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Improving sustainability of agriculture supplies distribution

- A case study of Foria AB

Master of Science Thesis in the Master Degree Programme Supply Chain Management

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Technical report no E2012:065

CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden, 2012

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Cover:

A collage of some of the equipment used and cargo delivered in the analyzed transports. See pages 28-32.

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ABSTRACT

This master thesis analyzes the distribution of general cargo from a centralized warehouse to a large number of widespread drop-off points. The research approach is practical and by analyzing a real-world case through both a financial analysis and by mimicking their operations in a proprietary simulation program, the authors were able to analyze how transport efficiency is affected by changes to the distribution setup.

The case used for the study is the distribution of agriculture supplies performed by Foria from Lantmännen's central warehouse in Västerås to farmers in the counties of Östergötland, Södermanland, Närke, northern Småland, Västmanland and Uppland. This distribution could be thought of as the distribution of general cargo, from a central warehouse to a large number of widespread drop-off points.

The aim of the thesis is twofold: (1) propose efficiency improvements for the focal company Foria so that their operations could improve both financially and from an environmental point of view. (2) Generalize the case specific results and draw general conclusions on which distribution efficiency improvements renders the best sustainability outcomes from both a financial perspective as well as an environmental perspective.

After an introduction, method description and literature review, the thesis describes the studied operations in detail and the algorithm describing their work operations which are the base for the simulation program are presented.

The analysis part starts with an in-depth problem analysis of focal company´s current way of working. Possible solutions to the identified problems are presented and two methods for attacking the issues, vehicle differentiation of the trucks and routing differentiation, are quantified in a financial analysis and through using the simulation program to analyze it both from a hauler´s perspective and an environmental perspective.

The results from this thesis confirm previous research assumptions and indications that there exist many inefficient and unprofitable transports due to poor choice of distribution strategy. Furthermore, the simulation analyses indicate a discrepancy in incentives for improving transport efficiency from a financial perspective and the incentives for improving from an environmental perspective.

Keywords: Transportation, Distribution Network Design, Simulation, Scenario Analysis.

ACKNOWLEDGEMENTS

This Master of Science thesis was conducted between September of 2011 and April of 2012 as part of the Master Degree Program in Supply Chain Management at Chalmers University of Technology in Gothenburg, Sweden. The thesis was carried out as a case study and a project for Foria AB’s office in Nyköping.

We would first of all like to send our gratitude to all the people working at Foria AB. This thesis would not have been possible without their help and cooperation. Thanks to the management team for their insights on the problem, thanks to the transport planners for helping us understand their work process, and thanks to the drivers for their guiding in an inspirational field study. We would especially like to thank Mr. Stefan Palmgren, our supervisor and tutor at Foria AB. Thank you for your support, guidance and feedback through the entire work process of this thesis.

We also want to thank our Chalmers supervisor Dr. Henrik Sternberg for his constant encouragement to pursuit excellence. We also want to acknowledge the staff at the division of Logistics and Transport at Chalmers University of Technology who has contributed to our learning along the two year master programme.

Last but not least, we want to recognize our computer systems engineering friends, Manuel Espinoza, Salvador Melendez and Guillermo Leon. Their help and support during the work of coding our algorithm into a functioning simulation program saved us a great deal of time.

Gothenburg, April 2012.

Adrian Ruiz de la Llata and Oscar Kjellberg

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ABBREVIATIONS

API	Application Programming Interface
BI	Business Intelligence
CCU	Cargo Capacity Utilization
DND	Distribution Network Design
EDN	External Distribution Network
EU	European Union
GHG	Greenhouse Gas
GPS	Geographical Positioning System
HDV	Heavy Duty Vehicle
ICT	Information and Communication Technology
IS	Information Systems
IT	Information and Technology
LCV	Light Cargo Vehicle
LTL	Less Than Truckload
MDV	Medium Duty Vehicle
NTM	Network for Transport and Environment
SCM	Supply Chain Management
SCP	Shipping Consolidation Problem
SEK	Swedish Kronor
TND	Transportation Network Design
TT	Transit Time
TSP	Traveler Sales Problem
T&D	Transportation and Distribution
US	United States
VSM	Value Stream Mapping
WMS	Warehouse Management Inventory

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1 INTRODUCTION

This chapter starts with a brief background description and the underlying reasons for this thesis. Following this the purpose, the research questions, and the delimitations for this research are presented.

1.1 BACKGROUND AND MOTIVATION

The demand for transportation is increasing on a yearly basis (Piecyk and McKinnon, 2011) and it is not only the shipped weight that is increasing. Supply chain efficiency measures such as reducing local warehouse levels increase the demand for more frequent, timely and small deliveries. Most industries, as well as the public, depend heavily on trucking companies to solve their demand for cargo transportation and motor hauler transportation is the predominantly used mode of inland transportation. In Sweden this compose around 60% of the total inland freight transported weight (International Transportation Forum, 2010).

Truck hauling ventures is normally a low margin business with fierce competition, usually margins lie within the range of 2-4% (SIKA Statistik, 2009). The transportation execution is often easy to copy which means that most of the actors mainly compete on price and relationships have often been at arm's length (Belman et al., 2005). An example of this is the recent market penetration of low-cost eastern European haulers on the Nordic market (Sternberg, 2011a), they are pushing an already low price down further and putting pressure on local haulers to increase their operation efficiency. However, many of actors the actors involved in distribution have realized the potential with closer relationships and logistic alliances have formed where one actor are providing a larger package of a value adding services (Lumsden, 2006b) and not only the actual transportation, e.g. planning processes or outsourcing the entire distribution process and handing over control and responsibility to an external expert (Esper and Williams, 2003).

Another important reason is to improve transportation efficiency is to reduce the environmental impact of transportation. Thomas and Harrison (2004) agree on major impacts such as human health implications, dilution of the ozone layer, greenhouse effect, hyper fertilization, acidification and destruction of landscapes. The transportation sector in general stands for 19% of the greenhouse gases (GHG) emitted in the European Union (EU-27) and out of this, road transportation share is up to 90% (Huggins, 2009). Reducing air pollution is already a priority for policymakers and through the establishment of regulations and environmental policies (Thomas and Harrison, 2004), policymakers are increasing pressure on Transportation and Distribution (T&D) companies to improve operating efficiency to reduce their environmental impact. Moreover, society is also pressuring companies towards being "green" and becoming environmental friendly has increased its importance as an order qualifier in the market (Jonsson, 2008, McKinnon, 2003).

The above-mentioned developments are the underlying motives for this thesis. A lot of research has previously been done in the field of transportation efficiency. E.g. Samuelsson and Tilanus (1997) described a general framework for measuring the physical efficiency of Less-than-truckload (LTL) transports, Crainic and Roy (1988) developed a mathematical model for the tactical planning of freight transportation, Chapman et al. (2003) discussed how innovation on logistics firms can help to re-design their structures and enhance relationships through information sharing and coordination, and Kalantari and Sternberg (2009) described the conceptual model of foliated transportation networks, which aims at increasing the efficiency of transportation networks by increasing resource utilization. However, an identified gap in previous research is the study and numerical analysis of real world problem based on actual transportation and not an optimization of an ideal situation or research limited to qualitative analysis and suggestions. Sternberg (2011b) states that there exist a lot of wasteful transport operations due to inefficient strategies and lack of knowledge about what drives the revenues and what drives the costs. This leads road transport operators to carry many unprofitable assignments. The close relationship and correlation between transport efficiency, profitability and environmental sustainability makes addressing unprofitable an interesting area of research since it will also likely improve environmental sustainability.

This thesis has its base in a case study of the Swedish logistics firm Foria AB. More specifically, the part of their operations which is responsible for distributing agriculture supplies to farmers in mid-eastern Sweden from Lantmännen´s central warehouse in Västerås. To analyze improvements to their operations a financial sustainability analysis is made comparing the impact of using an External Distribution Network (EDN) for part of this distribution. Secondly, a simulation model that analyzes the financial impact to local haulage companies and impact to transportation efficiency and environmental impact from different distribution design scenarios are developed. From this case study general conclusions are drawn.

1.2 Problem Area

The distribution of agricultural supplies is essentially the distribution of general cargo on pallets in a LTL setup. Our focal company shares the above described need for efficiency improvements, as most T&D companies have in order to stay competitive. Furthermore, Foria as the sponsors of this thesis has a request to receive suggestions that would improve the financial and environmental performance for their agriculture supplies distribution, which is an important aspect of this thesis. This means that the general research area for this thesis is methods for improving financial and environmental performance in the distribution of general cargo.

More specifically, it examines how distribution of general cargo from a central warehouse could be made more financially and environmentally sustainable through the use of fleet optimization techniques and/or the use transshipment terminals. The basis for suggestions and conclusions is the case study done at Foria's operations for Lantmännen in mid-eastern Sweden.

This thesis investigates the economic and environmental impact of modifying, in terms of fleet selection and adding transshipment terminals, Foria´s distribution model for agriculture products from Lantmännen´s central warehouse in Västerås to farmers in mid-eastern Sweden. The changes are then compared to the current distribution model and one year of shipment data for these shipments will be used as input to the analysis models and as reference for comparison.

From this case study a recommendation to focal company along with general conclusions on transport efficiency improvements regarding LTL-shipments of general cargo will be presented.

1.3 PURPOSE

This thesis analyzes the current distribution setup, in terms of fleet performance and delivery routes, the distribution of agriculture supplies from Lantmännen terminals in Västerås to the end user in the counties of Östergötland, Södermanland, Närke, northern Småland, Västmanland and Uppland as is shown in Figure 1.

With this analysis as a reference, the purpose is to propose distribution efficiency improvements so Foria will gain a better financial performance along with a reduced environmental impact from these shipments, without having a negative effect on the current service level. Moreover, these results are then to be analyzed to form general recommendations on how the distribution of general cargo from a central warehouse could be made more efficient and sustainable.

FORIA

Figure 1 Region where Foria is responsible for Lantmännen´s agriculture supplies distribution

1.4 Research questions

Derived from the problem identification and the purpose two sets of research questions were formulated. These research questions are the starting point from where the literature review, empirical data collection and analysis were carried out.

RQ1 are derived from the focal company´s need and the specific problem identification from the analyzed transport operations. RQ1 is split into four parts and presented below.

RQ1-1. What transport efficiency improvements should be implemented at Foria to increase the financial sustainability for the agriculture supplies distribution?

RQ1-2. How high are the possible financial gains for Foria?

RQ1-3. What environmental effects will the proposed transport efficiency improvements render?

RQ1-4. How will proposed changes affect the local hauler companies that today perform these transports?

Derived from the RQ1, which is targeted directly towards the focal company´s situation, RQ2 generalizes the results from the case study and puts them into a broader context.

RQ2. Given the conclusions from RQ1: How can distribution of general cargo from a central warehouse to a wide array of drop-of points become more sustainable?

1.5 Delimitations

This thesis focuses on improvements on the T&D activities that the focal company will perform in the new arrangement. All other activities performed by other external actors are out of the scope for potential improvements. Therefore, Lantmännen's distribution warehouse in Västerås, the customers (farmers) location, and the products are fixed external factors that are not feasible to change and they set the boundaries for any realistic improvement.

1.6 Outline of the thesis

This section presents how the thesis is structured and under what headings different segments will be found.

1 Introduction

This chapter starts with a brief background description and the underlying reasons for this thesis. Following this the purpose, the research questions, and the delimitations for this research are presented.

2 Research approach

In this chapter the research method this thesis is presented. It starts with a description of the general strategy for solving Foria’s problems, following this is a description of how data collection, problem analysis, and data analysis was done. Finally the reliability and validity of the results are discussed.

3 Literature review

This chapter describes and explains the academic literature that supports and function as reference in the analysis part of the master thesis. Three main areas will be presented and broken down into different subareas: Efficiency in LTL Transportation, DND and Fleet/Vehicle Differentiation.

4 Empirical findings

In this chapter the empirical findings are presented. This includes the roles, responsibilities and activities of the involved actors. Furthermore, the nature of the goods that is being transported as well as the properties of the vehicles being used for these transports today.

5 The simulation model

This chapter starts with describing the reasons for the constructed simulation model; following this, a through description of how the simulation model works in detail in the most important parts is presented. How it tries to mimic the behavior of a transport planner, how it creates shipments and simulates a year of transportation. Finally the limitations to the model and how it was validated is presented.

6 Analyses

In this chapter theory and empirical findings form the base for analysis. An initial problem analysis of the focal company´s situation within the agriculture supplies distribution identifies thirteen problems. Possible solutions to the identified problems are examined with three analyses from three perspectives; financial perspective, haulers perspective, and environmental perspective. These analyses will then acts as a reference from which general efficiency improvements can be sought in the research area of improving transport efficiency of general cargo from a central warehouse.

7 Results

This chapter presents the results from the different analyses made. First the qualitative general results from the case study analysis are presented; following this the quantitative results from the financial analysis as well as the two simulation analyses are presented. Finally the last subchapter answers research question 1 and research question 2.

8 Recommendations to Foria

In this chapter we provide our recommendations to the company based on the analysis and conclusions drawn. Recommendations are given on both a short-term and long-term perspective.

9 Conclusions

In this chapter the results of the research are discussed from a managerial and theoretical perspective. Lastly possibilities for future research and improvements are highlighted.

1.7 THE FOCAL COMPANY - FORIA AB

Foria is one of the biggest transport- and heavy equipment service companies in Sweden. They are mainly active in the middle of Sweden on the east coast; however, through partnerships with other actors they are able to offer services all over Sweden. During 2010, they had a turnover of 1.237 billion SEK, and made a profit of 9 million SEK. They have approximately 1000 units in their fleet of vehicles that are operating in their four different business areas, “Civil engineering services”, “Logistic services”, “Industry services” and “Environmental services”. (See Figure 2)

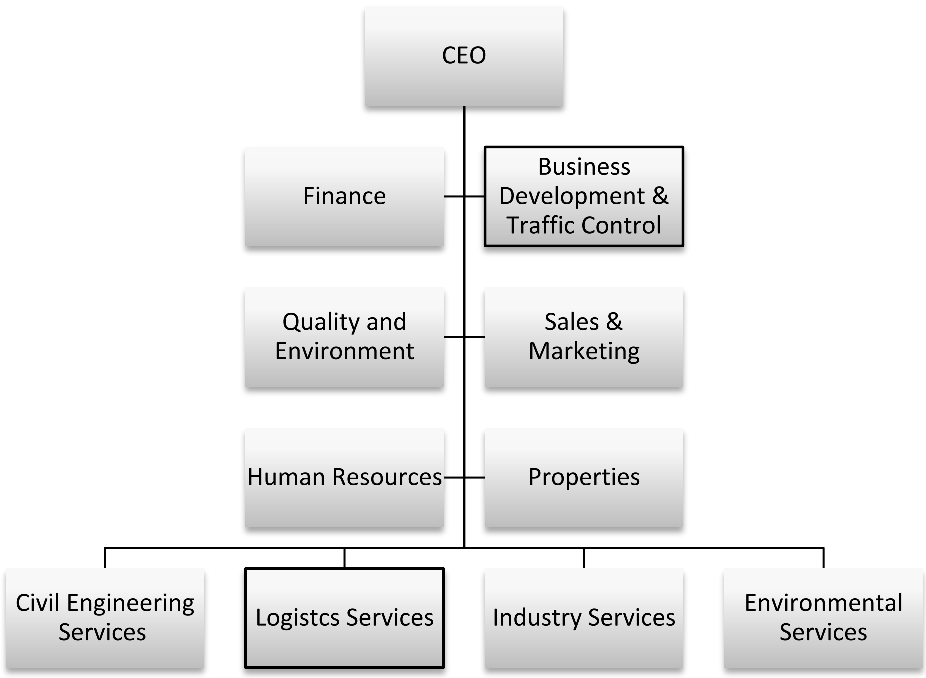

Figure 2 Organizational chart of Foria AB

This master thesis project has collaborated with Foria´s Business Development & Traffic Control in their business area Logistics Services. Within Logistics Services, they work with distribution services, long-haul traffic services, terminal and warehouse services, courier services, moving, relocation services, and total logistics solutions with outsourcing.

2 RESEARCH APPROACH

In this chapter the research method this thesis is presented. It starts with a description of the general strategy for solving Foria's problems, following this is a description of how data collection, problem analysis, and data analysis was done. Finally the reliability and validity of the results are discussed.

2.1 RESEARCH STRATEGY FOR THE THESIS

The starting point for this thesis was Foria's problem since it is written for, and in cooperation with Foria AB. A general way of describing the research methodology, different steps and parts of this thesis are:

- PROBLEM FORMULATION

  The problem at the focal company is specific and practical in its nature. This practical problem was generalized and broken down to its core to formulate research questions and to define the purpose of the thesis. After an initial orientation of the focal company's operations an overview of relevant literature were carried out to so a direction for the research could be formulated.
- LITERATURE REVIEW

  After an initial orientation, a deeper search of articles relating to the field was conducted and connected to our problem. However, continuously through the work with the thesis, study and review of articles, books and other media that related to the field of research have been done as the problem evolved over time.
- EMPIRICAL DATA COLLECTION

  The thesis aims at contributing to theory through solving a real world problem; therefore gathering of empirical data has been crucial to the thesis. Empirical data was collected both qualitatively and quantitatively.
- SIMULATION AND BUSINESS INTELLIGENCE ANALYSES

  As the understanding of the problems developed, two separate solutions to Foria's problems emerged. In order to answer Foria's two main questions, what is the best distribution network alternative and how should they motivate associated hauler companies' to change according to this? The first question was approached through a financial analysis through building an analysis tool in the Business Intelligence (BI) program Qlikview. The haulers' perspective through analyzing the impact in a simulation analysis created for this purpose. Environmental analyses were finally made through assessing the pollutant emissions impact of different distribution scenarios.
- VALIDATION OF RESULTS

  The results are validated both quantitatively through a statistical analysis and qualitatively through examination and scrutiny of the models and its results to identify possible errors.
- THEORETICAL DICSUSSION OF RESULTS

  Finally the results from analysis were related to previous reviewed literature in a theoretical discussion of the results.

- CONCLUSIONS AND RECOMMENDATIONS TO FORIA

  A visual and numerical financial analysis was done with Qlikview and a transport efficiency analysis through our simulation model. Conclusions were drawn based on these results and considering these results; recommendations to Foria were given both from a short-term perspective and a long-term perspective.

2.2 METHODOLOGY

Both a literature review and an empirical data gathering were carried out. The following subchapter will describe in detail how these were performed.

2.2.1 LITERATURE REVIEW

After an initial background orientation and problem description by Foria a deep literature review and general search within the fields of "Efficiency and Effectiveness in transportation" "Distribution and Transportation Network" and "Route and Fleet optimization" was done.

A selection of different e-journals was made based on significance to the topics Transportation/Logistic/Supply Chain Management from the pool of e-journals available at the Chalmers library through their licensing agreements. The following e-journals were identified to be connected with these topics, available at Chalmers and initially searched:

- Journal of Business Logistics (JBL) (ISSN: 0735-3766)
- International Journal of Logistics (IJL) (ISSN: 1367-5567)
- International Journal of Logistics Management (IJLM) (ISSN: 0957-4093)
- International Journal of Retail and Distribution Management (IJRDM)(ISSN: 0959-0522)
- International Journal of Physical Distribution and Logistics Management (IJPDLM) (ISSN: 0960-0035)
- Light and medium truck (LMT) (ISSN: 1091-9651)
- Logistic and transportation review (LTR) (ISSN: 0047-4991)
- Logistic Management (LM) (ISSN: 1540-3890)
- Professional Distributor (PD) (ISSN: 1553-6211)
- Transport Reviews (TR) (ISSN: 0144-1647)
- Transportation Journal (TJ) (ISSN: 0041-1612)
- Transportation Research Part B: Methodological (TRB) (ISSN: 0191-2615)
- Transportation Research Part D: Transport and Environment (TRD) (ISSN: 1361-9209)
- Transportation Research Part E: Logistics and Transportation Review (TRE) (ISSN: 1366-5545)
- International Journal of Integrated Supply Management (IJISM) (ISSN: 1477-5360)

A complementary search at Google Scholar was also performed.

When articles of interest were found the method of ancestry approach was implemented where searched through the reference lists of relevant articles narrowing the search net related to the topics of this thesis. Finally as the project progressed, information relevant to issues that rose was searched for at Google and Google Scholar.

To start with the literature review the following six search strings were used:

- “Transportation efficiency + effectiveness”
- “Fleet optimization”
- “Route optimization”,
- +Distribution +”milk-runs”
- +Distribution +”direct deliveries”
- +Distribution +”environmental impact”

First, for each search term it was looked at the first 30 results for every journal and also the 50 first results at Google Scholar. Based on the title of the article it was decided whether to read the abstract or disregard the article directly.

The second filter was based on the abstract. After the abstract had been read a decision was made whether further reading was of interest or if the article can be discarded at this stage.

2.2.1 Empirical data

Empirical data was collected in both qualitative forms from interviews, meetings and field studies as well as through quantitative form from shipping data and pricelists. The gathering, understanding and analysis of the empirical data were one of the central parts of this thesis.

Structuring the empirical data in a process map enabled the creation of an algorithm for representing the T&D activities. The historic shipping and sales data along with prices was the input for the cost calculations for the financial analysis that was performed to find the optimum mix of own drivers versus an EDN. The historic data was also the input to the simulation model emulating a year of shipments.

Qualitative empirical data collection

A two-day study visit to Foria´s office in Nyköping and Lantmännen´s warehouse in Västerås was held to broaden our understanding. The aim was to understand the perspectives of the different actors involved in case. Gather empirical data through interviews and also get an overview of the operations. During the two days several meetings and interviews were held with different actors involved in these shipments, see Table 1.

The method of choice for conducting these meetings and interviews were in a semi-structured style. Questions and topics were prepared in advance (see Appendix C) however the flow of conversation was flexible and new questions were allowed to rise during the interview and meetings and the topics were mainly used as support and starting points. To not miss any information or hinder the flow of ideas and thoughts with intensive note taking the conversations were recorded and revised afterwards.

To further deepen the authors understanding of the day-to-day operations, how these transports are performed, and the difficulties the drivers encounter and gain insight to possible improvements, field studies and orientation visits were held, see Table 2.

This gave the author's valuable insights and understanding of the operations that would have been hard to learn otherwise. The extent of such problems as e.g. not contracted and unreimbursed work activities were experienced firsthand. When creating and validating the simulation model this enhanced understanding was of great value.

Table 1 Summary of meetings and interviews

Meetings and interviews		
With	**Type**	**Objective**
Foria´s management accompanied with a management representative from Lantmännen	Meeting and a semi-structured group interview	Get a better understanding of Foria, who they and their operations. Get a better understanding of Foria's problem from a management perspective. Make sure that the authors and the management group was on the same page regarding the projects purpose and goals.
Foria´s transport planners	Meeting and a semi-structured group interview	Get an understanding of how the transport planners work with these shipments. Get a better understanding of Foria's problem from a transport planner perspective.
A Foria associated hauler and driver	Meeting and a semi-structured interview	Get an understanding of how the drivers and local haulers perceive these shipments Get a better understanding of Foria's problem from a driver perspective.
A farmer at the receiving end of these shipments.	Meeting and a semi-structured interview	Get an understanding of the receiver of these shipments perceive them. Get knowledge of any problems that the farmers might have regarding these shipments.

Table 2 Summary of field studies and orientation visits

Field studies and orientation visits		
Where	**With**	**Objective**
Foria´s operation office at Nyköping	Transport planners and Foria management	Get an orientation of the day-to-day work with these shipments at Foria
Lantmännen's warehouse in Västerås	Foria management, transport planners and Lantmännen representatives	Get an orientation of the day-to-day work with these shipments at Lantmännen and possible limitations at the starting end for these shipments.
Started with loading in Västerås and riding with a hauler during one day and unloading at various farms.	A Foria associated driver for a local hauler.	Experience how these shipments are performed and get a real world understanding of the problems facing the drivers on a day-to-day basis.
Started with loading in Västerås and riding with a hauler during one day and unloading at various farms.	A Foria associated driver for a local hauler.	Experience how these shipments are performed and get a real world understanding of the problems facing the drivers on a day-to-day basis.

Quantitative empirical data collection

The following quantitative data files describing the shipments and the restrictions for analysis were received from Foria, see Table 3.

Table 3 Summary of quantitative data collection

Quantitative data Received from Foria	
Type	**Description**
Excel file with one year of raw order data.	Order data for these shipments from 2010-2011 containing over 25000 order lines.
Excel file with distance and time data	The distance and expected travel time from Västerås to 3128 different customers based on the customer number.
Excel file with price matrix	Pricelist and reimbursement matrix per order based on weight from Västerås for different distances for the Foria associated drivers.
Excel file with price matrixes	Pricelist and reimbursement matrix per order based on weight from Västerås for different distances for an external network provider. One based on postal code for order below 1000kg and one based purely on distance for order above 1000.
Excel file with cost calculations.	Costs calculations for the trucks currently used based on the Swedish transport industry standard cost calculation tool, SåCalc.

2.3 The problem analysis models

To start the problem analysis a basic 5-Why's analysis originating from the Lean principles developed for the Toyota Production System by Toyoda (Liker, 2004) was done. This enhanced the initial understanding of the problem. As the project advanced it became evident that Foria's problems had several root causes, which generated a need for a deeper analysis.

2.3.1 Qualitative analysis methods

A so-called logic tree was created where a "tree" grows from the effect/problem with causes to the problem, which aims at finding the root causes to the overwhelming problem (Rasiel and Friga, 2002). The method is similar to the principle of an Ishikawa diagram first described by Kaoru Ishikawa (1968). The gain from this approach is a deeper understanding of the causes and effects of the problem compared to the simpler 5-why's analysis. To find solutions to the identified problems the same tree is used, but instead of asking "why", one asks "how".

Allenström and Linger visualization model

A drawback from a logic tree analysis is that it is not easy to overview from a reader perspective. To improve the presentation of the problem analysis for the intended audience, results from the logic tree analysis where transferred to the visualization model presented by Allenström and Linger (2010). This model is based on the well-known 7M's used in Ishikawa diagrams for production companies but adjusted to fit the specific environment for hauler firms.

The visualization method is presented in Figure 3. It is a matrix with two axes; the horizontal axis corresponds to the main processes of a T&D company identified through the use of the lean tool Value Stream Mapping (VSM). The vertical axis, motivated by the 7 M's used in Ishikawa diagrams, correspond to the possible categorizations of the problems identified (Allenström and Linger, 2010).

	Shipper	Order Entry	Planning & Traffic control	Transport Execution	Invoicing & Registration
Routines					
Manpower & Management					
Equipment					
Environment					

Figure 3 Visualization model (Allenström and Linger, 2010)

2.3.2 How was the financial analysis tool created and analyzed?

With the quantitative empirical data it is possible to calculate breaking points between the different pricelist on which is the best in different weight spans. The BI-program Qlikview was chosen as a method and a project specific interface was created in Qlikview. Before that was possible the raw data and pricelist needed to be analyzed and transformed into formats possible to load into the program. E.g. possible errors in the raw data were accounted for and scenarios were created to adjust for them. When the tool was built in Qlikview and the data was loaded the analysis was straightforward to perform in the visual interface of Qlikview.

2.3.3 How was the simulation model created and analyzed?

The aim of the simulation model is to emulate the work of a transport planner and thus empirical data regarding their way of working were the starting point. A process flow chart was created and approved. The optimization technique called *Greedy Algorithm* was used to in order to determine the routing of the trucks. The simulation results were then compared and analyzed against each other and conclusion of likely real world implications were drawn from a haulers point of view and an environmental point of view.

2.4 Validation

In order to ensure a high validity, i.e. making sure that we measure the right thing, the authors have interviewed people with good knowledge and insight to the operations as well as collecting several viewpoints by talking to all involved parties. Continuous contact with Foria and feedback on the proposed model has also made sure that the validity has been kept high.

2.4.1 Financial analysis

Quantitative empirical data as input is considered to have a very high validity, it is consists of historical data shipping and sales data, and up-to-date pricelists from their information system (IS). Some errors in weights are identified but they are adjusted for in the financial analysis, so overall the validity of quantitative analysis should be high.

Qlikview BI analysis software

Qlikview is well-known software, it presents the loaded excel data in a visually and easy to understand way, it does not alter it. Therefor the use of Qlikview does not affect this research validity in any negative way.

2.4.2 Simulation model

The simulation model simulates a year of shipments, emulates the work of a transport planner and measures the distance driven and the number of stops. Empirical data was the input for the creation of the algorithm describing how the simulation program works. Traffic controllers and an internal process developer scrutinized and confirmed that the algorithm is a valid representation of how transport planners work when they plan shipments.

To make sure that this program works as intended a visual validation of randomly selected shipments were made. Simulated shipments were loaded into to a driving optimization software using Google Maps[1]. The real world distance from Google Maps was compared with the simulated distance and the map offered a visual representation that provided confirmation that the routes chosen by the simulation model were logical. The error between the randomly selected simulation shipments and real world distances from the optimization program was also statistically examined and the confidence interval from analysis is presented in the results.

The coding of the program was done through pair programming. This reduces programing errors (Cockburn and Williams, 2000) and increases validity. Furthermore, when the program was finished it was scrutinized line by line simultaneously of three people to make sure that it followed the previously approved algorithm.

Possible errors and their effects in the simulation model

The program is a simulation and it is not as flexible as transport planner could be. E.g. the strict division into regions in the program would not be enforced as strictly in the real world and the transport planners would also take the possibilities of a return shipment into consideration when deciding whether to add the final orders or not. However, the effect of this is considered small since this is the same for all simulation runs.

The simulation program is loaded with the historic shipping and sales data. After the simulation program was created the authors identified a few possible errors in the smallest orders. This means that a truck could be loaded with more orders than possible in the real world. However, the analysis is made over an average of a year of simulated shipments; the impact of this should not have a noteworthy effect on the conclusions from the analysis.

2.5 RELIABILITY

Reliability, i.e. will that the results be repeatable and consistent, is thought to be very high. Both the financial analysis and the simulation analysis use the quantitative empirical data as input, which is consistent over time for the time period analyzed.

Reliability of input from the qualitative empirical data and qualitative analysis are not as high as the quantitative data since it derives from a subjective appreciation of the operations. However, people interviewed have many years of experience and descriptions from different actors from all corners have overlapped and matched. The problems and difficulties with these shipments have been well known for many by actors involved. Therefor we conclude that other researchers would get the same answers and should reach the same results.

[1] http://gebweb.net/optimap/

3 LITERATURE REVIEW

This chapter describes and explains the academic literature that supports and function as reference in the analysis part of the master thesis. Three main areas will be presented and broken down into different subareas: Efficiency in LTL Transportation, DND and Fleet/Vehicle Differentiation.

3.1 LOGISTIC PERFORMANCE

Logistics has become one of the most important factors in business competitiveness. Smooth connections among the supply chain (the essential function of logistics) has become the grounding of competitiveness in the global market where innovation and operation technology are no longer enough as qualifiers since everyday they are more reachable for the different players (Kim, 2010).

Logistic performance has been defined by the efficiency and effectiveness in the execution of the logistic related activities, e.g. T&D (Mentzer and Konrad, 1991). Within the recent years an increasing awareness of the importance of customers' value has enhanced the need for excellence and differentiation in the performance of the logistic activities. Thus, logistic performance is recently defined as "the degree of efficiency, effectiveness and differentiation associated with the accomplishment of the logistic activities" (Smith, 2000, Bobbitt, 2004).

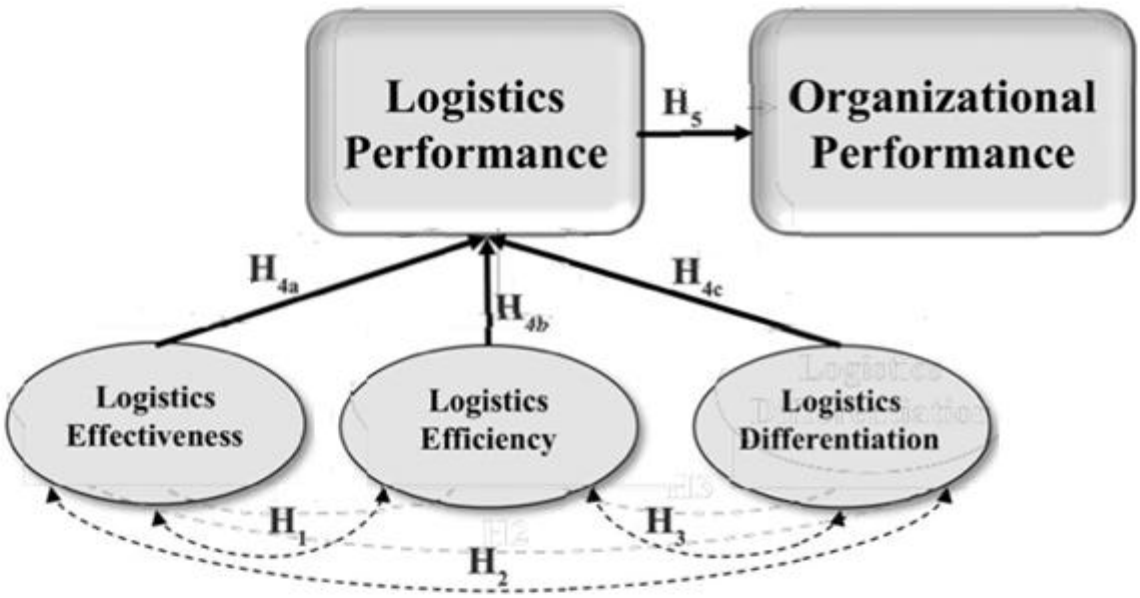

Figure 4 Logistics Performance Model (Fugate et al., 2010)

3.1.1 LOGISTICS EFFICIENCY AND EFFECTIVENESS

Efficiency is the measure of how the resources are utilized in order to achieve a goal and it is expressed as the percentage of the stated normal level of inputs supposed to be utilized, compared against the actual level of inputs utilized (Mentzer and Konrad, 1991).

Based on this general definition and applied in a logistic perspective, (see Figure 4) Fugate et al. (2010) defined efficiency of the logistic function as “the measure of how well the resources expended are utilized”.

In a general management perspective, effectiveness is expressed as the percentage of the actual outputs compared to the expected or stated normal outputs. Consequently, being 100% effective denotes full accomplishing of a particular goal (Mentzer and Konrad, 1991). Extending the definition to the area of interest of this thesis, logistic, Mentzer and Konrad (1991) defined logistic effectiveness as “the extent to which the logistics function’s goals are accomplished”.

Efficiency and effectiveness on transportation has been assessed by several researches within two main different perspectives: (a) Technical / Physical and (b) Strategic / Planning, and impacting mainly Environmentally, Economically and the Service level (See Table 4). Depending on the scope of the organizations, private companies may focus on a combination of them in order to secure profitability and good image while government may be strongly focus on reduce pollution (Samuelsson and Tilanus, 1997).

Table 4 Summary of articles relating to logistic efficiency and effectiveness

		Perspective		Impact		
Author (Researcher)	**Year**	**Technical / Physical**	**Strategic / Planning**	**Environ-mentally**	**Economic-ally**	**Service Level**
Samuelsson & Tilanus	1997	X		X	X	X
Kim	2010	X			X	
Crainic and Roy	1988		X		X	X
van de Klundert and Otten	2010		X		X	X
Vilkelis	2011		X	X		
Aronsson and Brodin	2006		X	X	X	
Li et al.	2006		X		X	X
Apte and Viswanathan	2002		X		X	X
Wang and Regan	2008		X		X	X
Chapman, Soosay and Kandampully	2003		X		X	X
Harmatuck	1990	X	X		X	

Samuelsson and Tilanus (1997) described a general framework for measuring the physical efficiency of LTL based on four basic transportation dimensions: time, distance, speed and transportation, emphasizing the importance on not to overlook possible efficiency loss in the physical part of the transportation, often easier to measure, rather than going straight for route optimization and other types of strategic approaches. In the same way, Kim (2010) evaluated various technical efficiency results in order to estimate logistics performance of trucks. Both Samuelsson and Tilanus (1997) and Kim (2010), consistently agreed on the importance of the identification and measure of physical and technical efficiencies in transportation as one important step for profit maximization.

On the other hand, strategic or planning perspectives can also improve the efficiency of transportation. Crainic and Roy (1988) developed a mathematical model for the tactical planning of freight transportation. By approaching it as and optimization problem where economic efficiency as well as service level were of main interest, their model proposed a better operating planning and minimizing cost compared to a manually done one. Moreover, strategies aiming to increase capacity utilization of the transport, e.g. consolidation, better IS, etc. will result in cost reductions and mitigation of negative environmental impact, i.e. congestion and pollution (Vilkelis, 2011, van de Klundert and Otten, 2010, Aronsson and Brodin, 2006).

Li et al. (2006) described and presented an example of a shipping consolidation problem (SCP), which main goal is to minimize the total cost (transportation and inventory) while satisfying service level constrains. Similarly, cross docking is another distribution strategy thoroughly described by Apte and Viswanathan (2000) which also aims to reduce transportation cost by efficiently maintain low inventory levels without compromising the deliveries. However, cross docking is just one innovative strategy that may be used together with other strategies, e.g. postponement, vendor managed inventory, mass customization, time-based scheduling and among others, in order to boost logistic and transportation efficiencies (Apte and Viswanathan, 2000, Wang and Regan, 2008).

Chapman et al. (2003) discussed how innovation on logistics firms can help to re-design their structures and enhance relationships through information sharing and coordination, resulting on overall efficiency improvement, flexibility for upcoming market changes and increase customer service. Furthermore, Harmatuck (1990) described the United States (US) carriers' strategies after the 1980 US Deregulation[2]. A large number of commodity carriers made strategic and operational strategies in order to cope with the competition. Terminal Expansions, Equipment, Discount pricing, Service Levels and Labor agreements were the most important and resulting on profit increase and efficiency on operations, however service quality did not increased as the others.

Another interesting approach to improve transportation technical efficiency, i.e. increase fill rate without diminishing the service level, is a model called "Foliated transportation network" (see Figure 6). Presented by Persson and Lumsden (2006) and furthermore explained by Kalantari and Sternberg (2009), this model combines the advantages of the direct distribution strategy and the hub-and-spoke distribution strategy.

[2] The 1980 US Deregulation, known as the Motor Carrier Act of 1980, opened free pricing and routes to be served by the truckers resulting in a significant growth of the competition and number of independent firms.

3.2 Distribution and Transportation Network Design

Distribution and transportation network design decisions concerning storage, location, markets, etc. will guide towards the determination of a proper supply chain structure (Chopra and Meindl, 2007). In the pursuit of this proper and profitable network structure, organizations are devoted to the optimization of their T&D networks through the use different strategies and consequently minimize inventory and reduce transportation costs (Li et al., 2006).

3.2.1 Distribution network design (DND)

As constantly customer needs change in any business, organizations must periodically evaluate their current distribution network and adapt it to match business requirements. In doing so, the most important goal is to find the balance between cost and service level (Tiede and Kay, 2005). Although most companies design their distribution networks based on cost and speed, these processes also have an influence on other factors, including carbon emissions. Optimizing a network design can reduce both costs and carbon emissions significantly (Vilkelis, 2011).

There are two key decisions regarding DND: Whether deliver to the customer location or picked up from a predefined site and second, if the flow includes an intermediary or intermediate location. Based on the choices for the two decisions, six distinct DND´s are proposed as shown in Table 5 (Chopra, 2003, Chopra and Meindl, 2007).

Table 5 Proposed Distribution Networks Designs (Chopra, 2003)

Distribution Network Design
Manufacturer storage with direct shipping
Manufacturer storage with direct shipping and merge in transit
Distributor storage with carrier delivery
Distributor storage with last mile delivery
Manufacturer/distributor storage with costumer pick-up
Retail storage with customer pick-up

There are two main criteria in order to select the most suitable DND: meeting the customer needs and the cost of meeting those needs. Then, the performance of the distribution network will depend on the satisfaction of the customer needs, directly impacting the revenues, and the supply chain costs of the network (Chopra, 2003).

Sharma, Moon and Bae (2008), adapted Chopra`s framework in order to outline the most important criteria and sub-criteria towards the design of an optimal distribution network (see Figure 5), where is necessary to prioritize the metrics both related to costs and customer service. For the cost factors, Chopra (2003) distinct: inventories, transportation, facilities and handling and information. Accordingly, in order to fulfill the customer needs, the factors to consider are: response time, product variety, product availability, etc.

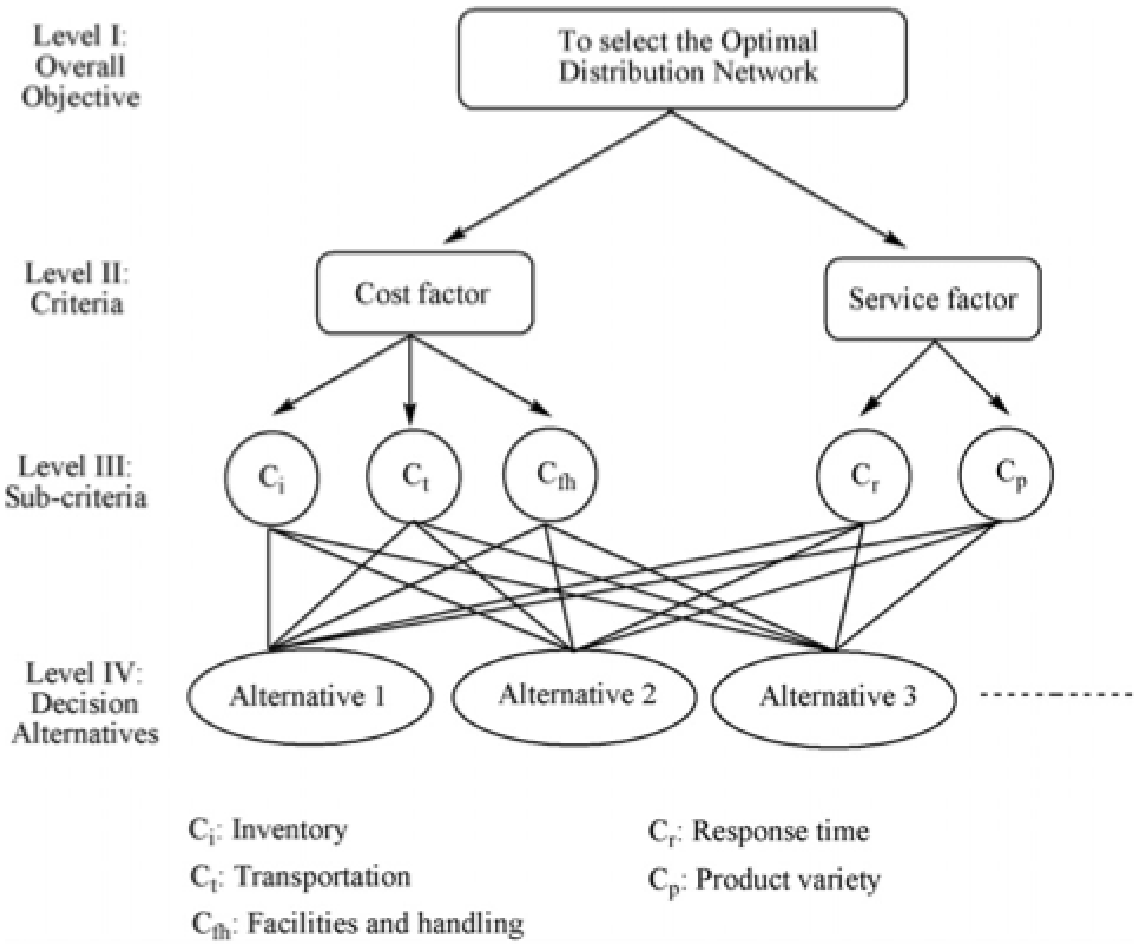

Figure 5. Designing the Optimal Distribution Network (Sharma et al., 2008)

Crainic and Roy (1988) classified in three groups the problems and policies required when designing a transportation network: strategic (long-term), tactical (medium-term) and operational (short-term). The strategic group entails for large investments and the decisions connected with this level of planning are connected to physical network design, location, resource acquisition and service policy definition. The tactical planning, which is not as dynamic as the previous group looks after the performance of the whole system and the decisions are sensitive only to wide variations. The selection of routes, traffic distribution and service network design are examples of decisions regarding this group. The operational planning, characterized by a dynamic environment, consisting on decisions as: scheduling, maintenance, terminals and routes daily operations, allocating resources, etc.

3.2.2 TRANSPORTATION NETWORK DESIGN (TND)

Regarding TND the decisions are mainly affected by the tradeoff between the service level (responsiveness) and the inventory and transportation costs. Different options proposed by Chopra and Meindl (2007) are shown in Table 6.

