A Mixed Method Approach to assess performance of alternatives of ‘inbound to manufacturing transport’ in central procurement at DanTrade

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PROJECT INFORMATION

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EXECUTIVE SUMMARY

Background information

FMCG Companies have a constant need to improve the performance of their supply chain to stay ahead of competitors; i.e. companies are continuously looking to reduce costs to deliver added value to customers for the lowest cost possible as well as performing well on corporate responsibility. Competitive advantage arises when the supply chain is not duplicable due to unique collaborations with both upstream and downstream suppliers. Next to the societal push to make the supply chain more sustainable, there are also increased costs related to environmentally unsustainable transport through high fuel use and e.g. emissions taxes. Two of the main drivers for supply chain innovations are therefore 1) reduction of costs and 2) making the supply chain greener, i.e. reduce the carbon footprint. Although transport of goods brings no added value to the final product, it is the essential element that brings the different entities of supply chain, supplier, manufacturer and customer together.

This research entails a case study at Danone's central sourcing company, DanTrade. At DanTrade both ingredients for products as well as services such as transport are sourced. The Global Logistics Team is occupied by finding the most performing method of transport from all As to all Bs. Next to Warehousing, transport to customers and more logistics related activities, Inbound to Manufacturing transport (I2M transport), or in other words, the transport of all ingredients and packaging material (R&P) from suppliers to the Danone factories, is new in the scope of central procurement. More specifically, project I2M focusses on uncovering the hidden value in this category of transport that is currently organised by the supplier of Raw and Packaging Material (DMS) on a Delivery Duty Paid (DDP) base. The projects consists of two phases, the first being Procurement and the second Supply Chain.

- *Procurement* – in this phase the aim is to negotiate reduced prices by comparing the transport price that is part of the all-in price that is paid DDP to DMS and prices from Logistic Service Providers (LSP) that are found through tendering.
- *Supply Chain* – this phase aims to re-engineer the physical chain and find hidden value. For this phase it is necessary to find room for improvement and how to use that opportunity. From the Procurement phase's tender procedure, high visibility of the geographical sourcing network and on quantities and qualities arises. The locations and quantities are considered as unchangeable in this analysis.

Research approach

The knowledge gaps that arise from this research are what type of re-engineering can lead to improved performance from a supply chain perspective. How do these re-engineering opportunities fit in the organisational context and how can this be analysed. This problem statement results in the following Research Question:

How can a Mixed Method Approach be designed to analyse increased performance of physical re-engineering opportunities in Inbound to Manufacturing road transport for a Central Sourcing Company?

To answer this question, research on what the alternatives are for I2M transport are for central logistic procurement and how an improvement of the supply chain is defined in this case should be done. To be able to address both the qualitative organisational aspect as well as the quantitative technical

aspects of the research question, a mixed method approach is used. The quantitative analysis focusses on the impact of the alternatives on a set of Key Performance Indicators (KPIs) defining the physical chain's performance. A set of Key Performance Indicators is determined; Transport Efficiency, Lead Time, Transport Cost, Emissions and Operational feasibility. Of these KPIs, four are listed as decision criteria. The KPI excluded is Transport Efficiency. TE is considered an indicator of performance and not a decision criterion as it not a goal by itself. The qualitative analysis focusses on both the institutional fit of the possible changes that that are caused by the hypothetical implementation of alternatives, as well as the decision makers preferences concerning the KPIs. The values of the KPIs are measured by means of a MCDA analysis using weights that are found by the Best Worst Method for MCDAs. As such, different decision maker perspectives are taken into account while interpreting the quantitative results. The conclusions are formed based on the output of the quantitative analysis of the hypothetical changes to the physical chain as well as the hypothetical institutional fit of any changes made. By analysing the alternatives in both a qualitative and quantitative matter, a mixed method approach is used.

Design Alternatives

Out of literature and Desk Research, two main goals for re-engineering opportunities arise, which are driving less empty-kilometres and higher fill rate of the equipment. The re-engineering options are combinable in a variable named Transport Efficiency, which indicates to which extent the Transport Capacity of the respective equipment is used. The re-engineering goals lead to the following Basic Alternatives; first of all, organising a return load and secondly combining different loads in one truck. There are also other parameters that can be considered, such as the use of a hub location and the use of different categories and equipment. These Basic Alternatives and the additional parameters lead to a set of Design Alternatives. *The analysis of the supply chain* leads to basic entities which can be tested for improvement, named Truck Types. There are seven Truck Types specified. Four of which are Ambient Transport with the respective weights of 24, 22, 10 and 5 tonnes. For the Temperature Controlled Trucks the maximum payload of 22 tonnes is regarded. So for this type of equipment 3 payloads are listed, 22, 10 and 5 tonnes. Downstream Trucks are considered 22 tonnes of Temperature Controlled Transport.

Design Alternative 1. Upstream backload – where the return load of an inbound lane is filled with another inbound lane. All, expect one, Truck Type pairs are suitable for this Alternative. However, when a temperature controlled TT is combined with an ambient TT, temperature controlled equipment has to be used. As Temp controlled equipment has a maximum payload of 22 tonnes, the combination with an ambient load of 24 tonnes is not possible. For this Alternative it should be considered that the loading and unloading locations are not the same.

Design Alternative 2. Downstream backload – where the return load of an inbound lane is filled with an downstream lane. As all downstream transport is Temperature Controlled and Full Truck Loads, the possible pairs are reduced to combinations with the TT Temperature Controlled 22 tonnes. All transport in this Alternatives is temperature controlled. The unloading of the first load and loading of the second point can be considered the same.

Design Alternative 3a and 3b. Combining suppliers – multiple loads of different suppliers are combined together in one truck on the same leg. There are two main Alternatives considered: *(a) Milk-Run and (b) Groupage.* The Milk-Run means passing by multiple suppliers and loading sequentially, while Groupage entails the gathering of products at a hub location such as a Cross-Dock or a (Danone) Warehouse. The return load is not considered for these Alternatives. Combining multiple loads in a truck requires the loads to be of a small size. Therefore the Truck Types suitable for this Alternatives are those with small quantities, in this case 5 and 10 tonnes. Many possible combinations are possible to be made from these Basic Design Alternatives. However, the more complex the Alternatives are, the higher lower the validity with the real world as they are simplified.

Results

Resulting from the *quantitative analysis* it is clear that not all the Design Alternatives are suitable for all types of Trucks. Generally, implementing Alternative 3a and 3b is only possible on Truck Types with smaller payloads. However, as the effects of efficiency are not linear, improving a payload from 5 to 10 tonnes is a larger relative improvement than 10 to 15 tonnes. Concerning the organisation of a backload (Alternative 1 and 2), the analysis shows that Transport Costs and Emissions are reduced, however when one of the Truck Types is ambient and changes to Temperature Controlled, the improvement is less due to the higher costs and emissions of a Temperature Controlled Truck compared to an Ambient Truck. Not one Design Alternative can be selected as 'the best solution', this is also emphasized by the different scores on the perspectives. In general, Design Alternative 2, scores best and is not a reduction of improvement in any case.

From the *qualitative analysis*, it can be concluded that the formal institutions are the cause of most changes when Design Alternatives are implemented hypothetically. Meaning, the formal requirements of commercial trading terms as well as international and internal standards on food safety and quality pose the first concerns regarding a possible implementation of Design Alternatives. Also, as long as the transport is organised on a DDP basis, the organiser of the Alternatives will not be in control. The effects of these are visible at the ** confidential** where a similar initiative has been implemented. The dependency of decisions by the organiser of transport impact the possibility for combinations. In case of ExWorks, this would not be the case. However, an ExWorks organisation of Transport requires more coordination and transfers the risk of transport of the product from the suppliers to the buyer. Design Alternatives 1 and 2, which may be feasible to organise under DDP can therefore be deemed more feasible or likely to increase performance than Design Alternative 3.

As loads are not transported in the same truck at the same time, it is possible for the supplier to do a check of the truck before loading his product and with that not jeopardizing the willingness of a supplier to do DDP. A major improvement, especially for Alternative 2, is making the alignment of timing unnecessarily be decoupling. This means that there is a certain buffer of products ready to take for the arriving truck. For Alternative 3a and 3b it will be more difficult to organise the transport through DDP as multiple DMS have to align on when the order is ready, on loading hours, on which LSP to use and on how to organise the responsibility and contract. Misalignment of timing will lead to an immediate impact of the lead time of products of either DMS with a load in the truck. As this alignment is not in control of Danone, it will highly reduce the predictability and loose its attractiveness. When Danone would organise this transport ExWorks, it is in need of a tool for matching the transport and making sure timing is aligned.

Conclusions

To answer the Research Question, three aspects should be taken into account. Multiple analyses need to be executed to cover the full scope of impact of a re-engineering opportunity or alternative. In a supply chain context, this typically entails a quantitative technical analysis to be able to discuss tangible results and an qualitative organisational analysis, to find the institutional fit of a change and its likeliness to be adopted. These two analyses should have the same object of study, in this case the Design Alternatives, to be able to form an integrated view of the alternative's feasibility and possibility to increase performance. The analyses should have the same object of study and need to be complementary. If not so, the relevance of having an integrated study may be questioned. A central sourcing company is the spider in the web in the supply chain and therefore has many interactions with different actors. A mixed method approach is therefore especially applicable to a company with a centralized and intermediary function.

PREFACE

One may say that the graduation project is a project where you can implement all that you have learned throughout years of study into one project. And I agree. However, I do not think this description suffices at all. Looking back on the past few months, I would say that a graduation project contains more firsts and learning moments than repetition of study elements. For example, as a real (soon-to-be) engineer, I have often vastly underestimated the importance of writing and re-writing during my project.

Executing a project based on logistics while having always been in the Energy & Industry domain, was sometimes difficult due to a fair knowledge gap. I am glad to have noticed that the SEPAM curriculum has prepared me for ‘attacking’ a new technical domain in providing a broad lens, a certain flexibility and a wide interest in different subjects.

Although the graduation project is deemed an individual project, many people have coached and supported me throughout. First of all, I would like to thank my committee. Dr. Warnier for having faith in me even after I was telling him more about my internship adventures then my graduation project during the first months. On a more serious note, he provided me with the exact insights I was lacking whenever I was stuck and our meetings, without exception, always resulted in me running out with tons of motivation to tackle the next obstacle.

Professor Verbraeck, who provided me with large amounts of very valuable feedback during the official meetings, that gave both direction and highlighted the weak points. Dr. Rezaei for spending multiple hours teaching me his BWM method and urged me to focus more on the important details. Also, I would like to say thank you to everyone at DanTrade who provided me with information, ideas and feedback during my internship.

Last, but definitely not least, I would like to thank my family and friends who I absolutely neglected the last months. But who, in scarce moments of social interaction, have supported me tremendously either through cooking or some proof reading.

The sum of a relatively new area of study, a first working experience in a multinational company and my first large solo project resulted in a learning curve which I have sometimes experienced as rather steep. It is therefore that I present with pride and a whim of relief, my master thesis.

Eva Verwijs

Delft, July 2015.

GLOSSARY

DDP	Delivery Duty Paid (International Commercial Terms) – Supplier is responsible for Transport
ExWorks	The buying party is responsible for Transport
DMS	Direct Material Supplier (of Raw and Packaging Materials)
LSP	Logistic Service Provider
I2M	Inbound to Manufacturing = upstream
WH	Warehouse
TT	Truck Type
Hub	Warehouse or Cross-Dock location
LTL	Lower than Truck Load
FTL	Full Truck Load
CBU	Commercial Business Unit
WWBU	World Wide Business Unit or Division
Opportunities for innovation	Same as re-engineering opportunities
Re-engineering opportunities	Any action that can be taken to improve the I2M delivery of goods
Parameters	Possible for DanTrade Logistics to change
Parameter Options	The possibilities existing for the parameters
Design Space	The combination of all parameters and their options. Where the alternatives are derived from.
Design Alternatives	The feasible combinations of parameter options that are further taken into account for analysis.
Truck Types	Seven 'dummy' trucks that are used to hypothetically implement Design Alternatives on
Truck Categories	A summary of the combinations made of
Real Cases	Comparable situations as that of an implementation of a Design Alternative that have occurred in reality.

CONTENTS

List of Tables

List of Figures

PART 1 GENERAL

1 INTRODUCTION & PROBLEM

With the changing economic climate, organizations are more than ever in need of making every aspect of their activities competitive, including their supply chain. According to Whipple & Frankel (2000) the key to a competitive supply chain lies in the organizations ability to use its unique resources and integrations. One of the organizations dealing with this challenge is Danone, founded in 1927 and currently one of the major FMCG companies in the world. This thesis presents a case study on **how to analyse** increased performance that arises from innovation in the transport of products from inbound to manufacturing locations, while focussing on the transport organised from the central sourcing company of Danone.

1.1 DANONE AND DANTRADE

The company Danone owns multiple brands that are divided over four divisions which are: Fresh Dairy Products, Waters, Early Life Nutrition and Medical Nutrition. The company has a wide geographical coverage and has factories, sales points and consumers in almost every country in the world. The corporate responsibility regarding sustainability is shown to various projects, plans and standards throughout the company. Consequently Danone's goal is to achieve a greater than 50% reduction of its carbon footprint by 2020 and to stabilize CO_2 emissions while continuing sales growth" (Danone 2015).

Danone's mission: "Bring Health through Food to as many people as possible"

DanTrade B.V., short for the Danone Trading Company, is one of the subsidiaries of Danone and functions as Danone's central sourcing enterprise; its primary activities being sourcing raw and packaging materials for Danone factories, as well as the procurement of indirect services. The reasons for setting up DanTrade as a central procurement company are threefold; to leverage Danone's worldwide size, to secure the sourcing and to build sustainable and competitive advantage (Danone, 2014). The scope of centralized sourcing may be enlarged in the future by including other divisions in case the enlargement is assumed to increase productivity. Danone is not alone in centralizing aspects of the enterprise for synergies regarding costs and service. Since decades decoupled decision making is replaced by more coordination and integration to secure supply and source efficiently regarding price, organisation and customer satisfaction (Thomas & Griffin, 1996).

Through central sourcing, DanTrade leverages the volume of product orders at the same supplier by various CBU's through one organisation. (Saeed, Malhotra, & Grover, 2005) Concerning the indirect services, central sourcing does not only leverage the volume and consequently the price. It also standardizes the way of working which may make any integration between former decoupled activities more feasible. (Kraljic, 1983) (Trent & Monczka, 2003).

DanTrade Global Logistics

One of the categories of DanTrade is DanTrade Global Logistics, which is part of the indirect services. This department is mainly involved in procurement concerning Warehousing, Pallets, Primary Transport and Upstream transport. The latter refers to the transport of the raw and packaging material supplier (Tier 1, first level of raw materials) to the factory, and the transport from the supplier's supplier (Tier 2, the second level of raw materials) to the factory of the Tier 1 supplier. The logistics team wants to make the transport activities more effective, and are setting up different projects to accomplish this. This part of the logistics organisation and the challenges they face form the context of this research.

1.2 INBOUND TO MANUFACTURING PROJECT

Within the logistics team a new project has started named I2M project; short for 'Inbound to Manufacturing. The objective of this project is to unlock the hidden value in Upstream Transport. The two main drivers behind the upstream project are cost reductions – either through avoidance or savings – and making the supply chain more sustainable. According to Thomas & Griffin (1996), the single largest component of logistics cost is transport cost, often comprising over half of total logistics cost. Generally, freight transport accounts for almost 10% of the total CO2 emissions in Europe and is highly impacted by efficiency of vehicle usage (Arvidsson, 2013; Cefic & ECTA, 2011; Léonardi & Baumgartner, 2004; Ligterink, Tavasszy, & de Lange, 2012). The project consists of two main parts: procurement and supply chain.

The Procurement phase

The procurement phase of the upstream project consists of several predefined steps. The first part is an Ad Hoc market analysis aiming at finding possible discrepancies between the transport prices offered by LSPs and the transport costs shared by the direct material suppliers. Currently, this entails mainly the transport from Tier1 to the Danone factories and partially the supply of goods from Tier2 to Tier1 in case they are in scope of DanTrade Direct. The raw and packaging materials are currently bought through at an all-in price. **confidential**

Confidential

FIGURE 1 - MAP OF LOCATIONS IN PROCUREMENT PHASE TRANSPORT TENDER

The Supply Chain Phase

The data acquired in the procurement phase does not only provide the possibility to negotiate on a like to like basis with direct product suppliers and logistic service providers, it also provides valuable insights in the supply network. These insights are the basis of possibilities for optimization from a supply chain perspective. This optimization is the second step of the upstream project and is the starting point for this thesis.

Visualized by a multiple coloured dots in figure 1 are the locations from and to which upstream transport was included in the earlier mentioned tender. These locations are connected with the blue dots which represent Danone locations. Together, they illustrate a detailed and extensive transport network.

The categories which are included in the current research are packaging, small quantity ingredients such as functional and health products, and larger quantity ingredients chocolate, fruit ingredients and dairy ingredients. The different categories have various different transport features such as temperature controlled, average order quantity, total quantity needed, expiry date and lead times. Features such as low average order quantity or no storing possibilities lead to unnecessary empty kilometres and/or half empty trucks. Through reducing the empty kilometres and increasing the payload, both the emissions and the costs should be minimized.

However, supply chain integration from solely a technical product point of view does not provide a thorough enough analysis on whether any optimization is actually an improvement. It also depends on softer and organizational performance indicators which are linked to the feasibility of the actions to take to fulfil this optimization. This notion often occurs in literature where supply chain integration is described on multiple layers, these mainly being the integration of flows (physical, information, financial), integration of processes and activities, integration of technologies and systems and integration of actors (structures and organizations) (Fabbe-Costes & Jahre, 2007). As any optimization should be an improvement of the supply chain, the performance of 'actions' on these layers should be defined. An overview of the features, options and anticipated results of the Inbound to Manufacturing (I2M) project can be found in figure 2.

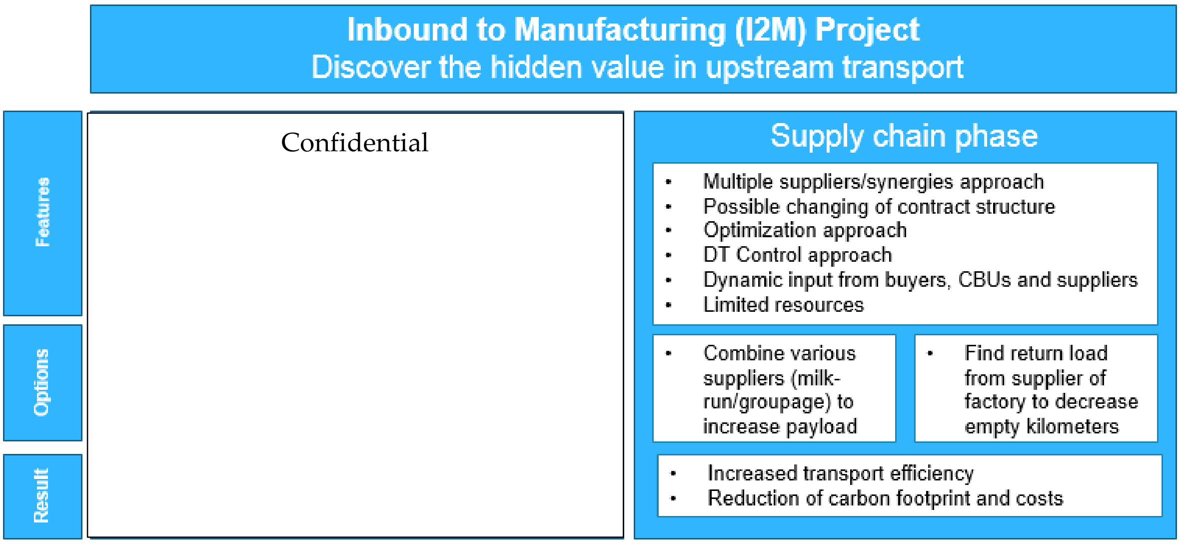

FIGURE 2 - OVERVIEW OF THE I2M PROJECT PHASES

Currently, the upstream project mainly focusses on the leverage of volume through negotiations and procurement. With the insight derived from the numerous inbound to manufacturing lanes in the tender, several opportunities for innovative alternatives may arise. However, any actions for implementation of alternatives that are considered to be taken should not only result in an improvement from a technical point of view, they should also take the soft and organizational KPIs into account. The upstream transport may be integrated in the central transport procurement in case it leads to significant improvement of the supply chain. In the following paragraph the problem will be explained in more detail.

1.3 RESEARCH PROBLEM

Implementing innovative alternatives in transport of R&P materials from Inbound to Manufacturing has multiple facets. It does not only evolve cooperation with multiple internal and external parties, its physical advantages are also to be analysed. As the innovation/integration is not (yet) natural or obvious in the system, it will involve **change**. In order to clarify the possible increased performance that arises from the innovative alternatives and the impacts of the change needed, the case should be analysed following a method that overarches all facets. In this paragraph a problem statement can be found as well as a more specific description of the scope of the Case Study at DanTrade. The relevance of the research from both a societal and scientific perspective will be described, leading to a presentation of the general goal and the expected deliverable.

1.3.1 Problem Description

DanTrade Logistics is looking to increase performance in transport of Raw and Packaging Material from the respective points of origin to the Danone factories. After financial improvement due to procurement optimization, the I2M project team is now looking to further increase performance from a supply chain perspective. The two main drivers for this phase of the project are increasing financial performance and reducing the carbon footprint of the transport. Transport re-engineering may lead to increased performance from a supply chain perspective. However the supply chain perspective takes into account the complex network of actors and activities, which may be influenced in the case of any innovation/integration. There are several knowledge gaps that arise from this problem statement:

- Which (type of) physical re-engineering can lead to improvement on the stated project drivers: financial performance and carbon footprint reduction?
- How can the change and impact of physical re-engineering be estimated?
- How can the two previously mentioned knowledge gaps be researched side by side?

Scope

The case study is based on the European transport lanes from Tier 1 suppliers to Danone factories, moving by ambient and temperature controlled vehicles that were included in the tender of the earlier Procurement phase of the I2M Project. Products that are shipped in bulk or in trucks with a temperature of -18ºC are not in scope, although they were included in the earlier mentioned tender. The reason for this exclusion is that the bulk material are transported in dedicated vehicles by specialised companies. As this transport is a specific market, it is believed to be less suitable for integration/innovation. In addition, the R&P that has to be transported in a truck with a temperature of -18 ºC represent a very small portion of the Inbound to Manufacturing lanes by specific suppliers. As this is not the general case, it is for now excluded from the analysis.

As the I2M project is in full motion, Raw and Packaging material product categories and Direct Material Supplier locations are added to the upstream project continuously. An addition of a supplier to the scope depends on multiple factors, such as the availability of transport- and cost model data, the negotiation status between buyer and supplier. Consequently, the ad hoc adding of lanes results in a fairly vague scope. Despite the fact that the supplier and material category scope may increase or change continuously, the data that is taken into account are the lanes that are actually tendered on the European market between August 2014 and March 2015.

Assumptions

In order to execute the analysis on the case study, several assumptions have been made, which are listed below. It is assumed that,:

- the available data derived from the Tender provides a realistic image of the transport market,
- the current quantities of ordering and the transport requirements that are currently known are optimal and have no room for improvement,
- the current downstream activity concerns Full Truck Loads of temperature controlled finished product
- the current supplier and factory or warehouse locations will be assumed to be fixed, even if they change during the project,
- the International Commercial Terms on which products are delivered now, are changeable within the company.

1.3.2 GOAL AND EXPECTED DELIVERABLE

The objective of this thesis is to provide a successful application of a method that can be used to indicate the feasibility and increased performance of innovative alternatives in a supply chain management context. More case specifically, the goal is to provide an analysis that defines the extent to which the integration of upstream transport can be an improvement of the supply chain in both a technical and organizational relevant way. The analysis should be applicable to a broader scope than the current one.

1.3.3 RELEVANCE OF RESEARCH

FMCG are continuously trying to improve the supply chain to make it more unique and less duplicable, (Ellram & Cooper, 2014) with the objective to gain competitive advantage and/or financial improvement. As the supply chain perspective entails both a technical and the organisational aspect it is important to include both in the analysis. This problem concentrates on a future step of an existing project which is the supply chain perspective of the integration of upstream transport in centralized logistics procurement. It is therefore fairly exploratory research and aims to contribute to the knowledge on the integration of the transport flows.

Societal and commercial relevance

The case study is performed in a corporate environment, namely that of DanTrade, consequently its commercial relevance needs to be considered. It analyses both the feasibility and the possible increased performance of the initiatives in the second phase of the project. It also has societal relevance as the reduction of the carbon footprint, one of the main drivers of the project, is closely related to corporate social responsibility. Environmental responsibility is one of the eight attributes identified in the Kinder Lydenberg, Domini (KLD) index, a thoroughly validated method to measure Corporate Social Performance, (Sharfman, 1996).

For DanTrade, It should inform on feasibility from various perspectives such as operational and organisational, and clarify the impact on performance indicators. As well as provide insight in whether an integration of flows is an improvement of the supply chain.

Scientific relevance

This research integrates a business model question in a multi-objective approach, thereby providing a case study on what can be the role of logistics in the complex supply network of a global purchasing firm (Trent & Monczka, 2003). It develops knowledge on the possibility of combining the reverse part of upstream transport with plants and other facilities and not only with waste, like most reverse flow studies. (Paksoy, Özceylan, & Weber, 2011) Lastly, it provides a method to analyse the performance and feasibility of an originally technical innovation and should demonstrate how the same research approach may be extrapolated onto a broader scope. Due to its integration in the unified whole, will impact other aspects of the supply chain internally and externally. That is why it is important to carefully analyse the place of an innovation in the context - to prevent it from becoming a possible one-time hit or a failure in any way.

1.4 CONCLUSION

The Inbound to Manufacturing Project, that is initiated in the DanTrade Logistics Team, is investigating the opportunities to increase financial performance and reduce the carbon footprint by means of innovative alternatives. The innovative alternatives are based on physical re-engineering options that are within reach of impact for the DanTrade Global Logistics team. Logistics performs an important function in the supply chain, namely that of connecting the supplier with the manufacturer and the customer. For that reason, it plays an important role in the actor network of raw and packaging material suppliers, internal parties and third parties such as logistics service providers.

By providing an integrated analysis of the both the organisational as the physical aspects of innovative alternatives that aim for financial performance and improved environmental sustainability, this research is relevant from both a commercial and societal as from a scientific perspective. The background as described in this chapter will be placed in literature to transform the problem statement into concrete research questions and to form an adequate approach to arrive at the earlier research goal and expected deliverable and so provide a way of analysing whether a transport alternative is both feasible and increases performance from a supply chain perspective.

2 SUPPLY CHAIN INTEGRATION IN LITERATURE

Since the term supply chain management first appeared in literature in the 1982, interest and research in this field have largely increased (Ellram & Cooper, 2014). This research focuses on the analysis transport from a supply chain perspective. To be able to place the research in an academic context as well as to create a (solid) base of knowledge, a literature review is executed. The literature review will first address the role of transport in the supply chain, followed by an explanation of what is considered supply chain performance. Lastly, it will be discussed how performance in the supply chain can be achieved according to the consulted literature.

2.1 THE ROLE OF TRANSPORT IN THE SUPPLY CHAIN

A chain is a 'series of linked things' (Merriam-Webster, 2015). This word in the term supply chain management underlines the management of interconnected parties in supplying a product. The definition of the International Centre for Competitive Excellence is "Supply chain management is the integration of business processes from end used through original suppliers that provides products, service and information that add value for customers." (Cooper, Lambert, & Pagh, 1997) A company (usually) has multiple suppliers, factories and customers, which can be considered as nodes in a network (Chen & Paulraj, 2004). Transport provides the physical and essential links between these nodes, as expressed as follows in Mason et al. (2007):

> "Transport can be defined as "the physical link connecting […] the fixed points in a logistics supply chain" (Coyle et al, 2003) and hence is a key integral process in contributing to the overall goal of successful supply chain management; the planning and control of material flow (Ellram, 1991), to delivery of superior value to the end customer (Christopher and Towill, 2000)."

Although transport is an essential element in the supply chain, it is also listed as one of the non-value adding activities, together with inventory and waiting (Frohlich & Westbrook, 2001). This means that transport does not directly increase the value of the product. Like storage space or inventory, transport can be regarded as a resource that should be used as efficiently as possible (Schoenherr & Swink, 2012). While transport does not add value to the product directly, it is an increasingly important element due to growing globalisation and dispersion of suppliers as well as manufacturing locations (Marasco, 2008). Adding to this, more and more companies are counting on last minute ordering and with that demanding a high flexibility of supplying parties. The Just-in-Time principle, a strategy that implies products being ordered at the last minute when there is a demand and arrive in time for production of that demand, is frequently applied in the food industry. This strategy decreases the need for stock and reduces the inventory time, which for the food industry is an important advantage concerning its limited shelf times (Fearne, Hughes, & Duffy, n.d.). The reduced need for inventory also leads to reduction of inventory costs, however may render the logistic i.e. transport management more complicated as it demands high flexibility (Das & Handfield, 1997; Marasco, 2008). The latter often increases transport costs which leads to the classic logistics trade-off between inventory and transport costs (Chopra & Meindl, 2001).

The basic form of a network of nodes (suppliers, manufacturers and customers) and links (transport flows) is that there exists a link for every buyer-suppliers relation. In other words, every factory has a separate link for all her suppliers. This type of network is called a direct shipment network. The links can have different characteristics which are caused by a multitude of factors at the supplying and demanding nodes. Examples of these are order quantity or density of supply and distance. As a result, the links or transport flows can be divided into two major categories, transport in Full Truck Loads (FTL and transport in Lower than full Truck Loads (LTL) (Chopra & Meindl, 2001).

Although transport does not directly add value to the product, it does, however, has a large impact on the service level. The management of transport finding a balance between cost reduction or savings and service level (Stank, Keller, & Daugherty, 2001). Optimisation can be divided over three levels, to describe the three levels examples related to transport are given. *Strategic level* decisions optimise for example the locations of factories and other manufacturer-related locations, also to they provide guidelines for quality and supplier relation management. On the *tactical level* optimisation of the necessary transport flows between these locations as well as decision on production quantities per factory can be taken. The *operational levels* work around the decisions made on the two other levels, for example the optimisation of the processing of deliveries in the factory (Schmidt & Wilhelm, 2000).

The optimisation of transport flows is associated with a number of transport-related metrics: The *transport costs per goods sold* and per shipment, as well as shipment sizes. Shipment sizes and cost of shipment are related; full use of shipment capacity leads to economies of scale, so that LTL and FTL shipping are considered to different markets (De Jong, Schroten, Van Essen, Otten, & Bucci, 2010). Smaller shipment size often lead to higher transport tariffs (Leitner, Meizer, Prochazka, & Sihn, 2011). There exist numerous possibilities of increasing the shipment size that is transported in one truck. An example of this is the milk-run, where multiple loading or unloading locations are served in order to fill the truck (Arvidsson, 2013; Chopra & Meindl, 2001, p. 396; Du, Wang, & Lu, 2007). Cross-docking is a form of indirect shipment where several products can be grouped together at one location to be transported together to their mutual destination (Chopra & Meindl, 2001, p. 397; Hosseini, Akbarpour Shirazi, & Karimi, 2014; Shi, Shang, Liu, & Zuo, 2014). As these two examples focus on LTL shipments, there are also other ways of finding economies of scale for FTL shipments. Examples of these are double stacking of pallets for goods that fulfil the floor space capacity but do not reach the maximum weight limit (Cochran & Ramanujam, 2006; Vanovermeire, Sörensen, Breedam, Vannieuwenhuyse, & Verstrepen, 2014). Another alternative to more optimally use the transport resources is organising a closed loop, to ensure that the a truck does not travel back empty, but instead is used in an optimal way (Govindan, Soleimani, & Kannan, 2014; Paksoy et al., 2011; Sbihi & Eglese, 2010).

The alternatives, such as those listed in the previous paragraph concerning multiple loads or location to be combined rather than single loads being shipped directly, require a significant degree of coordination and synchronisation between the different parties involved (Chopra & Meindl, 2001). The increased need of coordination and synchronisation may lead to an increase in the three main risks that concern transport: the risk that shipment is delayed, the risk that shipment does not reach its destination and the risk that the shipment contains mutually hazardous material (Chopra & Meindl, 2001; Speier, Whipple, Closs, & Voss, 2011). However, aggregation or combination of loads can lead to economies of scale that lead to financial performance. The price to pay for a shipment of aggregated loads is lower than the sum of the solely-shipped loads. Aggregation and optimal capacity use is therefore an objective of logistic service providers or any transport intermediary (Demir, Bektaş, & Laporte, 2014).

2.2 SUPPLY CHAIN AND PERFORMANCE

The goal of the supply chain is to maximize overall supply chain profitability (Chopra & Meindl, 2001). What makes a supply chain more profitable? Providing a customer with an added value against a lower cost compared to a competitor (Lambert, Emmelhainz, & Gardner, 1996). Reducing the transport capacity needed, for example by the alternatives mentioned in paragraph 1.1, reduces costs following resource-based theory (Schoenherr & Swink, 2012). The lesser use of resources will reduce the total cost of production, in case no other compromises need to be made. A supply chain does not have the reduction of costs or financial performance as a sole driver but rather is aimed at being as competitive as possible as a whole (Romano, 2003). Competitive advantage is not only financial performance, i.e. it is not only providing the added value to the customer to a lesser cost. It is also providing the right value for the customer or stakeholders needs. Customers' need is often a high level of responsiveness or may focus on lower costs. Through transport and inventory management, companies can trade off efficiency versus responsiveness. (Chopra & Meindl, 2001)

Competitive advantage arises when a supply chain can deliver an added value conform customers' needs through a non-duplicable, profitable supply chain; It distinguishes one supply chain from another and consequently leading to competitive advantage. It is not a company competing with another company but rather a supply chain competing against another supply chain (Fearne et al., n.d.) As a supply chain involves multiple parties, one can also consider it an integrated network of actors (Ellram & Cooper, 2014). Literature states that <u>more</u> integration, in other words, **new or reinforced links**, in the supply chain is often a driver for improved performance (Danese, Romano, & Formentini, 2013; Van der Vaart & Van Donk, 2008). Even stronger formulated, more intensely integrating the supply chain cannot be regarded as an auxiliary activity, but is a key factor in finding added value to differentiate one's supply chain from that of competitors.

Not including coordination with suppliers and customers in the supply chain prevents a company from having a smooth supply chain, as well does not coordinating upstream and downstream activities (Frohlich & Westbrook, 2001). Forming integrated relationships, or triads, between buyers of ingredients, the suppliers of the ingredients and logistic service providers can 'increase the likelihood of maximizing supply chain efficiency'. (Gentry (1996) in Marasco, 2008). This aligns with the earlier statements that an unique supply chain provides competitive advantages in the market, as a possible triad can be considered unique. The confirmation of that strategically interconnecting and aligning with parties in the supply chain can result in significant benefits is provided by Schoenherr & Swink (2012) in their analysis of Frohlich & Westbrook's research (2001). Internal alignment, the sharing of knowledge and information, organisational structures, people and technology are all known to be drivers for innovation (Flint, Larsson, Gammelgaard, & Mentzer, 2005). Where innovation creates and sustains competitive advantage. It is driven by satisfying customer needs, technological-driven competition, globalization (Soosay & Hyland, 2004).

Integration and performance

External integration is often aimed to increase both logistics and financial performance (Germain & Iyer, 2006). Through use of performance indicators that measure across supply chain relationships an indication of overall performance can be given (Stank et al., 2001). Subramanian et al. (2015) reviewed literature concerning performance indicators for economic, environmental and social sustainability for the supply chain and specify different categories under which strategic planning, purchasing, procurement and distribution/logistics. For economic sustainability, the reduction of inventory costs as well as the increase in capacity utilization, high quality and service, fast and reliable delivery are considered. Another important factor that is concerned is the reduction of lead time. Environment: reduce transport, reduce environmental impact (and more specifically reduce energy and CO2 intensity.

Successful external supply chain integration or collaboration with supply chain partners leads to increased (financial) performance and distinguishes one supply chain from another and consequently leading to competitive advantage. Baratt (2004) argues that often the reason for the failure of supply chain is the over-reliance on technical aspects in implementation. It is indispensable to analyse the context of the physical chain, to make sure successful integration is feasible. Integration between suppliers on a non-technical level equals collaboration. He gives the representation in figure 3 of the different possible collaborations, where the collaboration considered in this research are highlighted in yellow. Collaboration identifies as joint goals, shared resources and a common vision (Fugate, Mentzer, & Stank, 2010).

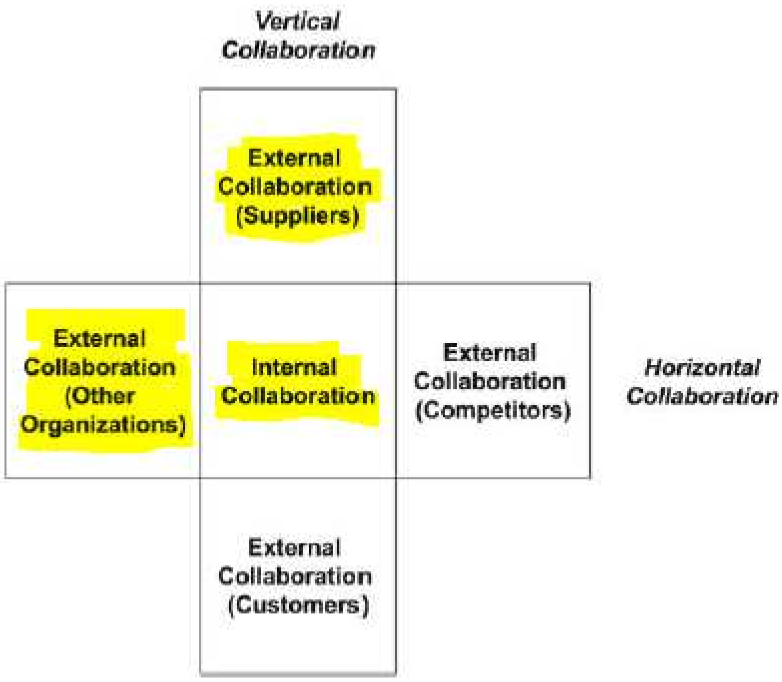

FIGURE 3 – TYPES OF COLLABORATIONS - ADAPTED FROM BARRATT (2004)

Performance is expected to be higher in case of 'organization fit'. Organizational fit is the alignment between parties on the goals to attain and how to reach them i.e. people that are working together through several layers of integration. Supply Chain Management can be very closely linked to industrial organisation and transaction cost theory (Ellram, 1991). Any change in organisation will take some time to adjust. They key to successful inter-organisational relations are based on mutual dependence, where interdependence and opportunism are the main pitfalls of successful cooperation (Joskow, 2010).

