their performance on other member firms in the supply chain (Lai et al., 2002). Firms wishing to improve their SCM in transport logistics need to constantly monitor their performance. Fugate et al. (2010) state that; excellence in logistics performance is related to high organizational performance.

Performance measurement should be based at least on more than one quantified performance indicator, preferably a heuristic multidimensional framework of performance evaluation, combining a larger number of performance indicators (Blanquart et al., 2009). The standard way of measuring transport performance is by ton/km and price/km, where the financial measure has traditionally been the primary measure of success in most companies. In buying logistics services it is very tempting to use price as the main decision variable, while this can result in sub-optimal purchasing performance. Financial costs are not the only part considered as logistics costs and “generally do not provide all required information about logistics performance” (Brewer and Speh, 2000 as read in Rafele, 2004). Therefore in this project’s perspective logistics costs contain all the expenses involved to outsourc a FTL from a departure point to a destination point. Nevertheless the economic aspect of transport significantly influences logistic performance (Rafele, 2004). Next to negotiations on price a buyer should manage supplier relationships in such a way that a climate is created where suppliers: actively support the company’s overall business strategy and value proposition, are continuously challenged to improve their added value and integrate in the company’s business processes to boost productivity (van Weele, 2010).

According to Blanquart et al. (2009) performance measurement should be based at least on more than one quantified performance indicator. The measures used in Chow et al. (1994) for logistics performance are mainly “soft” (e.g. self-reported perceptual data) by nature. One of the widely used operationalization of logistics performance (Stank et al., 2001) consists of seven self-reported items regarding the firm’s ability to meet certain abstract ends linked to order cycle times, reliability,
responsiveness, flexibility, and estimated customer satisfaction. The used measures in this field of investigation are mainly “soft” (e.g. self-reported perceptual data) by nature. In contrast, the use of “hard” logistics performance measures (e.g. financial reports-based figures) is much less common. Such measures are typically used only in econometric modelling or simulation studies rather than in empirical studies (Chow et al., 1994). Furthermore, the studied logistics performance measures are generally static, providing cross-sectional analysis of performance rather than a dynamic picture of performance development (Töyli et al., 2008).

The familiar phrases “best-in-class” and “world-class” and the popularity of benchmarking services, point to organizations’ desires to search for excellence. In the logistics discipline this dimension of comparing results of logistics activities to competitors as “logistics differentiation.” Evidence collectively reveals that the logistics function as a whole should strive to minimize the ratio of resources utilized against derived results (efficiency), accomplish pre-defined objectives (effectiveness) and gain superiority when compared to competitors (differentiation) (Bobbitt 2004 as cited in Fugate et al. 2010).

2.4.2. Tendering

Tendering in logistics is usually used to outsource long term contracts with freight carriers, usually for 1 or 2 years, or to outsource the transport services to common carriers that operate in spot markets (Tsai, M.-T. et al., 2011). A standard way of transport purchasing is executed via a transport tender; using only the trade-off of ‘perceived service’ vs. ‘costs’ as the determining factor. This model is clearly described by Holter et al. (2008). Service and cost considered as a trade-off is supported by Buer et al. (2009) as they state that striving for both Quality and Cost at the same time is quite hard, as not impossible. Although Holter et al. (2008) specifically developed this framework for Small and Medium Enterprises (SME’s) there has been no specific research on the application of this model for Large Enterprises. The adjustment for SME’s is made to offset the natural purchasing power advantage i.e. leverage at large companies.

The service (or quality of transport) trade-off can be defined and measured in many ways. In the model of Holter et al. (2008) the following Transport parameters are used; freight cost and related charges, transit time, transport visibility, on-time delivery and cost of intern transport management. In this model the transport provider was only changed in times of critical service failure and/or in case of fallout. This is a reactive purchasing process where senior management will get involved after a crisis already occurred (Holter et al., 2008).

In order to improve transport performance this purchasing process has to be altered into a proactive purchasing process. Holter et al. (2008) also present a model for this more proactive approach. In this approach they state that next to a trade-off between service/cost a trade-off between transit time/cost have to be made by senior management, in the presented sequence. After the first stage a Standard Operation Procedure (SOP), KPI’s, service quantified and a tender document can be determined. Data on the required transport are important input for the tender document to make the account attractive and to the cost model to calculate the total cost of each bid. According to Holter et al. (2008) having gathered the previous mentioned information there is a third senior management decision required in order to choose the desired LSP(s), based on the cost model and common purchasing aspects like culture fit, reputation, etc. Holter et al. (2008) presented this
framework in an advanced model which is included as Figure 2. This extended framework enables shippers to improve transport service purchasing and push suppliers to increase service.

![Figure 2 Extended transport purchasing and management process proposed by Holter et al. (2008)](image)

In a tender the seller/supplier is not the one who puts his products or service under auction. In this case demand of a product/service is put under auction by the buying party. Making use of a tender a buyer is ‘selling’ its request to different suppliers and takes out the best bid. The majority of today’s tenders take place online. “Online reverse auctions (i.e. tender) revolutionised corporate procurement in the beginning of the 21st century” (Radkevitch, 2008). The underlying reason for this revolution was the belief that using online tenders for purchasing processes created transparency in market prices. This gave companies the opportunity to optimise their purchase processes and reduce their contract prices by 5 to 40% (van Weele, 2010). The previous statements represent a shifting power balance in purchasing, moving from a sellers’ market to a buyers’ market. Online tenders have had a sudden negative impact on the yield of sellers, as much as they have had a positive impact on the cost reductions achieved by buyers. Radkevitch identifies three interrelated problems regarding reverse auctions, namely; auction (tender) context, service characteristics, and buyer-supplier relationships. Whereas van Weele (2010) states that the purchasing process can be obstructed by: supplier or brand specifications, inadequate supplier selection, personal relationships, lack of good contractual arrangements, overemphasis on price, poor administrative processes and delivery problems.

### 2.5. Research approach

In approaching this research project we make use of the regulative cycle by van Strien (1997 as cited in van Aken et al., 2007) presented in Figure 3. The regulative cycle takes the optimisation process as a reoccurring loop, where this optimisation project is represented by one loop. After identifying the set of problems, one

![Figure 3 the Regulative cycle (van Strien 1997 as cited in van Aken et al., 2007)](image)
problem has to be chosen before it will be diagnosed in order to design a solution plan. After that the solution design has to be implemented and assessed whether the solution design achieved the wanted end state. According to the end state a new set of problems might arise and the cycle starts over again.

This master thesis will be an interaction between theoretical fields, a part of the current business process and the envisioned objectives. This is an interaction process which is schematically presented in Figure 4. The identified theoretical fields are “Transport networks and supply chain management”, “Logistics outsourcing” and “Logistics performance measurement” presented in the top left box. The business process that the theoretical fields are interacting with is the “Primary logistics purchasing and tendering in Europe” which together resulted in the required objectives.

![Figure 4 schematic structure of conceptual project design](image)

The need for tendering is determined by defining transport purchasing as a commodity or a service and transport network characteristics. As stated before, The Company’s quantitative purchasing operations exist of a low level of automation and standardisation. Nevertheless we need to achieve an understanding on the current level of Quality and Cost before the corresponding strategy can be researched. When this picture is drawn the effects on variables for the developed strategy should be thoroughly investigated.

By analysing the current transport lane execution, purchasing process and behaviour, the aim is to generate, standardise and optimise proposals on European primary logistics (purchasing) performance, including an optimised bid selection model.

In this research approach our intermediate aim is a model that can predict transport tariffs per lane in such a way that we can define the cost perspective of logistics performance. For this we need to determine the predictor variables and the relation first. However there can be a difference between the predictive model on The Company tariffs and the general market tariffs. Where the Company network is only representing a minor share of the whole transport business in Europe the latter will
be leading in determining the tariffs. However as only the Company transport prices are available, these predictions are mainly valid for the Company transport network based on one year price validity. These predictions might deviate from the EU spot market. The next paragraph will delineate on how this project will be approached.

2.6. Project plan
This project plan will go over all Research Questions and explain how these will be answered. As stated earlier the questions can be divided into two parts; firstly the AS-IS situation has to be investigated and secondly the Goal situation can be drawn and supported by analyses. Below in Figure 5 the different phases wherein the rest of this report is clustered are visualised. Like the research questions these phases can be split up in two groups, were Data collection, Quality survey and Model building can be clustered under AS-IS, the other phases are part of the Goal cluster.

![Figure 5 Phase overview](image)

The research questions do hold to one particular phase but are answered throughout the report. The split between AS-IS and Goal is still present. Below we will delineate how we are going to answer each question.

2.6.1. AS-IS

RQ1. What is the current level of Cost?

This question will be answered by three analyses:

1. By creating a thorough understanding of the tariff breakdown, using; Fuel, labour, insurance, depreciation, maintenance, taxes and profit margin. Chapter 5
2. By executing a market analysis; what is currently offered, at which position does The Company stand as a shipper, what are the trends and to what extend is the market able to cooperate in optimisation programs. Chapter 5
3. Comparing the Company tariffs with the market tariffs. Chapter 5

RQ2. What is the current level of Quality?

This question will be answered by executing a Quality Survey amongst the major stakeholders on the top 10 suppliers in terms of financial spend. The results will be analysed to create an understanding where The Company is positioned on the C-Q efficient frontier. Chapter 5

RQ3. What is the current purchasing practice?

This question will be answered by the characterisation and validation of purchasing behaviour (tender process). Supported by literature the effects of this purchasing practise were assessed. Chapter 3
RQ4. How is The Company’s transport performance situated on the Cost-Quality efficient frontier?

This question will be answered by comparing the Quality survey results to Tariff levels, which should result in an understanding where The Company’s transport performance levels are situated. Chapter 5

2.6.2. Goal

In this second cluster we will focus on how to improve the AS-IS situation which is in line with drivers from higher management to improve operational performance.

RQ5. How can transport quality be improved through purchasing processes?

This question will be answered by investigating what causes the mark-up in the tariffs charged; either it represents increased quality or The Company’s transport network is not aligned with the market characteristics. As not every statistical region in the network is the same in terms of size, different size meaning different distances which is a significant factor in determining transport tariffs, we have to correct for the difference in network size. For this analysis we used the methodology presented by Daganzo (2005), further explained in Chapter 4 and 5. The result of the above research is used to compare Q-C efficient frontier with Q-C theory and create a new strategy to improve the current situation. Chapter 4

RQ6. How to differentiate strategies in transport service purchasing?

This last research question will be answered by identifying the appropriate purchasing method(s) from best practices literature in order to improve the current transport purchasing performance. This can be found in Chapter 6.
3. Current situation
This part of the thesis will assess and investigate the current situation, starting with the current operations organisation and responsibility distribution between these stakeholders. The other paragraphs will go into detail on the Company transport scope and its requirements. After that the Primary transport tender is described. Last we examine the European transport market.

3.1. The Company Operations organisation
In order to understand the operational process on a European level this part will give an overview of the different roles within this process, including the central and local Sourcing, Supply Chain staff and Logistics Service Providers (LSPs). Figure 6 presents an overview of the roles involved.

![Figure 6 Role interactions](image)

In The Company organisation every country or even factory has its own profit and loss account; meaning that the central organised teams are positioned in a more supportive role. In this set up the final decision makers on transport expenses and contracts are the local Supply Chain representatives; however the central team is responsible for transport purchasing and supply chain strategy. If a local representative has valid reasons to deviate from the central developed strategy he or she is free to do so. For more details on the operational execution of transport ordering and timeline we refer to Appendix 5 Transport ordering process, for the rest of this thesis we will focus on the tender process.

3.2. The Company Primary transport
Having covered the background of this study and showing the stakeholder structure of this company, the topic of research and its interactions is delineated in this paragraph. The different transport stakeholders defined multiple challenges in increasing transport performance throughout their business. Taking the Company business as a whole would simply be too broad, therefore we scoped Europe geographically and Primary logistics as part of the supply chain. Figure 7 represents primary logistics positioned in the Supply Chain of The Company.
For this assignment the unit of analysis is the logistics purchasing process through an annual transport tender. The logistics purchasing process currently contains a yearly tender among European transport and LSPs. These LSPs are given the challenge to bid on 263 lanes from 21 factories to 49 delivery points and to deliver the transport for the coming year, adding up to a total contract value of €XX.X million and 30,000 Full Truck Loads (FTL) in 2012. Each FTL stands for a 24 tonnes load equivalent for transporting semi-finished or finished products, in an ambient or refrigerated trailer or container, from origin to destination. For an overview of manufacturing locations in Europe we refer to Europe and for all loading and unloading points we refer to Appendix 3, both are included at the end of this thesis.

Within this transport scope a significant amount of data is available, transport data as input for the tender and tariff output from the tender. This tender data is the result of an annual Transport tender executed every year in search for a transport market benchmark. The output is an overview of (pre)selected suppliers and their bids including a bid evolution throughout the tender. The outline of the tender process can be viewed in Appendix 4 Process flow Transport Tender. This tender will be further delineated in paragraph 3.4.

3.2.1. The Company’s European primary transport network
The Company European transport network is based on the lane database which is continuously updated on SC changes. This lane database is the base document for each transport tender, containing all the routes from each origin to each destination and the required transport characteristics. On this document we made the first analysis, we investigate whether it makes sense to outsource transport in the first place. Figure 8 presents all European origins by the means of a black dot, the light blue circle is the destination point. The routes between these points from a bird’s eye view are shown by a blue line where the line width increases with the amount of shipments. For this picture the annual volumes from the 2011 lane database is used. This overview suggests that the network is unbalanced, e.g. Ireland being an export country and Turkey an import market. If the network was balanced it would have been interesting to investigate whether The Company is able to exploit a private fleet. Further investigation has to reveal to what extend the network is imbalanced and result in empty backloads. We assume The Company is not willing to deviate from her core business in trying to fill up these empty backloads with other companies’ loads, we know it does make sense to outsource.
Next to the amount of FTL’s from which destination and which origin, the lane database provides us more detailed information on; transport modality, transport equipment required, temperature controlled transport (9% of all FTL’s in 2011 tender), maximum transit time, current contracted transport tariffs and for which division the transport is executed.

3.3. The Company’s Primary transport requirements
To be able to measure whether a purchasing strategy and/or a tender provided the outcome that was intended, one should have a clear picture of its goal. In this paragraph we will discuss the data on The Company’s primary transport requirements. Next to the available data on tangible requirements the Company strategy is provided in how to prioritise amongst the different aspects of purchasing transport services.

3.3.1. General specifications and Loading-unloading specifications handbook
These documents contain the Company qualifiers for transport on an operational level, i.e. how all warehouses and factories operate and which requirements the LSPs have to comply with for a correct operation.

General specifications document
In short the general specifications document sets the quality standards to which the equipment and transport has to comply in order to prevent the risk on damaging the products. Where the main restriction is the temperature range in which the products has to be maintained during transport.
Next to that the document covers the Operational Requirements, which includes a general set of variables explained but also which KPI’s should be measured and on which format and interval they have to be communicated. A general safety procedure for drivers states what they can and cannot do, how and where they should do this. Last but not least it provides a clear distinction between which party is operationally responsible for which activity.

The loading-unloading handbook
This handbook contains more detail then the General specifications, where this handbook covers each warehouse and its particularities. Ranging from address, opening hours, delivery or loading slot booking to invoicing and customs procedures, this document covers all operational details. As both documents are relating to the service that the transport provider is supposed to deliver these documents are part of the tender and a final transport agreement when awarded.

