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Overcoming the obstacles of intermodal transport

– a shipper perspective on the effects of modal shift

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- Preface -

This thesis was written during the spring of 2009 as the final part of our almost five year long master degree at the Industrial Engineering and Management program in Lund. The project was initiated by UnitedLog Consulting, where we, along with Christofer Kohn, developed the thesis project to gain a better understanding of recent issues regarding intermodal transport and its role in a shipper's logistics system.

It has been an intensive, fun and interesting period, and we would like to express our gratitude towards our supervisors at both UnitedLog Consulting and at Lund University. A big thanks for all your comments and insightful remarks: Markus Thulin and Christofer Kohn at UnitedLog, and Sten Wandel and Ali Pazirandeh at the university. A special thanks also to all case company representatives that have dedicated time and resources to the study, without them this would not have been possible.

Finally, a big and sincere Thank You to family and friends, for support and laughs over lunches and cups of coffee throughout the spring.

Lund, June 2009

Fredrik Eng Larsson

David Kollberg

- Abstract -

Title: *Overcoming the obstacles of intermodal transport – a shipper perspective on the effects modal shift*

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Background: In a recent memorandum from the Swedish government the long term energy and climate policies of Sweden were stated and defined. The goals are ambitious. A wide range of industries are to be transformed as Sweden strives for sustainability and long-term competitiveness and the transport industry is one of the main targets. The transport industry is to be changed through economical measures such as taxation on CO_2 emissions and emissions certificate trading. These measures combined with increased customer awareness for environmental issues create incentives for firms to radically decrease the emissions caused by their transports. This thesis concerns how firms can achieve this by replacing road transport with intermodal road-rail transport.

Purpose: To discuss and analyze when, why, and how an intermodal solution has been successfully integrated into a shipper's logistics system and what consequences this has had on the system's performance.

Problem definition: How and where is intermodal transportation used in shippers' logistics systems?

How are tradeoffs regarding cost, customer service, and CO_2 emissions dealt with in the implementation process?

What changes need to be made in the shipper's logistics system in order for intermodal transport to be economical and possible?

Method: In this study a systems approach is used in order to capture the complex interrelations in a logistics system. Further, we utilize an abductive research method with qualitative data gathering trough case interviews. The case interviews were performed in a semi-structured manner with employees on key positions in the studied companies' logistics system. The collected data was then analyzed against a theoretical frame of reference compiled from an extensive literature study.

Conclusions: Although, in general, transport quality with regards to transit time and delivery precision was somewhat lower among the case companies, it was evident from the study that the perceived quality of the intermodal solution was not as low as suggested by previous findings. In fact, many of the firms claimed the intermodal solution to be better. It was also seen that:

- *Intermodal transportation may work well independently of the type of product and logistics strategy of the shipper*
- *The relative quality is more of a carrier selection issue than a mode choice issue*
- *Transit time and precision must not decrease with the implementation of an intermodal solution*
- *Tradeoffs tend to be more about purchasing convenience vs. price than transport quality vs. price or customer service vs. cost*
- *Process and planning changes may be needed at both consignor and consignee, but their relation to total costs is ambiguous*
- *Total CO_2 emissions are most likely to decrease when switching from an all-road to an intermodal solution*

Keywords: Intermodal transport, Modal shift, Sustainability, Green logistics

- Sammanfattning -

Titel: *Att övervinna hindren med intermodal transport – byte av transportslag ur varuägares perspektiv*

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Bakgrund: I en promemoria som nyligen utgavs av den svenska regeringen presenterades de övergripande och långsiktiga målen för Sveriges energi- och klimatpolitik. De ambitiösa målen innefattar en lång rad branscher och ämnar placera Sverige i en tätposition vad gäller hållbarhet och långsiktig konkurrenskraft. Ett av huvudområdena är transporter som ska förändras genom införandet av koldioxidskatter och utsläppshandel. Dessa styrmedel, kombinerat med ett ökat miljöfokus från konsumenter, skapar incitament för företag att minska sina transportrelaterade utsläpp. Detta examensarbete syftar till att undersöka hur företag kan uppnå målen genom att byta från lastbil till intermodal järnväg/lastbilstransport.

Syfte: Att diskutera och analysera när, varför och hur en intermodal lösning har kunnat implementeras framgångsrikt i ett företags logistiksystem och vilka konsekvenser detta har haft på systemets prestanda.