The complex but indispensable communication and information technology's importance is underlined by Romano (2003). As earlier stated successful supply chain integration makes a supply chain unique and also increases performance. In several articles the importance of coordination and the alignment of objectives as well as information is emphasized. As information sharing could be considered a technical challenge, the alignment of objectives is not. As an actor's perspectives and actions are mostly caused by the institutional context he is in, it is important to analyse the institutional context.

2.3 SUPPLY CHAIN PERSPECTIVE AND INCREASED PERFORMANCE

In the previous paragraph it is explained that more integration leads to higher performance. Two types of integration are selected from Barratt (2004) explanation, internal and external integration. Both integration will be explained in more detail below.

Internal integration

Internal integration can be defined as collaboration within a company. Instead of seeing different departments as separate functional elements within a greater whole, it focusses across functions and departments. Integration can be done through aligning on practices, procedures and behaviours, as well as synchronizing processes, systems and data (Zhao, Huo, Selen, & Yeung, 2011). These processes include, among others, transport, warehousing, planning, operations and purchasing (Germain & Iyer, 2006). One of the most important elements of internal integration is the cross-functional communication and alignment of functional performance measurement systems and objectives. In case cross-functional collaboration should take place, it is indispensable that both functions are aiming for the same objectives and not for possibly contradicting, narrow functional interests (Ellegaard & Koch, 2012). Integrated logistics operation and planning databases are an essential part of internal integration (Closs & Savitskie, 2003), as is higher level strategic planning integration (Sanders & Premus, 2005). Internal integration is a key performance driver for responsiveness which is a feature that distinguishes one supply chain from another (Williams, Roh, Tokar, & Swink, 2013) (Danese et al., 2013). Williams et al. emphasize the importance of integration over visibility. Communication and cross-functionally shared objectives create understanding of the visible and shared data, rather than possible unaligned use of the data. More strongly stated, the lack of internal integration on any level negatively affects the company's performance. (Ellegaard & Koch, 2012).

Successful internal integration is seen as a prerequisite or an enabler for external integration, the main driver for increased performance (Flynn, Huo, & Zhao, 2010; Zhao et al., 2011). This is a result from the need for information to be shared with external parties who often cooperate with multiple departments. In case a department is working on intensifying the 'link' with an external party, such as a customer or supplier, aligned internal information should be shared adequately to avoid causing disadvantages or miscommunication with other departments (Rodrigues, Stank, & Lynch, 2004). It can be concluded that literature states that in order to assure successful implementation of any external integration, the internal integration should be adept (Schoenherr & Swink, 2012).

External integration

External integration concerns collaborative relationships with supply chain partners such as customers and suppliers (Zhao et al., 2011). Schubert & Legner (2011) defines three different main aspects of inter-organisational collaboration, technical, organisational and institutional integration. Technical integration focusses on the sharing of data systems and any method of sharing information electronically across firms. An example of this can be transport management system TMS. Information and data sharing and visibility is often described in literature as an indispensable element for integration (Prajogo & Olhager, 2012)(Sanders & Premus, 2005). Organizational integration presents collaboration through efficiency-enhancing organizational structures and processes. Institutional integration defines all forms of formal and informal agreements. Social and cultural integration are also mentioned as possible aspects of integration (Schubert & Legner, 2011). To cope with external integration, operations should be able to handle a certain degree of independent behaviour by subsystems. Internal integration is beneficial to external integration following information processing theory, while the improved performance due to external integration can be deduced to a resource-based view. This is consistent with the earlier statement that the use of resources such as transport assets can be reduced through supply chain integration (Schoenherr & Swink, 2012).

Supplier cooperation on sustainable initiatives has proven to indeed contribute to the firms performance (Hollos, Blome, & Foerstl, 2012). External integration, alignment with customers and suppliers, also decreases the risk of unknown events, unanticipated situations and market uncertainties that may interrupt the supply chain, which is a reason why it increases performance (Lavastre, Gunasekaran, & Spalanzani, 2012). Increased interdependence on an external party also increases the risk of a more severe disruption. Therefore external integration always contributes to improving logistic performance of a firm by making a supply chain unique, responsive and not duplicable which increases performance (Gimenez & Ventura, 2005). "*Structural contingency theory suggests that how well an organization performs depends on the extent to which the strategy that it seeks to pursue is aligned with its design. The alignment between strategy and performance is describes as "fit" in the strategic management literature.*" (Flynn et al., 2010) The initiatives taken are not integrated in the main lines of the business through formal organizational mechanisms and information and communication infrastructure (Rozemeijer & van Weele, 2003). The durability of the process/project highly depends on the fit of the project within the organization.

2.4 Conclusion

In conclusion, innovation in transport or logistics is often aimed at increasing the transport performance i.e. transporting an amount of goods for a lower cost and an acceptable level of risk on disruptions. Transport forms an important element of the supply chain. However, supply chain performance is not necessarily the same as transport performance. Supply chain performance results from having competitive advantage. A company has competitive advantage when it is able to deliver either better fulfil the customers' requirements to a similar cost, or provide equal added value to a reduced cost. To be able to do any of the two, a supply chain should not be duplicable by a competitor, i.e. the supply chain should be unique. To reach uniqueness, a company should aim to align its activities and collaborate with other parties in its supply chain. Different extents and types of integration all directly or indirectly lead to increased supply chain performance. Vertical external supply chain collaboration i.e. with suppliers and customers can only be successful when internal supply chain collaboration is adept. Horizontal external supply chain collaboration may also differentiate one supply chain from another and increase its uniqueness.

3 RESEARCH APPROACH

The subject of research can be defined as an innovation in a complex sociotechnical system. Why can this system be considered a socio-technical system? Because it involves both 1) physical-technical elements, namely the physical supply chain re-engineering and 2) networks of interdependent actors. (Bruijn & Herder, 2009). This problem can be analysed from two perspectives.

- A technical-rational system perspective: a system consists of multiple subsystems, which often have conflicting functionalities (Bruijn & Herder, 2009) *e.g. Optimizing truck loads will lead to decreased flexibility for factory.*
- Institutional perspective: as in any socio-technical system, multiple actors are involved. They have different interests and perceptions of aspects in the system, so cooperation is not guaranteed. Also they operate according to a certain set of institutions, which need to be analysed to understand the possible success of the innovation (Geels, 2004).

The technical perspective is important to *'know what we are discussing'*. The institutional perspective is important as *the project involves people who formally have no obligatory communication*. The physical supply chain integration functions as the starting point of this thesis and the organisational perspective forms the facilitating and restricting environment. The two perspectives are particularly applicable on type of re-engineering mentioned in Chapter 1. The combination of several suppliers an especially good example of where technical opportunities meet collaboration.

The combination of two perspectives

Bruijn & De Herder state integration of these two perspectives is essential, however it cannot be replaced by one approach that integrates both perspectives. As integrating the actor perspective in a calculation model will decrease the value of the analysis: actor interests and behaviour are difficult to define by numbers and therefore not quantitative model material. While describing the physical chains changes only qualitatively does not lead to tangible and discussable results concerning e.g. financial performance. An approach should be found to include both perspectives without merging them into one, to make sure both perspectives are analysed to their full extent and give a representation of reality.

From the research problem and questions arises that the problem has two sides, a physical supply chain perspective and an organisational perspective. In other words; there is the physical integration and the impact that integration will have on the KPIs, and there is the organisational fit. While the first requires a mainly quantitative approach, the latter insists on a qualitative approach.

3.1 RESEARCH QUESTIONS

The problem statement is formed into a main research question.

How can a Mixed Method Approach be designed to analyse increased performance of physical re-engineering opportunities in Inbound to Manufacturing road transport for a Central Sourcing Company?

To answer this research question, a Case Study is carried out at DanTrade, the central sourcing Company of Danone. The specific case concerns Europe, temperature controlled products. The term 'Opportunities' is used as it relates to actions on which the Logistics Team has a direct influence. **A direct influence** an action they can either provoke or organise. This question will be answered by the use of three sub questions;

1. Why is a Mixed Method Approach for I2M opportunities in Central Sourcing applicable for measuring increased performance?
2. What are the physical re-engineering opportunities *and what are their effects*?
3. How can these opportunities be placed in an institutional context and how to they fit?

The first sub question gives insight in why the approach to these research question is an adequate one. The answer should provide information on the convincing elements as well as the doubt provoking ones. The second sub question stems from a technical-rational system perspective and requires quantitative research. The third research question is directly derived from the institutional perspective. Together the responses to the sub questions should answer the main research question.

3.2 METHODS USED

From the earlier description of the research problem and questions arises that the approach has two sides, a quantitative analysis for the anticipated changes in the technical system and a qualitative analysis addressing the institutional context and fit of those changes. For a case where both qualitative and quantitative research is needed, Creswell advises a mixed methods analysis. A Mixed Methods approach entails a research method that takes both qualitative and quantitative methods into account (Creswell, 2003).

3.2.1 QUANTITATIVE ANALYSIS

The quantitative analysis focusses in this case on how the re-engineering or change in transport organisation can impact the current situation and how this is possible an improvement or reduction of performance. As the project includes a change in the physical supply of Raw and Packaging materials, it is important to know what effects this will have on for example the number of kilometres that will be driven and how much volume will be transported at once. The changes lead to information on the levels of e.g. emissions and costs in the new situation. Typically, there does not exist a unique optimal solution for transport or other technical systems. It contains multiple indicators of performance that may mutually increase through change or may change in opposite directions. To make a decision whether a change is indeed an improvement, it is necessary to divide the decision into specific and understandable indicators of importance. As a decision maker may assign more value to one indicator as to another, it is also import to understand how these preferences can influence the most adequate solutions. An MCDA leads to a rational decision-making process and provides a possibility to integrate different parts of performance to produce a meaningful solution. In order to assign weights to the criteria in the MCDA, the Best-Worst Method (BWM) for Multi Criteria Decision Making is used (Rezaei, 2015a, 2015b). This method is appropriate as the preferences are based on expert opinions. Pairwise comparisons on this basis generally show inconsistency. Through providing a structure way of making the comparisons, BWM reduces these inconsistencies.

3.2.2 QUALITATIVE ANALYSIS

Qualitative research is needed to define the organisation fit of the possible change that arise from the hypothetical implementation of re-engineering opportunities. To determine this fit, the institutional context and the impact on this need to be analysed. This takes into account the institutional context as well as organisational feasibility. From the qualitative analysis the preferences concerning the performance criteria are also derived. As earlier described in the literature review, technical change that does not have a sufficient organisational fit are not likely to be successful and lead to increased performance (Geels, 2004). The qualitative analysis contains an assessment of the operational feasibility as well as the determination of preferences of decision maker concerning the key performance indicators.

3.2.3 MIXED METHODS

From the previous two paragraphs it can be derived that the qualitative and quantitative analysis are complementary on various stages. The objectives and drivers of the project lead to a certain number of re-engineering options that can be considered. The re-engineering options can be seen as any physical change that it is possible in the Inbound to Manufacturing Transport. However as the project is considered from DanTrade and the I2M project's perspective, it is delimited to a set of Design Options. The Design options are then analysed both as a changes in the physical/technical system and as impacts in the institutional context. From the Institutional analysis both the quantified operational feasibility and the qualitative institutional fit is derived. The System analysis leads to a quantitative model and a set of KPIs it influences, included in these KPIs is the Operational Feasibility. The combination of the results of the MCA and the Institutional fit leads to insights on the performance of the design options.

3.3 CONCLUSION RESEARCH APPROACH

The research is executed from two perspectives. An integration should lead to an improvement from a technical perspective, however it should be feasible and desirable from an organizational perspective. The possibility for improvement as well as the feasibility and desirability should be made measurable through a set of KPI's. The implementation of this research approach on the specified case study at DanTrade demonstrates the applicability of such an approach on an innovation aimed at performance in a commercial socio-technical environment.

3.4 OUTLINE

The outline of the report is as follows. This research approach is found in **PART 1**, which will further focus on answering the first sub question. This questions will be answered by means of literature research and desk research. Furthermore, this part will elaborate on the Company's features and the on what the project entails. Literature focusses on the reasons for which a mixed methods approach is needed and Supply Chain integration and innovations.

Part 2 and 3 both focus on sub questions 2 and 3. **PART 2** is more exploratory research concerning the objectives of the project, which are discussed in Chapter 4. A detailed overview from a technical system perspective is presented in Chapter 5. Then in Chapter 6, a description of the institutional context follows in which the current organisation and the legal framework in which it occurs is described, thereby including the qualitative analysis. In **PART 3**, the exploratory research are analysed more precisely. This is done through creating a number of design options in Chapter 7. The design options represent the actual physical system changes that are considered for further analysis. Chapter 8 places the design options in the earlier defined institutional context, to see which and what type of changes they require. After, Chapter 9 explains how the physical changes quantitatively impact the earlier defined KPIs. In **PART 4** the results are presented in Chapter 10, these are validated and verified in Chapter 11. Then finally in **PART 5**, the discussion and reflection can be found in Chapter 12. The conclusions, answers to the research questions, scientific contribution and recommendations for further research can be found in the final Chapter 13.

PART 2 ANALYSIS

4 PERFORMANCE INDICATORS FOR I2M

In Part 1, the main drivers of the project have been stated as financial performance and reduction of the carbon footprint, i.e. increasing the environmental sustainability of the inbound to manufacturing transport and reducing the total transport cost. In this chapter, these objectives will be explained in more detail. Following the literature review, organisational fit is a requirement for successful implementation of innovations (Schot & Geels, 2008). For that reason a broader framework to determine performance needs to be formed. This framework should consist of both quantitative as qualitative performance indicators in order to provide a mixed method approach (Creswell, 2003). Not all performance indicators may be equally important to stakeholders or project leaders, to grasp the subjective preferences weights will be assigned.

4.1 FROM DRIVERS TO PERFORMANCE INDICATORS

Supply chain performance is much broader than logistics performance, however also contains an overlap. Both entail financial performance. To measure the effect of tactical transport alternatives a set of quantitative and qualitative performance indicators has been formed based on performance indicators found in literature. A selection of five key performance indicators (KPIs) is made. Why these KPIs are selected and how they adequately determine performance in this case study is explained below.

4.1.1 TRANSPORT COSTS

Transport costs can comprehend many aspects. In this case, the all-in price provided by a Logistic Service Provider(LSP) is considered for the shipment per tonne-km. This comprises fuel costs as well as administrative and operational costs. The transport costs and future possible reduction or increase is considered on the scale of a shipment. As the case study, apart from being based on the European inbound to manufacturing transport is disconnected from any geographical information, transport costs influencing factors such as density of local LSP's, attractiveness of a specific shipment due to geographical location etc., are not taken into account.

There are also other costs that could be considered as transport costs, such as external costs, the cost of the impact of transport an society and environment (Janic, 2007). Due to the geographical decoupling as well as for the reason that external costs are generally difficult to determine, and that these costs are paid by society rather than Danone, these circumstances are not taken into account.

Factors influencing the transport costs that are taken into account are the price differences concerning equipment requirements, e.g. a temperature controlled truck is more expensive than an ambient truck. The reduction of the total amount of transport, buying less trucks will decrease the total costs. This is only the case if the average distance per truck does not increase to such an extent that the advantage is compensated (Aschauer, n.d.). As the transport cost is regarded on shipment level, the economies of scale or procurement negotiation advantages regarding large volumes are not taken into account.

4.1.2 EMISSIONS

The reduction of the carbon footprint or more concretely, the reduction of the amount CO_2 per tonne-kilometre that is emitted during the transport of the R&P, is stated as one of the main drivers for the SC phase of the I2M project. Making the transport 'greener' is not only a strategic objective for Danone, it belongs to a business attitude apparent in multiple food enterprises in order to develop more sustainable supply chains (Smith et al., 2005). Environmental responsibility is one of the eight attributes of the Kinder Lydenberg, Domini (KLD) index, a thoroughly validated method to measure

Corporate Social Performance, (Sharfman, 1996) as explained in the literature review, it also contributes to the corporate social responsibility of the company.

Reduction of emissions is possible in several ways – reduction of fuel consumption, changing to a cleaner fuel type such as biodiesel and capture of emissions. The latter two are not in the scope it this project. The reduction of fuel consumption and emissions is not only an objective due to the corporate social responsibility a multinational company has, it is also increasingly regulated. Taxes such as the EcoTaxe in France, as well as increased fuel prices increase the pressure to reduce the fuel consumption and emissions (Santos, Behrendt, & Teytelboym, 2010).

4.1.3 Lead Time

Lead time is an important indicator on which other parties in the supply chain count. It influences the time between the ordering of a product and its delivery. In case of the Just-In-Time principle, which often occurs in FMCG and perishable product industries, it is especially important to the low buffer inventories. The JIT principle leads to reduced need for inventory and time in stock (Mason et al., 2007).

This performance indicator concerns the duration between the moment the product is ready to load at a supplier up to the moment it has been unloaded at its final destination. As the evolvement of The Lead Time is important for the product quality as multiple products are restricted to travel more than a certain amount of hours, this is important to take into account when the Lead Time increases. A reduction in lead time can be seen as an advantage as it provides opportunity to order products on a shorter notice. However the most important feature of lead time is its reliability. Successful transport operations is an important indicator of the feasibility of the Just-In-Time principle. The predictability of lead time impacts the order time and the transport operations are based on this. Shortly, predictability is key as it impacts planning of production, inventory and procurement. An increased lead time is acceptable as long as it is within pre-set boundaries and is predictable. (Lambert, Cooper, & Pagh, 1998; Paksoy et al., 2011; Williams et al., 2013)

4.1.4 Transport Efficiency

Transport Efficiency indicates performance by measuring to which extent the capacity of a vehicle has been used. As transport is regarded a resource it indicates the efficiency of wage. This KPI, it can be understood what is, the remaining room for improvement or optimisation. It indicates to what extent the transport efficiently used concerning both volume and space of the vehicle as well as the amount of empty kilometres travelled (Mckinnon, 1999). Increasing the vehicle utilisation is often seen as a driver for financial performance. Due to the economies of scale this variable is included in the key performance indicator. However it is not used as a decision criterion, as it is not an objective to increase the transport efficiency in case it does not result in more tangible results such as financial improvement or reduction of emissions to weights. This variable provides a general indication of how well the total capacity of transport is used, it is also referred to as vehicle utilisation (Arvidsson, 2013). It indicates to what extent the transport efficiently used concerning both volume and space of the vehicle as well as the amount of empty kilometres travelled (Mckinnon, 1999).

4.1.5 Operational feasibility

Operational feasibility is based on internal, external and third party operational feasibility. It indicates whether the implementation of a technical change requires a different way of information sharing and physical process elements such as warehouses or cross-dock locations. The starting point of this KPI is the current situation. Although seemingly closely related to institutional fit, this operational feasibility is not allied to the willingness of a shareholder to collaborate. It only concerns if the alternative situation may be operationally easier or more difficult than the current situation. As it is a qualitative parameter it is measured on a Likert scale of 1 to 5, where the current situation is rated 3. The numerical outcome of this is taken into account for the MCDA.

4.1.6 DETERMINATION OF WEIGHTS

Five key performance indicators have been described, namely, transport cost measured in both €/km and €/tonne, emissions in gCO2/tonne-km, lead time measured in hours, transport efficiency, the indicator of vehicle utilisation as well as room for improvement in [%] and operational feasibility in a Likert scale of 1-5. Of these five performance indicator, four are objectives while transport efficiency is not an objective solely. A higher transport efficiency is assumed to have positive effects with regards to costs and emissions, however not directly with the other two KPIs. Therefore a distinction is made between TE and the other indicators as such that it is not a weighted criteria that indicates the preference to reach goals as are the others.

TABLE 1 - OVERVIEW OF KEY PERFORMANCE INDICATORS

Lead Time	Transport Efficiency	Transport Cost	Emission rate	Operational feasibility
[hr]	[% capacity]	[EUR/km] [EUR/tonne]	[gCO2/tonne]	0-5
Quantitative	Quantitative	Quantitative	Quantitative	Qualitative

To be able to identify to what extent a decision maker would perceive an alternative, i.e. a change, an improvement compared with another situation, the decision criteria need to be weighted. The weights for the multi criteria analysis are determined by using the Best Worst Multi-criteria (BWM) method. This method is appropriate for this case as the preference between criteria is based on expert opinion. Pairwise comparisons by expert opinions are likely to show inconsistencies. BWM provides a robust way of diminishing these inconsistencies by using reference comparisons versus secondary comparisons. Detailed results of the determination of weights by means of the BWM method and the results can be found in Appendix J.

4.2 CONCLUSION

A set of five performance indicators have been identified namely: **Transport Efficiency** which indicates the extent to which the transport equipment is optimally used and the possible room for change that is left, **Operational Feasibility** that is a qualitative measure of the information sharing and process change, **Lead Time** to monitor the impact on transport operations, **Emission Rate** providing insight in the environmental sustainability and **Transport Costs,** the indicator for financial performance. All performance indicators except Transport Efficiency are regarded as decision criteria and are weighted using the BWM method. Next to the performance on the hard performance indicators, the innovative alternatives are also tested on soft performance by measuring the discrepancies between the current institutional context and the required institutional context.

5 PHYSICAL SUPPLY CHAIN

Innovation from a supply chain perspective entails re-engineering the transport configuration of the physical supply chain. In this chapter the actual situation of the transport of raw and packaging materials to Danone factories will be described. In Chapter 4, a set of key performance indicators concerning Inbound to Manufacturing transport have been defined. Here, it will be indicated what the relation is of these KPIs with the configuration of transport. Firstly, the a description of the inbound to manufacturing physical chain will be given. Then, the different characteristics of the products and their transport will be described in more detail. These characteristics are categorised on logistics and institutional aspects. The logistics aspects are combined with the quantitative KPIs and formed into a system diagram. The System diagram provides insight in how the configuration of transport influences the key performance indicators.

5.1 PHYSICAL CHAIN

The physical part of the supply chain is as described in the background (Chapter 1.1). The raw and packaging materials that are needed to produce the finished goods of Danone are ordered from many different locations in the world. In this case the scope is Europe. Some goods are stocked or produced at multiple locations, as such they can be sourced from the location the most proximate to the factory. Other ingredients may be more specific products which are produced at few locations, requiring transport over a greater distance.

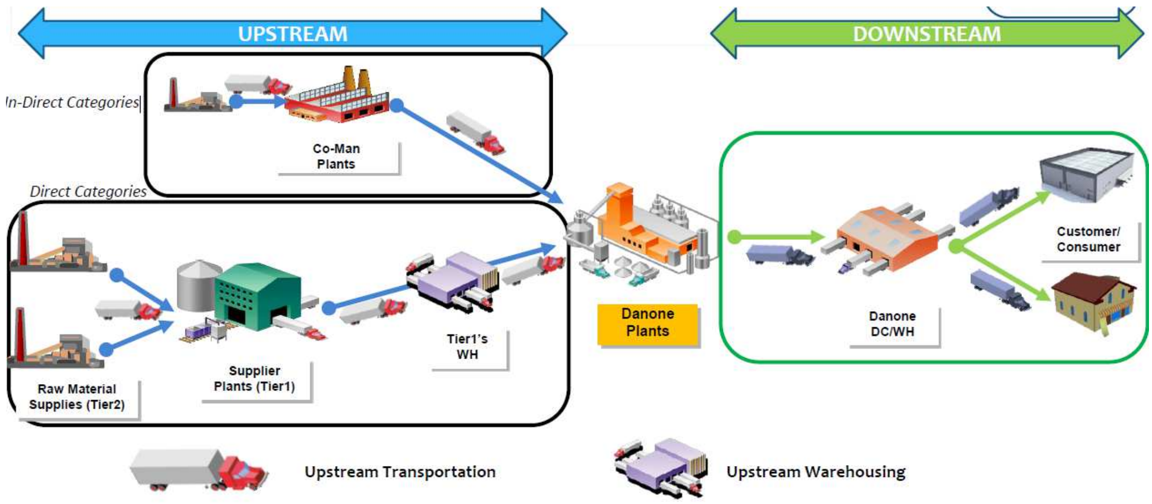

FIGURE 4 - END-TO-END OPERATION OF THE DANONE SUPPLY CHAIN

The R&P are typically transported in ambient trucks such as curtain side trailers or temperature controlled box trailers. The, mainly palletized, product is loaded at the direct material supplier, who inspects the goods and the truck before loading. As soon as the products are loaded, it drives to its destination, the Danone factory. Once arrived at destination the goods are unloaded and the truck leaves. The downstream logistics concern the transport of finished goods from the factories to Danone warehouses or large customer platforms directly and the distribution from the Danone warehouses to customers. The end to end operations concerning DanTrade are visualized in the figure 5 (copyright, I2M project).

5.2 TRANSPORT CHARACTERISTICS

From the general description of the transport in the Danone supply chain, a few characteristic themes can be identified, these are product (transport) characteristics, geographical implications, equipment requirements due to material features, and supply intensity.

Product characteristics

The raw and packaging materials come in different forms and shapes. This is an important feature concerning transport as it defines how much product can be transported at once. In this case, the products are classified by weight and size. In figure 3, examples of these materials are given. The maximum payload is 24 or 22 tonnes for ambient or temperature controlled trucks respectively, while the maximum pallet spaces for EPAL 80*120cm are 30 and 26 respectively. Typically, a product that is shipped with an average pallet weight of more than one metric tonne, cannot fill all pallet spaces. The product is shipped is then limited by weight. In another case, if the product weight is lower than 0.8 tonne, the amount of product shipped will be limited by empty pallet spaces in the truck. The three dimensional space use is not possible to use in this case as there is no data provided the height of pallets.

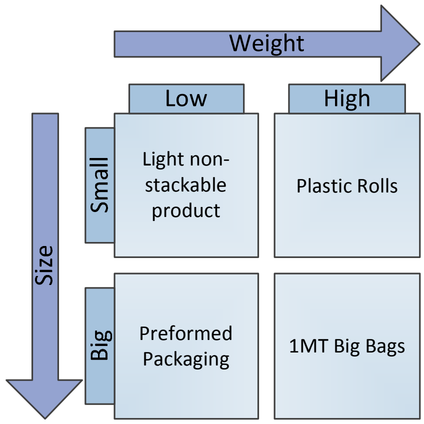

FIGURE 5 - MATERIAL FEATURES

Countries and Distance

Depending on the geographical location of both the DSM and the factory, the transport can either be national or international. Travelling multiple countries may increase the number of obligatory stops, due to border controls. As the scope of this research is Europe, this is not always an issue. However, crossing multiple countries can mean longer travelling distance which will increase the number of obligatory stops. The distance travelled is divided into two, the distance where the truck is carrying a load, the 'filled distance' and the distance where the truck is empty, 'empty distance'. This difference is important as it has an impact on the rate of lading.

Equipment Requirements

An important criteria is the equipment requirement for transport. The product can have ambient or temperature controlled requirement. Temperature controlled transport is either between 4-7 ^{o}C or minus 18 ^{o}C. As described in the scope, the transport under frozen conditions is out of scope for the analysis. The equipment in which the product is transported, has several impacts. It limits the maximum payload and the pallet spaces. Next to this, temperature controlled transport is on average 10% more expensive than ambient transport, as is noticed from the tender procedures.. The cooling installation causes a higher empty weight of the truck and a lower payload therefore the costs and the emissions that the truck entails are divided over a lower number of tonnes of product. From the general description it is derived that the downstream products are always transported in temperature controlled trucks.

Supply Intensity

The Raw and Packaging Materials that are considered in the project belong to many different product categories with different characteristics. The different products also lead to different ordering strategies and possibilities. To classify the R&P, they are analysed on their ordering concerning volume and frequency. R&P of which large quantities are needed or that can be easily stocked, will usually arrive in Full Truck Loads (FTL). Products that can be easily stocked but is not used in large quantities, is also possible to transport by FTL and the demand may be easy to forecast.

Products that are needed in very low quantities and are possible to stock, will often be transported in Lower Than Truck Load (LTL) quantities. This type of product is generally a very specific one such as a highly concentrated substance. Also transported in LTL are products that are used in fair quantities but has a very low shelf life. This product has to be supplied often and cannot be stocked. An overview of the different product categories and transport modes is visualized in Figure 7. The impact of product transported LTL is generally that due to underuse of the capacity, both relative emissions and price rate increase (Ligterink et al., 2012).

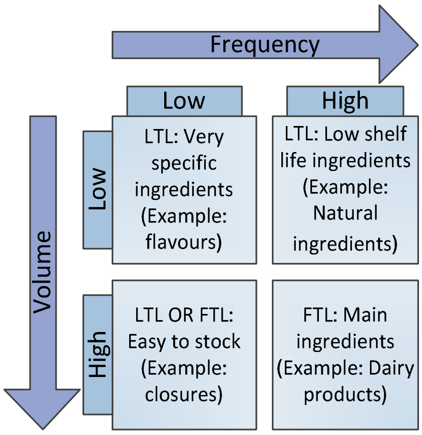

FIGURE 6 - FREQUENCY VERSUS VOLUME OF R&P

5.3 LOAD AND TRUCK LEVEL INPUT

From the physical supply chain and the different characteristic themes descriptions, the transport characteristics are summarized in the overview in table 2. The real information on the transport characteristics can be translated into quantitative information. The quantitative information can be used to calculate the impact on the KPIs.

The Material Features of a product define the average pallet weight. For pallet size the EPAL standard size is always assumed. It also, as described earlier, restricts the amount of product that can be loaded either by size or weight. Loading, unloading and crossing different countries can mean more stops. The distance indicates both the empty kilometres and the filled kilometres to be travelled. The equipment requirements can be either ambient or temperature controlled in this case study and simply indicates the equipment type. However, equipment type also impacts the maximum capacity of a truck as well as it impacts the transport price. The supply intensity indicates the payload, as well as influencing two factors, namely the price and emissions rate. More specific transport requirements like a special equipment or quality requirements, do not concern the basic system diagram however are included in the institutional context in Chapter 6.

TABLE 2 – TRANSPORT CHARACTERISTICS

Transport characteristic	**Options**				**Quantitative model input**
Material features	*Big size – high weight*	*Big size – low weight*	*Small size – high weight*	*Small size – low weight*	Av. Pallet weight. Maximum loading
Countries	*Same loading & unloading*	*Different loading & unloading*	*Multiple loading OR unloading countries*		Amount of stops
Distance	*Short distance < 1 day travelling*		*Long distance > 1 day travelling*		Empty distance Filled distance
Equipment requirements	*Ambient*	*Temperature Controlled*	~~*Frozen*~~		Equipment type Capacity restrictions Equipment price rate
Supply intensity	*High volume - high frequency*	*High volume - low frequency*	*Low volume high frequency*	*Low volume - low frequency*	Payload LTL price rate Emissions rate

The quantitative information can be divided into two types: quantitative input that is derived from an actual situation and directly influenced factors that are defined by the input as well as by factors outside the system. This leads to the following quantitative model input (Table 2 – Transport Characteristics): Average pallet weight, amount of stops, empty and filled distance, equipment type, payload. And the following directly influenced factors: equipment price rate, maximum loading, equipment capacity restrictions, LTL price rate and emissions rate.

The quantitative information is combined with the quantitative performance indicators, which are transport efficiency, lead time, transport cost related to weight, transport cost related to distance and emissions. The performance indicators are described in more detail in Chapter 4.

The quantitative input can be divided over two different levels. First of all, the Load level concerns only the load itself and the Journey level is the organisation of the transport of the product. The Load level in this case is equipment type, payload and average pallet weight . The Journey level is the division of empty and filled kilometres, the stops made and the number of Trucks needed to transport the payloads.

TABLE 3 - LEVELS OF QUANTITATIVE INPUT

Load Level	Journey Level
Equipment Type Payload Average Pallet Weight	Filled and Empty kilometres Amount of stops Trucks Needed

This partition of inputs leads to the following actions. The Load Level is defined by a number of Truck Types, described in the next paragraph, while the Journey Level will be defined by Design Alternatives in Chapter 7. The combination of Truck Types and Design Alternatives will lead to a total set of inputs out of which the impact on the KPIs can be determined.

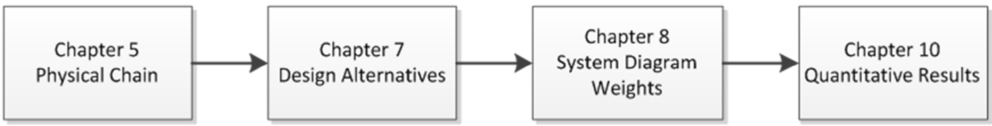

FIGURE 7 - SYSTEMATIC REPRESENTATION OF QUANTITATIVE DEVELOPMENT

5.4 TRUCK TYPES

The Truck Types embody the different levels of input possible on the Load Level. This is necessary to be able to test the future alternatives for transport configuration. Seven Selected Trucks Types are defined which are described here below. The Truck Types lead to a set of Load Level input variables that influence the Key Performance Indicators that are defined in Chapter 4. As the transport efficiency can be increased in two directions, kilometre and payload wise.. Both Full Truck Loads and Lower Than Truck Loads are taken into account. As often in practice a load bigger than 15 tonnes is considered a FTL, this type is not taken into account in the set of Truck Types. A visual representation of the selected Truck Types on a payload scale is given in Figure 8 - Truck Types.

- FTL AMB 24 – Concerns a full truck load of 24 tonnes under ambient conditions
- FTL AMB 22 – Concerns a full truck load of 22 tonnes under ambient conditions. This is chosen so to be able to see the optimal combination of upstream and downstream transport. It is not an actual full truck, however LSP consider a truck of 22 tonnes not a LTL transport.
- LTL AMB 10 – An ambient truck with a load of 10 tonnes and so the possibility to combine with another load. Except for when the it concerns very light material that will take up all the available volume
- LTL AMB 5 – An ambient truck with a small load of 5 tonnes.

- FTL FRIGO 22 – A fully loaded truck under temperature controlled conditions, usually used for transport of downstream finished products.
- LTL FRIGO 10 – A lower than truck load of 10 tonnes under temperature controlled conditions.
- LTL FRIGO 5 – A lower than truck load of 5 tonnes under temperature controlled conditions.

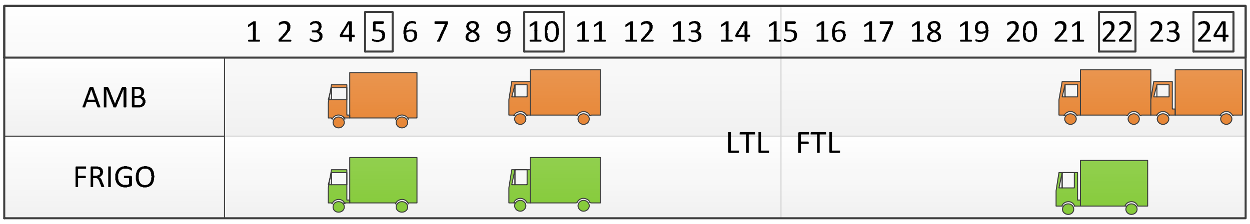

FIGURE 8 - TRUCK TYPES

5.5 CONCLUSION

In this chapter the transport characteristics of the supply chain are transformed into two sets of quantitative input that can be used to calculate the values of the quantitative performance indicators. The quantitative input can be divided on two levels, the Load Level and the Journey level. The inputs of the Load Level are determined by a set of Truck Types while the latter will be determined by alternatives in Chapter 7.

6 INSTITUTIONAL CONTEXT

The physical chain, as described in Chapter 5, is defined by the actions of multiple actors. All actors have different roles in the management of upstream transport and act on different levels and from different organisations. For example, the locations where from and to where transport takes place is decided on a strategic level. As are the types of ingredients needed for which product is sourced and where sourcing takes place. At an operation level, the flows resulting from the strategic level decisions making are managed and optimized. On a tactical level, the organised flows are received and handled on a daily basis. In this chapter the current roles of actors are defined and described as well as the relations between them.

Actor's decisions are steered or defined by the institutions they are subject to. An overview of the institutions on three different levels is given. These three pillars are formal regulative institutions, normative institutions and cognitive institutions. This follows the separation by Geels (2004). In this chapter, the actors that are directly involved in the organisation of transport on an operational and tactical level will be defined. Then a description of the institutional context in which they operate will be provided.

6.1 ACTOR ANALYSIS

The interactions between actors in the current organisation of upstream transport are visualized in figure 8. The actor diagram is divided in multiple parts. The whole has a field Danone for all actors that fall within the Danone organisation. Within Danone there is DanTrade and within DanTrade there is the Direct department which is occupied by the buying and organisation of Direct Goods (Raw and Packaging Material) and the Indirect department where the Logistics Department is based.

The Danone CBU indicates its demand for a material at a certain Direct Material Supplier to the DanTrade Direct Buyer. The DanTrade Direct Buyer negotiates a contract for the total sum of Material needed for multiple CBUs at a supplier. Negotiating for multiple CBUs gives the buyer volume leverage. It also leads to the fact that materials are bought under uniform requirements for all CBUs. The Direct Buyer agrees on an all-in price with the DSM and so includes transport. The DSM is therefore responsible for organising the transport. This is generally outsourced to a Logistic Service Provider. The agreement is based on a volume forecast for a certain period of time, e.g. one year. When the material is actually needed the CBU or factory issues a call-off in the operations system. This call-off is automatically transformed into an order that arrives at the DSM who ships the product as soon as it is ready to the factory by means of the LSP.

The Danone CBU also indicates the anticipated production quantities and where they should be shipped to, to the Global Logistics Team at DanTrade. The transport between the CBU's or to warehouses is organized by DanTrade. The secondary transport, from Warehouses to Customers is partly organized by national CBUs and partly together or by with DanTrade. The Global Logistics Team negotiates the contracts concerning Primary transport with the LSP. The LSPs are generally selected by means of a tender in which all the European Transport lanes are offered at once. Once a LSP has been assigned any lanes, a transport agreement is signed for one year which includes the additional transport requirements. As soon as the LSP is active on the lanes, operational communication is mainly done between the CBU and the LSP directly, while any negotiations or issues will be handled by DanTrade. Reporting on timeliness, operational issues and quality of material is done by both LSP and CBU to DanTrade. A more detailed description of the role of each actor or organisation is given. It should be mentioned that while DanTrade Logistics concerns one team, the Direct Buyer is in reality multiple people. The same accounts for the Raw and Packaging Material supplier and the factories.