3.3.2. The Company strategic axes
On top of all basic requirements The Company has formulated so called ‘strategic axes’, a list of important topics to strive for in supporting Supply Chain and the business as a whole. The nature of transport services and the way they are applied has become an immensely important consideration for firms, as firms seek to maintain a competitive advantage (Leinbach et al., 2007). The Company’s Supply Chain Direct Shipment program increases the need for reliable transport. The Direct Shipment program makes transport part of the production process, no or delayed transport results in a stop in production (The Company, SC needs analysis, Jan 2011). In a volatile and tight capacity market this requires for securitisation of capacity first. According to the Company logistics purchasing strategy 2011, the first strategic axis is “Security of Supply” followed by “Service level and Quality” and where “Cost and Cash” only comes third. The Company distinguishes between cost and cash by seeing costs as the actual amount of money to be paid for a certain product or service, where cash is seen as the term on which the payment of this product or service is due. In this case a cost position can be improved through productivity and a cash position by extending the payment terms. The full list of strategic axes is below presented in order of importance:

1. Security of Supply
2. Service Level and Quality
3. Cost and Cash
4. Safety towards human beings and goods
5. Reduction on CO\textsubscript{2}
6. Innovation

Although affluent documents are available on how transport services should be executed including a full spectrum of characteristics, The Company has limited to no fixed measures in place that provide data on whether these requirements are fulfilled. The data that is available on providing the service that was agreed on is based on incidents records. These incidents records are most of the time only provided to the central team in case a local stakeholder is not able to solve the issue. In terms of strategic axes only cost and cash is well measured as this is the base of a buyers’ bonus. Safety towards human beings is reported on a quarterly basis by the LSPs. Next to that The Company is rolling out initiatives to measure time delivery, time pick-up of goods and CO\textsubscript{2} reductions.
3.4. Annual Primary transport tender

For over 10 years The Company aimed to achieve the best transport prices through an annual European Primary transport tender. The output of this annual tender is used as a benchmark for the coming year and the base for further negotiations. In this annual tender all European LSPs are allowed to participate and bid. Although the Company logistics network requires strict dedication that not every LSP will be able to provide there is no pre-selection done by The Company. The earlier introduced “General Specifications”, “Loading and unloading specifications handbook” and the “Lane database” should make sure that the participants bid according to The Company’s needs. The tender is executed with help of an online tender tool that is split up in two phases: Subscription phase without feedback and competitive bidding phase including feedback.

3.4.1. Tender process

This execution of the tender is covered in the business scope as this tender is technically speaking open to all European LSPs, although The Company has specific Qualifiers in terms of service that not all LSPs are able to comply with. In this sense the scope is adjusted to a non-binding tender, e.g. a tender that is not automatically awarding the job to the best bid or bidder. The non-binding tender is part of the business scope despite transport services purchasing is performed with the means of an annual reverse auction or binding tender. The theory of transport the tender process is simplified presented below in Figure 9. When the outsourcing process of transport is executed via a tender, a set of qualifiers determines which suppliers are allowed to bid and which quality standards they have to live up to. After this supplier selection process and the base quality level is set the actual tender is started for a set period of time. After this bidding period the tender is closed and the lowest bidder naturally is awarded with that lane (van Weele, A., 2010). These tenders are only applicable if the service to purchase is a commodity.

![Figure 9 Transport Tender process – theory](image)

When we compare this theory with the Company Primary Tender process, see Appendix 4, we see a tender process that is not completely in line with theory. The tender is presented as a tender but has a non-binding outcome. The transport tariffs are used for benchmarking purposes in order to check the incumbent suppliers’ competitiveness. Based on this benchmark of tariffs the outcome of face-to-face negotiations determines the awarding of lanes, this process is visualised in Figure 10 below. The experiences of Supply Chain with the bidding companies are leading in whom to negotiate with. In this tender process the majority of lanes are awarded to the incumbent supplier. For example, from year 2011 to 2012 68% of the lanes were awarded to the supplier that was also awarded on the same lane in 2011. This awarding of lanes to the incumbent supplier represents 72% of the total 2012 lane value.

![Figure 10 The Company Primary Transport Tender practice](image)

The side-effect of this adjusted tender purchasing process can be that it is presented as a binding tender. The bidding behaviour of LSPs will change with the manner of tender execution, e.g. if a supplier knows in advance that after the tender another round of negotiations will take place he will try
to make sure he will be in the top bidders but will not provide their final bid yet. In this case the tender process is not transparent and will therefore not always result in a like-for-like comparable tender outcome. Some LSPs gained experience during the previous tenders and will not provide their final bid in the tender, where others will as they believe it is a reverse auction as presented. Besides the risk of losing credibility by not being transparent undesired bidding behaviour can occur.

### 3.4.2. Tender output database 2011 & 2012
The full database with tender results for 2011 and 2012 is available. This includes all different bidders and the prices compared to the prices paid for by the incumbent suppliers. The tender ranking on price compared to Supply Chain’s ranking, a combination of price and quality perception, is also included in these databases. As each factory and sales unit has their own profit and loss account this Supply Chain’s ranking is one of the determining factors in awarding lanes to a LSP.

In order to have an understanding which supplier portfolio The Company is awarding in order to execute the transport on all these lanes, we analysed suppliers and classified them according to their level of outsourcing. The majority of The Company’s LSPs used to ship the goods are asset light companies or even companies without assets. From 2011 to 2012 this share even increased from 70% to 80%. There can be several reasons for that, one of The Company being a company with an extensive logistics and supply chain department. In this way there is limited need for increased level of outsourcing in services on top of just the transport service. In general the customs required paperwork and related services are taken care of by The Company personnel in each country. However an increase in usage of asset light LSPs can point at more need of flexibility and capacity securitisation. In general asset light LSPs are able to make use of the imbalances in the transport network, not depending on one specialised and asset based company. In Appendix 4 Process flow Transport Tender the yearly tender outline is presented including timeline, deliverables and actions.

### 3.5. European Transport Market
The Company is sourcing in a complex and greatly dispersed transport market. The Company is making use of three different modalities and combinations of these modalities, where transport is depending on multiple exogenous factors, e.g. fuel/energy. These European transport market characteristics need to be examined in order to execute the master thesis.

To this day numerous companies provide market intelligence, both on national and European level. The disadvantage is that this intelligence is based on historical data, not incorporating future developments. Transport tenders are used in general to make price agreements for tomorrow and the coming future. In order to properly asses a tender outcome one has to deal with increasing uncertainty of market developments relative to time. Next to that these intelligence reports provide data that is not always comparable to a company’s situation where the intelligence figures are generalised over larger geographical areas. This research project will identify the cost drivers for transport tariffs to a more detailed level. This knowledge is necessary to support defining purchasing strategy related to the cost and quality trade-off in logistics services.

#### 3.5.1. European Transport market characteristics
The European economy is normally seen as the combined values of the EU27, which represent a Gross Domestic Product (GDP) of 11.8 trillion Euros and housed 500 million inhabitants in 2010. With around € 520 billion in Gross Value Added (GVA) at basic prices, the provision of transport services
(including storage, warehousing and other auxiliary activities) accounted for about 4.6% of total GVA in the EU27 in 2008. However it should be noted, that this figure only includes the GVA of companies whose main activity is the provision of transport (and transport-related) services and that private transport operations are not included.

In 2008, the transport services sector of the EU27 employed around 9.1 million people, some 4.5% of the total workforce. Around two thirds of them worked in land transport (road, rail, inland waterways), 2% in sea transport, 5% in air transport and 27% in warehousing and supporting transport activities (such as cargo handling, storage and warehousing). In 2009, total goods transport activities in the EU27 are estimated to have amounted to 3 632 billion ton/km. This figure includes intra-EU air and sea transport but not transport activities between the EU and the rest of the world. Road transport accounted for 46.6% of this total, rail for 10.0%, inland waterways for 3.3% and oil pipelines for 3.3%. Intra-EU maritime transport was the second most important mode with a share of 36.8% while intra-EU air transport only accounted for 0.1% of the total (EU Transport Statistical Pocketbook, 2011).

Freight transportation often accounts for even two-thirds of the total logistics cost (EU Logistics costs as a percentage of GDP- Transport, Warehousing, Inventory, and Administration) and has a major impact on the level of customer service. It is therefore not surprising that transportation planning plays a key role in logistics system management.

In 1983 Kraljic already noted that sourcing in the manufacturing industry became increasingly volatile. From the day of publishing Kraljic paper almost 30 years have gone by and the market volatility is still in place, even worsened during the crisis of 2008. In the logistics market transport prices remain unstable and are still behind the level of the pre-crisis year 2008. Although the price difference is small the available capacity (the ratio between absolute demand and absolute capacity) in 2010 (index 84.6) is 20.7% below the level of 2008 (index 106.7), see Figure 11. Taking into account that available capacity is one of the main drivers for price developments in the market, there should be other developments that influence the current price index (Gapgemini Transport market monitor 6th edition, 2011).

![Figure 11 Price and capacity index, yearly (2008-2010), Capgemini Transport monitor 6th edition, 2011](image)

### 3.5.2. Tariff and cost breakdown

Abundant sources such as carriers, freight forwarders (asset less or asset light carriers) and market intelligence reports provide transport tariff cost breakdown for the European market. As the
majority of the cost drivers cannot be influenced by LSPs, where Labour and Fuel account for more than 50% of total transport tariffs, fluctuations in these drivers will highly influence the total transport tariff and its relative breakdown. Therefore these general transport tariff breakdowns will be difficult to verify based on one instance or one particular circumstance. Below we will discuss each cost driver based on the European international transport database using 40 tons loadings, verified using the carriers, freight forwarders and market intelligence parties. A graphical presentation of relative breakdown in Europe for 2010 can be viewed below in Figure 12.

![Tariff breakdown international transport 40 tonne EU (2010)](image)

**Fuel**
The biggest part of transport tariffs is the fuel part ranging from 26% to 35% for the last 4 years. This driver is also the most volatile one as it is highly influenced by the worldwide economic climate. The latter mentioned was quite unstable for the last 4 years resulting in a 43% bandwidth of Fuel price in the same period, see Figure 13. In order to reduce a part of volatility, it is not uncommon to use fuel clauses that (partly) compensate for price increases.
Labour
In general labour costs ranged from 23% to 30% of the total transport tariff for the last 4 years. Based on the cost of the driver this includes; driving time and loading and unloading time. In the driving time the resting time regulated by the EU legislation is included as well: “After driving for four and a half hours, a break of at least 45 minutes is mandatory.” (Website European Commission, Road Safety).

Table 1 European country labour rate statistics

<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>€ 16.26</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>€ 10.23</td>
</tr>
<tr>
<td>Range</td>
<td>€ 31.59</td>
</tr>
<tr>
<td>Minimum</td>
<td>€ 2.05</td>
</tr>
<tr>
<td>Maximum</td>
<td>€ 33.64</td>
</tr>
</tbody>
</table>

As regulations allow full cabotage within the EU one has to incorporate the wages differing per country, ranging in Europe from 2.88 euro/h (BU) to 36.94 euro/h (BE) (Eurostat: online database codes: lc_an_costh_r2 and lc_an_costh). The full statistics on labour 35 labour rates throughout Europe can be found in Table 1.

Depreciation and maintenance
Both cost drivers are related to the type and condition of equipment. Together they add up to 15% of the total transport tariff. Both can be more or less influenced by the LSP, were it not the case that the European Commission is tightening her rules on greenhouse gasses exhaustion by trucks. These rules are translated in ‘Euro #’ engine types that have to be below a certain exhaustion limit. These limits are revised every few years, resulting in a forced fleet renewal.

An increasing number of shipping companies closely monitor their greenhouse gas exhaustion throughout their supply chain and aim for progressive reduction in transport. One of their resolutions is to push the LSPs to make use of the newest and thus cleanest Euro engine types only.

Road tax and overhead
Road tax and overhead also add up to 15% of the total transport tariff and are highly dependent on the characteristics per transport service, where road tax exists in many forms and is country or even
route dependant. The same holds for overhead, which can take multiple forms and is significantly depending on the amount of work that has to be done in order to execute the transport order.

**Gross margin**
The last cost driver is the part that can be influenced to a large extent, these last 12% are for both shipper and carrier base for negotiation. As the average profit margin in the transport sector ranges from 1 to 3% the other 9% represents general risk on empty mileage. As both the driver and the equipment have to return eventually to its origin or central depot the cost for this total route has to be covered. The amount of empty runs is twice the amount in national transport as in international transport. According to Eurostat, between 2007 and 2010, the ratio of empty running vehicle-kilometres in the total fell by one percentage point, from 25% to 24% (Eurostat, 2011).

### 3.5.3. Market intelligence Eurostat
The European Commission statistics agency, Eurostat, provides a good overview of inbound and outbound transport per region. This will be used to determine transport (im)balances in the European network. Next to that, reliable figures on transport trends, transport modalities etc. are freely accessible. The only disadvantage is that Eurostat is only providing historical data with a delay of at least one year. And due to political issues not all countries are providing the input for each database.

### 3.5.4. Market intelligence commercial parties
The market data from Eurostat was complemented with more recent market intelligence from commercial parties. The first is the Transporeon quarterly Transport Market Monitor, a combined effort of Capgemini Consulting and Transporeon on reviewing transport tariffs from different European LSPs. This report presents trends in tariffs and capacity and is freely accessible on a quarterly basis at [http://www.transporeon.com](http://www.transporeon.com).

For more detailed information on the European transport market the report European Road Freight 2010 from the consultancy company Transport Intelligence is used. This report is not only providing insights in the European general trends, but also on a more country and major LSP’s breakdown. This report was bought by The Company from the company Transport Intelligence at the end of 2010.

### 3.5.5. European Transport Network Balance
As stated previously transport tariffs are highly dependent on exogenous factors like fuel prices and labour rates. In a globalised economy these factors are influenced by macroeconomic drivers. But as indicated by market intelligence reports, transport tariffs can be highly dependent on available capacity. When transport tariffs depend on the European capacities this is an indication for buying a commodity, i.e. each ‘transport service’ is interchangeable by any other supplier providing a ‘transport service’.

This statement is supported by Jonkeren (2009) where he states that the trade balance in volumes between two regions will exceed the transport price in one direction compared to the other when “a positive proportion of carriers are required to return without paid cargo” (Pigou, 1913 as cited in Jonkeren 2009). A clear example of this effect would be the difference in tariffs for shipping 1 TUE container from Asia to Europe or from Europe to Asia. As well known the export volumes from Asia to Europe significantly exceed the export volumes from Europe to Asia, resulting in a significant higher tariff on the route Asia – Europe compared to Europe – Asia.
Jonkeren (2009) proves this relation by examining inland waterway transport prices in Northern Europe. However as the Northern Europe inland waterway transport business differs significantly from the European road business, especially their dependence on infrastructure, therefore we should be careful in expanding this theory to other situations or transport markets.

Until now we have suggested that the imbalance on a specific route influences the transport tariffs. Jonkeren (2009) shows that not the imbalance on a particular lane is leading the effect on transport tariffs but the imbalance in the regions itself. “Region imbalances play a much more prominent role than route imbalances in the determination of transport prices” (Jonkeren, 2009). Based on the Eurostat reports annual road freight transport by region of loading and unloading [road_go_ta_rl] and [road_go_ta_ru] (1000 journeys) we were able to produce an overview of deficits and surpluses per country, see Table 2, which indicates a more capacity tight market or abundant capacity. As stated before full data is not available on every country, therefore some countries lack these balances. Next to that it has to be noted that all balances are based on 2010 data, except for Greece and the United Kingdom.