Table 6 Proposed Transportation Networks Designs (Chopra and Meindl, 2007)

Transportation Network Design
Direct Shipping
Milk-runs
Central DC with storage
Central DC with cross-docking
Milk-runs via DC
Tailored network

Direct shipment transportation consists on the delivery of goods from one supplier to one buyer location, eliminating intermediaries and reducing complexity and coordination. Direct shipments are suitable if economy of scale can be found and if the demand is high enough, that optimal lot size is close to the size of a full truck. The effectiveness of direct shipping deteriorates as the economic lot sizes decrease (Gallego and Simchi-Levi, 1990, Persson and Lumsden, 2006, Chopra and Meindl, 2007).

Milk Runs or Peddling is a distribution strategy where one truckload is delivered to more than one customer, i.e. two or more drop points. The use of milk runs enables consolidation of multiple deliveries, which may result in better utilization of a truck (Chopra and Meindl, 2007).

Burns et al. (1985) presented the use of delivery regions and sub-regions for the analysis of the milk run transportation network. This region division of the different customers enables the definition of the truckloads and outlines the geographical area for the milk run routing.

For TND involving the use of a central distribution center, organizations can increase the service level with bigger product assortment and quick responsiveness but the inventory cost will be higher. An alternative of this is the use of cross docking strategies, however it requires more coordination and synchronization through the use of information technologies (Chopra and Meindl, 2007). In the same way, Distribution Centers allow the use of milk runs, which will depend on the size and consolidations possibilities of the goods.

According to Persson and Lumsden (2006), transportation companies today are hardly operating with a fix distribution strategy as pure direct shipments or completely hub-and-spoke networks. Thus, a tailored network design facilitates an appropriate combination of the previous described transportation network designs (Chopra and Meindl, 2007). Foliated transportation network, shown in Figure 6, is an example of a tailored network design.

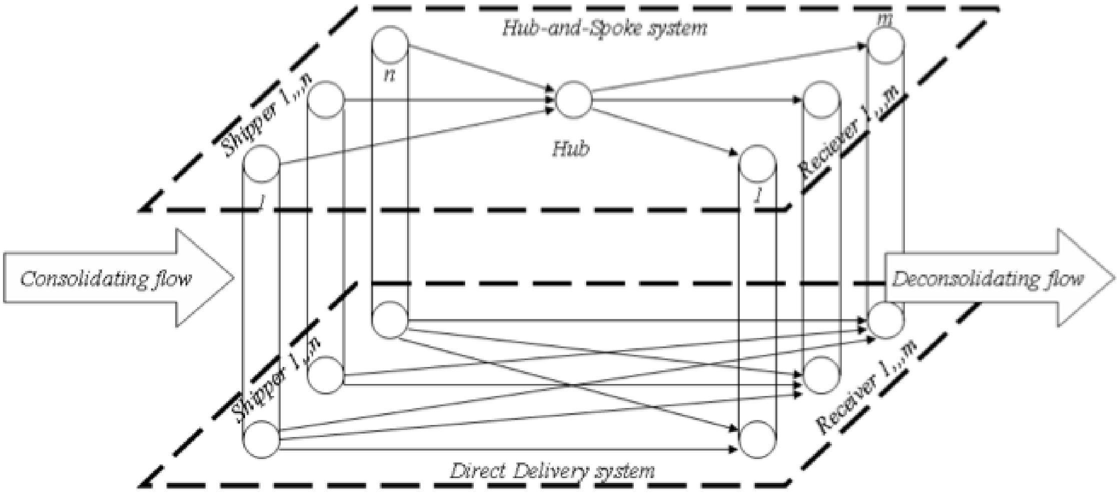

Figure 6 Foliated transportation network (Persson and Lumsden, 2006)

3.3 DISTRIBUTION AND TRANSPORTATION OPTIMIZATION

Optimization describes the process of finding an optimal solution among a large number of possibilities. Optimization problems involve decisions characterized by the three components: (1) resource constraints, e.g. time, money, etc. (2) variables, e.g. distance, cost, etc. and (3) objectives e.g. minimize cost.

Optimization problems directly related to T&D include the Traveler Sales Problems (TSP) and greedy algorithms, which are further described below.

3.3.1 TRAVELER SALES PROBLEM (TSP)

The TSP is a well-known optimization problem whose objective is to find the minimum total distance travelled by a salesman, from an origin location to a defined number of different cities, returning to the origin and visiting each city only once time (Gutin and Punnen, 2002).

One of the first persons to study similar problems to TSP problems was Leonhard Euler back in 1759, however it is believed that the first person on reported in a mathematical formulation a comparable TSP problem was Karl Menger with his “messenger problem” (Gutin and Punnen, 2002, Klanšek, 2011).

Optimization software had increase the reach of the TSP within the last years, e.g. it is possible to compare TSP studies before the 80’ with no more than 500 nodes to recent studies with almost one million of nodes or visits (Klanšek, 2011). Moreover, TSP optimization models have been used in numerous fields as manufacturing, logistics, and operational research among others (Klanšek, 2011, Gutin and Punnen, 2002).

3.3.2 GREEDY ALGORITHM

A greedy algorithm is the kind of algorithm that makes a choice base on the best

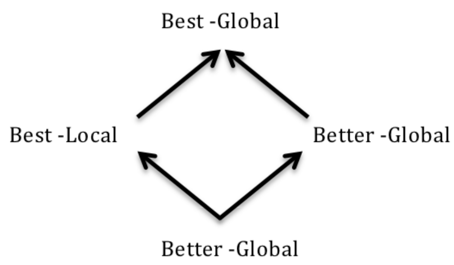

Figure 7 The four greedy principles with implications (Curtis, 2003)

available option at that precisely moment, called "local optimal" and, once the choice is made; it never goes back on previous decisions. Every step is constructed towards the overall solution of the problem, called "global optimal" (Curtis, 2003).

Curtis (2003) described the four greedy principles: Best global, better global, best local and better local (see Figure 7). While all greedy algorithms compile with the best global principle, the compliance with the other three principles defines how strong the algorithm in the pursuit for the optimal solution is. Following this, Curtis (2003) classified the greedy algorithms as shown in Table 7.

Table 7 Greedy Algorithms Classification (Curtis, 2003)

Greedy Algorithm Classification	Strength	Description
1. Best-global only	Minimum Greedy Algorithm	Best local choice can ultimately lead to a better solution
2. Better-Global and Best-Global only	Stronger than 1	Better local choice can ultimately lead to a better solution
3. Best-Local and Best-Global only	Stronger than 2	Repeatedly best local choice always results in a partial solution that is best so far.
4. Best-Local, Better-Global and Best-Global only	Stronger than 3	Repeatedly better local choice always results in a partial solution that is best so far.
5. Better-Local, Best-Local, Better-Global and Best-Global	The Strongest	Better partial solution can lead to one that is still better after the next construction step

The most emblematic and well-known greedy algorithms deal with minimum spanning tree theories, e.g. Dijkstra's minimum spanning tree, Prim's minimum spanning tree, Kruskal's minimum spanning tree, etc. (Chang et al., 2008, Wu et al., 2004). These three examples are situated on the "best-local" classification because by choosing the least weight of paths at every step (local optimal), this will secure the best solution until completing the solution to the problem.

3.4 ENVIRONMENTAL IMPLICATION OF TRANSPORTATION

Thomas and Harrison (2004) explained that the major environmental impacts from the transport sector are: human health implications, dilution of the ozone layer, GHG effect, hyper fertilization, acidification and destruction of landscapes that creates barriers. Table 8 presents the links between main emissions from the freight transport and environmental impacts.

Table 8. Link between emissions from transport and environmental impact (Thomas and Harrison, 2004)

<table>
<tr><th>Environmental impacts</th><th>CO</th><th>NOx</th><th>HC</th><th>PM</th><th>SOx</th><th>CO2</th></tr>
<tr><td>Human health</td><td>Nerves and Heart</td><td>Lungs and breathing by forming ground level ozone</td><td>Nerves and breathing, and may cause cancers</td><td>Important effects on life expectancy</td><td>Lungs and breathing</td><td rowspan="3">X</td></tr>
<tr><td>Dilution ozone layer</td><td rowspan="4">X</td><td>Through N2O only</td><td rowspan="2">X</td><td rowspan="4">X</td><td>X</td></tr>
<tr><td>Acidification</td><td>Damages forests and fish through acid rain</td><td>Damages forests and fish through acid rain</td></tr>
<tr><td>Greenhouse effect</td><td>Through N20</td><td>Through CH4</td><td rowspan="2">X</td><td>Increase of the global temperature and sea levels</td></tr>
<tr><td>Hyper fertilization</td><td>Leads to a lack of oxygen and dead sea bed as the number of algae increases</td><td>X</td><td>X</td></tr>
</table>

In order to develop a strategy concerning environmental performance targets and, at the same time securing the company's long term economy success, it is necessary to identify the specific environmental impact on the transportation system and thus propose viable alternatives leading to a low environmental impact (Aronsson and Brodin, 2006).

3.4.1 APPROACHES TO REDUCE EMISSIONS

There are different solutions or approaches to reduce transportation emissions and it is possible to classify them in three different categories: There are *technological solutions* such as alternatives fuels, greener engines or catalytic converters. There are also *logistics solutions* such as better vehicle utilization, route optimization or improving of route planning (Lumsden, 2006a). The last category concerns *social or behavioral solutions* for example better planning of the way of driving by reducing speed or braking patterns.

The International Energy Agency (1999) affirm that these solutions can reduce the environmental impacts on transport but none of these can stand alone as the ultimate solution. Holden and Høyer (2005) go even further, stating that these changes won't be enough as road transport increase and therefore there is a need to change the means of transportation.

3.4.2 ENVIRONMENTAL PERFORMANCE IN TRANSPORTATION

The Network for Transport and Environment (NTM) group developed a set of documents for transportation where it is provided the tools, instructions and pre-defined data in order to calculate and evaluate the environmental performance of a transport activities (NTM-Road, 2008). Even though NTM-Roads provided default data selected in order to be representative of a normal transport performed in European countries today, it is recommended to use situation specific data when available for more close to reality results.

Vehicle types and Characteristics

NTM-Road (2008) described ten different vehicles for road cargo transportation (see Table 8). From the smallest Light Cargo Vehicle (LCV) to the biggest Heavy Duty Vehicle (HDV), the descriptions and characteristics match all normal ranges of cargo trucks.

Fuel Consumption

When specific data is not available, NTM-Road (2008), suggest the use of fuel consumption figures contained in Table 45 (Appendix E). The fuel consumption data, given in liters per kilometer (l/km), is subject to different variants: the type of truck, the cargo capacity utilization (CCU) of the truck, the type of engine (Euro I – Euro V) and the type of road (motorway, rural or urban).

Vehicles Emissions

NTM-Road (2008) provide a compendium of tables where is possible to find pre-defined values for pollutant emissions in the road transport. These emissions are: HC, CO, NOx, PM, CO2, CH4 and SOx. Similarly than the fuel consumption data, the values are depending on the type of truck, the type of engine, the CCU, and the type of road.

Calculation Strategy

In order to calculate the environmental impact of a given transportation activity, NTM-Road (2008) defined the following strategy steps: First select the appropriate vehicle from Table 9. Secondly, set and calculate the fuel consumption from Table 45 (Appendix E) and with the parameters explained before. The next step is to select the appropriate emissions based on the tables and restrictions described before. And finally, find the distance for the transportation activity.

Table 9. Vehicle concepts/types and cargo capacity (NTM-Road, 2008)

No	Illustration	Nomenclature	Max weight[1]	Vehicle length (approx.)	Cargo capacity (typical values, inner dimensions)				
			[tonne]	[m]	[tonne]	pallets	[m]	[m3]	TEU
1	(no picture)	(LCV) Pick-up	< 2,5	5	0,6	1	1,8	3 - 6	0
2		(LCV) Van	< 3,5	7	1,5	3 - 5	3 - 4	10	0
3		(MDV) Light lorry/truck	3,5–7	8	5	14	4 - 6	35	0
4		(MDV) Medium lorry/truck	7-18	12	7	24	7,7	44	0
5		(MDV) Heavy lorry/truck	16–26	12	15	24	7,7	44	1
6		(HDV) Tractor + 'city-trailer'	16 - 26	12 - 15	15 - 16,5	20-28	8 - 12	50-64	1
7		(HDV) Lorry/truck + trailer	≤ 40	18,75	22	36	7,75 + 7,75	104	2
8		(HDV) Tractor + semi-trailer	≤ 40	16,5	26	33	13,6	92	2
9		(HDV) Tractor + MEGA-trailer	40 ≤ 50	16,5	33	33	13,6	110	2
10		(HDV) Lorry/truck + trailer or semi-trailer on dolly	≤ 60	24 - 25,25	40	51	7,7 + 13,5	140	3

4 EMPIRICAL FINDINGS

In this chapter the empirical findings are presented. This includes the roles, responsibilities and activities of the involved actors. Furthermore, the nature of the goods that is being transported as well as the properties of the vehicles being used for these transports today.

4.1 OPERATIONS OF INTEREST FOR THIS PROJECT

Figure 8 below describes how the studied shipments are performed from a historical perspective as well as how they performed as of December 2011.

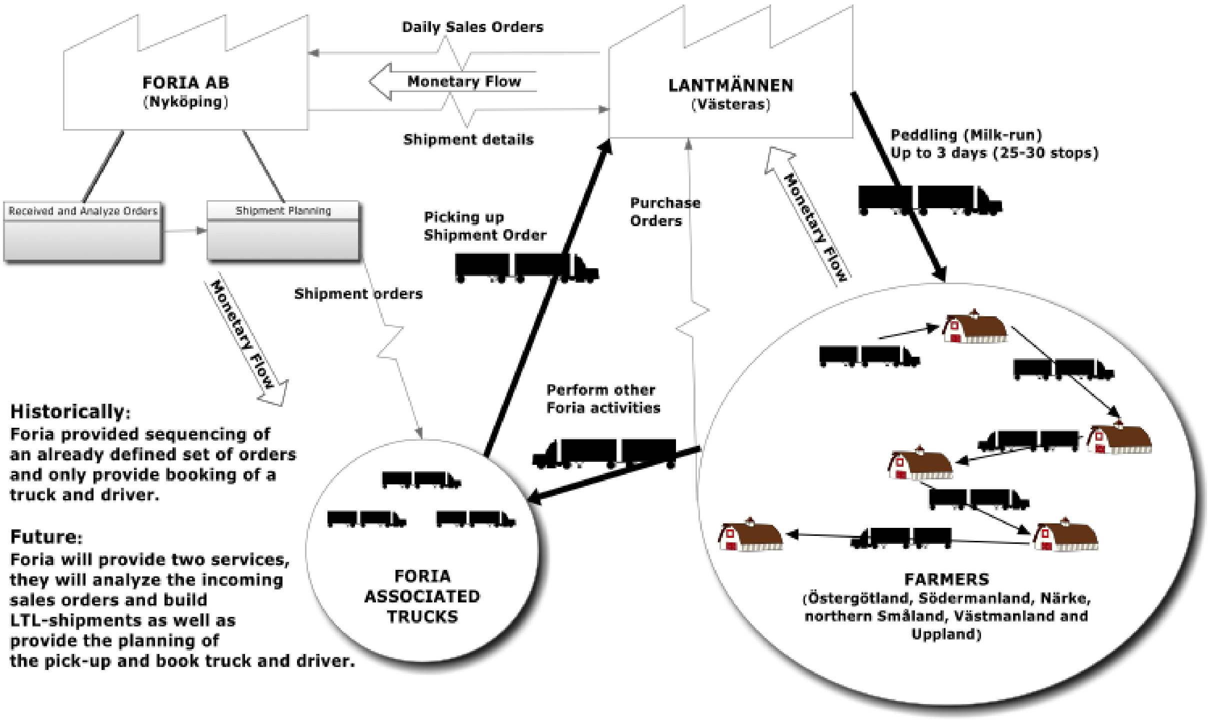

Figure 8 Value stream mapping of current operations

4.1.1 HISTORICALLY

Historically Lantmännen was the one who planned these shipments, and the already constructed and formed LTL-shipment plans were sent to Foria who booked a truck and driver. Foria then planned for loading at the warehouse in Västerås, and then charged Lantmännen based on the amount of kilometer driven, number of stops, waiting time etc. This meant that there were no incentives for Foria and their drivers to be effective and provide any efficiency improvements since they were reimbursed based on the amount of resources that were used to perform the transports. Interviews and field studies have shown that inefficiencies of these shipments were well known among the involved actors.

4.1.2 THE NEW CONTRACT – A SHIFT IN RESPONSIBILITIES

The inefficiencies were over time raised as an internal problem at Lantmännen. Negotiations started which led to a new contract with Foria, which will reduce Lantmännen's costs for these shipments. The new contract has a new reimbursement structure where Foria is reimbursed a fixed amount per order based on the distance from Västerås and its transport determining weight. The contract also includes a shift in responsibilities and ownership for some work processes and activities. From December 2011 Foria is also responsible for constructing and planning the LTL-shipments from the available orders, which means they now have a bigger possibility to impact the way these transports are performed.

Furthermore, the new contract means that Foria now have incentives to plan and perform these transports as effective and efficient as possible. And to quote the chairman of Foria:

"We have to do this in a better way since we won't get any economy in doing it the old way anymore. The price we have negotiated with Lantmännen for this new contract won't cover our expenses for this to be run as it always has. "– Håkan Larsson[3]

The underlying reason for this thesis from Foria's perspective is to gain knowledge of possible efficiency improvements. This through analyzing alternative distribution models in order for them to achieve profit in this new contract so the new contract terms becomes a win-win situation for both Lantmännen and Foria.

4.2 The involved actors

There are currently four different actors involved in these operations. The transport planners at Foria's office in Nyköping, the local haulage contractors performing the physical transports, Lantmännen AB Division Lantbruk[4], who is the supplier of cargo, and the end customer, the farmers purchasing agriculture supplies. The following subchapters will describe them closer.

4.2.1 Transport planners at Foria

In Foria's office in Nyköping sits six transport planners responsible for building and planning shipments from the incoming orders from Lantmännen. This is done manually with the support of IS showing available orders. Figure 28 in Appendix B displays a print screen from the order view from that IS.

Stefan Palmgren at Foria management team compares the job as a transport planner at Foria to the work of an air traffic controller[5]. The job requires a high multitasking skill since the planning and optimization work is done manually. The job does not require a university degree but the work profile generally requires a vocational education to become a qualified transport planner.

[3] Interview/meeting with Foria and Lantmännen management in Nyköping, Sweden, September 22nd 2011
[4] Lantbruk means agriculture in Swedish
[5] Interview/meeting with Foria and Lantmännen management in Nyköping, Sweden, September 22nd 2011

How the transport planners perform their work

The main order information the transport planner use when planning these shipments besides the address where the cargo is heading is:

- The method of delivery *(“Leveranssätt”* in Figure 28*)*
    - Some farmers and some cargo require a different unloading method, i.e. crane, forklift or the farmer might want to unload him or herself.
- First available day when the cargo is available for loading at Västerås *(“1:a dagen då godset finns tillgängligt”* in Figure 28*)*
    - Some orders are available a long time before the last required departure date; this means that they can be planned optimally.
- Last day of delivery *(“Sista dag för leverans* in Figure 28*)*
    - A delivery run for these shipments takes between 1-3 days depending on the number of stops and how widespread the drop-off points are. This means that the transport planner manually needs to estimate when the cargo will be delivered based on other orders on the same truck for the order not to be late. They have a service level requirement of 98% within latest delivery time and currently they are between 96-97%[6].
- Amount/Weight *(“Mängd”* in Figure 28*)*
    - The weight and size of the order is of course vital for the transport planner to know. The cargo is mainly weight dependent but the transport planner needs to manually adjust for some orders that will be limiting when it comes to their size.

With this information the transport planner tries to fill trucks so that orders going to the same region will be loaded together to minimize driving distance as well to try to achieve a high fill rate. Besides this they also take into account where the truck will finish so it is possible to find a return shipment to minimize empty driving.

4.2.2 FORIA ASSOCIATED HAULERS

The haulers that perform these transports are local haulage contractors based in the areas where these transports are performed. The drivers usually have a very good local knowledge and sometimes even personal relationships with the farmers. Many of them have been performing transports in these areas for years or even decades. They often have knowledge about the small roads on the countryside as well as limitations at the different drop-off points that any currently available Information and Communication Technology (ICT) never could replicate.

Difficulties associated with the local haulers

The relationship between Foria and the local haulage contractors makes the situation more complex. These local haulage contractors are also often part of the owning structure of Foria AB and associated to the organization. Foria have an agreement with them to provide

[6] Interview/meeting with Foria and Lantmännen management in Nyköping, Sweden, September 22nd 2011

them with shipments and business. This means that Foria cannot remove the agriculture supplies shipments for these haulers without being able to replace them with other.

4.2.3 The supplier of cargo - Lantmännen AB, Division Lantbruk

Lantmännen Lantbruk develops, manufactures and sells feed for livestock production. They are also a manufacturer and distributer in the crop production area and offer products such as seed, plant nutrients and crop protection products.

All orders for these shipments will be loaded at Lantmännen's logistic center in Västerås. The logistic center has a size of 10 000 m^2 and this is where warehousing; preparation and loading of the products to the farmers are carried out.

Difficulties associated with the loading facilities

There is not an automated warehousing and inventory IS at the logistic center to help and guide the workers. Shipments are prepared with paper notes and there is not any direct Information and Technology (IT) support. Due to the same lack of IT-support the warehouse are sensitive to any personal changes and obviously there is a waste of resources at the warehouse. There is also a higher risk of errors in the orders due to this.

4.2.4 The end customers - The farmers

The drop-off points, i.e. the farmers are wide spread over the counties of Östergötland, Södermanland, Närke, northern Småland, Västmanland and Uppland as is shown in Figure 9

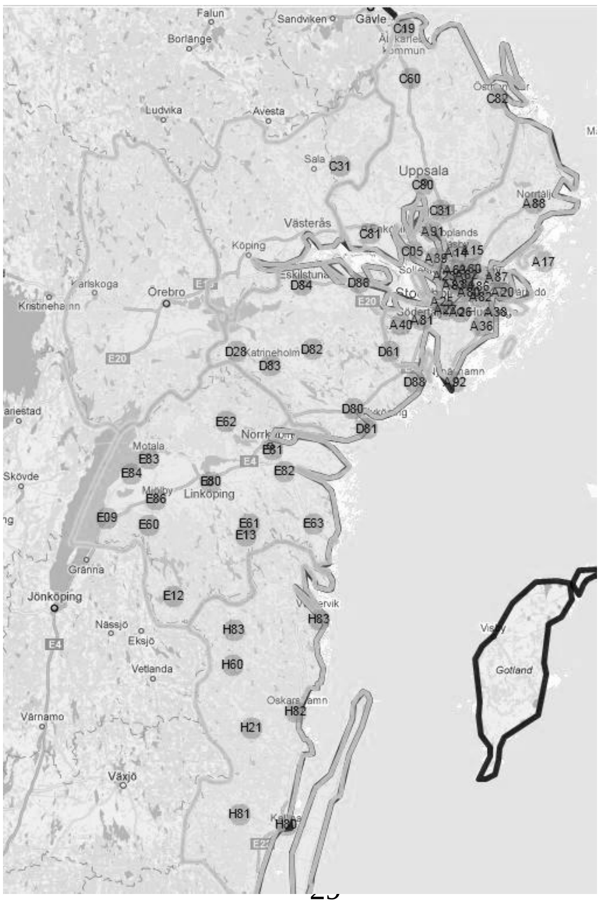

Figure 9 Service Area and sub regions with actual customer visits during 2010-2011

The number of different customers varies from year to year and there is no exact number of how many possible unloading sites they might have to visit. A conservative estimation by the process developer is 2200 possible unloading points, but this figure might go as high as 10000.

The farmers and other drop-off points vary in size. Some of them are big industrial farms, some are smaller family farms, some are very small "part time farms" were the farmer has a different daytime occupation but farming as a sideline occupation, and there are some deliveries to small local distributors of these types of products.

Difficulties associated with the drop-off points

The drop-off points are very wide spread with a lot of small farms located a bit in the outskirts; these are often the "trouble farms". Sometimes farms have a limited accessibility, the roads leading up to the farmer are small dirt roads and weather conditions can make them inoperative with the big trucks currently used. Sometimes there can also be an issue to turn around with a big truck with trailer. The bigger farms usually have designated drop-off zones; this is not always the case with the smaller ones.

The flow to the farmers is very different from the flow from the farmers. The flow from farmers is generally bulk cargo so this means that they cannot pick up goods from the farmers on the same time as they are delivering to them making return shipments harder to find.

Another issue associated normally with smaller one-man farms is that the farmer is quite often not available for receiving the cargo. This is an issue for two reasons; first there is no legal handover and sign off for the cargo. However, drivers do not see this as a big problem since they have a good trusting relationship with the farmers. Secondly, since the many farmers are not available to receive the cargo a common practice among drivers has become to perform extra time consuming work associated with the unloading process. Sometimes it is just something as easy as cover the cargo with a tarp to protect it against the weather, but more time consuming is moving the cargo into a farmhouse or shed. This work is not contracted and therefore not reimbursed.

Related to the above cargo receiving options at certain farms is the fact that some smaller farms are somewhat dependent on this service because they do not have access to an owned forklift. Sometimes small farms would require delivery with a truck that has extended unloading capabilities, which also put limitations to the type vehicle that can be used for delivery to certain farms.

4.3 WHAT THEY ARE TRANSPORTING AND ORDER INFORMATION

The cargo they are transporting could be referred to as general pallet cargo. Most of the shipments are on a regular EU standard sized pallet; however there might be some smaller orders that are on a smaller pallet too. The cargo consists of different agriculture supplies such as seeds, animal feed, salt stones etc., see Figure 26 and Figure 29 in Appendix B. There is no grouping problem of the cargo and everything can be loaded on the same truck.

The average order is about 1500-2000 kg, i.e. 2-3 pallets. But this figure is a little bit deceptive since big farms often order a lot more and smaller farms sometimes down to 200-300 kg, or even less. In general there are few really big orders and a lot of small ones.

The one year historic quantitative data has some errors, especially when it comes to the really small orders; see Figure 25 in Appendix B. However, it shows that around 56% of the orders are at or below one pallet in size, but this is only 8.7% of the total shipped weight.

There is a huge amount of unique articles, this means it is basically impossible to keep small stocks at a transshipment terminal and everything has to be sent directly from Västerås.

Sometimes the shape of the cargo means that they will not naturally fit good on a pallet and parts of the bags will poke out outside the pallet making loading and unloading more difficult. This issue can also be blamed on the workers at the warehouse for loading the pallet poorly.

4.4 CASE FLEET

Due to historic reasons and the fact that farmers need this type of truck during harvest season big 24 meter long HDV with a trailer have been used for these shipments. However, the trucks are specialized for bulk cargo during harvest season; this means that they are purposefully built lower than normal so they can get access into farmhouses for loading of the harvest.

The big HDV + trailer used for this distribution today have their own loading and unloading capacity, either through a long crane or a portable forklift, as can be seen in Figure 10 below.

These trucks are big and costly. This means that they are not very cost effective for driving around and delivering small orders with lots of stops. The unloading capabilities of the trucks are very good, both with the crane and forklift. Sometimes trucks are equipped with both in order to be able to handle a wider range of shipments. But this specialization “in everything” adds to the costs of these trucks and makes them even more expensive to run.

Due to their lower height they cannot load as much volume as normal HDV + trailer type of equipages. This means that they are more suitable for shipping cargo that is weight dependent rather than volume dependent. This makes finding return shipments more complex for the transport planners. They gave an example of isolation material shipments that they also have within their planning flow as something that these trucks cannot ideally be used for[7].

[7] Interview/meeting with Foria’s transport planners in Nyköping, Sweden, September 22nd 2011

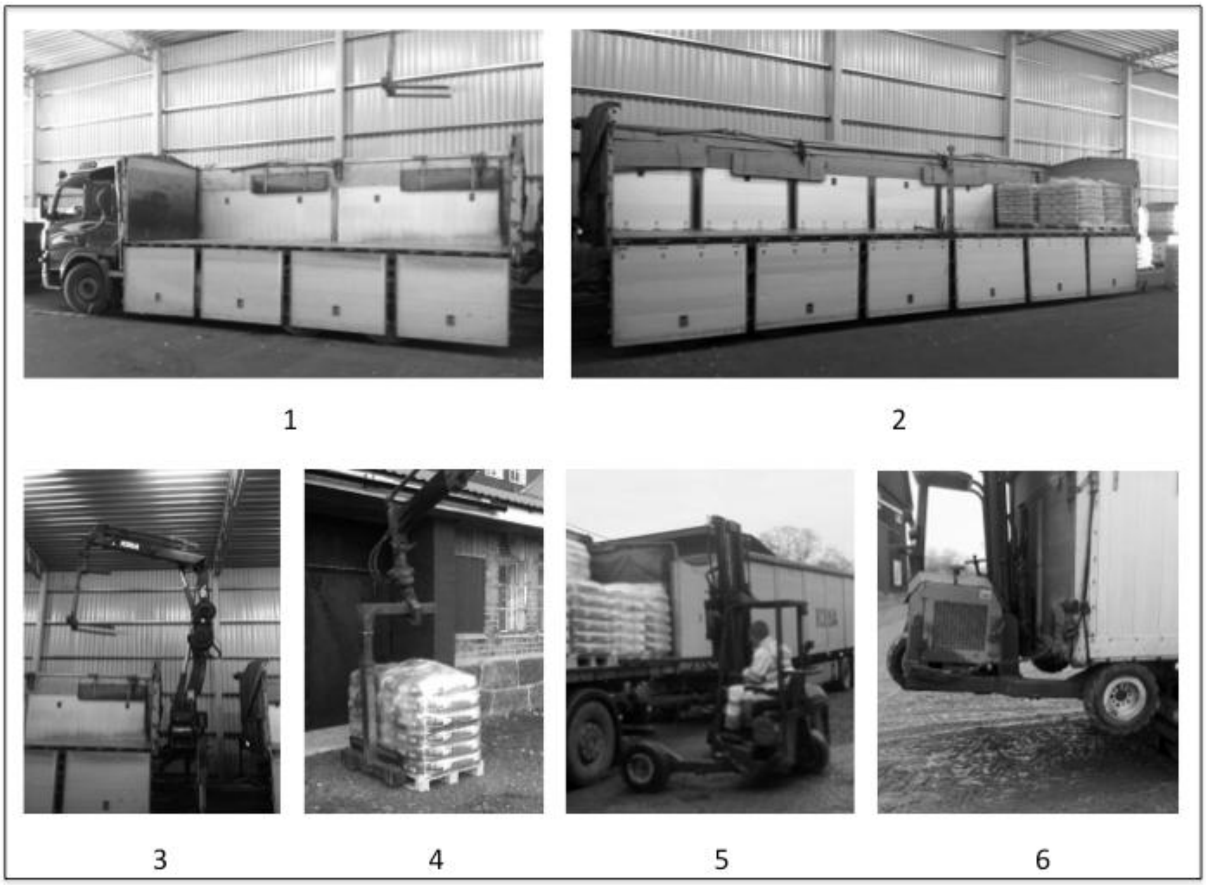

Figure 10 1: The truck, 2: The trailer, 3-4: The crane, 5-6: The portable forklift

4.5 TRANSPORTATIONS COSTS

Foria is a logistics service provider, and for these operations Foria do not own the vehicles that are performing the transports. The trucks are owned by local hauler companies that are associated with Foria both through partnerships and through ownership since the local hauler companies are part of the owner structure of Foria. Since the local hauler companies are part owners of Foria it is contracted that Foria´s tasks include supplying the local haulers with shipments. “Foria drivers” are in this case the local hauler companies and their employed drivers since they are performing these transports in Foria´s name.

This means however that costs can be looked at from two perspectives in this project. The costs for Foria, i.e. the amount they are reimbursing their haulers with per order. This is also Foria associated haulers drivers income for these shipments. This can be compared with the costs for an external solution where some orders could be outsourced to an EDN.

The second viewpoint is the costs for the local haulers, i.e. the costs for the truck and salary to the driver to perform the transportation. This can then be compared with their income, which is the cost for Foria, to measure their profitability.

4.5.1 COSTS FOR FORIA USING THEIR OWN DRIVERS

Foria reimburses their drivers per order depending on that orders weight and distance from Västerås. However, Foria will reimburse the Foria associated drivers with the same amount regardless of the weight from 1-1000 kg. I.e. to send an order of 50 kg 150 km cost them the same as sending as sending an order of 999 kg 150 km from Foria's perspective. From 1000 kg and upward, Foria has 13 different price intervals depending on the weight, which is then multiplied by the orders weight.

According to Foria management they purposefully pay a high amount and make a loss on the small orders in order to motivate Foria associated haulers to accept the small orders on the big trucks. They make up for this through making a higher profit on the bigger shipments.

4.5.2 COSTS TO USE AND EXTERNAL NETWORK PROVIDER

To be able to compare costs Foria has requested an EDN provider to leave a tendering for these shipments. Similar to Foria their cost are also weight and distance dependent. However, they offer 24 different weight dependent price intervals, with 16 of these being in the range 1-1000 kg.

Also differently from Foria, for orders below 1000 kg the distance factor is not directly proportional to the distance from Västerås. Instead the cost is postal code related. This is because the small orders will be sent through transshipment terminal and merged with other cargo flows; see Figure 30 in Appendix B.

For orders bigger than 1000 kg they have 8 different weight dependent price intervals and the distance is like for Foria based on distance from Västerås. To compare these two pricelists a combined price matrix was created, this can be seen in Figure 31 in Appendix B.

4.5.3 FREIGHT CALCULATION AND VOLUMETRIC WEIGHT

The chargeable weight is either the cargos actual weight or the volumetric weight, whatever is the highest. This is calculated according to Swedish industry standard for both Foria and the external network provider.

1 cu m = 280 kg, 1 EU pallet slot = 780 kg, 1 load meter = 1950 kg.

4.5.4 COSTS FOR THE FORIA ASSOCIATED HAULERS

The Foria associated haulers costs for performing these transports are based on costs derived from the Swedish industry standard cost calculation add in to Excel, SåCalc[8].

SåCalc uses fixed and varied costs associated with a certain truck to provide two different numbers that can be used to calculate the cost for performing a certain transport, one based on time and one based on the km driven. Based on the actual transport, if it is mainly time consuming with a lot of waiting time for and stops etc., one would use the time based cost to calculate the costs for the transport, otherwise the distance based number is used.

The cost for the HDV+trailer trucks currently used is 717 SEK/h or 17.6 SEK/km.

[8] http://www.akeriekonomi.se/Sacalc/ScBas.htm

5 THE SIMULATION MODEL

This chapter starts with describing the reasons for the constructed simulation model; following this, a through description of how the simulation model works in detail in the most important parts is presented. How it tries to mimic the behavior of a transport planner, how it creates shipments and simulates a year of transportation. Finally the limitations to the model and how it was validated is presented.

Complementing the qualitative descriptive empirical data, Foria also provided the authors with 12 months of orders data to use as input for numerical analysis of these shipments. In the beginning this raw order data consisted out of over 25000 order lines that through were combined into 9492 individual orders, i.e. 9492 unique visits to a drop-off point.

To be able to compare different distribution scenarios and calculate the impact of different changes to the fleet and order sizes the authors created a simulation model that would enabled analyses on this vast amount of order data. The simulation program was created through first thoroughly perform a process mapping for the shipments, this was subsequently refined and further analyzed until a clear algorithm for how the program should work were attained. This algorithm can be seen in its whole in Appendix A. In the following subchapters a description of how program works and its most important parts are described.

5.1 HOW THE PROGRAM WORKS

The program uses the statistical orders data provided by Foria in a database that was created in MySQL. Based on manual analysis of the data and from input from how transport planners work this data were divided up into two regions working independently, region east and region south. Furthermore a database containing the distances between all of 64 defined sub-regions was manually created. The reasons for this will be described in following subchapters.

Figure 11 Interface of the simulation model

5.1.1 INPUT TO THE PROGRAM

Before running the simulation the user needs to make certain choices in starting screen that affects the output of the simulation, see Figure 11.

First there is selection of which of the two regions that should be simulated.

Then there is a selection of the transit time, which is the time it takes from loading of an order before it is delivered to its destination.

The truck capacity is the next selection, this means that it is possible to decide which sized truck it is that will be performing the transportation and therefore create different scenarios that can be compared with each other.

Next selection is the so called alpha value. This is defined as the distance between drop-off points within the same sub-region. This will be further explained below.

The last two selections are to decide which of the orders in the database that should be considered in the simulation run. By excluding certain weight ranges it is possible to create more types of scenarios that can be compared and analyzed.

5.1.2 OUTPUT FROM THE PROGRAM

When a simulation run is completed, the program produces values that can be used in analyses of different scenarios. With this is output it is possible to give an approximation of how the local haulers will be affected when some of their orders will shipped by someone else e.g. It is also possible to measure the environmental impact of changes to the distribution model. The values given are:

- Total number of shipments by region (East/South)
- Total km driven by region (East/South)
- Average number of km driven per shipment
- Total number of stops
- Average number of stops per shipment
- Number of potential express shipments
- Average load in weight per shipment
- The cost for the year of shipments based on the reimbursement matrix from Foria to their local haulers

5.1.3 WORKING CONDITIONS AND ASSUMPTIONS FOR THE SIMULATION MODEL

- The simulation will start on the first calendar date when an order needs to be shipped according to the transit time (TT). E.g. With a defined TT of 2 days, and the earliest “Till datum” of all data as of Sep-30, the Simulation will start on Sep-28.
- The simulation will run every single calendar day, day by day, until it has finished all the orders in the database.
- The few orders with a weight bigger than 34,000 are assumed to be 34000, i.e. a single direct shipment.

- Express shipments are defined as those orders that need to be delivered before the available time plus the transit time, i.e. making it impossible to deliver them on time.
- When an order has a priority No. is ≤ 1, the order need to be shipped that day.
- In order to calculate the route and distance taken by each truck, the methodology of the greedy algorithm are applied.

5.2 THE ALGORITHM AND ITS PARTS

The program was written in the scripting language PHP. The code follows an algorithm that is validated by the transport planners and Foria management as a valid representation of their work flow step by step.

Basically the algorithm consists of few steps that try to mimic the behavior of a transport planner as well as calculate the distance driven by the created LTL-shipment.

5.2.1 THE START OF THE SIMULATION

Like real life the simulation counts one day at a time and the start for every LTL-shipment build will be triggered by an available order that reaches a so called "Prio1".

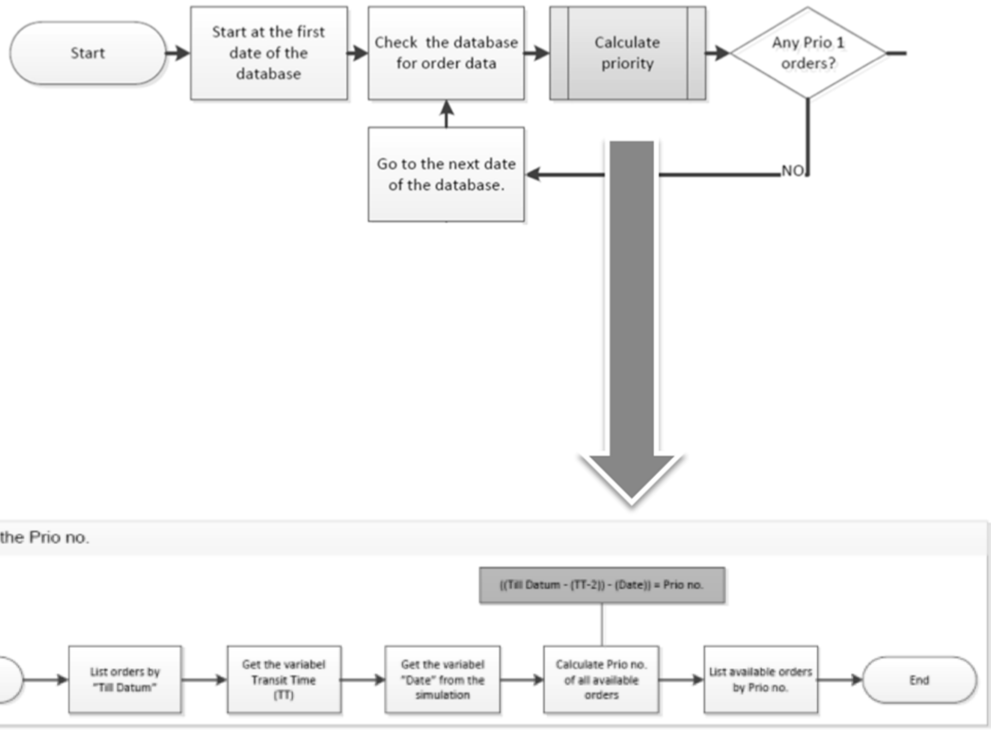

Figure 12 Start of simulation algorithm

Calculation of priority

The sub-process of the priority calculation for each order is very important because it does not only trigger the building of a new LTL-shipment, it will also define when an order will be loaded into a truck. The priority numbers are recalculated every iteration of the simulation, as illustrated in Figure 12. The orders that will need to be loaded first (high priority) on the simulated date are those with priority number ≤ 1.

The calculation of the priority for each order is defined as:

Priority no. = (Till Datum – (TT-2)) – Current Date

Where,

- Till Datum = Date when order need to be delivered
- TT = Transit time
- Current Date = The actual date of the simulation

5.2.2 Choosing one of two different LTL-building processes

Before the construction of a shipment starts, the simulation differentiates depending if (1) there is just one order with a priority number ≤ 1 or (2) several orders have priority number ≤ 1. See Figure 13.

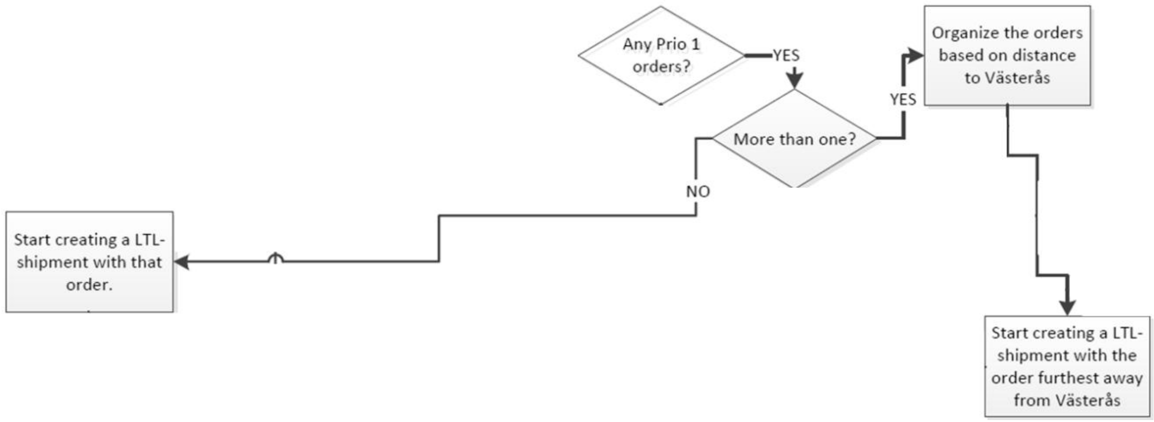

Figure 13 Simulation algorithm, one or several "Prio1" orders

In the former group (1), the simulation continues to fill the shipment by first adding available orders, as from steps in Figure 14 that fit on the truck and also are going to the same sub-region before taking priority order into account.

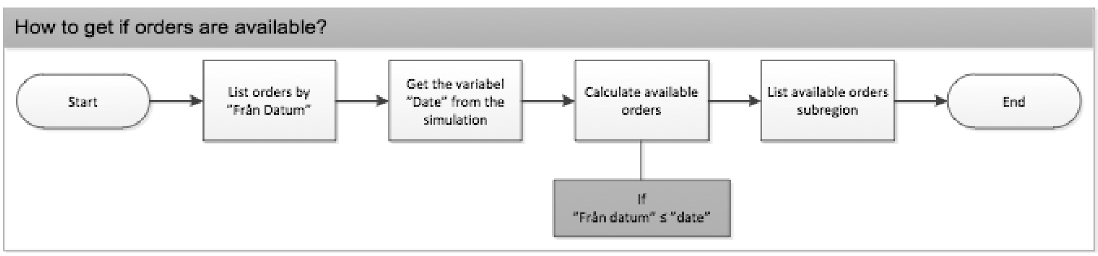

Figure 14 Simulation model available orders

Then, and if there is still space on the truck, other sub-regions available orders are added and listed by distance to the previously loaded sub-region until there are no more orders or the truck is full. This is LTL-shipment creation in based on so called Greedy optimization described by Curtis (2003) for our specific case, optimizing locally with the hope of finding the global optimum. See Figure 15.

In the latter group (2), first all the orders with priority number ≤ 1 are listed by distance to Västerås and the truck starts with order located the further away. The reasons for this is so that it should not be an single Prio1 order left at the end of the simulated day and thus creating a need for an almost empty shipment that needs to travel a long distance, see Figure 13.