Problemformulering: Hur och var används intermodal transport i ett varuägande företags logistiksystem?

Hur hanteras avvägningar med avseende på kostnader, kundservice och CO_2 utsläpp i implementeringsprocessen?

Vilka förändringar måste göras i företagets logistiksystem för att intermodal transport skall vara ekonomisk och möjlig?

Metod: I arbetet har vi använt oss av ett systemangreppsätt för att kunna täcka in de komplexa inbördes förhållanden som råder i ett logistiksystem. Vidare användes en abduktiv forskningsmetod där kvalitativ data samlades in genom intervjuer med personer på nyckelpositioner på de undersökta företagen. Denna insamlade empiriska data analyserades sedan mot en teoretisk referensram framtagen genom en omfattande litteraturstudie.

Slutsatser: Även om transportkvaliteten vad gäller transporttider och leverans-precision var något lägre hos fallföretagen, framgick det av studien att den upplevda kvaliteten på en intermodala lösning inte var så låg som etablerade teorier föreslår. Många av företagen hävdade till och med att den intermodala lösningen var bättre. Det framkom också att:

- *Intermodala transporter kan fungera väl oberoende av vilken typ av produkt och logistikstrategi som används*
- *Den relativa kvaliteten är mer en ”Carrier selection”-fråga än en ”Mode Choice”-fråga*
- *Transporttid och -precision måste inte minska vid införandet av en intermodal lösning*
- *Tradeoffs tenderar att vara mer en fråga om inköpsbekvämlighet vs pris än transpor kvalitet vs pris eller kundtjänst vs kostnad*
- *Förändringar i processer och planering kan behövas hos både avsändare och mottagare, men deras förhållande till de totala kostnaderna är osäker*
- *Totalt CO2-utsläpp kommer sannolikt att minska vid ett byte från lastbil till en intermodal lösning*

Nyckelord: Intermodal transport, Modal shift, Sustainability, Green logistics

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1 Introduction

Over the last couple of years a number of policies have been adopted on national and international levels to reach the common goals of sustainable development. From being a question concerning society as whole, sustainability issues have increasingly gained attention at the micro-layer and the interest of individual firms. In this chapter the political, economical and technological background that initiated this thesis will be described as well as a short discussion on intermodal transport and our research question and perspective. The discussion starts on the macro level.

1.1 Background: economics, transports, and sustainability

In a recent memorandum from the Swedish government the long term energy and climate policies of Sweden were stated and defined. The goals are ambitious. A wide range of industries are to be transformed as Sweden strive for sustainability and long term competitiveness and the transport industry is one of the main targets. Sweden, it is said, is to be the world leader in the changeover to more energy efficient, less climate affecting, transport solutions. The level of greenhouse gases is to be decreased by 40 percent by 2020 and by 2030 the Swedish vehicle fleet is to be fully independent of fossil fuels (Regeringen, 2009).

Similar policies have been adopted by many European countries and there are a number of reasons for these political actions. Since sustainability was defined by the Brundtland commission in 1987 as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland et al., 1987), a number of studies, reports, protocols and events have fuelled the public debate of sustainable development and environmental impact. From being a discussion of resource use and waste handling, the release of the Stern-review in 2006, and the ratification of the Kyoto protocol soon thereafter, the discussion has come to focus on the greenhouse gas emissions and the climate change these give rise to.

Although there are a number of greenhouse gases, Carbon dioxide, CO_2, is considered the most important. In 2004, CO_2 represented 77% of total greenhouse gas emissions and between 1970 and 2004, yearly global CO_2 emissions grew by approximately 80% (IPCC, 2007). The Kyoto protocol was established with the aim of reducing greenhouse gas emissions by five percent compared to 1990 levels. This was to be accomplished by creating binding targets for 37 industrialized countries regarding structural changes or market mechanisms (UNFCCC, 1998).