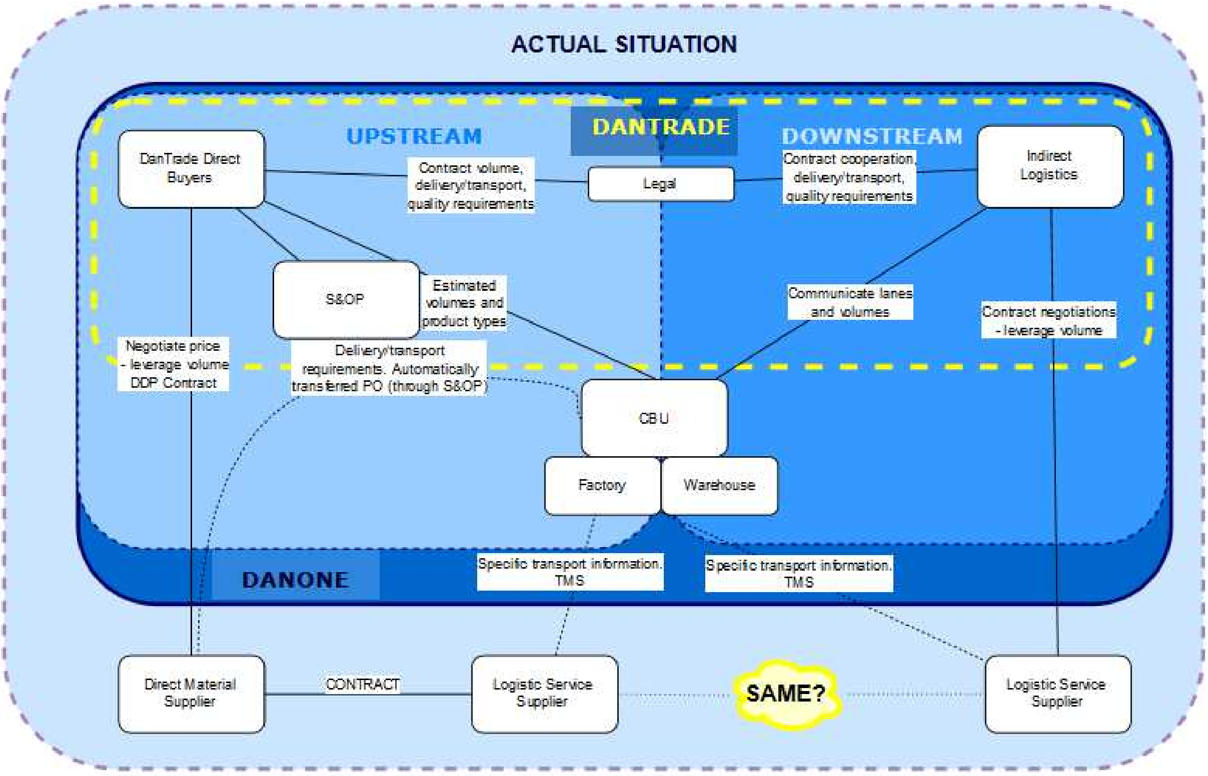

FIGURE 9 - CURRENT INTERACTIONS FOR ORGANISATION OF UP- AND DOWNSTREAM TRANSPORT

6.1.1 DanTrade

As a central sourcing company, DanTrade forms the spider in a web of procurement. Central sourcing is most suitable in companies with a medium to high corporate coherence and purchasing maturity. In case of Central sourcing the communication between local buyer and Central (DT) Buyers should be adept for the procurement to fulfil all requirements (Rozemeijer & van Weele, 2003).

6.1.2 DanTrade Logistics

As mentioned in Chapter 1, the principle goal of the Global Logistics team is to create volume leverage and consequently financial performance through increased negotiation power as well as organising the transport is the most optimal way. As the Logistics team is the negotiating and purchasing party and, more importantly, leading the organisation of transport, they are a key player.

6.1.3 DanTrade Direct buyers

In every category there exist multiple direct material buyers maintaining their specific relationships with the Raw and Packaging Material suppliers. They have as a main objective to negotiate the best possible price for good quality ingredients. They would also like to maintain a good relationship with the Direct Material Supplier and make sure the delivery on time is not jeopardized.

6.1.4 Factory

The Danone factories where the products arrive have a major concern which is the Product Delivery time (PDT). Factories will be highly reluctant to have the PDT increased, as it may directly impact their inventory and production. They have essential information such as quantities needed (send through PO information) and possible truck reception times and other transport relevant information.

6.1.5 OPERATIONS

The operations is an indispensable party in the organisation of the transport. The information flows on product required, order quantity and delivery locations pass through the information system. Also, Operations provides forecasting on product quantities and sourcing.

6.1.6 DIRECT MATERIAL SUPPLIER

The Direct Material Supplier is in this case generalised, however in reality concerns suppliers of many different product types, which have different company sizes and market power. The relation between buyer and supplier may be very different from one to another (Rezaei & Ortt, 2013b).

6.1.7 LOGISTICS SERVICE SUPPLIER

This actor also concerns multiple companies; the Logistic Service Providers will generally be positive to any additional business opportunities (Choy et al., 2008).

6.2 INSTITUTIONAL CONTEXT

The description of the institutional context is based on three pillars, the formal/regulative, the normative and cognitive part. In this overview a description is given of the institutions that impact the actions and decisions of the involved actors.

6.2.1 FORMAL/REGULATIVE

The formal/regulative pillar defines the rules that are either stated by law or by contract and organisation. As not handling according to these rules has direct and formal sanctions, their effects are straightforward. The most apparent and directly impacting rules are listed in table 4.

TABLE 4 - FORMAL AND REGULATIVE RULES OR INSTITUTIONS

Formal/regulative		
Rules/Institutions	**What does it entail**	**Which actors are impacted?**
INCOTERMS	The International Commercial Terms	All (Mostly: DMS, DT Direct buyer)
Transport Agreement	Corporate contract	LSP, DT Logistics
Direct Goods Buying Contract	Corporate contract	DMS, DT Direct Buyer
Driving Restrictions	EU Law	LSP
Food Quality Standards	Minimum requirements	All
Corporate Responsibility Program (Campbell)	In this scope: Reduction of emissions	All
Incentive structures	Organisational impact of financial performance	Danone, DanTrade

Overview of incoterms

Current inbound Raw & Packaging material are bought based on a DDP all-in price. ExWorks is another often used Incoterm for road transport. The official descriptions of what DDP and ExWorks entails can be found below. The incoterms define who is responsible for the transport.

In case of DDP it is the suppliers responsibility that the transport is organised according to the agreed requirements. In case of an ExWorks agreement the buyer is responsible for loading and transport of the ingredients. Generally changing to ExWorks leads to increased Risk in buying a product and the organisation of the Transport (Ioan, Gabriela, & Mihai, 2013).

Delivered Duty Paid

"Delivered Duty Paid" (DDP) means that the seller delivers the goods when the goods are placed at the disposal of the buyer, cleared for import on the arriving means of transport ready for unloading at the named place of destination. The seller bears all the costs and risks involved in bringing the goods to the place of destination and has an obligation to clear the goods not only for export but also for import, to pay any duty for both export and import and to carry out all customs formalities."

The International Chamber of Commerce – The Incoterms® rules
Retrieved from: http://www.iccwbo.org/products-and-services/trade-facilitation/incoterms-2010/the-incoterms-rules/

EXW

"Ex Works" (EXW) means that the seller delivers when it places the goods at the disposal of the buyer at the seller's premises or at another named place (i.e., works, factory, warehouse, etc.). The seller does not need to load the goods on any collecting vehicle, nor does it need to clear the goods for export, where such clearance is applicable."

The International Chamber of Commerce – The Incoterms® rules
Retrieved from: http://www.iccwbo.org/products-and-services/trade-facilitation/incoterms-2010/the-incoterms-rules/

Other incoterms exist as can be consulted in the official statement of incoterms and on every LSPs website. As many concern different modes or intermodal transport, they are not applicable to the European case of Inbound to Manufacturing transport.

Driving restrictions

Consists of both driving hour restrictions as well as restrictions on the maximum number of stops. Both limitations' official description can be found in the boxes below. These laws are important to consider in the case of transport organisation as it limits the possibilities for the organisation of transport.

CABOTAGE

Cabotage, meaning the national carriage of goods for hire or reward carried out by non-resident hauliers on a temporary basis in a host Member State, is governed by Regulation (EC) 1072/2009 as of 14 May 2010. This regulation replaced Regulations (EEC) No 881/92 and (EEC) No 3118/93, as well as Directive 2006/94/EC. The aim of the new Regulations is to improve the efficiency of road freight transport by reducing empty trips after the unloading of international transport operations.

Article 8 of the Regulation provides that every haulier is entitled to perform up to three cabotage operations within a seven day period starting the day after the unloading of the international transport.

A haulier may decide to carry out one, two or all three cabotage operations in different Member States and not necessarily the Member State in which the international transport was delivered. In this case only one cabotage operation is allowed in a given Member State to be carried out within three days of entering that Member State without cargo.

Regulation (EC) No 1072/2009 of the European Parliament and of the Council of 21 October 2009 on common rules for access to the international road haulage market (Articles 8 and 9 only)

DRIVING RESTRICTIONS

Daily driving period shall not exceed 9 hours, with an exemption of twice a week when it can be extended to 10 hours. Total weekly driving time may not exceed 56 hours and the total fortnightly driving time may not exceed 90 hours. Daily rest period shall be at least 11 hours, with an exception of going down to 9 hours maximum three times a week. Daily rest can be split into 3 hours rest followed by 9 hour rest to make a total of 12 hours daily rest. Weekly rest is 45 continuous hours, which can be reduced every second week to 24 hours. Compensation arrangements apply for reduced weekly rest period. Weekly rest is to be taken after six days of working, except for coach drivers engaged in a single occasional service of international transport of passengers who may postpone their weekly rest period after 12 days in order to facilitate coach holidays. Breaks of at least 45 minutes (separable into 15 minutes followed by 30 minutes) should be taken after 4 ½ hours at the latest.

Regulation (EC) No 561/2006 of the European Parliament and of the Council of 15 March 2006 on the harmonisation of certain social legislation relating to road transport and amending Council Regulations (EEC) No 3821/85 and (EC) No 2135/98 and repealing Council Regulation (EEC) No 3820/85

Food Quality Requirements

The upstream transport to Danone factories contains packaging material and various types of ingredients. Most of the product is transported with the requirement 'food grade'. As these products are manufactured into products for consumption, liability is important. Transport is regarded as an underexposed link in the supply chain regarding food Quality and Safety. Often trucks are inspected visually and tested on humidity and temperature before loading. (Fearne et al., n.d.; Ryan, 2014) Danone and especially DanTrade focusses on responsible sourcing. All suppliers have to comply with the high industry standards, company requirements and high industry standards. This is not only apply to DSM, it is also the case for Logistic Service Providers.

Corporate Social Responsibility

Corporate Social Responsibility can be considered a regulative institution as it provides a framework within which the organisation should operate. It dictates requirements, has a control measury through auditing suppliers and is regulated by sanctions if there is no compliance with the set requirements (Campbell, 2007).

Incentive Structures

A typical performance driver are incentive structures in corporate strategy. One is more eager to drive for financial performance when there is a clear reward. This is highly applicable to 'new' projects or collaborations as it concerns a task which was initially not part of the work (Eriksson, 2015).

6.2.2 NORMATIVE

Normative institutions typically concern responsibilities, duties, expectations, norms and shared values (Geels, 2004). It can also concern processes, in case they are not legally structured. In table 5, an overview of the normative institutions considered is provided.

TABLE 5 – NORMATIVE INSTITUTIONS

Normative		
Rules/Institutions	**What does it entail**	**Who does it impact?**
Ordering Process of Direct Materials	The procurement of Direct Material, ordering at DMS	DT Direct Buyer, DSM, CBU, Operations
Tendering procedure of lanes	Allocation of lanes to LSP and drawing up the Transport Agreement	DT Logistics, LSP, CBU
Authority structures	If people feel they have to cooperate with initiatives i.e. new projects.	All

The ordering process of direct materials concerns the steps that are followed from demand for a product at the CBU to the actual shipping at the supplier. This is an institution as it based on responsibilities of information sharing, tasks in taking certain decisions and expectations of a certain course of actions. The tendering procedure of lanes is considered an institution for similar reasons.

6.2.3 COGNITIVE

Cognitive institutions are more abstract and concern beliefs, agendas and priorities of actors. These may be individual, however can be impacted by the general institutions that are listed in table 6.

TABLE 6 - COGNITIVE INSTITUTIONS

Cognitive		
Rules/Institutions	**What does it entail**	**Who does it impact?**
Attitude to innovations	Environment open to innovations	All
Buyer/supplier relation	Highly diverse, some more traditional some more cooperative.	All
National differences	Scope is Europe, different nationalities may have different attitudes	All

Attitude to innovation may influence actors' belief on if there are possible gains that may benefit him in a new project (Damanpour & Evan, 1984). The attitude to project may be related with differences in nationalities and the relation between a buyer and supplier may influence the decisions they take. (Cadden, Marshall, & Cao, 2013). The cognitive institutions are harder to define and also more difficult to assign as a cause for an actor's actions to a specific institution. Also, the specific effect of cognitive institutions may differ per actor as they coincide with specific actor characteristics, such as personality. Nevertheless, they form an important context in which actors take decisions (Geels, 2004).

6.3 CONCLUSION

There are several internal and external actors active in the transport of R&P to Danone factories. The organisation of downstream transport is also taken into account. The actors take their decisions based on their institutional environment. Actions are influenced by (among other institutions) laws on driving, standards for food product quality. The contracts are based on the international commercial terms. Also non regulative institutions play a role in this context. Important normative institutions are the processes of ordering direct materials by CBUs at DSMs as well as the allocation of downstream lanes to LSPs. Lastly, there are also cognitive institutions which may influence the decisions and actions of actors, such as their national context, or attitude to innovations and new projects.

PART 3 SYSTEM

7 DESIGN ALTERNATIVES AND RATIONALE

The term 'innovative alternatives' may seem tautological but does not have to be. The definition of alternative is "something that can be chosen instead of something else : a choice or option", while innovative means "having new ideas about **how** something can be done" (Merriam-Webster.com, 2015). The alternative may not be new, however the method of implementation can be. It is also possible that the idea is new in its context or in the eyes of the stakeholder, as is the definition from Schumpeter. This, then, can also be considered an innovation (Flint et al., 2005).

The many opportunities for innovation of the Inbound to Manufacturing Transport that exist are in this chapter delimited by the conclusions drawn from Part 1. Subsequently, a Design Space is formed that results in a set of Design Alternatives to use for analysis of institutional fit and for implementation on Selected Truck Types as described in Chapter 5.

7.1 THE ORIGIN OF THE DESIGN SPACE

From the Chapter 5, Physical Supply Chain, it is concluded that there are several inputs that can be influenced to change the values of the KPIs. Also, it is indicated whether influencing is possible for DanTrade Logistics. The inputs are the number of stops, the empty kilometres, the filled kilometres, the payload, the average pallet weight and the number of trucks.

- *The number of stops:* The number of stops can be increased by stopping at various suppliers. As it is currently at a minimum value of 2 stops (loading and unloading) decreasing it is impossible.
- *The filled distance:* The filled kilometres can be changed by changing the location of the supplier or that of the factory, however this is a strategic level sourcing decision and not in DanTrade area of impact. It can also be changed by driving a different, longer or shorter, route between the two points.
- *The empty distance:* The empty distance can be reduced by filling the backload of the filled distance with another load.
- *The payload:* This can be changed by increasing the order quantity, by for example ordering more at the same time, or by combining multiple loads in one truck at the same time. As the former is not in DT Logistics scope, it is not further considered.
- *The average pallet weight:* Can be increased by different packaging, stacking or by any means of shipping differently. Or can be increased by either combining a payload with a low average pallet weight with one with high average pallet weight.
- *The number of trucks:* This can be changed by combining multiple trucks into one truck, or reducing the number of goods that need to be transported. As the latter is not in the possibility of DanTrade Logistics, this is not concerned.

From the ways of influencing, it can be concluded that there are two main ways of influencing the inputs and ,with that, KPIs. These are: organising a backload and combining multiple loads to fill a truck, which are two ways of combining different loads and suppliers in one truck. The combination of the transport of raw materials from two suppliers who do not necessarily ship the same type of products, means that the combined payload may not exceed the maximum payload of the truck. The organisation of a backload may mean that the same truck will transport finished goods as well as raw materials.

7.2 THE DESIGN SPACE

The Parameters for change which are derived from this are the following: Supplier Combining, Backload organising, Loading, Stopping. The parameters are assigned with different options which are indicated between brackets. Together this results in the Design Space which is visualized in Table 7 - Design Space for Alternatives. The parameter **Supplier combining** has three options. A single supplier (1) can be shipped by one truck, this is the current situation. Multiple suppliers that are shipped in one truck either consecutively (2) or simultaneously (3). The second parameter, the **organisation of a backload** (three options) can either be absent (1), either a downstream (2) or an upstream (3) backload can be organised. For **Loading**, the loading of goods at a supplier (1) or at a hub (2) is considered. The last parameter is **stopping**, and indicates how many stops after the first loading are done. In the basic situation that is considered, so one without any additional actions, this is a single stop (1), however multiple stops (2) could be made as well.

TABLE 7 - DESIGN SPACE FOR ALTERNATIVES

Parameter	Description	Size	Options		
Supplier combining	*If there will be multiple suppliers combined using one truck, not necessarily at the same time*	3	Single supplier	Multiple Suppliers - combined consecutively	Multiple Suppliers - combined simultaneously
Backload organising	*Concerning the filling of the truck at or close to the delivery location.*	3	No backload	Downstream backload	Upstream backload
Loading	*The location where the goods are loaded*	2	Load at supplier	Load at Hub	
Stopping	*In case a backload is included this option will always be multiple stops.*	2	Single	Multiple	
* A supplier is considered a single supply point of goods. Big companies can have multiple supply points. If Company A has two factories, x and y. Company Ax and Company Ay are considered different suppliers. ** This can be a Danone or supplier warehouse/a cross-dock/non-existing location					

From the Design Space, 36 alternatives can be formed by choosing one of the options for every parameter. Several options are incompatible with one another, for example: in case multiple suppliers are to be combined simultaneously and should be loaded at the supplier, it is impossible to have only a single stop after the first loading. A full list of the alternatives and the incompatibilities can be found in Appendix D. A set of feasible Design Alternatives has been selected, which will be described in the next paragraph.

7.3 DESIGN ALTERNATIVES

The Design Alternatives are the feasible alternatives that are derived from the Design Space. In this paragraph they are visualised and described by two means. A selection is highlighted in the Design Space and a schematic representation is provided. The schematic representation is based on a basic format, detached from geographical location, as visualised in **Error! Reference source not found.**. As the research concerns Inbound to Manufacturing Transport, the lines between the DMS and Danone Factory (DF) are considered. However, as there is also an option for a downstream backload the Danone Warehouse (DWH) and Customers (C) are also represented here below. As well as is the DMS warehouse as it may serve as a hub, like it is described in the Design Space.

7.3.1 Alternative 0 – The Current Situation

In the Design space in Table 8, only the options in the first column are highlighted. The current situation provides the base case for the physical chain. The schematic representation (Figure 10) shows that the base case also includes various variations. For example some products arrive from a DMS warehouse, while other arrive directly from the DMS' factory's production lines. Also, the downstream transport is sometimes executed from the factory to a customer directly, this can be the case when it concerns large customer platforms. However, most product passes a warehouse before distribution to customers.

Table 8 - Design Space - current situation

Parameter	Options		
Supplier combining	Single	Multi - not simultaneously	Multi - simultaneously
Backload organising	None	Downstream	Upstream
Loading	At supplier	At Hub	
Stopping	Single	Multiple	

In the schematic representation, a filled arrowhead means that the truck is carrying a load, no matter of which payload, an empty arrowhead means the truck is empty. In case both arrowheads are attached to one line, it means that the truck goes back and forth. A single arrowhead on a line means it is a one-way journey. No arrowhead at all, means it is not considered in the organisation i.e. it is not comprised by the project or design alternative. The schematic representation of the other Design Alternatives is that of the minimum amount of lanes that is needed.

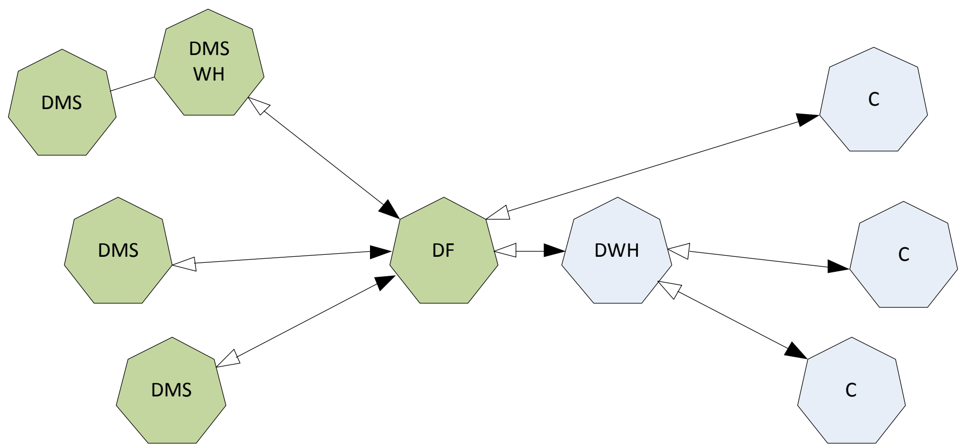

Figure 10 - Schematic representation of the current situation

7.3.2 Design Alternative 1 – An Upstream Backload

This Design Alternative is an example of the optimization of the empty kilometres. The truck loads R&P at the DMS and delivers it at the required Danone factory. Next, the truck travels to another DMS to load and returns to the other region where another DF is located.

Table 9 - Design Space - DA1 - upstream backload

Parameter	Options		
Supplier combining	Single	Multi - not simultaneously	Multi - simultaneously
Backload organising	None	Downstream	Upstream
Loading	At supplier	At Hub	

Stopping	Single	Multiple	

A schematic representation is given in Figure 11, and the selection of the design space can be found in Table 9 - Design Space - DA1 - upstream backload. It can be seen that the empty arrowheads are replaced. This alternative only leads to advantages if there is a certain geographical proximity of the locations between which the trucks travels empty. If the empty distances from DFs to DMS are equal or greater than the filled distance, there is no reduction in empty kilometres.

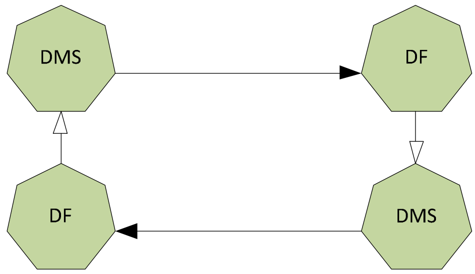

FIGURE 11 - SCHEMATIC REPRESENTATION OF DA 1

7.3.3 DESIGN ALTERNATIVE 2 – A DOWNSTREAM BACKLOAD

Design Alternative 2 is similar to the first alternative and also aims at reducing the empty kilometres. In this alternative the backload is filled with a downstream load of finished products.

TABLE 10 - DESIGN SPACE - DA 2 – DOWNSTREAM BACKLOAD

Parameter	Options		
Supplier combining	Single	Multi - not simultaneously	Multi - simultaneously
Backload organising	None	Downstream	Upstream
Loading	At supplier	At Hub	
Stopping	Single	Multiple	

An advantage here concerning empty kilometres is that the unloading location for R&P products is the same as the loading of finished products. Therefore, to reduce the empty kilometres, the distance between the downstream unloading location (DWH/C) and the DMS should be smaller than the sum of the two filled lanes (from DMS to DF and from DF to DWH/C). Only a single supplier is involved in this case as the downstream product are Danone's and are not considered a supplier.

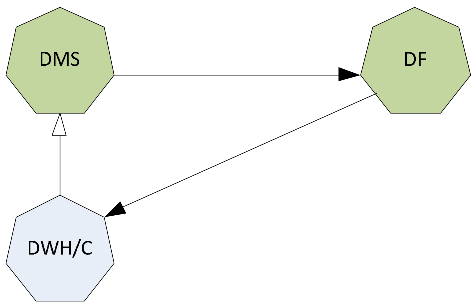

FIGURE 12 - SCHEMATIC REPRESENTATION OF DA 2

7.3.4 DESIGN ALTERNATIVE 3A – MILK-RUN

This Design Alternative is aimed at filling the truck on a single leg. The combination of this set of options for the parameters to a Design Alternative that is also known as the Milk-Run. A known phenomenon in logistics optimisation, as described in the literature review in Chapter 2. It occurs (among others) in Arvidsson (2013), Du et al. (2007), Hosseini et al. (2014) and Shi et al. (2014).

TABLE 11 - DESIGN SPACE - DA 3A - MILK RUN

Parameter	Options		
Supplier combining	Single	Multi - not simultaneously	Multi - simultaneously
Backload organising	None	Downstream	Upstream
Loading	At supplier	At Hub	
Stopping	Single	Multiple	

DA 3a entails the combining of multiple loads in a truck simultaneously. This combining is done by stopping at different suppliers sequentially. The number of loads/DMS that are combined is not necessarily two, although it may be assumed that this is the most frequent option, due to geographic proximity, coordination possibilities and payload, i.e. it not necessarily likely that three or more supplier are logically combinable on a route while all supplying in low quantities at the same moment. Additionally that these quantities are combinable in terms of quality and transport requirements.

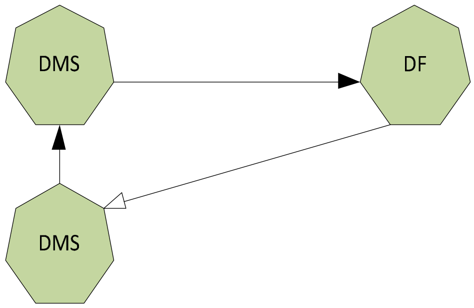

FIGURE 13 - SCHEMATIC REPRESENTATION OF DA 3A

7.3.5 DESIGN ALTERNATIVE 3B – GROUPAGE

This Design Alternative is a variation on Design Alternative 3a – Milk Run. By requesting a DMS to supply to an indicated hub, R&P can be gathered to fill a truck more than when the respective loads would have been shipped separately (Creazza, Dallari, & Melacini, 2010; Mckinnon, 1999).

TABLE 12 - DESIGN SPACE - DA 3B - GROUPAGE

Parameter	Options		
Supplier combining	Single	Multi - not simultaneously	Multi - simultaneously
Backload organising	None	Downstream	Upstream
Loading	At supplier	At Hub	
Stopping	Single	Multiple	

Compared with DA 3a, it only has to make one stop after having loaded at the hub location, namely unloading at the factory. The hub location can be a Danone Warehouse which is (also) used for the downstream transport of finished goods. It can also be a supplier warehouse in which they (sub)let space to third parties (in this case competitors) or customers (Danone for them). It could also be an existing or to be build warehouse or cross-dock by a LSP that could be used. In conclusions, the choice is not necessarily limited to Danone Warehouses.

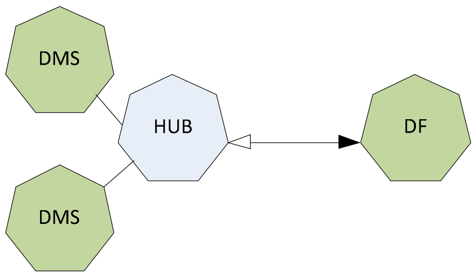

FIGURE 14 - SCHEMATIC REPRESENTATION OF DA 3B

7.4 DESIGN ALTERNATIVES – CROSS-COMBINATIONS

From the Design Space it can be concluded, that alternatives arise when multiple options are selected for one parameter. For the Design Alternatives considered in this paragraph, a double selection is made for the first parameter (supplier combining). Double selections for the other parameters are not considered as for those, the one options excludes the other in we only consider 'two legged transport', i.e. which is directly based on the current situation. Contrarily to Design Alternatives 1 to 3b, these Design Alternatives are optimised on both legs rather than one leg. It is possible to change the return leg of the one alternative for that of the other one. More details on these alternatives can be found in Appendix D. The resulting Design Alternatives are described below.

7.4.1 Design Alternative 4 – Extended Milk-Run

The Extended Milk-Run can be interpreted as a combination of Design Alternative 1 and 3a. In this alternative, more suppliers are combined. In theory, the number of loads combined at different supply points could be increased as long as the payloads are small enough and they have a certain proximity.

Table 13 - Design Space - DA 4 - Extended Milk-Run

Parameter	Options		
Supplier combining	Single	Multi - not simultaneously	Multi - simultaneously
Backload organising	None	Downstream	Upstream
Loading	At supplier	At Hub	
Stopping	Single	Multiple	

However, the higher the number of stops, the higher the amount of coordination moments. In order to minimize the lead time of the product that is loaded first, the amount of stops should also be minimized. Another difficulty concerning the increased length may be due to driving time restrictions. As it is required that products that are transported together in one truck have the same transport requirements i.e. can be transported under the same circumstances. It may prove difficult to find a sufficient amount of DMS of a sufficient geographical proximity.

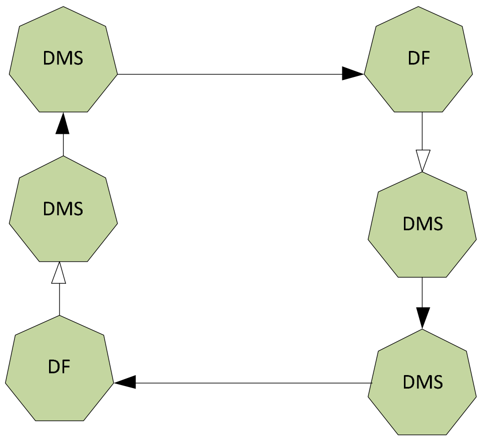

Figure 15 - Schematic representation of DA 4

7.4.2 Design Alternative 5 – Hub Shuttle

'Hub Shuttle' is the name assigned to the Design Alternative that has a truck loading and unloading at the same Danone warehouse. The products are gathered at the Warehouse like they are in Design Alternative 3b – Groupage, then the backload is organised as in Design Alternative 2 – Downstream Backload

Table 14 - Design Space - DA 5 - Hub Shuttle

Parameter	Options		
Supplier combining	Single	Multi - not simultaneously	Multi - simultaneously
Backload organising	None	Downstream	Upstream
Loading	At supplier	At Hub	
Stopping	Single	Multiple	

.

As such, it can be considered there is a shuttle service between the Warehouse and the factory. This shuttle service may provide a flexible way of combining loads as it concerns fixed loading and unloading points. The fixed points facilitate the searching of suppliers and reduce the need for very precise timing and coordination as products may be stored at the warehouse for a short while.

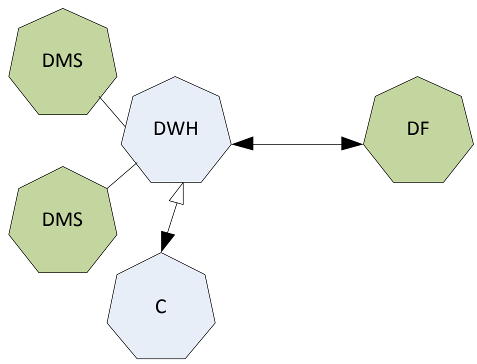

Figure 16 - Schematic Representation of DA5

7.5 APPLICABILITY ON TRUCK TYPES

It can be recognised from the descriptions of the Design Alternatives that not any Design Alternative is applicable to any Selected Truck Type. The Design Alternatives that focus on organising a backload (Design Alternative 1 and 2) can be applied to any type of Truck Type, however, the downstream backload can only be a temperature controlled truck with a (Full Truck) load of 22 tonnes. While the combining of loads simultaneously (Design Alternative 3a and 3b) are possible on Truck Loads with a size that leaves room for another load, typically Lower Than Full Truck Loads (LTL). A full overview of the possible combinations is given in Appendix D. From the Design Alternatives 1 and 2 are relevant to all types of scenarios FTL & LTL. Design Alternatives 3a, 3b, 4 and 5 are only relevant for LTL. Design Alternatives 2 and 5 are not relevant for goods with a payload higher than 22 tonnes or 26 pallets.

7.6 CONCLUSION DESIGN ALTERNATIVES

To use the ways DanTrade logistics can use from a supply chain perspective to influence the improvement of inbound to manufacturing transport, several Design Alternatives are constructed. The Design Alternatives influence, through implementation on Truck Types, the inputs of the System Diagram which eventually impacts the key performance indicators.

Design Alternatives 1 – 3b are basic Design Alternatives of which the impact on the KPIs will be quantitatively analysed and their institutional fit qualitatively determined. Naturally, endless other more detailed and complicated combinations could be made. However, as they require more coordination due to more locations and parties, they are not considered in the first analysis.

8 QUANTITATIVE ANALYSIS OF DESIGN ALTERNATIVES

In order to determine how the identified Key Performance Indicators can be impacted by the different Design Alternatives, it is necessary to find out how they are calculated. This chapter is constructed as follows: First of all, it is described what influences the KPIs and how they change. Reform this into formulas. Merge into system diagram, give an overview of all variables.

8.1 QUANTITATIVE KPIS

There are four quantitative KPIs identified. Transport costs, transport efficiency, emissions and lead time. Operational Feasibility is a qualitative KPI and is further described in Chapter 9. Here below they will be further described as well as and quantified.

8.1.1 TRANSPORT COSTS

Transport cost in this case is identified as the cost from door to door. It is calculated in both €/tonne as €/km to clarify the effects. LSP generally base their tariff on 1€/km concerning a FTL To calculate the cost reduction, this general transport price of 1€/km is taken into account. The general transport price is multiplied by the LTL factor as visualised in graph below This empirical factor comes from a large amount of tender data and is based on the quotations from more than 50 LSPs on more than 500 lanes.

The LTL factor depends on the Payload of the truck. However it does not take into account the return load. Any differences due to geography or country are also not taken into account. For a precise estimation of the transport cost, these are necessary factors to take into account. However as the calculated reduction will be presented as a reduction of the base price, this will show the impact. As the geographical factor is not changed by any of the design options, it will not change the percentage reduction in comparison with the base price. As the quotations in the tender are based on all-inclusive prices, the fuel costs are also included. In case the transport becomes more efficient, it's fuel use will be reduced. As fuel costs generally make up around 20% of the transport cost, there may be an supplementary indirect reduction of the total cost.

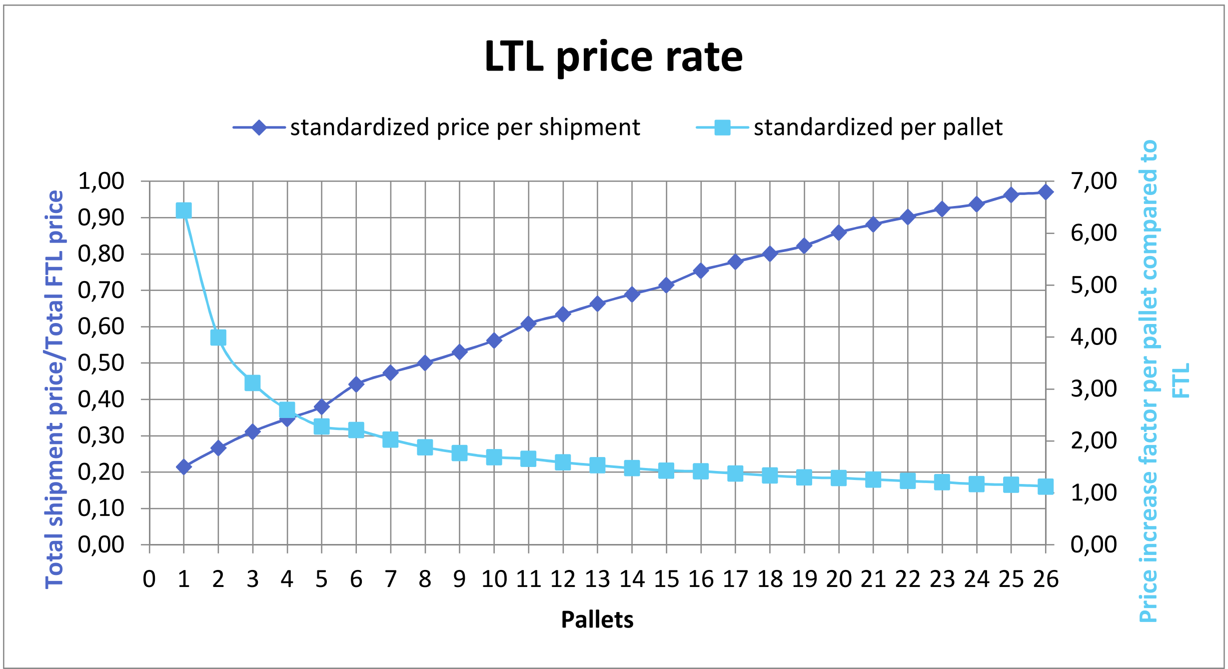

FIGURE 17 - INCREASED PRICE FOR LOWER THAN TRUCK LOAD TRANSPORT

It is important to note that the initial data is named in pallets. The pallets and their weight are related however both limit the maximum payload, c/q to what extent the truck has been filled to its capacity. Considering a maximum capacity of 24 tonnes or 30 EPAL pallets which have an advised maximum loading of 1tonne. Therefore it is not possible to load 30 pallets of 1 tonne in a truck. Hence the graph below which illustrates that the Max Payload is limited by space (number of pallets), average pallet weight and the combination of these two.

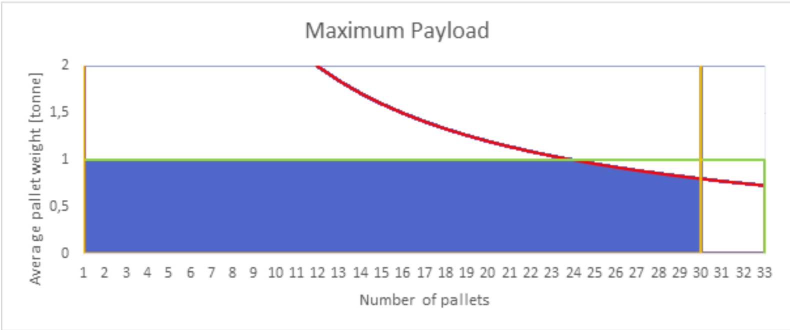

FIGURE 18 - MAXIMIZED PAYLOAD BY VOLUME AND SIZE

8.1.2 TRANSPORT EFFICIENCY

Both the reduction in empty kilometres or the increase in fill rate of a truck, indicate the efficiency of transport, however often indicate different legs of the route. The transport efficiency KPI takes both the measurement into account. The transport efficiency is a ratio of the vehicle kilometres and to what extent they are filled. For example a truck that drives a 1000 KM, is filled for half of these kilometres with 10 tonnes of goods while it has a capacity of 24 tonnes. Its values will be 1000 veh-km of which 50% empty and it will drive 5000 tonne-kms, while on the filled leg this could have been 12000 a fill rate of 42%. By dividing the total veh-km by the tonne-km and multiplying these with the maximum payload of this route, the result indicates the transport efficiency, for which 1 (or 100%) is the optimal value. A visualisation of the transport efficiency can be found in Figure 2.