When all the available orders going to the same sub-region as the first Prio1 order are loaded on the LTL-shipment, the next process is adding the next available Prio1 that is closest to the previous sub-region. This is because all Prio1 orders have to be shipped during the simulated day and if the truck gets full by other available orders an almost empty shipment could get created. If the truck reaches its capacity without loading all Prio1 orders, a new LTL-shipment will start following exactly the same process. When all the available Prio1 orders are loaded this process starts adding the closest one again in accordance with Greedy optimization described by Curtis (2003). See Figure 16.

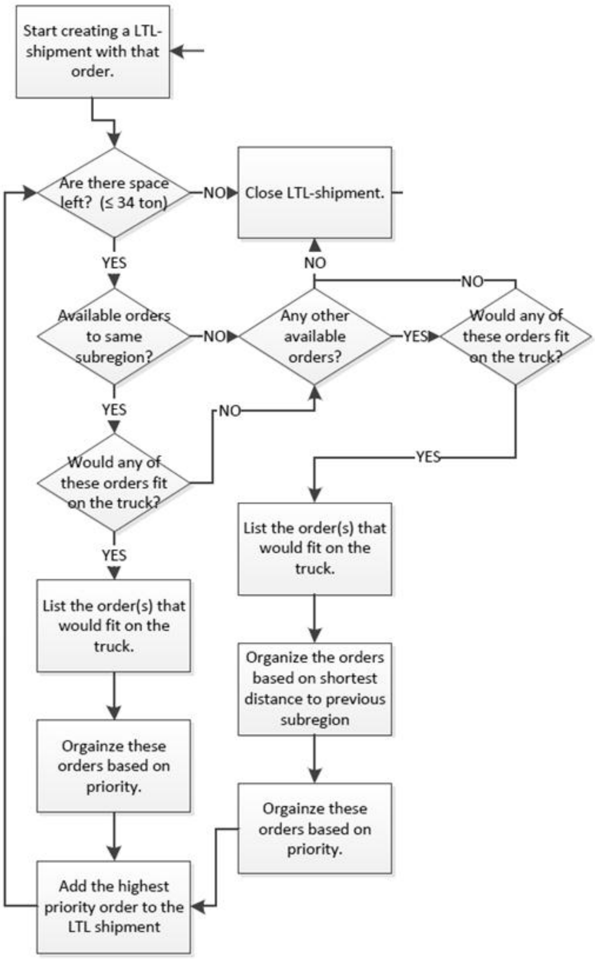

Figure 15 Simulation algorithm, LTL-shipment building process 1

The second LTL-shipment process with several Prio1 orders will most likely not produce as optimized shipments as the first one with only one due to the slight deviation from the Greedy optimization and not adding the closest available order all the time but instead prioritizing the closest Prio1 orders. However, the risk for creating almost empty shipments needs to be mitigated and this is the chosen way.

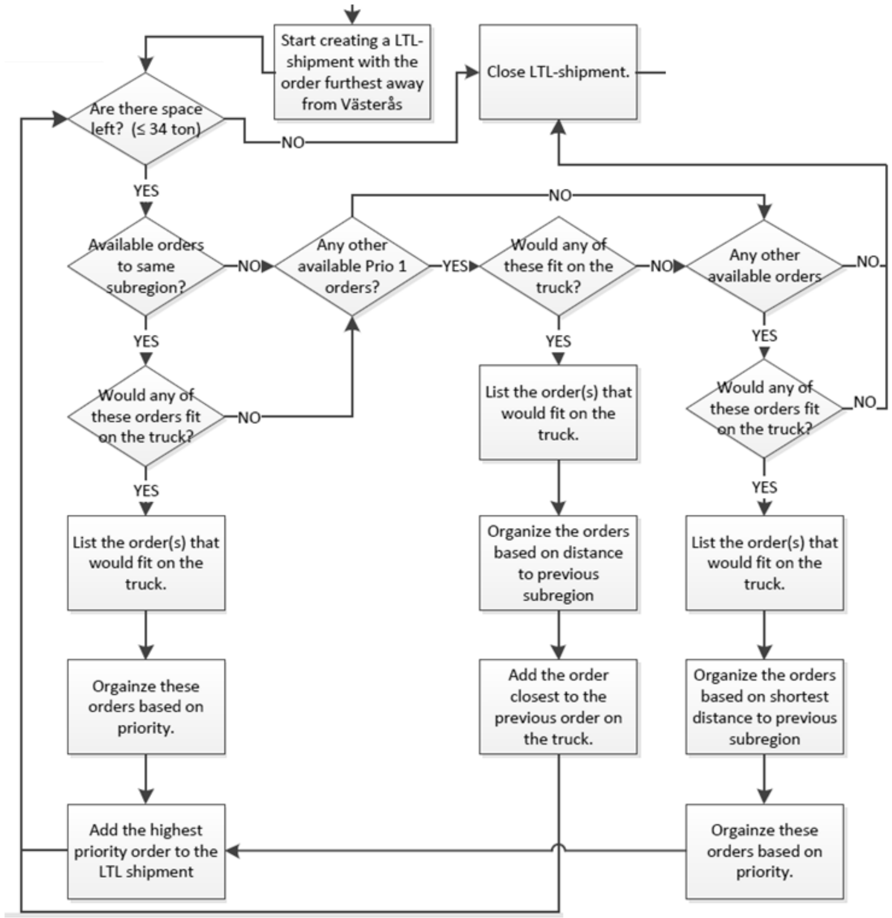

Figure 16 Simulation algorithm, LTL-shipment building process 2

5.2.3 CALCULATION OF THE DISTANCE TRAVELED BY THE TRUCK

Due to a limitation in Google Maps API where only 2500 geographical searches can be made within 24 hours, the simple and ideal scenario of obtaining the distances between customers based on their postal code was not possible.

This problem were solved by manually creating a database were the distances between all the 64 sub-regions were added. Once each shipment is constructed and closed, the traveled distance from sub-region to sub-region are added to the sum of traveled distance, which gives a good approximation of how far the truck has travelled, see Figure 17.

However, one problem existed. What about the distances between stops within the same sub-region? Without any adjustments for this that distance between these two locations would be considered 0 km, this obviously is not the case.

In order to cope with this problem, an estimated distance between drop-off points within sub-regions, called alpha (α) is added to the total distance for each time a sub-region is visited more than once during a LTL-shipment, see Figure 18. Alpha is further explained below.

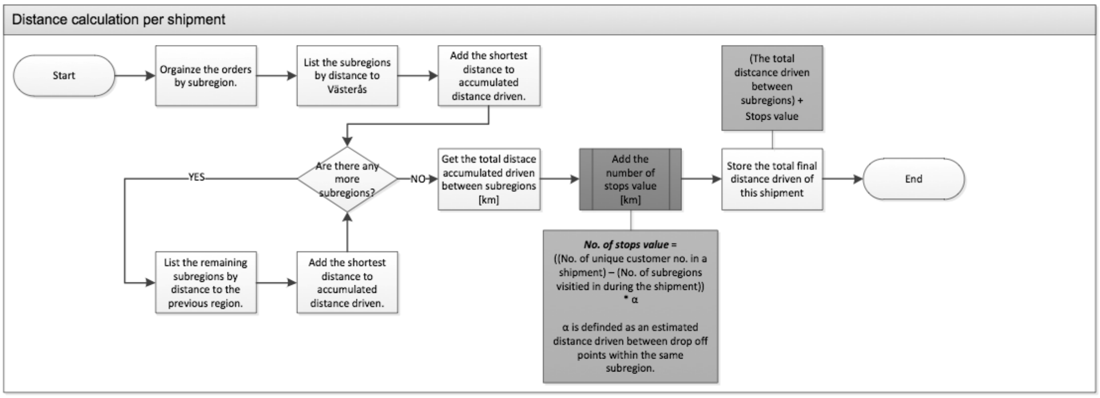

Figure 17 Simulation Algorithm, distance calculation

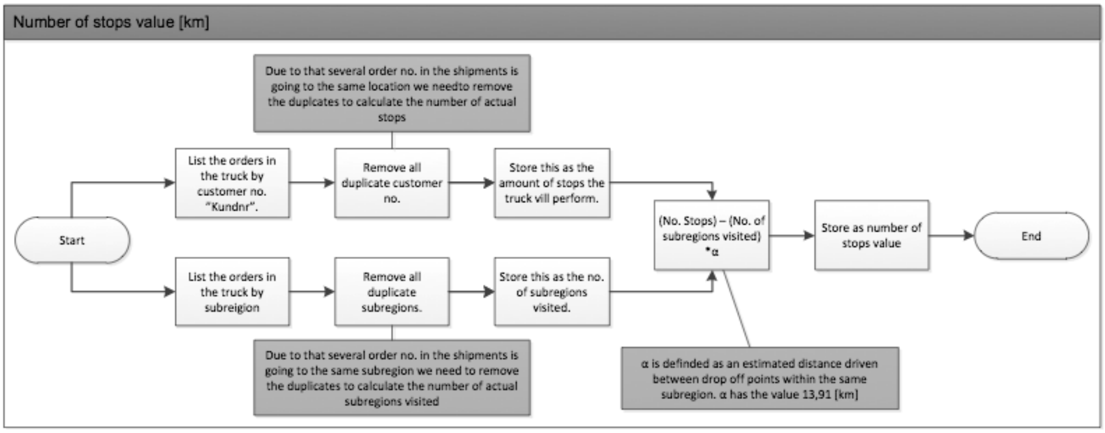

Figure 18 Simulation Algorithm, alpha calculation

5.2.4 HOW ALPHA WAS ESTIMATED

In order to define the likely distance alpha (α) between farms located in the same sub-region, the quantity of orders or visits in the sub-region was the criteria considered to rank the sub-regions.

From the empirical data the 20 sub-regions with the highest number of orders were obtained as displayed in Figure 19. It was decided to use 30% of the Sub-regions (20 sub-regions) because they hold 70% of the total orders (6291 orders), which is a close enough approximation to the 80-20 Pareto rule.

Then by using a scaled map of Sweden, see Appendix G, an estimated mean distance, from North to South and East to West, for each one of the top 20 sub-regions were gathered as shown in Table 10.

Following this the alpha values for each of the regions were calculated with Equation 1. The average value of all 20 "α"were then obtained it is defined as the distance between a farm and another farm within the same sub-region, i.e. 13.91 km.

$$\alpha = \frac{(E \dashrightarrow W\ distance) + (N \dashrightarrow S\ distance)}{4}$$

Equation 1 Alpha Estimation

The above formula it is calculated an approximation of the distance to the center, which is the average distance between two randomly located points a certain area.

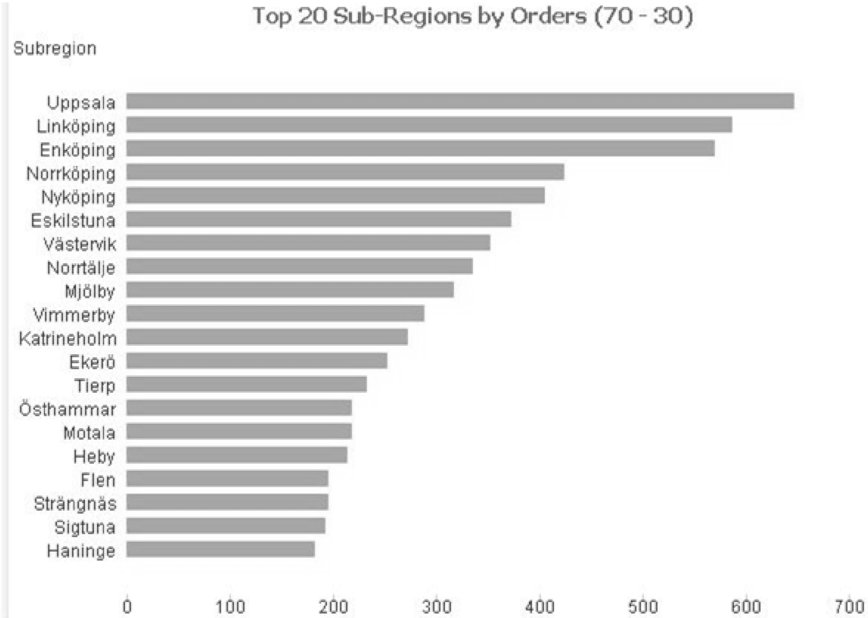

Figure 19 Top 20 sub-regions with unique visits

Table 10 Calculation of alpha value

No.	Sub-Region	Visits (Orders)	Approx. Area (km^2)	Av. Distance (km) East to West	Av. Distance (km) North to South	α
1	**Uppsala**	647	240	43.33	30.71	18.51
2	**Linköping**	587	140	23.5	41.25	16.1875
3	**Enköping**	570	110	32.5	30	15.625
4	**Norrköping**	424	180	39	21.42	15.105
5	**Nyköping**	405	140	29	21.25	12.5625
6	**Eskilstuna**	373	120	36.25	25	15.3125
7	**Västervik**	352	200	32.14	50	20.535
8	**Norrtälje**	336	220	35.71	37.5	18.3025
9	**Mjölby**	317	55	17	18.3	8.825
10	**Vimmerby**	288	120	32.5	24	14.125
11	**Katrineholm**	272	110	24	36.6	15.15
12	**Ekerö**	252	40	20	10	7.5
13	**Tierp**	233	150	30	35	16.25
14	**Östhammar**	219	160	37.5	28	16.375
15	**Motala**	218	100	22	28.75	12.6875
16	**Heby**	214	130	24	38.33	15.5825
17	**Flen**	196	80	22.5	32.5	13.75
18	**Strängnäs**	195	70	23.33	28.33	12.915
19	**Sigtuna**	192	25	12.5	11.6	6.025
20	**Haninge**	182	40	16	11.25	6.8125
					Av. α	**13.906875**
					St. deviation (σ)	3.944480477
					Plus σ	17.85135548
					Minus σ	9.962394523

Why alpha was estimated like this?

In order for one alpha to appear in our simulation model a shipment must have two unique customer numbers within the same sub-region, i.e. two unique stops in that sub-region during the same shipment. During one year of simulation each region will get between 280-290 unique shipments. This implies that sub-regions with around 285 unique visits will on average get one visit per shipment and will on average ”never” generate any need for alpha. However, our model optimizes the distance and will try to gather all the available orders to one sub-region on the same shipment and therefore sub-regions well below the average of one order per shipment will generate the need for alpha’s to be added to the accumulated distance and thus needs to be added to the sub-regions estimating the average alpha.

When analyzing all the sub-regions based on number of visits it is evident that the bigger ones are among the ones most frequently visited, this is also intuitive since they should have room for more drop-off points. When calculating the mean alpha it can then be tempting to add weights based on the amount of visits to a region since these regions will generate more alphas. However, for every added drop-off point within a sub-region during the same shipment the distance between them will decrease and the second, third, and so on alpha added for a specific sub-region on the same shipment should actually be smaller and smaller. A simplification that compensates this is to let the mean alpha be dragged down by the smaller regions in the top 20 not visited as often as the others.

Sensitivity analysis of alpha

Running the simulation with alpha values of $\alpha \pm \sigma$ enabled to perform a sensitivity analysis of the calculated alpha. The results and conclusions of this analysis is that the effect of the use of a general average alpha value for all sub-regions equally, will provide a potential error of around 6% of the estimated total km driven in year data. Thus and with 95% certainty it is possible to conclude that the error is not significant for the results. (Appendix L)

5.2.5 VALIDATION OF MODEL

To validate our simulation model a sample of 15 random shipments was chosen and manually, with an optimization tool called Geomap, the best route distance for these shipments were examined. Geomap uses Google maps and calculates the best route and then presents that route visually so the user can confirm that these results are valid, presentation of this can be found in Appendix K. The difference in distance from our simulation results and the real world distance from these shipments are presented below in Table 11. These results were then loaded into the statistical analysis software SPSS and the results from that are presented below in Table 12.

The results are mainly negative which means that the simulation model is expected to calculate the distance a bit short. With 99% certainty that the average distance error per shipment will be within the range of 9.7 km to long and 70.8 km to short. The average value of error is estimated at 30.6 km to short per shipment. The average distance calculated by our model is 567.64 km per shipment. This means that the error in distance in our simulation with 99% certainty lies between 1.71% to long and 12.48% to short, on average the error is 5.38%. Since the cost for carrier depends on the distance driven, but the reimbursement from Foria to the carriers are a fixed number per shipment this will heavily affect the profitability for the carriers.

Table 11 Simulation distances and real world distances

	Distance value from our simulation (km)	Value from Geomap (km)	Model value minus Geomap (km)	Percentage error
1	633,46	564	69,46	12,32%
2	457,89	494	-36,11	-7,31%
3	683,41	806	-122,59	-15,21%
4	463,26	537	-73,74	-13,73%
5	569,89	576	-6,11	-1,06%
6	562,09	639	-76,91	-12,04%
7	436,02	441	-4,98	-1,13%
8	696,56	730	-33,44	-4,58%
9	741,23	751	-9,77	-1,30%
10	445,11	475	-29,89	-6,29%
11	462,09	501	-38,91	-7,77%
12	432,85	388	44,85	11,56%
13	506,44	613	-106,56	-17,38%
14	655,98	639	16,98	2,66%
15	743,37	794	-50,63	-6,38%
Sum	8489,65	8948	-458,35	-5,12%

Table 12 Confidence interval calculation of simulation distances

Descriptives				
			Statistic	Std. Error
Model value minus GeoMap	Mean		-30,55667	13,523439
	99% Confidence Interval for Mean	Lower Bound	-70,81382	
		Upper Bound	9,70048	
	5% Trimmed Mean		-31,00019	
	Median		-33,44000	
	Variance		2743,251	
	Std. Deviation		52,376052	
	Minimum		-122,590	
	Maximum		69,460	
	Range		192,050	
	Interquartile Range		68,760	
	Skewness		,097	,580
	Kurtosis		-,092	1,121

5.2.6 Delimitations to the simulation model

A sub-region specific alpha could have been added directly into the simulation as well as for every added visit to a sub-region during a shipment the estimated value of alpha should have been decreased for that shipment. This would however require a lot more coding and make this already quite complex simulation even more complex.

Furthermore, the distance between farms are not a linear and drivers will sometimes have to drive a lot longer to get from one drop-off point to another

Finally, it is not unreasonable to assume that many drop-off points , the farms, are often close to each other due to that the land where farming is possible is limited and certain areas are more suitable for this type of undertaking.

Possible future developments to the model

The estimation of distance between two drop of points within a sub-region, alpha, can through systematic and rigorous analysis be further improved.

6 ANALYSES

In this chapter theory and empirical findings form the base for analysis. An initial problem analysis of the focal company´s situation within the agriculture supplies distribution identifies thirteen problems. Possible solutions to the identified problems are examined with three analyses from three perspectives; financial perspective, haulers perspective, and environmental perspective. These analyses will then acts as a reference from which general efficiency improvements can be sought in the research area of improving transport efficiency of general cargo from a central warehouse.

RQ1 is focal company specific and RQ2 aims at making the situation specific findings from the reference case general in terms of transportation efficiency improvements. The analysis chapter therefore departs from a root cause analysis of problems for the agriculture supplies distribution today performed by the focal company Foria, which will act as reference for a general case with distribution of general cargo.

This root cause analysis is performed in order to be able to answer RQ1-1, “What transport efficiency improvements should be implemented at Foria to increase the financial sustainability for the agriculture supplies distribution?” Furthermore, this acts as a starting point for an analysis in a general perspective about transportation efficiency. Following the identification of problems specific to the studied operations, solutions to these are sought both in the context of the studied distribution of agriculture supplies, in addition to transportation efficiency improvements that could be generalized from this reference case.

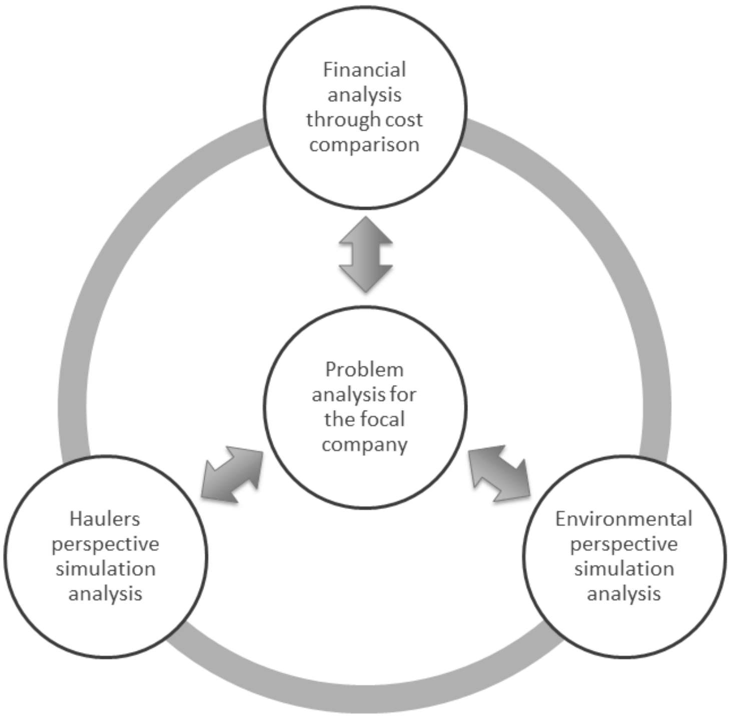

Figure 20 Relationship of the three numerical analyses

Thirteen possible solutions to the identified problems are qualitatively proposed. Out of these thirteen, three related to T&D network design are further analyzed quantitatively through a financial analysis[9] of costs, a simulation model[10] analysis from a haulers perspective, and a simulation model analysis from an environmental performance perspective. These three numerical analyses are independently performed but they are all connected to the identified problems for the studied agriculture supplies distribution (see Figure 20).

Two different distribution network improvements are suggested as part of the thirteen possible solutions. The financial analysis analyzes the impact of including a transshipment terminal in their distribution model as well as enabling the authors to answer RQ1-2, "How high are the possible financial gains for the focal company Foria?" The simulation model analyses analyzes the impact of applying a vehicle differentiation strategy to the distribution of agriculture supplies and enables the authors to answer RQ1-3, "What environmental effects will the proposed transport efficiency improvements render?" and RQ1-4, "How will proposed changes affect the local hauler companies that today perform these transports?".

A combination and qualitative analysis of the outcomes from the three different numerical analyses will enable the authors to evaluate RQ2, "How can distribution of general cargo from a central warehouse to a wide array of drop-of points become more sustainable?"

6.1 Root cause problem analysis of the agriculture supplies distribution

As the starting point in the root-cause problem analysis of the studied case the authors first assume that the professionals at the focal company are accurate in their appreciation of the situation: their old way of working won't be profitable for them in the future. Hence the starting question "Why will the old distribution model not be profitable in the future for Foria?"

As a second step this questions is broken down into three groups based on different process stages in the distribution as well as ownership of these processes. Finally, "why question analysis" towards each of these group, based on empirical findings from the case study and specific to this distribution of agriculture supplies, were performed and thirteen problems are identified. The contents of the root cause analysis are presented in Figure 21, which is comprehensively explained below.

[9] The financial analysis measures the impact to Foria's financial results of adding the option to use an EDN with a transshipment terminal for certain orders based on size and region. A better financial performance is not conclusive evidence for better transportation efficiency, it does however imply it.

[10] The simulation analysis from the hauler perspective measures the impact on what would happen to the hauler partner's profits when removing certain shipments (based on size) from their transport operations and send them through a another channel. Furthermore, the simulation analyses also measures the amount of km´s driven with each vehicle to perform the transports giving a direct indicator of transportation efficiency.

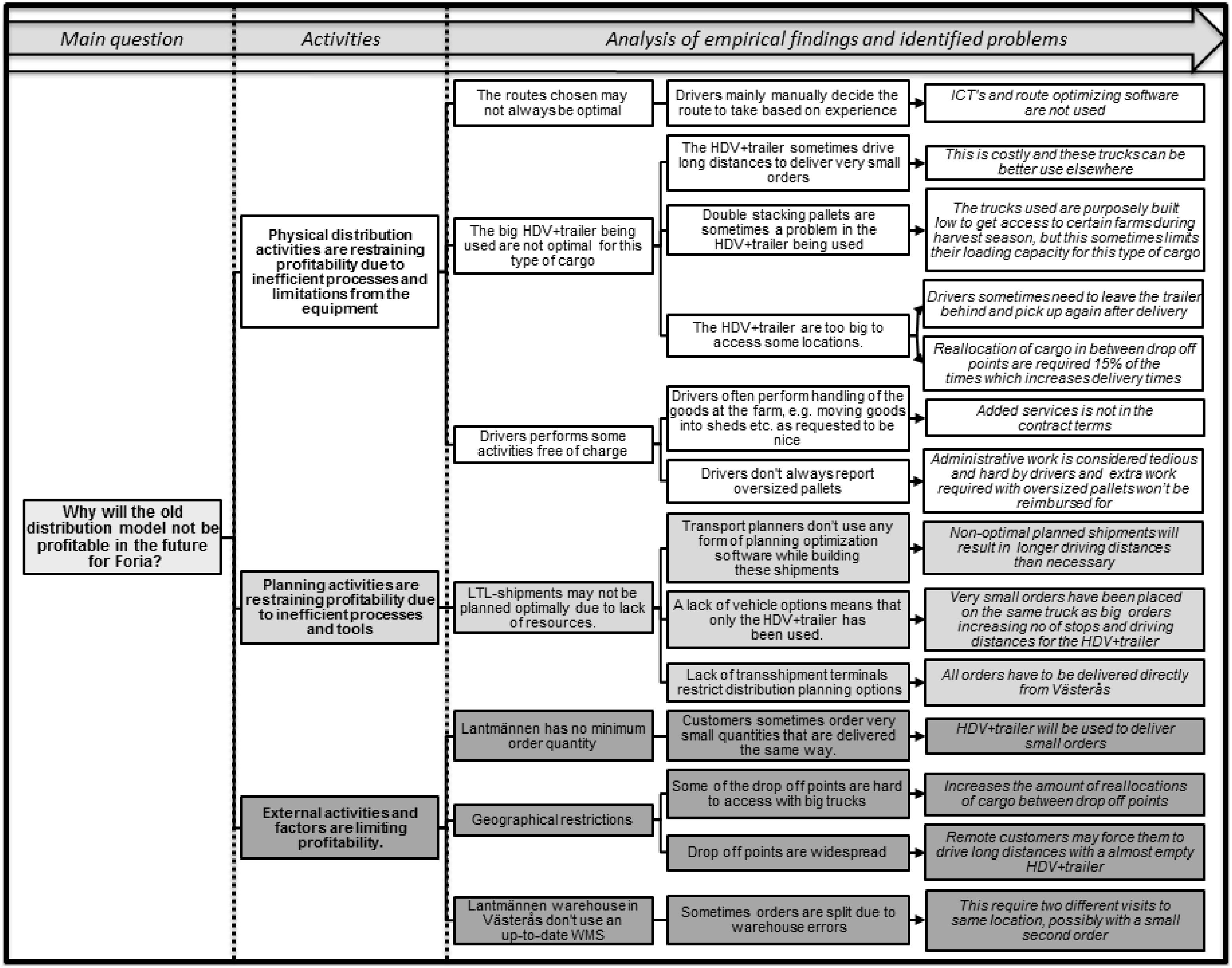

Figure 21 Root cause analysis of problems for the case studied

6.1.1 PHYSICAL DISTRIBUTION ACTIVITIES RESTRAINING PROFITABILITY

The top group of the root causes problem analysis focus on the last actual transportation part of the entire distribution process. The ones performing these processes today in the reference case are the hauler companies associated with the focal company and ultimately the drivers working there. Identified root causes to transport inefficiencies were searched for, both from an equipment viewpoint and execution a viewpoint based on findings from empirical data collection.

The routes chosen may not be optimal

It is the driver that in the end chooses which routes to take when delivering the cargo. Today this is mainly done manually based on experience and through simply looking at a map. Even though ICT's and route optimization software are readily available in many cases, they are often not used. E.g. during one of the field studies it became know that one of the truck drivers had a total of four different Geographical Positioning Systems (GPS) devices at his disposal. He had not however had any formal training on any of them and where not able to use all the available functionality from them. Normally this does not end up being a problem since the drivers often know the area well. They often know how to navigate better than any currently available GPS could suggest since the big trucks are restricted from entering certain roads. However, situations could arise when new drivers are learning or a new customer is about to be visited for the first time, this is when ICT's could be helpful and increase transport efficiency.

The HDV+trailer being used are not optimal for this type of cargo

Due to their sheer size the HDV+trailer are costly to operate but they can load a lot of cargo. Generally trucks of this size are used to deliver bigger orders, not small orders in the range of 1-100 kg as they are often being used for with these shipments.

Many of the HDV+trailer used are intentionally built low in order to be able to drive into farmhouses during harvest season and transport their grains as bulk cargo. This however means that sometimes double-stacking pallets become a problem when because this might become too high. So even though the big HDV-trucks are effective and performs these transports, their size means that they are not very transport efficient for this type of cargo.

Many of the drop-off point are at small farms out in the countryside and the roads here are often not of a very high standard. Normally small dirt roads cannot take the weight of the full carriage, especially during the wet season. The trucks size might also inhibit them from being able to turn around at the farm and get out at the farm due its size. Both of these issues means that sometimes the truck drivers need to park and leave the trailer behind at the side of the road because they could only access the farm with the truck alone. If the driver is going back the same way this could in the best-case scenario mean that he only loses a little bit of time for leaving and reattaching the trailer. Worse case-scenario the driver needs to go back to collect the trailer again before driving to the next drop-off point, adding both time and fuel consumption.

This truck size is also a cause to the problem with reallocation of cargo. Currently the drivers needs move cargo between truck and trailer 15% of the times because the full carriage won't get access to the next farm and pallets are loaded in the trailer.

Drivers perform some activities free of charge

As mention in chapter 4, it is not uncommon that there is no one at the farm to receive the cargo since the farmers might be off working somewhere on the farm or elsewhere. It has become common practice among drivers to help the farmers with some of the unloading activities and they spend time moving cargo into farmhouses or sheds. Of course it is nothing wrong with them performing these tasks per se, however today this is not in the contract terms and this work is unreimbursed and costing valuable time. Moreover, the drivers sometimes overlooks the fact that some of the pallets loaded at Västerås terminal are oversized and ignores to report this due to that this administrative work is considered a bit "tedious", and time-consuming since it should be done at a ICT-device from Foria. This means that the extra work associated with oversized pallets will not be reimbursed.

6.1.2 PLANNING ACTIVITIES ARE RESTRAINING PROFITABILITY

The middle group of the root causes analysis focus on activities during the planning stage. This is where the focal company Foria owns and controls the work processes themselves. Empirical findings indicated that resources were restraining planning possibilities and affected transport efficiency and profitability for Foria; hence this gave the starting point for analysis of this activity group.

LTL-shipments may not be planned optimally due to lack of resources

The transport planner plans these LTL-shipments manually, and human tacit knowledge is necessary for planning these shipments due to irregular limitations and restrictions such as special vehicle sizes. However, even though he has IS support, the amount of data the transport planner manually needs to keep track of is immense. Human error is likely to happen now and then regardless of how good a transport planner is at his job, which will result in that the trucks will driver a longer distance than necessary.

In the planning process all the orders are treated the same regardless of their size or destination, i.e. they are treated as LTL-order in a flow from Lantmännen´s warehouse in Västerås that should be loaded onto a HDV+trailer and sent to their destination on a peddling run within their delivery window.

This is not because the transport planners are incapable of planning in another way, it is merely because they have no options of different vehicle types or access to e.g. a transshipment terminal to merge with other cargo flows. The result is that small orders are shipped on the same truck as bigger orders and the HDV+trailer needs make more time consuming stops and sometimes drive long distances to deliver small orders not generating high revenues but still causing high costs for the haulers.

6.1.3 External activities and factors are limiting profitability

The third group of the root cause analysis focus on factors and activities not owned or directly managed by Foria in the distribution process. However, external factors and activities cause inefficiencies for these shipments and the identification of these is important in order to try be able influence partners, adjust planning and transportation activities to minimize their impact or just be aware of what is causing the transportation efficiencies and limiting profitability .

Lantmännen has no minimum order quantity

Lantmännen has no minimum order quantity and some of the farmers take advantage from this and are ordering really small batches. Of course small farmers should not have to order more than they need, but Lantmännen has no customer differentiation strategy and all orders are sent through the same channel. This currently results in that the HDV+trailer will be used to deliver very small orders, sometimes more suitable for the post office.

Geographical restrictions

As mentioned above some farms are hard to access with big trucks, which increases reallocations of cargo in between stops and the need to stop and drop of the trailer before performing the delivery. Furthermore, the area that is covered from Västerås is rather big and farms are spread out over a vast area, quite a few farms, often the smaller ones, are far out on the countryside and these remote customers may force the HDV+trailer to drive long distances to deliver a very small order.

Lantmännen warehouse in Västerås do not use an up-to-date WMS

The loading point for these shipment, Lantmännen´s warehouse in Västerås do not use an up-to-date WMS. The personnel get a pick-list on a piece of paper but it is only their experience and knowledge about where items are stored in the warehouse that will help them find the items that are to be picked. There is no linked WMS that knows exactly how many of specific items that are left and where in the warehouse they are stored. This means that sometimes orders to the same farmer will be split due to warehouse errors, which is causes Foria to have to plan another trip to the same location, most likely with a small second order.

6.2 Visualization framework

To improve the comprehensiveness of the root cause analysis the identified problems were translated to the visualization framework developed for hauler firms by Allenström & Linger (2010), see Table 13 below. This visualization model makes the root causes analysis more comprehensible for the reader, and it is also suitable for practically addressing problems since it does not only describe a problem, it also defines where and when the problem occurs. The model also traces a problem upstream, in the figure this is shown through number coding. Reading from left to right it is possible trace problems and effects that has the same number and if the problem occurs within the same horizontal column this is done through "X:Y", where Y show the order. The visualization model approach is also used below (see Table 14) as a mean to present solutions that can mitigate the discovered problems.

Table 13 Visualization framework adapted from Allenström & Linger (2010)

	Shipper	Order entry	Planning & traffic control	Transport execution	Invoicing & registration
Routines	**10** LTL-shipments has been built without route optimizing in mind		**9** LTL-shipments are planned without route optimizing software	**8:3, 9, 10,** The HDV+trailer might have been driving longer distances than necessary	
				8:2 Drivers mainly manually decide the route to take based on experience	
		4 All orders are treated the same regardless of size, destination etc.	**4** Very small orders have been placed on the same HDV+trailer as bigger ones		
Manpower & Management	**5** Pallets are sometimes oversized			**5** Drivers do not always report oversized pallets	**5** Extra work required with oversized pallets won't be reimbursed
			3 Need to plan extra visits, most likely with a small orders due to warehouse errors	**7** Drivers perform unpaid handling of the goods at the farms, e.g. moving goods into sheds etc.	**7** Added service is not in the contracted terms
				8:1 ICT's and route optimizing software are not used due an technical inability	
Equipment	**3** Västerås warehouse do not use an up to date WMS	**3** Often orders are split due to warehouse errors (lack of IT)	**1** Lack of vehicle options means that only the HDV+trailer are used	**1, 2, 3, 4, 6** Costly vehicles are driven long distances to deliver very small orders	
				2 All orders have to be delivered directly from Västerås	
			2 Lack of transshipment terminals restrict distribution planning options	**11** The trucks used are purposely built low to get access to certain farms during harvest season	
Environment	**6** Lantmännen has no MOQ defined.	**6** Customers sometimes order very small quantities.		**13** Some farms are hard to access increasing the amount of cargo reallocations	
	12 Lantmännen lack of customer categorization			**13** Weather conditions, especially in winter time affect the accessibility to the farms	
				12 Remote customers may force to drive long distances with an almost empty HDV+trailer	

6.3 HOW TO ADDRESS THE CASE COMPANY´S PROBLEMS

The root cause analysis identified how different activities have different problems, sometimes similar and related to each other. Improved visualization of the identified problems in Allenström & Linger´s (2010) visualization framework for hauler firms showed where and when problems occurred. This part of the analysis chapter contains a qualitatively based set of solution proposals to the identified problems. A total of thirteen possible solutions are presented, out of these three are related distribution and transportation network design and two different changes to the distribution model are thoroughly presented and numerically analyzed in following subchapters.

Lastly, the above used same visualization framework is used to present the thirteen solutions to the issues and problems identified in the root cause analysis (See Table 14 below.) In this table the ten solutions with blue background are limited to the qualitatively based suggestions of solutions. However, for the three solutions with orange background a deeper analysis is made through a financial analysis in Qlikview and simulation model analyses in a program created to simulate a year of these shipments. These analyses are based on the following changes to the current distributions model.

6.3.1 PROPOSALS OF DIFFERENT DISTRIBUTIONS MODELS

To mitigate the many of the issues mentioned in chapter 5, two different distribution models are proposed and analyzed: vehicle differentiation and use of transshipment terminal.

Considering the particularities of the agriculture transportation activities perform by Foria, these two proposals are based on the six different distribution models designs proposed and explained further in the literature review chapter. Addressing both cost criteria and service criteria as in Sharma et al. (2008) framework it was considered this two arrangements as the most suitable for the improvement of the logistic performance of the company.

Vehicle differentiation

The first change to the distribution model thought of was to include more options to the

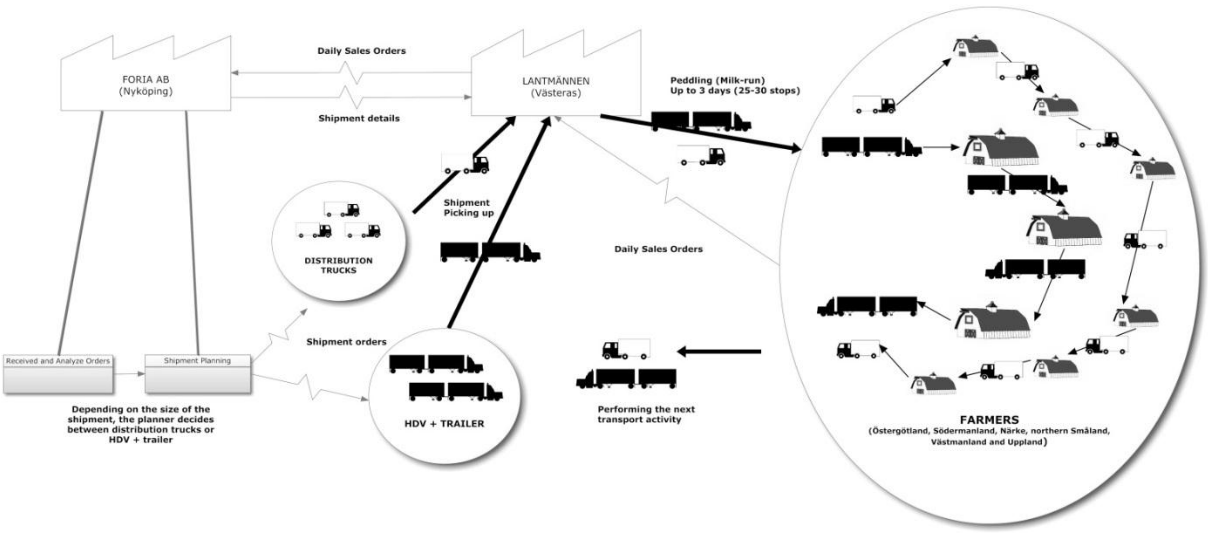

Figure 22 Vehicle differentiation

transport planner in the form of vehicle types. See Figure 22. I.e. instead of only having the big HDV+trailer to plan with smaller orders could instead be shipped with a smaller truck directly from Västerås and only orders big enough would be sent with a HDV+trailer.

Routing differentiation with transshipment terminals

The second change to the distribution model thought of was to include more options to the transport planner in the form of routing options. The option thought of was to send smaller orders to a transshipment terminal from where they would then be sent out with a more appropriate vehicle to solve the last mile problem with small orders.

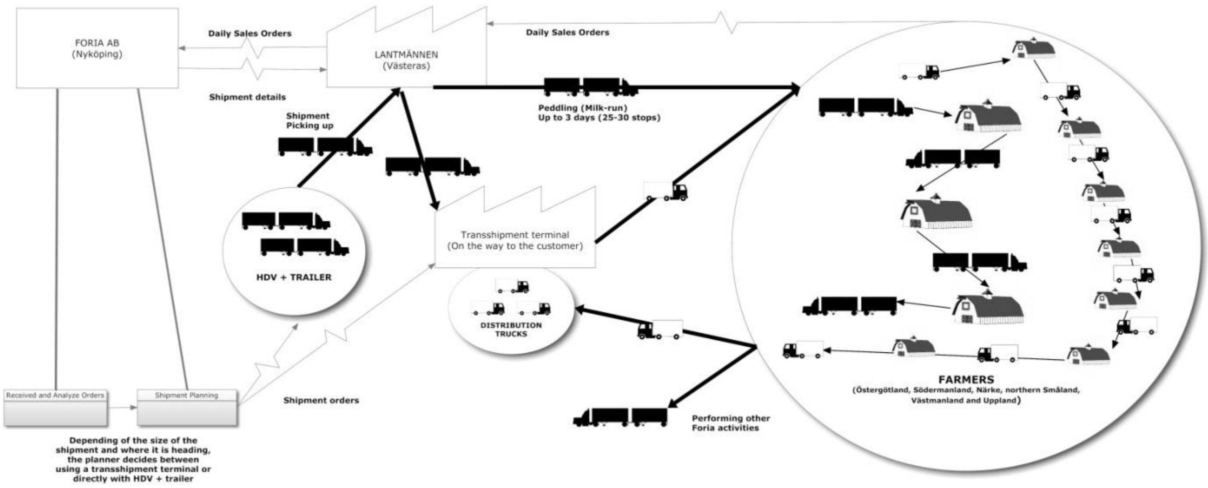

Figure 23 Distribution setup with a transshipment terminal

6.3.2 How would the focal company be able to implement these solutions?

The transport planners would most likely be able to handle an added option vehicle size in their planning process. And the focal company Foria has close partnerships with several hauler companies within that area. For a vehicle differentiation solution it should be likely that some of their partners would be able to provide these operations with more size appropriate trucks and thus costing less.

For the transshipment terminal approach the only possible solution for Foria at this stage is to use an outsourced service through an external distribution network (EDN) partner. Exactly how they would execute the distribution is impossible to say. The analyzed EDN partner has an existing network of terminals that they would most likely use and merges this flow with their existing flow of cargo. Which routes they will take is however impossible to predict. They will pick up the outsourced orders in Västerås at a fixed price based on weight and destination of the shipment.

Table 14 Solutions to the issues identified in the root cause analysis presented through Allenström & Linger (2010) visualization framework

	Shipper	Order entry	Planning & traffic control	Transport execution	Invoicing & registration
Routines	* Plan shipments using all available information not only delivery date	* Segregate orders by size and location	* Make use of route optimizing software as support for LTL shipment planning	*Be clearer to drivers what type of work activities is included at different locations * Make use of supporting ICT's and optimization tools	
Manpower & Management	* Avoid the use of oversized pallets			*Be clearer to drivers what type of work activities is included at different locations * Educate drivers to report all extra work required due to e.g. oversized pallets	* Contract and then charge activities that is still requested
Equipment	* Propose warehouse improvements in Västerås		* Different vehicle options *Add transshipment terminals as routing option	*Use smaller trucks for small orders	
Environment	* Propose Lantmännen to introduce a MOQ and customer categorization		*Investigate alternate distribution channels for customers purchasing small QTY *Influence Lantmännen for correct consolidation	* Use truck with better accessibility in order to cope with geographical limitations	

6.4 FINANCIAL ANALYSIS

Through the use of the software Qlikview[11], a financial price analysis was performed by comparing Foria's price matrix against the EDN partner price matrix and then being able to identify the breakpoint where is economically viable to outsource.

The "real magic" behind Qlikview is the loaded data itself, which is actually the base of successful results. Therefore if the data loaded into the software is incorrect, the entire Qlikview analysis will be worthless. For this analysis, an excel file was created (Appendix B, Figure 30 & Figure 31) where both prices matrices (Foria and the EDN) were identically matched to work together with no problem in any weight range of interest. This prices matrices file were loaded in Qlikview and the analysis was carried out. An overview of Qlikview is presented in the Appendix F (Figure 32 & Figure 33).

6.4.1 FORIA PRICE STRUCTURE

The total cost obtained for the 12 months of data, where 9492 orders were loaded into Qlikview by using the Foria price matrix as input is summarized in Table 15.

Table 15. Foria price structure obtained in Qlikview.

Foria	
Total count	*9492*
Sum	*7,167,603.483*
Average	*755.120*
Min	*454.239*
Max	*19,349.400*

6.4.2 EDN PRICE STRUCTURE

The total cost obtained for the 12 months of data, where 9492 orders were loaded into Qlikview by using the EDN partner price matrix as input is summarized in Table 16.

Table 16. EDN price structure obtained in Qlikview.