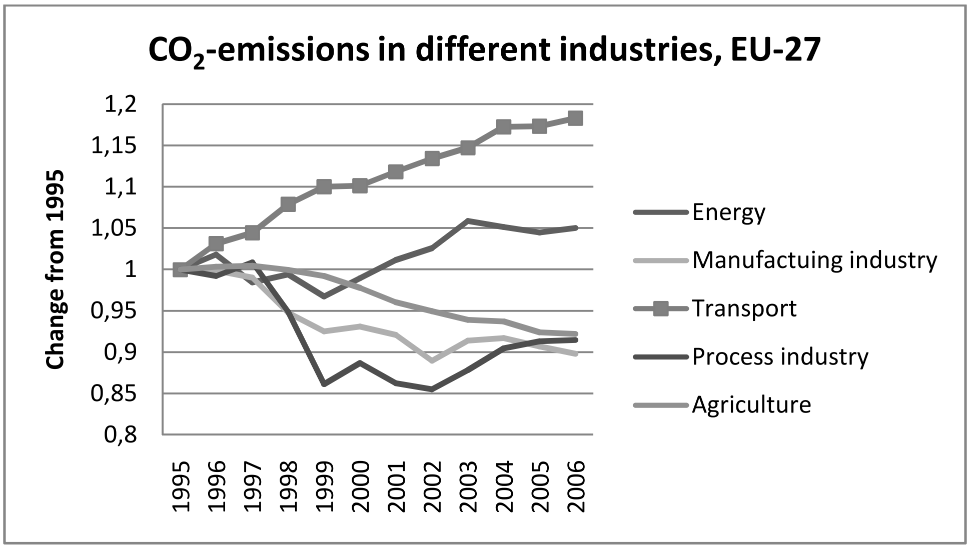

Figure 1.1. CO_2 equivalents for different industries, EU-27, baseline 1995 (Eurostat 2006)

Transport is, together with energy generation, the main contributor to the overall growth of CO_2-emissions (IPCC, 2007). For the EU27-countries, CO_2-emissions from the transport sector have increased by 19% from 1995 to 2006 as illustrated in Figure 1.1. In fact, while most industries have managed to decrease greenhouse gas emission over the last 20 years, the transport sector and its emissions have moved in the opposite direction. Although vehicles have become increasingly fuel efficient, cleaner and quieter, business trends such as globalization and centralization have offset the positive environmental effects (McKinnon, 2003). International trade and GDP have increased but transport emissions have increased at a faster rate, as can be seen in Figure 1.2. The dramatic rise in fuel and energy prices that has been seen over the last couple of years (IEA, 2009) has not offset this increase.

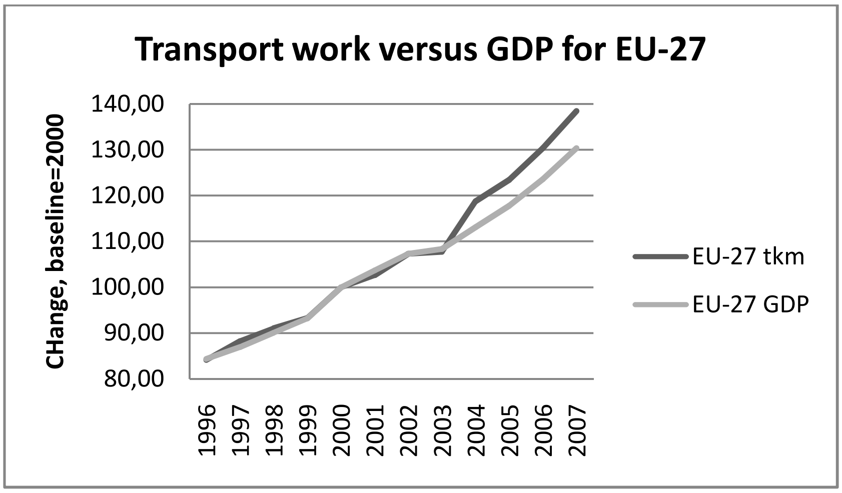

Figure 1.2. Relation between transport work and GDP for EU-27 (Eurostat, 2006)

The coupling of economic welfare and a growth in greenhouse gas emissions has been targeted as an area of concern (European Commission, 2001; Regeringen, 2006). While a growth in GDP is considered positive, economic growth must be able to continue without increasing greenhouse gas emissions if trade and development is to be sustainable. Although transportation is considered a prerequisite to economic growth by economists (e.g. Aiginger and Rossi-Hansberg, 2006), a decoupling can be established by more carefully analyzing the actual connection between growth in GDP and growth in CO_2-emissions from transports. For this analysis, McKinnon (2003) suggests a framework which is further developed by Woxenius (2005) in the equation-model described below[1].