Table 2 Annual Freight transport balances, based on Eurostat (2010)

<table>
<thead>
<tr>
<th>Row Labels</th>
<th>Sum loading</th>
<th>Sum unloading</th>
<th>Balance int.</th>
<th>Relative balance int.</th>
<th>Chance on a load</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT</td>
<td>1368</td>
<td>1625</td>
<td>257</td>
<td>8.59%</td>
<td>0.96</td>
</tr>
<tr>
<td>BE</td>
<td>3584</td>
<td>3708</td>
<td>124</td>
<td>1.70%</td>
<td>0.99</td>
</tr>
<tr>
<td>BG</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>100.00%</td>
<td>0.50</td>
</tr>
<tr>
<td>CH</td>
<td>347</td>
<td>702</td>
<td>355</td>
<td>33.84%</td>
<td>0.83</td>
</tr>
<tr>
<td>CZ</td>
<td>769</td>
<td>763</td>
<td>-6</td>
<td>-0.39%</td>
<td>1.00</td>
</tr>
<tr>
<td>DE</td>
<td>6521</td>
<td>6687</td>
<td>166</td>
<td>1.26%</td>
<td>0.99</td>
</tr>
<tr>
<td>DK</td>
<td>580</td>
<td>685</td>
<td>105</td>
<td>8.30%</td>
<td>0.96</td>
</tr>
<tr>
<td>EE</td>
<td>37</td>
<td>71</td>
<td>34</td>
<td>31.48%</td>
<td>0.84</td>
</tr>
<tr>
<td>ES</td>
<td>751</td>
<td>773</td>
<td>22</td>
<td>1.44%</td>
<td>0.99</td>
</tr>
<tr>
<td>FI</td>
<td>41</td>
<td>40</td>
<td>-1</td>
<td>-1.23%</td>
<td>1.00</td>
</tr>
<tr>
<td>FR</td>
<td>4289</td>
<td>5259</td>
<td>970</td>
<td>10.16%</td>
<td>0.95</td>
</tr>
<tr>
<td>GR</td>
<td>46</td>
<td>57</td>
<td>11</td>
<td>10.68%</td>
<td>0.95</td>
</tr>
<tr>
<td>HU</td>
<td>285</td>
<td>315</td>
<td>30</td>
<td>5.00%</td>
<td>0.98</td>
</tr>
<tr>
<td>IE</td>
<td>207</td>
<td>501</td>
<td>294</td>
<td>41.53%</td>
<td>0.79</td>
</tr>
<tr>
<td>IT</td>
<td>1560</td>
<td>1621</td>
<td>61</td>
<td>1.92%</td>
<td>0.99</td>
</tr>
<tr>
<td>LT</td>
<td>40</td>
<td>126</td>
<td>86</td>
<td>51.81%</td>
<td>0.74</td>
</tr>
<tr>
<td>LU</td>
<td>237</td>
<td>413</td>
<td>176</td>
<td>27.08%</td>
<td>0.86</td>
</tr>
<tr>
<td>LV</td>
<td>73</td>
<td>76</td>
<td>3</td>
<td>2.01%</td>
<td>0.99</td>
</tr>
<tr>
<td>NL</td>
<td>2016</td>
<td>2060</td>
<td>44</td>
<td>1.08%</td>
<td>0.99</td>
</tr>
<tr>
<td>NO</td>
<td>9706</td>
<td>10009</td>
<td>303</td>
<td>1.54%</td>
<td>0.99</td>
</tr>
<tr>
<td>PL</td>
<td>74</td>
<td>88</td>
<td>14</td>
<td>8.64%</td>
<td>0.96</td>
</tr>
<tr>
<td>PT</td>
<td>194</td>
<td>321</td>
<td>127</td>
<td>24.66%</td>
<td>0.88</td>
</tr>
<tr>
<td>RO</td>
<td>46</td>
<td>114</td>
<td>68</td>
<td>42.50%</td>
<td>0.79</td>
</tr>
<tr>
<td>SE</td>
<td>588</td>
<td>654</td>
<td>66</td>
<td>5.31%</td>
<td>0.97</td>
</tr>
<tr>
<td>SI</td>
<td>82</td>
<td>78</td>
<td>-4</td>
<td>-2.50%</td>
<td>1.00</td>
</tr>
<tr>
<td>SK</td>
<td>496</td>
<td>568</td>
<td>72</td>
<td>6.77%</td>
<td>0.97</td>
</tr>
<tr>
<td>UK</td>
<td>478</td>
<td>678</td>
<td>200</td>
<td>17.30%</td>
<td>0.91</td>
</tr>
</tbody>
</table>
Each LSP has to optimise its own network by driving the least amount of empty kilometres as possible. If a load has to be transported to an area B where there are more loads coming in than going out, the chance is significant that it has to drive empty to a different area before picking up another load. The last column shows a theoretical calculation of on the chance for a LSP to get a load in the region of unloading, e.g. if there are more loads going out than going in there is negative balance of available equipment. In general this should result in the driver not having to drive to far, however whether the LSP has access to these loads depends on multiple factors. It is evident that if there are more loads going into a region than going out the chance of getting a load in that region decreases. If the Company network, like presented in Figure 8, is unbalanced itself this will influence the chance of getting a backload as well. The theory behind this mechanism is explained by Daganzo (2005).

A remark on this table should be made, as the European network is expected to be more or less balanced in terms of loads. However this overview does not present a balanced Europe, in judging the overview correctly we have to take into consideration that; A) The overview is missing significant trade markets like Turkey and Russia, therefore the total balance could shift significantly, B) Europe is in terms of loads not balanced as we export more than we import and C) the table presents number of loads not truck movements. In the case it would present truck movements one would expect a truck to always return to its origin in the end.
To have a better understanding what this means for the Company network you will find below in Error! Reference source not found. a schematic presentation of a long-haul transport route. In this figure the white line is the lane from the A region to the B0 region, e.g. the transport service purchased by The Company. The colours of the B regions represent a load deficit (red) or a load surplus (green). In this case the destination region experiences a load deficit (more trucks are entering the region than loads are leaving the region). Therefore the chance is high that a truck has to drive empty to the closest region where there is load surplus and an increased chance to acquire a return load. This latter part is represented by the blue dotted line. In this example the region B1 adjacent to B0 has a load available to bring to the A region and the transporter is back where he started. In general a LSP will try to close his routing schedule and drive the minimum amount of empty kilometres as possible, which logically has influence on the transport tariffs.

Figure 14 Regional imbalance effect on transport routes
4. Hypothesis and Strategy Design

With our research questions we already made the distinction between As-Is and the Goal situation. In the previous chapters we investigated the current background situation, the transport requirements and introduced the Primary transport tender. This chapter will use the full understanding of current background information to start the discussion on answering the latter 3 research questions. As Chapter 3 shows three challenge directions, capacity, quality and costs we will delineate in this chapter how to test these factors and which are important to improve The Company’s purchasing strategy. The goal is to further improve transport performance by optimising transport purchasing. As point of departure we define logistics performance in paragraph 4.1. Paragraph 4.2 will start the strategy discussion based on the current The Company Supply Chain strategy. After that paragraph 4.3, 4.4 and 4.5 will cover the factors from the Company strategic axes we are able to measure and/or believe to influence logistics performance. Paragraph 4.6 will conclude this chapter with a short summary.

4.1. Logistics performance

Logistics performance in The Company is influenced by different variables. Transport tendering and purchasing focuses on two main variables: Quality and Cost. Cost and quality are a trade-off e.g. the higher the quality the higher cost incurred and the lower the cost the lower the quality. Low quality is available at low costs. At The Company costs are measured in terms of payment terms (free cash flow) and tariffs (savings/productivity). Quality is measured by KPI’s: security of supply, correct supply, safety and environment friendliness etc.. Figure 15 presents the theoretical playing field of a transport tender outcome. The green line, base quality level, is set by Supply Chain within The Company. Local Supply Chain is the budget holder for transport departing from their SP. The purple line, Cost-Quality efficient frontier, is the efficient frontier between cost and quality. Depending on the principal position a purchaser can aim for a position on this most optimal curve and reduce costs.

The Cost-Quality efficient frontier represents the optimal curve; a situation below this curve is not feasible without altering transport specifications. Where each shipper has its own set of transport specifications and quality demand the position of both lines might change, however the relation between C-Q will remain the same. As an example we use a shipper’s request for high certainty on capacity, this will lower the base quality close to zero performance issues. On the other hand, if the market is tight on capacity the C-Q efficient frontier can shift and lead time will go to infinite for a certain cost level. Moving towards the optimal C-Q efficient frontier will lead to an improvement in either Cost or Quality. Striving for both at the same time is quite hard (Buer et al., 2009). They show that in order to analyse a tender outcome that both includes both a quality and a cost measure one has to solve a bi-objective winner-determination.
optimisation problem (WDP). Although we think highly of logistics purchasers, this is not an easy problem to solve.

The current tender execution is only resulting in a tariff benchmark without a binding outcome. The aim of this tender has a cost reduction perspective - achievement, the outcome does not attribute to quality. Although The Company has some guidelines in measuring cost and quality they are not standard measured and used in the purchasing process. Quality is a result based on stakeholders’ opinions, i.e. without support of reverse auctions (tendering).

When we apply the framework of Holter et al. (2008) the The Company Logistics buying process is in theory in line. The three senior management trade-offs are part of the The Company process (service/costs, time/costs and the final purchase decision based on the cost model and common purchasing aspects like culture fit, reputation, etc.) are in place. The Standard Operating Procedure (SOP), tender document, tender data and cost model are defined or available from the business. According to the Holter framework the only thing that is missing are hard measures in quantifying the pre-determined KPI’s in order to execute a proper tender.

### 4.2. The Company Strategic axes

As stated before The Company developed a strategic axes containing, in order of importance, the following six axes. From our elaborate investigation presented in Chapter 3 we learned the dynamics of the below presented levers. Based on this knowledge we will discuss whether it makes sense to use these in order to purchase transport.

1. **Security of Supply**

With Security of Supply the Company is aiming for a commitment from suppliers to deliver the contracted annual shipment volumes, in some circumstances even a bit more. Although an annual volume is contracted examples exists of LSPs refusing to provide the transport service when requested. As shown in the previous paragraph the capacity available in the market may result in losing the availability of equipment for the agreed price. In this case the lead time between the call off of a truck and the arrival at the departure point may increase to infinity. Then the discussion will become whether or not the market change is part of a force majeure or the LSP is violating the legal agreement.

Due to the direct shipment policy implemented by Supply Chain this secured capacity is an important factor to consider when purchasing transport services. We however think it is not a factor that can be measured easily but has to be built from market characteristics, e.g. the amount of capacity available, and relation with suppliers. As indicated in 3.5.1 we have strong indicators that the European transport market is mainly a capacity driven market. Different market intelligence reports indicate that reduction in market capacity has a positive effect on tariffs and vice versa. For example; a quarterly market report on spot market prices in Europe supports this relation. The relation is expected to have a lower magnitude on longer term contracted tariffs, however the influence during the tender period can be tested. Casual relationships on availability of transport equipment have proven to be; a country’s economic status, harvest season of citrus fruits in the Mediterranean or simply temperature controlled equipment during winter/summer season. The previous presented makes us believe security of capacity should be part of the developing strategy for a management trade-off.
2. Service Level and Quality

Depending on the current level of Service and Quality the importance of this factor is defined. As stated before in paragraph 3.4.1 not every LSP is able to live up to the Company standards. This can be caused by the type of company, e.g. a company that is not used to transport food grade products, or a market that is not familiar to work with such high standards. Like the previous axis this factor should be relative to the market’s availability in order to rank its importance.

3. Cost and Cash

Traditionally one of the most important factors, this factor will remain the common unit for comparing transport services. In general the developed strategy should aim for comparable quality services for the lowest possible price. The difference between Cost and Cash is as follows; Cost is defined as the actual price to pay for a certain product/service, where Cash is the time period in which an invoice is due. From a purchasing/financial position reducing cost is productivity and freeing up cash by extending payment terms results in freeing up working capital.

4. Safety towards human beings and goods

Safety is a major topic in European transport, whether this will influence the transport tariffs to such an extent that it has to be management trade-off in itself is questionable. It might have been the case when The Company was transporting high value goods. However we feel this might be used together on one axis with Service level and quality.

5. Reduction on CO$_2$

According to The Company’s commitment in 2008 to reduce 30% of their Global CO$_2$ footprint by 2012 this axis is an important factor to focus on. However in transport it is shown that by altering the single variable itself responsible for Greenhouse gas exhaustion this does not directly lead to changes in logistics operations. Meaning, governmental charges on high polluting modes of transport will in general not lead to a switch of modality, but only to higher operational costs (Hoen et al., 2010). This factor will therefore not be considered as a management trade-off in itself.

6. Innovation

This last factor is quite difficult to measure at this stage and make a like-for-like comparison on transport performance. This factor might be part of service level and quality but will not be considered as a strategy factor.

4.3. Security of supply

Security of supply remains the most important factor for The Company in purchasing their logistics services. At this moment The Company has no tangible data on incidents elevated to the central level in not delivery the contracted logistics service. However we believe that the capacity available in the transport market in a certain time period can influence the price to be paid in securing this capacity. Country specific characteristics may play a role as well. For example a more matured legal system where a contracted transport service can be secured by a simple contract, contrary to some countries where the laws show significant difference with daily practise. This results in paying a higher price for a service in order to secure longer term capacity.
4.4. Quality
Service Level and Quality are two factors that can create added value to a transport service on top of the bare cost price delineated in paragraph 3.5.2. And as The Company states that Quality and Service is Key, this remains a significant factor for a management trade-off. Next to that we learned that although The Company is only buying a minor share of the whole European transport market, the specifications required make them fishing in a smaller pond. With The Company’s requirements on transport they demand service and quality levels that not every transport company is able to provide. Without any benchmark on this service and quality levels it is not possible to identify where The Company stands relative to the efficient frontier. Do these statements regarding quality and service hold in practice or are they more wishes than current practice? Better insight in these KPI levels should assist us in developing a strategy to approach the goal situation. We need to know where The Company is situated relative to the efficient frontier and the base quality level as presented in paragraph 4.1. Depending on this position we will be able to asses which direction we have to look in answering research questions 4, 5 and 6. Currently all information regarding quality of the transport services and LSPs are incident based reports from the local SC or other logistics stakeholders. Therefor are approach would be to interview these operational people in assessing the current quality position of The Company’s transport services. Chapter 5.1 will explain how we assessed these quality and service KPI’s in further detail.

4.5. Cost
One of the most important factors is the cost factor. As however the majority of pure cost based activities are known we would like to know which part can be used and influenced by other variables. In other words, if cost prices are common ground which part would be able to influence operations that costs can be avoided? A lead for this direction is given by Jonkeren (2009), who states that contrary to earlier beliefs transport tariffs are endogenous and can be influenced by its own characteristics instead of exogenous factors. Nevertheless in highly competitive markets a push to reduce the last margin would be the right approach.

From the preceding literature review it might be expected that transport tariffs are highly predictable when leaving the volatile fuel price out of scope. As it is not unheard of to compensate for fuel price increases fixing the fuel factor is a valid assumption. Another assumption we make here is that appropriate data relating to each lane’s characteristics is available.

As stated earlier we have full access to the tender outcome databases from 2011 and 2012. These databases contain for each lane besides lane specific requirements a final negotiated contract tariff. Using this data we would like to know which specifications and variables influence this final negotiated contract tariff. Below in Table 3 an overview of descriptive statistics of the 2011 database is presented.
Table 3 Descriptive statistics tender database 2011

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Range</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance</td>
<td>226</td>
<td>4197.00</td>
<td>13.00</td>
<td>4210.00</td>
<td>959.9956</td>
<td>661,32549</td>
<td>437351,400</td>
</tr>
<tr>
<td>2011 FTL Rate</td>
<td>226</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2011 FTL Volume</td>
<td>210</td>
<td>998</td>
<td>2</td>
<td>1000</td>
<td>104.70</td>
<td>151,472</td>
<td>22943,770</td>
</tr>
<tr>
<td>Maximum allowed</td>
<td>226</td>
<td>192.00</td>
<td>.00</td>
<td>192.00</td>
<td>53.4646</td>
<td>33,41990</td>
<td>1116,890</td>
</tr>
<tr>
<td>transit time (hours)</td>
<td>(0,1)</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>.23</td>
<td>.419</td>
<td>.176</td>
</tr>
</tbody>
</table>

In our quest to explain influence of different factors on transport tariffs distance should be a logical variable to start with. From market intelligence an average transport price should lay around €1.20 per km (in 2011). Based on The Company’s transport database this is €X.XX per km with a standard deviation of €X.XX per km, a significant difference. There might be two explanations for this deviation, A) The Company is paying above market price or B) this average price is not representative for the quality specifications The Company requires. Although distance might be a good explanatory variable for transport tariff it is probably not the only one. From the high The Company standard deviation in tariff per km it shows further motive to investigate which other variables influence the transport tariffs. For identifying the transport cost factors we used the work of Daganzo, 2005. Below we listed the different factors that we find likely to explain transport tariff variance and why we want to test this.