EDN	
Total count	*9492*
Sum	*7,203,284.844*
Average	*758.880*
Min	*168.453*
Max	*22,152.693*

6.4.3 COMPARISON BETWEEN FORIA PRICES AND EDN PRICES

As described previously, the data analyzed exclusively with the prices provided by Foria, would result in a total cost of 7,167,603.483 SEK. In the same way, the prices corresponding

[11] Qlikview is a Business Intelligence Software that helps you to analyze across all your data in a very intuitive and illustrative way to uncover hidden trends and make discoveries that drive innovative decisions. (http://www.qlikview.com/)

to the EDN partner would result in a total cost of 7,203,284.844 meaning a difference of 35,681.361 SEK on favor of Foria prices (see Table 17).

Table 17. Difference between Foria prices and EDN prices

	Foria	EDN	Original Difference
Total count	9492	9492	9492
Sum	7,167,603.483	7,203,284.844	-35,681.361
Average	755.120	758.880	-3.759
Min	454.239	168.453	-2,803.293
Max	19,349.400	22,152.693	489.193

Moreover, it is also possible to notice there is no specific County or Region showing a remarkable difference on the costs between Foria and the EDN (Appendix F, Figure 34)

However, as stated before, it is not of interest for Foria to outsource the entire distribution of the Lantmännen products to the EDN but to find the economically viable breakpoint.

6.4.4 THE BREAKING POINT

Then it becomes relevant to Foria find the breaking point where is economically viable to use the EDN services and increase the profit for the company. It is believed by Foria that the small size orders are the area of opportunity to contract the EDN services.

With the help of Qlikview, it was possible to confirm the thoughts about the small size orders and the break point where found at 449 kg. All orders between 0 and 449 kg would gather the bigger savings by outsource them with an EDN as it can be appreciated in Appendix F, Figure 35.

With that founding's it will then sound viable to outsource to the EDN the orders within the range of 0 to 449 kg and carry out by Foria all orders above 500 kg. With this scenario, the costs would be summed up as shown in Table 18.

Table 18. Breakpoint 450 kg (EDN 0-449 kg and Foria 450 kg– up)

EDN (0 - 449 kg)		Foria (450 kg - up)		TOTAL
Total count	3978	Total count	5514	9,492.000
Sum	1,224,501.372	Sum	4,859,629.926	6,084,131.298
Average	307.818	Average	881.326	1,189.144
Min	168.453	Min	472.263	640.716
Max	796.023	Max	19,349.400	20,145.423

The total cost of the total data analyzed would end in 6,084,131.298 SEK, which is 15% lower than performing the entire transportation by Foria. The reduction on the costs by differentiating the size of the orders would mean a total saving of 1,083,472.184 SEK compared to Foria's current distribution structure.

However, an important point to consider for the small orders is the most likely need of and adjustment because of the volumetric weight, as described in the next section.

6.4.5 The Breaking point with volumetric weight adjustment

The data file received has only the actual weight of the cargo. When the cargo is heavy, there is no problem related to the volumetric weight and the weight will actually decide the price for the order. The small orders however will sometimes, quite often even, be charged according to volumetric weight and this will of course influence the cost of using the EDN partner.

Additionally, after analyzing the small posts, it was identified many plausible weight errors. The "weight column" sometimes does not describe actual weight; it instead describes quantity of the item. E.g. 61761 - KRAFFT OIL 25 L ST" has the weight of 2 kg, here it is more likely there are two of them weighing 50 kg. In many cases this does not affect the price since all orders with 0-59 kg will get the same price from the EDN. Still, there would be times when the volumetric weight is higher than the actual weight.

Volume calculations and considerations

- 1 m3 equal to 280 kg and 1 EUR pallet place equal 780 kg.
- If the cargo is not stackable or the height of the cargo is over 1.4m, it will be calculated as 780 kg
- Cargo is normally put on a pallet, generally stackable and non-fragile and non-hazardous.
- A pallet weights around 20 kg and has a volume of around 0,135 m3, adding 38 kg on volumetric weight depending on which type of pallet (based on a mixture of one time pallets and EUR pallets). This could mean that some orders will bump up to another price range.
- The weight for one full pallet is around 600 kg. This can be considered full and height can be over 1,4m.
- The cargo is agriculture supplies type and its freight price is normally decided on weight according to experts. E.g. bags with seeds, bags with food for the animals and salt stones which are rather heavy, but also plastic wrapping and other supplies with a low density.

The impact of the volumetric weight will be analyzed in two ways: Safety Factor / Risk Factor and Qualitative Number Analysis. An outline of this analysis is shown in Figure 24.

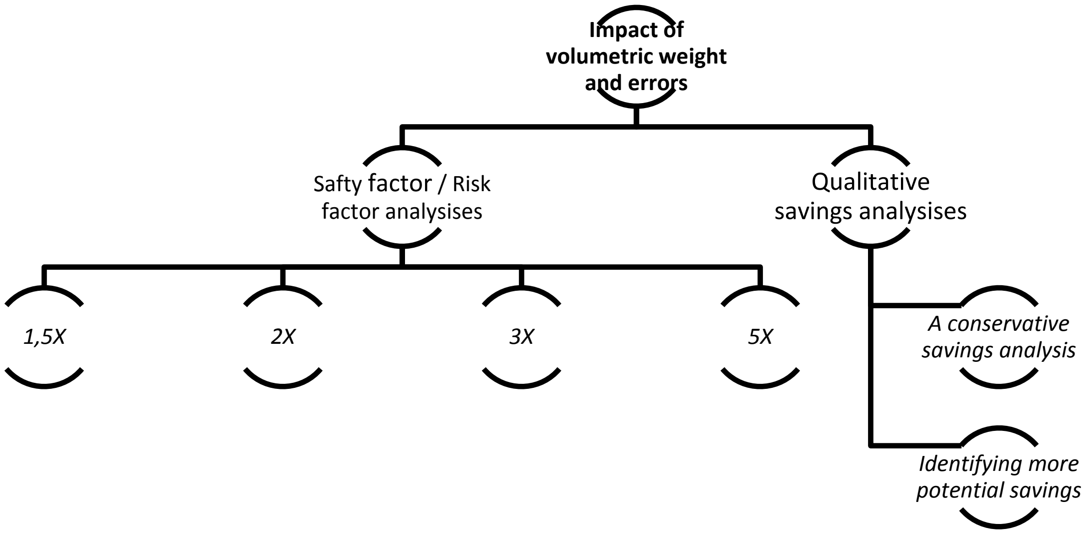

Figure 24. Outline of the volumetric weight analysis

Safety Factor / Risk Factor

This analyzes how sensitive the price difference between the EDN and Foria is because of the unknown volumetric weight the orders weight will be multiply by a factor (1,5X, 2X, 3X, and 5X up to a max weight of 780 kg).

1,5X factor

The weight for the orders from 1 - 519 kg will be multiplied by 1.5 and the orders between 520 kg and 779 kg will be adjusted to 780 kg. In this scenario, this factor adjustment has an effect on the breaking point dropping it to 299kg (Appendix F, Figure 36). Now the only orders viable to ship through the EDN will be those between 0 and 299kg.

After adjusting the dropping point, the new price will result in a total cost of 6,233,066.179 SEK for all orders; representing 13% of reduction compared to the total costs with Foria's price matrix (see Table 19)

Table 19. Safety factor 1,5X (Breakpoint 299kg)

EDN 1.5X (0 - 299 kg)		Foria 1.5X (300 kg - up)		TOTAL
Total count	3395	Total count	6097	9,492.000
Sum	1,034,418.126	Sum	5,198,648.053	6,233,066.179
Average	304.689	Average	852.657	1,157.345
Min	168.453	Min	472.263	640.716
Max	796.023	Max	19,349.400	20,145.423

2X factor

In the 2X case, the weight for orders from 1 - 389 kg will be doubled and the orders between 390kg and 779kg will be adjusted to 780 kg. As shown in the Appendix F, Figure 36, the breaking point in this scenario correspond to the orders contained in the weight range of 0 – 249 kg and the adjusted price structure is shown in Table 20.

Table 20. Safety factor 2X (Breakpoint 249kg)

EDN 2X (0 - 249 kg)		Foria 2X (250 kg - up)		TOTAL
Total count	3250	Total count	6242	9,492.000
Sum	1,071,727.713	Sum	5,282,239.548	6,353,967.261
Average	329.762	Average	846.242	1,176.004
Min	168.453	Min	472.263	640.716
Max	978.789	Max	19,349.400	20,328.189

3X factor

For the 3X scenario, the weight for orders from 1 - 259 kg will be tripled and the orders between 260 kg and 779 kg will then be adjusted to 780 kg. As the safety factor increases, the breaking point where the small orders should be sent through the EDN is reduced. In this case it dropped to 149 kg. (Appendix F; Figure 36). Likewise, the price adjustment is shown on Table 21.

Table 21. Safety factor 3X (Breakpoint 149kg)

EDN 3X (0 - 149 kg)		Foria 3X (150 kg - up)		TOTAL
Total count	2602	Total count	6890	9,492.000
Sum	833,983.278	Sum	5,658,596.718	6,492,579.996
Average	320.516	Average	821.277	1,141.793
Min	168.453	Min	454.239	622.692
Max	978.789	Max	19,349.400	20,328.189

5X factor

In the 5X factor case, the weight for orders from 1 – 155 kg will be five folded and the orders between 156 kg and 779 kg will be adjusted to 780 kg. With a safety factor of 5 times the weight, the total cost increase 9.12% compared to the unadjusted EDN price structure. However the total cost of 6,670,286.550 SEK is still 6.9% lower than the total cost calculated from using only Foria trucks (see Table 22).

Table 22. Safety factor 5X (Breakpoint 79kg)

EDN 5X (0 - 79 kg)		Foria 5X (80 kg - up)		TOTAL
Total count	1960	Total count	7532	9,492.000
Sum	636,309.738	Sum	6,033,976.812	6,670,286.550
Average	324.648	Average	801.112	1,125.760
Min	168.453	Min	454.239	622.692
Max	648.489	Max	19,349.400	19,997.889

These different safety scenarios described along before, allowed an evaluation of the sensitivity of the mixed price model (Foria & the EDN) depending on volumetric weigh at what the small orders may being restricted to.

The advantage of a tool like Qlikview to analyze a big amount of data in a very visual and structure way permitted us to identify the effects of a modification on the inputs. It was decided to evaluate changes on the order weight because as expressed previously and based in experience and in our field study, it is a common practice to count small orders not solely by their weight but also by their volume.

Qualitative Number Analysis

The qualitative approach to the volumetric weight, attacks the problem from a different angle compared to the previous safety approach. Instead of just multiplying the weight orders with a pre-defined factor, it will be selected an appropriate weight adjustment in a deeper transportation reasoning related to common practitioners' thinking. Two scenarios: Conservative Analysis and Max Profit scenario will be described.

Conservative Analysis

By analyzing an approximate "minimum savings" and breaking point in a very conservative analysis with a minimum weight set to 280 kg.

The warehouse personnel may pack the small orders poorly and on inappropriate pallets; the minor errors in the order column for the small orders won't matter. This will be applied to all orders up to 260 kg (280 kg – 20kg for the weight of the pallet added). From 260 kg and up, 20 kg will be added for the weight of the pallet and up to 480 kg (500 kg minus 20 kg for the pallet and extra 100 kg as safety margin to the average pallet size of 600 kg.). The orders between 480 kg and 779 kg will be changed to 780 kg as equivalent of a EUR pallet place.

Table 23. Conservative Scenario results overview

EDN Conservative (0 - 449 kg)		***Foria Conservative (450 kg - up)***		***TOTAL***
Total count	*3890*	***Total count***	*5602*	*9,492.000*
Sum	*1,694,025.024*	***Sum***	*4,909,507.275*	*6,603,532.299*
Average	*435.482*	***Average***	*876.385*	*1,311.867*
Min	*345.714*	***Min***	*472.263*	*817.977*
Max	*796.023*	***Max***	*19,349.400*	*20,145.423*

As is possible to appreciate on Appendix F; Figure 37, the conservative scenario, reaches the break point also at 449 kg, meaning that the viable financial strategy for Foria will be to outsource to the EDN all orders from 0 kg to 449kg and execute by themselves the shipments with the orders bigger than the breakpoint. As analyzed in Qlikview. The cost of this scenario (6,603,532.299 SEK) is 7% lower than the Foria price matrix for the entire range of weights (see Table 23).

In this conservative scenario, ten different weight ranges are contained between 0 kg and 449 kg (the breaking point). With the help of Qlikview it is possible to analyze each range of weight individually and find patterns or particular characteristics in order to support any decision taking. For example, in the first eight weight ranges (0 kg – 299 kg) all conservatives' prices are lower than the Foria reference, with a notorious bigger difference in the county of Östergötland (Appendix F; Figure 39)

The two remaining weight ranges before reaching the breaking point (350 kg – 449 kg) even though having in general a conservative lower price than the original from Foria, they share the particularity of having a higher cost in the county of Uppland. (Appendix F; Figure 40). This EDN higher cost trend in the county of Uppland continues growing for all the rest of weight ranges but it is in between 500 and 1000 kg when the difference is larger.

Max Profit

A second deeper qualitative analysis will use the same approach but with the intention of adjust the lower weights to the price ranges from the EDN in order to identify more potential savings but still taking volumetric price increases and errors in data into account. The classification of the orders will is according to Table 24.

Table 24. Order weight adjustment for Max Profit Scenario

Order weight range	Adjusted range
1 - 5 kg's	0 - 59 kg's
6 - 25 kg's	60 - 79 kg's
26 - 45 kg's	79 -99 kg's
46 - 95 kg's	100 - 149 kg's
96 - 145 kg's	150 - 199 kg's
146 - 195 kg's	200 - 249 kg's
196 - 245 kg's	250 - 299 kg's
246 - 295 kg's	300 - 349 kg's
295 - 580 kg's	same + 20kg's (pallet)
580 - 780 kg's	780 (pallet size)

For the orders within the range of 295 - 580 kg the impact of volumetric weight is considered small due to the fact that the freight price is generally gross weight dependent. The weight of an average pallet (20 kg) it will however be added. Furthermore, according to Foria the typical weight of a full pallet is 600 kg, thus all the orders above 580 kg will be adjusted to 780 kg for EUR pallet place.

As displayed on Table 25 constructed from the analysis performed in Qlikview, The Max Profit approach to cope with the possible underestimation on weight of the small orders is the most profitable volumetric weight adjustment out of all the different scenarios described. The cost of 6,203,292.375 SEK accounts for a reduction of about 13% percent of the comparison price obtained with Foria's price matrix.

Table 25. Max Profit Scenario overview

EDN Max Profit (0 - 449 kg)		***Foria Max Profit (450 kg - up)***		***TOTAL***
Total count	*3890*	***Total count***	*5602*	*9,492.000*
Sum	*1,293,785.100*	***Sum***	*4,909,507.275*	*6,203,292.375*
Average	*332.593*	***Average***	*876.385*	*1,208.977*
Min	*168.453*	***Min***	*472.263*	*640.716*
Max	*796.023*	***Max***	*19,349.400*	*20,145.423*

As well as in the conservative price scenario and the comparison one the Max Profit scenario also reaches the break point at the weight range of 449 kg. (Appendix F; Figure 38)

Likewise the previous conservative scenario, the max profit scenario shows also the characteristic of the notorious big difference in the county of Östergötland for the orders in the weight range 0 kg – 299 kg (Appendix F; Figure 41) and the higher cost in the County of Uppland for the orders weighting from 350 kg and above. (Appendix F; Figure 42)

6.5 SIMULATION ANALYSIS – HAULER'S PERSPECTIVE

The simulation model created was used to measure the impact of changes to the minimum order sizes and how this would affect the efficiency and profitability for the haulers performing the transports today. A simulation run of Foria's current way of working is used as a base value to which all the other simulations run is compared. Six simulation runs were compared were orders between 450-3000 kg are outsourced shipped via an EDN and the impact on current haulers are analyzed in line with Samuelsson and Tilanus (1997).

The financial performance for the analysis is based on the reimbursement matrix that gives every order a unique cost for Foria and income for the driver. This is then compared to the costs for performing the transports based on both time and distance driven. The cost is based on Swedish industry standard SåCalc[12].

6.5.1 OUTSOURCE TO AN EDN ALL ORDERS UP TO 450 KG

This level was examined since this corresponds to Foria's most financially suitable weight as derived from the financial analysis.

Looking at the transport efficiency measurements it is obvious that the results for the haulers ought to have been improved. The distance between drop of points have increased with 17.2%, the average amount stops per shipment have been reduced with 34%, the average distance driven per shipment has been reduced with 22.65% and the fill-rate has increased by almost 8%. However the profit margin in the remaining shipments for the haulers has decreased!

Previously the haulers moving a lot of very small orders, but were getting paid the same as for an order of 999 kg. In our simulation model there is no limit to the amount of orders one truck can carry, and as previously mentioned in the financial analysis, the database probably have weight errors, e.g. with 308 orders in the range of 1-5 kg the volumetric weight is most likely going to be higher. A possible reason to this decrease on profit margin is then "a simulation error", that trucks in the current way of working are getting loaded with too many orders on occasion and thus earn more money on some shipments than is actual possible. Another possible reason is that Foria is actually "overpaying" their drivers for the really small orders. With good planning and a lot of really small orders the financial incitement for the haulers are to continue with the small orders in spite of the low transport efficiency.

The volumetric analysis perspective was added to the thesis work subsequent to the creation of the simulation program. But knowing this, a future add-on to this simulation model could be to limit the amount of orders allowed on a truck to a certain number. Another likely improvement could be to load the simulation model with a database of orders where the weights are volumetrically adjusted as in the above financial analysis.

[12] http://www.akeriekonomi.se/Sacalc/ScBas.htm

The result indicates that Foria is paying their own carriers too much for these small orders, at least if the goal is motivate the carriers to drop these shipments in favor of other ones. This means that Foria should consider changing the reimbursement matrix[13] for the carriers or select a higher level of outsourcing that is not as financially optimal for Foria, based on the results from the financial analysis. .

6.5.2 OUTSOURCE TO AN EDN ALL ORDERS UP TO 780 KG

This level was analyzed since this relates to one pallet slot in many freight regulations.

Succeeding the 450 kg simulation the 780 kg simulation run achieves an even better level of transport efficiency. The reduced amount of stops (47.3 %) and reduced average distance driven (32.95%) that are cost drivers for haulers have here managed to get the upper hand over the possible incorrect reimbursement matrix. The haulers could here be financially motivated to change distribution model based on the results from the simulation model.

Even though they are losing some of their current business and the absolute profit has declined when comparing to the current way of working, the profit margin on remaining shipments has increased. If Foria management could offer the haulers other shipments the local haulers would could here be motivated to drop the small orders.

6.5.3 OUTSOURCE TO AN EDN ALL ORDERS UP TO 1000 KG

This level was examined since this is where Foria starts to differentiate their reimbursement to their carriers based on weight, up until 1000 kg the carriers are reimbursed the same amount per shipment regardless of size.

Here it becomes more and more clear that the trucks used for these shipments could find better profitability with other types of shipments. Compared to current way of working the average distance between stops have increased by over 31.15 %, the amount of stops per run have decreased to almost half, and the average distance per shipment is decreased by over 34.17 %.

Compared the all the simulations runs analyzed the fill-rate here reaches its maximum level and is 9.62 % higher compared to Foria´s current way of working and the profit margin keeps increasing on the remaining shipments.

Why the fill-rate has become better is not entirely clear, with more small orders one would assume it is easier to fill up a truck if on keep adding orders until no more of the available fits. A possible explanation to why the fill-rate improves when small-orders are removed is that when there is a high amount of small orders with short lead time that could create a need for “too many” when there is no other available cargo and thus reducing the fill-rate.

[13] A consequence of changing the reimbursement levels to drivers is that the calculated financial breakpoint is the same anymore and the financial analysis would have to be done once more with the new costs for Foria haulers.

6.5.4 OUTSOURCE TO AN EDN ALL ORDERS UP TO 1500 KG

1500 kg were chosen as it is the next price interval; this is close to two pallets slots.

The trend with ever increasing average fill-rates on the trucks has turned and is now a little bit worse compared to 1000 kg, but still better than the current way of working (8.81 %). But even though the fill rate isn't increasing anymore, the increased distance between stops (54.51 %), the reduced amount of stops (-64.48 %), and average reduced distance per shipment (-45.11 %) have improved the profit margin heavily on the remaining orders for the haulers.

If Foria could replace the lost business with other shipments the haulers should be very glad to give up the small orders and only concentrate on them from 1500 kg and up.

6.5.5 OUTSOURCE TO AN EDN ALL ORDERS UP TO 2000 KG

The 2000 kg level was tested to investigate if the profit margin would continue to rise as rapidly for the haulers.

The fill-rate continues to decrease compared to previous simulation, this means that transport planners are getting difficulties with finding small orders that could fill up the last space. However, it is still better than the base value (7.51 %).

Even though that the average distance between stops continues to increase, (69.66 %) the average stops per shipments keeps being reduced (70.98 %), and the average distance per shipment is even more decreased (50.76 %). The profit margin for the haulers on the remaining orders seems to have reached a halt. Driving with as few stops as to shorten the distance and with a high fill-rate is the way to achieve financial sustainability for haulers and increase transport efficiency. The results from this simulation implies that Foria has an higher profit margin on the orders from 1500-2000 with their current reimbursement matrix.

6.5.6 OUTSOURCE TO AN EDN ALL ORDERS UP TO 3000 KG

The 3000 kg level was simulated as it is the last remotely interesting level for Foria to outsource to an EDN based on the financial analysis, and also to further verify the results from 1500 and 2000 kg simulations.

The fill-rate here continues, as expected, to drop compared to 2000 kg, still better than the base value though (6.42 %). The cost drivers for the haulers, distance and stops are continuously improving, as expected. Average distance between stops has increased with 101.81 %, average stops per shipment have decreased by 79.52 %, and average distance driven has decreased by 58.68 %.

Also as expected the profit margin on the remaining orders for the haulers starts to increase again, however not as rapidly as between e.g. 1000-1500kg.

The total amount of weight shipped with Foria’s local hauler companies is now reduced with 37.5% and if we increase the weight to e.g. 5000 kg Foria would start losing money by outsourcing to an END. Therefor this was the last level checked.

6.6 ENVIRONMENTAL ANALYSIS

In order to carry out the analysis of the transportation performance from an environmental perspective, it was used as input the results obtained in the simulation (distances and trucks) and applied to the NTM-Road (2008) instructions and tables, previously described in the theoretical framework chapter.

6.6.1 ASSUMPTIONS AND SPECIFICATIONS

- The distribution truck is defined as a vehicle type3 (Medium Duty Vehicle (MDV) Light Lorry truck) from NTM-Road vehicle type table (Appendix E) and with the characteristics described on it.
- No alpine or hilly compensation was used since Sweden is not considered as an alpine country.
- Due to the conditions of Foria operations, where through the use of transportation planning, shipments are planned inbound and outbound Västerås warehouse, pre-position distance will not be considered.
- Foria's trucks comply as minimum with EURO IV Emissions standards and the calculations are based on this type of engine.
- For the distribution of the Lantmännen products, it was decided to set the mix between the different road categories as: 50 % Motorway, 45 % Rural and 5 % Urban
- The calculation of the emissions is not considering the speed of the trucks.

6.6.2 POLLUTANT EMISSION IN DIFFERENT TRANSPORTATION SETUPS SCENARIOS

It was decided to compare in an environmental perspective, i.e. fuel consumption and pollute emissions, all shipments done with HDV+trailer against the use of smaller MDV Lorry distribution trucks in two different scenarios: First, using the MDV Lorry trucks for all the orders below 450 kg and the current HDV+trailer trucks for the rest of the big orders (above 450 kg). Secondly, using the MDV Lorry trucks for all the orders up to 780 kg and for the rest of the orders, above 780 kg, continue using the current HDV + trailer trucks.

Scenario 1: Environmental impact of all shipments done by HDV trucks + trailer

In this scenario, all the shipments are performed by the HDV + trailers trucks with the characteristics defined previously. In order to calculate the emissions and fuel consumption following the NTM Road guidelines, we used the data presented in Table 26.

Table 26. Pre-defined data for the environmental performance calculations in scenario 1 (Simulation)

HDV truck + trailer	
Total number of shipments	574
Distance driven per shipment (km)	569 km
CCU (%)	40%
%Motorway road	50%
%Rural road	45%
%Urban road	5%

Fuel consumption calculation
Based on the NTM-Road table of fuel consumption for the selected vehicles (Appendix E, Table 45), fuel consumption in l/km was calculated for HDV trucks + trailer used by Foria as shown in Table 27. The capacity utilization obtained in the simulation is around 80 %. Thus, and for the milk-run distribution where the cargo is linearly being reduced while delivering, we used an average half of the capacity, i.e. 40 % of capacity. (Appendix E, Table 46)

Table 27. Summary of the fuel consumption for scenario 1

Fuel consumption liters	One HDV + trailer	All 574 HDV + trailer
Motorway	109.589	62904.316
Rural	113.584	65197.090
Urban	15.209	8730.178
Total	**238.383**	**136831.584**

Pollutant emissions calculations
Once the fuel consumption was calculated with the initial defined parameters, with the use of the NTM –Road tables for emissions based on type of truck and type of road (Appendix E, Tables 47-49), the different pollutions emitted by the trucks were calculated as can be seen in Table 28. It is worth to notice that the calculations give the emissions for a single truck, therefore in order to get the total pollutant emissions for this scenario is necessary to multiply each parameter by the number of shipments

Table 28. Total pollutant emissions (Scenario 1 simulation with 574 trucks).

All 574 HDV + trailer Type of Emission	HC	CO	NOx	PM	CO2	CH4	SOx
Motorway	3069.731	21890.702	943564.734	4856.213	164872211.188	61.646	209.471
Rural	2868.672	22167.011	1004035.182	4824.585	170881572.156	58.677	217.106
Urban	576.192	3753.977	132698.711	899.208	22881797.534	11.349	29.071
Total Emissions Scenario 1 (g/ all shipments)	**6514.594**	**47811.689**	**2080298.627**	**10580.006**	**358635580.878**	**131.673**	**455.649**

As is possible to see and, characteristically of the road transportation, CO2 and NOx are the emissions with a higher presence. The trucks used by Foria are assumed, as stated previously, to comply at least with EURO IV emission standards meaning that regarding technical and technological perspective there is rather little room for improvement. However the good area of improvement is the use of different types of trucks that suits better the operations of Foria.

Scenario 2: Environmental impacts of shipping all orders below 450 kg by distribution truck and use the HDV+trailer for the orders above 450 kg.

In this scenario, HDV + trailers trucks are used to dispatch only the orders above 450 kg while all the orders less than 450 kg are shipped in smaller distribution trucks described previously. The pre-defined data used for this scenario environmental analysis is display in Table 29.

Table 29. Pre-defined data for the environmental performance calculations in scenario 2 (Simulation)

	Truck Type	
	MDV Lorry Truck	HDV truck + trailer
Total Truck shipments	340	515
Distance per truck (km)	439 km	440 km
CCU	14%	43%
%Motorway	50%	50%
%Rural	45%	45%
%Urban	5%	5%

Fuel Consumption

As shown in Table 30, the fuel consumption it was also calculated based on the NTM-Road table of fuel consumption for selected vehicles type (Appendix E, Table 45)
In this scenario, the capacity utilization obtained in the simulation for the HDV+trailer is 86% and 28% for the smaller MDV lorry trucks. Using again the average half of the capacity the CCU used is 43% and 14% correspondingly. (Appendix E, Table 47)

Table 30. Summary of the fuel consumption for scenario 2

Fuel consumption liters	One MDV Lorry Truck	One HDV + trailer	All 340 MDV Lorry Truck	All 515 HDV + trailer	TOTAL
Motorway	27.240	86.447	9261.583	44520.102	**53781.685**
Rural	21.663	89.460	7365.533	46072.085	**53437.619**
Urban	2.488	12.034	846.006	6197.737	**7043.742**
Total	51.392	187.942	17473.122	96789.924	**114263.046**

Pollutant Emissions Calculations

Once the fuel consumption was calculated with the initial pre-defined parameters, again with the use of the NTM –Road tables for emissions based on type of truck and type of road (Appendix E, Tables 47-52) the different pollutions emitted by the two different trucks used were calculated as can be seen in Table 31.
In the same way than in the previous scenario the total emissions are considering the totality of the shipments, i.e. 340 for the MDV Lorry truck and 515 for the HDV truck and trailer. Consequently, Table 32 displays the grand total for the pollutant emissions corresponding to 855 shipments of both types of trucks.

Table 31. Total pollutant emissions (Scenario 2 simulation with 340 MDV Lorry trucks and 515 HDV + trailer).

All 515 HDV + trailer	Type of Emission						
	HC	CO	NOx	PM	CO2	CH4	SOx
Motorway	2172.581	15492.995	667801.530	3436.952	116687187.342	43.630	148.252
Rural	2027.172	15664.509	709510.115	3409.334	120754935.833	41.465	153.420
Urban	409.051	2665.027	94205.596	638.367	16244267.629	8.057	20.638
Total Emissions (g/ all shipments)	**4608.803**	**33822.531**	**1471517.241**	**7484.653**	**253686390.804**	**93.152**	**322.310**

All 340 MDV Lorry Truck	Type of Emission						
	HC	CO	NOx	PM	CO2	CH4	SOx
Motorway	370.463	2685.859	126883.687	555.695	24274609.043	7.076	30.841
Rural	347.653	2629.495	104590.572	571.565	19305062.570	6.924	24.527
Urban	64.212	407.775	11421.077	94.922	2217380.887	1.286	2.817
Total Emissions (g/ all shipments)	**782.328**	**5723.129**	**242895.336**	**1222.182**	**45797052.500**	**15.285**	**58.185**

Table 32. Total pollutant emissions (Scenario 2 simulation with 855 trucks).

All Shipments (340 MDV Lorry truck and 515 HDV + trailer)	Type of Emission						
	HC	CO	NOx	PM	CO2	CH4	SOx
Total Emissions (g/ all shipments)	**5391.132**	**39545.660**	**1714412.577**	**8706.835**	**299483443.304**	**108.437**	**380.496**

Scenario 3: Environmental impacts of shipping all orders below 780 kg by distribution truck and use HDV+ trailer for the orders above 780 kg.

In this third scenario, the HDV + trailers trucks are used to dispatch all the orders above 780 kg and all the orders less than 780 kg are shipped in the smaller distribution trucks. Table 33 displays the pre-defined data used for this scenario environmental analysis.

Table 33. Pre-defined data for the environmental performance calculations in scenario 3 (Simulation)

	Truck Type	
Mode	MDV Lorry Truck	HDV truck + trailer
Total Truck shipments	429	478
Distance per truck (km)	475 km	384 km
CCU	32%	44%
%Motorway	50%	50%
%Rural	45%	45%
%Urban	5%	5%

Fuel Consumption

Table 34 displays the data, based on the NTM-Road table of fuel consumption for selected vehicles type (Appendix E, Table 45), and used for the fuel consumption calculations in scenario 3. In this scenario, the capacity utilization obtained in the simulation for the HDV+trailer was 88% and 64% for the smaller MDV Lorry trucks. Once more, the average half of the capacity the CCU is used with the values of 44% and 32% correspondingly. (Appendix E, Table 48)

Table 34. Summary of the fuel consumption for scenario 3

Fuel consumption liters	One MDV Lorry Truck	One HDV + trailer	All 429 MDV Lorry Truck	All 478 HDV + trailer	TOTAL
Motorway	30.115	75.940	12919.335	36299.244	**49218.579**
Rural	24.171	78.548	10369.295	37545.929	**47915.223**
Urban	2.795	10.582	1199.012	5058.326	**6257.338**
Total	57.081	165.070	24487.642	78903.498	**103391.140**

Pollutant Emissions Calculations

Once the fuel consumption was calculated with the initial defined parameters, and again with the use of the NTM –Road tables for emissions based on type of truck and type of road (Appendix E, Tables 47-52) the different pollutions emitted by the two different trucks used were calculated as can be seen in Table 35.

In the same way than in the previous scenario the total emissions are considering the totality of the shipments, i.e. 429 for the MDV Lorry truck and 478 for the HDV truck and trailer.

Consequently, displays the grand total for the pollutant emissions corresponding to 907 shipments of both types of trucks.

Table 35. Total pollutant emissions (Scenario 3 simulation with 429 MDV Lorry trucks and 478 HDV + trailer).

All 478 HDV + trailer	Type of Emission						
	HC	CO	NOx	PM	CO2	CH4	SOx
Motorway	1771.403	12632.137	544488.653	2802.302	95140317.266	35.573	120.876
Rural	1652.021	12765.616	578207.302	2778.399	98407879.133	33.791	125.028
Urban	333.850	2175.080	76886.555	521.008	13257872.488	6.576	16.844
Total Emissions (g/ all shipments)	**3757.273**	**27572.833**	**1199582.510**	**6101.708**	**206806068.887**	**75.940**	**262.749**

All 429 MDV Lorry Truck	Type of Emission						
	HC	CO	NOx	PM	CO2	CH4	SOx
Motorway	516.773	3746.607	176994.890	775.160	33861577.035	9.870	43.021
Rural	489.431	3701.838	147243.984	804.657	27177921.278	9.747	34.530
Urban	91.005	577.924	16186.663	134.529	3142610.714	1.822	3.993
Total Emissions (g/ all shipments)	**1097.209**	**8026.369**	**340425.537**	**1714.347**	**64182109.027**	**21.440**	**81.544**

Table 36. Total pollutant emissions (Scenario 3 simulation with 907 trucks).

All Shipments (429 MDV Lorry truck and 478 HDV + trailer)	Type of Emission						
	HC	CO	NOx	PM	CO2	CH4	SOx
Total Emissions (g/ all shipments)	**4854.483**	**35599.202**	**1540008.047**	**7816.054**	**270988177.914**	**97.380**	**344.292**

Comparison for the three different scenario setups

The most interesting analysis for the environmental impact is the comparison between the three different scenarios in order to support the financial results obtained in the financial analysis.

As is possible to see in Table 37, there is a significant reduction of 17% on average for the pollutant emissions when comparing Scenario 1 (the current Foria setup) against Scenario 2. Even though scenario 2 requires the use of more trucks, more kilometers are driven and the capacity utilization is fairly low, environmentally wise it is a better option than scenario 1. This is easily explained by the huge difference in size and fuel consumption between the HDV + trailer and the MDV Lorry truck.

Table 37. Total pollutant emissions Scenario 1 versus Scenario 2

	Type of Emission						
Scenario	HC	CO	NOx	PM	CO2	CH4	SOx
Scenario 1 (574 HDV trucks + trailer)	6514.59	47811.69	2080298.63	10580.01	358635580.88	131.67	455.65
Scenario 2 (340 MDV Lorry Truck and 515 HDV trucks + trailer)	5391.13	39545.66	1714412.58	8706.84	299483443.30	108.44	380.50
Environmental Impact Reduction	17%	17%	18%	18%	16%	18%	16%

Consistently as in the previous comparison, Scenario 3 reveals also a substantial environmental reduction compared to Scenario 1, in this case reaching an average drop of 25% for the different types of emission (Table 38). This Scenario 3 helps to confirm the statement made in the previous comparison about the huge environmental different between the two types of trucks analyzed, because even though trucks and kilometers driven have increased again, the pollutant emissions dropped stronger.

Table 38. Total pollutant emissions Scenario 1 versus Scenario 3

	Type of Emission						
Scenario	HC	CO	NOx	PM	CO2	CH4	SOx
Scenario 1 (574 HDV trucks + trailer)	6514.59	47811.69	2080298.63	10580.01	358635580.88	131.67	455.65
Scenario 3 (429 MDV Lorry Truck and 478 HDV trucks + trailer)	4854.48	35599.20	1540008.05	7816.05	270988177.91	97.38	344.29
Environmental Impact Reduction	25%	26%	26%	26%	24%	26%	24%

6.6.3 Environmental Qualitative Analysis

As seen on the comparisons between the scenarios of the quantitative analysis, the positive results; i.e. reduction on pollutant emissions, give strong arguments to assume that using an outsourced EDN will render even better results. This since they are likely to be even more efficient since it has better planning possibilities due to the already developed network and a higher flow of cargo regions and sub-regions (Chopra, 2003, Chopra and Meindl, 2007, Burns et al., 1985).

7 RESULTS

This chapter presents the results from the different analyses made. First the qualitative general results from the case study analysis are presented; following this the quantitative results from the financial analysis as well as the two simulation analyses are presented. Finally the last subchapter answers research question 1 and research question 2.

7.1 RESULTS FROM THE ANALYSES

In total four different analyses were made, (1) a case study and problem analysis of the focal company´s operations. (2) A financial analysis on the impact for the focal company´s economic result by using an EDN instead of the local hauler companies for part of the unprofitable orders. (3) A simulation analysis assessing how the local haulers would be affected when some of the orders would be shipped elsewhere. (4) A simulation analysis estimating the environmental effects by improving the transport efficiency.

7.1.1 RESULTS FROM THE CASE STUDY ANALYSIS

The specific problems with possible solutions to them are presented and further analyzed in Chapter 6 above. However, aggregated from the thirteen specific problems it was clear that four general themes of problems existed. These four identified themes were present at all three analyzed operation stages, suggesting that some issues need to be targeted from a strategic perspective from the organizations and not only through solving an isolated issue a locally.

Problems related to flexibility

The lack of flexibility with regards to vehicle selection limits the transport planner in his work and this is a cause for problems related to the use of big trucks. There is also an inflexibility issue when it comes to the lack of routing options. The inflexibility here gives little room for the transport planners to optimize the shipments and improve transport efficiency more than they do today.

However, too much flexibility is not always a positive thing in all situations when it comes to increase transport efficiency. E.g. the trucks are purposely built low to be flexible during harvest season, but this hinders them when it comes to double stacking pallets and makes them less flexible for other shipments. Furthermore, Lantmännen is very flexible about letting their customers purchase various order sizes, but this flexibility causes problems further downstream when sent through an inflexible distribution channel.

Problems related to using inappropriate trucks

Many of the issues facing the focal company are related to the size of the trucks that are being used to deliver small orders. The inflexibility in vehicle selection makes these big and expensive trucks drive around like distribution trucks in peddling runs with low filling rates which are costly. Furthermore, these big trucks also have limited access to some drop-off points causing costly time-consuming reallocations of cargo between the truck and trailer in between stops.

Big trucks are very efficient and cost effective when it comes to moving big quantities of cargo between two or a few locations, but in the case of sending small orders to many different customers in a widespread area they are most likely not the best choice due to their high operating costs.

Execution related

A few of the issues identified in the problem analysis of the focal company are execution related, i.e. that someone is doing something wrong. This may be purposefully as when the drivers perform unreimbursed work at the farmers or disregard to report oversized pallets. It may also be by mistake as when drivers accidentally drive a longer distance than necessary because they took a wrong turn or when transport planners don not plan as optimal as possible.

Technology related

A few issues are also technology related. Across all the different actors and organizations involved there seem to be some resistance towards using ICT's and software's to support manual activities, e.g. when drivers do not use the GPS´s or the fact that no route optimizing software is used when these shipments are planned.

High investment costs are of course a barrier in certain cases, as in the case with a lack of WMS at Lantmännen and route optimization software at Foria. Still, sometimes this reluctance might come from an inability and lack of training in using these tools, as e.g. the case with drivers and GPS´s or the fact that they sometimes disregard to report oversized pallets in the ICT device.

7.1.2 RESULTS FROM THE FINANCIAL ANALYSIS

- Potential savings for Foria through outsourcing the smaller orders is immense.
    - A conservative estimation is ≈ 0,5 MSEK
    - A more realistic estimation is closer to ≈ 1 MSEK
- For Foria the highest savings will be with outsourcing up to 450 kg.
    - Even if total savings is decreased from 450 and up they will continue to save money up till the range of 2500-4999.

7.1.3 RESULTS FROM THE SIMULATION ANALYSIS – HAULER´S PERSPECTIVE

- The cost drivers for haulers are the distance driven and the amount of stops per shipment.
    - Both of these are heavily reduced when the small orders are removed which will increase the profit margins for haulers on the remaining shipments.
- Fill rates increase when small orders are removed.
    - The authors believe this is because many of the small orders have a small delivery window and thus are in a hurry. This may create a need for more shipments than there is cargo for during a specific time to that region.
- Haulers will see a decline in total profit. However, the remaining business will see an increase in profit margin when the small orders are removed.

- The profit margins seem to continuously increase when smaller orders are removed, but not as fast after 1500 kg.

7.1.4 RESULTS FROM THE ENVIRONMENTAL ANALYSIS

- By only using vehicle differentiation it is possible to heavily reduce the environmental impact of these shipments.
- The current way of distributing the agriculture supplies with a big HDV+trailer for all orders are polluting the environment a lot more than needed.
  - By only applying a vehicle differentiation strategy up-to 450 kg the environmental impact from shipments could be reduced by around 17%.
  - By applying a vehicle differentiation strategy up to 780 kg the environmental impact is even less. Pollutions are reduced with around 25%.
- The use of an EDN combines the benefits of vehicle differentiation as well as the use of routing differentiation through transshipment terminals where different cargo flows going to same regions can be merged. Therefor this option as a DND should be even more efficient and render less environmental impact than using solely vehicle differentiation.

7.1.5 COMBINED RESULTS FROM THE ANALYSES

- The reimbursement structure to Foria carriers needs to be reviewed to increase the motivation for them to change.
  - Changing the reimbursement structure would also alter the ideal levels for both Foria and carriers since both calculations dependent on this the analyses would have to be done again with new numbers to find ideal levels.
- Some form of a differentiated distribution model based on weight is essential to increase profitability for both haulers and Foria.
- The simulation analysis shows that from a strict environmental point of view it would be better to implement a vehicle differentiation strategy compared to perform the shipment in the traditional way.
  - From a financial point of view there is no significant evidence that only vehicle differentiation will motivate any change in the DND, the financial motivations come from introducing transshipment terminals.
- The possible savings by using an EDN for small orders and big HDV´s for bigger orders are huge, especially when considering that these are found in the transportation industry.
- Introducing flexible routing and focusing on using appropriate vehicle sizes is a highly efficient way of increasing transport efficiency in peddling run setups with many different order sizes.

7.2 ANSWERS TO RESEARCH QUESTIONS

The specific research questions stated in Chapter 1 are here answered.

7.2.1 RQ1

RQ1 are targeted to the focal company Foria´s specific requirements and issues.

RQ1-1. What transport efficiency improvements should be implemented at Foria to increase the financial sustainability for the agriculture supplies distribution?

From our quantitative analyses it is found that Foria should differentiate their DND base on the order size. The differentiation should include a combination of transshipment terminal as well as size appropriate delivery vehicles for different order sizes.

From our qualitative analyses it is found that Foria should give attention to the removal of waste and non-value adding activities from their operations. This includes either to contract or eliminate unreimbursed work done by the drivers during unloading, and to improve administrative routines so drivers will report oversized pallets.

RQ1-2. How high are the possible financial gains for Foria?

Based on the comparative price analysis Foria would be able to save between 0.5 - 1 million SEK (conservative estimate-likely potential estimate) through outsourcing at the best possible level, i.e. up to 450 kg.

Furthermore, if Foria is able to either contract or eliminate unreimbursed work done by drivers they would be able to save or gain approximately 400 000 SEK (See Appendix J).

RQ1-3. What environmental effects will the proposed transport efficiency improvements render?

By implementing a better DND the environmental impact from these transports will be reduced significantly. By changing the DND for all orders up to 450 kg, which is the financially best option, the pollutant emissions are decreased on average 17% compared to current DND. Moreover, the environmental impact will become even less if the outsourced weight range is higher. E.g. outsourcing all orders up to 780 would results in an average pollutant emission reduction of 26%.

The above calculations are however done solely based on vehicle differentiation because it is not possible to analyze the impact from using an EDN with our simulation model. However, a qualitative assessment would be that the pollutant emissions from using an EDN are even less due to the increased transportation efficiency suggested by the decreased cost as well as previous research within this field.

RQ1-4. How will proposed changes affect the local hauler companies that today perform these transports?

The local hauler companies are today getting paid the same for all orders up to 1000 kg. According to Foria this is necessary in order to get them to accept these small orders on the big trucks. However, our simulation results indicate that Foria is reimbursing the local hauler companies a bit too high for the really small orders. When outsourcing all orders up to 450 kg, which is the financially best option for Foria, our simulation model suggests that the profitability would slightly decrease for the local haulers.

If this is due to errors in the raw order data, as mentioned in chapter 7, it is likely that some of the small orders are expected to be bigger and the simulation program could potentially load a truck with more orders than possible, which would render a compensation that is higher than possible for certain shipments in the simulation.

7.2.2 RQ2

The second research question builds on the results from the previous one and aims at generalizing the findings from the case specific situation.

RQ2. Given the conclusions from RQ1: How can distribution of general cargo from a central warehouse to a wide array of drop-of points become more sustainable?

Differentiating DND based on order size is crucial for the transport efficiency. The simulation analysis shows that from a strict environmental point of view it would be better to implement a vehicle differentiation strategy from a central warehouse. Even if this means that the total number of kilometers driven will increase slightly, this since the smaller trucks pollute a lot less. However, from a financial point of view there is no significant[14] evidence that only vehicle differentiation will motivate any change in the DND.