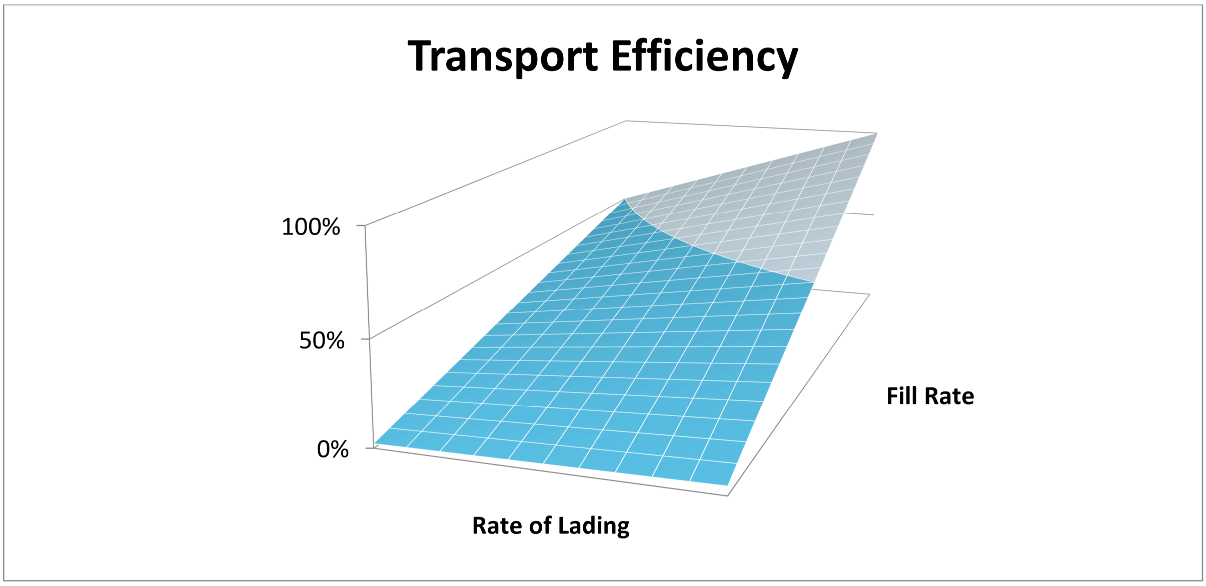

FIGURE 19 - TRANSPORT EFFICIENCY

8.1.3 EMISSION REDUCTION

Emission reduction highly depends on the efficiency of the fuel use of the vehicle. Both empty kilometres and reduced payload influence this efficiency. A lighter truck uses less fuel. However 1 truck transporting 20 tonnes of goods weights 40 tonnes including its own weight. Although a truck with 10 tonnes will emit less than a truck transporting 20 tonnes. Two trucks transporting 10 tonnes and together weighing 2*30 = 60 tonnes, will emit more than the single truck. Concerning the payload, the maximum payload is different for ambient trucks and temperature controlled.

According to CEFIC the standard CO2 emissions for road freight is 62 gCO2/tonne-km based on heavy truck with 25% empty backhaul and 80% Payload. An emission factor can be used to correct this emission for different lading and fill rates. The evaluation of emissions per tonne-km depended on lading and fill rate is visualised in the graph below (Cefic & ECTA, 2011). As the temperature controlled truck's own weight is generally 2 tonnes bigger than that of a ambient truck, the emission factor should be corrected for temperature controlled transport.

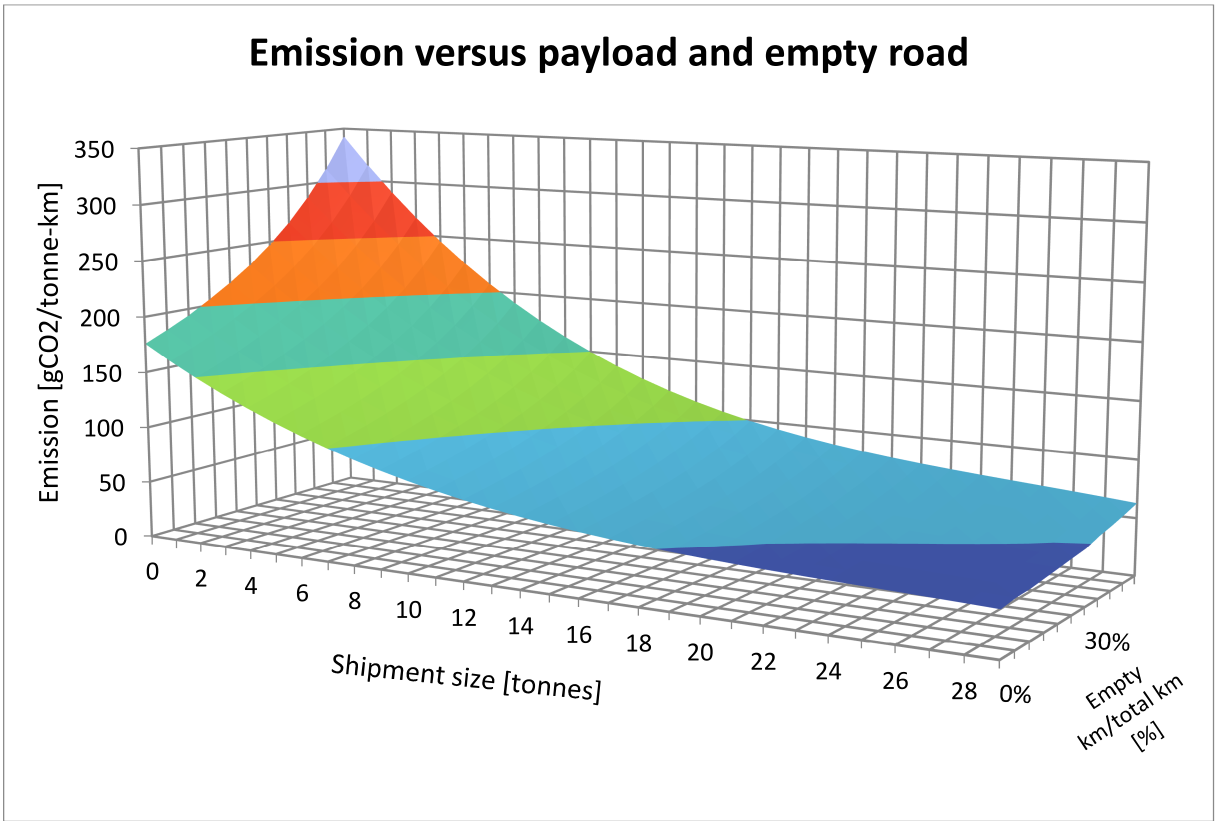

FIGURE 20 - EMISSIONS VERSUS PAYLOAD AND EMPTY KILOMETRES

The equipment, payload and the lading rate are not the only factors that will impact the fuel use of a truck. The assumption on how fuel consumption is effected is highly simplified as other factors may have major effect. Factors that have major influences are *technical improvements*, a truck that was building 2014 is generally more efficient than one build in 1996. The way of driving, this may be impacted by *behaviour of the driver* as well as caused by the *road quality* and *geography* (e.g. road inclines and declines), *speed* which can depend on *congestion* as well as maximum *speed limits*. Even *meteorological effects* may be considered such as the effects of strong winds or slippery roads. (Demir et al., 2014; Léonardi & Baumgartner, 2004; Ligterink et al., 2012)

Even though the effects of the above named factors may have an impact on the fuel efficiency, it is both complex and arbitrary to microscopically simulate the exact emission per truck. Most of the factors above are caused by external events and are difficult to forecast. Moreover, as the research is not conducted on a specific route or uniform geographical area, no assumptions can be made.

8.1.4 LEAD TIME

The lead time is calculated regarding by two variables the driving time and the (un)loading time. The driving time is calculated by dividing the total filled kilometres by 65 km/h. This should be considered per delivery point. The empty kilometres are not taken into account in the driving time. The (un)loading time is considered 1,5 hours. In line with the Danone transport specifications, a slot for loading or unloading is one hour. The free waiting time is 30 minutes., this is the time the truck may be delayed without any consequences or charges. If the truck arrives more than 30 minutes late, it should rebook its slot, which in case of multiple stopping points may duplicate the issue to the next stopping points. As the lead time is an important indicator of service level, in case of a DDP organisation with multiple stopping points the LSP / DSM and Danone should make clear commitments on this.

8.1.5 SYSTEM DIAGRAM

When all KPIs and the variables that influence them are considered in one system diagram, it results in the image below. In appendix C, the system diagram such as in Figure 21 is visualised per KPI and with described formulas and variables. Here below it can be seen that the truck options R1 to Rn will define the values of the input variables who will impact the KPIs.

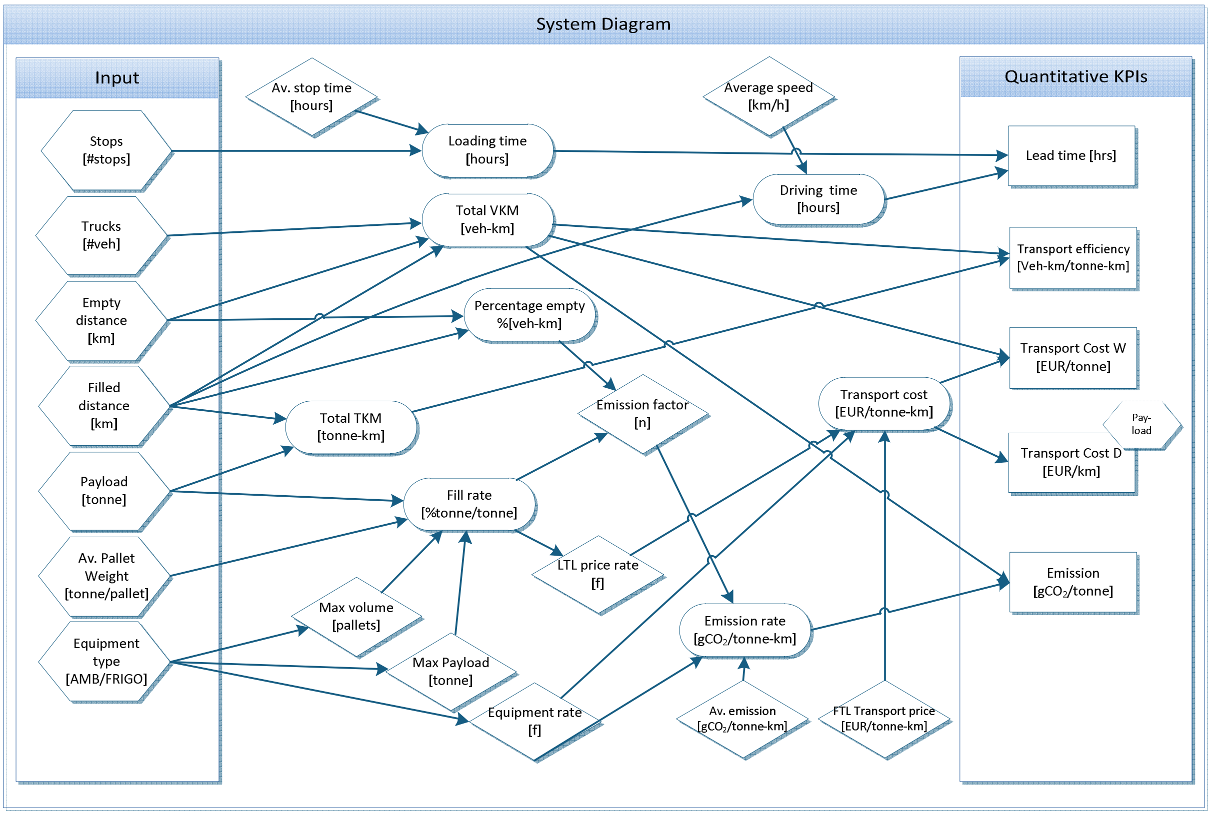

FIGURE 21 - SYSTEM DIAGRAM

8.2 VARIABLES USED IN THE CALCULATION MODEL

In this paragraph an overview of the variables can be found.

INPUT VARIABLES			
These values are impacted by the choice of design options and scenarios.			
ID	Name	UOM	Type
n_{stops}	Extra stops	[stops]	The additional stops besides initial loading and unloading.
n_{veh}	Trucks	[veh]	The number of trucks needed for the transport of the selected goods from selected suppliers
l_e	Empty distance	[km]	The distance in kilometres that is travelled without any goods in the truck.
l_f	Filled distance	[km]	The distance in kilometres that is travelled with goods in the truck.
W	Payload	[tonne]	The total weight of the goods that is transported in one truck.
m_{pallet}	Av. Pallet Weight	[tonne/pallet]	The average weight of the pallets, this may restrict the maximum payload.

EXTERNAL INPUT				
These external factors are based on market data derived from the tender, general limitations or external factors.				
ID	Name	UOM	Type	Based on:
t_{stop}	Av. Stop time	[hr]	1,5 hr	(Agarwal, 2015)
v	Av. Speed	[km/hr]	65 km/h	(Ligterink et al., 2012)
P_t	FTL Transport price	[€/tonne-km]	.04€/km	Derived from tender information
W_{max}	Max Payload	[tonne]	24 tonne (ambient) 22 tonne (temperature controlled)	(Ligterink et al., 2012)
X_{max}	Max volume	[pallet]	30 pallets (ambient) 26 pallets (temperature controlled)	(Ligterink et al., 2012)
$e_{average}$	Av. Emission	[gCO2/tonne-km]	62 gCO2/tonne-km	(Cefic & ECTA, 2011)

DATABASE FACTORS			
There are several factors of which the value can be found on the lookup sheet in appendix F, they represent values that change according to the input variables.			
ID	Name	UOM	Type

α	Emission factor	[n]	To be multiplied with av. emission. Varies from 0.7 to 5.53.
β	LTL price rate	[n]	Varies from 1 for FTL to 4.5 for a load of 1 pallet.
γ	Empty mileage risk	[%]	An increase in price defined by the change on an empty backload. For options including backload this is set to 0. For options without a backload it is 9%. (Rijnswou, 2012)
..	Equipment price rate	[n]	As temperature controlled equipment has less transport capacity and higher empty fuel use, an increase in prices of generally 8-12% is witnessed in the transport quotations. The average increase for temperature controlled equipment is therefore considered 10% (Tender information)

INTERMEDIARY VARIABLES			
These variables are the on the road to calculating the KPIs			
ID	Name	UOM	Type
X_{real}	Pallets in truck	[pallet]	Due to a high average pallet weight the maximum amount of pallets in the truck may be less than the square meters divided by pallet size.
W_{real}	Real Max payload	[tonne]	Due to low average pallet weight the maximum payload may be lower due to volume restrictions.
t_{load}	Loading time	[hr]	The additional time of loading determined by the amount of stops and the average (un)loading time.
d_{veh}	Total VKM	[veh-km]	The total number of kilometres driven by the trucks
d_{tonne}	Total TKM	[tonne-km]	The transport intensity
$\eta_{fillrate}$	Fill Rate	[%tonne]	The percentage to which the truck is filled regarding the real maximum payload.
e_{real}	Emission rate	[gCO2/tonne-km]	The actual emission considering the emission factor.
C_t	Transport cost	[EUR/tonne-km]	The actual transport cost determined by the payload, the equipment type and the chance on empty backload.
$t_{driving}$	Driving time	[hr]	The total filled kilometres divided by the average speed.
η_{lading}	Percentage empty	[%km]	The percentage of empty kilometres which is necessary to determine the emission factor.

The quantitative KPIs are explained from input to result. Fuel costs are a big part of total transport cost. However an all in price has been taken into account. Theoretically the reduced fuel price due to high engine efficiency for higher payloads.

8.3 DESIGN ALTERNATIVES AND TRUCK TYPES

In the tables below the combination between Design Alternatives and the identified Truck Types is shown. It is indicated if the Truck Type belongs to Leg A or Leg B. In this table 'Yes' means that design option is theoretically possible in an ambient truck. 'Frigo' means that the combination is possible, although only in a temperature controlled truck. 'No' means that the implementation Design Alternative is not possible.

TABLE 15 - POSSIBILITY OF IMPLEMENTATION OF DA 1 – UPSTREAM BACKLOAD

	TYPE	LEG B						
DA 1	Leg A	FTL AMB 24	FTL AMB 22	LTL AMB 10	LTL AMB 5	FTL FRIGO 22	LTL FRIGO 10	LTL FRIGO 5
	FTL AMB 24	Yes						
	FTL AMB 22	Yes	Yes					
	LTL AMB 10	Yes	Yes	Yes				
	LTL AMB 5	Yes	Yes	Yes	Yes			
	FTL FRIGO 22	**No**	Frigo	Frigo	Frigo	Frigo		
	LTL FRIGO 10	**No**	Frigo	Frigo	Frigo	Frigo	Frigo	
	LTL FRIGO 5	**No**	Frigo	Frigo	Frigo	Frigo	Frigo	Frigo

In Table 15 - Possibility of implementation of DA 1, the difference between leg A and leg B is not important as they may be exchanged. Therefore only half of the table has been filled in. It can be seen that combining the temperature controlled (FRIGO) trucks with an ambient truck of 24 tonnes is not possible, this is due to the fact that when a load with temperature controlled requirements is combined with a truck with ambient requirements, a FRIGO truck will be used. As the Frigo truck has a maximum payload i.e. capacity of 22 tonnes, the 24 tonnes ambient cannot be combined.

TABLE 16 - POSSIBILITY OF IMPLEMENTATION OF DA2 - DOWNSTREAM BACKLOAD

	TYPE	LEG B						
DA 2	Leg A	FTL AMB 24	FTL AMB 22	LTL AMB 10	LTL AMB 5	FTL FRIGO 22	LTL FRIGO 10	LTL FRIGO 5
	FTL AMB 24					**No**		
	FTL AMB 22					Frigo		
	LTL AMB 10					Frigo		
	LTL AMB 5					Frigo		
	FTL FRIGO 22					Frigo		
	LTL FRIGO 10					Frigo		
	LTL FRIGO 5					Frigo		

As concerns a downstream backload, only the downstream Truck Type, i.e. FTL FRIGO 22 is considered for leg B, the other options are not considered. This is visualised in Table 16 - Possibility of implementation of DA2 - Downstream Backload.

TABLE 17 - POSSIBILITY OF IMPLEMENTATION OF DA 3 – MILK-RUN AND GROUPAGE

	TYPE	LEG A						
DA 3	Leg A	FTL AMB 24	FTL AMB 22	LTL AMB 10	LTL AMB 5	FTL FRIGO 22	LTL FRIGO 10	LTL FRIGO 5
	FTL AMB 24	**No**						
	FTL AMB	**No**	**No**					

	22							
	LTL AMB 10	No	No	Yes				
	LTL AMB 5	No	No	Yes	Yes			
	FTL FRIGO 22	No	No	No	No	No		
	LTL FRIGO 10	No	No	Frigo	Frigo	No	Frigo	
	LTL FRIGO 5	No	No	Yes	Frigo	No	Frigo	Frigo

Design Alternative 3a and b are the same concerning the possibilities of combining loads and are therefore combined in Table 17 - Possibility of implementation of DA 3. It can be seen that these alternative are only possible on LTL Truck types.

Cross-combination Design Alternatives

Next to the four basic Design Alternatives; DA 1, DA 2, DA 3a and DA 3b, cross combination Design Alternatives have also been described in Chapter 7. In the following tables DA 4 and DA 5 are visualised. As they concern the combination of two basic Design Alternatives, leg A represents the outcome of one of the basic Design Alternatives and Leg B represent a single Truck Type.

TABLE 18 - POSSIBILITY OF IMPLEMENTATION OF DA 4 - EXTENDED MILK-RUN

	TYPE		LEG B						
	LEG A		FTL AMB 24	FTL AMB 22	LTL AMB 10	LTL AMB 5	FTL FRIGO 22	LTL FRIGO 10	LTL FRIGO 5
DA 4	LTL AMB 10	LTL AMB 10	Yes	Yes	Yes	Yes	Frigo	Frigo	Frigo
	LTL AMB 10	LTL AMB 5	Yes	Yes	Yes	Yes	Frigo	Frigo	Frigo
	LTL AMB 10	LTL FRIGO 10	Frigo	Frigo	Frigo	Frigo	Frigo	Frigo	Frigo
	LTL AMB 10	LTL FRIGO 5	Frigo	Frigo	Frigo	Frigo	Frigo	Frigo	Frigo
	LTL AMB 5	LTL AMB 5	Yes	Yes	Yes	Yes	Frigo	Frigo	Frigo
	LTL AMB 5	LTL FRIGO 10	Frigo	Frigo	Frigo	Frigo	Frigo	Frigo	Frigo
	LTL AMB 5	LTL FRIGO 5	Frigo	Frigo	Frigo	Frigo	Frigo	Frigo	Frigo
	LTL FRIGO 10	LTL FRIGO 10	Frigo	Frigo	Frigo	Frigo	Frigo	Frigo	Frigo
	LTL FRIGO 10	LTL FRIGO 5	Frigo	Frigo	Frigo	Frigo	Frigo	Frigo	Frigo
	LTL FRIGO 5	LTL FRIGO 5	Frigo	Frigo	Frigo	Frigo	Frigo	Frigo	Frigo

The possible combinations for implementation of DA 3, they are shown in column 'leg A of Table 18. When combined with all the possible Truck Types for backloads like in DA 1, it can be seen that the majority of combinations entails the use of temperature controlled equipment.

TABLE 19 - POSSIBILITY OF IMPLEMENTATION OF DA 5 - HUB SHUTTLE

	TYPE		LEG B						
	LEG A		FTL AMB 24	FTL AMB 22	LTL AMB 10	LTL AMB 5	FTL FRIGO 22	LTL FRIGO 10	LTL FRIGO 5
DA 5	LTL AMB 10	LTL AMB 10					Frigo		
	LTL AMB 10	LTL AMB 5					Frigo		

	LTL AMB 10	LTL FRIGO 10					Frigo		
	LTL AMB 10	LTL FRIGO 5					Frigo		
	LTL AMB 5	LTL AMB 5					Frigo		
	LTL AMB 5	LTL FRIGO 10					Frigo		
	LTL AMB 5	LTL FRIGO 5					Frigo		
	LTL FRIGO 10	LTL FRIGO 10					Frigo		
	LTL FRIGO 10	LTL FRIGO 5					Frigo		
	LTL FRIGO 5	LTL FRIGO 5					Frigo		

As DA 5 considers the downstream backload of DA 2, only the downstream Truck Type is considered. For Leg A the possible combinations that resulted from DA3 are used like in DA 4. Logically, this possibility of implementation results in only Frigo trucks as can be seen in Table 19 - Possibility of implementation of DA 5 - Hub shuttle.

8.4 CONCLUSION

Not all combinations of Truck Types are possible for every Design Alternative, depending on the payload and the way of combining entailed by the DA. The implementation of DAs on Truck types leads to input for the System Diagram which transforms the quantitative model input through a set of variables to values on the key performance indicators. These will be presented and interpreted in Chapter 10.

9 INSTITUTIONAL ANALYSIS OF DESIGN ALTERNATIVES

In this chapter the Design Alternatives, as described in Chapter 7, are hypothetically placed in the institutional context as described in Chapter 6. First of all, an overview is presented of the impacts of the Design Option on the specified institutions. Subsequently, the attitude of the actors towards the design options is formulated, the attitudes are, similarly to actions, largely based on the institutions. Next to the attitude, the power of actors is also formulated. The Operational Feasibility, one of the five Key Performance Indicators, is based on the process-oriented normative institutions. This chapter should therefore result in two conclusions; a quantitative rating of the Design Options on Operational Feasibility and a qualitative and softer description of the institutional fit.

Integration on operational and tactical level should go hand in hand. Not clear if strategic level brings the same goals. Collaborative transport is an example of external collaboration in the upstream supply chain. Collaboration is intensive and should focus on small successful parts (Barratt, 2004), then it can evolve into niche innovation and get implemented more (Schot & Geels, 2008).

An important note to take into account particularly in the actor analysis is that supplier segmentation (Rezaei & Ortt, 2013a) means that all suppliers are different and not one collaboration will work for all. The segmentation approach has received a lot of attention in literature and is a likely context for successful collaboration (Barratt, 2004). For example, Coca Cola has segmented customers in logistics needs why not do the same with suppliers, (Fuller, 1993 in Barratt, 2004).

9.1 IMPACTED INSTITUTIONS

The institutional terrain within which corporations operate is not static instead there are dynamic pressures which can cause this terrain to shift over time. Globalization, stakeholder activism, political decision making can cause institutions to change. Institutional change may encourage social responsible ways (Campbell, 2007). The Design Options are most influenced by the regulative institutional context. An important parameter is the International Commercial Terms, the effects of which are described below.

9.1.1 CHANGED INCOTERMS

In Figure 22 - Interactions on basis of Delivery Duty PaidFigure 23 - Interaction on basis of ExWorks the actor interactions are visualised for both DDP and ExWorks situations. In any situation where the contract with the Direct Material Supplier is on DDP basis, even if agreements are made about the transport methods and possible integrations, the organisational structure does not change. However negotiations and (informal) agreements can take place. The result of this type of organisation may highly depend on the willingness of deciding actors to cooperate (Ioan et al., 2013).

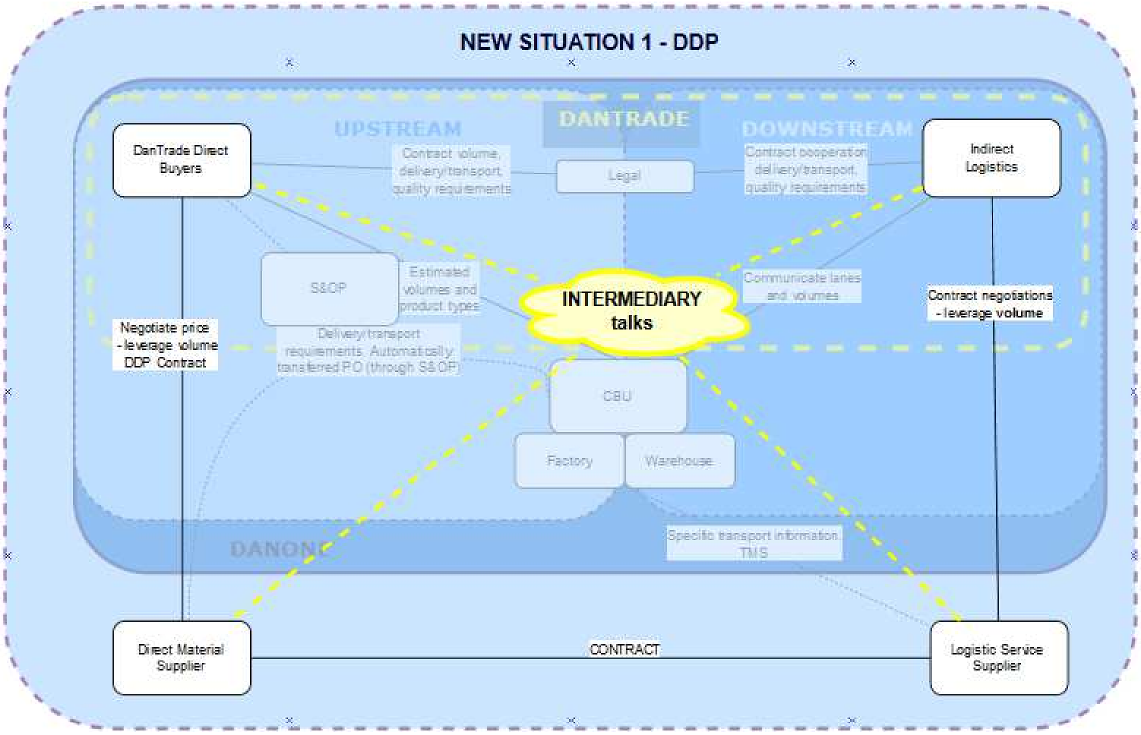

FIGURE 22 - INTERACTIONS ON BASIS OF DELIVERY DUTY PAID

In the situation where the contract with the Direct Material Supplier is changed to ExWorks, Danone will have the organize the transport by themselves. This means that the transport requirements for the product that is bought should be known either through the Direct Buyers or through the S&OP

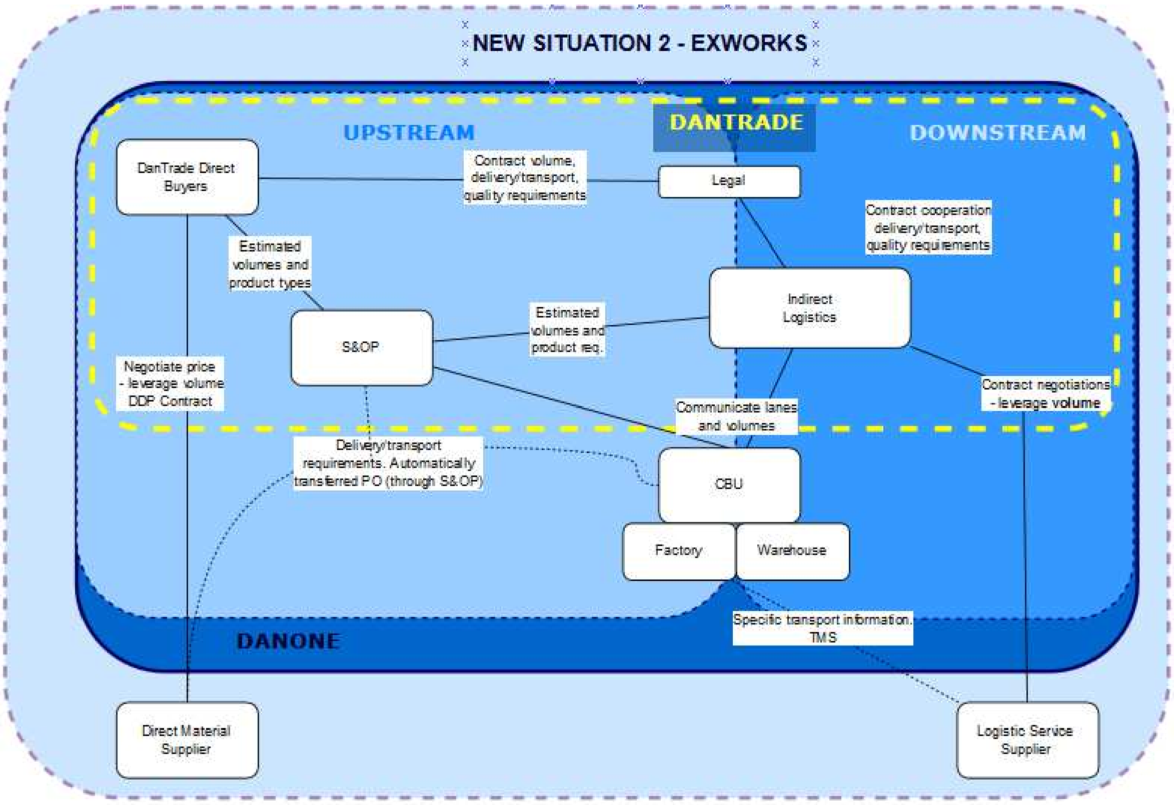

FIGURE 23 - INTERACTION ON BASIS OF EXWORKS

department. This is necessary for DanTrade logistics to be able to find a LSP that can deliver the product from the Direct Material supplier's factory to the Danone CBU.

The change to ExWorks leads to organisational changes, while the project in DDP is based on negotiations. When the transport will be changed from DDP to ExWorks, the loading and inspection of the truck will take place at an external location, namely that of the Direct Material Supplier. The risk is therefore not only transformed to the buying party (Danone), the risk may also increase as the interest of the seller in thoroughly inspecting the truck may have diminished.

If any combination is to be made with an upstream or downstream return load or another upstream location, while the driving time is already very long, this may lead to a either a too long of a driving time for the driver or a too long lead time for the transported product.

9.1.2 Operational feasibility

The operational feasibility has been determined in consultation of the I2M project team, (Agarwal, 2015), and is further founded on desk research. An overview of the valuation of the options on internal, external (DMS) and 3rd party (LSP) is provide in the table below. The current situation is considered to have a score of 3. This means that any value lower than three is a decrease in performance while more than three indicates an improvement. To make these values comparable to the other KPIs, it is normalized between 1 and 5, i.e. the maximum values that were concerned during the interview.

Table 20 - Operational Feasibility

Operational feasibility			
Option	**Danone**	**Direct Material Supplier**	**3Rd party (LSP)**
1 upstream backload	2/3 – as cycles of different suppliers will have to be matched, this coordination decreases the operational feasibility.	2/3 – as cycles of different suppliers will have to be matched, this coordination decreases the operational feasibility.	3 - If the cycle time coordination is organized by either Danone or the DSM, the 3rd part suppliers will not notice anything.
2 Downstream backload	2 – as cycles of different parts of the factory have to be matched, this may highly depend on internal factory organisation	3 - The DSM is not affected by the backload.	3 - If the cycle time coordination is organized by either Danone or the DSM, the 3rd part suppliers will not notice anything.
3 Milk-run	2 – cycles of different suppliers will have to be matched, while other ingredients are waiting, same as 1 but more crucial.	2 – cycles of different suppliers will have to be matched, while other ingredients are waiting, same as 1 but more crucial.	3 - If the cycle time coordination is organized by either Danone or the DSM, the 3rd part suppliers will not notice anything.
3b Groupage	3 In case a WH has to be found 4 In case Danone WH is used.	3 – DSM is not directly affected.	3 – However depending on the fact if supplier is involved in loading the

			truck*
4 Extended Milk-run	1/2 – cycles of different suppliers will have to be matched, while other ingredients are waiting, same as 1 but more crucial.	1/2 – cycles of different suppliers will have to be matched, while other ingredients are waiting, same as 1 but more crucial.	3 – However in case of long distance, driver times should be analysed by LSP.
5 Hubbing	2/3 - In case of new WH 4 - In case Danone WH is used.	3 – DSM is not directly affected.	3 – In case the WH is organized by other LSP, 4 - in case LSP's WH

*The loading of the truck is done either by employees at the factory or by the driver himself. This depends per factory and has changed recently in some factories.

9.2 POWER/ATTITUDE ANALYSIS ACTORS TOWARDS OPTIONS

An actor analysis is executed in Chapter 6 to describe the most important players in any upstream transport integration. For each actor a short description of their goals and attitude will be given, as well as an indication on their interest and power. The scores on these subjects will be visualized in a Power versus Interest grid.

It should be mentioned that while DanTrade Logistics concerns one team, the Direct Buyer is actually multiple tens of people. The same accounts for the Raw and Packaging Material supplier and the factories. Commitment of internal actors may highly depend on the amount of possible savings for their department. From interview information: in case an integration makes the work of a planning department in a factory increasingly complex while the savings are only assigned into the global logistics department, it might influence the willingness of this department to put in additional effort. Interest should be considered an aggregated term that combines multiple sorts of interest. A short description of interest and power of influence of different actors is given below.

9.2.1 DANTRADE LOGISTICS

I2M Project Team is interested in creating as much performance through the design options as possible. As long as the upstream transport is organized DDP, their power is determined by negotiations and the decision making power is low. In case the Incoterms would be changed to ExWorks, the power of the logistics team would be high . Power: high and low. Interest: High

9.2.2 DIRECT BUYERS

Direct buyers want to maintain a good relationship with the Direct Material Supplier and make sure the delivery on time and other service parameters are not jeopardized. Due to the possible savings on transport costs they are positive but due to supplier relationship management also cautious. A Direct Buyer has a big convincing power and possesses indispensable information to make the project work. The Direct buyer is likely also concerned about the risk that combining multiple products would entail. Power: High. Interest: Diverse

9.2.3 DIRECT MATERIAL SUPPLIER

The direct material supplier is probably highly influenced by direct buyer relationship. For combining products the operational activities may be impacted at the direct material supplier, such as loading hours. The supplier will either have to possibly disappoint his own logistic supplier or reduce the use of their own trucks. The power is considered as high, as in the current situation they organize the transport. However they may be convincible depending on the earlier named features. In a change to ExWorks, their cooperation will still be important to the organization of any integration and therefore will still be high. Their interest will likely always be high due their current business contracts. Power: high. Interest: high.

9.2.4 Factory

The Lead Time of the truck travelling and the organisation of any integration, may together increase the total product delivery time. The Danone factories where the products arrive have a major concern which is the Product Delivery time (PDT). Factories will be highly reluctant to have the PDT increased, as it may directly impact their inventory and production. They have essential information such as quantities needed (send through PO information) and possible truck reception times and other transport relevant information, which makes them powerful. Power: high. Interest: High

9.2.5 Operations

The operations is an indispensable party in the organisation of the transport. The information flows on product required, order quantity and delivery locations pass through the information system. Also, Operations provides forecasting on product quantities and sourcing. Initially these forecast led to basis of information on which the first tender was build. The forecasting may play a crucial role in the preparing of any integration possibilities: Interest: low. Power: High.

9.2.6 Logistics Service Supplier

The Logistic Service Providers will generally be positive to any additional business opportunities. However, they are fairly similar as they might all be positive for an opportunity to gain additional business. Power: low. Interest: high.

9.2.7 Power versus Interest Grid

Comparing, most actors have high interest in upstream transport integration. As a result, it is important that the actors are aligned and have a positive opinion of the project. It should be considered that both the Logistic Service Provider, Direct Material Supplier and the factories consists of multiple entities whose attitude, interest and power and attitude may change individually. These changes can be due to personality, however also to cognitive institutions as described in Chapter 6.

Table 21 - Power versus Interest Table

Power*Interest		Power	
		Low	High
Interest	High	DT Log WhatsUp (DDP)	Direct Material Supplier Factory DT Log Downstream DT Log WhatsUp (ExW)
	Low	Logistic Service Provider	Operations

9.3 CONCLUSION ON INSTITUTIONAL ANALYSIS

To conclude, the international commercial terms are one of the most important regulative institutions that is impacted by the design options. It is not essential to change the incoterms for the implementation of a Design Alternative. However successful implementation or even realisation of the Design Alternatives under circumstances that the organising party is not in control and actions are based on negotiations, i.e. DDP, is less likely than when the organising party is in control i.e. has a contract stating the actions in ExWorks. In case the implementation is based on negotiations, Design Alternative 1 and 2 have a better score as they concern less convincing power as suppliers do not share equipment at the same time. The sharing of equipment may lead to issues concerning Food Quality Standards and the alignment of Corporate Social responsibility.