4.5.1. Hypothesis 1: Distance

The distance to travel on a lane is likely to influence the transport tariff. Multiple mentioned factors depend on the driven distance, where the amount of fuel used is probably the most important one. After each number of kilometres driven the equipment needs to be serviced and will wear, it makes sense to connect maintenance and depreciation to this factor. In the majority of EU countries, road tax for trucks is collected on usage basis resulting in a fee per distance driven. As stated in the next paragraph we expect that labour rate has an influence on tariff as well, however the labour costs are related to time and time is related to distance. Due to the EU rest time regulation this will not be linear, see [http://ec.europa.eu/transport/road_safety/users/professional-drivers/index_en.htm](http://ec.europa.eu/transport/road_safety/users/professional-drivers/index_en.htm).

**Hypothesis 1**

The distance of the lane has a positive effect on transport tariff.

In order to calculate the distance driven for a certain lane we can use the departure point and destination point. This thesis is executed from a shipper’s perspective, meaning we only have access to the loading point and unloading point. Which distance a truck had to drive from his departure position to the loading point and from the unloading point to his destination is unknown.

The distance between the loading and unloading point can be approached by using the Haversine formula which calculate the expected distance to travel based on the loading (A) and unloading (B) points coordinates (latitude and longitude). \( R \) stands for the perimeter of the earth where a road factor \( d \) is used to adjust for the detour of roads and slope of the earth’s surface. The complete calculation method can be found [http://mathworld.wolfram.com/GreatCircle.html](http://mathworld.wolfram.com/GreatCircle.html), the formula used
is as follows:

\[
Dist\ AB = 2R\sigma \cdot \text{Arccos} \left( \sin \left( \text{lat}_A - \text{lat}_B \right) \frac{\text{lat}_A \cdot \cos \text{lat}_B}{2} + \cos \text{lat}_A \cdot \cos \text{lat}_B \cdot \sin \left( \text{lon}_A - \text{lon}_B \right) \frac{\text{lon}_A - \text{lon}_B}{2} \right)
\]

Daganzo (2005) presents a method to estimate the distance within an area between two points, i.e. the unloading point \((B)\) and the destination of the truck \((Q)\). This estimation requires the area of the region where truck is unloading. However if we start comparing the distances estimated from the unloading point to the destination of the truck, the area sizes should not significantly deviate from each other. As we currently do not know how \(B\) and \(Q\) are situated within this area we apply the following Euclidean norm for two arbitrarily placed points.

\[ E\ \text{Dist}\ BQ = 0.511 \cdot \bar{A} \cdot \sigma \]

4.5.2. **Hypothesis 2: Labour costs**

Labour rate represents a significant part of the total tariff breakdown, however the exact amount is just the European average. As the salaries in transport can differ up to €24 per hour a European average might not be representative. This means that the labour rate paid in the drivers’ residence country will determine the transport tariff. However, it is not always known whether a driver is paid according the salary of the country of loading or unloading. On international transport a driver has to return home one day but might make use of full cabotage on his way back. Although full cabotage is still limited in some countries (e.g. France) it is difficult to know exactly for which country’s salary is driving. Next to that, larger LSPs have multiple legal entities in which they can pay the driver according to the corresponding nation’s legislation. Therefore we assume that the labour costs on a lane are the average of the loading and the unloading country.

**Hypothesis 2**

Loading and unloading country average labour costs have a positive impact on the transport tariff.

To see whether the average labour costs between countries is a better indicator for transport tariffs then a European average we use the following formula

\[ W_{bc}(l, u) = \frac{(Wlc + Wuc)}{2} \]

4.5.3. **Hypothesis 3: Temperature controlled equipment**

The Company produce products that have to stay within a certain temperature range in order to remain the high quality level of the products. In order to make sure the products stay within the temperature range refrigerated transport equipment is used in some circumstances. This applies in the winter period to the geographically Northern regions to avoid frost damage and in the summer period for the more Southern regions to avoid overheating. As this is a different and more expensive type of equipment we think this will increase transport tariffs.

**Hypothesis 3**

Using temperature controlled equipment will have a positive effect on transport tariffs.

To see whether this is effect is significantly true, we use a dummy variable. When ambient trailers are used the variable Temp contains a ‘0’, if the temperature controlled equipment is used this will contain a ‘1’.
\[ Temp = \{0,1\} \]

4.5.4. **Hypothesis 4: Country**
Each country has its own characteristics next to the previous mentioned that might influence the transport tariff.

**Hypothesis 4**
The different countries of loading and unloading have impact on the transport tariffs.

In order to measure this statement we created dummy variables for every loading and unloading country. Except for the United Kingdom, this was used as are reference country. Each time the dummy variable showed a value of ‘0’ this meant that country was not applicable, contrary to the value ‘1’. If all dummy variables showed ‘0’ this meant the reference country the United Kingdom was applicable. The following structure was used to create dummy variables;

\[ Load\_‘country – code’ = 0,1 \text{ and } Delivery\_‘country – code’ = \{0,1\} \]

4.5.5. **Hypothesis 5: Load balance destination area**
Next to general country characteristics we believe that the shortage or abundance of cargo will impact the transport tariffs. As further modelling will explain a possible imbalance will determine whether it is a buyers’ or a sellers’ market, thus influencing transport tariffs. This variable is expected to overlap some of the variance explained by Load\_‘country – code’ and Delivery\_‘country – code’, however as there might be different important factors only present in one specific country next load imbalance we would like to test for this specific factor separately. To test whether the destination area balance is of influence we tested the following hypothesis.

**Hypothesis 5**
The load balance of the destination area has a positive influence on transport tariffs.

This hypothesis can be by tested by including the probability of getting a load by the relative balance of international loads loaded \( l_l_i \) and loads unloaded \( l_u_i \) in the destination area, as presented in Table 2Table 2 Annual Freight transport balances, based on Eurostat (2010). The variable \( LdsP \) was calculated as following:

\[ LdsP_i = \min \left( 2 - \frac{l_l_i - l_u_i}{l_l_i}, 1 \right) \]

4.5.6. **Hypothesis 6: Maximum allowed transit time**
THE COMPANY produces in a lean environment and made the transport service part of the production scheme. This means that LSPs are restricted to a certain amount of transit time. If these values are quite strict for the route at hand this might influence the transport tariffs as well. Meaning a Maximum allowed transit time might inflict different costs than the previous variables can explain, e.g. a pair of drivers on a truck instead of one. Whether a restriction on time is critical depends on the distance. To test this, we constructed the following hypothesis.

**Hypothesis 6**
Maximum allowed transit time has a positive impact on transport tariffs.
The maximum allowed transit times are given in hours on a lane with a certain distance, resulting in a required average speed. This can be included as a variable to test its influence. Therefore the variable Average velocity \((Av)\) was created.

\[
Av = \frac{\text{Distance}}{\text{Maximum allowed transit time}}
\]

4.5.7. Hypothesis 7: The amount of loads on annual basis
Each lane has an expect amount of FTL to be shipped each year. The question is whether economies of scale reduced price effect are present in the Company tariffs as well. This might be the case when fixed costs of the LSP are shared among more trucks and shipments. In short the relation would be the more FTL you will order on an annual basis the lower the price per FTL will be.

Hypothesis 7
FTL volume has a negative linear impact on transport tariffs.

Where the FTL Volume is a given per lane we can include the variable \(LV_i\) in the test without any adjustments as follows:

\[
LV_i = \text{FTL Volume (year)}
\]

4.5.8. Hypothesis 8: The Company road balance
Last of all we believe that the balance of loads from The Company’s own network will impact the transport tariffs. As shown with Figure 8, the Company European transport network is unbalanced. And according to Table 2 the European network is neither. Hypothesis 5 already took care of the European imbalance. However we might be able to offset the effect of Hypothesis 5 by providing a much required load from the Company network. Whenever a carrier is able to close his routing loop by gaining both the one-way load and the return load this will be much more profitable for him. Therefore we will test the influence of the Company road balance in the same model as follows.

Hypothesis 8
The load balance of the Company network will have influence on transport tariffs.

This hypothesis can be by tested by including the relative balance of the Company Primary European transport balance, international loads loaded \(ll_i\) and loads unloaded \(lu_i\). The variable \(Drb_i\) was calculated as following:

\[
Drb_i = \frac{ll_i - lu_i}{lu_i}
\]

4.5.9. Relations between variables
We already presented the basic statics of the date in Table 3, however after fully analysing the data we expect that some of the above mentioned variables have relationships between each other. A more elaborate overview of the data’s statistics can be found in Appendix 7, especially Table 17. Our main concern is high multicolinearity.

From the relation between distance and transport tariff we expect the most significant results. Some of the predictor variables however relate to distance; labour costs, modality and transit time. The longer the distance the more hours a driver has to drive, the higher the labour costs will be.
The last one, maximum allowed transit time, relates to distance as well, the longer the distance the longer the maximal transit time should be. However this relation with distance may not be the most important one, where production processes are leading in determining the maximum allowed transit time. If all maximum transit times are also the minimum time needed to cover the distance of a lane, MTT will not have any additional explanatory value in transport tariff variance.

Another group of variables that might correlate with each other are; labour costs, country, load balance destination area and The Company road balance.

As explained earlier the variable Labour costs is an average of the labour costs between the loading and the unloading country. Country also represents a part of the variance in labour costs while labour rates are country specific. From the statistical analysis might be concluded that Labour costs has non-significant explanatory power and country significant power. As long as the vast majority country variables are significant it might mean that there is an underlying factor, for example Labour costs. However if only a few country variables are significant one can conclude there are country specific characteristics that influence the depending variable. The same holds for load balance destination area and The Company road balance as both represent a specific characteristic from this specific geographical area. The reason why all are set up for testing although this spurious covariance might be expected is to test if there is any unique country or geographical characteristics unidentified yet that have significant explanatory power. E.g. Russia and Turkey have not ratified the Schengen treaty, resulting in increased custom costs. This way we think we can investigate and control for any geographical influencing characteristics.

4.6. Summary

From the first paragraph of this chapter we see that our first priority should be assessing the current quality levels. In the case the results of this analysis show The Company finds itself below the base quality level, using the reversed scale from paragraph 4.1, we can take the next steps in analysing the cost position. From the Company strategic axes most important factor of security of supply is missing in this overview. Although we do find this an important factor, we state that the factor in itself is hard to measure. Nevertheless the effect of this factor translates in either a position below the base quality level in case all ordered capacity is delivered, and/or an increased transport tariff in making sure the capacity is available to The Company at all times. Overall we expect that costs should be used as the common benchmark, where quality challenge and capacity challenge are the main management trade-offs to be made in purchasing transport in striving for the best transport performance. This remains however under the assumption that the base quality levels are met, if this is not the case there remains only one solution to improve quality which cannot be seen as a strategy. As long as this scenario can be excluded a strategy can be applied to approach the efficient frontier as close as possible. The closer to this efficient frontier the higher the transport performance is. Theoretically it should not be possible to be positioned below this efficient frontier. In practise this would mean that not all costs of the transport service are covered thus resulting in a non-sustainable situation.
5. Analysis
By making use of the background information delineated in Chapter 3, analysis approach and the strategy design from Chapter 4; this chapter will answer the remaining research questions as stated in Chapter 2. Although the main aim of this research project is to analyse how to improve purchasing strategy on transport, the sub-research projects are to determine models that can predict transport performance. As stated in the end of Chapter 4 we will analyse the current level of Quality perceived in The Company by making use of a survey in paragraph 5.1. After that a full investigation of cost factors from theory on the Company database follows in paragraph 5.2. Concluding this chapter on where The Company positioned itself compared to the market.

5.1. Current Quality level (Survey)
This paragraph will delineate on how we analysed the current level of Quality perceived in transport services acquired and where the Company is situated relative to the Q-C efficient frontier. The quality survey was held amongst all local supply chain stakeholders on the top 10 LSPs in terms of turnover. These stakeholders were asked to review their suppliers on; safety, on time and in-time delivery, equipment, reliability, flexibility, tariffs, communication and overall quality. On each variable the requirements were clearly described in the tender documents as described in paragraph 3.3.1. These requirements are defined by the local stakeholders or they should be familiar with the definitions as part of a group wide KPI reporting system. Only escalated issues are communicated to the central purchasing team, as the central team are contract owners. The local stakeholders, existing of supply chain managers and logistics managers, were asked to provide their view on the LSPs that the supplied factory/business unit. An overview of which company supplies which factory/business unit can be viewed in Figure 8.

![Figure 16 LSP supply overview](image)

From the 17 local stakeholders 11 responded, a response rate of 65%. In total they created 39 cases, resulting in an average of 3.9 responses per LSP. The data file only contains 39 cases, which is quite small but still workable. However, evaluating each LSP’s quality performance separately would not give any statistical significant conclusions. Therefore we kept the dataset together and looked for an overall quality score.

One cannot measure quality directly, it has many facets. The survey output contains 16 data fields for each case. We reduced the amount of variables and tested which facets define quality for transport services using Principal Factor Analysis. From theory we already defined that the variables
measured are supposed to represent the current level of quality. For details on statistical assumptions and testing we refer to Appendix 6.

Rerunning the analysis with Orthogonal and Oblique rotation shows component matrices suggesting 4 latent variables explain the variance in the dataset best, supported by the Scree plot in Figure 21. The table in Appendix 6 containing the total variance explained shows these 4 latent variables explaining 82% of the variance from the survey results. These four factors were named ‘Good business partner’, ‘Arrival timeliness’, ‘Equipment quality’ and ‘Safety’. Table 4, presented below, provides the statistics and average scores of The Company’s LSP pool on these four factors, using a scale from 5 (excellent) to 0 (poor).

Table 4 Averaged Quality survey results

<table>
<thead>
<tr>
<th>Factor</th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Std. deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good business partner</td>
<td>3.32</td>
<td>2.95</td>
<td>4.22</td>
<td>0.43</td>
</tr>
<tr>
<td>Arrival Timeliness</td>
<td>3.05</td>
<td>2.25</td>
<td>4.00</td>
<td>0.54</td>
</tr>
<tr>
<td>Equipment quality</td>
<td>4.11</td>
<td>3.65</td>
<td>4.58</td>
<td>0.33</td>
</tr>
<tr>
<td>Safety</td>
<td>3.66</td>
<td>3.25</td>
<td>4.00</td>
<td>0.28</td>
</tr>
</tbody>
</table>

**Note: Results are average rates on a scale from 5 (excellent) to 0 (poor)**

5.1.1. Open questions
This survey also left room for the grader to share his/her opinion on which factor should be improved in order to improve LSPs overall performance and how this should be approached. The answers are different for each case, however we listed the most frequently proposed improvements and approaches. The direction to focus on in order to improve the LSPs performance is categorised according to the 4 latent factors presented earlier. As Table 5 shows, improvements are especially proposed on “Arrival timeliness or insight in” and “Good business partner”, were the other factors are not mentioned often. Not surprisingly is that in order to improve arrival timeliness a tool that provides performance on construct was the most mentioned advice. Next to that creating or have a LSP as a good business partner instead of distant organisation that arranges trucks based on a call off is preferred. In terms of how to approach this performance improvement we see especially that “Driver training” is mentioned quite often, this should result in increased driver’s awareness of the Standard Operating Procedures (SOP) and The Company’s quality standards.