This implies that there exist a discrepancy between pure monetary motives for improving transport efficiency and environmental motives in Sweden. This discrepancy is due to an imbalance in costs associated with the physical truck and personnel associated costs. This imbalance could either be targeted by increasing the cost of running the physical vehicle or by reducing the cost for manning it. E.g. increase the tax on fuel or through a targeted tax reduction for truck workers, similar to the one of people under the age of 26 in Sweden.

Furthermore, the huge possible savings shown in the comparative price analysis, between using only big HDV´s for all orders and sending smaller orders through an EDN with a transshipment terminal suggests that this distribution method is highly efficient. The theoretical benefits from combining transport flows and getting economies of scope when delivering small orders towards many and a wide spread set of drop-off points is confirmed in this research.

[14] In our case study the financially cost is about the same for all different vehicle differentiation scenarios. (See Appendix I) E.g. the best environmentally scenario 3 is calculated as 0.7% more expensive than the scenario 1. However, a small and very likely, change to the km/cost will shift this in favor of any of the three options. Therefore we cannot say anything regarding the financial performance more than it is likely to be similar; the calculations do not provide any significant results.

8 RECOMMENDATIONS TO FORIA

In this chapter we provide our recommendations to the company based on the analysis and conclusions drawn. Recommendations are given on both a short-term and long-term perspective.

8.1 SHORT TERM

- ✓ *Start using an EDN as soon as possible for all orders below 780kg.*

After the results obtained in the price and simulation analysis, in this range both Foria and their carriers should be motivated to change. Even though is not the best profitable price brake for Foria (which is 450 kg) 780 kg, the standard weight for a pallet, is a balance point with profit made by the carriers and Foria itself.

- ✓ *Foria should negotiate with EDN providers and put extra attention in the ranges 449-1500 kg.*

After the breakpoint of 450 kg it is no longer profitable for Foria to outsource to an EDN. However the motivation to negotiate the prices with the EDN within the range of 449-1500 kg is that as seen on the simulation analysis results, when outsource all orders up to 1500 kg the carriers reach higher profitability. If prices can be negotiated with the EDN and the breakpoint moves as close as possible to 1500 kg, the result would be both beneficial for Foria and their carriers (win-win situation).

- ✓ *Some profit sharing with own carriers might be necessary.*

Yet the decision of outsourced the small orders to the EDN would improve the profitability and efficiency of Foria operations, the carriers may experience a decrease on their profit explained by the current price structured where the carriers are overpaid in small orders. To compensate this and also motivate the carriers in favor of the outsourcing, Foria may need to share somehow with the carriers part of the profit gained through this outsource strategy.

- ✓ *Improve instructions and routines to the drivers and contract and charge requested value adding activities.*

Along the field study and the interviews it was noticed that small details as not following routines for loading and unloading the cargo, either due to the lack of them or due to the lack of capacitation to the drivers, resulted in enormous loss of time and effort. If extra activities performed by the drivers were really necessary for the farmers the option would be to contract and charge those activities. In the other case, all the non-value adding activities performed by the drivers that they should not been doing need to be removed with correct training and capacitation.

8.2 LONG TERM

- ✓ *Many split orders are due to external inefficiencies. Foria should try to influence Lantmännen to consolidate more of them and improve their performance.*

After the first visit to Lantmännen warehouse in Västerås it were spotted right away rather big inefficiencies and areas of improvement, e.g. the lack of IT for the warehouse management that may be one of the principal causes for problems as splitting orders or losing materials. Since Lantmännen warehouse activities are out of the jurisdiction and scope of Foria it is fairly complicated to influence a considerable change quickly. However, and due to the relationship that it has being built after the transportation contract between the two companies, it is not a close topic and moreover the consequences of improving Västerås warehouse would impact positively both parties.

- ✓ *The reimbursement structure needs to be changed to synchronize the ideal weight ranges between Foria and carriers. This requires further analysis since they are heavily dependent on each other.*

In the long term, after having outsourced the small orders to the EDN, depending on the weight range selected for the outsourced transportation activities and the prices negotiations, it will become really important to work on update the reimbursement structure for the Foria carriers since the current one would not matched the activities carried. For example it may be necessary to reduce the minimum weight parameter (currently 1000 kg) to one close to the break price of the outsourcing.

9 CONCLUSIONS

In this chapter the results of the research are discussed from a managerial and theoretical perspective. Lastly possibilities for future research and improvements are highlighted.

The case study results obtained through the financial analysis and the simulation analyses indicates that routing differentiation, i.e. using a transshipment terminal, would give the best outcome both in terms of financial performance as well as environmental sustainability performance. However, many transport companies and logistic service providers, like the focal company of our case study, do not always have the infrastructure and cargo volumes needed for arranging an efficient distribution network with transshipment terminals in-house. A viable solution for this is partnerships and subcontracting part of the T&D business to an external actor and act as coordinator for their customers as well as transport provider. Consequently, this implies that trust and contract negotiations between the company and subcontractors become immensely important to facilitate these solutions and to increase transportation efficiency.

In this case study it was found that the use of an EDN for part of the shipments would result in a potential saving of up to 1 Million SEK as well as a considerable reduction of the environmental impact of the company's transportation activities. This because the use of an EDN reduces the flexibility related problems with routing small orders in the same manner as big orders. The EDN increases routing options through use of their terminals and thus expanding the network range. It also has the option of different types and sizes of vehicles on different transportation stages, which reduces costs and increase filling rates, i.e. reducing the need for unprofitable and inefficient transports.

This thesis contributes to theory by building upon and confirming previous research assumptions and indications that a lot of the transports carried out of general cargo are not profitable and there exist a major efficiency gap. The thesis validates previous research in a practical manner through the use of simulation analyses of an actual distribution network. The simulation model constructed is based on how the focal company actually performs their transport and distribution activities today. Essentially this is practical use of existing distribution network theory, hence is possible to conclude that the results achieved from these simulation analyses indicates a valid practical efficiency gap.

Furthermore, the discrepancy recognized and verified between pure monetary motives for improving transport efficiency and environmental sustainability motives is also of value. This thesis gives added weight to the necessity for policymakers to balance the cost of polluting and actual transport costs. Yet, this thesis puts no value in what method is the best for accomplishing that balance. This is one area where future research could be needed for policy makers to be able to assess the effects of such changes to the transportation environment.

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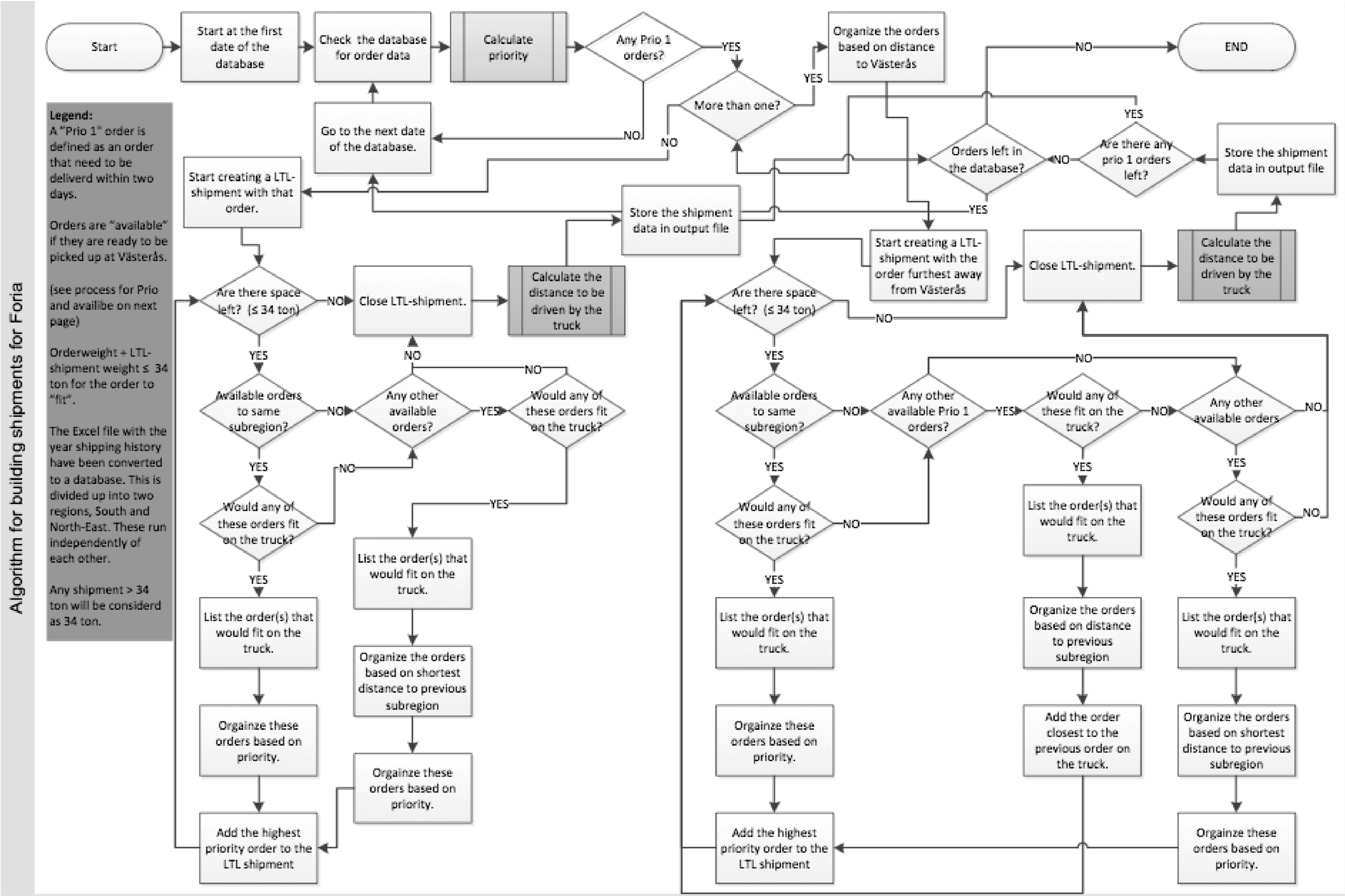
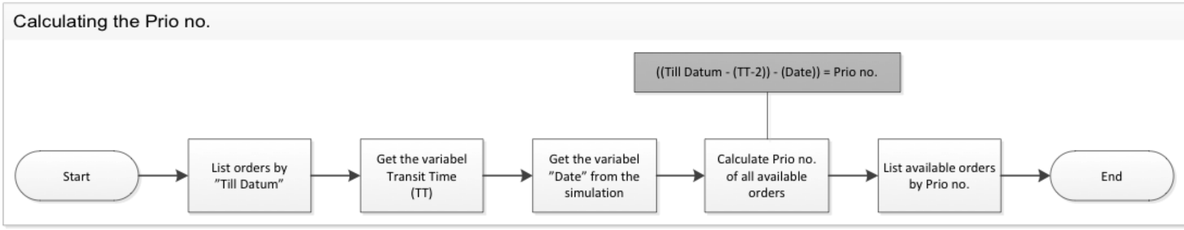
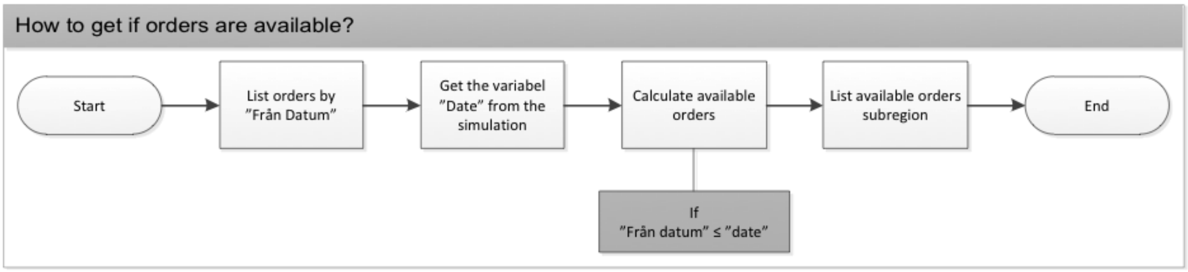
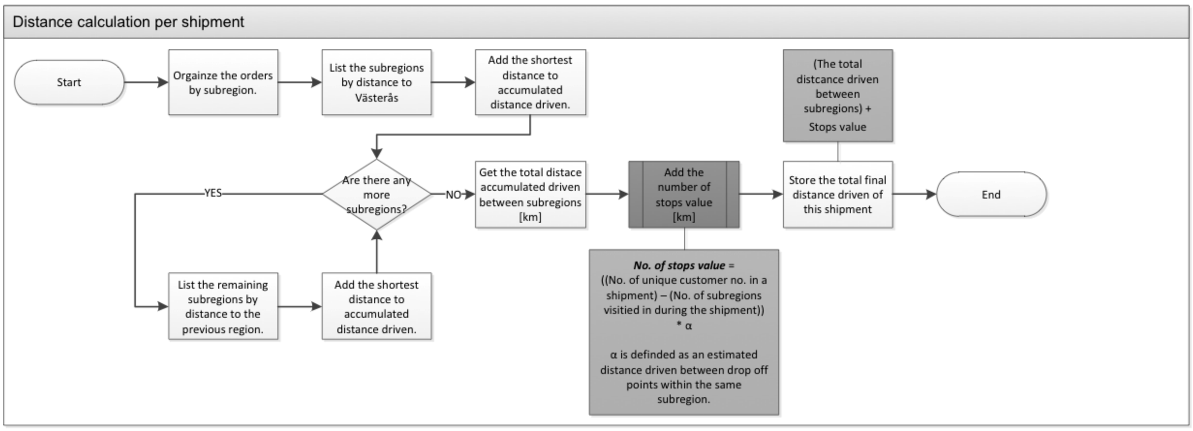
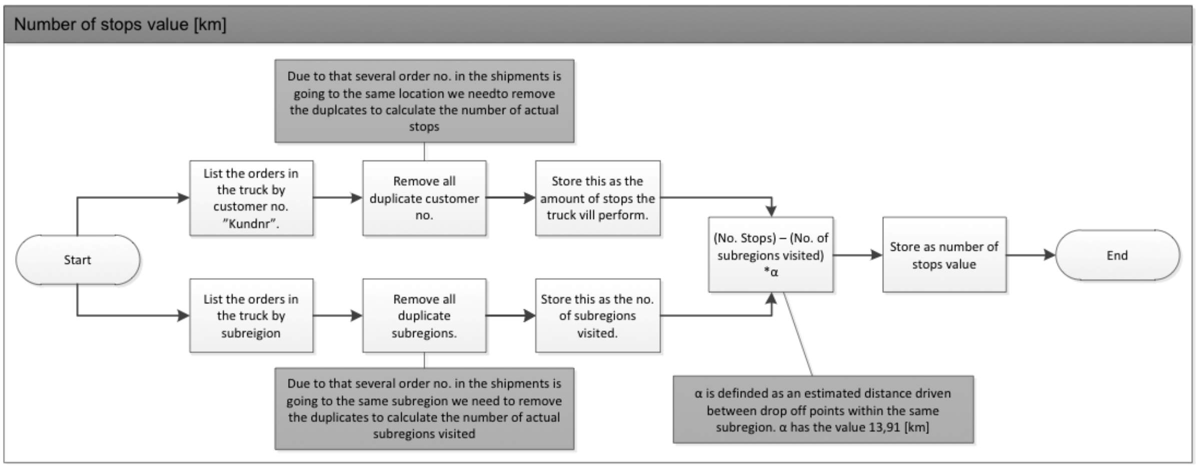
APPENDIX A – THE SIMULATION ALGORITHM


Algorithm for building shipments for Foria
Legend:
A "Prio 1" order is defined as an order that need to be deliverd within two days.
Orders are "available" if they are ready to be picked up at Västerås.
(see process for Prio and availibe on next page)
Orderweight + LTL-shipment weight ≤ 34 ton for the order to "fit".
The Excel file with the year shipping history have been converted to a database. This is divided up into two regions, South and North-East. These run independently of each other.
Any shipment > 34 ton will be considerd as 34 ton.
Start
Start at the first date of the database
Check the database for order data
Calculate priority
Any Prio 1 orders?
YES
NO
More than one?
YES
NO
Organize the orders based on distance to Västerås
END
Go to the next date of the database.
Start creating a LTL-shipment with that order.
Store the shipment data in output file
Orders left in the database?
Are there any prio 1 orders left?
Store the shipment data in output file
Start creating a LTL-shipment with the order furthest away from Västerås
Are there space left? (≤ 34 ton)
Close LTL-shipment.
Calculate the distance to be driven by the truck
Available orders to same subregion?
Any other available orders?
Would any of these orders fit on the truck?
Would any of these orders fit on the truck?
List the order(s) that would fit on the truck.
List the order(s) that would fit on the truck.
Organize the orders based on shortest distance to previous subregion
Orgainze these orders based on priority.
Orgainze these orders based on priority.
Add the highest priority order to the LTL shipment
Are there space left? (≤ 34 ton)
Close LTL-shipment.
Calculate the distance to be driven by the truck
Available orders to same subregion?
Any other available Prio 1 orders?
Would any of these fit on the truck?
Any other available orders
Would any of these orders fit on the truck?
Would any of these orders fit on the truck?
List the order(s) that would fit on the truck.
List the order(s) that would fit on the truck.
List the order(s) that would fit on the truck.
Organize the orders based on distance to previous subregion
Add the order closest to the previous order on the truck.
Organize the orders based on shortest distance to previous subregion
Orgainze these orders based on priority.
Orgainze these orders based on priority.
Add the highest priority order to the LTL shipment


Calculating the Prio no.
((Till Datum - (TT-2)) - (Date)) = Prio no.
Start
List orders by "Till Datum"
Get the variabel Transit Time (TT)
Get the variabel "Date" from the simulation
Calculate Prio no. of all available orders
List available orders by Prio no.
End


How to get if orders are available?
Start
List orders by "Från Datum"
Get the variabel "Date" from the simulation
Calculate available orders
List available orders subregion
End
If "Från datum" ≤ "date"


Distance calculation per shipment
Start
Orgainze the orders by subregion.
List the subregions by distance to Västerås
Add the shortest distance to accumulated distance driven.
(The total distcance driven between subregions) + Stops value
YES
Are there any more subregions?
NO
Get the total distace accumulated driven between subregions [km]
Add the number of stops value [km]
Store the total final distance driven of this shipment
End
List the remaining subregions by distance to the previous region.
Add the shortest distance to accumulated distance driven.
No. of stops value = ((No. of unique customer no. in a shipment) – (No. of subregions visitied in during the shipment)) * α
α is definded as an estimated distance driven between drop off points within the same subregion.


Number of stops value [km]
Due to that several order no. in the shipments is going to the same location we needto remove the duplcates to calculate the number of actual stops
List the orders in the truck by customer no. "Kundnr".
Remove all duplicate customer no.
Store this as the amount of stops the truck vill perform.
Start
(No. Stops) – (No. of subregions visited) *α
Store as number of stops value
End
List the orders in the truck by subreigion
Remove all duplicate subregions.
Store this as the no. of subregions visited.
Due to that several order no. in the shipments is going to the same subregion we need to remove the duplicates to calculate the number of actual subregions visited
α is definded as an estimated distance driven between drop off points within the same subregion. α has the value 13,91 [km]

APPENDIX B – IMAGES AND TABLES

A		B	C	D	E	F	H	
Artikel		Ordernr	Radnr	Lagerställe	Plan Dat	Orderstatu	Best kvant (weight)	Fr
52603	KRAFFT SPORT P 25 KG SK	1E+08	1	102	2011-08-11	77	-1200	
32530	STRÄCKF POLIWRAP ECO 750	1E+08	1	102	2011-01-17	77	-32	
61758	KRAFFT MINER GRÖN PELL 8KG ST	6035772	2	102	2010-11-02	77	1	
63450	KRAFFT VITAMIN MULTI P 10KG ST	6035805	7	102	2010-11-02	77	1	
63451	KRAFFT VITAMIN B P 10 KG ST	6035805	8	102	2010-11-02	77	1	
63452	KRAFFT VITAMIN E P 10 KG ST	6035805	9	102	2010-11-02	77	1	
61761	KRAFFT OIL 25 L ST	6036426	6	102	2010-11-05	77	1	
62362	KRAFFT MINER VIT PELL 8 KG ST	6036634	2	102	2010-11-05	77	1	
62362	KRAFFT MINER VIT PELL 8 KG ST	6036896	2	102	2010-11-02	77	1	
63451	KRAFFT VITAMIN B P 10 KG ST	6038156	1	102	2010-11-08	77	1	
24167	VÅRRAPS ZAPPA ELADO C 2,1 M ST	6039496	3	102	2011-03-25	77	1	
64444	MINERALHINK FÅR U CU 22KG GRÖN	6039601	6	102	2010-11-08	77	1	
61297	KRAFFT MINER BLÅ PELL 8 KG ST	6039980	3	102	2010-11-09	77	1	
64072	DESINFEKTION DESIDOS 45 TABL	6039980	5	102	2010-11-09	77	1	
63457	KRAFFT VITAMIN B P 3 KG ST	6039980	6	102	2010-11-09	77	1	
61757	KRAFFT MINER RÖD PELL 8 KG ST	6042124	8	102	2010-11-15	77	1	
61297	KRAFFT MINER BLÅ PELL 8 KG ST	6042378	9	102	2010-11-15	77	1	
61757	KRAFFT MINER RÖD PELL 8 KG ST	6043837	4	102	2010-11-15	77	1	

Figure 25 Errors in weight column in the historic order lines data

Figure 26 Typical order, pallets with animal feed

Figure 27 Foria associated haulers trucks

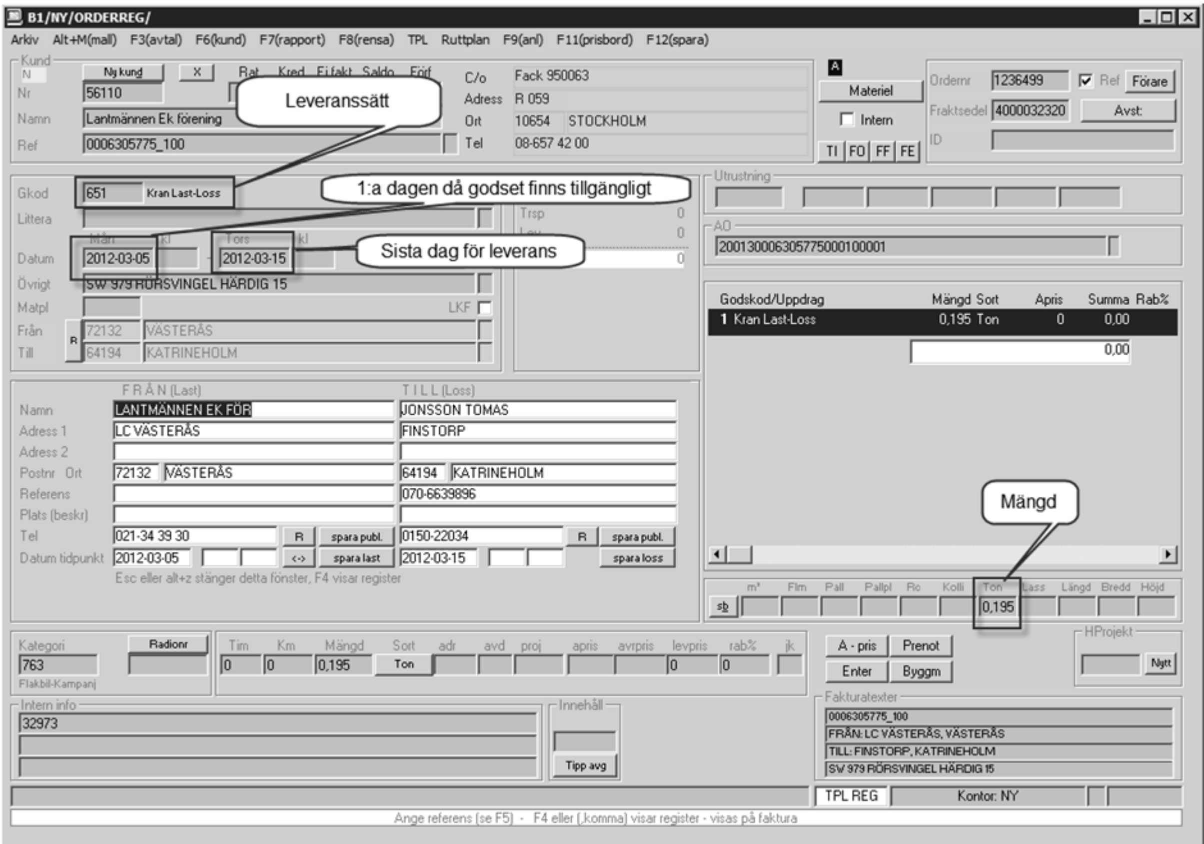


Figure 28 Screenshot from the transport planners IS interface.

Artikel		Ordernr	Radnr	Lagerställe	Plan Dat	Orderstatu	Lev kvant	Best kvant	Från datum	Till Datum	Adressnr	Kundnr	Kundnamn	Adressrad 1	Adressrad 3	LE'	Avlastningsort	
61236	KRAFFT MINER BLÅ GRAN SK 25KG	5989530	1	102	2010-11-29	77	600	600	20101129	20101202	99	1317863	BOKO STAE	SKYTTEHO	178 90 EK	#	A25	Ekerö
62751	EFFEKT MAXI ZN 25 KG SK	6015469	4	102	2011-03-18	77	600	600	20110321	20110321	99	703355	OHLSSON I	VAVD 255	819 65 HÅ	11	C60	Tierp
61014	KALVNÄRING KAVAT 25 KG SK	6022850	1	102	2010-11-24	77	625	625	20101215	20101220	99	53462	PETTERSS(	SIMTUNA K	749 71 FJ	#	C81	Enköping
61302	SLICKSTEN SP UNIVERSAL 10 KGST	6022850	2	102	2010-11-24	77	30	30	20101124	20101129	99	53462	PETTERSS(	SIMTUNA K	749 71 FJ	#	C81	Enköping
62787	EFFEKT KALVA 25 KG SK	6022981	1	102	2010-12-07	77	600	600	20101206	20101209	99	1303851	BERGSTRÖ	PERSBYLÅ	748 94 ÖF	#	C60	Tierp
61015	KALVNÄRING RUSTIK 25 KG SK	6027023	1	102	2010-11-02	77	625	625	20101028	20101102	99	35645	BJÄRSÄTEF	BJÄRSÄTEF	640 20 BJ	#	D83	Katrineholm
62751	EFFEKT MAXI ZN 25 KG SK	6027023	2	102	2010-11-02	77	600	600	20101028	20101102	99	35645	BJÄRSÄTEF	BJÄRSÄTEF	640 20 BJ	#	D83	Katrineholm
64578	EFFEKT SP KALVA SELENJÄ 1000KG	6028580	4	102	2010-11-02	77	1000	1000	20101101	20101104	99	19034610	GUSTAVSS(	KARLSLUNI	610 21 NC	#	E81	Norrköping
62773	MIXA MAXI CU 1000 KG SS	6028580	8	102	2010-11-02	77	1000	1000	20101101	20101104	99	19034610	GUSTAVSS(	KARLSLUNI	610 21 NC	#	E81	Norrköping
64540	EFFEKT SP KÖTT M SELENJÄ 25 KG	6029082	1	102	2010-11-02	77	600	600	20101028	20101102	99	1305029	SEDVALL K	LÖTEN 307	819 61 SK	#	C60	Tierp
51990	LAMM 503 P SK 25 KG	6029600	2	102	2010-11-09	77	1200	1200	20101105	20101110	101	19022166	HÄGGE-NIL	HUMMELVIK	610 42 GRY	#	E63	Valdemarsvik
64540	EFFEKT SP KÖTT M SELENJÄ 25 KG	6030192	1	102	2010-11-01	77	2400	2400	20101101	20101104	99	23043	BJÄRNLID N	STORA DÖN	585 97 LII	#	E80	Linköping
61302	SLICKSTEN SP UNIVERSAL 10 KGST	6030192	2	102	2010-11-01	77	60	60	20101101	20101104	99	23043	BJÄRNLID N	STORA DÖN	585 97 LII	#	E80	Linköping
57012	DUVFODER SK 25 KG	6030377	9	102	2010-11-01	77	600	600	20101103	20101108	104	9725912	LANTMÄNN	SÄTTUNAG	582 73 LINK	#	E80	Linköping
26565	BIOFER 10-3-1 700 KG	6031327	1	102	2010-11-15	77	18900	18900	20101001	20101231	99	33175	JERNBERG	VALLBY LID	745 98 EN	#	C81	Enköping
61245	PROTECT JÄRNPASTA7*80 GRAM ST	6031736	1	102	2010-11-08	77	4	4	20101022	20101022	99	17460	LINDAHL ÖI	EKEBY GÅF	640 23 VÅ	11	D83	Katrineholm
34012	SALTTABLETTER AXAL PRO 25 KG	6032140	2	102	2010-11-02	77	2000	2000	20101029	20101103	99	19557	RUNTUNA K	KENT GUST	611 93 NY	#	D80	Nyköping
51981	TACKA P SK 25 KG	6032140	8	102	2010-11-01	77	600	600	20101029	20101103	99	19557	RUNTUNA K	KENT GUST	611 93 NY	#	D80	Nyköping
61303	SLICKSTEN SP NATURSALT 10KG ST	6032140	9	102	2010-11-01	77	10	10	20101029	20101103	99	19557	RUNTUNA K	KENT GUST	611 93 NY	#	D80	Nyköping
64444	MINERALHINK FÅR U CU 22KG GRÖN	6032140	10	102	2010-11-01	77	2	2	20101029	20101103	99	19557	RUNTUNA K	KENT GUST	611 93 NY	#	D80	Nyköping
69463	TORVMIX RS	6032140	11	102	2010-11-01	77	36	36	20101029	20101103	99	19557	RUNTUNA K	KENT GUST	611 93 NY	#	D80	Nyköping
61314	STENSALT H&M (2632) 25KG	6032141	1	102	2010-11-01	77	1050	1050	20101027	20101101	99	33609	FJELLSKÄR	FJELLSKÄR	611 97 ST	#	D80	Nyköping
55005	ALLFODER PK SK 25 KG	6032280	1	102	2010-11-01	77	1200	1200	20101027	20101101	99	38562	BORUP RUT	GRÄVSTA 2	153 07 HÖ	#	A81	Södertälje
51922	SUND BLÅSIPPA 100 P SK 25 KG	6032776	1	102	2010-11-01	77	600	600	20101027	20101101	99	1306273	ROSENQVIS	VEDBO GÅF	640 33 BE	#	D80	Nyköping
51922	SUND BLÅSIPPA 100 P SK 25 KG	6032827	1	102	2010-11-01	77	1200	1200	20101027	20101101	99	27606	LG:S ENTRI	SJÖSTUGA	590 53 UL	#	E80	Linköping
52601	KRAFFT GRUND P 25 KG	6033239	1	102	2010-11-01	77	1800	1800	20101028	20101102	99	2025823	LILJA M & P	ENSTA GÅR	178 93 DF	#	A25	Ekerö
59046	KORNKROSS (360/P) 20 KG SK	6033239	2	102	2010-11-01	77	360	360	20101028	20101102	99	2025823	LILJA M & P	ENSTA GÅR	178 93 DF	#	A25	Ekerö
51987	RABBFOR P SK 25 KG	6033252	1	102	2010-11-01	77	600	600	20101029	20101103	106	9725912	LANTMÄNN	ÖSTANÅGA	596 34 SKÄI	#	E86	Mjölby
59068	HAVREKROSS (300/P) 15 KG	6033252	2	102	2010-11-01	77	300	300	20101029	20101103	106	9725912	LANTMÄNN	ÖSTANÅGA	596 34 SKÄI	#	E86	Mjölby
61507	PROTECT SALTBALANS NÖT+1,5KGST	6033252	3	102	2010-11-01	77	4	4	20101029	20101103	106	9725912	LANTMÄNN	ÖSTANÅGA	596 34 SKÄI	#	E86	Mjölby
34012	SALTTABLETTER AXAL PRO 25 KG	6033252	4	102	2010-11-04	77	6000	6000	20101029	20101103	106	9725912	LANTMÄNN	ÖSTANÅGA	596 34 SKÄI	#	E86	Mjölby
34008	GATUSALT 25 KG	6033252	5	102	2010-11-01	77	4200	4200	20101029	20101103	106	9725912	LANTMÄNN	ÖSTANÅGA	596 34 SKÄI	#	E86	Mjölby
34007	GATUSALT 1000 KG SS	6033252	6	102	2010-11-01	77	3000	3000	20101029	20101103	106	9725912	LANTMÄNN	ÖSTANÅGA	596 34 SKÄI	#	E86	Mjölby

Figure 29 Screenshot from a few of the original raw orderliness from the year of shipping data

EDN																
Vikt(kg) / PostNr	0-59	60-79	80-99	100-149	150-199	200-249	250-299	300-349	350-399	400-449	450-499	500-599	600-699	700-799	800-899	900-999
P10	217	227	249	277	310	361	400	435	492	530	565	601	651	689	722	755
P20	229	238	261	305	378	462	542	609	694	754	822	876	935	996	1043	1087
P21	229	238	261	305	378	462	542	609	694	754	822	876	935	996	1043	1087
P22	233	243	264	305	385	470	549	615	705	762	835	884	931	996	1047	1112
P23	233	243	264	305	385	470	549	615	705	762	835	884	931	996	1047	1112
P24	233	243	264	305	385	470	549	615	705	762	835	884	931	996	1047	1112
P25	255	273	293	344	425	500	587	656	749	822	886	931	1005	1115	1177	1238
P26	255	273	293	344	425	500	587	656	749	822	886	931	1005	1115	1177	1238
P27	255	273	293	344	425	500	587	656	749	822	886	931	1005	1115	1177	1238
P28	264	293	331	374	475	575	655	726	820	891	971	1031	1140	1268	1350	1411
P29	264	293	331	374	475	575	655	726	820	891	971	1031	1140	1268	1350	1411
P30	221	231	253	292	358	436	511	571	650	707	767	814	872	928	971	1013
P31	227	236	258	292	366	444	517	579	659	715	780	820	869	928	975	1038
P33	253	282	319	347	432	517	581	640	720	783	846	894	998	1115	1191	1247
P34	303	312	331	362	447	536	618	694	796	870	944	998	1067	1147	1219	1287
P36	303	312	331	362	447	536	618	694	796	870	944	998	1067	1147	1219	1287
P35	302	312	334	362	432	521	602	679	767	842	913	975	1053	1126	1187	1242
P37	338	367	404	432	527	634	716	796	893	979	1061	1131	1256	1398	1494	1567
P38	338	367	404	432	527	634	716	796	893	979	1061	1131	1256	1398	1494	1567
P39	338	367	404	432	527	634	716	796	893	979	1061	1131	1256	1398	1494	1567
P40	217	227	249	286	351	428	498	554	629	687	743	788	846	900	941	984
P41	217	227	249	286	351	428	498	554	629	687	743	788	846	900	941	984

FORIA	
Vikt(kg) / KM	0 - 999
10KM	454,24
20KM	463,25
30KM	472,26
40KM	481,28
50KM	490,29
60KM	499,3
70KM	508,31
80KM	517,32
90KM	526,34
100KM	535,35
110KM	544,36
120KM	553,37
130KM	562,38
140KM	571,4
150KM	580,41
160KM	589,42
170KM	598,43
180KM	607,45
190KM	616,46
200KM	625,47
210KM	634,48
220KM	643,49

Figure 30 Price matrix combined below 1000 kg (part of)

	EDN (1000 - 2499)				EDN		EDN		EDN (7000 - 10000)				EDN (10000 - 14999)					
	FORIA		FORIA		FORIA		FORIA (5000 - 7999)				FORIA		FORIA		FORIA (12000 - 15999)			
KM \ KG	Min - 999-1499		1500-2499		2500-4999		5000-6999		7000-7999		8000-9999		10000-11999		12000-14999		15000-1599	
	FORIA	ONROAD	FORIA	ONROAD	FORIA	ONROAD	FORIA	ONROAD	FORIA	ONROAD	FORIA	ONROAD	FORIA	ONROAD	FORIA	ONROAD	FORIA	ON
10KM	454,2386	616,161	354	616,161	273	332,778	176	198,801	176	161,061	115	161,061	104	130,203	104	130,203	104	10
20KM	463,2508	616,161	362,5156	616,161	279,1563	332,778	181,3281	198,801	181,3281	161,061	119,1875	161,061	108,2344	130,203	108,2344	130,203	108,2344	10
30KM	472,2629	616,161	371,0313	616,161	285,3125	332,778	186,6563	198,801	186,6563	161,061	123,375	161,061	112,4688	130,203	112,4688	130,203	112,4688	10
40KM	481,2751	636,918	379,5469	636,918	291,4688	350,982	191,9844	213,009	191,9844	173,049	127,5625	173,049	116,7031	139,638	116,7031	139,638	116,7031	[illegible]
50KM	490,2872	636,918	388,0625	636,918	297,625	350,982	197,3125	213,009	197,3125	173,049	131,75	173,049	120,9375	139,638	120,9375	139,638	120,9375	[illegible]
60KM	499,2994	657,897	396,5781	657,897	303,7813	369,519	202,6406	227,217	202,6406	184,371	135,9375	184,371	125,1719	154,845	125,1719	154,845	125,1719	[illegible]
70KM	508,3115	657,897	405,0938	657,897	309,9375	369,519	207,9688	227,217	207,9688	184,371	140,125	184,371	129,4063	154,845	129,4063	154,845	129,4063	[illegible]
80KM	517,3237	678,654	413,6094	678,654	316,0938	387,39	213,2969	241,203	213,2969	195,804	144,3125	195,804	133,6406	160,284	133,6406	160,284	133,6406	13
90KM	526,3358	678,654	422,125	678,654	322,25	387,39	218,625	241,203	218,625	195,804	148,5	195,804	137,875	160,284	137,875	160,284	137,875	13
100KM	535,348	699,189	430,6406	699,189	328,4063	405,261	223,9531	255,411	223,9531	207,459	152,6875	207,459	142,1094	169,83	142,1094	169,83	142,1094	14
110KM	544,3601	699,189	439,1563	699,189	334,5625	405,261	229,2813	255,411	229,2813	207,459	156,875	207,459	146,3438	169,83	146,3438	169,83	146,3438	14
120KM	553,3722	720,168	447,6719	720,168	340,7188	423,132	234,6094	268,62	234,6094	218,892	161,0625	218,892	150,5781	180,264	150,5781	180,264	150,5781	15
130KM	562,3844	720,168	456,1875	720,168	346,875	423,132	239,9375	268,62	239,9375	218,892	165,25	218,892	154,8125	180,264	154,8125	180,264	154,8125	15
140KM	571,3965	741,591	464,7031	741,591	353,0313	440,892	245,2656	282,717	245,2656	230,325	169,4375	230,325	159,0469	190,254	159,0469	190,254	159,0469	16
150KM	580,4087	741,591	473,2188	741,591	359,1875	440,892	250,5938	282,717	250,5938	230,325	173,625	230,325	163,2813	190,254	163,2813	190,254	163,2813	16
160KM	589,4208	762,348	481,7344	762,348	365,3438	458,874	255,9219	296,814	255,9219	241,647	177,8125	241,647	167,5156	199,689	167,5156	199,689	167,5156	16
170KM	598,433	762,348	490,25	762,348	371,5	458,874	261,25	296,814	261,25	241,647	182	241,647	171,75	199,689	171,75	199,689	171,75	16
180KM	607,4451	783,216	498,7656	783,216	377,6563	476,856	266,5781	310,911	266,5781	253,413	186,1875	253,413	175,9844	210,234	175,9844	210,234	175,9844	17
190KM	616,4573	783,216	507,2813	783,216	383,8125	476,856	271,9063	310,911	271,9063	253,413	190,375	253,413	180,2188	210,234	180,2188	210,234	180,2188	17
200KM	625,4694	804,195	515,7969	804,195	389,9688	494,838	277,2344	325,008	277,2344	264,735	194,5625	264,735	184,4531	220,335	184,4531	220,335	184,4531	18
210KM	634,4816	804,195	524,3125	804,195	396,125	494,838	282,5625	325,008	282,5625	264,735	198,75	264,735	188,6875	220,335	188,6875	220,335	188,6875	18
220KM	643,4937	824,619	532,8281	824,619	402,2813	513,264	287,8906	339,105	287,8906	276,057	202,9375	276,057	192,9219	229,881	192,9219	229,881	192,9219	19
230KM	652,5059	824,619	541,3438	824,619	408,4375	513,264	293,2188	339,105	293,2188	276,057	207,125	276,057	197,1563	229,881	197,1563	229,881	197,1563	19
240KM	661,518	845,265	549,8594	845,265	414,5938	531,246	298,5469	353,202	298,5469	288,045	211,3125	288,045	201,3906	240,204	201,3906	240,204	201,3906	20
250KM	670,5302	845,265	558,375	845,265	420,75	531,246	303,875	353,202	303,875	288,045	215,5	288,045	205,625	240,204	205,625	240,204	205,625	20
260KM	679,5423	866,799	566,8906	866,799	426,9063	549,006	309,2031	367,188	309,2031	299,256	219,6875	299,256	209,8594	250,305	209,8594	250,305	209,8594	21
270KM	688,5544	866,799	575,4063	866,799	433,0625	549,006	314,5313	367,188	314,5313	299,256	223,875	299,256	214,0938	250,305	214,0938	250,305	214,0938	21
280KM	697,5666	887,223	583,9219	887,223	439,2188	566,655	319,8594	381,285	319,8594	310,467	228,0625	310,467	218,3281	259,851	218,3281	259,851	218,3281	22
290KM	706,5787	887,223	592,4375	887,223	445,375	566,655	325,1875	381,285	325,1875	310,467	232,25	310,467	222,5625	259,851	222,5625	259,851	222,5625	22
300KM	715,5909	907,98	600,9531	907,98	451,5313	584,637	330,5156	394,605	330,5156	322,344	236,4375	322,344	226,7969	269,952	226,7969	269,952	226,7969	23
310KM	724,603	907,98	609,4688	907,98	457,6875	584,637	335,8438	394,605	335,8438	322,344	240,625	322,344	231,0313	269,952	231,0313	269,952	231,0313	23
320KM	733,6152	928,737	617,9844	928,737	463,8438	602,397	341,1719	408,48	341,1719	333,888	244,8125	333,888	235,2656	280,497	235,2656	280,497	235,2656	24
330KM	742,6273	928,737	626,5	928,737	470	602,397	346,5	408,48	346,5	333,888	249	333,888	239,5	280,497	239,5	280,497	239,5	24
340KM	751,6395	949,716	635,0156	949,716	476,1563	620,268	351,8281	422,577	351,8281	344,766	253,1875	344,766	243,7344	289,821	243,7344	289,821	243,7344	25
350KM	760,6516	949,716	643,5313	949,716	482,3125	620,268	357,1563	422,577	357,1563	344,766	257,375	344,766	247,9688	289,821	247,9688	289,821	247,9688	25
360KM	769,6638	969,807	652,0469	969,807	488,4688	638,472	362,4844	436,452	362,4844	356,088	261,5625	356,088	252,2031	299,922	252,2031	299,922	252,2031	25
370KM	778,6759	969,807	660,5625	969,807	494,625	638,472	367,8125	436,452	367,8125	356,088	265,75	356,088	256,4375	299,922	256,4375	299,922	256,4375	25

Figure 31 Price matrix combined above 1000 kg (part of)

APPENDIX C – INITIAL TOPICS FOR THE OPEN INTERVIEWS

Meeting and interview with management.

- Explanation of current operations (including transport management role)
- Goals, promises, contracts, obligations, etc. towards Lantmännen
- Fleet size and type vehicles
- Type of cargo
- Shipment history
- Drop-of points geographical data,
- Service performance, etc.
- How is the selling-buying service between the farmers and Foria (order receiving, acknowledgment, etc?)
- Can Foria influence size and frequency of the shipments to the farmers or only fulfilling exactly orders?
    - If not, can they be changed for the future?
- Cooperation with the other external partners?
- How do you believe the operations can be improved?

Meeting and interview with transport planners

- Explanation of current operations from your perspective
- How do you perform your tasks
    - What are the problems you face on a daily basis?
- How do you believe the operations can be improved?

Meeting and interview with driver

- Explanation of current operations from your perspective
- How do you see today operations (what are the daily tasks and concerns)
- How you believe the operations can be improved?
- Threats with current operations towards your business?
- When you deliver the goods to the farm, how easy is, do you receive help from the farmers?