The results of the Design Alternatives' qualitative analysis also forms quantitative input for the MCDA in form of operational feasibility. The operational feasibility is deemed to decrease for every Design Alternative compared to the current situation. Design Alternative 3b forms an exception, due to the positive score for the possible use of a Danone Warehouses for Groupage. The attitude and interest of actors may also impact the possible implementation and the resulting performance. Their attitude is mostly influenced by the formal and normative institutions such as rules and incentive and organisational systems. The differentiation in specific attitudes and interest can be defined by the cognitive institutions and are not generalizable for a category of actors such as 'buyers'.

PART 4 RESULTS

10 QUANTITATIVE RESULTS

The Design Alternatives as described in Chapter 7 are hypothetically implemented on the different truck categories. This results in different values on the Key Performance Indicators (KPIs). The effects are calculated by use of the model as explained in Chapter 8. The quantitative results are presented in three parts.. First the not weighted outcome will be presented, followed by the values of the weights of different perspectives. Then the weighted results and relative increases and decreases in performance will be presented. The presentation of results is followed by the interpretation of results. The detailed results can be found in Appendix K.

10.1 UNWEIGHTED QUANTITATIVE RESULTS

The unweighted results for all 5 performance indicators are presented. To be able to compare the general impact of the design options on all the possible combinations, they have been generalised into six truck categories. For Design Alternative 1 and 2 these are as follows: FTL means a full truck load for both legs, while COMBI means a combination of a Full Truck Load on one leg and an LTL in the other direction. An LTL means that during both legs the truck is filled with a LTL load. The addition FRIGO means the combination truck is a temperature controlled truck. For Option 3, LTL means that two LTL ambient loads are combined in one truck, LTL-FRIGO means the LTL loads, even if one of the loads has no temperature controlled requirements, are combined in a LTL truck. A distinction is made between the performance indicator Transport Efficiency and the other four, Lead Time, Transport Costs, Emissions and Operational Feasibility. The latter four are also summed up to a total score, i.e. the Transport Efficiency is not included in the Total Sum. Due to this, it is possible to compare the increased performance with the increased transport efficiency, often an indicator for performance as described in the literature review.

As all Design Alternatives aim to increase the Transport Efficiency, this value of this performance indicators naturally increases when Design Alternatives are implemented on the Truck categories. When comparing the results of different Design Alternatives on different categories, the base case i.e. the situation without implementation of any Design Alternative should always be considered. For the combinations that are made through Design Alternatives that can be transported in Ambient Trucks, it is to be seen in Table 22 - Ambient Transport - Unweighted Results, that Design Alternative 1, which can be implemented on every truck category (for implementation possibilities see Chapter 8), leads to improved performance in all cases. Design Alternative 3a and 3b, which can only be implemented on LTL trucks, do not lead to an increased performance compared to the base case. The biggest reduction is caused by the low values for lead time. In particular, raw and packaging materials which are transported LTL provide room for improvement from a supply chain perspective.

TABLE 22 - AMBIENT TRANSPORT - UNWEIGHTED RESULTS

UNWEIGHTED						
FTL		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
	Transport Efficiency	0,469	0,869			
	Lead Time	0,791	0,791			
	Transport Cost	0,976	0,998			
	Emissions	0,883	0,965			
	Operational Feasibility	0,500	0,417			
	TOTAL	3,151	3,171			
COMBI		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
	Transport Efficiency	0,304	0,569			

	Lead Time	0,791	0,791			
	Transport Cost	0,878	0,955			
	Emissions	0,674	0,905			
	Operational Feasibility	0,500	0,417			
	TOTAL	2,844	3,068			
LTL		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
	Transport Efficiency	0,139	0,269		0,182	0,182
	Lead Time	0,791	0,791		0,194	0,194
	Transport Cost	0,779	0,851		0,856	0,856
	Emissions	0,466	0,726		0,658	0,658
	Operational Feasibility	0,500	0,417		0,333	0,583
	TOTAL	2,537	2,785		2,041	2,291

The unweighted results for Temperature Controlled truck categories display similar results as can be seen in Table 23 - Temperature Controlled - Unweighted results. In this case Design Alternative 2, the downstream backload, can also be implemented on the truck categories FTL-FRIGO and COMBI-FRIGO. On these two categories, DA 2 shows the highest increase in performance. The decrease in performance caused by the implementation of Design Alternative 3a and 3b are slightly smaller than for that of the Ambient Truck categories.

TABLE 23 - TEMPERATURE CONTROLLED - UNWEIGHTED RESULTS

FTL-FRIGO		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
	Transport Efficiency	0,479	0,907	1,000		
	Lead Time	0,791	0,791	0,989		
	Transport Cost	0,976	0,998	1,000		
	Emissions	0,852	0,941	0,983		
	Operational Feasibility	0,500	0,417	0,417		
	TOTAL	3,120	3,147	3,388		
COMBI-FRIGO		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
	Transport Efficiency	0,312	0,602	0,664		
	Lead Time	0,791	0,791	0,989		
	Transport Cost	0,896	0,967	0,970		
	Emissions	0,637	0,873	0,938		
	Operational Feasibility	0,500	0,417	0,417		
	TOTAL	2,825	3,049	3,313		
LTL-FRIGO		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
	Transport Efficiency	0,149	0,296		0,311	0,311
	Lead Time	0,791	0,791		0,194	0,194
	Transport Cost	0,819	0,877		0,918	0,918
	Emissions	0,417	0,685		0,709	0,709
	Operational Feasibility	0,500	0,417		0,333	0,583
	TOTAL	2,527	2,770		2,155	2,405

Transport Efficiency is not given any weight as it is not a criterion. Transport Cost and Emissions both depend on TE, therefore, a high correlation is assumed. Through testing using Pearson correlation efficient, a score of .80 is obtained. This can be explained by the fact that transport cost and emissions both are derived from fill rate and rate of lading (i.e. the empty distance) as well. When a trend line is added to the graph comparison of transport efficiency with the sum of the other four KPIs, i.e. total performance in Figure 24- Correlation between Transport Efficiency and Performance (unweighted), the best estimation comes from a linear trend line with a R-squared value of 0,63. Although all Design alternatives increase the Transport Efficiency, they do not always increase the unweighted performance.

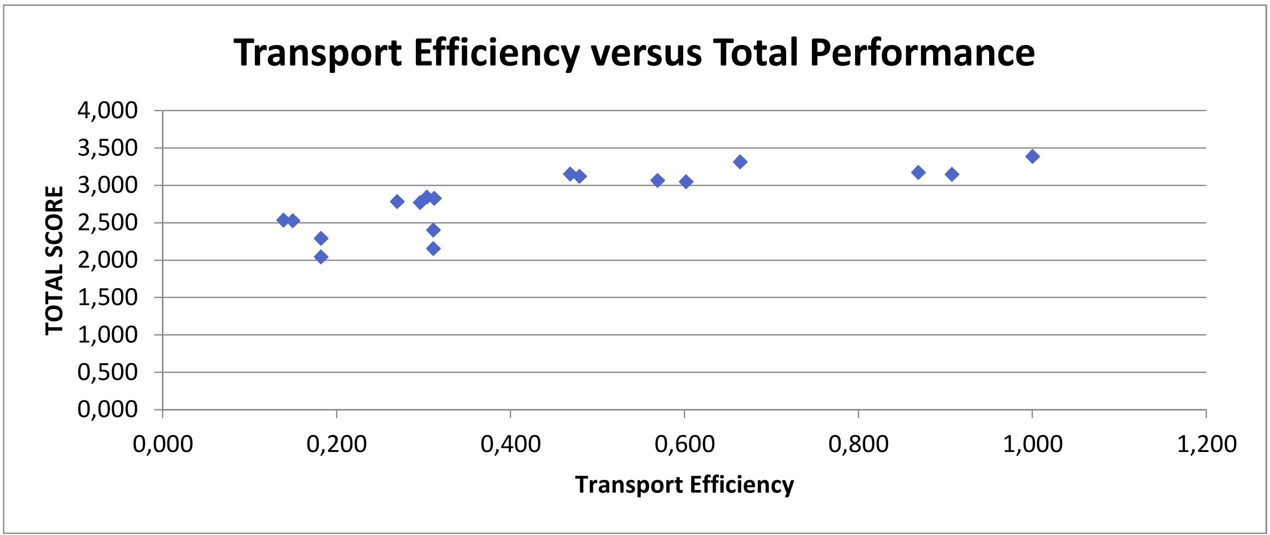

FIGURE 24- CORRELATION BETWEEN TRANSPORT EFFICIENCY AND PERFORMANCE (UNWEIGHTED)

10.2 WEIGHTED QUANTITATIVE RESULTS

Different decision makers may have different preferences for increase or decrease of certain KPIs as discussed earlier in Chapter 4. Here the weights that result from the determination through the Best-Worst Multi-Criteria decision-making method are presented. The detailed calculation of weights can be found in Appendix J.

There are four commercial perspectives taken into account. First of all, the General Project Management perspective. This perspective concerns DanTrade however not directly linked to logistics. The operational feasibility, representing the fit with processes for this perspective is therefore an important criterion. Secondly the Global Logistics Manager perspective, rather than focussing on the performance of the I2M project also the impacts of logistical change on other parties, in this case represented mainly through a high value of Lead Time. Thirdly, the I2M Project Team Perspective, which is as concerned with Transport Cost and Operational Feasibility. This equal value of transport cost and operational feasibility may be explained by the first three DanTrade perspectives are combined together in an average, the integrated DanTrade perspective. This perspective adds value through providing an integrated commercial approach of actors at DanTrade. On average and in the separate DanTrade perspectives, the emission rate is regarded as the least important criterion. Fourthly, a sustainable perspective is created. The sustainable perspective presents rather opposite values than the former perspectives. The sustainable perspective is based on primarily environmental sustainability, the operational feasibility is more organisational sustainability, economical sustainability is transport cost and lastly lead time, is not considered highly important as it can be anticipated upon. The Consistency Indicator explains to what extent the stated preferences for the specific criteria are consistent with each other, where a value closer to zero is indicates higher consistency.

TABLE 24 - WEIGHTS PERSPECTIVES

Criteria	Perspectives				
	General Project Manager	Global Logistics Manager	I2M Project Team	*Integrated DanTrade Perspective*	Sustainable
Lead Time	0,18	0,30	0,16	*0,21*	0,06
Transport Cost	0,18	0,43	0,40	*0,33*	0,14
Emissions	0,08	0,08	0,04	*0,07*	0,52
Operational Feasibility	0,58	0,19	0,40	*0,39*	0,28
Consistency Indicator (ξ)	0,125	0,135	0,095	*n/a*	0,040

When the weights are implemented on the MCDA the results as presented in Table 24 - Weights perspectives occur. Table 25 presents the sum scores of the different options regarding all categories. The detailed results with specific values on all KPIS can be found in Appendix K. A first superficial look at the results show that the scores of the options are relatively robust. From all perspectives, Design Alternative 2 is the most preferable option. DA 3a and b have a lower improvement, which can be stated from the lower values and reddish colours. Also, it is visible that the General Project Manager Perspective is the most negative perspective, scoring always lower than the other perspectives.

TABLE 25 - OVERVIEW OF WEIGHTED TOTAL PERFORMANCE SCORES PER PERSPECTIVE

BASE		**FTL**	**COMBI**	**LTL**	**FTL-FRIGO**	**COMBI-FRIGO**	**LTL-FRIGO**
	Global Logistics Manager	0,82	0,76	0,70	0,82	0,77	0,72
	General Project Manager	0,66	0,63	0,60	0,66	0,63	0,60
	I2M Project Team	0,75	0,71	0,66	0,75	0,71	0,67
	Integrated DT	0,75	0,70	0,65	0,74	0,70	0,66
	Sustainable	0,78	0,66	0,54	0,77	0,64	0,52
DA 1	Global Logistics Manager	0,82	0,80	0,74	0,82	0,80	0,75
	General Project Manager	0,63	0,61	0,58	0,62	0,61	0,58
	I2M Project Team	0,73	0,71	0,66	0,73	0,72	0,67
	Integrated DT	0,73	0,71	0,66	0,73	0,71	0,67
	Sustainable	0,81	0,77	0,66	0,79	0,75	0,64
DA 2	Global Logistics Manager				0,88	0,87	
	General Project Manager				0,66	0,65	
	I2M Project Team				0,77	0,75	
	Integrated DT				0,77	0,76	
	Sustainable				0,83	0,80	
DA 3a	Global Logistics Manager			0,54			0,58
	General Project Manager			0,42			0,44
	I2M Project Team			0,53			0,56
	Integrated DT			0,50			0,52
	Sustainable			0,57			0,60
DA 3b	Global Logistics Manager			0,59			0,62
	General Project Manager			0,57			0,58

	I2M Project Team			0,63			0,66
	Integrated DT			0,60			0,62
	Sustainable			0,64			0,67

The scores for the hypothetically implemented Design Alternatives are compared with the scores for the base case. The results of this comparison are presented in Table 26 - Change in performance compared to base case. In this table, the scores which show a reduction of 5% compared to the base case are highlighted in red, while the results that show an increased performance of at least 5% are highlighted green. These results confirm the earlier superficial observation that DA 2 increases performance. It provides a robust choice as it increases performance or has it stay the same in every case. Meanwhile DA 3a and 3b have mostly negative scores and thus reduced performance compared to the base case. The sustainable perspective forms an exception. The highest improvement in performance possible is perceived by the sustainable perspective through implementation of DA 3b on the LTL-FRIGO category. DA1 seems to have the least effect as it has few very negative or very positive scores. Here again, the sustainable perspective forms an exception as it generally shows the DA 1 is a large improvement. Although DA 1 is applicable on any truck category, the performance for the COMBI and LTL categories is better than on the FTL categories.

TABLE 26 - CHANGE IN PERFORMANCE COMPARED TO BASE CASE

BASE		**FTL**	**COMBI**	**LTL**	**FTL-FRIGO**	**COMBI-FRIGO**	**LTL-FRIGO**
DA 1	Global Logistics Manager	100%	105%	105%	100%	104%	104%
	General Project Manager	94%	97%	97%	94%	97%	97%
	I2M Project Team	97%	101%	101%	97%	101%	100%
	Integrated DT	97%	101%	101%	97%	101%	101%
	Sustainable	103%	116%	123%	103%	117%	124%
DA 2	Global Logistics Manager				108%	113%	
	General Project Manager				100%	103%	
	I2M Project Team				102%	106%	
	Integrated DT				104%	108%	
	Sustainable				108%	124%	
DA 3a	Global Logistics Manager			77%			80%
	General Project Manager			71%			73%
	I2M Project Team			81%			83%
	Integrated DT			77%			79%
	Sustainable			105%			116%
DA 3b	Global Logistics Manager			84%			87%
	General Project Manager			95%			97%
	I2M Project Team			96%			98%
	Integrated DT			91%			94%
	Sustainable			118%			130%

10.3 INTERPRETATION OF QUANTITATIVE RESULTS

The results, as presented in the two previous paragraphs, are interpreted by analysing their causes. The unweighted results showed an improvement of the performance of all truck categories through implementation of DA1 and DA2. In the weighted scenarios, this is only the case in the Sustainable perspective scenario. This difference is caused by the low weight that is assigned to the criterion emission rate. Emission rate shows a large improvement when any Design Alternative is implemented, explaining the large difference between the Sustainable perspective and the other perspective. Lead time is another important criterion that is defining the total performance. An increase in lead time leads to a much lower score on the criterion and, with that, reducing the performance score of DA 3a and 3b. the alternatives that have an increased lead time. General logistics and I2M project have a similar perspective, although the Global Logistics perspective is slightly more positive. The differences between 3a and 3b are caused solely by the valuation of operational feasibility. The good scoring of DA 1 on the COMBI and LTL categories may be considered unexpected as it is concerns not improving the payload but only the empty kilometres. And therefore may be more looked at for FTLs. This makes this a useful analysis. The high correlation found suggest that there is a strong relationship between Increased Transport Efficiency and increased performance, however the basis of calculation of transport costs and emissions is also payload and empty distance travelled, the same basis as transport efficiency. This should therefore be taken into account.

It is important to note that the TOTAL score of the design options, does not take into account the Transport Efficiency and is thus a sum of Lead Time, Transport Cost, Emissions and Operational feasibility. Concerning Option 1 and 2, the larger payloads have a much bigger improvement concerning transport efficiency as do the lower payloads. For option 3 the improvement for LTL FRIGO is better than that of regular LTL, this is due to the higher fill rate percentage of the LTL truck as here 5 or 10 tonnes compare to a maximum of 22 tonnes, while for regular trucks this to 24 tonnes. Costs follows the same pattern as the transport efficiency, however for emissions Ambient trucks generally score better than the temperature controlled trucks. This is caused by the fact that transporting 10 tonnes in a Frigo truck with a maximum payload of 22 tonnes is already more efficient than transporting the 10 tonnes in an ambient truck of 24 tonnes.

11 VERIFICATION AND VALIDATION

11.1 VERIFICATION

The working of the model is verified by several means. First the input of the model will be changed, to see what are the effects on the Truck Types. Also, as the final weighted results are the product of the weights and the normalised KPI values, these also provide a certain validation.

Truck Types

The working of the model is verified by changing the input parameters and analysing the changes in the results. They have been analysed for all parameters. As an example the difference between 500km and 1000km distance with a fixed ratio between empty and filled distance is shown. It can be seen that the all criteria where distance is no decisive factor do not change, while the criteria which are measured by tonnes have doubled.

What should be taken into consideration is that the generalised scores on the performance indicators take into account all Truck Types. However, it has been concluded that there is a dependency between the most adequate Design Alternative and the type of truck. Therefore it can be stated that for goods that are transported in full trucks, the most adequate design Alternative is including a backload. However for goods transported in small quantities the combining of suppliers in trucks preferably at a Warehouse to avoid waiting multiple times for loading partially, is the preferred Alternative.

TABLE 27 - KPI S OF VALUES R TRUCK TYPES IN BASE CASE (500 KM)

500KM - 1 tonne	Lead Time	Transport Efficiency	Transport Cost W	Transport Cost D	Emission
	[hr]	[veh-km/tonne-km]	[EUR/tonne]	[EUR/km]	[gCO2/tonne]
FTL AMB 24	7,7	0,50	€ 42,31	€ 1,02	72.423
FTL AMB 22	7,7	0,46	€ 42,31	€ 0,93	77.375
LTL AMB 10	7,7	0,21	€ 61,77	€ 0,62	151.036
LTL AMB 5	7,7	0,10	€ 87,15	€ 0,44	225.316
FTL FRIGO 22	7,7	0,50	€ 42,31	€ 0,93	72.423
LTL FRIGO 10	7,7	0,23	€ 56,69	€ 0,57	128.133
LTL FRIGO 5	7,7	0,11	€ 74,04	€ 0,37	190.652

TABLE 28 - KPIS OF VALUES TRUCK TYPES IN BASE CASE FOR (1000 KM)

1000KM - 1 tonne	Lead Time	Transport Efficiency	Transport Cost W	Transport Cost D	Emission
	[hr]	[veh-km/tonne-km]	[EUR/tonne]	[EUR/km]	[gCO2/tonne]
FTL AMB 24	15,4	0,50	€ 84,62	€ 1,02	144.846
FTL AMB 22	15,4	0,46	€ 84,62	€ 0,93	154.750
LTL AMB 10	15,4	0,21	€ 123,54	€ 0,62	302.072
LTL AMB 5	15,4	0,10	€ 174,31	€ 0,44	450.632
FTL FRIGO 22	15,4	0,50	€ 84,62	€ 0,93	144.846
LTL FRIGO 10	15,4	0,23	€ 113,38	€ 0,57	256.266
LTL FRIGO 5	15,4	0,11	€ 148,08	€ 0,37	381.304

The overview of parameters changed is presented in Table 29 - Validity when changing quantitative model input.

TABLE 29 - VALIDITY WHEN CHANGING QUANTITATIVE MODEL INPUT

Input	Description	Valid?
Extra stops	If changed all values stay the same	Yes
Trucks	If changed all values stay the same	Yes
Empty distance	If changed while maintaining ratio empty/filled distance nothing changes, if changed without maintaining ratio, values change	Yes
Filled distance	If changed while maintaining ratio empty/filled distance nothing changes, if changed without maintaining ratio, values change	Yes
Payload	Fixed with Truck Type	Yes
Av. Pallet Weight	If changed all values stay the same	Yes

Ranges

The values on the KPIS can be influenced by changing the minimum and maximum of the ranges that are used to normalise the real values. In Chapter 10 Quantitative Results, it becomes clear that the values for lead time are rather extreme. This values are based on logic rather than on data. When the range of lead time is increased from 12,2 to 8,4 hours to 20 to 8,4 hours, the following results occur. It can clearly be seen in Table 30 - Change in performance compared to base case (with changed lead time range), that the results are more positive when the range of the lead time is increased. This is due to the fact that the impact of the mainly disadvantageous score of Lead Time is reduced.

TABLE 30 - CHANGE IN PERFORMANCE COMPARED TO BASE CASE (WITH CHANGED LEAD TIME RANGE)

BASE		FTL	COMBI	LTL	FTL-FRIGO	COMBI-FRIGO	LTL-FRIGO
DA 1	Global Logistics Manager	100%	104%	105%	100%	104%	104%
	General Project Manager	94%	97%	97%	95%	97%	97%
	I2M Project Team	97%	101%	101%	97%	101%	100%
	Integrated DT	97%	101%	101%	98%	101%	101%
	Sustainable	103%	116%	122%	103%	117%	124%
DA 2	Global Logistics Manager				103%	107%	
	General Project Manager				97%	100%	
	I2M Project Team				99%	103%	
	Integrated DT				100%	104%	
	Sustainable				107%	123%	
DA 3a	Global Logistics Manager			95%			97%
	General Project Manager			84%			85%
	I2M Project Team			91%			93%
	Integrated DT			90%			92%
	Sustainable			109%			120%
DA 3b	Global Logistics Manager			101%			103%
	General Project Manager			107%			108%
	I2M Project Team			106%			108%
	Integrated DT			104%			106%

	Sustainable			122%			134%

The other ranges are based on fixed values, resulting either from the tender information (transport costs), from Cefic & ECTA (2011) for emissions and from maximum theoretical values for Operational feasiblity (1 to 5 Likert Scale) and Transport Efficiency from 2% to 100% for payloads from 1 to 24 tonnes.

11.2 VALIDATION

Internal validity threats

The operational feasibility is based on limited sources, while it has been given a very large weight. This means that the limited sources have a very large influence on the outcome of the Multi Criteria Analysis and are therefore sensible to a bias. However they are based on discussions and have arguments to validate the reasons for giving certain scores.

The student has a detailed image of the context due to field experience during the internship. However this may also lead to a certain bias. The student has therefore no criteria and has received external feedback to diminish the bias.

External validity

It is a risk that the transport data used does not give a real view on the actual price. As it is based on single loading and unloading transport. However, as prices are usually very negotiable this can change a lot. Also prices are generalized over all of Europe, while big differences may occur due to region and country and crossing borders. However that is why a base case is calculated. In that way the outcome is comparable to the outcome of any integration. Construct validity does not occur as variables are based on multiple sources. (Creswell, 2003)

Real cases

Another possibility to show the validity and relevancy of the results is by comparing them to real life cases. There are several cases which are alike the Truck combinations and Design Alternatives that are presented in this report. From the real cases, it can be concluded that indeed the different incoterms structure may pose difficulties for being in control of a system. It also shows that initiatives are taken to implement alternatives that are alike to the Design Alternatives, which means that in some cases it is operational feasible to implement. A detailed description of the real cases can be found in Appendix L.

11.3 CONCLUSION

The Truck Type combinations that resulted in the most improvement in the model, do not yet seem to occur in the real cases. Due to the fact that most inbound raw and packaging material is transported in ambient trucks while all outbound products are transported in Temperature Controlled trucks, less valuable combinations can be made.

PART 5 CONCLUSIONS

12 DISCUSSION & REFLECTION

In this chapter elements of the report are discussed and reflected upon. It concerns both contextual and researched elements. The executed research and its results are subject to several choices made. These choices will be discussed and possible limitations resulting from these will be highlighted.

12.1 CHOICE AND INTERDEPENDENCY OF KPIS

The Key Performance Indicators that are chosen to represent performance in the supply chain do not cover all possible aspects of supply chain performance. Supply Chain reliability and responsiveness are regarded two important aspects of supply chain performance (Schubert & Legner, 2011; Williams et al., 2013). Finding unambiguous indicators for supply chain performance, may prove to be very difficult, seen the vast amount of research that can be found on this subject. More in-depth research would have to be executed, to find if the chosen performance indicators well-enough represent the performance as is aimed for in this project. Moreover, to find valid scores for both reliability and responsiveness of alternativeness, two performance indicators that are named in both the literature and in the case study, real implementation would have to be analysed. With the current generalised and abstract analysis, it can be considered highly challenging and subjective to find valid values for these KPIs.

The interdependency of the KPIs is a factor that is to be taken into account in this analysis. The high correlation between Transport Efficiency and the performance including transport costs and emission rate is caused by the fact that they are both based on the payload (the extent to which the truck is filled) and the empty kilometres. While also the impact of the needed equipment is taken into account when concerning costs and emissions, there are many other factors. These factors could either differentiate or strengthen the case.

12.2 LINK TRUCK CATEGORIES AND DESIGN ALTERNATIVES

The starting point in this research is finding opportunities to increase the transport efficiency by optimising the vehicle utilisation. This is done through either increasing the payload of a truck or reducing the empty kilometres driven. This opportunities are formed into Design Alternatives and tested on the different Truck categories. However, for FTL truck categories it is not possible to increase the payload. Therefore, Design Alternatives aiming at increasing the payload can only the implemented on Truck categories with a LTL truckload. Choosing the 'best' Design Alternative is therefore slightly similar to choosing a category of trucks to improve. Despite of this relatedness and the fact that they are not so much comparable on the same Truck Types, the MCA gives insight in the performance of the different Design Alternatives in their most applicable environment.

12.3 THE LIMITED PERSPECTIVES

The weights of the criteria are only analysed from the perspective of DanTrade and a fictional perspective based on literature. To enhance the understanding of the assumed attitudes of the other actors, such as the factory and LSPs, their perspectives and weights on the KPIs may be of much added value. However, as these actors are not decision makers on the implementation of the project, a different more direct approach to develop the knowledge concerning their attitude may be more in place.

12.4 OPPORTUNITY-BASED

The implementation of any of the Design Alternatives can only happen if there is a possibility of two truck types to be combined. This possibility depends on the geographical locations of both the suppliers and the Danone locations, the moment of call-off or ordering, the combinability of products concerning quality and volume etcetera. Therefore, the number of lanes or the geographic density of supplier and manufacturing locations does not necessarily imply that there will be many possibilities to implement the DAs. However, a large density of supplier locations can be considered to increase the chance of possibilities occurring when the restrictions, i.e. if two products can be combined in a truck, do not increase.

12.5 WAREHOUSING

Alternative 3b has a very positive scores in the KPI analysis. However the Warehousing costs for storing products are not taken into account, neither is the stock management or the information system that needs to be added to a Downstream Warehouse in order to consider any Upstream goods to be stocked.

12.6 LOGISTIC SERVICE PROVIDER'S STRATEGY

It is assumed throughout the model that in case the backload is not provided by Danone, there is no backload at all. However it is unlikely that LSPs do not optimize their network to assure a backload. They usually own routing optimisation and combination systems and work for multiple suppliers. This leads to three conclusions:

- The CO_2 emissions and transport efficiency are probably higher than is assumed in this model. However as there is no insight in whether or not the LSP has been able to organise a backload on a certain route this is unsure.
- In case the Incoterms would be changed to ExWorks this would still occur as the transport is still outsourced to third party logistic service providers.
- For the transport price, a percentage increase is considered for the chance on an empty backload; the price is not doubled for a 50% lading rate. This is based on earlier research at Danone. (Rijnswou, 2012)

12.7 ORDER QUANTITIES

It is currently assumed that the order quantity represents the most optimal order quantity for all parties and is therefore unchangeable. However, in case it would be possible to change low order quantities to larger order quantities, the transport efficiency, the emissions and the transport costs will improve. When the order quantity is doubled from 5 to 10 tonnes, the results are comparable with the results of the combination of two LTL AMB 5 trucks in Alternative 3.

12.8 FUTURE DEVELOPMENT

There are several possible future changes that can highly impact the business case of the WhatsUp projects' supply chain perspective. One of these is the integration of different divisions of Danone within the scope of the project. The possibility of a combination is dependent on the location of the supplier and the factory , provided that the number of locations increases, so will the number of combinations that may occur.

The same account for the closing and opening of factories and warehousing. Any change in the network may result in a new range of possibilities for implementing one of the design Alternatives.

13 CONCLUSIONS & RECOMMENDATIONS

The aim of this research for DanTrade was to find a way to analyse the new phase of the I2M project, namely the supply chain phase and the possible increased performance resulting from actions. As the scope of the supply chain phase was still very large and undefined, a rather broad and exploratory research has been executed. In this chapter first the main conclusions will be presented by answering the sub research questions, followed by the recommendations for both DanTrade and future research.

13.1 CONCLUSIONS

In Chapter 2 and 3 the knowledge gaps as well as the research questions have been defined. The knowledge gap concerned the following: the integration of flows in upstream and between upstream and downstream transport hold potential to increase efficiency and, as a consequence, reduce the costs and emissions of the supply chain. However, the supply chain is not only a complicated geographical network of flows, it is also a complex network of actors and activities, which will be influenced in the case of an eventual integration. Therefore, one can wonder which (type of) physical re-engineering innovation/integration can lead to improvement on the stated project drivers: financial performance and carbon footprint reduction? And how can the change and impact of physical re-engineering innovation/integration be estimated? And moreover, how can the two previously mentioned knowledge gaps be researched side by side?

These questions and knowledge gaps led to the following Research Question:

How can a Mixed Method Approach be designed to analyse increased performance of physical re-engineering opportunities in Inbound to Manufacturing road transport for a Central Sourcing Company?

This Research Question will be answered below by means of answering the three Sub Questions that are described in Chapter 3.

Sub Question 1:

Why is a Mixed Method Approach for I2M opportunities in Central Sourcing applicable for measuring increased performance?

From the literature review and problem description it arises that the supply chain is as much a physical network as an organisational one. In order for an innovative alternative that affects multiple actors to be successfully implemented, collaboration is required. A Central Sourcing company has an intermediary and negotiating role. The central position of this organisation leads to contact with many actors. Actors base their actions on their institutional context. The opportunities that can be found in Inbound to Manufacturing Transport can be defined as innovative alternatives; innovative because they concern a new way of organising flows. These should therefore not only be analysed on their potential for increasing performance but also on their institutional fit. When there is enough institutional fit, actors will be more willing to participate in realising the innovative alternative. Without collaboration or participation between the actors involved, increased performance is unlikely to happen. It is therefore important that both the actor – as well as the technical perspective are taken into account when analysing an innovative alternative in the supply chain. This can be done through applying a Mixed Method Approach.

Although the current set of KPIs are possible not comprehending a complete supply chain performance indicators, they do provide a basic coverage of the more tangible performance indicators. For these indicators a generalised out of which more strategic-level conclusions can be drawn.

Sub Question 2:

What are the feasible physical re-engineering opportunities *and what is their impact on performance?*

To answer this question, it should first be defined what is considered as 'performance' in this case. There are five key performance indicators defined in the analysis. These are: Lead Time (the time the product travels from the supplier to the Danone factory), the Operational Feasibility (which consists of the internal, external and 3rd party's changes in processes), the Transport Costs (in €/tonne-km based on outsourcing costs of Trucks in Europe) and the Emission rate (the amount of CO_2 emitted by the transport in tonne-km) and lastly the Transport Efficiency (an indication of the Vehicle Utilisation in %). The latter solely is excluded from the decisions criteria on whether or not a re-engineering opportunity positively impacts performance or not. However, the Transport Efficiency is a performance indicator as it indicates to what extent the transport is optimally used as well as it indicates how much more room for change there is left on a certain lane.

The Design Alternatives arise from possible physical re-engineering opportunities that exist and of which some are described in the literature review. Two important streams of re-engineering opportunities are 1) organising a return trip and 2) increasing the payload of the truck. The Design Alternatives analysed concern these basic re-engineering opportunities in a way more specified to the case in consideration. Coherent with literature, the reverse load generally has the most positive effect on the performance. Increasing the payload has a less positive effect on performance. This is mainly due to the fact that it has a lower operational feasibility as well as the increased lead time due to combining different loads of different suppliers with possibly unaligned schedules.

Sub Question 3:

How can these opportunities be placed in an institutional context and how do they fit?

The Design Alternatives are analysed regarding their institutional fit based on three institutional pillars: formal/regulative, normative and cognitive institutions. From the institutional analysis it shows that the design Alternatives that are based on the return load provide the most feasible Alternative in case the order procedure remains on the same incoterm basis (Delivery Duty Paid). However, the organisation of the transport on a DDP basis, does not guarantee any implementation of the Design Alternative as such as the transport is still organised by an external party. Convincing suppliers to combine the truck without clear advantage for them may be challenging. For that reason, the design Alternatives based on the principle of combining multiple suppliers necessitates that the transport is organised by the buying party, i.e. Danone. The organisation of transport on an ExWorks basis, would result in extra work as the transport needs to be organised, planned, implemented and monitored. The additional tasks are not the only consequence that are concerned when changing the International Commercial Terms from DDP to ExWorks. The risk allocation may change as well.

13.1.1 Answer to the Research question

The main research question can be answered following the findings regarding the sub questions. In order to find the performance of alternatives of transport organisation through a Mixed Method

Approach, multiple analysis need to be performed to cover the full scope of impact of a re-engineering opportunity i.e. alternative. In a supply chain context, this typically entails a physical/technical analysis and an organisational/stakeholder analysis. Between these two analysis, elements of integration should be present. The analyses should have the same object of study and need to be complementary. If not so, the relevance of having an integrated study may be questioned. A central sourcing company is the spider in the web in the supply chain and therefore has many interactions with different actors. A mixed method approach is therefore especially applicable to a company with a centralized and intermediary function.

13.1.2 SCIENTIFIC AND SOCIETAL CONTRIBUTION

An optimization problem is analysed with an integrated approach of qualitative and institutional as well as quantitative and technical analysis. It also provides a case study on what can be the role of logistics in the complex supply network of a global purchasing firm (Trent & Monczka, 2003). Lastly, it addresses a wider scope than that of the cases it is based on, thereby providing a general preliminary basis for any more detailed studies into one of the topics addressed. Next to this, it provides an approach that can be applied for other types of alternatives and innovations. The Mixed Method approach shows that neither a technical or institutional analysis solely suffices to analyse the possible change and performance induced by implementation of alternatives.

13.2 RECOMMENDATIONS

In this paragraph the recommendations following the conclusions are described.

13.2.1 FOR FURTHER RESEARCH

As described in the Chapter discussion, there are several limitation to this research. An important example is that to have a more realistic insight in whether or not Design Alternative 3, concerning Groupage at a Warehouse is an Alternative, the costs of the use of a warehouse should be included. Another aspect to be researched is the relation of transport efficiency to transport costs in more detail. Questions such as to what extent does a logistic service provider always charge the risk on empty mileage and when operation feasibility is rated low, does this impact the operation costs related to the integration. In this case, how can they be integrated in the total transport cost? Lastly, the fuel costs are included in the all-in transport cost price. However as the emission is reduced, we can assume the fuel use is reduced as well, an interesting question would be that if transport cost and fuel costs would be considered separate parameters, how would the preference of criteria change? And to what extent does the reduction in fuel use reduce the total transport cost?

13.2.2 FOR DANTRADE

To have a deeper insight in the possibility of integrating upstream transport in central procurement, a risk analysis for change to ExWorks and specifically on the combination of different goods in one truck may be required. To find feasible Alternatives on a day to day basis, investigation may be needed in time slot cycle optimization and how to combine suppliers without increasing the waiting time of a truck to an unacceptable level. An analysis of which Raw and Packaging materials can be combined in one truck regarding their quality requirements. A network mapping to see if any possibilities arise concerning the geographical location of Warehouses and supplier factories.

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APPENDICES

A. EMISSION FACTOR

The emission factor is an important parameter in the analysis.

" Data used is guidelines for measuring and managing CO2 emission from freight transport operations" (Cefic & ECTA, 2011)

There data is based on carbon emission factors for 40-44 tonne trucks with varying payloads and levels of empty running. Very applicable to this analysis. However this data is only available for a payload of 10 to 29 tonnes

To utilize this data for the full scope of research it is decided to be extrapolated for all possible payloads. Including 0.

Extrapolation is done through following steps. Data of one column is plotted. Several trend lines are analysed on fit.