Table 5 Improvements and how to approach open questions results

<table>
<thead>
<tr>
<th>Improvements</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrival timeliness or insight in</td>
<td>24</td>
</tr>
<tr>
<td>Good business partner</td>
<td>17</td>
</tr>
<tr>
<td>Ok</td>
<td>4</td>
</tr>
<tr>
<td>Equipment quality</td>
<td>3</td>
</tr>
<tr>
<td>Safety</td>
<td>2</td>
</tr>
</tbody>
</table>
## 5.1.2. Conclusions

Because of this small dataset and small number of questions per latent construct we have to be careful in drawing conclusions. However, the aim of this Principal Component Analysis was to reduce data. We can now clearly tell that there are 4 constructs that seem to be represent all demands from the Company strategic axes. If we look at how the LSPs in general score on these four constructs we would be able to confirm that The Company is situated below the base quality level on the C-Q efficient frontier. Where we have to keep in mind that quality is a reversed scale and thus showing a positive position for The Company. Next to that we have a good overview of the most important improvement opportunities and how to approach this. Not surprisingly, measuring and monitoring of performance and quality is one of the largest wishes. For more detail about the survey and the statistical analysis we refer to Appendix 6 Quality survey.

## 5.2. Building the cost model

With the lane characteristics and transport tariff breakdown known we will make an overview on how the different variables can determine the exact cost levels of transport tariffs in this paragraph. We will start with an overview of cost drivers already identified in paragraph 3.5.2. Based on these cost drivers a theoretical cost model is build. After which in the last paragraph the cost model is tested on the Company transport database resulting in an analysis of the Company paid costs benchmarked to the market cost drivers.

### 5.2.1. Cost drivers

First we list all the cost variables according to the breakdown of chapter 3.5.2 and list their expected independent variables that determine their power. This way we created an overview of variables that show an interaction effect or that can be included on its own in predicting the transport tariff. An overview of these cost variables and their independent variables can be found in Table 6

<table>
<thead>
<tr>
<th>Cost variables</th>
<th>Independent variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel</td>
<td>Distance (km) &amp; average fuel consumption</td>
</tr>
<tr>
<td>Labour costs</td>
<td>Driving hours including (un)loading time &amp; Labour rate</td>
</tr>
<tr>
<td>Depreciation</td>
<td>Equipment age &amp; distance (km)</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Equipment age &amp; distance (km)</td>
</tr>
<tr>
<td>Road tax</td>
<td>Country &amp; distance (km)</td>
</tr>
<tr>
<td>Overhead</td>
<td>Type of supplier &amp; supplied services &amp; modality</td>
</tr>
<tr>
<td>Empty mileage</td>
<td>Load balance departure area &amp; destination area</td>
</tr>
</tbody>
</table>

### 5.2.2. Cost model

Using the overview of cost variables and their independent variables from 5.2.1 we created a formula that represents the transport cost model. This model is based on the theory presented by Daganzo (2005) and has not been tested on the Company database. For this model we use averages.
as for the constant like depreciation, maintenance, etc. The reason behind this is that it is not possible to determine these factors per situation based on the data we have. However the assumptions on these constants are made based on the requirements from The Company, where for example average Fuel consumption is an average in Europe using Euro 5 engines (a requirement). However the terrain throughout Europe differs significantly per country, therefore try to offset influences like country during the testing in the next paragraph. The total cost of a transport order can be calculated with the following formula:

\[ TT(i) = km_i \cdot Fc + Dp + Mt + Rt + \frac{km_i}{As} + Lt \cdot Rf \cdot Lr_i + Ov + Em_i \]

Where,

- \( TT_i \) is the Transport Tariff on lane \( i \) (outcome)
- \( km_i \) is the distance to travel on lane \( i \) in kilometres (calculated)
- \( Fc \) is the average Fuel consumption per km (assumption)
- \( Dp \) is the average Depreciation per km (calculated)
- \( Mt \) is the average Maintenance costs per km (calculated)
- \( Rt \) is the average Road tax per km (calculated)
- \( As \) is the average Speed driven in km/h (assumption)
- \( Lt \) is the average loading and unloading time (assumption)
- \( Rf \) is the resting factor per driving hour (calculated)
- \( Lr_i \) is the average Labour rate on lane \( i \) (calculated)
- \( Ov \) is the average Overhead (calculated)
- \( Em_i \) is the expected amount of Empty mileage to drive on lane \( i \) (calculated)

### 5.2.3. Testing the cost model

Having the theoretical cost model build we would like to test whether this model is actually able to predict transport tariffs. As however not every factor is available or cannot be calculated we tested on the following available cost drivers:

- Distance (Fuel consumption, depreciation, maintenance, road taxes and overhead) - [Dist]
- Equipment (Temperature controlled or ambient) - [Temp]
- Region (Empty mileage, road taxes) - [Lds]
- The Company network balance - [Crb]

The theoretical model shows a linear relationship between the variables in predicting the transport tariff. From the analysis in Appendix 7 Cost driver analysis it shows that all four factors have
significant exploratory power on the Company transport tariffs database. Where distance already explains the majority of the transport tariff variance (77.3%), the other factors explain some more 9.2%. Because distance has such a large exploratory power we change the testing model in using price per km as the dependent variable:

- Price per km [Rate/km]

But first we compare the standardised Beta coefficients of the previous model and see the explanatory power of distance compared to the other factors in Table 7. The second important coefficient is European transport network balance, followed by Temperature controlled equipment and The Company road network balance.

Table 7 Coefficients linear regression model

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>Collinearity Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
</tr>
<tr>
<td>1</td>
<td>(Constant)</td>
<td>25,601</td>
<td>5,192</td>
</tr>
<tr>
<td></td>
<td>Crb</td>
<td>4,791</td>
<td>,470</td>
</tr>
<tr>
<td></td>
<td>Dist</td>
<td>.012</td>
<td>,000</td>
</tr>
<tr>
<td></td>
<td>Temp</td>
<td>2,571</td>
<td>,593</td>
</tr>
<tr>
<td></td>
<td>LdsP</td>
<td>-12,901</td>
<td>5,288</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Rate

Table 8 Non-transformed Linear regression coefficients

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
</tr>
<tr>
<td>1</td>
<td>(Constant)</td>
<td>139,516</td>
</tr>
<tr>
<td></td>
<td>Crb</td>
<td>244,997</td>
</tr>
<tr>
<td></td>
<td>Dist</td>
<td>.817</td>
</tr>
<tr>
<td></td>
<td>Temp</td>
<td>122,037</td>
</tr>
<tr>
<td></td>
<td>LdsP</td>
<td>411,703</td>
</tr>
</tbody>
</table>

When we want to look at the actual predictive values we need to use the output from the linear regression based on the non-transformed variables. In checking the assumptions of normality we encountered some issues and had to transform the data in order to prevent that we were not able to interpret the results correctly, the exact procedure followed can be found in Appendix 7. As you can see in Table 8 for each km driven we can already identify X.XXX euro. As we stated earlier that on average the costs of a transport service is X.XX euro/km we still have to explain X.XXX euro. We expected the use of temperature controlled equipment to be a disturbing factor in the transport tariffs as it requires different and more expensive equipment. For each time temperature controlled truck is
used the price is increased by XXX euro’s, the variable Temp was a dummy variable containing only 1’s and 0’s.

Regarding the network balances you can see that both The Company and the European Market have a positive influence on transport tariffs, note that these are untransformed coefficients. Nevertheless we know that The Company in general exports more than imports and ends up in a region where the balances are the opposite, thus increasing prices. In the transformed table the European Market balance has a negative influence on price, this is due to changing Lds into a probability ranging from 0 to 1. Both the values of Lds and LdsP are presented in Table 2. For a more detailed analysis on the actual costs we refer to the next paragraph.

After experiencing the limited explanatory power on Rate as a dependent variable by all independent variables next to distance we decided to rerun the tests using Rate/km as a dependent variable, leaving distance as a predictive variable out of our model. This resulted in an explanatory power of 29.5% by Crb, Temp and LdsP as can be seen in Table 27. As the other variables did not change we can rely on assumption testing for linear regression done previously. However all the checks regarding the linear regression itself has to be done again. The coefficients of this linear regression model are presented in Table 9 below.

Table 9 Coefficients linear regression model Rate/km

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>Collinearity Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
</tr>
<tr>
<td>1</td>
<td>(Constant)</td>
<td>1.461</td>
<td>.309</td>
</tr>
<tr>
<td></td>
<td>Crb</td>
<td>.215</td>
<td>.028</td>
</tr>
<tr>
<td></td>
<td>Temp</td>
<td>.126</td>
<td>.036</td>
</tr>
<tr>
<td></td>
<td>LdsP</td>
<td>-.764</td>
<td>.321</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Rate/km

#### 5.2.4. Current Cost level vs. market

“What is the current level of costs?” the first research question will be finalised in this paragraph. Where the ‘costs’ should be benchmarked in order to have an understanding of the ‘level’, a comparison was made based on general market trends from the quarterly Transporeon market reports. These reports only contain information on relative change compared to previous periods. In general it is hard to gain access to European tariff data, due to obvious reasons competitors are hesitant to share exact tariffs. Some market intelligence providers offer to check your tariffs on competitiveness for significant research fees.

In our case we did not have access to the actual tariff databases and therefore can only make valid statements about relative changes in The Company transport tariffs compared to market trends. In the sense of transport cost price we make more firm statements in the beginning of paragraph 5.2 as we feel more confident to do so.
What the previous analysis does not tell us is how our cost levels are related to the transport market. Based on the Transporean market report trends we can analyse the results from the Company tender outcome versus the market evolution and determine the performance achieved by this tender. For three years in a row The Company achieved to outperform the market price increase. Over 2010 market prices rose at 7.9 % where The Company encountered an overall transport price increase of 4.5%, -3.4% vs. market effect (Capgemini/TRANSPOREON 2011). For The Company in the year 2012 an overall transport price increase of 6% is expected excluding 1% price increase due to fuel increase.

For now in *Confidential*

Figure 18 you will find a comparison of The Company tariff trends compared with European transport market trends. This overview was created by a Central The Company Supply Chain employee, who used 2008 as a base price index. The year 2008 experienced the start of new economic turmoil, resulting in a global economic crisis. During this crisis a significant increase of capacity and thus drop of transport prices was witnessed in the European transport market. After 2009 economies gently started to recover, the same effect was witnessed in the European transport market. As the graph shows the Company prices dropped less significantly during the tender in 2008. This reason behind this difference might be due to the fact that The Company tenders during the summer period to gain prices for upcoming year, for details on the tender planning we refer to Appendix 4 Process flow Transport Tender. In this set-up prices were agreed before the 2008 crisis was fully unfolded. However the upcoming year The Company prices dropped significantly against an increase in market prices, again the difference might lie between comparing two different situations. In this case the difference can be influenced by comparing spot market prices and yearly contracted tender prices.

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Figure 18 2008 -2012 Primary transport price evolution (The Company, 2011)
5.3. The Company vs. European transport market

In this paragraph the Company network and the European transport market are compared in detail. As a part of this comparison we test the hypotheses defined in paragraph 4.5 and see whether the Company tariffs can be predicted by general tariff breakdown theory and the European market characteristics.

5.3.1. European cost model vs. The Company tariffs

We start with an overview of country based imbalances from the Company network and the EU transport market, see Table 10. As stated earlier, regional imbalances are leading in their impact on transport tariffs. In the table below we specified if The Company is transporting more goods into an area then exporting from a region and the market is showing the same imbalance as an aligned network. According to the relation explained in 3.5.5 this should have a positive effect on transport tariffs as a truck has to drive empty mileage in order to pick up a new load.

Table 10 The Company network vs. EU transport market

<table>
<thead>
<tr>
<th>Country</th>
<th>The Company Rel. balance</th>
<th>EU Rel. balance</th>
<th>Alignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT</td>
<td>+++</td>
<td>8.59%</td>
<td>Yes</td>
</tr>
<tr>
<td>BE</td>
<td>++</td>
<td>1.70%</td>
<td>Yes</td>
</tr>
<tr>
<td>CH</td>
<td>+++</td>
<td>33.84%</td>
<td>Yes</td>
</tr>
<tr>
<td>CZ</td>
<td>--</td>
<td>-0.39%</td>
<td>Yes</td>
</tr>
<tr>
<td>DE</td>
<td>+</td>
<td>1.26%</td>
<td>Yes</td>
</tr>
<tr>
<td>DK</td>
<td>+++</td>
<td>8.30%</td>
<td>Yes</td>
</tr>
<tr>
<td>ES</td>
<td>-</td>
<td>-1.23%</td>
<td>No</td>
</tr>
<tr>
<td>FI</td>
<td>+++</td>
<td>-10.16%</td>
<td>No</td>
</tr>
<tr>
<td>FR</td>
<td>-</td>
<td>5.00%</td>
<td>Yes</td>
</tr>
<tr>
<td>HU</td>
<td>+++</td>
<td>41.53%</td>
<td>No</td>
</tr>
<tr>
<td>IE</td>
<td>++</td>
<td>1.92%</td>
<td>Yes</td>
</tr>
<tr>
<td>IT</td>
<td>++</td>
<td>2.01%</td>
<td>Yes</td>
</tr>
<tr>
<td>LV</td>
<td>++</td>
<td>1.08%</td>
<td>No</td>
</tr>
<tr>
<td>NL</td>
<td>--</td>
<td>8.64%</td>
<td>No</td>
</tr>
<tr>
<td>PL</td>
<td>--</td>
<td>24.66%</td>
<td>No</td>
</tr>
<tr>
<td>PT</td>
<td>-</td>
<td>42.50%</td>
<td>Yes</td>
</tr>
<tr>
<td>RO</td>
<td>+++</td>
<td>5.31%</td>
<td>Yes</td>
</tr>
<tr>
<td>SE</td>
<td>++</td>
<td>-2.50%</td>
<td>No</td>
</tr>
<tr>
<td>SI</td>
<td>+++</td>
<td>6.77%</td>
<td>Yes</td>
</tr>
<tr>
<td>SK</td>
<td>+++</td>
<td>17.30%</td>
<td>Yes</td>
</tr>
</tbody>
</table>

5.4. Summary

In paragraph 5.1 we presented the findings on our quality survey and with all scores above 3 (average) and one above 4 (good), therefore we can place the LSPs below the base quality level. However, as these scores are averages of LSP scorings by different The Company stakeholders we would lose a significant amount of information by using one general average. From Table 4 it shows
that some of the minima’s are below the average score of 3, meaning they might not live up to the basic quality level.

The cost factor is as explained in paragraph 5.2.3 hard to benchmark with competitors. Relatively we can say that The Company is since 2009 outperforming the market in price evolution. However we cannot state with confidence that for all lanes The Company is well positioned relative to the efficient frontier. To be correct, we are not able to determine the exact position relative to the efficient frontier. As proved in 5.3.1 there are too many lane specific factors that determine whether transport performance on one lane is sufficient.

What we did achieve was predicting a significant of the variance in transport Rate and Rate/km. The variables identified that show impact on the overall transport tariff are the Company network balance, temperature controlled equipment and the European transport market balance. These new insights are used to define the strategy in Chapter 6.
6. Strategy
After positioning The Company’s transport performance relative to the C-Q efficient frontier and investigating what drives this positioning we will delineate the strategies how to improve this position. From the quality survey it is shown that The Company is on average positioned well below the “Base quality level” (reverse scale), however the need for (improved) measuring tools on quality remains. In general average quality levels are high; however the spread is significant and fluctuates per destination. As shown earlier quality and costs cannot be seen separate from each other and the European Network Balance has explanatory power on tariffs. Based on these findings we propose the usage of multiple strategies instead using one strategy for all lanes, which differentiate on lane classification.