Meeting and interview with farmer

- Explanation of current operations from your perspective
- How satisfy are you with the current delivery service
    - Could be done better in anyway?
- How often do you receive goods?
    - Is this frequency matching your operations?
- How flexible are your operations (small warehouse or storage room, buffer in case of late delivery, and capability of receiving goods in advance.)
- How you believe the delivering operations can be improved

Meeting with terminal staff at Västerås

- Explain the operations of the terminal (how they work, how big part is the terminal of the Lantmännen transport.
- What is the role of the terminal within these operations?
    - How much is the analyzed flow for Foria?

APPENDIX D – SIMULATION RESULTS HAULERS PERSPECTIVE

In this appendix the numerical results from the simulation runs comparing the effects on the haulers are presented.

Table 39 Comparison of simulation results, outsourcing all orders up to 450 kg

Differences

Foria carriers is shipping all orders equal to or bigger than 450 kg.			
Shipment information	Real distance lower range (-1,71 %)	Real distance median range (+5,38%)	Real distance higher range (+12,5%)
Average distance between stops	17,21%	17,21%	17,21%
Average stops per shipment	-34,00%	-34,00%	-34,00%
Average distance per shipment in percent	-22,65%	-22,65%	-22,65%
Efficiency output			
Increase/decrease in average fill rate during trip assuming weight will decrease in truck on a linear basis in percent points	3,22%	3,22%	3,22%
Average fill rate during trip assuming weight will decrease in truck on a linear basis increase/decrease	7,97%	7,97%	7,97%
Increase/drecrease in average tonne-km work performed per shipment	-9,83%	-9,83%	-9,83%
Cost output (Distance calculation)			
Net profit	- 552 733,38 kr	- 428 594,19 kr	- 303 950,36 kr
Profit margin (percent points)	-1,44%	-1,55%	-1,65%
Profit margin increase/decrease by	-6,82%	-9,98%	-16,83%
Cost output (Time calculation)			
Net profit	- 496 510,97 kr	- 418 706,95 kr	- 340 586,65 kr
Profit margin (percent points)	-0,65%	-0,72%	-0,78%
Profit margin increase/decrease by	-3,19%	-4,25%	-5,88%

Table 40 Comparison of simulation results, outsourcing all orders up to 780 kg

Differences

Foria carriers is shipping all orders equal to or bigger than 780 kg.			
Shipment information	Real distance lower range (-1,71 %)	Real distance median range (+5,38%)	Real distance higher range (+12,5%)
Average distance between stops	28,32%	28,32%	28,32%
Average stops per shipment	-47,30%	-47,30%	-47,30%
Average distance per shipment in percent	-32,95%	-32,95%	-32,95%
Efficiency output			
Increase/decrease in average fill rate during trip assuming weight will decrease in truck on a linear basis in percent points	3,87%	3,87%	3,87%
Average fill rate during trip assuming weight will decrease in truck on a linear basis increase/decrease	9,57%	9,57%	9,57%
Increase/drecrease in average tonne-km work performed per shipment	-19,50%	-19,50%	-19,50%
Cost output (Distance calculation)			
Net profit	- 642 267,72 kr	- 465 020,47 kr	- 287 052,67 kr
Profit margin (percent points)	0,38%	0,41%	0,43%
Profit margin increase/decrease by	1,79%	2,63%	4,43%
Cost output (Time calculation)			
Net profit	- 579 192,47 kr	- 468 103,06 kr	- 356 562,06 kr
Profit margin (percent points)	1,34%	1,36%	1,38%
Profit margin increase/decrease by	6,60%	8,09%	10,39%

Table 41 Comparison of simulation results, outsourcing all orders up to 1000 kg

Differences

Foria carriers is shipping all orders equal to or bigger than 1000 kg.			
Shipment information	Real distance lower range (-1,71 %)	Real distance median range (+5,38%)	Real distance higher range (+12,5%)
Average distance between stops	31,15%	**31,15%**	31,15%
Average stops per shipment	-49,80%	**-49,80%**	-49,80%
Average distance per shipment in percent	-34,17%	**-34,17%**	-34,17%
Efficiency output			
Increase/decrease in average fill rate during trip assuming weight will decrease in truck on a linear basis in percent points	3,89%	3,89%	3,89%
Average fill rate during trip assuming weight will decrease in truck on a linear basis increase/decrease	9,62%	9,62%	9,62%
Increase/drecrease in average tonne-km work performed per shipment	-20,89%	**-20,89%**	-20,89%
Cost output (Distance calculation)			
Net profit	- 656 910,98 kr	- **469 900,38 kr**	- 282 129,56 kr
Profit margin (percent points)	0,83%	**0,89%**	0,95%
Profit margin increase/decrease by	3,95%	**5,78%**	9,74%
Cost output (Time calculation)			
Net profit	- 591 305,54 kr	- **474 096,97 kr**	- 356 411,93 kr
Profit margin (percent points)	1,87%	**1,91%**	1,95%
Profit margin increase/decrease by	9,19%	**11,35%**	14,68%

Table 42 Comparison of simulation results, outsourcing all orders up to 1500 kg

Differences

Foria carriers is shipping all orders equal to or bigger than 1500 kg.			
Shipment information	Real distance lower range (-1,71 %)	Real distance median range (+5,38%)	Real distance higher range (+12,5%)
Average distance between stops	54,51%	54,51%	54,51%
Average stops per shipment	-64,48%	-64,48%	-64,48%
Average distance per shipment in percent	-45,11%	-45,11%	-45,11%
Efficiency output			
Increase/decrease in average fill rate during trip assuming weight will decrease in truck on a linear basis in percent points	3,56%	3,56%	3,56%
Average fill rate during trip assuming weight will decrease in truck on a linear basis increase/decrease	8,81%	8,81%	8,81%
Increase/drecrease in average tonne-km work performed per shipment	-35,01%	-35,01%	-35,01%
Cost output (Distance calculation)			
Net profit	- 791 723,26 kr	- 548 553,02 kr	- 304 394,26 kr
Profit margin (percent points)	3,07%	3,29%	3,51%
Profit margin increase/decrease by	14,51%	21,24%	35,82%
Cost output (Time calculation)			
Net profit	- 717 832,92 kr	- 565 426,40 kr	- 412 400,32 kr
Profit margin (percent points)	4,46%	4,60%	4,74%
Profit margin increase/decrease by	21,91%	27,35%	35,75%

Table 43 Comparison of simulation results, outsourcing all orders up to 2000 kg

Differences

Foria carriers is shipping all orders equal to or bigger than 2000 kg.			
Shipment information	Real distance lower range (-1,71 %)	Real distance median range (+5,38%)	Real distance higher range (+12,5%)
Average distance between stops	69,66%	**69,66%**	69,66%
Average stops per shipment	-70,98%	**-70,98%**	-70,98%
Average distance per shipment in percent	-50,76%	**-50,76%**	-50,76%
Efficiency output			
Increase/decrease in average fill rate during trip assuming weight will decrease in truck on a linear basis in percent points	3,04%	**3,04%**	3,04%
Average fill rate during trip assuming weight will decrease in truck on a linear basis increase/decrease	7,51%	**7,51%**	7,51%
Increase/drecrease in average tonne-km work performed per shipment	-43,09%	**-43,09%**	-43,09%
Cost output (Distance calculation)			
Net profit	- 908 806,40 kr	**- 638 473,21 kr**	- 367 041,07 kr
Profit margin (percent points)	3,18%	**3,41%**	3,64%
Profit margin increase/decrease by	15,04%	**22,02%**	37,15%
Cost output (Time calculation)			
Net profit	- 841 751,82 kr	**- 672 320,96 kr**	- 502 201,35 kr
Profit margin (percent points)	4,43%	**4,57%**	4,72%
Profit margin increase/decrease by	21,73%	**27,16%**	35,55%

Table 44 Comparison of simulation results, outsourcing all orders up to 3000 kg

Differences

Foria carriers is shipping all orders equal to or bigger than 3000 kg.			
Shipment information	Real distance lower range (-1,71 %)	Real distance median range (+5,38%)	Real distance higher range (+12,5%)
Average distance between stops	101,81%	101,81%	101,81%
Average stops per shipment	-79,52%	-79,52%	-79,52%
Average distance per shipment in percent	-58,68%	-58,68%	-58,68%
Efficiency output			
Increase/decrease in average fill rate during trip assuming weight will decrease in truck on a linear basis in percent points	2,59%	2,59%	2,59%
Average fill rate during trip assuming weight will decrease in truck on a linear basis increase/decrease	6,42%	6,42%	6,42%
Increase/drecrease in average tonne-km work performed per shipment	-53,20%	-53,20%	-53,20%
Cost output (Distance calculation)			
Net profit	- 1 050 351,59 kr	- 743 061,66 kr	- 434 522,54 kr
Profit margin (percent points)	4,17%	4,47%	4,77%
Profit margin increase/decrease by	19,70%	28,84%	48,65%
Cost output (Time calculation)			
Net profit	- 998 393,82 kr	- 805 800,39 kr	- 612 424,04 kr
Profit margin (percent points)	4,76%	4,95%	5,14%
Profit margin increase/decrease by	23,36%	29,40%	38,72%

APPENDIX E – ENVIRONMENTAL TABLES AND FIGURES

Table 45. Fuel consumption for the vehicles concepts/types (NTM, 2008)

Vehicle size				Fuel Consumption					
NTM notation	ARTEMIS notation	Truck size	Fuel / engine combination	Motorway		Rural		Urban	
		Max vehicle weight		Cargo capacity utilisation by weight		Cargo capacity utilisation by weight		Cargo capacity utilisation by weight	
		[tonne]		0%	100%	0%	100%	0%	100%
Small lorry/truck	Truck <7,5t	3,5 - 7,5	Diesel, Euro 1-5	0,122	0,137	0,107	0,126	0,110	0,134
Medium lorry/truck	Truck 7,5-12t + 12-14t	7,5 - 14	Diesel, Euro 1-5	0,165	0,201	0,152	0,197	0,171	0,228
Large lorry/truck	Truck14-20t + 20-26t	14 - 26	Diesel, Euro 1-5	0,204	0,273	0,199	0,284	0,244	0,352
Tractor + "city-trailer"	TT/AT 14-20+20-28t	14 - 28	Diesel, Euro 1-5	0,201	0,294	0,205	0,318	0,255	0,402
Lorry/truck + trailer	TT/AT 28-34 + 34-40t	28 - 40	Diesel, Euro 1-5	0,226	0,360	0,230	0,396	0,288	0,504
Tractor + semi-trailer	TT/AT 28-34 + 34-40t	28 - 40	Diesel, Euro 1-5	0,226	0,360	0,230	0,396	0,288	0,504
Tractor + MEGA-trailer	TT/AT 40-50t (tidigare >34-40t)	40 - 50	Diesel, Euro 1-5	0,246	0,445	0,251	0,495	0,317	0,634
Lorry/Truck + Semi-trailer	TT/AT 50-60t	50 - 60	Diesel, Euro 1-5	0,282	0,540	0,334	0,608	0,369	0,783

Table 46. Data used to calculate fuel consumption based on Cargo Capacity and type of road (Scenario 1)

		Fuel Consumption (l/km)								
		Motorway			Rural			Urban		
Type of Truck (NTM)	Truck size max weight ton.	Cargo Capacity utilization			Cargo Capacity utilization			Cargo Capacity utilization		
		0%	100%	40%	0%	100%	40%	0%	100%	40%
HDV truck + trailer	60	0.282	0.540	0.385	0.334	0.608	0.443	0.369	0.783	0.536

Table 47. Data used to calculate fuel consumption based on Cargo Capacity and type of road (Scenario 2)

		Fuel Consumption (l/km)								
		Motorway			Rural			Urban		
Type of Truck (NTM)	Truck size max weight ton.	Cargo Capacity utilization			Cargo Capacity utilization			Cargo Capacity utilization		
		0%	100%	14% MDV 43% HDV	0%	100%	14% MDV 43% HDV	0%	100%	14% MDV 43% HDV
MDV Lorry Truck	7.5	0.122	0.137	0.124	0.107	0.126	0.110	0.110	0.134	0.113
HDV truck + trailer	60	0.282	0.540	0.393	0.334	0.608	0.452	0.369	0.783	0.547

Table 48. Data used to calculate fuel consumption based on Cargo Capacity and type of road (Scenario 3)

		Fuel Consumption (l/km)								
		Motorway			Rural			Urban		
Type of Truck (NTM)	Truck size max weight ton.	Cargo Capacity utilization			Cargo Capacity utilization			Cargo Capacity utilization		
		0%	100%	32% MDV 44% HDV	0%	100%	32% MDV 44% HDV	0%	100%	32% MDV 44% HDV
MDV Lorry Truck	7.5	0.122	0.137	0.122	0.107	0.126	0.107	0.11	0.134	0.11
HDV truck + trailer	60	0.282	0.54	0.282	0.334	0.608	0.334	0.369	0.783	0.369

Table 49. Emissions for HVD + trailer truck in urban road type (NTM-Road, 2008)

Vehicle gross weight	40 - 60 [tonne]
Engine / Fuel	Diesel / Diesel (european)
Load factor	50%
Road type	Mix of **urban road** types (weighted average, SvARTEMIS)
Speed limit	Mix of rural road types (weighted average, SvARTEMIS)
Slope/topography	Weighted average (distribution from HBEFA 2.1)

[g/l]	HDV/ Euro0	HDV/Euro1	HDV/Euro2	HDV/Euro3	HDV/Euro4	HDV/Euro5
HC	2,05	2,21	1,44	1,221	0,066	0,0661
CO	6,37	6,32	5,10	5,83	0,43	0,431
NOx	35,2	28,4	30,1	23,3	15,2	8,70
PM	1,44	1,32	0,572	0,558	0,103	0,1024
CO2	2621	2621	2621	2621	2621	2621
CH4	0,0409	0,0442	0,0289	0,0244	0,0013	0,001321
SOx	0,00333	0,00333	0,00333	0,00333	0,00333	0,00333

Table 50. Emissions for HVD + trailer truck in rural road type (NTM-Road, 2008)

Vehicle gross weight	40 - 60 [tonne]
Engine / Fuel	Diesel / Diesel (european)
Load factor	50%
Road type	Mix of **rural road** types (weighted average, SvARTEMIS)
Speed limit	Mix of rural road types (weighted average, SvARTEMIS)
Slope/topography	Weighted average (distribution from HBEFA 2.1)

Vehicle gross weight 40-60t. Load factor 50%.

[g/l]	HDV/ Euro0	HDV/Euro1	HDV/Euro2	HDV/Euro3	HDV/Euro4	HDV/Euro5
HC	1,41	1,66	1,06	0,887	0,044	0,0445
CO	4,83	5,01	4,00	4,15	0,34	0,336
NOx	37,3	29,4	30,0	23,0	15,4	8,61
PM	1,24	1,09	0,492	0,442	0,074	0,0735
CO2	2621	2621	2621	2621	2621	2621
CH4	0,0283	0,0332	0,0212	0,0177	0,0009	0,000890
SOx	0,00333	0,00333	0,00333	0,00333	0,00333	0,00333

Table 51. Emissions for HVD + trailer truck in motorway road type (NTM-Road, 2008)

Vehicle gross weight	40 - 60 [tonne]
Engine / Fuel	Diesel / Diesel (european)
Load factor	50%
Road type	Mix of **motorway** types (weighted average, SvARTEMIS)
Speed limit	Mix of motor way types (weighted average, SvARTEMIS)
Slope/topography	Weighted average (distribution from HBEFA 2.1)

Vehicle gross weight 40-60t. Load factor 50%.

[g/l]	HDV/ Euro0	HDV/Euro1	HDV/Euro2	HDV/Euro3	HDV/Euro4	HDV/Euro5
HC	1,50	1,67	1,03	0,896	0,0488	0,0489
CO	6,67	6,81	5,90	6,37	0,348	0,347
NOx	35,4	27	28	21,9	15,0	8,40
PM	1,40	1,27	0,70	0,506	0,0772	0,0771
CO2	2621	2621	2621	2621	2621	2621
CH4	0,0299	0,0334	0,0206	0,0179	0,00098	0,00098
SOx	0,00333	0,00333	0,00333	0,00333	0,00333	0,00333

Table 52. Emission for MVD Lorry truck in urban road type (NTM-Road, 2008)

Vehicle gross weight	3,5 - 14 [tonne]
Engine / Fuel	Diesel / Diesel (european)
Load factor	50%
Road type	Mix of **urban road** types (weighted average, SvARTEMIS)
Speed limit	Mix of rural road types (weighted average, SvARTEMIS)
Slope/topography	Weighted average (distribution from HBEFA 2.1)

[g/l]	HDV/ Euro0	HDV/Euro1	HDV/Euro2	HDV/Euro3	HDV/Euro4	HDV/Euro5
HC	7,24	2,40	1,62	1,38	0,0759	0,0758
CO	12,75	6,05	5,00	5,76	0,482	0,478
NOx	33,7	26,0	28,9	21,1	13,5	7,83
PM	2,15	1,27	0,548	0,574	0,1122	0,1116
CO2	2621	2621	2621	2621	2621	2621
CH4	0,1447	0,0481	0,0324	0,0277	0,00152	0,00152
SOx	0,00333	0,00333	0,00333	0,00333	0,00333	0,00333

Table 53. Emission for MVD Lorry truck in rural road type (NTM-Road, 2008)

Vehicle gross weight	3,5 - 14 [tonne]
Engine / Fuel	Diesel / Diesel (european)
Load factor	50%
Road type	Mix of **rural road** types (weighted average, SvARTEMIS)
Speed limit	Mix of rural road types (weighted average, SvARTEMIS)
Slope/topography	Weighted average (distribution from HBEFA 2.1)

[g/l]	HDV/ Euro0	HDV/Euro1	HDV/Euro2	HDV/Euro3	HDV/Euro4	HDV/Euro5
HC	4,76	1,67	1,09	0,92	0,0472	0,0473
CO	10,58	4,67	4,07	4,06	0,357	0,356
NOx	36,9	27,7	29,4	21,3	14,2	8,17
PM	1,79	0,97	0,481	0,417	0,0776	0,0775
CO2	2621	2621	2621	2621	2621	2621
CH4	0,0952	0,0334	0,0219	0,0185	0,00094	0,00095
SOx	0,00333	0,00333	0,00333	0,00333	0,00333	0,00333

Table 54. Emission for MVD Lorry truck in motorway road type (NTM-Road, 2008)

Vehicle gross weight	3,5 - 14 [tonne]
Engine / Fuel	Diesel / Diesel (european)
Load factor	50%
Road type	Mix of **motorway** types (weighted average, SvARTEMIS)
Speed limit	Mix of motor way types (weighted average, SvARTEMIS)
Slope/topography	Weighted average (distribution from HBEFA 2.1)

[g/l]	HDV/ Euro0	HDV/Euro1	HDV/Euro2	HDV/Euro3	HDV/Euro4	HDV/Euro5
HC	3,70	1,40	0,88	0,74	0,04	0,04
CO	10,65	5,10	4,34	4,36	0,29	0,29
NOx	36,5	26,4	27,6	19,9	13,7	7,74
PM	1,72	0,99	0,54	0,38	0,06	0,06
CO2	2621	2621	2621	2621	2621	2621
CH4	0,0740	0,0280	0,0176	0,0148	0,000764	0,000768
SOx	0,00333	0,00333	0,00333	0,00333	0,00333	0,00333

APPENDIX F – FINANCIAL ANALYSIS (QLIKVIEW)

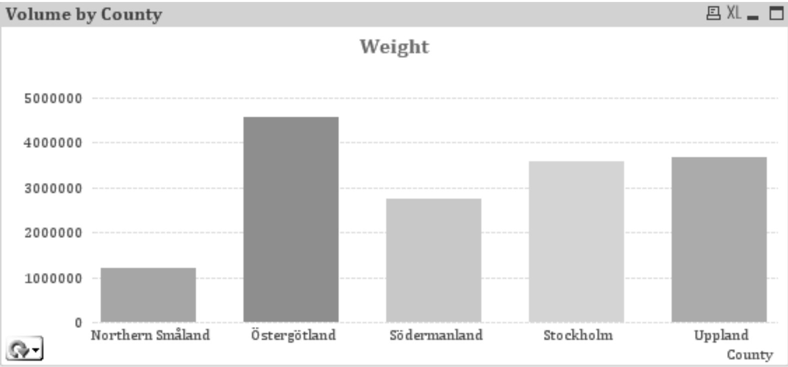


Figure 32. Qlikview overview: Regions by Volume (Weight and Order)

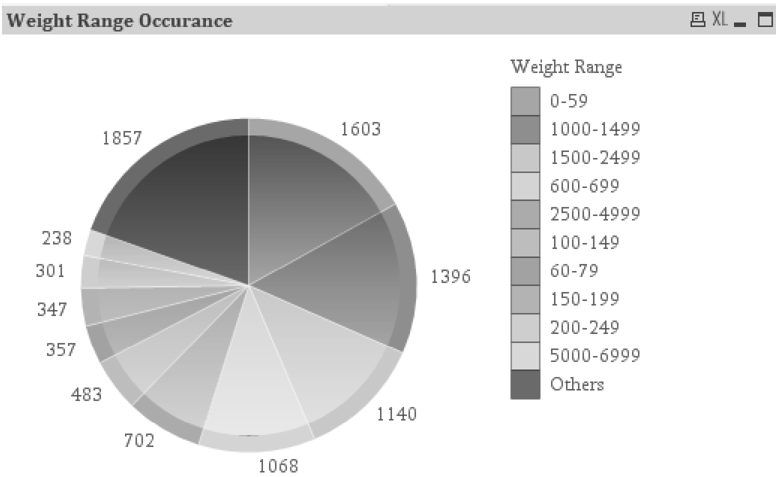


Figure 33 Qlikview overview: Weight Range occurrence

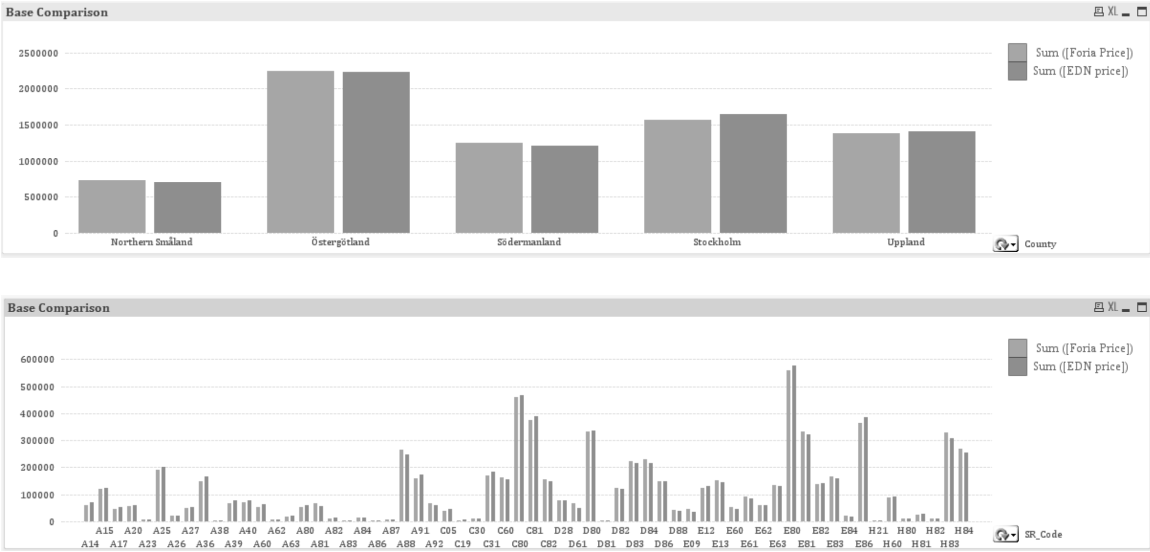


Figure 34. County and Sub-region prices comparison between Foria and EDN

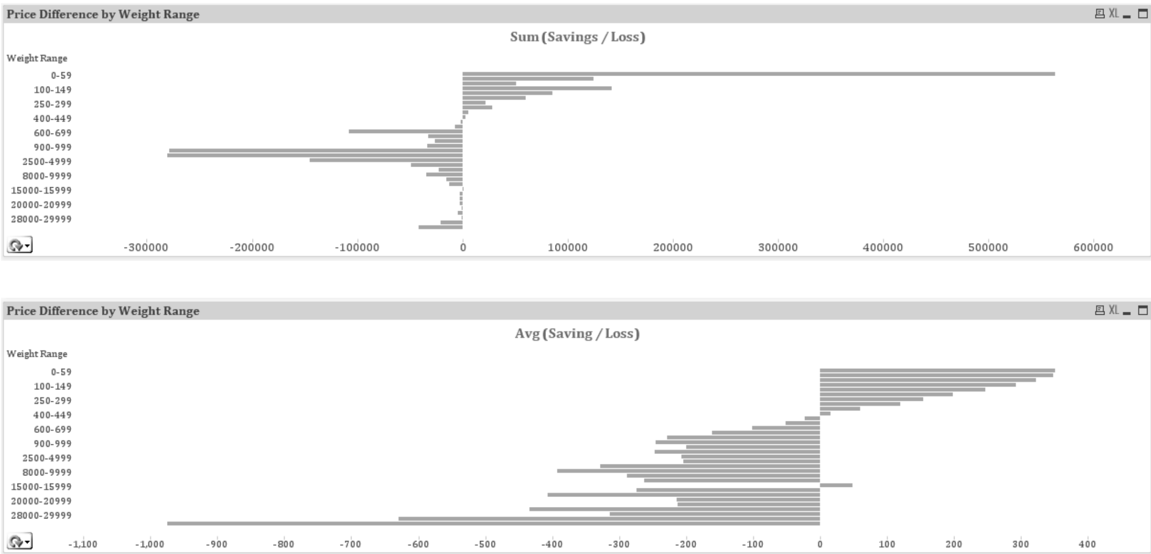


Figure 35. The Breaking Point (Foria vs. EDN)

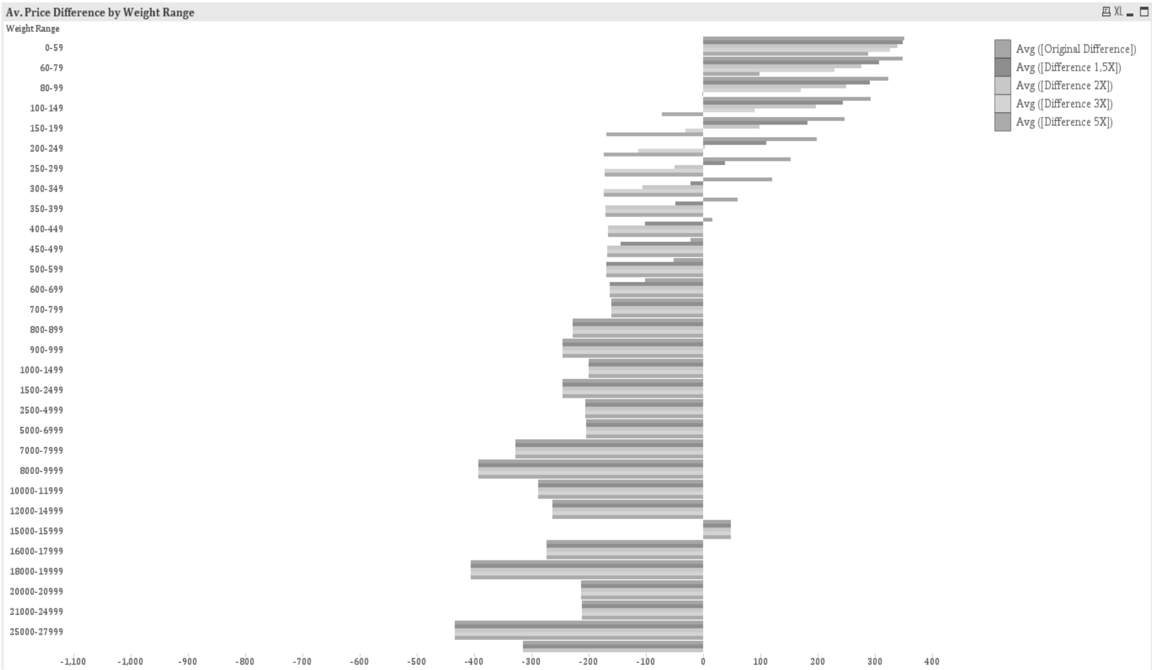


Figure 36. Breaking point overview with the different sensitive volumetric weight adjustments

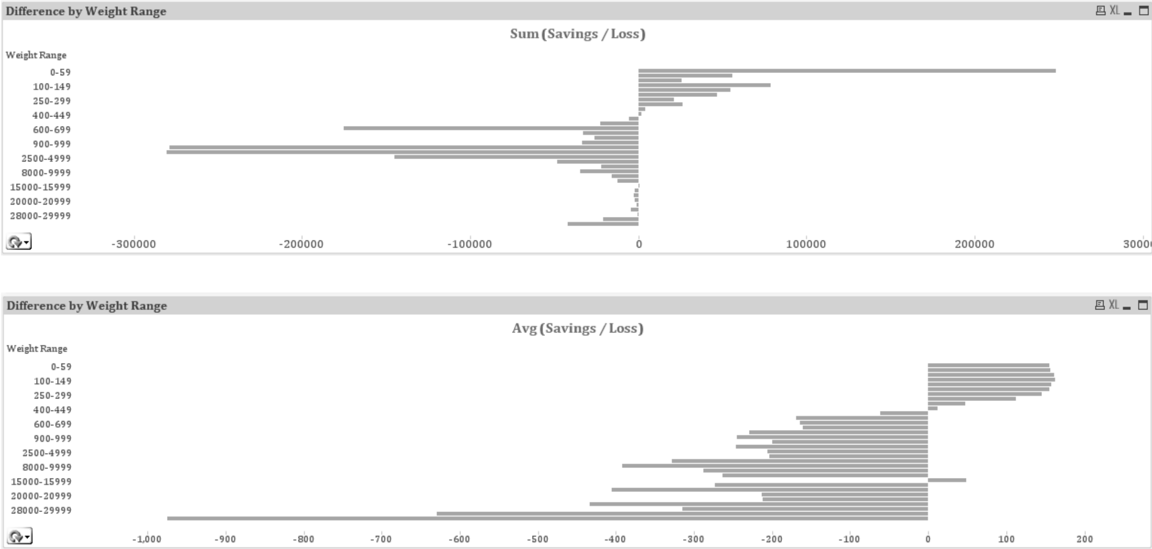


Figure 37. The Breaking Point volumetric adjustment (Conservative Scenario)

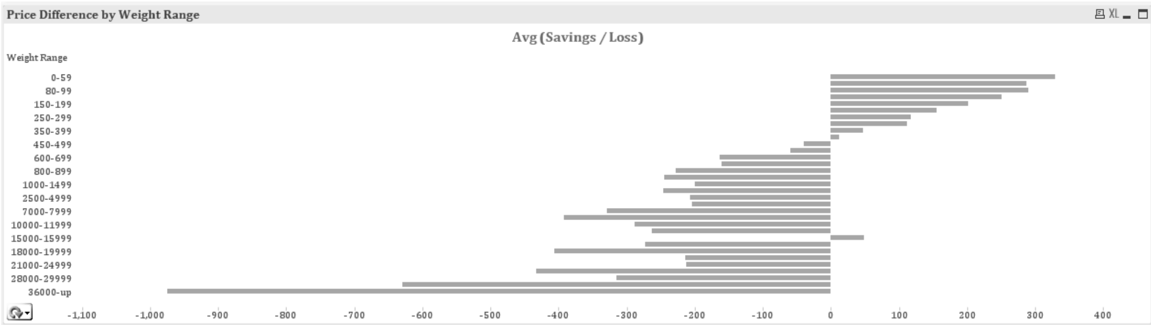


Figure 38. The Breaking Point volumetric adjustment (Max Profit Scenario)

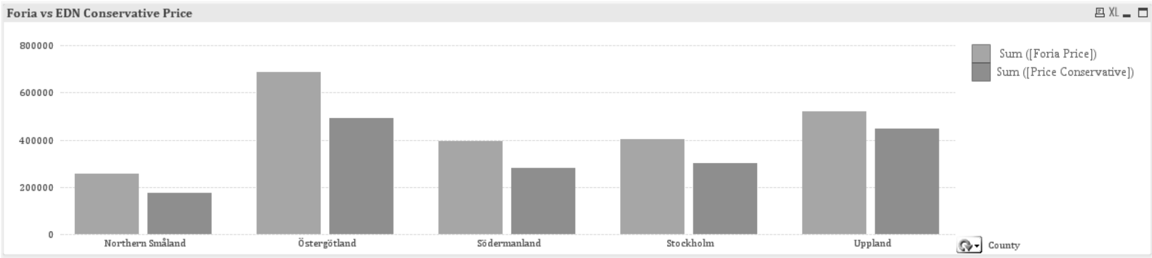


Figure 39. Conservative Scenario price comparison by county (0 kg – 299 kg)

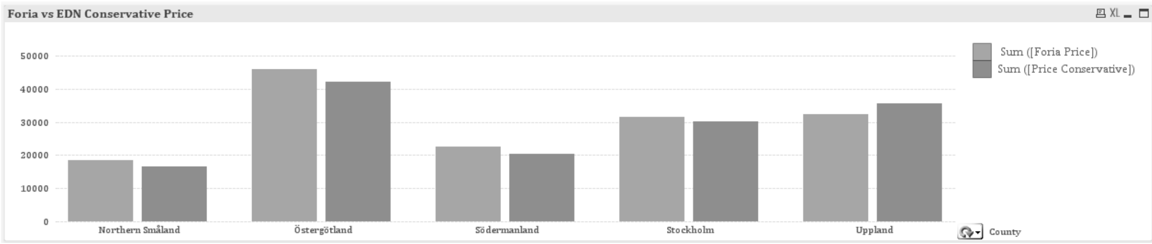


Figure 40. Conservative Scenario price comparison by county (350 kg – 449 kg)

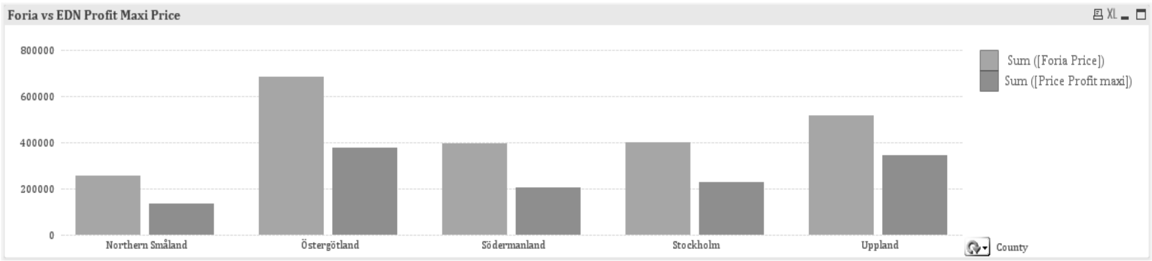


Figure 41. Max Profit Scenario price comparison by county (0 kg – 299 kg)

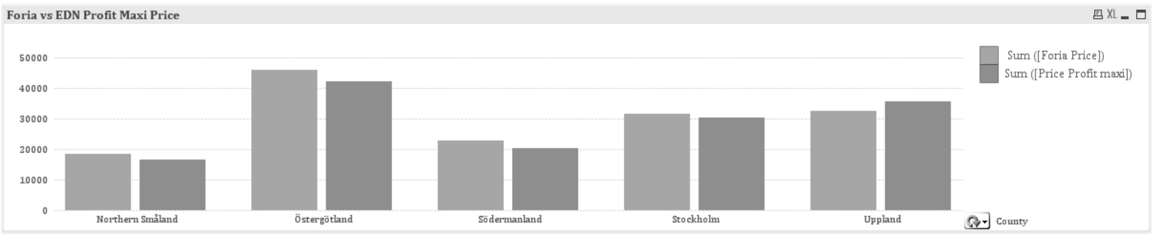
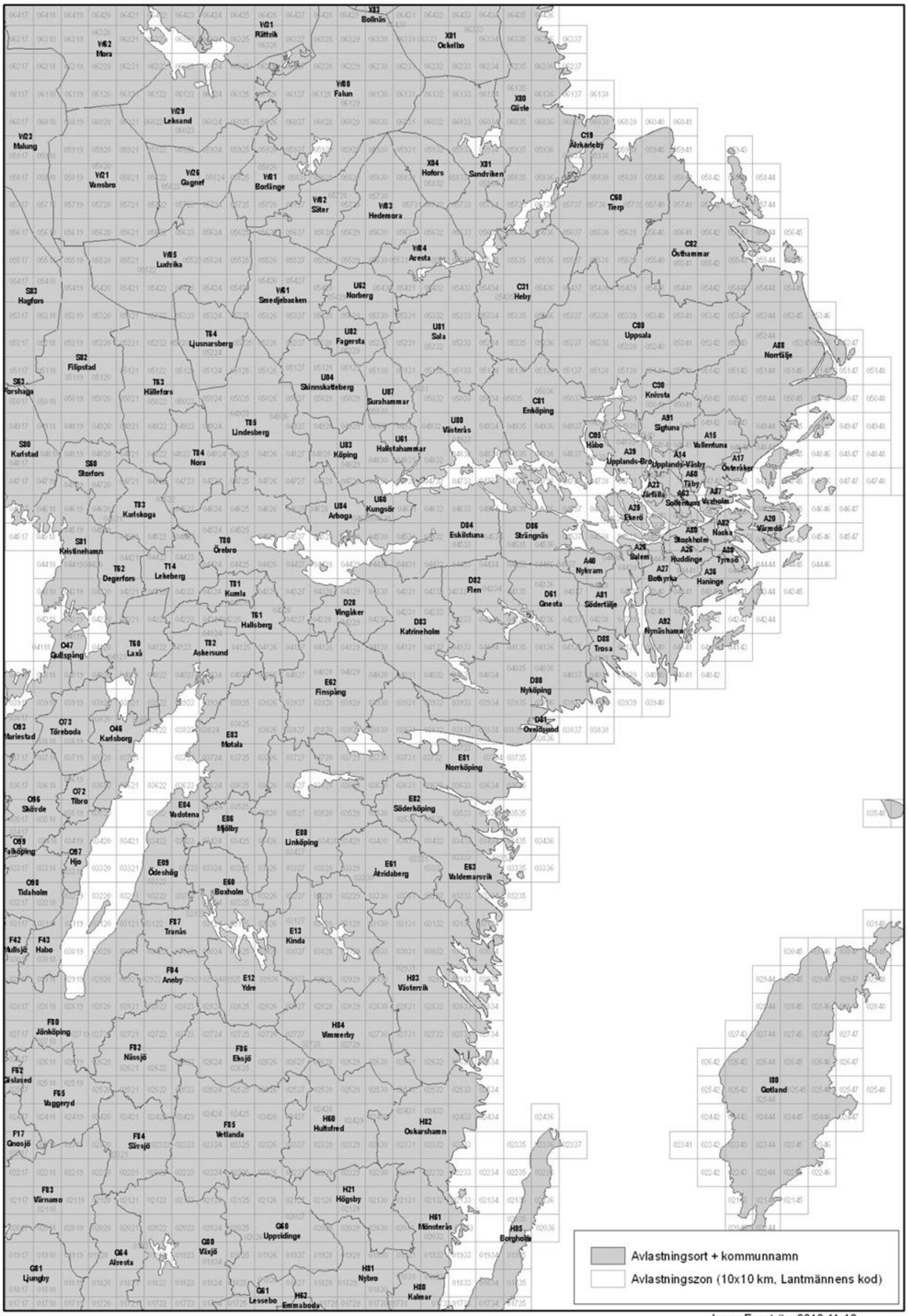


Figure 42. Max Profit Scenario price comparison by county (350 kg – 449 kg)

APPENDIX G - SCALED MAP OF SWEDEN



Jonas Engström 2010-11-12

APPENDIX H –SUMMARIES OF INTERVIEWS, MEETINGS AND FIELD STUDIES

Summary of interview/meeting with Management and transport planner´s at Foria

Date: September 22th to September 23th 2011

Agenda:

- Management and transport planners' interview / meeting
- Driver Interview
- Farmer visit and interview
- Västerås Warehouse visit

Present at the meeting.

Chairman at Foria, Håkan Larsson. He has a long experience with this type of transports and he is a driving force and initiator for this new extended contract with Lantmännen from Foria (The Lantmännen project is about 10% of Foria business).

Joakim Ivarsson representing Lantmännen. He has been the counterpart in negotiations for the new contract between Foria and Lantmännen and he is responsible for these transports at Lantmännen today.

Kjell Johansson, traffic manager at Foria. He has an operative responsibility for these types of transports at Foria today.

Stefan Palmgren, business developer at Foria. Our key contact and tutor at Foria for this master thesis.

Tobias Gagneskog and Ulrik Karlsson, transport planners at Foria. They work with these transports today and providing the trucks to Lantmännen. They are also the ones who will plan these shipments in the future.

Oscar Kjellberg and Adrian Ruiz de la Llata, master thesis writers from Chalmers.

The interview/meeting was held partly in English and partly in Swedish. This is a summary of the important points put forward on the meeting. It is not a transcript from meeting and the quotes and ideas are not organized in a chronological order presented at the meeting, instead they are organized around certain topics. The text is not an exact quote of what has been said by someone, partly due to the fact that it is sometimes translated and it was a group meeting/interview where several people spoke around a certain issue.

Why do they need to change the current way of working? What is the problem?

- It is fundamental for Foria to find synergy effects between the Lantmännen shipments and other shipments within Foria to get better economy in the entire system. It is important for Foria to make these shipments right from the beginning. On a more general level Foria need to consider all of their transport flows into account when planning out transports. (I.e. the transports planners need to be able to find return shipments for the drivers after they've delivered the goods for Lantmännen and shipments into Västerås for when they pick up the cargo.) – *Håkan*

- The problem that we want you to look at is the small pallet shipments from Västerås out to the farmers. This is the problem today. – *Stefan*

- Up until now we've had a specific day. E.g. Wednesday we go with a truck into the southern parts of Östergötland and Thursdays we go with a truck to the northern parts etc. This has been a problem for Lantmännen since the farmers can order many of the same items online and it will be delivered the next day. But with Lantmännen it will be delivered next week. They do not want this anymore. – *Håkan*
    - Do not see this as such a very big problem however. Order day 1. And then delivery at day 2-5. And if it is urgent they can order express shipment. – *Joakim*

- But the main question is, how we are going to reach the end customer with all the flow of goods from Västerås without having to drive around with a truck and trailer for 100km extra on the small "back roads of nowhere "to drop of a small little shipment of 25 KGs? – *Håkan*

- The biggest problem is that each round is so wide spread. There are many unloading points and there is a long distance between each unloading point. Each trip takes 2-3 days. Depending on where the driver lives, he might have to go some distance to Västerås quite early on morning, sometimes empty but we try to find a load into Västerås for them, to load for a 2-3 day trip. - Transport planner.

- One of our basic approaches is that we are going to load more on these trucks because we do not fill them as it is today. We have trucks that we do not fill more than 60% over time; we need to get that up to at least 80%. And if we load more on the trucks, we will make more money and they will make more money, win-win. – *Håkan*

- Since the drivers are also the owners of Foria we have the responsibility to give them a better economy as well. We just do not buy them in and then do not care; we need to make better use of their trucks so we can improve the economy for all. – *Stefan*

- One problem is that we need to prove that this is better for the drivers compared to the old model so that they are willing to change and come along with this.

- If you can show us with figures that it will be better for them we can take that and show our drivers so that they will be willing to change. – Stefan

What type of cargo is it? How is it packaged? Size etc.?

- There are different kinds of shipments. Sometimes there are several whole pallets; sometimes it is just 5 KG's of seeds. It is either on pallets or big bags. The flow to the farmers is also very different from the flow from the farmers. The flow from farmers is generally bulk cargo so this means that they cannot pick up goods from the farmers on the same time as they are delivering to them. – *Håkan*

- The goods for this flow are all palletized and they can be loaded together, there are not grouping problems and different cargo can be in the same truck etc. – *Håkan*

- Average order size is about 2-3000 KGs – *Joakim*

- Average order is 1500-2000 KGs (2-3 pallets) Usually big farmers take more and some of the smaller farms just 200-300 KGs, sometimes even less. In general there is a lot of small shipments, and some really big.

- Very many unique articles – this means it is basically impossible to keep small stocks at a transshipment terminal; everything has to be sent from Västerås.

- Everything that you should consider for this flow from Västerås should be considered as being palled goods. – *Joakim, Håkan, Stefan*

Problems and issues with this flow that need to be considered?

- One issue is the unloading at the farmers. They do not have any unloading docks or anything like that. Usually it is just a courtyard made out of gravel, and the driver and truck needs to be prepared for this and be able to unload regardless. – *Joakim Ivarsson*
    - This is sometimes an issue, however, a regular distribution truck with a manual pallet mover and hydraulic ramp should be sufficient for this type of cargo.

- Sometimes they need to reallocate and reload shipments on the road due to access problems to the roads. I.e. the truck + trailer are too big so they need to move goods and go in only with the truck and maybe leave the trailer. 15% of all shipments are like this.

Information about the customers

- Minimum 2200 different customers, maybe more. Maybe even 10000 possible off-loading points.