See following results of trend line analysis:

The basic formula used where e= emission and W is payload

$$e = \tau W^6 + \varphi W^6 + \vartheta W^6 + \mu W^6 + \gamma W^6 + \beta W^6 + \alpha$$

		Number of polynomials				
Power	factor	6	5	4	3	2
W^6	τ	1,00E-06	0	0	0	0
W^5	φ	-2,00E-04	-3,00E-05	0	0	0
W^4	ϑ	1,01E-02	3,00E-03	5,00E-04	0	0
W^3	μ	-3,19E-01	-1,43E-01	-4,67E-02	-8,80E-03	0
W^2	γ	5,90E+00	3,52E+00	1,75E+00	6,81E-01	1,67E-01
W^1	β	-6,39E+01	-4,72E+01	-3,15E+01	-1,87E+01	-9,20E+00
W^0	α	3,88E+02	3,40E+02	2,86E+02	2,31E+02	1,76E+02
Fit Average		-347,125%	-55,730%	5,993%	-0,292%	-0,024%
Fit Stdev		421,563%	64,221%	6,240%	0,609%	2,000%

As a trend line with three polynomials has proven to be the best fit, considering standard deviation and average. This one is chosen to extrapolate the PL from 0 to 10 tonnes. When this is done for all variables this gives the following formulas:

levels of empty running	Trend line formula
0%	$y = -0,0066x^3 + 0,511x^2 - 13,982x + 175,67$
5%	$y = -0,0069x^3 + 0,5373x^2 - 14,723x + 184,48$
10%	$y = -0,0073x^3 + 0,5655x^2 - 15,515x + 193,99$
15%	$y = -0,0078x^3 + 0,6034x^2 - 16,524x + 205,36$
20%	y = -0,0083x3 + 0,6412x2 - 17,562x + 217,55
25%	$y = -0,0088x^3 + 0,6806x^2 - 18,695x + 231,25$
30%	y = -0,0095x3 + 0,7315x2 - 20,078x + 247,26
35%	$y = -0,0102x^3 + 0,7891x^2 - 21,648x + 265,58$
40%	$y = -0,0111x^3 + 0,8571x^2 - 23,51x + 287,22$
45%	$y = -0,0121x^3 + 0,9338x^2 - 25,645x + 312,44$
50%	$y = -0,0133x^3 + 1,0248x^2 - 28,176x + 342,43$

These formulas give the following graphical result:

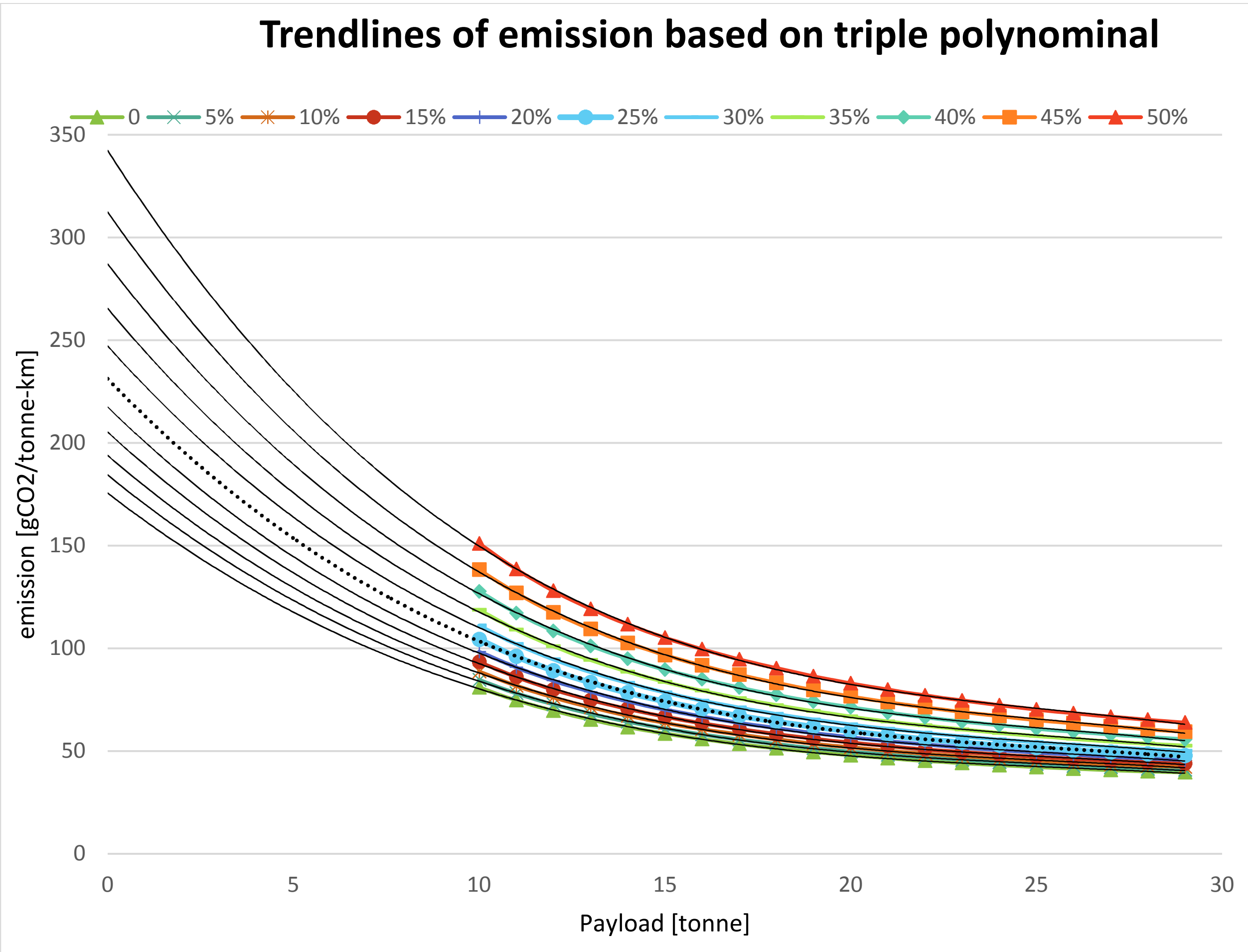
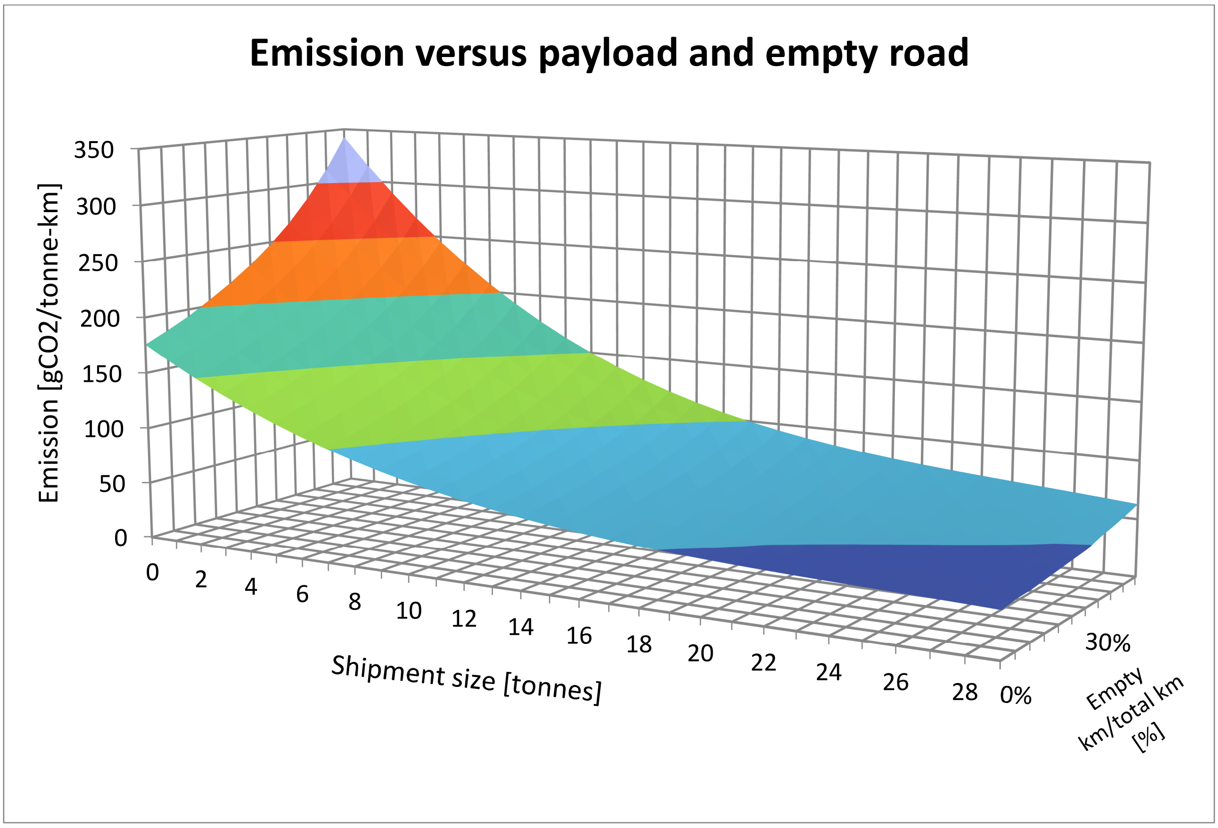


FIGURE 25 - POLYNOMIAL TREND LINES FOR EMISSION

The accuracy of fit for all the columns is as follows:

	0%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
fit average	0,57%	0,66%	0,59%	0,55%	0,54%	0,61%	0,85%	0,67%	0,63%	0,61%	0,62%
Fit Stdev	-0,283%	0,460%	-0,278%	-0,090%	-0,117%	-0,292%	-0,697%	0,366%	0,243%	0,107%	-0,155%

Finally giving the following 3D result, which nicely visualizes the fluent evolving of the factor



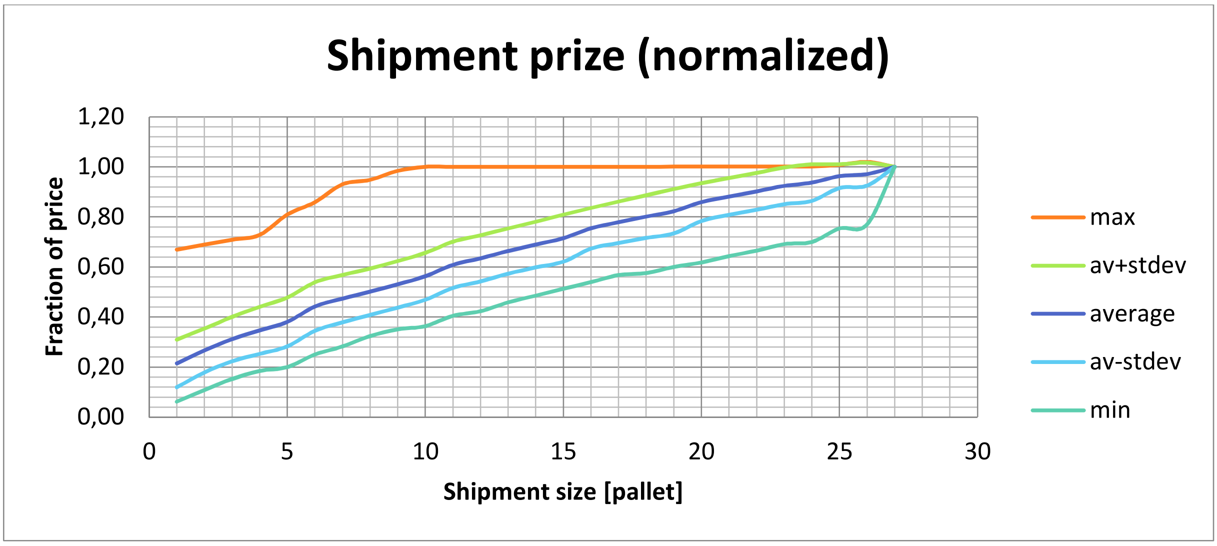
With this information the average emission is formed into a standardized factor which is easy to calculate with. The standard/mean is 25% empty running and a fill rate of 80% which is 19 tonnes if a maximum payload of 24 tonnes is considered.

Real values												
Payload		% of truck-kms run empty										
[%]	**[tonne]**	**0%**	**5%**	**10%**	**15%**	**20%**	**25%**	**30%**	**35%**	**40%**	**45%**	**50%**
0%	0	175,7	184,5	194,0	205,4	217,6	231,3	247,3	265,6	287,2	312,4	342,4
4%	1	162,2	170,3	179,0	189,4	200,6	213,2	227,9	244,7	264,6	287,7	315,3
8%	2	149,7	157,1	165,2	174,7	184,9	196,5	210,0	225,4	243,5	264,8	290,1
13%	3	138,1	145,0	152,3	161,0	170,4	181,1	193,4	207,5	224,1	243,6	266,8
17%	4	127,5	133,7	140,5	148,4	157,0	166,8	178,0	191,0	206,2	224,0	245,3
21%	5	117,7	123,4	129,6	136,9	144,7	153,7	164,0	175,8	189,7	206,0	225,5
25%	6	108,7	114,0	119,7	126,3	133,5	141,7	151,1	161,9	174,6	189,6	207,4
29%	7	100,6	105,4	110,6	116,6	123,2	130,7	139,3	149,2	160,8	174,5	190,9
33%	8	93,1	97,6	102,3	107,8	113,8	120,7	128,6	137,7	148,3	160,8	175,8
38%	9	86,4	90,5	94,8	99,8	105,4	111,7	118,9	127,2	137,0	148,5	162,2
42%	10	81,0	84,7	88,8	93,4	98,5	104,4	111,1	118,8	127,8	138,4	151,1
46%	11	74,8	78,2	81,9	86,1	90,8	96,1	102,1	109,1	117,3	127,0	138,6
50%	12	69,7	72,8	76,2	80,0	84,3	89,2	94,7	101,1	108,6	117,5	128,1
54%	13	65,4	68,2	71,4	74,9	78,9	83,4	88,5	94,4	101,3	109,5	119,3
58%	14	61,7	64,4	67,3	70,6	74,2	78,4	83,2	88,7	95,1	102,7	111,8
63%	15	58,6	61,0	63,8	66,8	70,3	74,2	78,6	83,7	89,7	96,8	105,3
67%	16	55,9	58,2	60,7	63,6	66,8	70,5	74,6	79,5	85,1	91,7	99,7
71%	17	53,5	55,7	58,1	60,8	63,8	67,2	71,2	75,7	81,0	87,2	94,7
75%	18	51,4	53,5	55,8	58,3	61,2	64,4	68,1	72,4	77,4	83,3	90,4
79%	19	49,6	51,5	53,7	56,1	58,8	61,9	65,4	69,5	74,2	79,8	86,5
83%	20	48,0	49,8	51,9	54,2	56,8	59,7	63,0	66,9	71,4	76,7	83,0
88%	21	46,6	48,3	50,3	52,5	54,9	57,7	60,9	64,5	68,8	73,9	80,0
92%	22	45,3	47,0	48,8	50,9	53,3	55,9	59,0	62,5	66,5	71,4	77,2
96%	23	44,2	45,8	47,6	49,6	51,8	54,3	57,2	60,6	64,5	69,1	74,7
100%	24	43,2	44,7	46,4	48,3	50,5	52,9	55,7	58,9	62,7	67,1	72,4
104%	25	42,3	43,8	45,4	47,3	49,3	51,7	54,3	57,4	61,0	65,2	70,3
108%	26	41,5	42,9	44,5	46,3	48,3	50,5	53,1	56,0	59,5	63,6	68,5
113%	27	40,8	42,2	43,7	45,4	47,3	49,5	52,0	54,8	58,1	62,1	66,8
117%	28	40,2	41,5	43,0	44,6	46,5	48,6	51,0	53,7	56,9	60,7	65,3
121%	29	39,7	41,0	42,4	44,0	45,7	47,8	50,1	52,7	55,8	59,5	63,9

Standardised values												
Payload		% of truck-kms run empty										
[%]	**[tonne]**	**0,00**	**0,05**	**0,10**	**0,15**	**0,20**	**0,25**	**0,30**	**0,35**	**0,40**	**0,45**	**0,50**
0%	0	2,84	2,98	3,13	3,32	3,51	3,74	3,99	4,29	4,64	5,05	5,53
4%	1	2,62	2,75	2,89	3,06	3,24	3,44	3,68	3,95	4,27	4,65	5,09
8%	2	2,42	2,54	2,67	2,82	2,99	3,17	3,39	3,64	3,93	4,28	4,69
13%	3	2,23	2,34	2,46	2,60	2,75	2,92	3,12	3,35	3,62	3,94	4,31
17%	4	2,06	2,16	2,27	2,40	2,54	2,69	2,88	3,08	3,33	3,62	3,96
21%	5	1,90	1,99	2,09	2,21	2,34	2,48	2,65	2,84	3,06	3,33	3,64
25%	6	1,76	1,84	1,93	2,04	2,16	2,29	2,44	2,62	2,82	3,06	3,35
29%	7	1,62	1,70	1,79	1,88	1,99	2,11	2,25	2,41	2,60	2,82	3,08
33%	8	1,50	1,58	1,65	1,74	1,84	1,95	2,08	2,22	2,40	2,60	2,84
38%	9	1,40	1,46	1,53	1,61	1,70	1,80	1,92	2,06	2,21	2,40	2,62
42%	10	1,31	1,37	1,43	1,51	1,59	1,69	1,79	1,92	2,06	2,24	2,44
46%	11	1,21	1,26	1,32	1,39	1,47	1,55	1,65	1,76	1,89	2,05	2,24
50%	12	1,13	1,18	1,23	1,29	1,36	1,44	1,53	1,63	1,75	1,90	2,07
54%	13	1,06	1,10	1,15	1,21	1,27	1,35	1,43	1,53	1,64	1,77	1,93
58%	14	1,00	1,04	1,09	1,14	1,20	1,27	1,34	1,43	1,54	1,66	1,81
63%	15	0,95	0,99	1,03	1,08	1,14	1,20	1,27	1,35	1,45	1,56	1,70
67%	16	0,90	0,94	0,98	1,03	1,08	1,14	1,21	1,28	1,37	1,48	1,61
71%	17	0,86	0,90	0,94	0,98	1,03	1,09	1,15	1,22	1,31	1,41	1,53
75%	18	0,83	0,86	0,90	0,94	0,99	1,04	1,10	1,17	1,25	1,35	1,46
79%	19	0,80	0,83	0,87	0,91	0,95	1,00	1,06	1,12	1,20	1,29	1,40
83%	20	0,78	0,80	0,84	0,88	0,92	0,96	1,02	1,08	1,15	1,24	1,34
88%	21	0,75	0,78	0,81	0,85	0,89	0,93	0,98	1,04	1,11	1,19	1,29
92%	22	0,73	0,76	0,79	0,82	0,86	0,90	0,95	1,01	1,07	1,15	1,25
96%	23	0,71	0,74	0,77	0,80	0,84	0,88	0,92	0,98	1,04	1,12	1,21
100%	24	0,70	0,72	0,75	0,78	0,82	0,85	0,90	0,95	1,01	1,08	1,17
104%	25	0,68	0,71	0,73	0,76	0,80	0,84	0,88	0,93	0,99	1,05	1,14
108%	26	0,67	0,69	0,72	0,75	0,78	0,82	0,86	0,90	0,96	1,03	1,11
113%	27	0,66	0,68	0,71	0,73	0,76	0,80	0,84	0,89	0,94	1,00	1,08
117%	28	0,65	0,67	0,69	0,72	0,75	0,79	0,82	0,87	0,92	0,98	1,05
121%	29	0,64	0,66	0,68	0,71	0,74	0,77	0,81	0,85	0,90	0,96	1,03

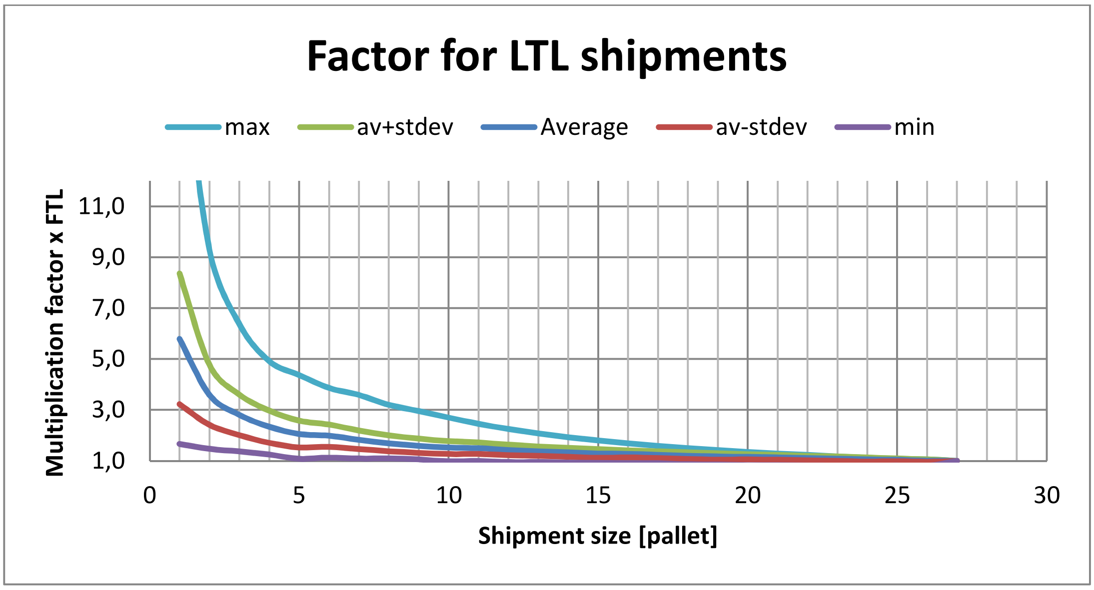
B. LTL FACTOR

This analysis is based on large amount of Tender Data, 600 quotations on 476 lanes, all separate quotations for 1 to 26 pallets. The quotations are for the full shipment. So generally a quotation for 15 pallets is higher than a quotations for 3 pallets. There is no average weight identified apart from the range 300-1000kg. It can therefore be assumed that suppliers consider bidding on pallet places. This is not clearly to be seen from the system diagram because it makes the overview unnecessarily detailed. This data is normalized to fit into the unit 0 to 1 where 1 displays the FTL load rate



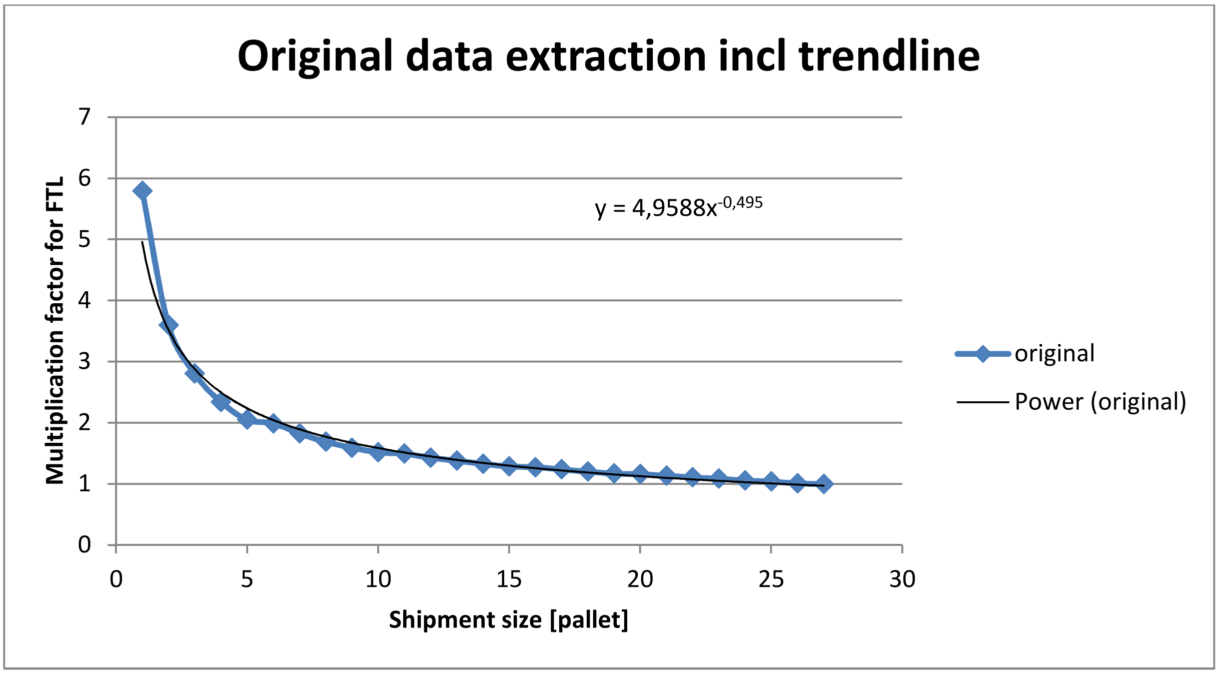
As can clearly be seen from this graph, suppliers exist that consider shipments of above 10 pallets the same price as for a FTL. However the majority does not so it still relevant to consider all shipment sizes.

To better point out the difference in price per pallet shipped the price per shipment is divided by the number of pallets and normalized where FTL is 1. This gives the following graphical result:

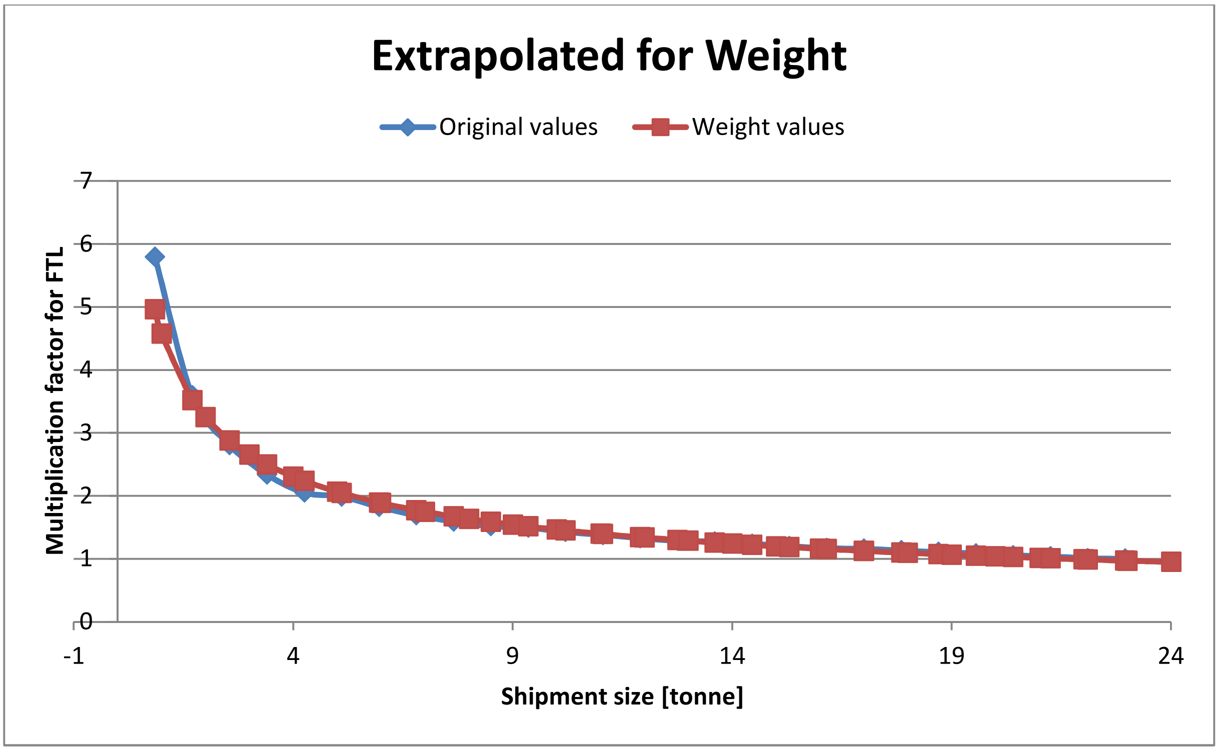


From this graph it can be derived that a shipment of 5 pallets is on average twice as expensive per pallet than a the shipment of a FTL per pallet.

Concerning pallet weight, there is not one rule that explains the weight of pallets. Packaging material could come in 24 pallets of 1 ton. However when it is preformed cups it will more likely be 30*0,5 tons. Then small shipment of ingredients such as flavours may be delicate material which is not easy to stack so will way 300kg per pallet. anything, to make parameter usable an average weight of 850kg is taken. Next, the current data per pallet is plotted and a trend line is inserted.

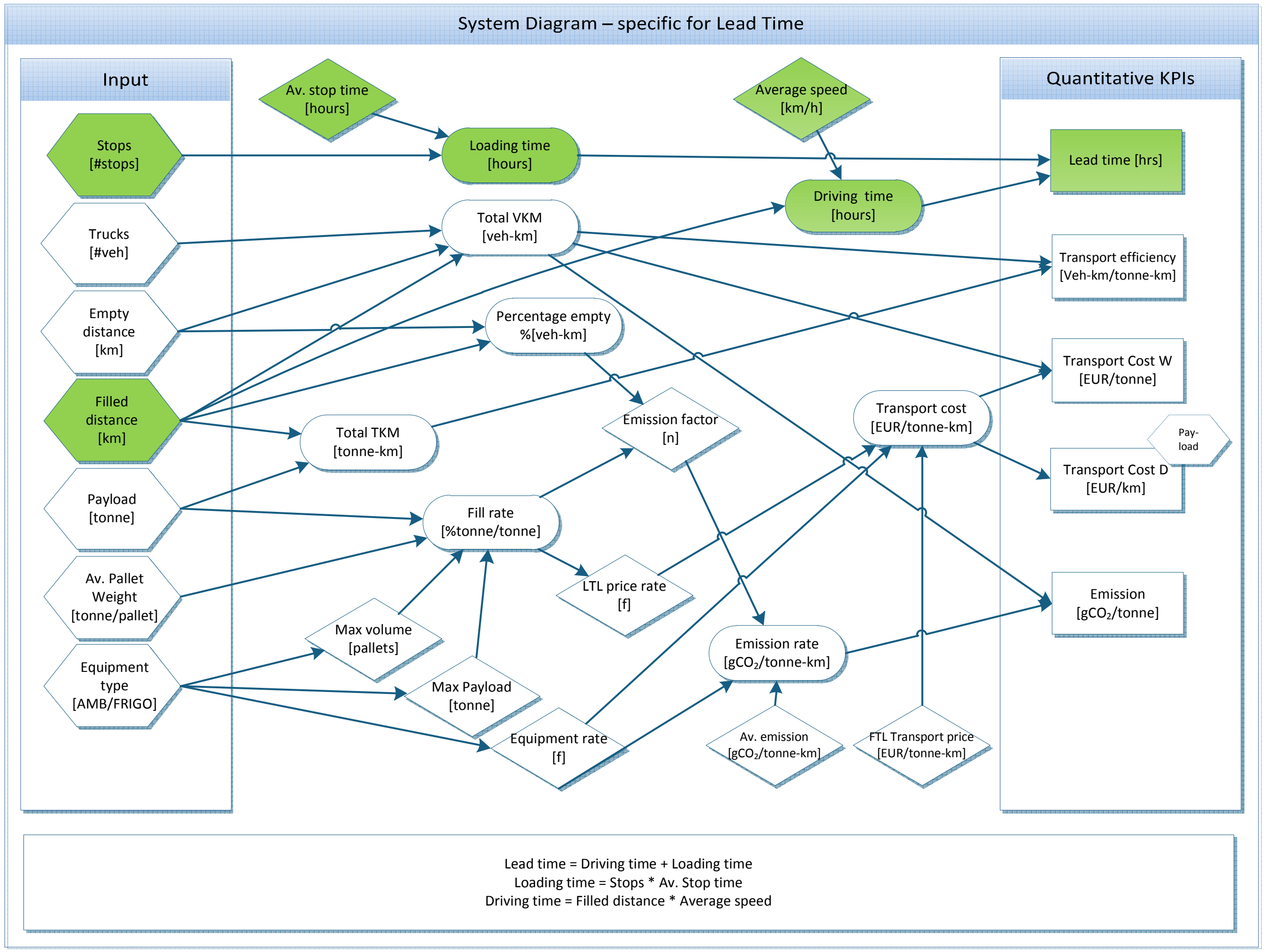


From this trend line, weight values can be assumed. (average pallet weight of 850 kg is taken into account. It is plotted below; a more fluent LTL price factor can be used for the calculations.