6.1. Lane differentiation
In order to define which lanes require what strategy, we will use the following differentiation variables next to the lane’s characteristics; The Company load balance and European market balance. One might expect quality requirements as an important differentiation factor. However, we state that whether these high quality levels on logistics service are deliverable depends on the regional market situation. Instead we use the distance between quality required and quality standards delivered on a lane. These variables together form the “Lane purchasing strategy” visually presented in Figure 19. On the x-axes the network alignment between company’s network and market network and on the y-axes the challenge on quality on a lane. In this overview each dot presents the positioning of a The Company lane. Each quadrant clusters a group of lanes which require their own strategy:

- High quality challenge and advantageous network alignment; we recommend to use smaller LSP’s who are sensitive for opportunities closing their routing network and a long term relation to secure quality levels in difficult markets.
- Low quality challenge and advantageous network alignment; in general a more matured market where a pure cost driven strategy like reverse auctions will bring the best results.
- Low quality challenge and disadvantageous network alignment; in this situation securing capacity is the main goal possibly to be combined with a cost driven strategy. In general larger LSP’s are able to secure capacity best due to their large network; a longer relationship is not required in this competitive situation.
- High quality challenge and disadvantageous network alignment; this is the most difficult scenario where a longer term relation is required to be able to invest in quality and capacity, in general larger LSP’s are able to provide this service best.
6.2. Quality requirement’s feasibility
In the Lane purchasing strategy we introduce two new variables made up from earlier presented data. ‘Quality challenge [Q]’ represents the distance relative to the C-Q efficient frontier. Current quality measuring tools provide limited reliable data; therefore the quality level will be an approximation.

6.3. The Company network balance vs. European market balance
‘Network alignment’ is defined as the difference between the The Company transport network balance and the European transport Network. The balance between offer and demand determine the negotiation position; in this sense ‘Network alignment’ represents this position. In the case the European transport network shows an imbalance of loads in one direction and the The Company network requires loads in the opposite direction, one can make advantage of empty back-loads in the European network and negotiate lower rates. Compared to the situation where both networks show the same (im)balance direction, where general market prices will higher.

6.4. Implementation
In case of low quality challenge and significant difference in network balances, tendering on costs (reverse auction) would be the best approach. In this highly competitive market smaller LSP’s will be able to provide the best price with short term contracts, reducing the amount of overhead. When the quality challenge increases tendering singularly on costs will be less effective. To meet the quality standards one has to invest in a supplier relationship and build and implement measurement tools to closely monitor performance. A partnership approach with this ‘smaller’ LSP would be the best strategy. To secure a quality commitment a medium contract term would be sufficient.
In case of a low quality challenge but a more challengeable ‘Network alignment’ the approach should be focusing on securing supply (transport capacity). This can be done by making use of a tender that includes transport capacity. Where larger LSP’s have the flexibility of subcontracting and/or rearranging their own network, they would be the best candidates.
The most difficult situations would be where the quality challenge is high and network (im)balances are aligned. In this case, careful examination of larger LSP’s should result in possible transport business partners. In this less competitive market it is difficult to secure quality and capacity for competitive tariffs. By building transport partners based on longer relationships a mutual beneficial situation can be created. The LSP will secure future business and will be willing to invest in quality and relations, creating dependency on this supplier can be a side effect.
7. Evaluation

This part contains the discussion of results from the Master thesis project. How can we put these results into practise in order to improve transport performance and what are the limitations of this research project. Finally suggestions for further research are made.

7.1. Conclusion

Looking at the earlier defined research questions we were able to answer all of them. First of all we were able to determine that Logistics performance can be defined by scoring on two axes, namely Cost and Quality. However there many more levers that should be included in improving a position relative to the efficient Cost-Quality frontier. The levers that influence this Cost-Quality position relative to the efficient frontier where significantly tested as the balance in the company’s transport network alignment with the European transport network. We have shown that securing capacity is another important factor in improving logistics performance. However the variable itself is difficult to measure. We state that in securing capacity this has direct effect on the cost position or, in case capacity is not secured, it does not meet the base quality level as lead time becomes infinite. Next to that we saw that although European market should be a unified market, countries specifics play a significant role, both on the cost and the quality factor. Therefore it does not make sense to use one general purchasing approach for all lanes.

Regarding The Company’s Quality position we found 4 latent variables explaining 82% of the variance from the survey results. These four factors were named ‘Good business partner’, ‘Arrival timeliness’, ‘Equipment quality’ and ‘Safety’. The scorings on these factors were adequate enough to determine that The Company finds itself on the good side of the minimum quality level.

Regarding the cost position we were not able to define the exact position of The Company relative to the efficient frontier. However we identified the earlier presented levers that are able to improve this position and gave an indication of The Company’s position based on market intelligence reports.

Despite the fact that transportation costs are quite transparent we identify room for productivity and added value for a logistics purchaser. Finally we came up with a strategy that uses these levers in influencing the position relative to the efficient frontier. This strategy differentiates in four lane clusters based on a company’s and market network alignment and a quality challenge on a specific route. Where the best buying position would be in a more matured market and a network imbalance in opposite directions and the most challenging situation where the quality standards require additional attention and network imbalances are congruent. The latter requires more of a service approach aiming for a partnership on the longer term leaving the Logistic Service Provider room to invest. The wages between the different countries, the amount of trucks (volume) on a lane and the maximum transit time have been proven not to significantly impact transport rates.

With the lane differentiation purchasing strategy we were able to assess the Company’s lane overview and positioned each lane in this overview. Although the quality challenge cut-off point is not fixed we can conclude that using a pure cost based strategy would result in suboptimal tender outcome for this lane database. The vast majority of the lanes are positioned in one of the other three strategy quadrants and should be addressed accordingly in achieving the best logistics performance.


**7.2. Recommendations**

A valid judgment on quality is not possible due to the lack of KPI measurement tools; therefore it is advised to improve these monitoring systems. Without improved indication of quality levels it will be less effective in determining the strategy per lane. However differentiation per lane would already be better than one strategy applied to all lanes. By using only one tender mechanism, i.e. reverse auctions this will be only successful on 5% of the lanes, therefore we suggest to use different tender strategies. Finally we recommend The Company, supported by an internal stakeholder survey, to improve quality KPI measurement in order to monitor current quality levels and correctly utilise the Lane differentiation purchasing strategy. For consistency purposes the strategy has to be tested on The Company and other companies’ lanes.

**7.3. Research limitations and future research**

This research only focussed on European (road) transport leaving countries like Turkey and Russia out of scope. The research is based on an international FTL transport for the Company network, as this only represents only a minor part of the European transport market testing the cost levers framework on other company’s datasets would bring more reliable results.

The newly developed strategy has not been tested in practise; however results from this should be compared to the previous situation in refining the strategy. This immediately brings us in the next challenge where levels of quality have to be defined on KPI levels adjacent to key user’s opinions.

In general trade and macroeconomic data are out-dated, by the time Eurostat has fully checked on consistency and reliability at least a year has gone by. The results from this analysis therefore can only be used for strategy, i.e. longer term, purposes. The moment of writing this thesis there was no source available that could provide us any day-to-day market balance updates.
Definitions

Logistics deals with the planning and control of material flows and related information in organizations, both in the public and private sectors. Broadly speaking, its mission is to get the right materials to the right place at the right time, while optimizing a given performance measure (e.g. minimizing total operating costs) and satisfying a given set of constraints (e.g. a budget constraint).

In the military context, logistics is concerned with the supply of troops with food, armaments, ammunitions, and spare parts, as well as the transport of troops themselves. In civil organizations, logistics issues are encountered in firms producing and distributing physical goods. The key issue is to decide how and when raw materials, semi-finished goods should be acquired moved and stored. Logistics problems also arise in firms and public organizations producing services. This is the case of garbage collection, mail delivery, public utilities and after-sales service.

Logistics systems

A logistics system is made up of a set of facilities linked by transportation services. Facilities are sites where materials are processed, e.g. manufactured, stored, sorted, sold or consumed. They include manufacturing and assembly centres, warehouses, distributions centres (DC's), transhipments points, transportation terminals, retail outlets, mail sorting centres, garbage incinerators, dump sites, etc.

Transportation services move materials between facilities using vehicles and equipment such as trucks, tractors, trailers, crews, pallets, containers, vessels cars and trains.

Cross docking (re-distribution cross docking/ post-distribution cross docking)

When designing and operating a logistics system, one needs to address several fundamental issues. For example, what mode of transportation should be used to transport products? Should vehicles be company-owned or leased? What is the best fleet size? How should shipment be scheduled? How should vehicle be routed? Should some transportation be carried out by common carriers?

Logistics decisions are traditionally classified as strategic, tactical and operational, according to the planning horizon.
References

Articles


Buer, T. and Pankratz, G., A genetic algorithm for a bi-objective winner-determination problem in a transporation-procurement auction, *Diskussionsbeiträge der Fakultät für Wirtschaftswissenschaft der FernUniversität in Hagen* Herausgegeben vom Dekan der Fakultät, Nr. 439, 2009


Jonkeren, O.E., *Adaption to Climate Change in Inland Waterway Transport*, 2009, Chapter 4, pp. 62-83


**Market reports**
Capgemini and Transporeon, Transport Market Monitor (6th edition), February 2011


**Websites**
European Commission website, Road Safety:

European Commission website, Transport:
Appendix 1 Organisational chart

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Appendix 2 Manufacturing locations Europe

*Confidential*

Appendix 3 Overview of departure and delivery points Europe

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Appendix 4 Process flow Transport Tender

April
- Stakeholder alignment tender scope and qualifiers
  - SP&SU collect data

May/June
- LSP Qualifiers
- Transportation scope
- Tender outline and timing

Update and verify Lane Database (next years estimated volumes) and Specifications Handbook

July
Tender phase #1
- Lane database (volume estimation)
- Loading and Unloading specifications

July-August
Tender phase #2
- First bids
- Number of LSPs participating

August
- Bid history & Final bids
- LSP cost price ranking

September - November
- Supply Chain at SP identify preferred suppliers for negotiation
- Determine cost evolution
- Preferred suppliers
- Budget guideline

December
- Revised lane volumes
- Negotiated transport rates & awarded LSP’s
- Implement awarded lanes

End tender
Appendix 5 Transport ordering process

*) In case of a Pull system transport ordering is based on sales forecast and ordered one day in advance. This gives the transport company 24 hours to arrange their planning accordingly.

In case of Push system transport is ordered when production for that truck commenced, leaving the transport company with 3 to 4 hours to pick up the goods.
Appendix 6 Quality survey

In order to have a better indication where The Company’s transport services provided by LSP’s are situated on the C-Q efficient frontier we have executed a survey among the main stakeholders. The actual survey outline is attached at the end of this document. Below we will describe the survey set-up, data analysis and results.

Survey set-up

Although The Company has defined some of its quality variables, currently she has no proper monitoring tool in place to measure and monitor transport services quality. Only escalated issues are communicated to the central purchasing team, as they are contract owners. The local stakeholders, existing of supply chain managers and logistics managers, were asked to provide their view on the 10 largest LSP’s based on turnover. The overview of these companies and the factory/business unit supplied can be viewed in Figure 20.

These stakeholders were asked to review their suppliers on; safety, on time and in-time delivery, equipment, reliability, flexibility, tariffs, communication and overall quality. On each variable the requirements were clearly described in the tender documents as described in paragraph 3.3.1. These requirements are defined by the local stakeholders or they should be familiar with the definitions as part of a group wide KPI reporting system. For this survey the online tool Surveymonkey (http://www.surveymonkey.com/) was used.

Response

Out of the 17 stakeholders approached 11 responded, resulting in a response rate of 65%. Were each LSP was at least rated once and had an average of 3.9 responses, in total 39 responses.

Data analysis

The data file only contains 39 cases, which is quite small but still workable. However, evaluating each LSP’s quality performance separately would not give any statistical significant conclusions. Therefore we will keep the dataset together and look for an overall quality level.

As question 1.3 only shows ‘0’ as a result without any variance, this variable will not be used in any analysis.

As questions 3 and 4 left the option for two ways of reporting, depending on whether there was a measuring tool in place, we had to transform the results. The percentage results were transformed to the scale from 5 (Excellent) to 1 (Poor).

Missing data

After examining the data we found a case with too many missing values (case 1596056577 (nr. 9) >50% missing
values). As this case would influence the results too much we decided to delete the case, leaving us with 38 (N=38) cases. No other values were missing in the data file.

Assumptions
After the data transformation we can split the data into three parts: 1) the absolute number of incidents [scale], 2) rates on a scale from 5 (Excellent) to 1 (Poor) [ordinal] and 3) textual feedback [nominal]. On the rating questions only the quality of equipment showed a slightly violation of the kurtosis value for normality. All variables on the scaling questions are positively skewed and show peaked distributions. The reason for this is that these variables are measuring the amount critical incidents which in general do not occur.

The Kolmogorov-Smirnov and Shapiro-Wilk’s tests indicate non-normality of data on all variables. However all normal Q-Q probability plots show normal data for the ordinal variables.

As the data set is quite small (N=38) it is difficult to say which value is an outlier, each case in itself has quite some impact on the overall data. Therefore we decided to interfere only with quite large outliers. For example, the value of 80 on insufficient equipment quality which is 20 times the standard deviation. As we are not able to judge whether this is a typing error or the other stakeholders did not have proper records available we decided to change it to the second highest value (15).

Statistical analysis
One cannot measure quality directly, it has many facets. The survey output contains 16 data fields for each case. We would like to reduce the amount of variables and test which facets define quality for transport services by making use of Exploratory Factor Analysis or Principal Factor Analysis. From theory we already defined that the variables measured are supposed to represent the current level of quality. In this paragraph we will investigate which cluster of variables (factors) predict quality.

Question 1.1 and 1.2 show high multicollinearity, after examination they have exactly the same values for each case and both measure safety incidents. Not including one of them would be the solution. After deleting this variable the determent of the correlation matrix increased significantly to 0.000006, however this is still not good enough. After careful examination of the correlation matrix the rating question on “overall” shows high multicollinearity with other variables, which makes sense, “overall” should represent the other variables outcomes as well. We think not all variables and variance is represented by this question we delist it for further analysis and look for better determent values. After doing this the R

KMO and Bartlett’s test of sphericity and the anti-image Matrices indicated should exclude some more variables: Arrive on time, Time NOT met, Quality of equipment, Arrival timeliness and Communication. Except for Communication these variables are already measured by other variables and it thus does not make sense to include duplicates with less explanatory power. After rerunning the test Bartlett’s test of sphericity is close to 0.7 and significant indication no big issues with the sample size of 38.

Rerunning the analysis with Orthogonal and Oblique rotation shows component matrices suggesting 4 latent variables explain the variance in the dataset best, supported by the Scree plot in Figure 21. Table 11 shows this 4 latent variables explain 81% of the variance.
### Table 11 Total variance explained

<table>
<thead>
<tr>
<th>Component</th>
<th>Initial Eigenvalues</th>
<th>Extraction Sums of Squared Loadings</th>
<th>Rotation Sums of Squared Loadings&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>% of Variance</td>
<td>Cumulative %</td>
</tr>
<tr>
<td>1</td>
<td>2,706</td>
<td>38,656</td>
<td>38,656</td>
</tr>
<tr>
<td>2</td>
<td>1,130</td>
<td>16,141</td>
<td>54,797</td>
</tr>
<tr>
<td>3</td>
<td>0,987</td>
<td>14,098</td>
<td>68,894</td>
</tr>
<tr>
<td>4</td>
<td>0,891</td>
<td>12,723</td>
<td>81,617</td>
</tr>
<tr>
<td>5</td>
<td>0,550</td>
<td>7,858</td>
<td>89,475</td>
</tr>
<tr>
<td>6</td>
<td>0,405</td>
<td>5,783</td>
<td>95,258</td>
</tr>
<tr>
<td>7</td>
<td>0,332</td>
<td>4,742</td>
<td>100,000</td>
</tr>
</tbody>
</table>

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

These 4 latent variables correlations were both orthogonal and oblique rotated to see which rotation fitted these variables best. These component matrices can be found in Table 12, Table 13 and Table 14. The Oblique rotation matrices indicate violation of the constructs independency assumption, when the Oblique and Orthogonal matrices are the same this assumption is not violated. As Table 12 differs significantly from Table 13 and Table 14, the constructs are interdependent as seen in Table 14. Using the oblique rotation we think:

- Latent factor 1 can be called **Good business partner**;
- Latent factor 2 can be called **Arrival timeliness**;
- Latent factor 3 can be called **Equipment quality**;
- Latent factor 4 can be called **Safety**.