- We have a lot of small farms located a bit in the outskirts; these are often the "trouble farms". The bigger farms usually have a designated off-loading zone.

- Sometimes the actual farmer won't be there to receive the goods at the farms. They just say drop it off here etc. In these cases the driver tries to accommodate the farmers requests as much as possible as well as try to cover the goods so the weather won't damage it.

Information about the current operations

- The basic operations time for these transports operations is 1-3 days. Often 1 day, but longer when going to the southern parts. – *Håkan*

- It can take up to three days to deliver all the shipments because there can be more 45 stops for one truck. – *Kjell*

- It is about 2-3 full trucks a week today but is likely to increase to 1-2 trucks a day leaving Västerås.

- There is quite big seasonal variation.

- Today the transport planners just receive fixed shipments and they make sure that there is a truck in Västerås to pick it up and they try to plan so they have shipments for the truck into Västerås and at its ending position.

- It is an entirely computerized process, there is no need for papers, digital waybills etc. However the actual planning is done manually by the know-how from the transport planners and local knowledge from drivers.

- Today the main concern for the transport planners is how he will get shipments into Västerås and shipments for the drivers when he's done with this Lantmännen round. They also need to take the truck size into account sometimes since some trucks are to big to enter certain farms and to minimize travel times for drivers they also try to take where they live into account.

Information about the trucks used today.

- The big HDV-Trucks + trailer used for this distribution today have their own loading and unloading capacity. Either through a crane or a portable forklift. – *All combined*

- They are driving around with a 24m long carriage and delivering small cargo.

- They are specialized for bulk cargo pickup during harvest season from farmers. This means that they are often quite low and cannot load as much on height as a regular delivery truck.

- The trucks are built to fit the harvest season and so that they can get access to the farms so they are not able to load as much regular cargo as regular expedition trucks due to a limited height. For example isolation material (which is usually volume restricted) cannot be shipped with this type of trucks. Ideally we need to find shipments of heavier cargo where the weight sets the boundaries. – *Transport planner and Håkan*.

- One problem is the unloading. These trucks that we use today are equipped with either a long arm that we can use for loading and unloading or the portable forklift. This won't be available in smaller distribution trucks. One problem that we have today is that the trucks we have are specialized in "everything", they do bulk transports and they have this expensive arms or forklift for unloading or sometimes even both. For the future we need to focus more, say these trucks are used for bulk, these for bags, these for pallets etc. It is too expensive to equip every truck with all these features.

- These trucks might be low, but they can load a lot, and they take bulk so for some shipments they are really practical. – *Håkan*

The new agreement between Foria and Lantmännen

- It is a normal customer buyer relation. Basically Lantmännen is going to send everything they have from Västerås into Foria's "machine" and they we are going to solve their problems. We will be their sole supplier for this type of flow. This means we have to think in a new way – regarding these shipments. However, the problem we are giving you to solve is one part of this entire contract. – *Håkan*

- We have a service demand of 98%. This means delivery within 2-5 days. Today we are at 96-97%. Of course faster is better but generally as long as we deliver within this period it is OK. – *Håkan and Joakim*

- All the agreements and terms are not finalized since we started by setting a price frame for Lantmännen, what the shipments are allowed to cost; Now Lantmännen and Foria are negotiating what are supposed to be included in this.

- We have to do this in a better way since we will not get any economy in doing it the old way anymore. The price we have negotiated with Lantmännen for this new contract won't cover our expenses for this to be run as it always has. – *Håkan*

Limitations / the future / other issues

- Possibilities for renting space in terminals in Norrköping and Örebro. They won't build a new terminal.

- However, finding and getting a load back from Norrköping or Örebro shouldn't be a major concern. – *Transport planners*

- In the future the transport planners will receive the sales orders and then plan each run and what should be on each truck etc. with respect to geographic location, dates and so on.

- Today the lead-time is fairly short when the actual transport is on the way. This means that the maximum waiting time in a transshipment terminal should be max 1 day.

- Perhaps fixed delivery dates for certain areas are a good solution? At least Lantmännen won't object to that. – *Joakim*

- The previous setup has been that Lantmännen has been doing the planning and we at Foria have been supplying them with our resources. In the future we are going to take over this planning. We'll receive the pile of orders and organize shipments as good as possible. – *Stefan*

- One issue is the small goods and another issue is the big shipments?
  Today we load all of these together, but in the future maybe a separation between the small shipments of 500-1000 kg could be handled differently and the big shipments with several pallets in another way. – *Transport planners*

- It could be more cost effective to drive around since it is costly to unload and offload an extra time as well. – *Håkan*

- It is important to gather shipments together. Sometimes a farmer gets both a small shipment and a big shipment. Then it is more cost effective to gather these and not just by rule divide them up into: 1) big shipment direct, 2) small shipment transshipment terminal; it is important to sort by customer and not by shipment, because today partial deliveries are sometimes an issue. – *Transport planner, Joakim*.

- Another problem is Stockholm. Heavy traffic slows us down and opening hours at some drop off points do not match our logistic flows, the driver might want to make the drop off at 7 to get the best possible route, but maybe it is not possible to do that until 10 or 11. – Transport planner

- One thing to consider is that if we are going to continue with the "milk runs" for the big shipments, it is necessary to check if there enough cargo to fill up a truck with small shipments at least once or twice a week. – *Transport planner*.

- One thing could be that we bring all the goods on a big truck as now but we'll unload the small shipments somewhere on the way and distribute these with a smaller truck. – *Joakim*

- Depending on what type of shipment we could get into Västerås and from where will determine which driver and truck we'll use for this specific run. However, this will be a limitation in the model and considered a different problem, we will only consider the flow outbound from Västerås to make it simpler. *Transport planners, Oscar, and Stefan and Håkan*.

Summary of interview with driver

Driver Name: Tobias Avren

Tobias is the driver and owner of a big HVD truck and trailer with crane.. Even though he only bought the truck 6 months ago, he has 11 years driving experience where 8 years are with Lantmännen and therefore, the driver know all the routine knowledge (know-how) about these shipments.

Cargo transported:

Foria trucks basically transport big bags & pallets for Lantmännen. Normally the pallets are EU standard, but sometimes smaller pallets are transported as well.

Description of their regular activities:

- Tobias never transports full cargo to only one single farm from the warehouse located in Västerås and normally, each trip consists on between 20 and 30 deliveries to different farms. Each trip is done generally once a week in a milk-run distribution setup, which takes between 2-3 days due to the geographically wide spread locations.

- When the driver loads the cargo at Västerås, he receives a waybill with information of what products are loaded (description, quantity in pallets and weight).

- The proportion of the shipments is approximately 70% big size deliveries (8-10 pallets) going normally to the big farms or supplier stores, and 30% small deliveries (2-3 pallets) normally for small animal farms.

Problems perceived by the driver

- A poor availability of products ordered by the farmers in Lantmännen's warehouse sometimes results on costly extra transport in the same week. Some reasons for this are the really bad warehouse administration at Västerås and also the huge assortment of products.

- Mainly the animal farms, which fairly often order small goods, cannot take the big trucks and trailers, so frequently the driver need to leave the trailer on the road outside the farm and serve just with the truck. Besides, sometimes (not that often) loading/unloading activities are necessary in the road when re-arrangement of the cargo is necessary.

- In order to avoid the re-arrangement problem, the driver needs to be aware of the farms that cannot take the trailers and then load the corresponding goods only in the truck. But sometimes the driver is not familiarized with the farm and does not know is possible to drive in with the trailer or not. However the truck drive may know a colleague driver whose knows the information.

- In the rain season the road gets soft and muddy and that makes the loading activities harder for a small distribution truck. There might be some similar problems whit the snow. Sometimes even the ground is so soft that it is impossible for the driver to get into the farm with the truck and thus the farmer need to pick the products outside the farm.

- In the past, the driver was able to see what the farmer ordered and what he actually gets. But today the driver is only able to see what is loaded and if something is missing from the actual farmer order, the driver can`t provide any information.

- Animal farms have a higher demand during the winter season when all animals are in the barns. This high season demands for pallets to deliver are shared with the loading/unloading problems of the rainy and snowy season described before.

- Sometimes due to the geographical separation of the customers, one single delivery can take several hours. Considering the average of 25-30 customers per run, according to the driver this may results in late night deliveries to other customers, which some farmers complain off.

- There are some small farms that order small batches quite often because there is not restriction on that from Lantmännen (There is not MOQ). So instead of get one pallet of product that would last 3-4 weeks they order small amounts every week, which is rather inefficient.

- According to the driver sometimes the milk-run route could be from north Stockholm to all the way down in Norrköping (2-3 days). Drivers are aware that this configuration is not efficient.

Complains from farmers mentioned by the driver

- Farmers often complain that when the shipment is received they are missing part of the order.

- The delivery of goods sometimes is really late (9 in the evening). This is really common according to driver.

Some considerations:

- There are some "picky" farmers about how may do the delivery to their farm and who is not.

- The idea of the smaller trucks looks reasonable to the driver however he thinks that might be some considerations needed with the weight loading capacity of the small trucks because some of the products are really heavy (pallets could weight sometimes up than 1 ton).

- According to the truck driver, Rain and bad climate conditions may make harder to unload the goods with smaller trucks.
- The truck driver would feel more comfortable to deliver on familiar areas, so an idea would be to assign the shipments to specific drivers in specific areas as much as possible, so the drivers would have a better knowledge of the roads and the farms.

- For unloading the big trucks there are two possibilities; Forklift and Crane. With both is possible to unload any kind of goods (pallet or bags) but Forklift is the most efficient for Pallets and Crane is the most efficient for Bags.

- The agreement for this distribution indicates that driver needs to drop the shipment just in the side and the farmer need to take care of it by themselves. However drivers put the shipments always in a safety place.

- The idea of changing the distribution setup by adding distribution trucks and assigning other activities to the bigger trucks where they could be use more economically efficient would be very welcome according to Tobias.

- A good idea is a field study where we could go for a delivery day with a truck in order to get firsthand experience and trucking culture.

Summary of interview with a farmer

Oscar Kjellberg, Adrian Ruiz de la Llata, Stefan Palmgren and Joakim Ivarsson conducted an interview with a crop farmer just outside Nyköping. The interview was conducted in Swedish and thus the quotes in this summary are not the exact expression.

The farmer is a crop farmer and usually do not order that many small shipments from Lantmännen, however he has small shipments from other suppliers and he also is an elected trustee for farmers within his area and thus have some general "farmer side" knowledge.

Regarding different farms

- Different farms have different kinds of inbound flows. We are a crop farm and have a very different logistics compared to for example an animal farm. I believe they have more small shipments coming in. – Farmer

Regarding the trucks and smaller shipments

- Usually it is not the truck that's the problem, the important part is that we get what we order and get it on time, and the method of delivery is usually not an issue.

- It is often no problems to receive small shipments a little now and then because one do not have to plan that much for receiving the goods, it is usually easy to take care of comparing to if you receive a big shipment of several pallets that require you to work a bit to receive and take care of the goods.

- To summarize, we can receive goods from various types of vehicles, with smaller trucks we can assume we would got more frequent deliveries which is only a plus.

Possible improvements

- More frequent deliveries. Today shipments from Lantmännen usually only comes one day a week. If you had smaller trucks that might be able to increase to two possible delivery days a week?
  - Schenker drives every other day for other deliveries.

    - Schenker and DHL use other types of smaller trucks with hydraulic lift at the back for these small shipments that sometimes comes.

- As a farmer you cannot always control when you need to do something's, the weather and other outer factors determine when you need to work and need certain items. So the service level and delivery time is usually more important than what type of transport that is used.

What is not working today?

- Sometimes we cannot items from Lantmännen on times. They do not have enough items in storage so when we order we have to wait.

- It is generally the animal farms that have problems today. They sometimes need stuff really quickly; maybe they have run out of food for the animals or something. Sometimes it can take a few days to get stuff from Lantmännen home. When comparing to e.g. spare parts to machinery we can get that the next day, but from Lantmännen it is usually delivery once a week, this should be improved.

- It is usually the items that one do not order that often and little of that becomes time critical since one usually do not have an own safety stock of these type of items.

- Another problem today is that the drivers can come really late and drop of shipments. This is a problem, at least for me since I do not live here and would have to drive here to receive it. Especially if they call when they are just a few minutes a way, if they would call in advance, let us say a few hours even that would usually not be a problem since it is possible to plan for it.

Summary of visit at the Lantmännen terminal.

- Grain Terminal Warehouse (Silos with storage capacity of 90,000 tons).

"Quick analysis" to every grain shipment supplied in order to classify the grains and defines price and usage.

- Feed Plant
  Capacity of 20,000 tons of raw material and 3,500 tons of feed

- Logistic Center (10,000 sqm)
  Activities as warehousing, preparation and loading of the products to be shipped to the farmers are carried here.

Considerations:

- In our particular case, we are only interested on the logistic center because here is where the trucks of Foria are filled and sent out.

- There is no helpful warehousing and inventory information system at the logistic center. Shipments are prepared with paper notes and there is not any direct computer support. Therefore the risk of not founding the products to ship is imminent.

- Due to the same lack of IT support there a lot of empty bins and waste of space of the warehouse capacity. (out of scope)

Summary of field study 1

Description

On November 17th, 2011 a field study was carried out. It consisted on the observation of one day of distribution activities performed by a Foria truck. The study started by loading the cargo at Lantmännen warehouse in Västerås in the morning and finished the same day at approximately the 18:00 hours.

Driver: Tobias Avren

Truck: Volvo truck with crank and a trailer. The truck capacity is 12 tons where the crank weights 3 tons, thus when the crank is one the cargo capacity is 9 tons. The trailer capacity is 24 tons, resulting on a total capacity of around 33 tons including the crank.

Purpose

To gain firsthand experience of Foria's distribution activities for Lantmännen agriculture products, through the observation of one full day of work on one of Foria's trucks.

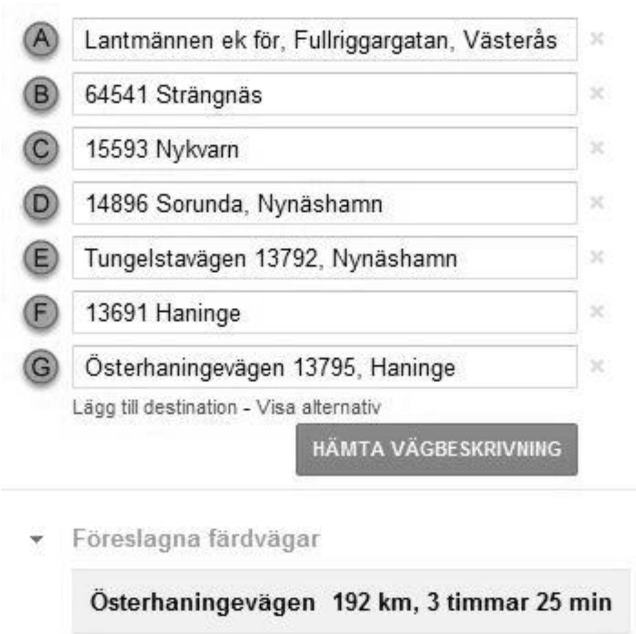
Summary and Observations

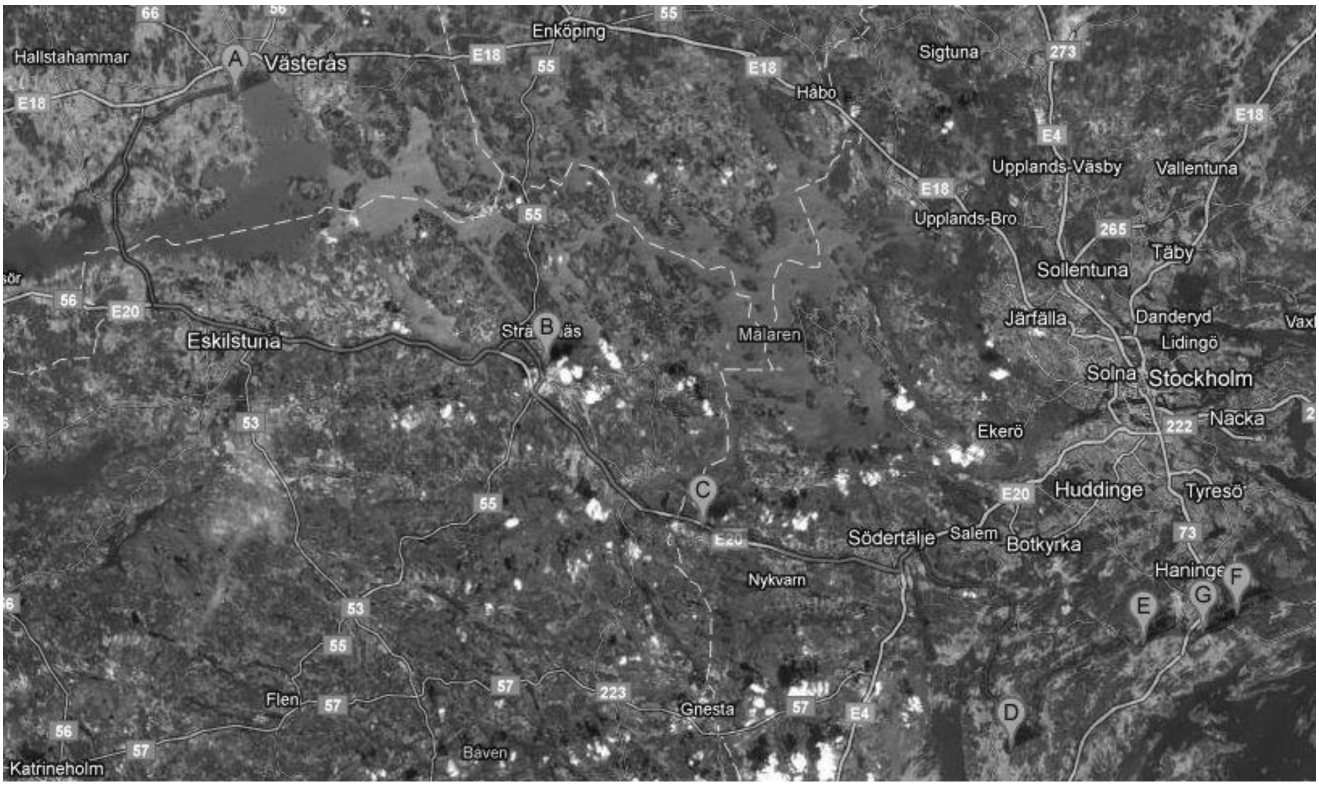
- Loading activities at Västerås warehouse took around 35 min. with one forklift.
- This shipment was not a full cargo. It was only 20 tons.
- The route to take in order to make the deliveries is completely decided by the driver based on his knowledge of the roads and farms. After receiving the waybills of the shipment, he decided the arrangement of the pallets depending on where he wants to go first.
- All shipments needed to be delivered in the surroundings of Västerås –Stockholm (country side) except one small pallet that needed to be delivered downtown central Stockholm.
- 14 delivery points in total, the driver suggested 6 deliveries the first day and 8 deliveries the day after.
- After the first and second delivery, the trailer was dropped in a Lantmännen warehouse somewhere in between the route.

- Foria device can check, fuel consumption, location, driving behavior, etc.

- Not many younger drivers at Foria

Route





Summary of field study 2

Reflections made by Oscar during the "ride-along" with the driver Kenneth from Järna Åkeri who is one of the drivers at a hauler driving these transports for Foria.

- The driver is giving "Added service" to the recipients almost all the time. (This is here defined as doing more than just unloading the goods on the side of the vehicle)

- During the pick-up of goods in Västerås they still used paper work in spite of the investments in different IT solutions and IS from Foria.

- The driver is supposed to monitor and check that he receives all the goods, however, it is impossible for him to do more than count the number of pallets.

- The driver is giving "Added service" to the recipients almost all the time. (This is here defined as doing more than just unloading the goods on the side of the vehicle)

- The driver had a total of four (!) different GPS systems.
    - One built-in in the truck, this was outdated and had not been updated for years. This was not used at all and was outdated both in terms of software and hardware even though it had the best "place" as it was built into the dashboard with a big screen.
    - The driver had a smartphone with a built in GPS from Garmin with updated maps. This was sometimes used since it could give directions and "talk". However it was built for HDV-vehicles so the driver knew that he couldn't trust it completely because sometimes it would lead him into roads that were not accessible due to the size of the truck. The driver also had a limited knowledge of the functions of the GPS, ha had not received any formal training and could only use the basic functions.
    - The ICT mobile device from Foria for digital waybills etc. also had a built in GPS. The driver didn't use that one at all.
    - The driver had himself purchased a Samsung Galaxy 10 inch tablet with built in GPS. This was the one most heavily used by the driver. The advantage of this one was it had a big screen. It gave the driver a bird's eye view of the area with satellite images and he could plan how he would access different farms to make sure he would be able to turn around or have an easy way out to the next stop due to the size of his vehicle. This function was superior in the tablet and provided the driver with valuable information when accessing some of the farms. As an observant it seems like the free GPS service from Google was superior to the other systems due to its easy interface, big screen and satellite bird-eye-view which made it possible for the driver to plan his access to different farms.

- The coordinates provided on the waybills were useless for the driver since they were in a nonstandard format. Both the driver and I tried to enter them into the phone GPS which could handle three different standards coordinate formats but the address that showed up was completely wrong. According to the driver the coordinates on the waybill were in some proprietary format for another shipping company that the standard GPS couldn't use.

- The driver did a lot more than just unload the goods outside the truck. He tried to put the goods in a protected place or put the goods where the farmers would like to have them. This would not have been possible without the forklift that was on the truck.

The drop off points

- First delivery was at farm not far from Västerås. It was two pallets and the goods were dropped off outside a barn on a gravel area. The driver didn't receive any help from the customer, and they didn't sign of on the goods even though there were people nearby. It would have been impossible to move the goods around on the drop of spot without the use of the portable fork lifter. The tablet GPS was helpful to the driver here when orienting him around the small roads around the farm. In some sense the driver gave some added service to the farmer by putting the goods along the side of a little house with a little bit of protection over it and not just beside the truck, his meant that the farmer didn't have to attend to the good immediately.

- The second delivery was 6 pallets. The driver had some troubles since the loading staff at Västerås terminal had put some pallets on top of another set of pallets and the drivers forklift were unable to reach them. Luckily this drop of point was a sort of warehouse and they had bigger forklifts here and they could help the driver to move the goods off the truck. The unloading area was made of tarmac. The driver both gave good service to the recipient and got some needed help back in return.

- The third drop-off was 4 pallets. There were no real unloading place; we just stopped into the side of the road, it was however tarmacked. The driver had previous knowledge of the area and knew that he had to enter the farm from a certain direction in order to be able to unload without blocking the traffic. There was a farmer there to receive the goods but the driver did the unloading himself with the forklift and gave added service to the farmer.

- The forth stop was 2 pallets to a small farm. Nobody was there to receive the goods. The driver had very much help of the forklift to give extra service to the farmer by unloading the goods and putting them underneath shelter, they also had phone contact and for the next time the driver agreed to put the goods inside the barn for the farmer.

- The fifth stop was the smallest one, a single pallet of around 600 kg's. However, the drop off point was a on a gravel road and it had been raining so it was really muddy. The forklift was really helpful here because the ground was so bad were they had access with the big truck and he needed to move the pallets quite a bit from the truck, there was someone there to receive the goods.

- The last stop for the day was 5 pallets, a total of 3,5 tons. We arrived pretty late and they had stopped working and there was nobody there when we arrived. The unloading spot was however a tarmac area, but there were quite a lot of goods and the forklift was very useful at this location to. The driver gave some added service by putting the goods inside a garage with protection against bad weather.

Info from the driver during interview/conversation.

- He had done some stops before I joined him earlier that day for another round of shipments. He means that they can usually manage 10-12 stops on a normal day.

- This day I was with him had been a "good" day. A total of 14 stops, but with fairly big shipments and not a lot of small posts.
    - The driver himself complains a lot about the shipments to Granngården Butiker, which usually were very small shipments.

- He believes that shipments below 200 KGs would be a good size for using a different type of delivery vehicle, like a "Mercedes Sprint" or something.

- Normally a full pallet is around 600 kg's, which could be quite heavy to maneuver around with a manual pump forklift, especially at drop off points. (Thinking about both that drop off points might not be level and be out of dirt.)

- He does however enjoy these rounds, he does not mind sleeping in his truck and riding around for a few days. He likes to drive long distances and really enjoys his work. He wants to make deliveries and he says that it almost "itches in his body when he got goods on the truck and he just want to deliver it".

- Regarding dropping off goods with signing over the goods, which according to him is common practice, works well. It is a mutual trust between the drivers and farmers and he hasn't heard of anyone being untrustworthy.
    - He does however describe one situation where he had to make a phone call to one off the farmers who said he had not received all the goods and make him count them again because he was sure and remembered that he had delivered a certain amount and then the farmer corrected himself and said that he had counted wrong the first time.
    - He also questions what to do sometimes when the farmers are not at the scene? Should they take the goods back? Dropping it off with mutual trust is probably the best solution, at least for the moment.

- He also feels that it is quite a lot of administrative work with paper right now. He likes to drive, but today there is lot of different papers, waybills, route planning and so on. This he does not get paid for which he feels a little bit displeasure about.

Appendix I – Financial analysis of vehicle differentiation scenarios

When calculating the cost for different vehicle differentiation scenarios no significant change in cost could be found. As can be seen below the change in cost is slightly more when using vehicle differentiation, but just a very minor change to cost of using the different vehicles, i.e. through changing diesel prices, could tilt it to the be in minor favor of the opposite. The cost used for the smaller truck here is based on proposal from SåCalc, but this is not an "exact" science so therefor it is impossible to state any valid difference in costs.

E.g. the 780 kg best environmentally version is 0.7% more expensive than the current way. But just small, and very likely, changes to the km/cost will shift this in favor of any of the three options; therefore we cannot say anything regarding the financial performance more than it is likely to be similar regardless of scenario.

		Local distribution truck The one used in environmental calculation	**Agriculture truck** Costs according to SåCalc	**Difference**	
Cost per 10 km according to SåCalc to use vehicle		126,07 kr	176,87 kr		
Cost per km		12,61 kr	17,69 kr		
Scenario 1 - Base Value					
Foria as is today					
km	326606				
cost	5776667		5776667,258		
Scenario 2					
km	149260	226600			
cost	1881704	4007865,136	5889569,537	2,0%	More expensive
Scenario 3					
km	203775	183552			
cost	2568969	3246476,882	5815445,892	0,7%	More expensive

APPENDIX J – ESTIMATION OF COST FOR UNREIMBURSED WORK

It is hard to define the cost or value of the unreimbursed work the drivers currently perform. Will the customers be willing to purchase the added service that they have been receiving for free or will they refuse and take their business elsewhere?

The work is however being performed and it is not in the contract terms, therefor at least an approximation of the value of it is in order.

Based on the two field studies, interviews with drivers and interviews management the following two conservative estimations were made indicating values within the same range.

Input

Cost per hour for using the HDV+Trailer and driver: 717 SEK

Shipments yearly with current way of working: 574

Stops yearly with current way of working: 9167

Estimations

Assuming that the drivers perform one hour of non-reimbursed work per shipment.

717 kr * 574 = 411 558,00 SEK

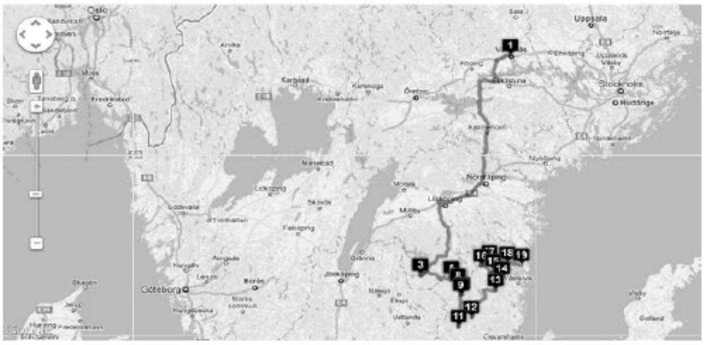
Assuming that the drivers need to perform 10 minutes of unpaid work every third stop

717 SEK * (1/6) * 9167 * (1/3) = 365152 SEK

APPENDIX K – VISUAL VALIDATION OF SIMULATION MODEL AND DISTANCES

Truck: 7 Distance: 633.46km. Weight: 33985kg. Date: 2010-11-03 Stops: 20 Cost: 17 148,00 SEK

Artikel	Ordernr	BestKvant	FrånDatum	TillDatum	Kundnr	Kundnamn	Adressrad1	Adressrad3	Code	Avlastningsort	Region	Status	Priority	id	Cost
Item X	6042324	500	2010-11-01	2011-02-28	1316580	Ann Onym	Ann Onym	594 93 GAMLEBY	H83	Västervik	0	7	-428	3981	661.51800375
Item X	6066295	540	2010-11-01	2011-02-28	36035	Ann Onym	Ann Onym	594 92 GAMLEBY	H83	Västervik	0	7	-428	4068	661.51800375
Item X	6062911	575	2010-11-01	2011-02-28	11086	Ann Onym	Ann Onym	590 90 ANKARSRUM	H83	Västervik	0	7	-428	4101	697.56658875
Item X	6080956	575	2010-11-01	2011-02-28	38465	Ann Onym	Ann Onym	594 93 GAMLEBY	H83	Västervik	0	7	-428	4102	661.51800375
Item X	6066314	615	2010-11-01	2011-02-28	20763	Ann Onym	Ann Onym	590 80 SÖDRA VI	H84	Vimmerby	0	7	-428	4792	697.56658875
Item X	6037006	625	2010-11-03	2010-11-08	19009068	Ann Onym	Ann Onym	590 81 GULLRINGEN	H84	Vimmerby	0	7	-540	4828	670.53015
Item X	6084069	630	2010-11-01	2011-02-28	23116	Ann Onym	Ann Onym	593 95 VÄSTERVIK	H83	Västervik	0	7	-428	5022	679.54229625
Item X	6062758	645	2010-11-01	2011-02-28	17602	Ann Onym	Ann Onym	590 80 SÖDRA VI	H84	Vimmerby	0	7	-428	5076	697.56658875
Item X	12097006	675	2010-11-01	2011-02-28	19038153	Ann Onym	Ann Onym	594 93 GAMLEBY	H83	Västervik	0	7	-428	5157	661.51800375
Item X	6046130	720	2010-11-01	2011-02-28	62800282	Ann Onym	Ann Onym	598 91 VIMMERBY	H84	Vimmerby	0	7	-428	5227	706.578735
Item X	6134251	800	2010-11-01	2011-04-15	26298	Ann Onym	Ann Onym	590 80 SÖDRA VI	H84	Vimmerby	0	7	-382	5399	697.56658875
Item X	6086857	890	2010-11-01	2011-03-31	60455329	Ann Onym	Ann Onym	570 60 ÖSTERBYMO	E12	Ydre	0	7	-397	5492	706.578735
Item X	6098811	975	2010-11-01	2011-03-31	1307360	Ann Onym	Ann Onym	570 82 MÅLILLA	H60	Hultsfred	0	7	-397	5615	733.61517375
Item X	6066474	1490	2010-11-01	2011-02-28	19026462	Ann Onym	Ann Onym	577 93 HULTSFRED	H60	Hultsfred	0	7	-428	7028	926.9765625
Item X	6066362	1605	2010-11-01	2011-02-28	19021440	Ann Onym	Ann Onym	594 94 GAMLEBY	H83	Västervik	0	7	-428	7157	882.524296875
Item X	6051286	1620	2010-11-01	2011-02-28	19039496	Ann Onym	Ann Onym	590 81 GULLRINGEN	H84	Vimmerby	0	7	-428	7161	904.5675
Item X	6036243	1850	2010-11-03	2010-11-03	19205	Ann Onym	Ann Onym	570 60 ÖSTERBYMO	E12	Ydre	0	7	-545	7481	1096.009375
Item X	6086550	4985	2010-11-01	2011-02-28	19025091	Ann Onym	Ann Onym	594 91 GAMLEBY	H83	Västervik	0	7	-428	8872	1492.734375
Item X	6069782	6115	2010-11-01	2011-02-28	1314789	Ann Onym	Ann Onym	598 40 VIMMERBY	H84	Vimmerby	0	7	-428	9041	1188
Item X	6049634	7555	2010-11-01	2011-02-28	32279	Ann Onym	Ann Onym	590 95 LOFTAHAMMAR	H83	Västervik	0	7	-428	9154	1724



Trip duration: 9 hrs 13 min
Trip length: 564 km (350.8 miles)

Truck: 64 Distance: 457.89km. Weight: 33555kg. Date: 2011-01-10 Stops: 14 Cost: 13 288,51 SEK

Artikel	Ordernr	BestKvant	FrånDatum	TillDatum	Kundnr	Kundnamn	Adressrad1	Adressrad3	Code	Avlastningsort	Region	Status	Priority	id	Cost
Item X	6080523	614	2011-01-07	2011-01-12	1319875	Ann Onym	Ann Onym	605 99 NORRKÖPING	E81	Norrköping	0	64	-475	4787	580.4086875
Item X	12163156	625	2011-01-10	2011-01-13	1310322	Ann Onym	Ann Onym	585 96 LINKÖPING	E80	Linköping	0	64	-474	4999	652.5058575
Item X	6080023	1050	2011-01-07	2011-01-12	11491	Ann Onym	Ann Onym	605 99 NORRKÖPING	E81	Norrköping	0	64	-475	6045	609.429121875
Item X	6081659	1050	2011-01-10	2011-01-10	19035796	Ann Onym	Ann Onym	645 94 STRÄNGNÄS	D86	Strängnäs	0	64	-477	6046	543.1898469375
Item X	6079407	1200	2011-01-10	2011-01-13	30926	Ann Onym	Ann Onym	590 55 STUREFORS	E80	Linköping	0	64	-474	6238	761.377878
Item X	6079883	1200	2011-01-07	2011-01-12	1320937	Ann Onym	Ann Onym	595 93 MJÖLBY	E86	Mjölby	0	64	-475	6240	772.1924535
Item X	6080724	1200	2011-01-07	2011-01-12	19026463	Ann Onym	Ann Onym	585 92 LINKÖPING	E80	Linköping	0	64	-475	6243	750.5633025
Item X	6080666	1256	2011-01-07	2011-01-12	62900144	Ann Onym	Ann Onym	595 92 MJÖLBY	E86	Mjölby	0	64	-475	6775	812.015625
Item X	6081664	1800	2011-01-10	2011-01-10	1316559	Ann Onym	Ann Onym	596 92 SKÄNNINGE	E86	Mjölby	0	64	-477	7310	943.7625
Item X	6080719	1900	2011-01-07	2011-01-12	33533	Ann Onym	Ann Onym	590 21 VÄDERSTAD	E86	Mjölby	0	64	-475	7559	1021.09375
Item X	6080394	2860	2011-01-07	2011-01-12	19012015	Ann Onym	Ann Onym	582 73 LINKÖPING	E80	Linköping	0	64	-475	8312	1027.27625
Item X	6080771	4300	2011-01-07	2011-01-12	19018391	Ann Onym	Ann Onym	590 16 BOXHOLM	E60	Boxholm	0	64	-475	8788	1466.09375
Item X	6080878	5330	2011-01-10	2011-01-13	19029907	Ann Onym	Ann Onym	582 73 LINKÖPING	E80	Linköping	0	64	-474	8931	1449.2603125
Item X	6081117	9170	2011-01-10	2011-01-13	33707	Ann Onym	Ann Onym	595 91 MJÖLBY	E86	Mjölby	0	64	-474	9242	1899.33625

Trip duration: 7 hrs 33 min
Trip length: 494 km (307.1 miles)

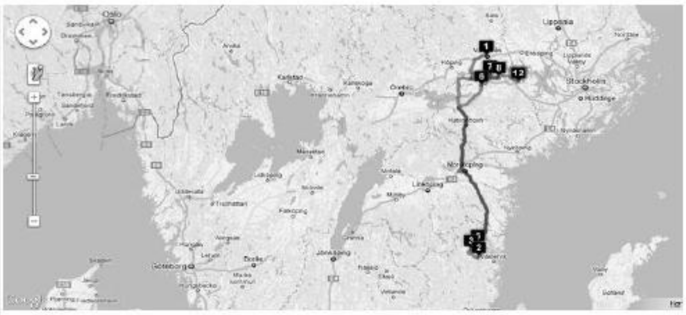
Truck: 70 Distance: 683.41km. Weight: 33899kg. Date: 2011-01-18 Stops: 20 Cost: 16 534,02 SEK

Artikel	Ordernr	BestKvant	FrånDatum	TillDatum	Kundnr	Kundnamn	Adressrad1	Adressrad3	Code	Avlastningsort	Region	Status	Priority	id	Cost
Item X	6085236	600	2011-01-18	2011-01-21	19043004	Ann Onym	Ann Onym	610 42 GRYT	E63	Valdemarsvik	0	70	-466	4259	643.49371125
Item X	6085751	600	2011-01-18	2011-01-21	19030514	Ann Onym	Ann Onym	610 41 RINGARUM	E63	Valdemarsvik	0	70	-466	4260	616.4572725
Item X	6085754	600	2011-01-18	2011-01-21	16190	Ann Onym	Ann Onym	615 95 VALDEMARSVIK	E63	Valdemarsvik	0	70	-466	4261	634.481565
Item X	6085765	625	2011-01-18	2011-01-21	14991	Ann Onym	Ann Onym	610 27 VIKBOLANDET	E81	Norrköping	0	70	-466	4872	625.46941875
Item X	6084773	680	2011-01-18	2011-01-20	1315772	Ann Onym	Ann Onym	590 91 HJORTED	H83	Västervik	0	70	-467	5162	706.578735
Item X	6085682	700	2011-01-18	2011-01-21	13161	Ann Onym	Ann Onym	641 96 KATRINEHOLM	D83	Katrineholm	0	70	-466	5184	526.33581
Item X	6083819	760	2011-01-14	2011-01-19	1313700	Ann Onym	Ann Onym	643 31 VINGÅKER	D28	Vingåker	0	70	-468	5345	544.3601025
Item X	6084402	1000	2011-01-17	2011-01-20	35281	Ann Onym	Ann Onym	635 05 ESKILSTUNA	D84	Eskilstuna	0	70	-467	5691	499.29937125
Item X	6085952	1000	2011-01-18	2011-01-21	1315347	Ann Onym	Ann Onym	573 94 TRANÅS	E12	Ydre	0	70	-466	5692	688.5544425
Item X	6084650	1200	2011-01-17	2011-01-20	33709	Ann Onym	Ann Onym	594 92 GAMLEBY	H83	Västervik	0	70	-467	6256	793.8216045
Item X	6085324	1225	2011-01-18	2011-01-21	60327320	Ann Onym	Ann Onym	573 94 TRANÅS	E12	Ydre	0	70	-466	6636	843.4791920625
Item X	6084806	1500	2011-01-17	2011-01-20	35276	Ann Onym	Ann Onym	594 91 GAMLEBY	H83	Västervik	0	70	-467	7042	824.7890625
Item X	6083672	1525	2011-01-14	2011-01-19	12976	Ann Onym	Ann Onym	632 22 ESKILSTUNA	D84	Eskilstuna	0	70	-468	7093	591.7953125
Item X	6083689	1800	2011-01-14	2011-01-19	16541	Ann Onym	Ann Onym	640 40 STORA SUNDBY	D84	Eskilstuna	0	70	-468	7311	729.16875
Item X	6084066	1800	2011-01-14	2011-01-19	19036574	Ann Onym	Ann Onym	590 93 GUNNEBO	H83	Västervik	0	70	-468	7313	1035.73125
Item X	6085948	1800	2011-01-18	2011-01-21	28162	Ann Onym	Ann Onym	585 97 LINKÖPING	E80	Linköping	0	70	-466	7315	943.7625
Item X	12165588	2000	2011-01-18	2011-01-21	31171	Ann Onym	Ann Onym	590 98 EDSBRUK	E63	Valdemarsvik	0	70	-466	7778	1021.09375
Item X	6085482	2300	2011-01-18	2011-01-21	23534	Ann Onym	Ann Onym	594 91 GAMLEBY	H83	Västervik	0	70	-466	7983	1036.484375
Item X	6085369	4400	2011-01-18	2011-01-21	1307360	Ann Onym	Ann Onym	570 82 MÅLILLA	H60	Hultsfred	0	70	-466	8797	1705.859375
Item X	6083296	7784	2011-01-14	2011-01-19	9725912	Ann Onym	Ann Onym	594 32 GAMLEBY	H83	Västervik	0	70	-468	9172	1523

Trip duration: 13 hrs 50 min
Trip length: 806 km (501.2 miles)

Truck: 17 Distance: 463.26km. Weight: 33402kg. Date: 2010-11-11 Stops: 9 Cost: 9 412,21 SEK

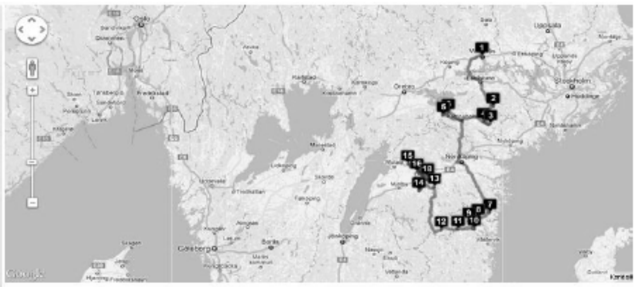
Artikel	Ordernr	BestKvant	FrånDatum	TillDatum	Kundnr	Kundnamn	Adressrad1	Adressrad3	Code	Avlastningsort	Region	Status	Priority	id	Cost
Item X	6042768	600	2010-11-11	2010-11-11	9725912	Ann Onym	Ann Onym	594 32 GAMLEBY	H83	Västervik	0	17	-537	4138	616.4572725
Item X	6042581	655	2010-11-11	2010-11-11	38548	Ann Onym	Ann Onym	594 91 GAMLEBY	H83	Västervik	0	17	-537	5093	661.51800375
Item X	6039878	810	2010-11-09	2010-11-12	14108	Ann Onym	Ann Onym	635 05 ESKILSTUNA	D84	Eskilstuna	0	17	-536	5429	499.29937125
Item X	6037760	1200	2010-11-10	2010-11-15	1312585	Ann Onym	Ann Onym	593 95 VÄSTERVIK	H83	Västervik	0	17	-533	6166	815.4507555
Item X	6042139	1200	2010-11-11	2010-11-16	12392	Ann Onym	Ann Onym	635 08 ESKILSTUNA	D84	Eskilstuna	0	17	-532	6180	582.09375
Item X	6040637	1450	2010-11-09	2010-11-12	35642	Ann Onym	Ann Onym	645 94 STRÄNGNÄS	D86	Strängnäs	0	17	-536	6995	620.4140625
Item X	6040034	1810	2010-11-09	2010-11-12	30618	Ann Onym	Ann Onym	632 36 ESKILSTUNA	D84	Eskilstuna	0	17	-536	7431	702.393125
Item X	6042149	3362	2010-11-11	2010-11-16	9725912	Ann Onym	Ann Onym	594 32 GAMLEBY	H83	Västervik	0	17	-532	8549	1290.377625
Item X	6040680	4800	2010-11-10	2010-11-15	19035796	Ann Onym	Ann Onym	645 94 STRÄNGNÄS	D86	Strängnäs	0	17	-533	8836	1066.484375
Item X	6098681	7015	2010-11-01	2011-03-31	35642	Ann Onym	Ann Onym	645 94 STRÄNGNÄS	D86	Strängnäs	0	17	-397	9123	1154.5
Item X	6037924	10500	2010-10-01	2010-12-31	35698	Ann Onym	Ann Onym	645 94 STRÄNGNÄS	D86	Strängnäs	0	17	-487	9287	1403.2265625



Trip duration: 8 hrs 10 min
Trip length: 537 km (334.3 miles)

Truck: 48 Distance: 569.89km. Weight: 33698kg. Date: 2010-12-20 Stops: 16 Cost: 14 236,93 SEK