C. SYSTEM DIAGRAM – QUANTATIVE VARIABLES

FIGURE 26 - SYSTEM DIAGRAM - SPECIFIC FOR LEAD TIME



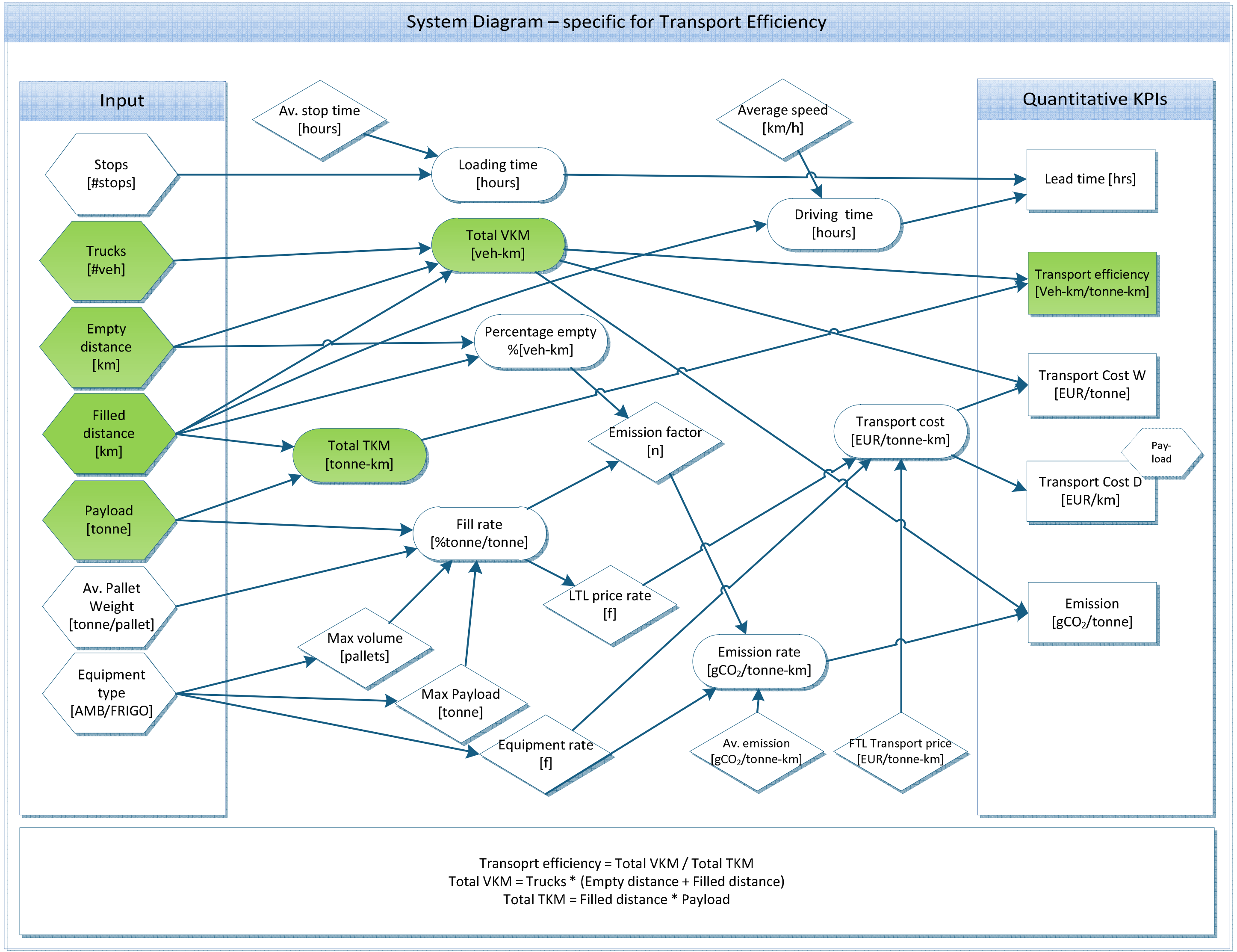


Figure 27 - System Diagram - specific for Transport Efficiency

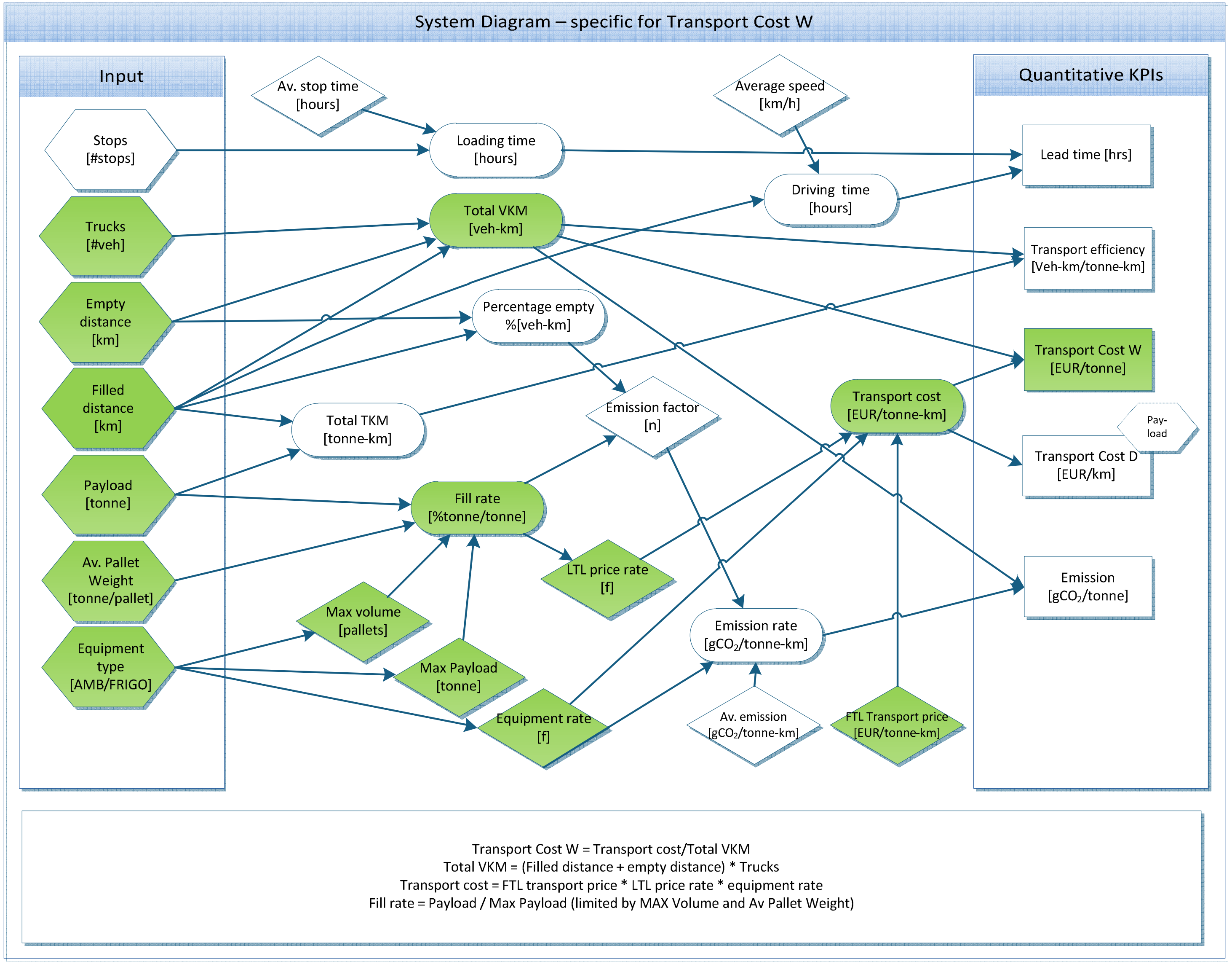


FIGURE 28 - SYSTEM DIAGRAM - SPECIFIC FOR TRANSPORT COST W

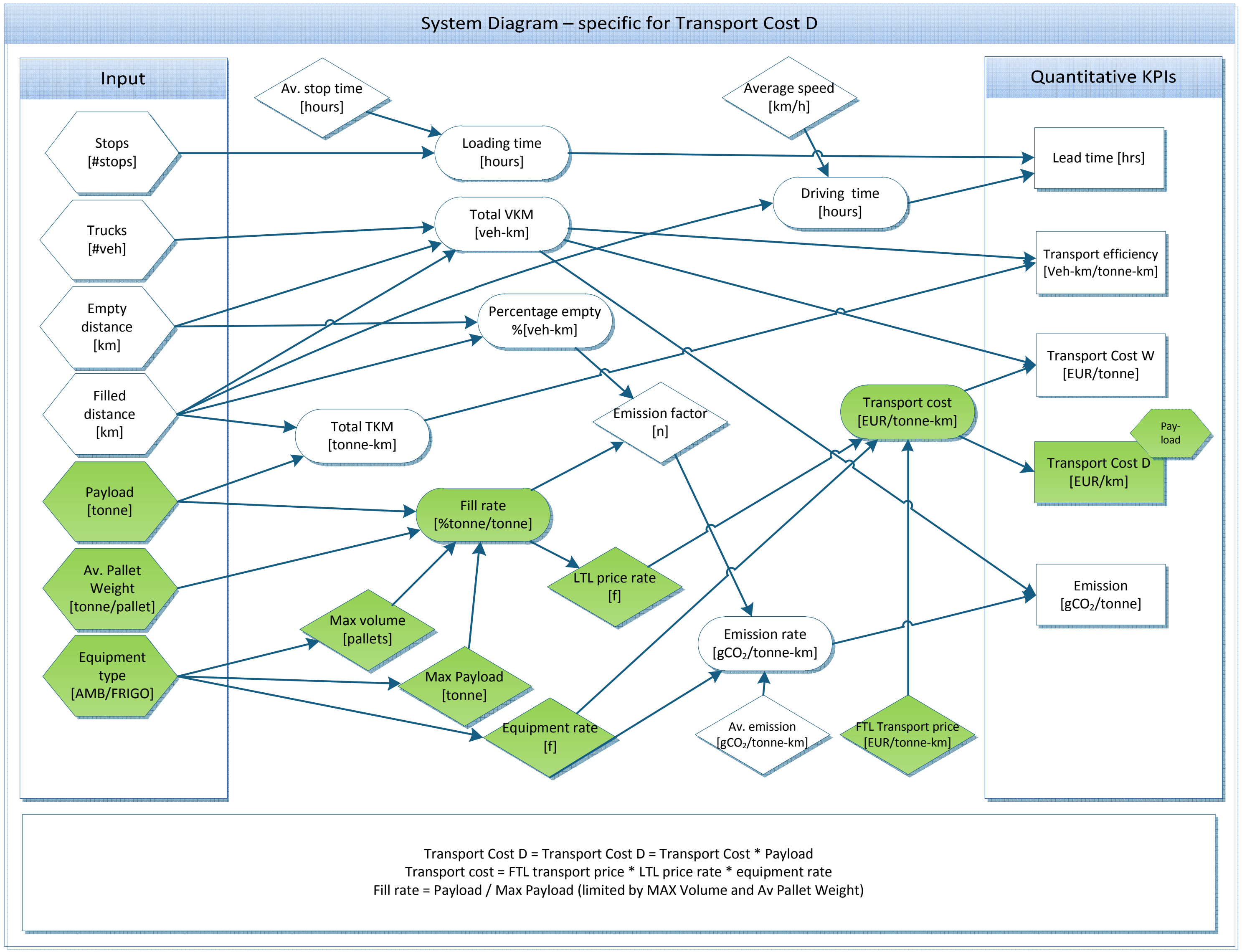


Figure 29 - System Diagram - specific for Transport Cost D

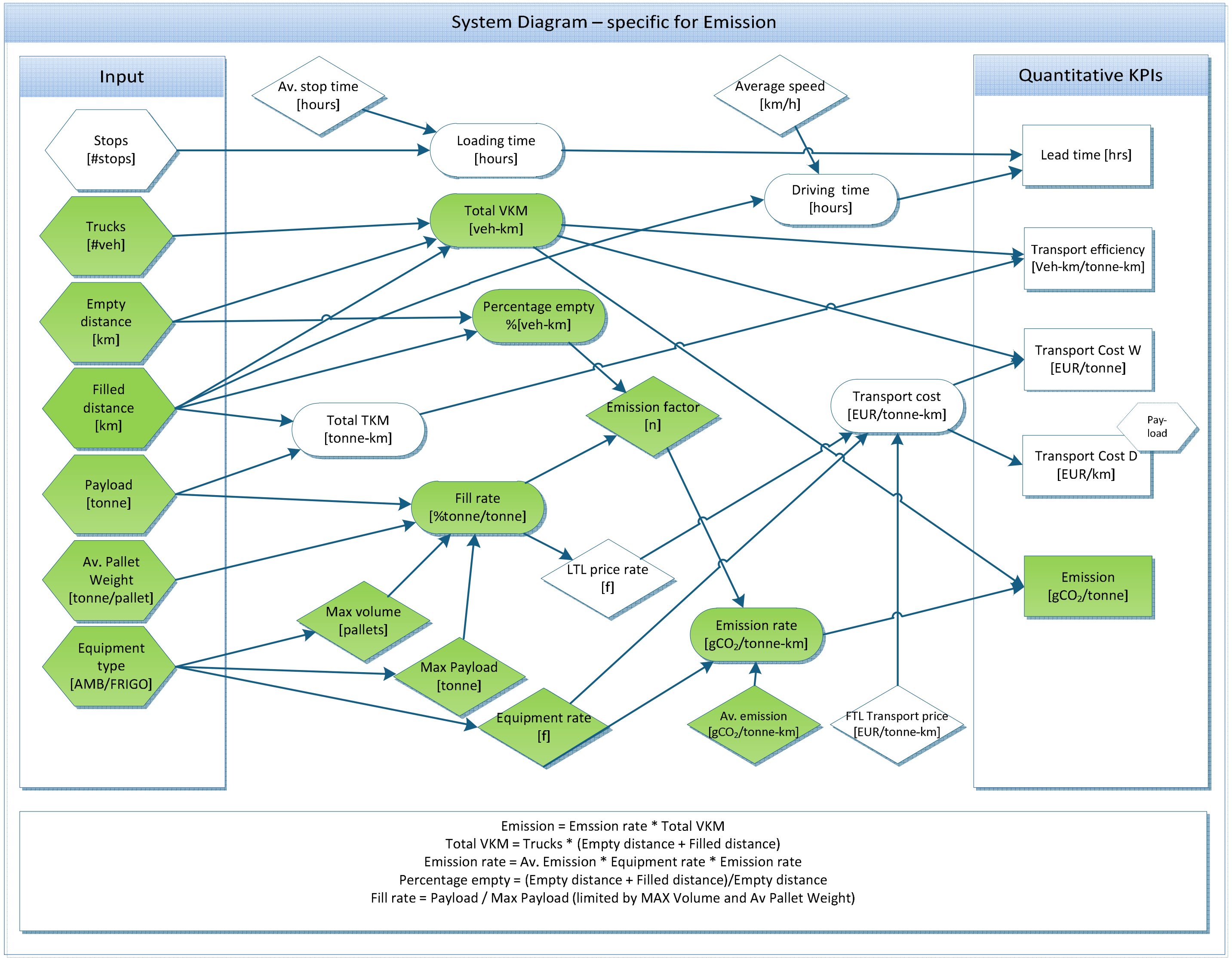


FIGURE 30 - SYSTEM DIAGRAM - SPECIFIC FOR EMISSION

D. APPENDIX - DESIGN ALTERNATIVE SELECTION

This appendix contains the detailed elaboration on how the specific Design Alternatives as described in Chapter 7 have been chosen. This appendix contains the detailed elaboration on how the specific Design Alternatives as described in Chapter 7 have been chosen.

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DESIGN SPACE AND FORMATION OF DESIGN ALTERNATIVES

The Design Space is formed using the parameters that can influence the Inputs of the System Diagram that eventually influence the KPIs, as presented in Table 31. In the first column of the Design Space, the Parameter ID can be found, followed by its name and description in columns 2 and 3. The fourth column displays the number of Options there exist for these Parameters. In case all combinations of Parameter Options are considered, this leads to 36 possibilities. This number is obtained by multiplying 3*3*2*2.

TABLE 31 - DESIGN SPACE INCLUDING NUMERIC IDS

ID	Parameter	Description	Size	Options	Options	Options
P1	Supplier combining*	*If there will be multiple suppliers combined using one truck, not necessarily at the same time*	3	P1.1 Single supplier	P1.2 Multi-Supplier - combined consecutively	P1.3 Multi-supplier - combined simultaneously
P2	Backload organising	*Concerning the filling of the truck at or close to the delivery location.*	3	P2.1 No backload	P2.2 Downstream backload	P2.3 Upstream backload
P3	Loading	*The location where the goods are loaded*	2	P3.1 Load at supplier	P3.2 Load at Hub	Table 31
P4	Stopping	*In case a backload is included this option will always be multiple stops.*	2	P4.1 Single	P4.2 Multiple	-

***** *A supplier is considered a single supply point of goods. Big companies can have multiple supply points. However if Company A has two factories, x and y. Company Ax and Company Ay are considered different suppliers.*

****** *Danone WH/cross-dock/ non-existing location*

Not all thirty-six alternatives will be considered for the implementation on the Selected Truck Types. This is due to the fact that the combination of some options is impossible. The options which are not compatible with one another and the reason for that follow:

- P1.1 with P2.3: As an upstream backload will have to be searched at a supplier, it is impossible to use a single supplier.
- P1.1 + P2.1 with P4.2: If there are no multiple loading points, doing multiple stops after loading is irrelevant.
- P1.3 + P3.1 with P4.1: If multiple suppliers are loaded in one truck and all goods are picked up at the supplier, multiple stops are obligatory.

- P1.2 with P2.1: In case multiple suppliers are transported by the same truck not at the same time, one will be considered backload
- P1.2 with P2.2: If a downstream load occupies the backload, there is no room for an upstream backload by an extra not-combined supplier.
- P2.2 with P4.1: Having a backload implies having more than one stop.
- P1.2 with P4.1: Having a backload implies having more than one stop.
- P1.1 with P3.2 and P1.2 with P3.2: It is possible to load at a Hub rather than at a supplier, however as there is a unique load in the truck this would shorten the total distance organised by Danone, however not the total distance. Also would it entail an additional coordination moment (namely the timing of arrival and departure), storage costs and organising effort.
- P2.1 + P3.2 with P4.2: Loading at a hub location to combine multiple loads in one truck is aimed at reducing the number of stops to a single one. Having multiple stops is therefore the contrary.

From these exclusions can be seen that Parameter 4 functions more as a consequence of the other parameters than as a parameter as such. Table 32 represents all possible combinations, the combinations which are not possible due to the incompatibilities as listed before, are highlighted in grey. The combinations highlighted in pink are the Design Alternatives, which will be considered for further analysis. The Design Alternatives highlighted in white are feasible however require the selection of both P1.2 and P1.3. They concern more complicated Design Alternatives and will also be described in Chapter 7.

TABLE 32 - OVERVIEW OF ALL COMBINATIONS OF PARAMETERS

Combi-nations	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Design Alternative?
COMBI 1	P1.1	P2.1	P3.1	P4.1	Design Alternative 0 - Current Situation
COMBI 2	P1.1	P2.1	P3.1	P4.2	
COMBI 3	P1.1	P2.1	P3.2	P4.1	.
COMBI 4	P1.1	P2.1	P3.2	P4.2	
COMBI 5	P1.1	P2.2	P3.1	P4.1	
COMBI 6	P1.1	P2.2	P3.1	P4.2	Design Alternative 2 - Downstream Backload
COMBI 7	P1.1	P2.2	P3.2	P4.1	
COMBI 8	P1.1	P2.2	P3.2	P4.2	
COMBI 9	P1.1	P2.3	P3.1	P4.1	
COMBI 10	P1.1	P2.3	P3.1	P4.2	
COMBI 11	P1.1	P2.3	P3.2	P4.1	
COMBI 12	P1.1	P2.3	P3.2	P4.2	
COMBI 13	P1.2	P2.1	P3.1	P4.1	
COMBI 14	P1.2	P2.1	P3.1	P4.2	
COMBI 15	P1.2	P2.1	P3.2	P4.1	
COMBI 16	P1.2	P2.1	P3.2	P4.2	
COMBI 17	P1.2	P2.2	P3.1	P4.1	
COMBI 18	P1.2	P2.2	P3.1	P4.2	
COMBI 19	P1.2	P2.2	P3.2	P4.1	
COMBI 20	P1.2	P2.2	P3.2	P4.2	
COMBI 21	P1.2	P2.3	P3.1	P4.1	
COMBI 22	P1.2	P2.3	P3.1	P4.2	Design Alternative 1 - Upstream Backload
COMBI 23	P1.2	P2.3	P3.2	P4.1	
COMBI 24	P1.2	P2.3	P3.2	P4.2	
COMBI 25	P1.3	P2.1	P3.1	P4.1	

COMBI 26	P1.3	P2.1	P3.1	P4.2	Design Alternative 3a – Milk Run
COMBI 27	P1.3	P2.1	P3.2	P4.1	Design Alternative 3b - Groupage
COMBI 28	P1.3	P2.1	P3.2	P4.2	
COMBI 29	P1.3	P2.2	P3.1	P4.1	
COMBI 30	P1.3	P2.2	P3.1	P4.2	Design Alternative 5 (if 1.2 included)
COMBI 31	P1.3	P2.2	P3.2	P4.1	
COMBI 32	P1.3	P2.2	P3.2	P4.2	Design Alternative 5 (if 1.2 included)
COMBI 33	P1.3	P2.3	P3.1	P4.1	
COMBI 34	P1.3	P2.3	P3.1	P4.2	Design Alternative 4 (if 1.2 included)
COMBI 35	P1.3	P2.3	P3.2	P4.1	Design Alternative 4 (if 1.2 included)
COMBI 36	P1.3	P2.3	P3.2	P4.2	Design Alternative 4 (if 1.2 included)

CROSS-DESIGN ALTERNATIVE COMBINATIONS

The selected basic Design Alternatives 1 to 3b, which are described in Chapter 7, are alternatives on a one-leg approach. In other words, they organise either a backload (Alternative 1 and 2) or they improve the initial load (Alternative 3a and 3b). Design Alternative 4 and 5 take both legs into account and can be assumed to be a combinations of two alternatives. Respectively Alternative 4 – extended milk-run is a combination of 1 and 3a while Alternative 5 – Hub shuttle is a combination of 2 and 3b. More combinations of Design Alternatives are possible and the full range of possibilities is presented in Table 32. The Cross-Alternative Combinations (XCOMBI) 1 and 2 represent Design Alternatives 4 and 5. As these XCOMBIs entail combinations between a load and a backload optimisation, it is possible to implement them on a two legged approach. Other XCOMBIs that are possible to implement on two legs are number 4,7,8 and 9. XCOMBI 4 is as feasible, however is much alike Design Alternative 5, without bringing the possible additional advantage of the use of the hub on both legs. The 7th XCOMBI may prove to be more difficult due to the obligatory return by Temperature Controlled equipment, this means all suppliers on the milk-run have to be able to be transported in Temperature Controlled equipment, as this is more complicated or less likely than the Design Alternative 4, it is not included as Design Alternative. XCOMBI 3, 5 and 6 include both backloads, which means to implement this at least three legs are needed. This also account for 8 and 9, as the optimisation of the load in two different ways is considered to be on two different legs. It could also be considered that there exists a hybrid version of the Groupage and the Milk-Run, for example several grouped loads are loaded consecutively at different locations. The reasons why these XCOMBIs are not taken into account as Design Alternatives is that all of them concern a vast amount more of coordination or orders and a requirement for geographical proximity of location. For this research, basic Design Alternatives 1 to 3b are considered for analysis, a combination of which can always be considered afterwards.

TABLE 33 – CROSS-ALTERNATIVE COMBINATIONS

	Design Alternative					
	1 Upstream Backload	2 Downstream Backload	3a Milk Run	3b Groupage	Legs	
XCOMBI 1	x		x		2	Design Alternative 4
XCOMBI 2		x		x	2	Design Alternative 5
XCOMBI 3	x	x			3	
XCOMBI	x			x	2	possible

4						
XCOMBI 5	x	x	x		3	
XCOMBI 6	x	x		x	3	
XCOMBI 7		x	x		2	diff because of frigo
XCOMBI 8	x		x	x	3	Complicated
XCOMBI 9		x	x	x	3	
XCOMBI 10			x	x	2	
XCOMBI 11	x	x	x	x	4	

E. MODEL FORMULAS

$t_{delivery} = \left(\frac{\left(n_{veh}(l_e + l_d)\right)}{v}\right) + n_{stops}t_{stop}$	KPI – Lead Time
$t_{delivery} = t_{driving} + t_{load}$	
$t_{driving} = v$	
$t_{load} = n_{stops} \times t_{stop}$	
$d_{veh} = n_{veh}(l_e + l_d)$	

$\varphi = \frac{n_{veh}(l_e + l_d)}{W l_d}$	KPI – Transport Efficiency
$\varphi = \frac{d_{veh}}{d_{tonne}}$	
$d_{tonne} = W l_d$	

$C_w = \beta P_t \times n_{veh}(l_e + l_d)$	KPI – Transport Cost per tonne
$C_w = C_t d_{veh}$	
$C_t = \beta P_t$	
$\eta_{fillrate} = \frac{W}{W_{max}}$	

$C_d = \beta P_t \times W$	KPI – Transport Cost per distance
$C_d = C_t W$	

$E_w = \alpha E e_{average} \times n_{veh}(l_e + l_d)$	KPI – Emission per tonne
$E_w = e_{real} d_{veh}$	
$e_{real} = \alpha e_{average}$	
$\eta_{lading} = \frac{l_e}{(l_e + l_f)}$	

F. VARIABLES

ID	Name	UOM	Type
n_{stops}	Extra stops	[stops]	Input
n_{veh}	Trucks	[veh]	Input
l_e	Empty distance	[km]	Input
l_f	Filled distance	[km]	Input
W	Payload	[tonne]	Input
m_{pallet}	Av. Pallet Weight	[tonne/pallet]	Input
α	Emission factor	[n]	Lookup factor
β	LTL price rate	[n]	Lookup factor
γ	Empty mileage risk	[%]	Lookup factor
	Equipment price rate	[n]	Lookup factor
t_{stop}	Av. Stop time	[hr]	Extern
v	Av. Speed	[km/hr]	Extern
P_t	FTL Transport price	[€/tonne-km]	Extern
W_{max}	Max Payload	[tonne]	Extern
X_{max}	Max volume	[pallet]	Extern
$e_{average}$	Av. Emission	[gCO2/tonne-km]	Extern
Xreal	Pallets in truck	[pallet]	Variables
Wreal	Real Max payload	[tonne]	Variables
t_{load}	Loading time	[hr]	Variables
d_{veh}	Total VKM	[veh-km]	Variables
d_{tonne}	Total TKM	[tonne-km]	Variables
$\eta_{fillrate}$	Fill Rate	[%tonne]	Variables
e_{real}	Emission rate	[gCO2/tonne-km]	Variables
C_t	Transport cost	[EUR/tonne-km]	Variables
$t_{driving}$	Driving time	[hr]	Variables
η_{lading}	Percentage empty	[%km]	Variables
$t_{delivery}$	Lead Time	[hr]	Quantitative KPIs
φ	Transport Efficiency	[veh-km/tonne-km]	Quantitative KPIs
C_w	Transport Cost W	[EUR/tonne]	Quantitative KPIs
C_d	Transport Cost D	[EUR/km]	Quantitative KPIs
E_w	Emission	[gCO2/tonne]	Quantitative KPIs

G. THE LOOK-UP SHEET

THE LOOKUP SHEET				Price Rate[1]	Emission rate[2]										
Payload					% of truck-kms run empty										
[tonne]	Pallets [0,3T]	Pallets [0,5T]	Pallets [0,85T]	[n]	0%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
0	0	0	0	0,00	2,84	2,98	3,13	3,32	3,51	3,74	3,99	4,29	4,64	5,05	5,53
1	4	2	2	4,58	2,62	2,75	2,89	3,06	3,24	3,44	3,68	3,95	4,27	4,65	5,09
2	7	4	3	3,25	2,42	2,54	2,67	2,82	2,99	3,17	3,39	3,64	3,93	4,28	4,69
3	10	6	4	2,66	2,23	2,34	2,46	2,60	2,75	2,92	3,12	3,35	3,62	3,94	4,31
4	14	8	5	2,30	2,06	2,16	2,27	2,40	2,54	2,69	2,88	3,08	3,33	3,62	3,96
5	17	10	6	2,06	1,90	1,99	2,09	2,21	2,34	2,48	2,65	2,84	3,06	3,33	3,64
6	20	12	8	1,88	1,76	1,84	1,93	2,04	2,16	2,29	2,44	2,62	2,82	3,06	3,35
7	24	14	9	1,75	1,62	1,70	1,79	1,88	1,99	2,11	2,25	2,41	2,60	2,82	3,08
8	27	16	10	1,63	1,50	1,58	1,65	1,74	1,84	1,95	2,08	2,22	2,40	2,60	2,84
9	30	18	11	1,54	1,40	1,46	1,53	1,61	1,70	1,80	1,92	2,06	2,21	2,40	2,62
10	34	20	12	1,46	1,31	1,37	1,43	1,51	1,59	1,69	1,79	1,92	2,06	2,24	2,44
11	37	22	13	1,40	1,21	1,26	1,32	1,39	1,47	1,55	1,65	1,76	1,89	2,05	2,24
12	40	24	15	1,34	1,13	1,18	1,23	1,29	1,36	1,44	1,53	1,63	1,75	1,90	2,07
13	44	26	16	1,29	1,06	1,10	1,15	1,21	1,27	1,35	1,43	1,53	1,64	1,77	1,93
14	47	28	17	1,24	1,00	1,04	1,09	1,14	1,20	1,27	1,34	1,43	1,54	1,66	1,81
15	50	30	18	1,20	0,95	0,99	1,03	1,08	1,14	1,20	1,27	1,35	1,45	1,56	1,70
16	54	32	19	1,16	0,90	0,94	0,98	1,03	1,08	1,14	1,21	1,28	1,37	1,48	1,61
17	57	34	20	1,13	0,86	0,90	0,94	0,98	1,03	1,09	1,15	1,22	1,31	1,41	1,53
18	60	36	22	1,09	0,83	0,86	0,90	0,94	0,99	1,04	1,10	1,17	1,25	1,35	1,46
19	64	38	23	1,07	0,80	0,83	0,87	0,91	0,95	1,00	1,06	1,12	1,20	1,29	1,40
20	67	40	24	1,04	0,78	0,80	0,84	0,88	0,92	0,96	1,02	1,08	1,15	1,24	1,34
21	70	42	25	1,01	0,75	0,78	0,81	0,85	0,89	0,93	0,98	1,04	1,11	1,19	1,29
22	74	44	26	1,00	0,73	0,76	0,79	0,82	0,86	0,90	0,95	1,01	1,07	1,15	1,25
23	77	46	28	1,00	0,71	0,74	0,77	0,80	0,84	0,88	0,92	0,98	1,04	1,12	1,21
24	80	48	29	1,00	0,70	0,72	0,75	0,78	0,82	0,85	0,90	0,95	1,01	1,08	1,17
Risk on empty milage[3]				-	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%

1) Based on Tender Data, 2) Based on CEFIC values based on McKinnon, 3, Based on research by van Rijnswou, 2012

H. MODEL – DETAILED IMPLEMENTATION

By use of Microsoft Office – Excel a full representation of the values indicated in the model are given in Table 34. The first 4 columns define the variables, representing the ID, full name, unit of measurement (UOM) and type of variable used).

TABLE 34 - TRUCK TYPES BASIC CALCULATIONS

				FTL AMB 24	FTL AMB 22	LTL AMB 10	LTL AMB 5	FTL FRIGO 22	LTL FRIGO 10	LTL FRIGO 5
ID	**Name**	**UOM**	**Type of variable**	**Ambient**	**Ambient**	**Ambient**	**Ambient**	**Frigo**	**Frigo**	**Frigo**
n_{stops}	Extra stops	[stops]	Input	1	1	1	1	1	1	1
n_{veh}	Trucks	[veh]	Input	1	1	1	1	1	1	1
l_e	Empty distance	[km]	Input	500	500	500	500	500	500	500
l_f	Filled distance	[km]	Input	500	500	500	500	500	500	500
W	Payload	[tonne]	Input	24	22	10	5	22	10	5
m_{pallet}	Av. Pallet Weight	[tonne/pallet]	Input	0,85	0,85	0,85	0,85	0,85	0,85	0,85
α	Emission factor	[n]	Lookup factor	1,17	1,25	2,44	3,64	1,25	2,44	3,64
β	LTL price rate	[n]	Lookup factor	1	1	1,46	2,06	1	1,34	1,75
γ	Empty mileage risk	[%]	Lookup factor	10%	10%	10%	10%	10%	10%	10%
	Equipment price rate	[n]	Lookup factor	1	1	1	1	1,1	1,1	1,1
t_{stop}	Av. Stop time	[hr]	Extern	1,5	1,5	1,5	1,5	1,5	1,5	1,5
v	Av. Speed	[km/hr]	Extern	65	65	65	65	65	65	65
P_t	FTL Transport price	[€/tonne-km]	Extern	0,04	0,04	0,04	0,04	0,04	0,04	0,04
W_{max}	Max Payload	[tonne]	Extern	24	24	24	24	22	22	22
X_{max}	Max volume	[pallet]	Extern	30	30	30	30	26	26	26
$e_{average}$	Av. Emission	[gCO2/tonne-km]	Extern	61,9	61,9	61,9	61,9	61,9	61,9	61,9
Xreal	Pallets in truck	[pallet]	Variables	29	26	12	6	26	12	6
Wreal	Real Max payload	[tonne]	Variables	24	24	24	24	22	22	22
t_{load}	Loading time	[hr]	Variables	1,5	1,5	1,5	1,5	1,5	1,5	1,5
d_{veh}	Total VKM	[veh-km]	Variables	1000	1000	1000	1000	1000	1000	1000
d_{tonne}	Total TKM	[tonne-km]	Variables	12000	11000	5000	2500	11000	5000	2500
$\eta_{fillrate}$	Fill Rate	[%tonne]	Variables	100%	92%	42%	21%	100%	45%	23%
e_{real}	Emission rate	[gCO2/tonne-km]	Variables	72,423	77,375	151,036	225,316	85,1125	166,1396	247,8476
C_t	Transport cost	[EUR/tonne-km]	Variables	0,04	0,04	0,04	0,04	0,04	0,04	0,04
$t_{driving}$	Driving time	[hr]	Variables	7,7	7,7	7,7	7,7	7,7	7,7	7,7
η_{lading}	Percentage empty	[%km]	Variables	50%	50%	50%	50%	50%	50%	50%
$t_{delivery}$	Lead Time	[hr]	KPI	9,19	9,19	9,19	9,19	9,19	9,19	9,19
γ	Transport Efficiency	[veh-km/tonne-km]	KPI	0,50	0,46	0,21	0,10	0,50	0,23	0,11
C_w	Transport Cost W	[EUR/tonne]	KPI	42,31	42,31	61,77	87,15	42,31	56,69	74,04
C_d	Transport Cost	[EUR/tonne-km]	KPI	0,04	0,04	0,06	0,09	0,04	0,06	0,07
E_w	Emission	[kgCO2/tonne]	KPI	72,4	77,4	151,0	225,3	85,1	166,1	247,8

From the 7 Truck types, 25 combinations can be made regarding the Design Alternatives as described in Chapter 7. To be able to compare the implementations of Design Alternatives with the current situation, the sum of two truck types without DA is calculated, the results of which are shown in

Table 36 and Table 37. The lower part of the tables represent the normalised values. The values have been normalised concerning the ranges as shown in Table 35.

Table 35 - Ranges for Normalisation of KPI values

RANGES			MIN	MAX	Source
Lead Time	[hr]	Quantitative KPIs	12,2	8,4	Logic (see validation)
Transport Efficiency	[veh-km/tonne-km]	Quantitative KPIs	0,02	1	Numbers based on the minimum transport efficiency if the backload is empty and only 1 tonne of goods is transported in a 24 tonne truck.
Transport Cost W	[EUR/tonne]	Quantitative KPIs	0,01	0,002	Tender information
Transport Cost	[EUR/tonnekm]	Quantitative KPIs	0,20152	0,04	Tender information
Emission	[kgCO2/tonne]	Quantitative KPIs	315	43	(Cefic & ECTA, 2011)
Operational feasibility	-	Quali	1	5	Likert Scale 1-5

Table 36 - Base case: representing the summed value of two trucks without any Design Alternative implemented

Truck 1	FTL AMB 24	FTL AMB 24	FTL AMB 24	FTL AMB 24	FTL AMB 22	FTL AMB 22	FTL AMB 22	FTL AMB 22	FTL AMB 22	FTL AMB 22	LTL AMB 10	LTL AMB 10	LTL AMB 10
Truck 2	FTL AMB 24	FTL AMB 22	LTL AMB 10	LTL AMB 5	FTL AMB 22	LTL AMB 10	LTL AMB 5	FTL FRIGO 22	LTL FRIGO 10	LTL FRIGO 5	LTL AMB 10	LTL AMB 5	FTL FRIGO 22
lead time = sum	9,19	9,19	9,19	9,19	9,19	9,19	9,19	9,19	9,19	9,19	9,19	9,19	9,19
Transport Efficiency	0,50	0,48	0,35	0,30	0,46	0,33	0,28	0,48	0,34	0,29	0,21	0,16	0,35
Transport Cost W	42,31	42,31	52,04	64,73	42,31	52,04	64,73	42,31	49,50	58,17	61,77	74,46	52,04
Transport Cost D	0,04	0,04	0,05	0,06	0,04	0,05	0,06	0,04	0,05	0,06	0,06	0,07	0,05
Emission	72	75	112	149	77	114	151	81	122	163	151	188	118
lead time = sum	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79
Transport Efficiency	0,49	0,47	0,34	0,29	0,45	0,32	0,27	0,47	0,33	0,27	0,19	0,14	0,34
Transport Cost	0,98	0,98	0,92	0,84	0,98	0,92	0,84	0,98	0,93	0,88	0,86	0,78	0,92
Emission	0,89	0,88	0,75	0,61	0,87	0,74	0,60	0,86	0,71	0,56	0,60	0,47	0,72

Table 37 - Base case (continued.)

Truck 1	LTL AMB 10	LTL AMB 10	LTL AMB 5	LTL AMB 5	LTL AMB 5	LTL AMB 5	FTL FRIGO 22	FTL FRIGO 22	FTL FRIGO 22	LTL FRIGO 10	LTL FRIGO 10	LTL FRIGO 5
Truck 2	LTL FRIGO 10	LTL FRIGO 5	LTL AMB 5	FTL FRIGO 22	LTL FRIGO 10	LTL FRIGO 5	FTL FRIGO 22	LTL FRIGO 10	LTL FRIGO 5	LTL FRIGO 10	LTL FRIGO 5	LTL FRIGO 5
lead time = sum	9,19	9,19	9,19	9,19	9,19	9,19	9,19	9,19	9,19	9,19	9,19	9,19
Transport Efficiency	0,22	0,16	0,10	0,30	0,17	0,11	0,50	0,36	0,31	0,23	0,17	0,11
Transport Cost W	59,23	67,90	87,15	64,73	71,92	80,60	42,31	49,50	58,17	56,69	65,37	74,04
Transport Cost D	0,06	0,07	0,09	0,06	0,07	0,08	0,04	0,05	0,06	0,06	0,07	0,07
Emission	159	199	225	155	196	237	85	126	166	166	207	248
lead time = sum	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79

Transport Efficiency	0,20	0,14	0,09	0,29	0,15	0,09	0,49	0,35	0,29	0,21	0,15	0,10
Transport Cost	0,87	0,82	0,70	0,84	0,79	0,74	0,98	0,93	0,88	0,89	0,84	0,78
Emission	0,58	0,42	0,33	0,59	0,44	0,29	0,85	0,70	0,55	0,55	0,40	0,25

The same combinations are used to implement the Design Alternatives where possible. Whether it is possible to implement a Design Alternative or not can be found in Chapter 8.3. The implementation is not just the sum of the KPIs, it leads to different input values and lookup factors. As described in the System Diagram. An overview of the Input variables and the found lookup factors is presented below.

TABLE 38 - DESIGN ALTERNATIVE 1 - MODEL INPUT

ID	FTL AMB 24	FTL AMB 24	FTL AMB 24	FTL AMB 24	FTL AMB 22	FTL AMB 22	FTL AMB 22	FTL AMB 22	FTL AMB 22	FTL AMB 22	LTL AMB 10	LTL AMB 10	LTL AMB 10
	FTL AMB 24	FTL AMB 22	LTL AMB 10	LTL AMB 5	FTL AMB 22	LTL AMB 10	LTL AMB 5	FTL FRIGO 22	LTL FRIGO 10	LTL FRIGO 5	LTL AMB 10	LTL AMB 5	FTL FRIGO 22
Description	**Ambient**	**Ambient**	**Ambient**	**Ambient**	**Ambient**	**Ambient**	**Ambient**	**Frigo**	**Frigo**	**Frigo**	**Ambient**	**Ambient**	**Frigo**
Extra stops	2	2	2	2	2	2	2	2	2	2	2	2	2
Trucks	1	1	1	1	1	1	1	1	1	1	1	1	1
Empty distance	100	100	100	100	100	100	100	100	100	100	100	100	100
Filled distance	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Payload	48	46	34	29	44	32	27	44	32	27	20	15	32
Av. Pallet Weight	0,85	0,85	0,85	0,85	0,85	0,85	0,85	0,85	0,85	0,85	0,85	0,85	0,85
Emission factor	0,75	0,77	0,94	1,03	0,79	0,98	1,09	0,79	0,98	1,09	1,43	1,65	0,98
LTL price rate	1,00	1,00	1,13	1,20	1,00	1,16	1,24	1,00	1,09	1,16	1,46	1,63	1,09
Empty mileage risk	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Equipment price rate	1	1	1	1	1	1	1	1,1	1,1	1,1	1	1	1,1

TABLE 39 - DESIGN ALTERNATIVE 2 - MODEL INPUT

	FTL FRIGO 22	FTL FRIGO 22	FTL FRIGO 22	FTL AMB 22	LTL AMB 10	LTL AMB 5
	FTL FRIGO 22	LTL FRIGO 10	LTL FRIGO 5	FTL FRIGO 22	FTL FRIGO 22	FTL FRIGO 22
Description	**Frigo**	**Frigo**	**Frigo**	**Frigo**	**Frigo**	**Frigo**
Extra stops	1	1	1	1	1	1
Trucks	1	1	1	1	1	1
Empty distance	0	0	0	0	0	0
Filled distance	1000	1000	1000	1000	1000	1000
Payload	44	32	27	44	32	27
Av. Pallet Weight	0,85	0,85	0,85	0,85	0,85	0,85
Emission factor	0,70	0,86	0,90	0,70	0,86	0,90
LTL price rate	1,00	1,09	1,16	1,00	1,09	1,16
Empty mileage risk	0%	0%	0%	0%	0%	0%
Equipment price rate	1,1	1,1	1,1	1,1	1,1	1,1

TABLE 40 - DESIGN ALTERNATIVE 3 – MODEL INPUT

ID		LTL AMB 10	LTL AMB 10	LTL AMB 10	LTL AMB 10	LTL AMB 5	LTL AMB 5	LTL AMB 5	LTL FRIGO 10	LTL FRIGO 10	LTL FRIGO 5
		LTL AMB 10	LTL AMB 5	LTL FRIGO 10	LTL FRIGO 5	LTL AMB 5	LTL FRIGO 10	LTL FRIGO 5	LTL FRIGO 10	LTL FRIGO 5	LTL FRIGO 5
Description		**Ambient**	**Ambient**	**Frigo**	**Frigo**	**Ambient**	**Frigo**	**Frigo**	**Frigo**	**Frigo**	**Frigo**
Extra stops		2	2	2	2	2	2	2	2	2	2
Trucks		1	1	1	1	1	1	1	1	1	1
Empty distance		500	500	500	500	500	500	500	500	500	500
Filled distance		550	550	550	550	550	550	550	550	550	550
Payload		20	15	20	15	10	15	10	20	15	10
Av. Pallet Weight		0,85	0,85	0,85	0,85	0,85	0,85	0,85	0,85	0,85	0,85
Emission factor		1,34	1,65	1,43	1,65	2,09	1,65	2,09	1,43	1,65	2,09
LTL price rate		1,04	1,20	1,04	1,20	1,46	1,20	1,46	1,04	1,20	1,46
Empty mileage risk		10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Equipment price rate		1	1	1,1	1,1	1	1,1	1,1	1,1	1,1	1,1

The model output is as follows:

TABLE 41 - MODEL OUTPUT DA 1 (PART 1)

Truck Category	**FTL**	**FTL**	**COMBI**	**COMBI**	**FTL**	**COMBI**	**COMBI**	**FTL-FRIGO**	**COMBI-FRIGO**	**COMBI-FRIGO**	**LTL**	**LTL**
Normal and standardized values for option 1	FTL AMB 24	FTL AMB 24	FTL AMB 24	FTL AMB 24	FTL AMB 22	FTL AMB 22	FTL AMB 22	FTL AMB 22	FTL AMB 22	FTL AMB 22	LTL AMB 10	LTL AMB 10
Alternative 1	FTL AMB 24	FTL AMB 22	LTL AMB 10	LTL AMB 5	FTL AMB 22	LTL AMB 10	LTL AMB 5	FTL FRIGO 22	LTL FRIGO 10	LTL FRIGO 5	LTL AMB 10	LTL AMB 5
lead time = sum	9,19	9,19	9,19	9,19	9,19	9,19	9,19	9,19	9,19	9,19	9,19	9,19
Transport Efficiency	0,91	0,87	0,64	0,55	0,83	0,61	0,51	0,91	0,66	0,56	0,38	0,28
Transport Cost	0,04	0,04	0,04	0,05	0,04	0,05	0,05	0,04	0,04	0,05	0,06	0,06
Emission	51,07	52,43	64,00	70,18	53,68	66,77	74,03	59,05	73,45	81,43	97,68	112,56
lead time = sum	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79
Transport Efficiency	0,91	0,87	0,64	0,54	0,83	0,60	0,50	0,91	0,65	0,55	0,37	0,27
Transport Cost	1,00	1,00	0,97	0,95	1,00	0,96	0,94	1,00	0,98	0,96	0,89	0,85
Emission	0,97	0,97	0,92	0,90	0,96	0,91	0,89	0,94	0,89	0,86	0,80	0,74

TABLE 42 - MODEL OUTPUT DA 1 (PART 2)

Truck Category	**COMBI-FRIGO**	**LTL-FRIGO**	**LTL-FRIGO**	**LTL**	**COMBI-FRIGO**	**LTL-FRIGO**	**LTL-FRIGO**	**FTL-FRIGO**	**COMBI-FRIGO**	**COMBI-FRIGO**	**LTL-FRIGO**	**LTL-FRIGO**	**LTL-FRIGO**
	LTL AMB 10	LTL AMB 10	LTL AMB 10	LTL AMB 5	LTL AMB 5	LTL AMB 5	LTL AMB 5	FTL FRIGO 22	FTL FRIGO 22	FTL FRIGO 22	LTL FRIGO 10	LTL FRIGO 10	LTL FRIGO 5
Alternative 1	FTL FRIGO 22	LTL FRIGO 10	LTL FRIGO 5	LTL AMB 5	FTL FRIGO 22	LTL FRIGO 10	LTL FRIGO 5	FTL FRIGO 22	LTL FRIGO 10	LTL FRIGO 5	LTL FRIGO 10	LTL FRIGO 5	LTL FRIGO 5
lead time = sum	9,19	9,19	9,19	9,19	9,19	9,19	9,19	9,19	9,19	9,19	9,19	9,19	9,19
Transport Efficiency	0,66	0,41	0,31	0,19	0,56	0,31	0,21	0,91	0,66	0,56	0,41	0,31	0,21
Transport Cost	0,04	0,05	0,06	0,07	0,05	0,06	0,07	0,04	0,04	0,05	0,05	0,06	0,07
Emission	73,45	107,45	123,81	142,60	81,43	123,81	156,86	59,05	73,45	81,43	107,45	123,81	156,86
lead time = sum	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79
Transport Efficiency	0,65	0,40	0,30	0,17	0,55	0,30	0,19	0,91	0,65	0,55	0,40	0,30	0,19
Transport Cost	0,98	0,92	0,89	0,82	0,96	0,89	0,82	1,00	0,98	0,96	0,92	0,89	0,82
Emission	0,89	0,76	0,70	0,63	0,86	0,70	0,58	0,94	0,89	0,86	0,76	0,70	0,58

TABLE 43 - MODEL OUTPUT DA 2

Truck Category	FTL-FRIGO	COMBI-FRIGO	COMBI-FRIGO	FTL-FRIGO	COMBI-FRIGO	COMBI-FRIGO
	FTL FRIGO 22	FTL FRIGO 22	FTL FRIGO 22	FTL AMB 22	LTL AMB 10	LTL AMB 5
Alternative 1	FTL FRIGO 22	LTL FRIGO 10	LTL FRIGO 5	FTL FRIGO 22	FTL FRIGO 22	FTL FRIGO 22
lead time = sum	8,44	8,44	8,44	8,44	8,44	8,44
Transport Efficiency	1,00	0,73	0,61	1,00	0,73	0,61
Transport Cost	0,04	0,04	0,04	0,04	0,04	0,04
Emission	47,66	58,56	61,28	47,66	58,56	61,28
lead time = sum	0,99	0,99	0,99	0,99	0,99	0,99
Transport Efficiency	1,00	0,72	0,61	1,00	0,72	0,61
Transport Cost	1,00	0,98	0,96	1,00	0,98	0,96
Emission	0,98	0,94	0,93	0,98	0,94	0,93

TABLE 44 - MODEL OUTPUT DA 3

Truck Category	LTL	LTL	LTL-FRIGO	LTL-FRIGO	LTL	LTL-FRIGO	LTL-FRIGO	LTL-FRIGO	LTL-FRIGO	LTL-FRIGO
Normal and standardized values for Alternative 1	LTL AMB 10	LTL AMB 10	LTL AMB 10	LTL AMB 10	LTL AMB 5	LTL AMB 5	LTL AMB 5	LTL FRIGO 10	LTL FRIGO 10	LTL FRIGO 5
Alternative 1	LTL AMB 10	LTL AMB 5	LTL FRIGO 10	LTL FRIGO 5	LTL AMB 5	LTL FRIGO 10	LTL FRIGO 5	LTL FRIGO 10	LTL FRIGO 5	LTL FRIGO 5
lead time = sum	11,46	11,46	11,46	11,46	11,46	11,46	11,46	11,46	11,46	11,46
Transport Efficiency	0,40	0,30	0,43	0,32	0,20	0,32	0,22	0,43	0,32	0,22
Transport Cost	0,04	0,05	0,04	0,05	0,06	0,05	0,06	0,04	0,05	0,06
Emission	87,15	107,44	102,56	118,18	136,12	118,18	149,73	102,56	118,18	149,73
lead time = sum	0,19	0,19	0,19	0,19	0,19	0,19	0,19	0,19	0,19	0,19
Transport Efficiency	0,38	0,28	0,42	0,31	0,18	0,31	0,20	0,42	0,31	0,20
Transport Cost	0,97	0,93	0,97	0,93	0,86	0,93	0,86	0,97	0,93	0,86
Emission	0,84	0,76	0,78	0,72	0,66	0,72	0,61	0,78	0,72	0,61

These values are averaged for truck categories per variable.