Before we start using these latent constructs to draw conclusions, we would like to know whether these results are reliable by looking at Cronbach’s α. For:

- Latent factor 1, **Good business partner**, this is 0.782;
- Latent factor 2, **Arrival timeliness**, this is 0.512;
- Latent factor 3&4 only depend on one measured variable.

Cronbach’s α for Good business partner is good, while Arrival timeliness is disputable but still not bad. Latent factor 3 and 4 were measured by other variables that showed too much multicolinearity and were therefore excluded.
### Table 12 Orthogonal rotation Component Matrix\(^a\)

<table>
<thead>
<tr>
<th></th>
<th>Component</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexibility</td>
<td></td>
<td></td>
<td>0.893</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reliability</td>
<td></td>
<td></td>
<td>0.790</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tariffs</td>
<td></td>
<td></td>
<td>0.673</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Too_late</td>
<td></td>
<td></td>
<td></td>
<td>0.806</td>
<td></td>
</tr>
<tr>
<td>Too_early</td>
<td></td>
<td></td>
<td></td>
<td>0.783</td>
<td></td>
</tr>
<tr>
<td>Equipment_rejected</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.896</td>
</tr>
<tr>
<td>Safety</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.981</td>
</tr>
</tbody>
</table>

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
\(a\). Rotation converged in 6 iterations.

### Table 13 Oblique rotation Pattern Matrix\(^a\)

<table>
<thead>
<tr>
<th></th>
<th>Component</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexibility</td>
<td></td>
<td></td>
<td>0.931</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reliability</td>
<td></td>
<td></td>
<td>0.776</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tariffs</td>
<td></td>
<td></td>
<td>0.629</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment_rejected</td>
<td></td>
<td></td>
<td></td>
<td>0.886</td>
<td></td>
</tr>
<tr>
<td>Too_late</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.835</td>
</tr>
<tr>
<td>Too_early</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.775</td>
</tr>
<tr>
<td>Safety</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.981</td>
</tr>
</tbody>
</table>

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
\(a\). Rotation converged in 16 iterations.

### Table 14 Oblique rotation Structure Matrix

<table>
<thead>
<tr>
<th></th>
<th>Component</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexibility</td>
<td></td>
<td></td>
<td>0.879</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reliability</td>
<td></td>
<td></td>
<td>0.833</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tariffs</td>
<td></td>
<td></td>
<td>0.743</td>
<td></td>
<td>-0.520</td>
</tr>
<tr>
<td>Equipment_rejected</td>
<td></td>
<td></td>
<td></td>
<td>0.907</td>
<td></td>
</tr>
<tr>
<td>Too_late</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.838</td>
</tr>
<tr>
<td>Too_early</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.776</td>
</tr>
<tr>
<td>Safety</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.987</td>
</tr>
</tbody>
</table>

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
Open questions
This survey also left room for the grader to share his/her opinion on which factor should be improved in order to improve LSPs overall performance and how this should be approached. The answers are different for each case, however we will list the most frequently proposed improvements and approaches. The feedback on which direction of performance should be focused on in order to improve the LPS’s are cauterized according the 4 latent factors found above.

As Table 15 shows improvements are especially proposed on “Arrival timeliness or insight in” and “Good business partner”, were the other factors are not mentioned often. In terms of how to approach this performance improvement we see especially monitoring solutions in general and specifically on arrival timeliness. Next to that “Driver training” is mentioned quite often, this should result in increased driver’s awareness of the Standard Operating Procedures (SOP) and The Company’s quality standards.

Table 15 Improvements and how to approach open questions results

<table>
<thead>
<tr>
<th>Improvements</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrival timeliness or insight in</td>
<td>24</td>
</tr>
<tr>
<td>Good business partner</td>
<td>17</td>
</tr>
<tr>
<td>Ok</td>
<td>4</td>
</tr>
<tr>
<td>Equipment quality</td>
<td>3</td>
</tr>
<tr>
<td>Safety</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Approach</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No input</td>
<td>15</td>
</tr>
<tr>
<td>Performance monitoring</td>
<td>12</td>
</tr>
<tr>
<td>Monitor arrival timeliness &amp; communication</td>
<td>11</td>
</tr>
<tr>
<td>Driver training</td>
<td>8</td>
</tr>
</tbody>
</table>

Conclusions
Because of this small dataset and small number of questions per latent construct we have to be careful in drawing conclusions. However, the aim of this Principal Component Analysis was to reduce data. We can now clearly tell that there are 4 constructs that seem to be represent all demands from the Company strategic axes. If we look at how the LSPs in general score on these four constructs we would be able to indicate where The Company stands on the C-Q efficient frontier. Next to that we have a good overview of the most important improvement opportunities and how to approach this. Not surprisingly, measuring and monitoring of performance and quality is one of the largest wishes.
Survey outline and questions

Evaluating Primary Transport Suppliers' Performance

General questions

Please re-use the link from the e-mail in order to rate all the suppliers in the overview below.

<table>
<thead>
<tr>
<th>#</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

*Confidential*

*1. Please name the 2011 incumbent carrier you are evaluating now*

*2. How many incidents took place at this carrier classified according to WISE reporting definitions*

<table>
<thead>
<tr>
<th>Vehicle</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal</td>
<td></td>
</tr>
<tr>
<td>Accidents with lost time</td>
<td></td>
</tr>
<tr>
<td>Accidents without lost time</td>
<td></td>
</tr>
</tbody>
</table>

*3. Transport performance influencing Supply Chain performance; specify how often trucks arrive*

If you used Transwide Slet please specify the exact percentage, otherwise rate the suppliers performance on a scale from 5 (excellent) to 1 (poor).  

| Too early (30 min or more) |  |
| On time |  |
| Too late (50 min or more) |  |

*4. Transport performance influencing Supply Chain performance; specify how often the agreed transit time is NOT met*

If you used Transwide Slet + please specify the exact percentage, otherwise rate the suppliers performance on a scale from 5 (excellent) to 1 (poor).

*5. How often did you refuse transport equipment because it was not according to the quality standards from the Specifications Handbook?*

(Clean, ordered, well maintained, safe, no damage)
### Evaluating Primary Transport Suppliers’ Performance

#### Rating the transport supplier

<table>
<thead>
<tr>
<th>#1. Rate your carrier’s performance in 2011 for the following variables on a scale from 5 (excellent) to 1 (poor):</th>
</tr>
</thead>
<tbody>
<tr>
<td>**</td>
</tr>
<tr>
<td>Equipment quality (how clean, neat, orderly, well maintained, etc. is the transport)</td>
</tr>
<tr>
<td>Reliability (how well does the transport meet the agreed schedule)</td>
</tr>
<tr>
<td>Flexibility (how capable is the supplier of varying toll minute changes, i.e. supply of capacity)</td>
</tr>
<tr>
<td>Safety (how well does the supplier maintain a safe environment, i.e. safety vest, safety shoes, strict adherence to road regulations)</td>
</tr>
<tr>
<td>Tariff (how satisfied are you with the costs paid compared to the quality received)</td>
</tr>
<tr>
<td>Arrival (how on time, based on the agreed arrival time, how would you rate their compliance)</td>
</tr>
<tr>
<td>Communication (how would you rate the level of communication with the supplier in order to support your business inquiries)</td>
</tr>
<tr>
<td>Overall (what is your overall opinion on the supplier’s performance)</td>
</tr>
</tbody>
</table>

#### Evaluating Primary Transport Suppliers’ Performance

#### Open questions

1. In order of importance, name three factors that you would like to improve in your transport operations:

2. What kind of approaches would you like to be implemented in order to improve the current performance of this supplier (e.g. report overview of delivery, driver training, etc.):

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*Confidential*

---

Figure 23 Quality survey Page #2

Figure 24 Quality survey Page #3

Figure 25 Quality survey Page #4
Appendix 7 Cost driver analysis

In order to know which factors we expect from theory to explain variance in the dependent variable we run an exploratory regression analysis. As the different delivery and loading countries are included as separate dummy variables we needed to run 3 different analyses due to number of variables constraints. Below you will find three different correlation schemes.

Table 16 coefficients in ANOVA Linear regression\textsuperscript{a}

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>(Constant)</td>
<td>106,415</td>
<td>77,909</td>
<td>1,366</td>
</tr>
<tr>
<td></td>
<td>Dist</td>
<td>.737</td>
<td>.041</td>
<td>.705</td>
</tr>
<tr>
<td></td>
<td>Wbc</td>
<td>-1,496</td>
<td>2,457</td>
<td>-.016</td>
</tr>
<tr>
<td></td>
<td>Mtt</td>
<td>2,773</td>
<td>.813</td>
<td>.135</td>
</tr>
<tr>
<td></td>
<td>Temp</td>
<td>135,817</td>
<td>43,411</td>
<td>.081</td>
</tr>
<tr>
<td></td>
<td>Lds</td>
<td>378,783</td>
<td>185,256</td>
<td>.051</td>
</tr>
<tr>
<td></td>
<td>Crb</td>
<td>240,061</td>
<td>34,115</td>
<td>.190</td>
</tr>
<tr>
<td></td>
<td>LV</td>
<td>.102</td>
<td>.156</td>
<td>.016</td>
</tr>
</tbody>
</table>

\textsuperscript{a. Dependent Variable: Rate}

As you can see from Table 16, \textit{Wbc} and \textit{LV} tend not to significantly explaining the variance in \textit{Rate}. In the same test including the dummy variables for destination countries relative to the Netherlands, 12 out of 22 show significant exploratory power to \textit{Rate}. The last test including all dummy variables for loading countries relative to the Netherlands, only loading in France shows a significant relation.

Before we move on we need to take a closer look at the actual data. These results are based on raw data and still might include outliers and may not comply with the assumptions that need to be valid in order to execute a proper linear regression analysis.

Detecting outliers

Start N=230

By plotting each variable in a histogram including the normality curve one can spot the obvious outliers by vision. Figure 26 shows such an obvious example, where Figure 27 shows the same figure after deleting this outlier.
In plotting all these Histograms we found several outliers and deleted the following cases:

- I – J
- G – H
- E – F (2644 FTL)
- C – D (1822 FTL)
- A to B

New N=225

Besides, 5 cases in LV and 4 cases in Mtt have a z-score above 3.29. Meaning they deviated to such an extent of the standardised mean that they can be considered as outliers. As we have a reasonable amount of samples N > 200 and after close examination of these cases we decided it is safe to keep these scores.

After deleting 4 cases from the original file we are left with the following statistics. From Table 17 it is shown that LV is positively skewed and has a high Kurtosis. Where also Lds and Mtt are high on Kurtosis.

After running this descriptive analysis we checked for multivariate outliers using the Mahalanobis distance, which is not showing any multivariate outliers.
Table 17 Descriptive statistics all variables

<table>
<thead>
<tr>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wbc</td>
<td>226</td>
<td>$4.30</td>
<td>$32.73</td>
<td>$21.38</td>
<td>-.608</td>
<td>-.671</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.322</td>
</tr>
<tr>
<td>Balance_truckday</td>
<td>226</td>
<td>-2182.00</td>
<td>4121.00</td>
<td>608,3363</td>
<td>1496,23770</td>
<td>.627</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.322</td>
</tr>
<tr>
<td>Rel_Bal_truckday</td>
<td>160</td>
<td>-.10</td>
<td>.02</td>
<td>-.0145</td>
<td>.03027</td>
<td>-1.665</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.192</td>
</tr>
<tr>
<td>Int#_empty_Loads</td>
<td>152</td>
<td>154.00</td>
<td>4609.00</td>
<td>1903,8421</td>
<td>1406,21805</td>
<td>.624</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.197</td>
</tr>
<tr>
<td>Rel_empty_loads</td>
<td>152</td>
<td>.24</td>
<td>.39</td>
<td>.3364</td>
<td>.03304</td>
<td>-.534</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>.197</td>
</tr>
<tr>
<td>NUTS_3_int#_balance</td>
<td>221</td>
<td>-6.00</td>
<td>970.00</td>
<td>245,1629</td>
<td>338,33813</td>
<td>1.527</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>.164</td>
</tr>
<tr>
<td>Lds</td>
<td>210</td>
<td>-.03</td>
<td>.43</td>
<td>.0814</td>
<td>.09830</td>
<td>1.684</td>
</tr>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>.168</td>
</tr>
<tr>
<td>Rate</td>
<td>226</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.334</td>
</tr>
<tr>
<td>LV</td>
<td>226</td>
<td>1</td>
<td>1000</td>
<td>97.36</td>
<td>148,401</td>
<td>3.066</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.162</td>
</tr>
<tr>
<td>Mtt</td>
<td>226</td>
<td>.00</td>
<td>192.00</td>
<td>53,4646</td>
<td>33,41990</td>
<td>1.393</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.162</td>
</tr>
<tr>
<td>Temp</td>
<td>226</td>
<td>.00</td>
<td>1.00</td>
<td>.2257</td>
<td>.41895</td>
<td>1.321</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.162</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td>104</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From the below overview it can be concluded that only (rel.) empty loads and (rel.) balance truckday are significantly showing missing data. (above 20%). We will therefore not use these variables. Next to that we have to check LV and Lds on randomness of missing data.

Table 18 Univariate statistics

<table>
<thead>
<tr>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Missing</th>
<th>No. of Extremes b</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std. Deviation</td>
<td>Count</td>
<td>Percent</td>
</tr>
<tr>
<td>Dist</td>
<td>225</td>
<td>976.3542</td>
<td>676.57847</td>
<td>0</td>
</tr>
<tr>
<td>Wbc</td>
<td>225</td>
<td>$21.395673</td>
<td>$7.7449550</td>
<td>0</td>
</tr>
<tr>
<td>Rate</td>
<td>225</td>
<td>$1.084177E3</td>
<td>$7.0706179E2</td>
<td>0</td>
</tr>
<tr>
<td>Mtt</td>
<td>225</td>
<td>54.1289</td>
<td>34.44232</td>
<td>0</td>
</tr>
<tr>
<td>Temp</td>
<td>225</td>
<td>.2267</td>
<td>.41961</td>
<td>0</td>
</tr>
<tr>
<td>Lds</td>
<td>225</td>
<td>.0815</td>
<td>.09493</td>
<td>0</td>
</tr>
<tr>
<td>Rel_Bal_truckday</td>
<td>160</td>
<td>-.0145</td>
<td>.03027</td>
<td>65</td>
</tr>
<tr>
<td>Rel_empty_loads</td>
<td>151</td>
<td>.3365</td>
<td>.03310</td>
<td>74</td>
</tr>
<tr>
<td>LV</td>
<td>225</td>
<td>96.1994</td>
<td>110.45582</td>
<td>0</td>
</tr>
<tr>
<td>Crb</td>
<td>225</td>
<td>.2865</td>
<td>.55948</td>
<td>0</td>
</tr>
</tbody>
</table>

a. . indicates that the inter-quartile range (IQR) is zero.
b. Number of cases outside the range (Q1 - 1.5*IQR, Q3 + 1.5*IQR).
From Table 19 it shows that Little’s MCAR test is not significant and the data is Missing Completely At Random (MCAR). We will use regression-based methods to impute this missing data.

Table 19 EM Means

<table>
<thead>
<tr>
<th>LV</th>
<th>Lds</th>
</tr>
</thead>
<tbody>
<tr>
<td>104.58</td>
<td>.0814</td>
</tr>
</tbody>
</table>

a. Little’s MCAR test: Chi-Square = 1.707, DF = 2, Sig. = .426

Next to that the data in LV is still positively skewed, see Table 20. And with some more outlier tests results the highest values for LV seem to incur this skeweness of the data. Therefore we will replace these outliers with the mean plus two times the standard deviation. i.e. 105+2x151.5=408 After doing this for the 6 highest values and rerunning the tests on skeweness this shows a non-significant result.