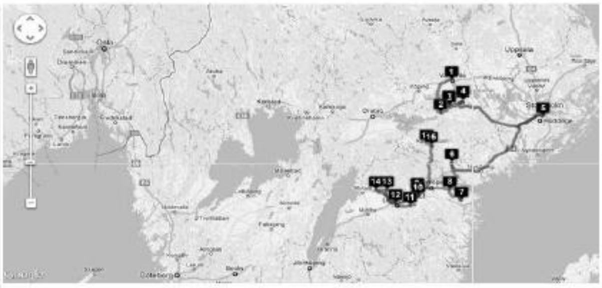
Artikel	Ordernr	BestKvant	FrånDatum	TillDatum	Kundnr	Kundnamn	Adressrad1	Adressrad3	Code	Avlastningsort	Region	Status	Priority	id	Cost
Item X	6067497	600	2010-12-16	2010-12-21	36050	Ann Onym	Ann Onym	590 76 VRETA KLOSTER	E80	Linköping	0	48	-497	4216	625.46941875
Item X	6068999	600	2010-12-17	2010-12-22	19006474	Ann Onym	Ann Onym	615 92 VALDEMARSVIK	E63	Valdemarsvik	0	48	-496	4222	652.5058575
Item X	6067937	615	2010-12-16	2010-12-21	33904	Ann Onym	Ann Onym	594 94 GAMLEBY	H83	Västervik	0	48	-497	4793	661.51800375
Item X	6067450	625	2010-12-16	2010-12-21	33793	Ann Onym	Ann Onym	642 94 FLEN	D82	Flen	0	48	-497	4856	526.33581
Item X	6068317	625	2010-12-16	2010-12-21	2601824	Ann Onym	Ann Onym	590 42 HORN	E13	Kinda	0	48	-497	4857	688.5544425
Item X	6069291	625	2010-12-17	2010-12-22	34277	Ann Onym	Ann Onym	640 32 MALMKÖPING	D82	Flen	0	48	-496	4858	517.32366375
Item X	12136234	625	2010-12-16	2010-12-21	213504	Ann Onym	Ann Onym	643 93 VINGÅKER	D28	Vingåker	0	48	-497	4998	544.3601025
Item X	6069514	636	2010-12-17	2010-12-22	39654	Ann Onym	Ann Onym	590 98 EDSBRUK	H83	Västervik	0	48	-496	5054	652.5058575
Item X	6070302	1000	2010-12-20	2010-12-23	30605	Ann Onym	Ann Onym	590 96 ÖVERUM	H83	Västervik	0	48	-495	5676	670.53015
Item X	6067094	1200	2010-12-17	2010-12-22	30926	Ann Onym	Ann Onym	590 55 STUREFORS	E80	Linköping	0	48	-496	6215	761.377878
Item X	6069296	1312	2010-12-17	2010-12-22	20191	Ann Onym	Ann Onym	642 95 FLEN	D82	Flen	0	48	-496	6875	633.1875
Item X	12136136	1350	2010-12-20	2010-12-21	9725912	Ann Onym	Ann Onym	594 32 GAMLEBY	H83	Västervik	0	48	-497	6927	760.921875
Item X	6069229	1825	2010-12-17	2010-12-22	19043415	Ann Onym	Ann Onym	590 52 NYKIL	E80	Linköping	0	48	-496	7449	956.8703125
Item X	6070402	1956	2010-12-20	2010-12-23	1313700	Ann Onym	Ann Onym	643 92 VINGÅKER	D28	Vingåker	0	48	-495	7612	836.40625
Item X	6068148	2000	2010-12-16	2010-12-21	21401	Ann Onym	Ann Onym	590 28 BORENSBERG	E83	Motala	0	48	-497	7644	959.53125
Item X	6067569	4220	2010-12-15	2010-12-21	19029907	Ann Onym	Ann Onym	582 73 LINKÖPING	E80	Linköping	0	48	-497	8779	1359.53125
Item X	6069842	13884	2010-12-20	2010-12-23	9725912	Ann Onym	Ann Onym	582 73 LINKÖPING	E80	Linköping	0	48	-495	9357	2430



Trip duration: 10 hrs 7 min
Trip length: 576 km (358.2 miles)

Truck: 165 Distance: 562.09km. Weight: 33899kg. Date: 2011-05-25 Stops: 16 Cost: 13 911,90 SEK

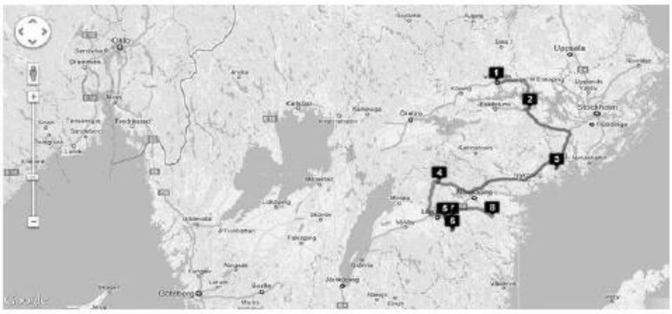
Artikel	Ordernr	BestKvant	FrånDatum	TillDatum	Kundnr	Kundnamn	Adressrad1	Adressrad3	Code	Avlastningsort	Region	Status	Priority	id	Cost
Item X	6175503	600	2011-05-23	2011-05-26	21373	Ann Onym	Ann Onym	640 20 BJÖRKVIK	D83	Katrineholm	0	165	-341	4485	562.384395
Item X	6173249	656	2011-05-23	2011-05-26	213786	Ann Onym	Ann Onym	590 28 BORENSBERG	E83	Motala	0	165	-341	5099	616.4572725
Item X	6177448	1000	2011-05-25	2011-05-30	1318154	Ann Onym	Ann Onym	610 32 VIKBOLANDET	E81	Norrköping	0	165	-337	5820	607.44512625
Item X	6178126	1000	2011-05-25	2011-05-30	35281	Ann Onym	Ann Onym	635 05 ESKILSTUNA	D84	Eskilstuna	0	165	-337	5821	499.29937125
Item X	6173150	1200	2011-05-23	2011-05-26	35281	Ann Onym	Ann Onym	635 05 ESKILSTUNA	D84	Eskilstuna	0	165	-341	6381	594.8671875
Item X	6176067	1200	2011-05-23	2011-05-26	1311648	Ann Onym	Ann Onym	611 99 TYSTBERGA	D80	Nyköping	0	165	-341	6383	696.490425
Item X	6176426	1250	2011-05-23	2011-05-26	18901	Ann Onym	Ann Onym	641 91 KATRINEHOLM	D83	Katrineholm	0	165	-341	6744	658.734375
Item X	6177325	1250	2011-05-25	2011-05-30	19034610	Ann Onym	Ann Onym	610 21 NORSHOLM	E81	Norrköping	0	165	-337	6745	735.375
Item X	6175429	1602	2011-05-25	2011-05-30	16814	Ann Onym	Ann Onym	585 62 LINGHEM	E80	Linköping	0	165	-337	7154	799.02253125
Item X	6176734	1801	2011-05-24	2011-05-27	27746	Ann Onym	Ann Onym	610 27 VIKBOLANDET	E81	Norrköping	0	165	-340	7419	928.950171875
Item X	6175560	2000	2011-05-23	2011-05-26	19023009	Ann Onym	Ann Onym	632 21 ESKILSTUNA	D84	Eskilstuna	0	165	-341	7713	744.0625
Item X	6175739	2329	2011-05-23	2011-05-26	19029907	Ann Onym	Ann Onym	582 73 LINKÖPING	E80	Linköping	0	165	-341	7993	959.53125
Item X	6177283	2500	2011-05-24	2011-05-27	19044813	Ann Onym	Ann Onym	590 75 LJUNGSBRO	E80	Linköping	0	165	-340	8175	974.921875
Item X	6173099	3000	2011-05-23	2011-05-26	17862	Ann Onym	Ann Onym	610 20 KIMSTAD	E81	Norrköping	0	165	-341	8405	1114.5
Item X	6178497	3000	2011-05-25	2011-05-25	32973	Ann Onym	Ann Onym	641 94 KATRINEHOLM	D28	Vingåker	0	165	-342	8407	1003.6875
Item X	6176569	3001	2011-05-24	2011-05-27	11822	Ann Onym	Ann Onym	635 13 ESKILSTUNA	D84	Eskilstuna	0	165	-340	8438	893.172625
Item X	6176685	6510	2011-05-24	2011-05-27	9725912	Ann Onym	Ann Onym	582 73 LINKÖPING	E80	Linköping	0	165	-340	9080	1523



Trip duration: 10 hrs 9 min
Trip length: 639 km (397.2 miles)

Truck: 177 Distance: 436.02km. Weight: 10305kg. Date: 2011-06-09 Stops: 8 Cost: 5 576,10 SEK

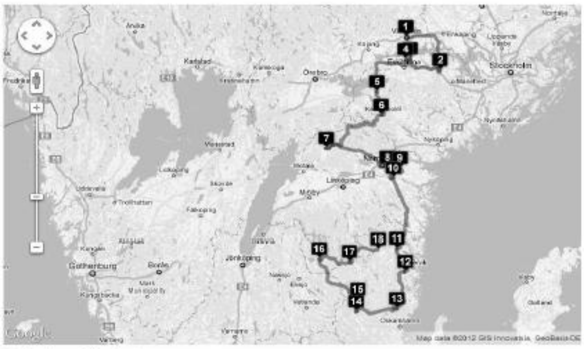
Artikel	Ordernr	BestKvant	FrånDatum	TillDatum	Kundnr	Kundnamn	Adressrad1	Adressrad3	Code	Avlastningsort	Region	Status	Priority	id	Cost
Item X	6187755	600	2011-06-09	2011-06-09	14968	Ann Onym	Ann Onym	585 92 LINKÖPING	E80	Linköping	0	177	-327	4514	625.46941875
Item X	6181457	1000	2011-06-09	2011-06-14	16814	Ann Onym	Ann Onym	585 62 LINGHEM	E80	Linköping	0	177	-322	5827	607.44512625
Item X	6187728	1000	2011-06-09	2011-06-14	24068	Ann Onym	Ann Onym	585 95 LINKÖPING	E61	Åtvidaberg	0	177	-322	5835	634.481565
Item X	6187617	1105	2011-06-09	2011-06-14	2610079	Ann Onym	Ann Onym	610 75 VÄSTERLJUNG	D88	Trosa	0	177	-322	6112	641.3515996875
Item X	6187549	1200	2011-06-09	2011-06-14	1306495	Ann Onym	Ann Onym	645 94 STRÄNGNÄS	D86	Strängnäs	0	177	-322	6401	620.4140625
Item X	12362692	1500	2011-06-09	2011-06-14	19035796	Ann Onym	Ann Onym	645 94 STRÄNGNÄS	D86	Strängnäs	0	177	-322	7078	620.4140625
Item X	6188862	1800	2011-06-09	2011-06-09	36970	Ann Onym	Ann Onym	614 90 SÖDERKÖPING	E82	Söderköping	0	177	-327	7369	897.778125
Item X	6187461	2100	2011-06-09	2011-06-14	1312807	Ann Onym	Ann Onym	612 94 FINSPÅNG	E62	Finspång	0	177	-322	7869	928.75



Trip duration: 6 hrs 45 min
Trip length: 441 km (274.2 miles)

Truck: 167 Distance: 696.56km. Weight: 33648kg. Date: 2011-05-26 Stops: 17 Cost: 15 154,25 SEK

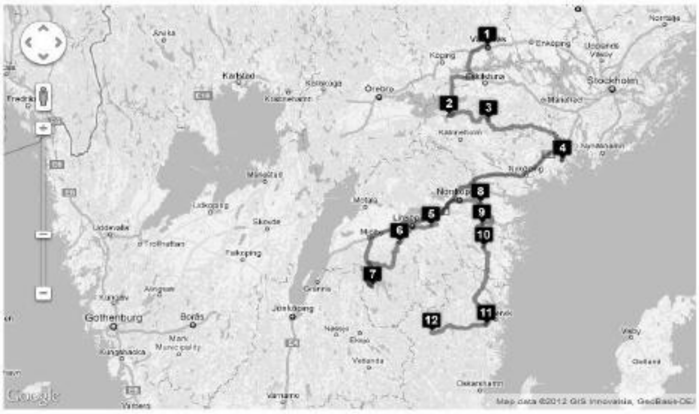
Artikel	Ordernr	BestKvant	FrånDatum	TillDatum	Kundnr	Kundnamn	Adressrad1	Adressrad3	Code	Avlastningsort	Region	Status	Priority	id	Cost
Item X	6178554	600	2011-05-26	2011-05-31	38650	Ann Onym	Ann Onym	605 92 NORRKÖPING	E81	Norrköping	0	167	-336	4490	598,43298
Item X	6178739	600	2011-05-26	2011-05-31	39373	Ann Onym	Ann Onym	590 34 TJÄLLMO	E83	Motala	0	167	-336	4492	598,43298
Item X	6176448	629	2011-05-26	2011-05-31	19039496	Ann Onym	Ann Onym	590 81 GULLRINGEN	H84	Vimmerby	0	167	-336	5009	670,53015
Item X	6179494	645	2011-05-26	2011-05-31	62800082	Ann Onym	Ann Onym	572 96 FÅRBO	H82	Oskarshamn	0	167	-336	5081	724,6030275
Item X	6178415	671	2011-05-26	2011-05-31	32962	Ann Onym	Ann Onym	643 96 JULITA	D83	Katrineholm	0	167	-336	5144	517,3236638
Item X	6179624	950	2011-05-26	2011-05-26	87336001	Ann Onym	Ann Onym	635 08 ESKILSTUNA	D84	Eskilstuna	0	167	-341	5584	508,3115175
Item X	6178576	1000	2011-05-26	2011-05-31	26803	Ann Onym	Ann Onym	577 91 HULTSFRED	H60	Hultsfred	0	167	-336	5824	724,6030275
Item X	6178801	1510	2011-05-26	2011-05-31	21488	Ann Onym	Ann Onym	610 33 VIKBOLANDET	E81	Norrköping	0	167	-336	7089	753,1360938
Item X	6179102	1850	2011-05-26	2011-05-31	19205	Ann Onym	Ann Onym	570 60 ÖSTERBYMO	E12	Ydre	0	167	-336	7503	1096,009375
Item X	6179054	2000	2011-05-26	2011-05-31	19209	Ann Onym	Ann Onym	635 09 ESKILSTUNA	D84	Eskilstuna	0	167	-336	7714	728,671875
Item X	18522429	2000	2011-05-26	2011-05-31	1307360	Ann Onym	Ann Onym	570 82 MÅLILLA	H60	Hultsfred	0	167	-336	7796	1159,609375
Item X	6178955	2129	2011-05-26	2011-05-31	19033456	Ann Onym	Ann Onym	645 41 STRÄNGNÄS	D86	Strängnäs	0	167	-336	7895	790,234375
Item X	6180084	2400	2011-05-26	2011-05-26	19036574	Ann Onym	Ann Onym	590 93 GUNNEBO	H83	Västervik	0	167	-341	8064	1082,65625
Item X	6179465	3310	2011-05-26	2011-05-31	24610	Ann Onym	Ann Onym	614 30 SÖDERKÖPING	E82	Söderköping	0	167	-336	8538	1229,665
Item X	6179038	3884	2011-05-26	2011-05-31	9725912	Ann Onym	Ann Onym	594 32 GAMLEBY	H83	Västervik	0	167	-336	8689	1359,53125
Item X	6176027	4720	2011-05-26	2011-05-31	19035872	Ann Onym	Ann Onym	641 52 KATRINEHOLM	D83	Katrineholm	0	167	-336	8831	1119,765625
Item X	6178581	4750	2011-05-26	2011-05-31	19021440	Ann Onym	Ann Onym	594 94 GAMLEBY	H83	Västervik	0	167	-336	8833	1492,734375



Trip duration: 12 hrs 21 min
Trip length: 730 km (454.1 miles)

Truck: 205 Distance: 741.23km. Weight: 23997kg. Date: 2011-07-21 Stops: 12 Cost: 10 309,36 SEK

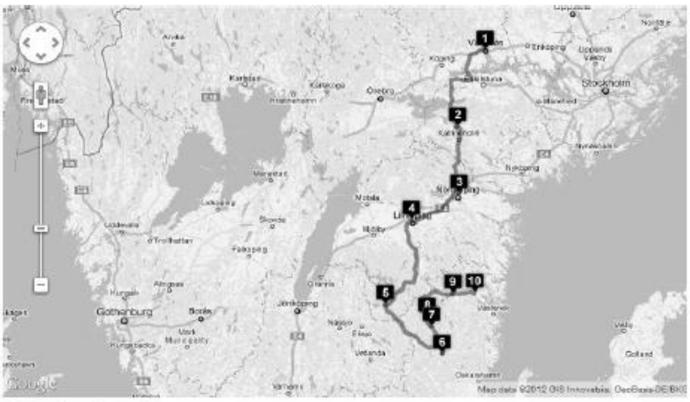
Ordernr	BestKvant	FrånDatum	TillDatum	Kundnr	Kundnamn	Adressrad1	Adressrad3	Code	Avlastnings ort	Region	Status	Priority	id	Cost
6216673	625	2011-07-21	2011-07-26	10228	Ann Onym	Ann Onym	640 31 MELLÖSA	D82	Flen	0	205	-280	4945	517,3236638
6216595	800	2011-07-21	2011-07-26	37306	Ann Onym	Ann Onym	590 52 NYKIL	E80	Linköping	0	205	-280	5410	634,481565
6212620	1000	2011-07-21	2011-07-26	16814	Ann Onym	Ann Onym	585 62 LINGHEM	E80	Linköping	0	205	-280	5875	607,4451263
6216669	1000	2011-07-21	2011-07-26	14554	Ann Onym	Ann Onym	640 31 MELLÖSA	D82	Flen	0	205	-280	5878	517,3236638
6216599	1225	2011-07-21	2011-07-26	19022984	Ann Onym	Ann Onym	573 94 TRANÅS	E12	Ydre	0	205	-280	6666	843,4791921
6215986	1340	2011-07-20	2011-07-25	32739	Ann Onym	Ann Onym	590 93 GUNNEBO	H83	Västervik	0	205	-281	6909	863,109375
6216698	1800	2011-07-21	2011-07-26	15912	Ann Onym	Ann Onym	640 25 JULITA	D28	Vingåker	0	205	-280	7384	744,496875
6216349	1885	2011-07-21	2011-07-26	30541	Ann Onym	Ann Onym	610 33 VIKBOLANDET	E81	Norrköping	0	205	-280	7551	940,1732031
6215008	2000	2011-07-19	2011-07-22	2610079	Ann Onym	Ann Onym	610 75 VÄSTERLJUNG	D88	Trosa	0	205	-284	7741	897,96875
6216785	2200	2011-07-21	2011-07-26	17543	Ann Onym	Ann Onym	610 40 GUSUM	E82	Söderköping	0	205	-280	7928	974,921875
6216683	2400	2011-07-21	2011-07-26	36970	Ann Onym	Ann Onym	614 90 SÖDERKÖPING	E82	Söderköping	0	205	-280	8079	944,140625
6215156	7722	2011-07-19	2011-07-22	33195	Ann Onym	Ann Onym	598 94 VIMMERBY	H84	Vimmerby	0	205	-284	9170	1824,5



Trip duration: 11 hrs 29 min
Trip length: 751 km (466.9 miles)

Truck: 228 Distance: 445.11km. Weight: 28766kg. Date: 2011-09-05 Stops: 8 Cost: 9 779,78 SEK

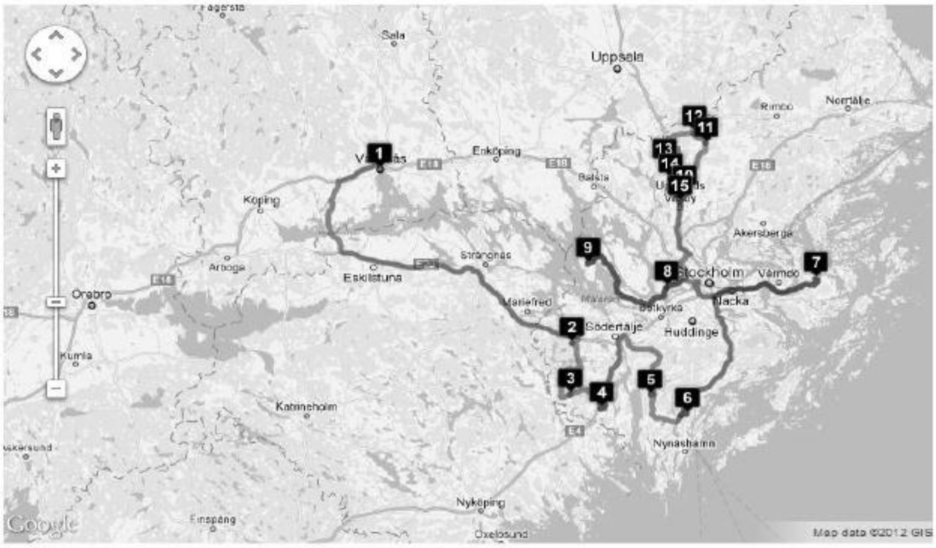
Ordernr	BestKvant	FrånDatum	TillDatum	Kundnr	Kundnamn	Adressrad1	Adressrad3	Code	Avlastnings ort	Region	Status	Priority	id	Cost
12489068	600	2011-09-05	2011-09-08	34935	Ann Onym	Ann Onym	594 94 GAMLEBY	H83	Västervik	0	228	-236	4728	661,5180038
6242765	1000	2011-09-01	2011-09-06	19026462	Ann Onym	Ann Onym	577 93 HULTSFRED	H60	Hultsfred	0	228	-238	5908	733,6151738
6244845	1850	2011-09-05	2011-09-08	19205	Ann Onym	Ann Onym	570 60 ÖSTERBYMO	E12	Ydre	0	228	-236	7511	1096,009375
6243344	2400	2011-09-05	2011-09-08	2601527	Ann Onym	Ann Onym	641 96 KATRINEHOLM	D83	Katrineholm	0	228	-236	8087	805,625
6244730	2400	2011-09-05	2011-09-08	62800282	Ann Onym	Ann Onym	598 91 VIMMERBY	H84	Vimmerby	0	228	-236	8090	1113,4375
6244851	2450	2011-09-05	2011-09-08	33462	Ann Onym	Ann Onym	590 80 SÖDRA VI	H84	Vimmerby	0	228	-236	8153	1098,046875
6242842	4392	2011-09-01	2011-09-06	9725912	Ann Onym	Ann Onym	594 32 GAMLEBY	H83	Västervik	0	228	-238	8796	1359,53125
6244582	5674	2011-09-05	2011-09-08	9725912	Ann Onym	Ann Onym	582 73 LINKÖPING	E80	Linköping	0	228	-236	8974	1523
6233725	8000	2011-09-05	2011-09-08	1316973	Ann Onym	Ann Onym	602 38 NORRKÖPING	E81	Norrköping	0	228	-236	9193	1389



Trip duration: 7 hrs 45 min
Trip length: 475 km (295.8 miles)

Truck: 10 Distance: 462.09km. Weight: 33989kg. Date: 2010-11-07 Stops: 17 Cost: 13 141,23 SEK

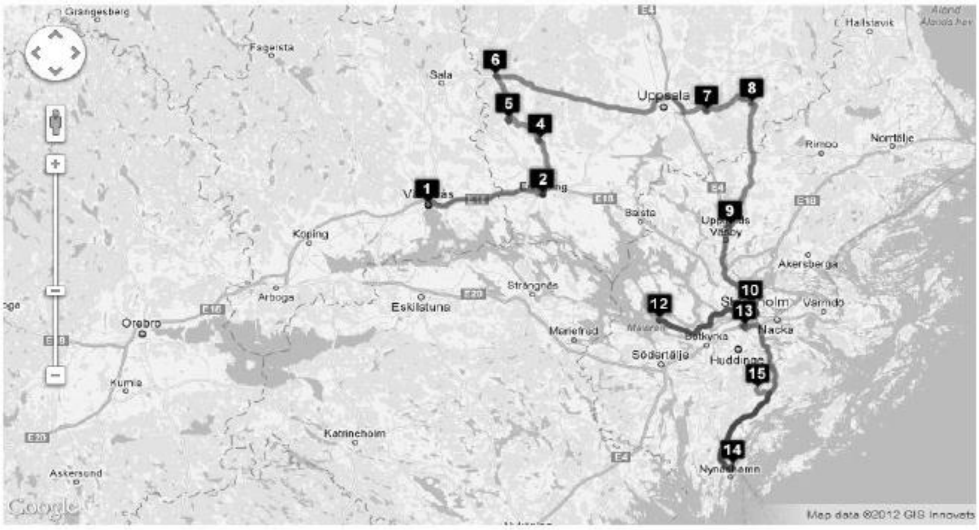
Ordernr	BestKvant	FrånDatum	TillDatum	Kundnr	Kundnamn	Adressrad1	Adressrad3	Code	Avlastnings ort	Region	Status	Priority	id	Cost
6123588	50	2010-11-01	2011-03-31	9188	Ann Onym	Ann Onym	148 96 SORUNDA	A92	Nynäshamn	1	10	-397	1499	580,4086875
6064506	105	2010-11-01	2011-02-28	2106235	Ann Onym	Ann Onym	148 91 ÖSMO	A92	Nynäshamn	1	10	-428	2242	589,4208338
6064865	170	2010-11-01	2011-03-31	213381	Ann Onym	Ann Onym	155 91 NYKVARN	A40	Nykvarn	1	10	-397	2808	544,3601025
6138000	260	2010-11-01	2011-04-15	22103301	Ann Onym	Ann Onym	150 21 MÖLNBO	A81	Södertälje	1	10	-382	3334	562,384395
6128302	340	2010-11-01	2011-04-15	9912	Ann Onym	Ann Onym	195 93 MÄRSTA	A91	Sigtuna	1	10	-382	3617	562,384395
6131489	345	2010-11-01	2011-04-15	2610033	Ann Onym	Ann Onym	153 92 HÖLÖ	A81	Södertälje	1	10	-382	3626	571,3965413
6077576	550	2010-11-01	2011-03-31	5005228	Ann Onym	Ann Onym	195 94 MÄRSTA	A91	Sigtuna	1	10	-397	4082	553,3722488
6041765	630	2010-11-01	2011-03-31	2019040	Ann Onym	Ann Onym	195 95 ROSERSBERG	A91	Sigtuna	1	10	-397	5013	553,3722488
6037855	1000	2010-11-04	2010-11-09	2003390	Ann Onym	Ann Onym	178 92 ADELSÖ	A25	Ekerö	1	10	-539	5640	553,3722488
6038310	1200	2010-11-05	2010-11-10	19041247	Ann Onym	Ann Onym	194 92 UPPLANDS VÄSBY	A14	Upplands Väsby	1	10	-538	6169	642,4175475
6038292	1386	2010-11-05	2010-11-10	1317590	Ann Onym	Ann Onym	178 93 DROTTNINGHOLM	A25	Ekerö	1	10	-538	6947	671,5078125
6038453	1493	2010-11-05	2010-11-10	2024248	Ann Onym	Ann Onym	139 53 VÄRMDÖ	A20	Värmdö	1	10	-538	7029	709,828125
6091502	3000	2010-11-01	2011-03-31	19007614	Ann Onym	Ann Onym	195 93 MÄRSTA	A91	Sigtuna	1	10	-397	8357	1040,625
6036468	3860	2010-11-03	2010-11-08	19022462	Ann Onym	Ann Onym	195 92 MÄRSTA	A91	Sigtuna	1	10	-540	8688	1119,765625
6136441	4000	2010-11-01	2011-04-15	36544	Ann Onym	Ann Onym	153 92 HÖLÖ	A81	Södertälje	1	10	-382	8715	1226,328125
6128303	5600	2010-11-01	2011-04-15	681411	Ann Onym	Ann Onym	197 00 BRO	A39	Upplands-Bro	1	10	-382	8966	1154,5
6139549	10000	2010-11-01	2011-04-15	19023445	Ann Onym	Ann Onym	195 94 MÄRSTA	A91	Sigtuna	1	10	-382	9272	1505,78125



Trip duration: 9 hrs 11 min
Trip length: 501 km (311.9 miles)

Truck: 37 Distance: 432.85km. Weight: 29635kg. Date: 2010-12-13 Stops: 14 Cost: 9 522,70 SEK

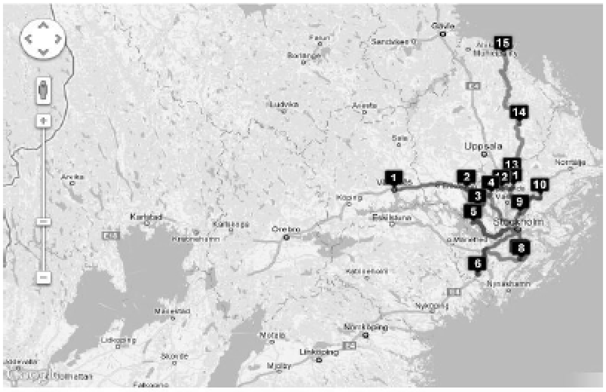
Ordernr	BestKvant	FrånDatum	TillDatum	Kundnr	Kundnamn	Adressrad1	Adressrad3	Code	Avlastnings ort	Region	Status	Priority	id	Cost
6062643	25	2010-12-13	2010-12-16	19041815	Ann Onym	Ann Onym	745 31 ENKÖPING	C81	Enköping	1	37	-502	946	481,2750788
6063192	25	2010-12-13	2010-12-16	19044500	Ann Onym	Ann Onym	113 44 STOCKHOLM	A80	Stockholm	1	37	-502	947	544,3601025
6062908	60	2010-12-13	2010-12-16	2006385	Ann Onym	Ann Onym	178 90 EKERÖ	A25	Ekerö	1	37	-502	1628	544,3601025
12124606	60	2010-12-13	2010-12-16	1315759	Ann Onym	Ann Onym	126 30 HÄGERSTEN	A20	Värmdö	1	37	-502	1780	553,3722488
6063876	300	2010-12-13	2010-12-13	1306487	Ann Onym	Ann Onym	744 91 HEBY	C31	Heby	1	37	-505	3435	508,3115175
6062751	600	2010-12-13	2010-12-16	1314231	Ann Onym	Ann Onym	745 95 ENKÖPING	C81	Enköping	1	37	-502	4208	481,2750788
6063107	600	2010-12-13	2010-12-16	19038603	Ann Onym	Ann Onym	178 90 EKERÖ	A25	Ekerö	1	37	-502	4209	544,3601025
6063724	600	2010-12-13	2010-12-16	19041016	Ann Onym	Ann Onym	194 92 UPPLANDS VÄSBY	A14	Upplands Väsby	1	37	-502	4212	535,3479563
6063697	625	2010-12-13	2010-12-16	1005131	Ann Onym	Ann Onym	755 97 UPPSALA	C80	Uppsala	1	37	-502	4854	535,3479563
6063148	880	2010-12-13	2010-12-16	19025549	Ann Onym	Ann Onym	749 71 FJÄRDHUNDRA	C81	Enköping	1	37	-502	5485	508,3115175
6062876	960	2010-12-13	2010-12-16	1078997	Ann Onym	Ann Onym	149 45 NYNÄSHAMN	A92	Nynäshamn	1	37	-502	5596	598,43298
6063303	1200	2010-12-13	2010-12-16	87336001	Ann Onym	Ann Onym	137 36 VÄSTERHANINGE	A36	Haninge	1	37	-502	6210	607,640625
6062762	2400	2010-12-13	2010-12-16	1020262	Ann Onym	Ann Onym	740 10 ALMUNGE	C80	Uppsala	1	37	-502	8020	851,796875
6118007	21300	2010-11-01	2011-03-31	57158	Ann Onym	Ann Onym	749 72 FJÄRDHUNDRA	C81	Enköping	1	37	-397	9401	2228,5125



Trip duration: 6 hrs 45 min
Trip length: 388 km (241.4 miles)

Truck: 71 Distance: 506.44km. Weight: 23908kg. Date: 2011-02-17 Stops: 14 Cost: 10 129,79 SEK

Ordernr	BestKvant	FrånDatum	TillDatum	Kundnr	Kundnamn	Adressrad1	Adressrad3	Code	Avlastnings ort	Region	Status	Priority	id	Cost
6104831	120	2011-02-17	2011-02-21	770081	Ann Onym	Ann Onym	197 92 BRO	A39	Upplands-Bro	1	71	-435	2426	517,3236638
6106329	276	2011-02-17	2011-02-22	1315453	Ann Onym	Ann Onym	153 93 HÖLÖ	A81	Södertälje	1	71	-434	3363	571,3965413
6106255	601	2011-02-17	2011-02-22	19000724	Ann Onym	Ann Onym	197 91 BRO	A39	Upplands-Bro	1	71	-434	4739	517,3236638
6106361	625	2011-02-17	2011-02-22	1301624	Ann Onym	Ann Onym	819 64 HÅLLNÄS	C60	Tierp	1	71	-434	4890	625,4694188
6105595	650	2011-02-17	2011-02-22	2007748	Ann Onym	Ann Onym	178 92 ADELSÖ	A25	Ekerö	1	71	-434	5090	553,3722488
6107211	900	2011-02-17	2011-02-17	2032043	Ann Onym	Ann Onym	183 79 TÄBY	A60	Täby	1	71	-439	5511	553,3722488
6106437	1000	2011-02-17	2011-02-22	1310924	Ann Onym	Ann Onym	746 93 BÅLSTA	C05	Håbo	1	71	-434	5711	499,2993713
6106127	1200	2011-02-17	2011-02-22	87336001	Ann Onym	Ann Onym	137 36 VÄSTERHANINGE	A36	Haninge	1	71	-434	6278	607,640625
6106516	1410	2011-02-17	2011-02-22	14225	Ann Onym	Ann Onym	137 91 VÄSTERHANINGE	A36	Haninge	1	71	-434	6970	697,0546875
6106021	1500	2011-02-17	2011-02-22	3021888	Ann Onym	Ann Onym	195 96 ROSERSBERG	A91	Sigtuna	1	71	-434	7049	671,5078125
6105509	1625	2011-02-17	2011-02-22	19031857	Ann Onym	Ann Onym	186 97 BROTTBY	A15	Vallentuna	1	71	-434	7175	713,6289063
6106279	3419	2011-02-17	2011-02-22	19022462	Ann Onym	Ann Onym	195 92 MÄRSTA	A91	Sigtuna	1	71	-434	8568	1119,765625
6105909	5280	2011-02-17	2011-02-22	4009767	Ann Onym	Ann Onym	747 93 ALUNDA	C80	Uppsala	1	71	-434	8926	1238,7375
6106532	5302	2011-02-17	2011-02-22	19023445	Ann Onym	Ann Onym	195 94 MÄRSTA	A91	Sigtuna	1	71	-434	8929	1243,898906



Trip duration: 11 hrs 59 min
Trip length: 613 km (381.2 miles)

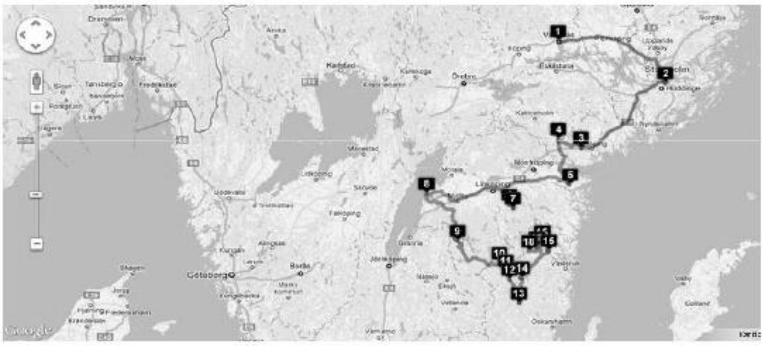
Truck: 23 Distance: 655.98km. Weight: 33472kg. Date: 2010-11-17 Stops: 18 Cost: 15 677,60 SEK

Artikel	Ordernr	BestKvant	FrånDatum	TillDatum	Kundnr	Kundnamn	Adressrad1	Adressrad3	Code	Avlastningsort	Region	Status	Priority	id	Cost
Item X	6046397	500	2010-11-17	2010-11-17	1316559	Ann Onym	Ann Onym	596 92 SKÄNNINGE	E86	Mjölby	0	23	-531	3983	634.481565
Item X	6044344	600	2010-11-16	2010-11-19	35695	Ann Onym	Ann Onym	640 32 MALMKÖPING	D82	Flen	0	23	-529	4142	517.32366375
Item X	6045597	600	2010-11-17	2010-11-22	30846	Ann Onym	Ann Onym	597 94 ÅTVIDABERG	E61	Åtvidaberg	0	23	-526	4149	643.49371125
Item X	6046346	600	2010-11-17	2010-11-17	1312153	Ann Onym	Ann Onym	590 33 FORNÅSA	E83	Motala	0	23	-531	4153	634.481565
Item X	6044657	625	2010-11-16	2010-11-19	1315197	Ann Onym	Ann Onym	570 60 ÖSTERBYMO	E12	Ydre	0	23	-529	4831	706.578735
Item X	6045881	1000	2010-11-17	2010-11-22	1806184	Ann Onym	Ann Onym	611 70 JÖNÅKER	D80	Nyköping	0	23	-526	5650	571.39654125
Item X	6045285	1060	2010-11-17	2010-11-22	17569	Ann Onym	Ann Onym	573 94 TRANÅS	E12	Ydre	0	23	-526	6073	729.86770905
Item X	6043702	1200	2010-11-15	2010-11-18	60806274	Ann Onym	Ann Onym	570 80 VIRSERUM	H60	Hultsfred	0	23	-530	6182	901.9673595
Item X	6044135	1260	2010-11-15	2010-11-18	16065	Ann Onym	Ann Onym	590 42 HORN	E13	Kinda	0	23	-530	6778	863.109375
Item X	6045446	1700	2010-11-17	2010-11-22	62500312	Ann Onym	Ann Onym	640 34 SPARREHOLM	D82	Flen	0	23	-526	7235	717.6125
Item X	6044604	1800	2010-11-16	2010-11-19	12181	Ann Onym	Ann Onym	642 96 MALMKÖPING	D82	Flen	0	23	-529	7292	759.825
Item X	6044123	1850	2010-11-15	2010-11-18	1319844	Ann Onym	Ann Onym	611 97 STIGTOMTA	D80	Nyköping	0	23	-530	7484	843.946875
Item X	6043837	1866	2010-11-15	2010-11-18	1310270	Ann Onym	Ann Onym	642 34 FLEN	D82	Flen	0	23	-530	7530	787.68525
Item X	6045347	1875	2010-11-17	2010-11-22	19205	Ann Onym	Ann Onym	570 60 ÖSTERBYMO	E12	Ydre	0	23	-526	7535	1110.8203125
Item X	6046647	2200	2010-11-17	2010-11-17	20763	Ann Onym	Ann Onym	590 80 SÖDRA VI	H84	Vimmerby	0	23	-531	7923	1098.046875
Item X	6045896	3150	2010-11-17	2010-11-22	34231	Ann Onym	Ann Onym	590 18 MANTORP	E86	Mjölby	0	23	-526	8490	1247.79375
Item X	6129082	4900	2010-11-01	2011-04-15	36255	Ann Onym	Ann Onym	585 93 LINKÖPING	E80	Linköping	0	23	-382	8859	1386.171875
Item X	6044543	6686	2010-11-16	2010-11-19	9725912	Ann Onym	Ann Onym	611 35 NYKÖPING	D80	Nyköping	0	23	-529	9094	1523

Trip duration: 10 hrs 32 min
Trip length: 639 km (397.1 miles)

Truck: 55 Distance: 743.37km. Weight: 30525kg. Date: 2010-12-28 Stops: 16 Cost: 14 624,58 SEK

Artikel	Ordernr	BestKvant	FrånDatum	TillDatum	Kundnr	Kundnamn	Adressrad1	Adressrad3	Code	Avlastningsort	Region	Status	Priority	id	Cost
Item X	6074358	600	2010-12-27	2010-12-30	1313197	Ann Onym	Ann Onym	585 95 LINKÖPING	E61	Åtvidaberg	0	55	-488	4232	634.481565
Item X	6076154	600	2010-12-28	2011-01-03	20763	Ann Onym	Ann Onym	590 80 SÖDRA VI	H84	Vimmerby	0	55	-484	4236	697.56658875
Item X	6073399	648	2010-12-28	2010-12-29	1319964	Ann Onym	Ann Onym	597 92 ÅTVIDABERG	E61	Åtvidaberg	0	55	-489	5083	634.481565
Item X	6075912	690	2010-12-28	2010-12-28	1311648	Ann Onym	Ann Onym	611 99 TYSTBERGA	D80	Nyköping	0	55	-490	5173	580.4086875
Item X	6067465	850	2010-12-27	2010-12-30	19025100	Ann Onym	Ann Onym	592 93 BORGHAMN	E84	Vadstena	0	55	-488	5462	643.49371125
Item X	6075049	978	2010-12-27	2010-12-30	29431	Ann Onym	Ann Onym	594 92 GAMLEBY	H83	Västervik	0	55	-488	5619	661.51800375
Item X	18217377	1000	2010-12-28	2011-01-03	19043537	Ann Onym	Ann Onym	611 97 STIGTOMTA	D80	Nyköping	0	55	-484	5966	562.384395
Item X	6076239	1200	2010-12-28	2011-01-04	21373	Ann Onym	Ann Onym	640 20 BJÖRKVIK	D83	Katrineholm	0	55	-483	6232	674.861274
Item X	12147874	1200	2010-12-28	2011-01-03	19021440	Ann Onym	Ann Onym	590 96 ÖVERUM	H83	Västervik	0	55	-484	6534	793.8216045
Item X	6074579	1225	2010-12-27	2010-12-30	39518	Ann Onym	Ann Onym	598 94 VIMMERBY	H84	Vimmerby	0	55	-488	6631	854.5190712188
Item X	6075638	1250	2010-12-27	2010-12-30	19026462	Ann Onym	Ann Onym	577 93 HULTSFRED	H60	Hultsfred	0	55	-488	6717	917.0189671875
Item X	6074630	2125	2010-12-27	2010-12-30	19009068	Ann Onym	Ann Onym	590 81 GULLRINGEN	H84	Vimmerby	0	55	-488	7892	1051.875
Item X	6073936	2370	2010-12-28	2010-12-29	19042468	Ann Onym	Ann Onym	610 27 VIKBOLANDET	E81	Norrköping	0	55	-489	8000	974.921875
Item X	6074059	2504	2010-12-23	2010-12-29	9725912	Ann Onym	Ann Onym	594 32 GAMLEBY	H83	Västervik	0	55	-489	8178	961.0665
Item X	6075494	2525	2010-12-28	2010-12-30	17569	Ann Onym	Ann Onym	573 94 TRANÅS	E12	Ydre	0	55	-488	8194	1093.4828125
Item X	6075260	2560	2010-12-27	2010-12-30	12561	Ann Onym	Ann Onym	598 95 VIMMERBY	H84	Vimmerby	0	55	-488	8209	1155.92
Item X	6073937	8200	2010-12-23	2010-12-29	19021440	Ann Onym	Ann Onym	594 94 GAMLEBY	H83	Västervik	0	55	-489	9198	1732.7625



Trip duration: 13 hrs 29 min
Trip length: 794 km (493.6 miles)

APPENDIX L – ALPHA SENSITIVITY ANALYSIS

Original Parameters Alpha = 13.91					Original Parameters Alpha = 21.79					Original Parameters Alpha = 6.01			
Current State All orders ship by Foria					Current State All orders ship by Foria					Current State All orders ship by Foria			
	REGION EAST	REGION SOUTH	Combined			REGION EAST	REGION SOUTH	Combined			REGION EAST	REGION SOUTH	Combined
TT	2	2	2		TT	2	2	2		TT	2	2	2
Truck Capacty	34000	34000	34,000 kg		Truck Capacty	34000	34000	34,000 kg		Truck Capacty	34000	34000	34,000 kg
Alpha	13,91	13,91	13.91 km		Alpha	21,79	21,79	21,79		Alpha	6,01	6,01	6,01
Max size	n/a	n/a	n/a		Max size	n/a	n/a	n/a		Max size	n/a	n/a	n/a
Min size	n/a	n/a	n/a		Min size	n/a	n/a	n/a		Min size	n/a	n/a	n/a
Number of shipments needed during a simulation:	284	290	574		Number of shipments needed during a simulation:	284	290	574		Number of shipments needed during a simulation:	284	290	574
Kilometers [km] driven:	135534,13	190835,26	326369,39		Kilometers [km] driven:	150687,37	201339,3	352026,67		Kilometers [km] driven:	127938,28	180304,56	308242,84
Average number of km driven:	477,2328521	658,0526207	567,6427364		Average number of km driven:	530,589331	694,2734483	612,4313896		Average number of km driven:	450,4869014	621,7398621	536,1133817
Total stops:	4084	5083	9167		Total stops:	4084	5083	9167		Total stops:	4084	5083	9167
Total cost:	2939143	4223224,24	7162367,24		Total cost:	2939143	4223224,24	7162367,24		Total cost:	2939143	4223224,24	7162367,24
Number of potential express shipments	523	505	1028		Number of potential express shipments	523	505	1028		Number of potential express shipments	523	505	1028
Average load (weight) per shipment:	25561,90845	29409,31724	27485,61285		Average load (weight) per shipment:	25561,90845	29409,31724	27485,61285		Average load (weight) per shipment:	25561,90845	29409,31724	27485,61285
Total Weight	7259582	8528702	15776741,77		Total Weight	7259582	8528702	15776741,77		Total Weight	7259582	8528702	15776741,77
Number of Orders	4208	5293	9501		Number of Orders	4208	5293	9501		Number of Orders	4208	5293	9501
					Error	percent							
				1	-25657,28	-7,86%		25657,28					
				2	18126,55	5,55%							
								21891,915					
				Average	-3765,365		6,7%						