$$CO_2 \text{ emissions} = GDP \times \underbrace{\frac{\text{Tons x Kilometers}}{\text{GDP}}}_{\text{TRANSPORT INTENSITY}} \times \underbrace{\frac{\text{Vehicle kilometers}}{\text{Ton kilometers}}}_{\text{TRAFFIC INTENSITY}} \times \underbrace{\frac{\text{kWh}}{\text{Vehicle kilometers}} \times \frac{CO_2 \text{ emissions}}{\text{kWh}}}_{\text{EMISSIONS INTENSITY}}$$

Figure 1.3. GDP and CO2 emissions, freely from (Woxenius, 2005)

The emissions problem can, according to Woxenius (2005), be tackled by targeting any of the three ratios in Figure 1.3:[2]

- The *transport intensity*, that is, the amount of transport work (weight x distance) per unit of economic output, is reduced through strategic decisions on firm level regarding sourcing, facility location and transport network design.
- The *traffic intensity* can be reduced through higher utilization of carriers, better planning methods and consolidating efforts.
- The *emissions intensity*, that is, the amount of emissions per travelled kilometer, can be reduced by the use of more energy efficient modes of transport and less polluting engine technology. (Woxenius 2005)

The model is merely a framework to highlight the role of particular efforts and to put these into relation to other efforts on the road to the overarching goal of environmental sustainability. A certain effort could target one ratio or more, and a change in one of the ratios has implications for possibilities for change in all the others. For example, the use of more energy efficient, less polluting, vehicles (last two ratios) may be possible *only after* a change of structure which raises the transport intensity substantially (Aronsson and Huge Brodin, 2006; Kohn, 2008b; Woxenius, 2005). In fact, the many “low level” measures taken by firms to reduce their carbon footprint have, as seen in Figure 1.1, been offset by measures taken at a higher level.

This thesis is concerned with one such effort: a split in mode of transport. For some companies it is the result of dedicated work in reducing the carbon footprint of the firm, for others it is not an active choice but merely a coincidence, with the environmental effects being a positive side-effect of a decision made with other intentions. Whatever the attitude of the firm, the intermodal setup is an interesting solution since it in some instances seem to clash with established concepts on how to deliver cost efficient customer service. Before we get into detail about this, let us concern ourselves

[1] In his 2003 publication, McKinnon describes four ratios, with Modal Split being the fourth. This is left out in the model by Woxenius (2005) and our version of it, since it is a merely a measure that affects the last two ratios; traffic intensity and fuel efficiency. Modal split is addressed throughout the thesis, but if it were to be considered as a ratio, the emissions from rail-traffic are left out of the analysis, something we wish to avoid.

[2] I valid point is that a decline in GDP would also generate less emissions and lead to a more environmentally sustainable situation. Although ecologically sound, this would be contra-productive from the overall goal of sustainability, since economic sustainability is a prerequisite for sustainability at all (Elkington, 2004). For a further discussion see section xxxx.

with why intermodal transport solutions are advocated by the national and international governmental bodies as a promising solution for long-term sustainability.

1.1.1 Intermodal transport as a measure for sustainability

As the downsides of increasing road transport have become evident in the form of greenhouse gas emissions, road congestion, and noise pollution, one remedy that has been suggested from policy-makers and researchers to tackle the current situation is a shift in mode of transport, from faster modes to slower (European Commission, 2001; McKinnon, 2003). An intermodal transport solution, where a *combination* of road and rail is used, is considered a promising solution to come to terms with the negative environmental impact of transportation (Kohn, 2008a; McKinnon, 2003; Woxenius, 2005). With this type of solution, the last two ratios of Figure 1.3 can be dealt with simultaneously:

Firstly, the *emissions intensity* may be reduced, since rail freight is a more energy efficient mode of transport. A study by the IRU[3] shows that intermodal transport causes, on average, 20-50% less CO_2-emissions than all-road transport on 19 tested European routes (Flodén, 2007; IFEU and SGKV, 2009). From a swedish perspective, calculations carried out by NTM (2007) show potential emission reductions of up to 95 %, depending on the amount of electrified railway being used and the mix of energy sources serving the railway net[4].