Table 20 LV statistics

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>N  Valid</td>
<td>210</td>
</tr>
<tr>
<td>Missing</td>
<td>16</td>
</tr>
<tr>
<td>Mean</td>
<td>104.70</td>
</tr>
<tr>
<td>Median</td>
<td>48.50</td>
</tr>
<tr>
<td>Mode</td>
<td>10</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>151.472</td>
</tr>
<tr>
<td>Skewness</td>
<td>2.979</td>
</tr>
<tr>
<td>Std. Error of Skewness</td>
<td>.168</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>10.794</td>
</tr>
<tr>
<td>Std. Error of Kurtosis</td>
<td>.334</td>
</tr>
<tr>
<td>Minimum</td>
<td>2</td>
</tr>
<tr>
<td>Maximum</td>
<td>1000</td>
</tr>
<tr>
<td>Sum</td>
<td>21986</td>
</tr>
</tbody>
</table>

**Normality**

After having deleted the majority of flaws from the data we need to be sure the data is normally distributed. The Kolmogorov-Smirnov (K-S) test shows significant results for all variables but Rate and Dist. As this is test is easily influenced by large data sets (above N=200) we investigate the Q-Q Plots and find non-normal data as well.

While we did all in our power to reach normality in the data to this point we will leave it for now and continue with the checking assumptions for Linear Regression. Bearing in mind that most of the time non-normal data will violate the other assumptions as well. However, in knowing that we are dealing with non-normal data we can use the parametric tests that are able to deal with non-normal data.
**Homogeneity**

In order to test on homogeneity (variance equally spread over a variable) we applied Levene’s test. From this it turned out that Wbc, Mtt and LV are heterogeneous. After transforming the data in a following way, we achieved as close as possible normal, linear and homogeneity data for all variables, for more details see Table 21.

```sql
COMPUTE Dist=SQRT(Dist).
COMPUTE Wbc=(Wbc*Wbc).
COMPUTE Rate= confidential.
COMPUTE Mtt=SQRT(Mtt).
COMPUTE Temp=(Temp).
COMPUTE Lds=(Lds).
COMPUTE LV=LN(LV).
COMPUTE Crb=1/Crb.
EXECUTE.
```

Table 21 Statistics on all variables included

<table>
<thead>
<tr>
<th></th>
<th>Dist</th>
<th>Wbc</th>
<th>Rate</th>
<th>Mtt</th>
<th>Temp</th>
<th>Lds</th>
<th>LV</th>
<th>Crb</th>
</tr>
</thead>
<tbody>
<tr>
<td>N Valid</td>
<td>225</td>
<td>225</td>
<td>225</td>
<td>225</td>
<td>225</td>
<td>225</td>
<td>225</td>
<td>225</td>
</tr>
<tr>
<td>Missing</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mean</td>
<td>29.1557</td>
<td>517.4925</td>
<td>31.1575</td>
<td>7.0258</td>
<td>.23</td>
<td>.0815</td>
<td>3.8927</td>
<td>.2865</td>
</tr>
<tr>
<td>Median</td>
<td>29.9071</td>
<td>520.9806</td>
<td>31.3050</td>
<td>6.9282</td>
<td>.00</td>
<td>.0814</td>
<td>4.0775</td>
<td>.1647</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>11.26338</td>
<td>300.74949</td>
<td>10.67213</td>
<td>2.18834</td>
<td>.420</td>
<td>.09493</td>
<td>1.27745</td>
<td>.55948</td>
</tr>
<tr>
<td>Variance</td>
<td>126.864</td>
<td>90450.258</td>
<td>113.894</td>
<td>4.789</td>
<td>.176</td>
<td>.009</td>
<td>1.632</td>
<td>.313</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.010</td>
<td>-0.085</td>
<td>0.231</td>
<td>0.631</td>
<td>1.314</td>
<td>1.739</td>
<td>-0.329</td>
<td>0.074</td>
</tr>
<tr>
<td>Std. Error of Skewness</td>
<td>0.162</td>
<td>-0.017</td>
<td>0.062</td>
<td>0.116</td>
<td>0.237</td>
<td>0.320</td>
<td>-0.127</td>
<td>0.074</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-0.231</td>
<td>-1.277</td>
<td>-0.197</td>
<td>0.509</td>
<td>-0.275</td>
<td>2.985</td>
<td>-0.467</td>
<td>-1.643</td>
</tr>
<tr>
<td>Std. Error of Kurtosis</td>
<td>0.323</td>
<td>0.323</td>
<td>0.323</td>
<td>0.323</td>
<td>0.323</td>
<td>0.323</td>
<td>0.323</td>
<td>0.323</td>
</tr>
</tbody>
</table>

After transforming the data only Wbc scores a significant result on Levene’s test. Meaning this variable has homogeneity of variance. The Histograms and Normal probability plots show improved results on normality and linearity. These tests will be run again after doing the linear regression analysis.

**Covariation**

On the bivariate correlation tests all variables show a significant correlation with ‘rate’. As we have not completed the linearity assumption tests and some variables are not as normal as we would wanted them to be, we also used non-parametric statistics as (Spearman and Kendall’s tau) both giving the same results.

All variables show a positive correlation with ‘rate’ except for LV and Wbc showing a negative correlation.
**Correlation**

Before starting the linear regression analysis we would like to use non-parametric tests to be sure that the violations of Normality and Homogeneity do not make us draw wrong conclusions. For this we will use Spearman’s correlation coefficient which does not make any assumption on the variable distribution. In this test we split up into two groups, direction theory based (1-tailed) and theory based without a direction (2-tailed). Table 22 shows the 1-tailed correlation tests where all variables show a strong relation to Rate. The same holds for the 2-tailed test. This gives us confidence to continue with linear regression despite the violations of normality and homogeneity.

Table 22 Correlations (1-tailed)

<table>
<thead>
<tr>
<th></th>
<th>Rate</th>
<th>Dist</th>
<th>Lds</th>
<th>Crb</th>
<th>Temp</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spearman’s rho</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate1</td>
<td>Correlation Coefficient</td>
<td>1.000</td>
<td>0.897***</td>
<td>0.264***</td>
<td>0.133**</td>
</tr>
<tr>
<td>Sig. (1-tailed)</td>
<td></td>
<td>0.000</td>
<td>0.000</td>
<td>0.026</td>
<td>0.002</td>
</tr>
<tr>
<td>N</td>
<td>214</td>
<td>214</td>
<td>214</td>
<td>214</td>
<td>214</td>
</tr>
<tr>
<td>Dist1</td>
<td>Correlation Coefficient</td>
<td>0.897***</td>
<td>1.000</td>
<td>0.166***</td>
<td>0.060</td>
</tr>
<tr>
<td>Sig. (1-tailed)</td>
<td>0.000</td>
<td>0.007</td>
<td>0.192</td>
<td>0.006</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>214</td>
<td>214</td>
<td>214</td>
<td>214</td>
<td>214</td>
</tr>
<tr>
<td>Lds</td>
<td>Correlation Coefficient</td>
<td>0.264**</td>
<td>0.166**</td>
<td>1.000</td>
<td>-0.193**</td>
</tr>
<tr>
<td>Sig. (1-tailed)</td>
<td>0.000</td>
<td>0.007</td>
<td>0.002</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>214</td>
<td>214</td>
<td>214</td>
<td>214</td>
<td>214</td>
</tr>
<tr>
<td>Crb1</td>
<td>Correlation Coefficient</td>
<td>0.133**</td>
<td>0.060</td>
<td>-0.193**</td>
<td>1.000</td>
</tr>
<tr>
<td>Sig. (1-tailed)</td>
<td>0.026</td>
<td>0.192</td>
<td>0.002</td>
<td>0.277</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>214</td>
<td>214</td>
<td>214</td>
<td>214</td>
<td>214</td>
</tr>
<tr>
<td>Temp</td>
<td>Correlation Coefficient</td>
<td>0.197***</td>
<td>0.172**</td>
<td>-0.196**</td>
<td>0.041</td>
</tr>
<tr>
<td>Sig. (1-tailed)</td>
<td>0.002</td>
<td>0.006</td>
<td>0.002</td>
<td>0.277</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>214</td>
<td>214</td>
<td>214</td>
<td>214</td>
<td>214</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (1-tailed).

*. Correlation is significant at the 0.05 level (1-tailed).
Linear Regression
After exploring the data and its characteristics, the assumptions checked we can start the actual regression analysis. This linear regression analysis can be divided in three groups, with all having Rate as the dependent variable:

- Dist;
- Dist, Temp, Lds and Crb;

As stated in the theory we expect relations between several variables and therefore we should be careful in interpreting the results.

As it is quite obvious from theory that Dist is an explanatory factor we use this as a base scenario. Using the Enter method in two phases, we first include Rate and Dist and then the groups mentioned above. This base relation between Rate and Dist already shows great predictive results, with all assumptions met achieving a $R^2$ of 0.827.

In the elaborate model we only added specific indicators that shown significant coefficients in the explorative analysis. Using the Enter method for including Dist, Lds, Crb and Temp results in a $R^2$ of 0.845, adding 1.9 % of variance explained to the base model. All coefficients show a positive relationship with rate.

Assumptions checking

- The correlation matrix shows no multicollinearity indications with a relation above 0.9. However Crb shows no significant relation with Rate, due to violation of normality we tested the correlation using the non-parametric test Spearman’s rho before. Spearman’s showed a significant relation between Rate and Crb, so we can proceed.
- The Durban-Watson statistic (assumption on independent errors) is with 1.204 within the critical range of 1 to 3.
- The ANOVA table tells us that this model is significantly better in predicting the outcome then using the mean as a ‘best guess’.
- VIF values shows no multicollinearity concern, where the average of VIF = 1.1
- The Residual statistics show no concerns whatsoever, checked standardised residuals, Cook’s distance, average leverage and Mahalanobis distance.
- The Histogram of the standardised residuals shows a slightly peaked normality plot but the normality probability plot proves normality. According to the ZRESD against the ZPRED plot there are no issues regarding Homoscedastiy and linearity, all assumptions are met.

For the SPSS output on Group 2 see the below placed Table 23, Table 24, Table 25, Table 26, Figure 30, Figure 28 and Figure 29.
### Table 23 Model summary

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. Error of the Estimate</th>
<th>Change Statistics</th>
<th>Durbin-Watson</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>R Square Change</td>
<td>F Change</td>
</tr>
<tr>
<td>1</td>
<td>.921</td>
<td>.848</td>
<td>.845</td>
<td>3.88658</td>
<td>.848</td>
<td>291.679</td>
</tr>
</tbody>
</table>

a. Predictors: (Constant), Lds, Temp, Crb, Dist  
b. Dependent Variable: Rate

### Table 24 ANOVA

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Regression</td>
<td>4</td>
<td>4405.953</td>
<td>291.679</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>209</td>
<td>15,106</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>213</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Predictors: (Constant), Lds, Temp, Crb, Dist  
b. Dependent Variable: Rate

### Table 25 Coefficients

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>95,0% Confidence Interval for B</th>
<th>Correlations</th>
<th>Collinearity Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td>t</td>
<td>Sig.</td>
</tr>
<tr>
<td>1</td>
<td>(Constant)</td>
<td>5.752</td>
<td>.762</td>
<td>7.547</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Crb</td>
<td>.107</td>
<td>.043</td>
<td>.067</td>
<td>2.457</td>
</tr>
<tr>
<td></td>
<td>Dist</td>
<td>.813</td>
<td>.026</td>
<td>.879</td>
<td>31.485</td>
</tr>
<tr>
<td></td>
<td>Temp</td>
<td>1.853</td>
<td>.659</td>
<td>.078</td>
<td>2.814</td>
</tr>
<tr>
<td></td>
<td>Lds</td>
<td>12.744</td>
<td>2.874</td>
<td>.126</td>
<td>4.435</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Rate
Table 26 Untransformed coefficients

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>95.0% Confidence Interval for B</th>
<th>Correlations</th>
<th>Collinearity Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td>t</td>
<td>Sig.</td>
</tr>
<tr>
<td>1</td>
<td>(Constant)</td>
<td>139.516</td>
<td>32.529</td>
<td>4.289</td>
<td>.000</td>
</tr>
<tr>
<td>Crb</td>
<td>244.997</td>
<td>32.903</td>
<td>.217</td>
<td>7.446</td>
<td>.000</td>
</tr>
<tr>
<td>Dist</td>
<td>.817</td>
<td>.030</td>
<td>.798</td>
<td>27.468</td>
<td>.000</td>
</tr>
<tr>
<td>Temp</td>
<td>122.037</td>
<td>41.488</td>
<td>.082</td>
<td>2.941</td>
<td>.004</td>
</tr>
<tr>
<td>Lds</td>
<td>411.703</td>
<td>183.344</td>
<td>.065</td>
<td>2.246</td>
<td>.026</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Rate

Figure 28 Histogram Standardised Residuals
Figure 29 Scatter plot Standardised residual

Figure 30 Normal probability plot Std. Residuals
Linear regression using Rate/km

After experiencing the limited explanatory power on Rate as a dependent variable by all independent variables next to distance we decided to rerun the tests using Rate/km as a dependent variable, leaving distance as a predictive variable out of our model. This resulted in an explanatory power of 29.5% by Crb, Temp and LdsP as can be seen in Table 27. As the other variables did not change we can rely on assumption testing for linear regression done previously. However all the checks regarding the linear regression itself has to be done again. The following overview show this outcome; Table 27, Table 28, Table 29, Figure 32, Figure 33 and Figure 31.

This outcome tells us:

- Model is significant in predicting 29.5% of the variance in the dataset, Durbin-Watson test shows no issue;
- ANOVA test supports the above statement;
- The relation of the coefficients remains unchanged, however the magnitude shows a well expected difference. The statistics on all coefficients shows significant results; incuding Tolerance and the VIF statistic.
- The histogram shows an improved situation regarding normally distributed variance.
- The same result is shown in the normal probality plot, a improved situation compared with Rate as a dependent variable.
- The standardised residuals plot does not show any concerns regarding the linear regression either.

Table 27 Model summary Rate/km

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. Error of the Estimate</th>
<th>Change Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>R Square Change</td>
</tr>
<tr>
<td>1</td>
<td>.552a</td>
<td>.305</td>
<td>.295</td>
<td>.21505</td>
<td>.305</td>
</tr>
</tbody>
</table>

a. Predictors: (Constant), LdsP, Temp, Crb
b. Dependent Variable: Ratekm
### Table 28 ANOVA Rate/km

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Regression</td>
<td>4,185</td>
<td>3</td>
<td>1,395</td>
<td>30,168</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>9,527</td>
<td>206</td>
<td>.046</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>13,712</td>
<td>209</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Predictors: (Constant), LdsP, Temp, Crb
b. Dependent Variable: Ratekm

### Table 29 Coefficients Rate/km

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>95.0% Confidence Interval for B</th>
<th>Correlations</th>
<th>Collinearity Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td>t</td>
<td>Sig.</td>
</tr>
<tr>
<td>1</td>
<td>(Constant)</td>
<td>1,461</td>
<td>.309</td>
<td>4,730</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Crb</td>
<td>.215</td>
<td>.028</td>
<td>.457</td>
<td>7,555</td>
</tr>
<tr>
<td></td>
<td>Temp</td>
<td>.126</td>
<td>.036</td>
<td>.204</td>
<td>3,470</td>
</tr>
<tr>
<td></td>
<td>LdsP</td>
<td>-.764</td>
<td>.321</td>
<td>-.145</td>
<td>-2,381</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Ratekm
Figure 32 Histogram Standardized Residual Rate/km

Figure 33 Normal Probability plot Rate/km
Figure 34 Scatterplot Standardized Residuals Rate/km