TABLE 45 - UNWEIGHTED VALUES PER DA AND TRUCK CATEGORY

Lead Time	FTL	COMBI	LTL	FTL-FRIGO	COMBI-FRIGO	LTL-FRIGO
Base	0,79	0,79	0,79	0,79	0,79	0,79
DA 1	0,79	0,79	0,79	0,79	0,79	0,79
DA 2				0,99	0,99	
DA 3			0,19			0,19
Transport Efficiency	FTL	COMBI	LTL	FTL-FRIGO	COMBI-FRIGO	LTL-FRIGO
Base	0,47	0,30	0,14	0,48	0,31	0,15
DA 1	0,87	0,57	0,27	0,91	0,60	0,30
DA 2				1,00	0,66	
DA 3			0,18			0,31
Transport Cost	FTL	COMBI	LTL	FTL-FRIGO	COMBI-FRIGO	LTL-FRIGO
Base	0,98	0,88	0,78	0,98	0,90	0,82
DA 1	1,00	0,95	0,85	1,00	0,97	0,88
DA 2				1,00	0,97	
DA 3			0,86			0,92
Emissions	FTL	COMBI	LTL	FTL-FRIGO	COMBI-FRIGO	LTL-FRIGO
Base	0,88	0,67	0,47	0,85	0,64	0,42
DA 1	0,97	0,91	0,73	0,94	0,87	0,69
DA 2				0,98	0,94	
DA 3			0,66			0,71
Operational Feasibility	FTL	COMBI	LTL	FTL-FRIGO	COMBI-FRIGO	LTL-FRIGO
Base	0,50	0,50	0,50	0,50	0,50	0,50
DA 1	0,42	0,42	0,42	0,42	0,42	0,42
DA 2	0,42			0,42	0,42	
DA 3a			0,33			0,33
DA 3b			0,58			0,58

I. PREFERENCE QUESTIONNAIRES

CRITERIA RATING

Criteria	In the report the descriptions are as follows:
Lead time	The time in hours that the product will travel
Transport cost	The cost per tonne of product
Reduction of emissions	The reduction in emissions per tonne of product
Operational feasibility	How feasible the integration is rated for both internal and external parties (qualitative)

1 *(please fill in purple cells)*

Which criterium do you find MOST important concerning upstream transport?
Which criterium do you find LEAST important concerning upstream transport?

2 *(please fill in purple cells)*

Comparing to the most important criterium: , how would you rate the following criteria?		
0		Lead time
0		Transport cost
0		Reduction of emissions
0		Operational feasibility

3 *(please fill in purple cells)*

Comparing to the least important criterium: , how would you rate the following criteria?		
Lead time		0
Transport cost		0
Reduction of emissions		0
Operational feasibility		0

The questionnaires has been filled in together with the participants in a face-to face session on June 2nd, 2015.

CRITERIA RATING - Function: Global Logistics Manager

Criteria	In the report the descriptions are as follows:
Lead time	The time in hours that the product will travel
Transport cost	The cost per tonne of product
Reduction of emissions	The reduction in emissions per tonne of product
Operational feasibility	How feasible the integration is rated for both internal and external parties (qualitative)

1 *(please fill in purple cells)*

Which criterium do you find MOST important concerning upstream transport?
Transport cost
Which criterium do you find LEAST important concerning upstream transport?
Reduction of emissions

2 *(please fill in purple cells)*

Comparing to the most important criterium: Transport cost, how would you rate the following criteria?		
Transport cost	1. equally as important as	Lead time
Transport cost		Transport cost
Transport cost	7. strongly more important than	Reduction of emissions
Transport cost	3. slightly more important than	Operational feasibility

3 *(please fill in purple cells)*

Comparing to the least important criterium: Reduction of emissions, how would you rate the following criteria?		
Lead time	2. equally to slightly more important than	Reduction of emissions
Transport cost		Reduction of emissions
Reduction of emissions		Reduction of emissions
Operational feasibility	3. slightly more important than	Reduction of emissions

Notes: An increase in lead time is not important, the predictability of lead time however is a very important factor. Whether or not deliveries can be anticipated upon is the most important.

CRITERIA RATING - Function: Change Manager

Criteria	In the report the descriptions are as follows:
Lead time	The time in hours that the product will travel
Transport cost	The cost per tonne of product
Reduction of emissions	The reduction in emissions per tonne of product
Operational feasibility	How feasible the integration is rated for both internal and external parties (qualitative)

1 *(please fill in purple cells)*

Which criterium do you find MOST important concerning upstream transport?
Operational feasibility
Which criterium do you find LEAST important concerning upstream transport?
Reduction of emissions

2 *(please fill in purple cells)*

Comparing to the most important criterium: Operational feasibility, how would you rate the following criteria?		
Operational feasibility	4. slightly to reasonably more important than	Lead time
Operational feasibility	4. slightly to reasonably more important than	Transport cost
Operational feasibility	6. reasonably to strongly more important than	Reduction of emissions
Operational feasibility		Operational feasibility

3 *(please fill in purple cells)*

Comparing to the least important criterium: Reduction of emissions, how would you rate the following criteria?		
Lead time	3. slightly more important than	Reduction of emissions
Transport cost	4. slightly to reasonably more important than	Reduction of emissions
Reduction of emissions		Reduction of emissions
Operational feasibility		Reduction of emissions

CRITERIA RATING - Function: I2M Project Manager

Criteria	In the report the descriptions are as follows:
Lead time	The time in hours that the product will travel
Transport cost	The cost per tonne of product
Reduction of emissions	The reduction in emissions per tonne of product
Operational feasibility	How feasible the integration is rated for both internal and external parties (qualitative)

1 *(please fill in purple cells)*

Which criterium do you find MOST important concerning upstream transport?
Transport cost
Which criterium do you find LEAST important concerning upstream transport?
Reduction of emissions

2 *(please fill in purple cells)*

Comparing to the most important criterium: Transport cost, how would you rate the following criteria?		
Transport cost	3. slightly more important than	Lead time
Transport cost		Transport cost
Transport cost	7. strongly more important than	Reduction of emissions
Transport cost	1. equally as important as	Operational feasibility

3 *(please fill in purple cells)*

Comparing to the least important criterium: Reduction of emissions, how would you rate the following criteria?		
Lead time	6. reasonably to strongly more important than	Reduction of emissions
Transport cost		Reduction of emissions
Reduction of emissions		Reduction of emissions
Operational feasibility	7. strongly more important than	Reduction of emissions

CRITERIA RATING - Function: fictional

Criteria	In the report the descriptions are as follows:
Lead time	The time in hours that the product will travel
Transport cost	The cost per tonne of product
Reduction of emissions	The reduction in emissions per tonne of product
Operational feasibility	How feasible the integration is rated for both internal and external parties (qualitative)

1 *(please fill in purple cells)*

Which criterium do you find MOST important concerning upstream transport?
Reduction of emissions
Which criterium do you find LEAST important concerning upstream transport?
Lead time

2 *(please fill in purple cells)*

Comparing to the most important criterium: Reduction of emissions, how would you rate the following criteria?		
Reduction of emissions	8. strongy to infinitely more important than	Lead time
Reduction of emissions	4. slightly to reasonably more important than	Transport cost
Reduction of emissions		Reduction of emissions
Reduction of emissions	2. equally to slightly more important than	Operational feasibility

3 *(please fill in purple cells)*

Comparing to the least important criterium: Lead time, how would you rate the following criteria?		
Lead time		Lead time
Transport cost	3. slightly more important than	Lead time
Reduction of emissions		Lead time
Operational feasibility	4. slightly to reasonably more important than	Lead time

J. DETERMINATION OF WEIGHTS IN THE MCDA

The increased performance by the implementation of a Design Alternative on a Truck Category is determined by the its normalised scores on the performance indicators multiplied by a weight. The weights are used to indicate the decision makers' preference of one criteria over another. As indicated before, the weights for the criteria are determined by using the linear form of the Best-Worst Method (BWM), which uses pairwise comparison to determine the weights belonging to the preference of decision makers (Rezaei, 2015a). The linear model results in a unique solution for the weights, rather than ranges of weights which result from the non-linear application. Although ranges of weights may provide very valuable information in terms of variance in the preferences of decision makers, in this case a unique solution is preferred. The unique solution is preferred as it permits to draw more simple and clear comparisons between decision makers (Rezaei, 2015b). In this Appendix, a description is given of the implementation of the BWM.

THE BEST-WORST METHOD

There are five performance indicators in this research of which four are decision criteria. These are: lead time (c1), transport cost (c2), emissions (c3), operational feasibility (c4). This results in the following Matrix where a_{ij} shows the preference from criterion i over criterion j. The Pairwise comparison is done on a 1/9 to 9 scale. The values 1 to 9 represent the following preferences based on a Likert scale. The numbers are given names to provide better comprehension by decision makers when indicating preferences.

1. equally as important as
2. equally to slightly more important than
3. slightly more important than
4. slightly to reasonably more important than
5. reasonably more important than
6. reasonably to strongly more important than
7. strongly more important than
8. strongly to infinitely more important than
9. infinitely more important than

Following BWM, the following steps are taken. Firstly, out of the set of criteria the best and worst, or in this case the most and least important, are identified by the decision maker. The most important criterion is defined as c_b and the least important criterion as c_w. Next, the preference of c_b over all other criteria is indicated. Then, the preferences of all criteria, except c_b over c_w are determined.

Following the linear model, the optimal weights are determined by minimizing the maximum value of the absolute differences regarding criterion j.

$$\min \max_j \{|w_B - a_{Bj}w_j|, |w_j - a_{jW}w_W|\} \quad (J.1)$$

s.t.

$$\sum_j w_j = 1 \quad (J.2)$$

To obtain the values in the linear case, the following formulas are prescribed:

Which is subject to:

$$|w_B - a_{Bj}w_j| \leq \xi^L, \text{ for all } j \quad (J.3)$$

$$|w_j - a_{jW}w_W| \leq \xi^L, \text{ for all } j \quad (J.4)$$

By minimising the consistency indicator ξ^L, the optimal weights for c_n are found.

APPLICATION TO THE RESEARCH

In the case, the preferences of three decision makers are determined as well as for one fictional case. Together with the decision maker, the questionnaires in Appendix x were filled. The solutions were found by using the Excel Solver. Here below, the calculations and resulting weights for the four perspectives are presented. The consistency indicator ξ^{L*} is also indicated. The closer to zero the higher the level of consistency.

$$a_{Bj} \times a_{jW} = a_{BW} \quad (J.5)$$

When the preference of the best criterion over criterion j and the preference of criterion j over the worst criterion together has the same value as the preference of the best over the worst criterion, the pairwise comparison is fully consistent and the consistency indicator (ξ^{L*}) will be equal to zero.

Decision maker 1 – General Project Management perspective

Decision maker 1 indicated operational feasibility (c4) as the most important criterion and emissions (c3) as the least important. The biggest difference indicated (a_{BW}) is 6. In this linear model, a consistency indicator here is 0,125. This inconsistency could be attributed by the preferences regarding both lead time (c1) and transport costs (c2), the products of which are respectively 12 and 16 rather than 6.

The MOST IMPORTANT criterion	C1 – lead time	C2 – transport cost	C3 - emissions	C4 – operational feasibility
C4 – operational feasibility	4	4	6	1

The LEAST IMPORTANT criterion	C3 - emissions
C1 – lead time	3
C2 – transport cost	4
C3 - emissions	1
C4 – operational feasibility	6

TABLE 46 - PREFERENCES OF GENERAL PM PERSPECTIVE

Results:
$w_1^* = 0{,}175$ $w_2^* = 0{,}175$ $w_3^* = 0{,}075$ $w_4^* = 0{,}575$ $\xi^{L*} = 0{,}125$

TABLE 47 - RESULTING WEIGHTS GENERAL PM PERSPECTIVE

Decision maker 2 – Global Logistics Management perspective

The maximum difference between the most important criterion transport cost (c2) and the least important criterion emissions (c3) is 7. The consistency indicator is slightly higher than in the first perspective. This is might be due to the inconsistency in the preferences indicated on lead time (c1), where the product of the preferences is 4 rather than 7.

The MOST IMPORTANT criterion	C1 – lead time	C2 – transport cost	C3 - emissions	C4 – operational feasibility
C2 – transport cost	1	1	7	3

The LEAST IMPORTANT criterion	C3 - emissions
C1 – lead time	2
C2 – transport cost	7
C3 - emissions	1
C4 – operational feasibility	3

TABLE 48 - PREFERENCES OF GLOBAL LOGISTICS PERSPECTIVE

Results:
$w_1^* = 0{,}2973$ $w_2^* = 0{,}4324$ $w_3^* = 0{,}0811$ $w_4^* = 0{,}1892$ $\xi^{L*} = 0{,}1351$

TABLE 49 - RESULTING WEIGHTS GLOBAL LOGISTICS PERSPECTIVE

Decision maker 3 – I2M Project Team Perspective

The I2M project team perspective is similar to that of the Global Logistics management. However the transport cost and operational feasibility are indicated to be of the same importance. The consistency indicator has a value of 0,0948. This could be due to the inconsistency regarding lead time (c1) of which the product is 18 rather than 7.

The MOST IMPORTANT criterion	C1 – lead time	C2 – transport cost	C3 - emissions	C4 – operational feasibility
C2 – transport cost	3	1	7	1

The LEAST IMPORTANT criterion	C1 – lead time
C1 – lead time	6
C2 – transport cost	7
C3 - emissions	1
C4 – operational feasibility	7

TABLE 50 - PREFERENCES OF I2M PROJECT PERSPECTIVE

Results:

$w_1^* = 0{,}1638$
$w_2^* = 0{,}3966$
$w_3^* = 0{,}0431$
$w_4^* = 0{,}3966$

$\xi^{L*} = 0{,}0948$

TABLE 51 - RESULTING WEIGHTS I2M PROJECT PERSPECTIVE

Integrated DT Perspective

As all three real perspectives concern DanTrade, also an integrated perspective is constructed. This is done by taking the average values of the first three perspectives. Which results in the following weights:

Criteria	General PM	Global Logistics	I2M Project	Integrated DanTrade	Sustainable
Lead Time	0,175	0,2973	0,1638	0,21	0,071
Transport Cost	0,175	0,4324	0,3966	0,33	0,143
Emissions	0,075	0,0811	0,0431	0,07	0,500
Operational Feasibility	0,575	0,1892	0,3966	0,39	0,286

Decision maker 4 – Sustainable Fictional Case

The maximum preference that is indicated in the fictional case is 8. This is slightly larger than the differences indicated in the three real preference perspectives. A large difference can result in clearly distinct values. The consistency indicator is not equal to zero, this may be due to the inconsistency in the preferences on transport cost, of which the product is 12 rather than 8.

The MOST IMPORTANT criterion	C1 – lead time	C2 – transport cost	C3 - emissions	C4 – operational feasibility
C3 - emissions	8	4	1	2

The LEAST IMPORTANT criterion	C1 – lead time
C1 – lead time	1
C2 – transport cost	3
C3 - emissions	8
C4 – operational feasibility	4

TABLE 52 - PREFERENCES OF FICTIONAL PERSPECTIVE

Results:

$w_1^* = 0{,}06$
$w_2^* = 0{,}14$
$w_3^* = 0{,}52$
$w_4^* = 0{,}28$

$\xi^{L*} = 0{,}04$

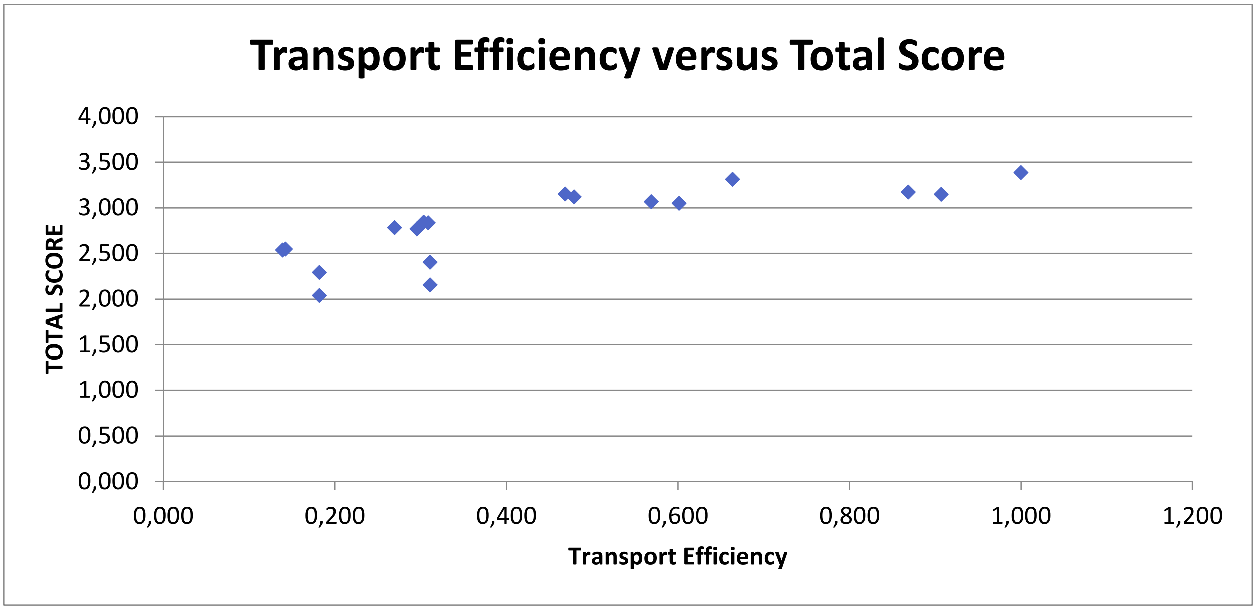
CONCLUSIONS

In all real perspectives there exists inconsistency concerning the preferences on lead time (c1). This is consistent with the feedback given on this key performance indicator i.e. that the lead time itself is not the performance indicator, but that the predictability of the lead time is indicating the performance. Furthermore both logistics perspectives i.e. the Global Logistics perspective and the I2M Project

K. DETAILED RESULTS

UNWEIGHTED						
FTL		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
	Transport Efficiency	0,469	0,869			
	Lead Time	0,791	0,791			
	Transport Cost	0,976	0,998			
	Emissions	0,883	0,965			
	Operational Feasibility	0,500	0,417			
	TOTAL	3,151	3,171			
COMBI		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
	Transport Efficiency	0,304	0,569			
	Lead Time	0,791	0,791			
	Transport Cost	0,878	0,955			
	Emissions	0,674	0,905			
	Operational Feasibility	0,500	0,417			
	TOTAL	2,844	3,068			
LTL		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
	Transport Efficiency	0,139	0,269		0,182	0,182
	Lead Time	0,791	0,791		0,194	0,194
	Transport Cost	0,779	0,851		0,856	0,856
	Emissions	0,466	0,726		0,658	0,658
	Operational Feasibility	0,500	0,417		0,333	0,583
	TOTAL	2,537	2,785		2,041	2,291
FTL-FRIGO		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
	Transport Efficiency	0,479	0,907	1,000		
	Lead Time	0,791	0,791	0,989		
	Transport Cost	0,976	0,998	1,000		
	Emissions	0,852	0,941	0,983		
	Operational Feasibility	0,500	0,417	0,417		
	TOTAL	3,120	3,147	3,388		
COMBI-FRIGO		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
	Transport Efficiency	0,312	0,602	0,664		
	Lead Time	0,791	0,791	0,989		
	Transport Cost	0,896	0,967	0,970		
	Emissions	0,637	0,873	0,938		
	Operational Feasibility	0,500	0,417	0,417		
	TOTAL	2,825	3,049	3,313		
LTL-FRIGO		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
	Transport Efficiency	0,149	0,296		0,311	0,311
	Lead Time	0,791	0,791		0,194	0,194
	Transport Cost	0,819	0,877		0,918	0,918
	Emissions	0,417	0,685		0,709	0,709
	Operational Feasibility	0,500	0,417		0,333	0,583
	TOTAL	2,527	2,770		2,155	2,405

Original scores – Alternative 3a.3b are worse than base case. Except Alternative 3b for LTL Frigo



Transport Efficiency is not given any weight as it is not a criteria, as it is not a decision criterion. It is an indicator of performance. To measure the correlation between TE and the total score of the four decision criteria, the Pearson correlation efficient (.79) is measured. The high correlation can be explained by the fact that transport cost and emissions both are derived from fill rate and rate of lading as well as Transport Efficiency.

TABLE 53 - WEIGHTS PERSPECTIVES

	Perspectives				
Criteria	General Project Manager	Global Logistics Manager	I2M Project Team	*Integrated*	Sustainable
Lead Time	0,18	0,30	0,16	*0,21*	0,06
Transport Cost	0,18	0,43	0,40	*0,33*	0,14
Emissions	0,08	0,08	0,04	*0,07*	0,52
Operational Feasibility	0,58	0,19	0,40	*0,39*	0,28
Consistency Indicator (etha)	0,125	0,1351	0,948	*n/a*	0,04

Results with criteria

WEIGHTED Global Logistics Manager						
FTL		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,47	0,87			
0,30	Lead Time	0,24	0,24			
0,43	Transport Cost	0,42	0,43			
0,08	Emissions	0,07	0,08			
0,19	Operational Feasibility	0,09	0,08			
1,00	TOTAL	0,82	0,82			
COMBI		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,30	0,57			
0,30	Lead Time	0,24	0,24			
0,43	Transport Cost	0,38	0,41			
0,08	Emissions	0,05	0,07			
0,19	Operational Feasibility	0,09	0,08			
	TOTAL	0,76	0,80			
LTL		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,14	0,27		0,18	0,18
0,30	Lead Time	0,24	0,24		0,06	0,06
0,43	Transport Cost	0,34	0,37		0,37	0,37
0,08	Emissions	0,04	0,06		0,05	0,05
0,19	Operational Feasibility	0,09	0,08		0,06	0,11
	TOTAL	0,70	0,74		0,54	0,59
FTL-FRIGO		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,48	0,91	1,00		
0,30	Lead Time	0,24	0,24	0,29		
0,43	Transport Cost	0,42	0,43	0,43		
0,08	Emissions	0,07	0,08	0,08		
0,19	Operational Feasibility	0,09	0,08	0,08		
	TOTAL	0,82	0,82	0,88		
COMBI-FRIGO		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,31	0,60	0,66		
0,30	Lead Time	0,24	0,24	0,29		
0,43	Transport Cost	0,39	0,42	0,42		
0,08	Emissions	0,05	0,07	0,08		
0,19	Operational Feasibility	0,09	0,08	0,08		
	TOTAL	0,77	0,80	0,87		
LTL-FRIGO		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,15	0,30		0,31	0,31
0,30	Lead Time	0,24	0,24		0,06	0,06
0,43	Transport Cost	0,35	0,38		0,40	0,40
0,08	Emissions	0,03	0,06		0,06	0,06
0,19	Operational Feasibility	0,09	0,08		0,06	0,11
	TOTAL	0,72	0,75		0,58	0,62

WEIGHTED General Project Manager (Change Manager)						
FTL		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,47	0,87			
0,18	Lead Time	0,14	0,14			
0,18	Transport Cost	0,17	0,17			
0,08	Emissions	0,07	0,07			
0,58	Operational Feasibility	0,29	0,24			
1,00	TOTAL	0,66	0,63			
COMBI		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,30	0,57			
0,18	Lead Time	0,14	0,14			
0,18	Transport Cost	0,15	0,17			
0,08	Emissions	0,05	0,07			
0,58	Operational Feasibility	0,29	0,24			
	TOTAL	0,63	0,61			
LTL		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,14	0,27		0,18	0,18
0,18	Lead Time	0,14	0,14		0,03	0,03
0,18	Transport Cost	0,14	0,15		0,15	0,15
0,08	Emissions	0,03	0,05		0,05	0,05
0,58	Operational Feasibility	0,29	0,24		0,19	0,34
	TOTAL	0,60	0,58		0,42	0,57
FTL-FRIGO		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,48	0,91	1,00		
0,18	Lead Time	0,14	0,14	0,17		
0,18	Transport Cost	0,17	0,17	0,18		
0,08	Emissions	0,06	0,07	0,07		
0,58	Operational Feasibility	0,29	0,24	0,24		
	TOTAL	0,66	0,62	0,66		
COMBI-FRIGO		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,31	0,60	0,66		
0,18	Lead Time	0,14	0,14	0,17		
0,18	Transport Cost	0,16	0,17	0,17		
0,08	Emissions	0,05	0,07	0,07		
0,58	Operational Feasibility	0,29	0,24	0,24		
	TOTAL	0,63	0,61	0,65		
LTL-FRIGO		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,15	0,30		0,31	0,31
0,18	Lead Time	0,14	0,14		0,03	0,03
0,18	Transport Cost	0,14	0,15		0,16	0,16
0,08	Emissions	0,03	0,05		0,05	0,05
0,58	Operational Feasibility	0,29	0,24		0,19	0,34
	TOTAL	0,60	0,58		0,44	0,58

WEIGHTED I2M Project Team						
FTL		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,47	0,87			
0,16	Lead Time	0,13	0,13			
0,40	Transport Cost	0,39	0,40			
0,04	Emissions	0,04	0,04			
0,40	Operational Feasibility	0,20	0,17			
1,00	TOTAL	0,75	0,73			
COMBI		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,30	0,57			
0,16	Lead Time	0,13	0,13			
0,40	Transport Cost	0,35	0,38			
0,04	Emissions	0,03	0,04			
0,40	Operational Feasibility	0,20	0,17			
	TOTAL	0,71	0,71			
LTL		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,14	0,27		0,18	0,18
0,16	Lead Time	0,13	0,13		0,03	0,03
0,40	Transport Cost	0,31	0,34		0,34	0,34
0,04	Emissions	0,02	0,03		0,03	0,03
0,40	Operational Feasibility	0,20	0,17		0,13	0,23
	TOTAL	0,66	0,66		0,53	0,63
FTL-FRIGO		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,48	0,91	1,00		
0,16	Lead Time	0,13	0,13	0,16		
0,40	Transport Cost	0,39	0,40	0,40		
0,04	Emissions	0,04	0,04	0,04		
0,40	Operational Feasibility	0,20	0,17	0,17		
	TOTAL	0,75	0,73	0,77		
COMBI-FRIGO		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,31	0,60	0,66		
0,16	Lead Time	0,13	0,13	0,16		
0,40	Transport Cost	0,36	0,38	0,38		
0,04	Emissions	0,03	0,04	0,04		
0,40	Operational Feasibility	0,20	0,17	0,17		
	TOTAL	0,71	0,72	0,75		
LTL-FRIGO		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,15	0,30		0,31	0,31
0,16	Lead Time	0,13	0,13		0,03	0,03
0,40	Transport Cost	0,32	0,35		0,36	0,36
0,04	Emissions	0,02	0,03		0,03	0,03
0,40	Operational Feasibility	0,20	0,17		0,13	0,23
	TOTAL	0,67	0,67		0,56	0,66

WEIGHTED Integrated DanTrade						
FTL		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,47	0,87			
0,21	Lead Time	0,17	0,17			
0,33	Transport Cost	0,33	0,33			
0,07	Emissions	0,06	0,06			
0,39	Operational Feasibility	0,19	0,16			
1,00	TOTAL	0,75	0,73			

COMBI		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,30	0,57			
0,21	Lead Time	0,17	0,17			
0,33	Transport Cost	0,29	0,32			
0,07	Emissions	0,04	0,06			
0,39	Operational Feasibility	0,19	0,16			
	TOTAL	0,70	0,71			

LTL		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,14	0,27		0,18	0,18
0,21	Lead Time	0,17	0,17		0,04	0,04
0,33	Transport Cost	0,26	0,28		0,29	0,29
0,07	Emissions	0,03	0,05		0,04	0,04
0,39	Operational Feasibility	0,19	0,16		0,13	0,23
	TOTAL	0,65	0,66		0,50	0,60

FTL-FRIGO		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,48	0,91	1,00		
0,21	Lead Time	0,17	0,17	0,21		
0,33	Transport Cost	0,33	0,33	0,33		
0,07	Emissions	0,06	0,06	0,07		
0,39	Operational Feasibility	0,19	0,16	0,16		
	TOTAL	0,74	0,73	0,77		

COMBI-FRIGO		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,31	0,60	0,66		
0,21	Lead Time	0,17	0,17	0,21		
0,33	Transport Cost	0,30	0,32	0,32		
0,07	Emissions	0,04	0,06	0,06		
0,39	Operational Feasibility	0,19	0,16	0,16		
	TOTAL	0,70	0,71	0,76		

LTL-FRIGO		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,15	0,30		0,31	0,31
0,21	Lead Time	0,17	0,17		0,04	0,04
0,33	Transport Cost	0,27	0,29		0,31	0,31
0,07	Emissions	0,03	0,05		0,05	0,05
0,39	Operational Feasibility	0,19	0,16		0,13	0,23
	TOTAL	0,66	0,67		0,52	0,62

WEIGHTED Sustainable						
FTL		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,47	0,87			
0,06	Lead Time	0,05	0,05			
0,14	Transport Cost	0,14	0,14			
0,52	Emissions	0,46	0,50			
0,28	Operational Feasibility	0,14	0,12			
1,00	TOTAL	0,78	0,81			
COMBI		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,30	0,57			
0,06	Lead Time	0,05	0,05			
0,14	Transport Cost	0,12	0,13			
0,52	Emissions	0,35	0,47			
0,28	Operational Feasibility	0,14	0,12			
	TOTAL	0,66	0,77			
LTL		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,14	0,27		0,18	0,18
0,06	Lead Time	0,05	0,05		0,01	0,01
0,14	Transport Cost	0,11	0,12		0,12	0,12
0,52	Emissions	0,24	0,38		0,34	0,34
0,28	Operational Feasibility	0,14	0,12		0,09	0,16
	TOTAL	0,54	0,66		0,57	0,64
FTL-FRIGO		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,48	0,91	1,00		
0,06	Lead Time	0,05	0,05	0,06		
0,14	Transport Cost	0,14	0,14	0,14		
0,52	Emissions	0,44	0,49	0,51		
0,28	Operational Feasibility	0,14	0,12	0,12		
	TOTAL	0,77	0,79	0,83		
COMBI-FRIGO		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,31	0,60	0,66		
0,06	Lead Time	0,05	0,05	0,06		
0,14	Transport Cost	0,13	0,14	0,14		
0,52	Emissions	0,33	0,45	0,49		
0,28	Operational Feasibility	0,14	0,12	0,12		
	TOTAL	0,64	0,75	0,80		
LTL-FRIGO		**BASE**	**DA 1**	**DA 2**	**DA 3a**	**DA 3b**
1,00	Transport Efficiency	0,15	0,30		0,31	0,31
0,06	Lead Time	0,05	0,05		0,01	0,01
0,14	Transport Cost	0,11	0,12		0,13	0,13
0,52	Emissions	0,22	0,36		0,37	0,37
0,28	Operational Feasibility	0,14	0,12		0,09	0,16
	TOTAL	0,52	0,64		0,60	0,67

Overview:

BASE		FTL	COMBI	LTL	FTL-FRIGO	COMBI-FRIGO	LTL-FRIGO
	Global Logistics Manager	0,82	0,76	0,70	0,82	0,77	0,72
	General Project Manager	0,66	0,63	0,60	0,66	0,63	0,60
	I2M Project Team	0,75	0,71	0,66	0,75	0,71	0,67
	Integrated DT	0,75	0,70	0,65	0,74	0,70	0,66
	Sustainable	0,78	0,66	0,54	0,77	0,64	0,52
DA 1	Global Logistics Manager	0,82	0,80	0,74	0,82	0,80	0,75
	General Project Manager	0,63	0,61	0,58	0,62	0,61	0,58
	I2M Project Team	0,73	0,71	0,66	0,73	0,72	0,67
	Integrated DT	0,73	0,71	0,66	0,73	0,71	0,67
	Sustainable	0,81	0,77	0,66	0,79	0,75	0,64
DA 2	Global Logistics Manager				0,88	0,87	
	General Project Manager				0,66	0,65	
	I2M Project Team				0,77	0,75	
	Integrated DT				0,77	0,76	
	Sustainable				0,83	0,80	
DA 3a	Global Logistics Manager			0,54			0,58
	General Project Manager			0,42			0,44
	I2M Project Team			0,53			0,56
	Integrated DT			0,50			0,52
	Sustainable			0,57			0,60
DA 3b	Global Logistics Manager			0,59			0,62
	General Project Manager			0,57			0,58
	I2M Project Team			0,63			0,66
	Integrated DT			0,60			0,62
	Sustainable			0,64			0,67

BASE		FTL	COMBI	LTL	FTL-FRIGO	COMBI-FRIGO	LTL-FRIGO
DA 1	Global Logistics Manager	100%	105%	105%	100%	104%	104%
	General Project Manager	94%	97%	97%	94%	97%	97%
	I2M Project Team	97%	101%	101%	97%	101%	100%
	Integrated DT	97%	101%	101%	97%	101%	101%
	Sustainable	103%	116%	123%	103%	117%	124%
DA 2	Global Logistics Manager				108%	113%	
	General Project Manager				100%	103%	
	I2M Project Team				102%	106%	
	Integrated DT				104%	108%	
	Sustainable				108%	124%	
DA 3a	Global Logistics Manager			77%			80%
	General Project Manager			71%			73%
	I2M Project Team			81%			83%
	Integrated DT			77%			79%
	Sustainable			105%			116%
DA 3b	Global Logistics Manager			84%			87%
	General Project Manager			95%			97%
	I2M Project Team			96%			98%
	Integrated DT			91%			94%
	Sustainable			118%			130%

L. REAL CASES

The design alternatives are hypothetically tested on performance. In an ideal situation, the design alternatives would be implemented in real life and their performance would be measured and validated with the model. In the scope of this project this is not possible. Therefore, another way has been used to passively test the Alternatives. This Appendix compares real cases that have occurred in the project preliminary to really starting the supply chain phase. It occurs that there are several real cases where indeed initiatives and opportunities exist that resemble the Design Alternatives.

The specific descriptions of the real cases is confidential.