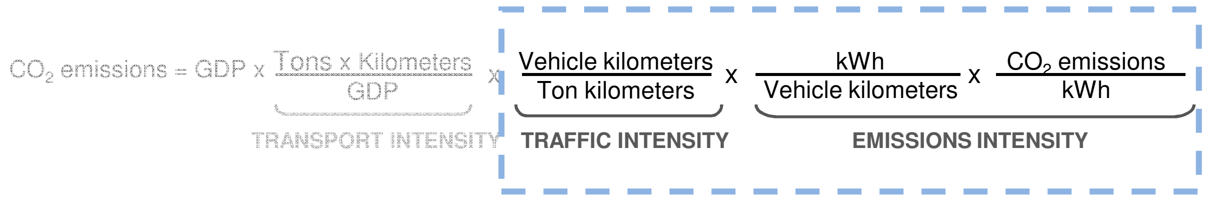

Figure 1.4. Potential areas of improvement with intermodal transport as method

Secondly, the *traffic intensity* may be reduced, something which is also highlighted by the European Commission (2001) in their white paper on future transport. Congestion of European roads is an increasing problem and to allow more freight to go by rail will ease the situation. A freight train transports, on average, close to 20 times[5] the load of a truck, and the traffic intensity ratio, as described by Woxenius (2005), will therefore decrease with a more extensive use of rail freight. Freight consolidation is often considered one of the most important measures for a decrease in emissions caused by transportation (Aronsson and Huge Brodin, 2006).

The aforementioned problems of emissions, congestion, and noise pollution on European roads have caused the European Union and many national governments to invest heavily into intermodal research (Bontekoning et al 2004). In 2006, the Swedish government proclaimed in the transport policy guidelines (Regeringen 2006), that:

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[3] International Road Transport Union

[4] As calculated by CO2-calculation tool from NTM (http://www.ntm.a.se/ntmcalc/) with figures provided by Banverket, The Swedish Rail Administration. The assumed setup is 10 km road-500 km electrified rail-10 km road as compared to 520 km all-road. Truck utilization is 70%. A number of parameters can be changed (utilization, truck type, electricity source etc.) and in reality a number of factors such as weather, terminal handling and the actions of the drivers influence the result as well. The figures are given to illustrate the potential in a Swedish environment and should not be seen as an absolute or empirical truth.

[5] Avarage payload per train in Sweden: 490 tons, maximum payload per truck: 40 tons, utilization 70%. Figures from (Nelldal, 2005)

> "A strategic challenge for the transport policy is to contribute to a separation between transport growth and the negative effects of transport. An important step in this is to promote environmental friendly and safe transport solutions. Intermodal transport solutions, where railroad and shipping are fully utilized, should therefore be supported." (Regeringen 2006, 291)

Ambitious targets have been set on macro level but despite the interest from researchers and policy-makers, the growth in intermodal transport has not been as considerable as expected. For example, in the late 1980s, the Swedish government estimated that the amount of goods transported by means of intermodal transport would increase from 3.5 million tons annually to 10 million tons by the end of 1999 (Regeringen 1988). It did increase indeed, but only to a humble 4.8 million tons by 1999 (Banverket 1999).

1.1.2 Taking the discussion to firm level

For the shippers[6] in Europe, road freight is the preferred mode of transport (Wu and Dunn, 1995). Intermodal transports have seen a lot of attention from the macro environment but on firm level only a limited number of companies use an intermodal setup. According to Lammgård (2007), only 3.7% of the Swedish shippers use intermodal transportation in their logistics system. Industries particularly hesitant to rail transport are the food, construction, and industry products industries (Lumsden, 2006).

It is obvious that despite the many positive attributes of intermodal transport it has failed to gain interest from the shippers. Well proven, faster solutions are preferred and have gained an increase in popularity as business trends such as Just-In-Time, Lean-thinking, and Time-based-competition all utilize faster transport modes to gain competitive advantage (Abrahamsson, 1992; Christopher, 1998). A key role of logistics is to deliver customer service (Christopher, 1998) and according to Harpers and Evers (1993), shippers simply perceive intermodal transport as lacking in quality with respect to this. Environmental aspects alone will not cause a firm to switch to a different mode of transport if quality requirements cannot be met, which is often the case with railway transport, according to executives at Swedish retailers H&M and Ica (Karlsson, 2008).

The purpose, however, of using an intermodal setup, is to utilize the different strengths of the different modes of transport in a cost efficient manner (Flodén, 2007). Rail freight, which is used for the long haul, has been employed for a long time to move products of forests, mines, and agriculture, and for long freight hauls of low value products rail freight is a financially more attractive option. In fact, it is argued, for medium and long distances, rail freight is less costly than road freight and more reliable than water freight (Coyle et al., 1996). It is also indicated by Harpers and Evers (1993) and Booz & Company (2009) that those companies that do employ a rail-bound solution are more positive to this type of solution then those that do not. In the Europe-wide survey conducted by Booz & Company (2009), as many as 75% of the responding rail freight customers were either satisfied or very satisfied with the overall quality of rail freight.

In an intermodal setup, this long haul advantage of rail freight is combined with the short haul advantages of the more flexible road transport (Flodén, 2007). In this way, the two strengths are combined into one long haul solution with the accessibility of road freight.

[6] The term shipper will be equivalent to the goods owner in this thesis, that is, either the consignor or the consignee – or both. See further the discussion on perspective in section 1.3.2 below.

However, with strategic decisions calling for faster delivery, transport mode is chosen accordingly. Timeliness, availability, and transport quality are all factors mentioned by firms as important decision variables when choosing transport mode (Ludvigsen, 1999) and a general perception is that intermodal transport is not competitive enough in these areas (Bontekoning et al., 2004; Evers et al., 1996; Ludvigsen, 1999). According to Flodén (2007) and Lammgård (2007), an intermodal solution is slower and is advocated to offer a lower degree of service compared to unimodal truck transport.

Now though, researchers as well as politicians and even consumers call for firms to utilize less polluting modes of transportation (LEK Consulting, 2007; Regeringen, 2009). Most companies hesitate, claiming less polluting modes of transport would jeopardize their ability to deliver cost efficient customer service. However, exceptions exist. Some firms do employ this type of solutions within their logistics systems, even when low-cost and high-volume is not the strategy being pursued. By doing so, they go against the mainstream's view on how to deliver cost efficient customer service. Therefore, to better understand how an intermodal solution actually affects the variables that shippers consider crucial, it is motivating to study these exceptions.

1.2 Purpose and research question

Being a prioritized field by the European Union, intermodal transport has seen a good deal of research over the past ten years (Bontekoning et al 2004). However, most of this research has been conducted on issues concerning technical solutions (e.g. Bergqvist et al., 2007) or policy decisions (e.g. Woxenius, 2005) with less attention given to the transport buyers and their logistics systems. Intermodal transport, and the modal shift, can be seen as an initiative towards sustainability (McKinnon, 2006; Regeringen, 2006; SIKA, 2008b) but despite this only limited attention has been given to investigate how the transport solution affects the firms' logistics systems from a holistic view, as advocated by McKinnon (2003).

Policy makers as well as researchers claim that modal shift among shippers is one of many possible solutions to the climate problem and the interest is extensive, not only from policy makers, but also to a growing extent from private consumers (LEK Consulting, 2007). At the same time, rail-bound transport solutions are by far outgrown by truck transport. That is, while many of the actors in society ask for less polluting modes of transportation, goods owning companies fail to meet this demand. One reason may be the lack of analysis regarding the actual effects this type of solutions would have on a shipper's logistics system; research shows that the attitude towards intermodal transport among shippers often is negative, but more positive by those that are using it (Evers et al., 1996).

This implies that there may be many false preconceptions about the true impact of intermodal transportation on the logistics system's performance. In this thesis, we want to investigate the successful examples in order to better understand how these companies have reasoned, what they have done and what the effects have been. What changes have been necessary and what has been the effect on cost and service measures? To bring clarity to this, *the purpose of this thesis is to discuss and analyze when, why, and how an intermodal solution has been successfully integrated into a shipper's logistics system and what consequences this has had on the system's performance.*

This yields the following research questions:

- **How and where is intermodal transportation used in shippers' logistics systems?**

- **How are tradeoffs regarding cost, customer service, and CO_2 emissions dealt with in the implementation process?**
- **What changes need to be made in the shipper's logistics system in order for intermodal transport to be economical and possible?**

The goal of the thesis is to find these enablers and key success factors.

1.3 Scope and delimitations

1.3.1 The intermodal setup studied

The terms *intermodal transport*, *multimodal transport,* and *combined transport* are often used interchangeably when talking about a transport being performed with two or more transport modes. To avoid confusion, the definitions provided by the OECD Glossary of Statistics will be used in this thesis. The glossary's definition is derived from material collected from Eurostat, European Conference of Ministers of Transport (ECMT) and United Nations Economic Commission for Europe (UNECE) and it defines *intermodal transport* as

> "movement of goods (in one and the same loading unit or a vehicle) by successive modes of transport without handling of the goods themselves when changing modes."

That is, different modes of transport are used with the goods being transported within in *the same loading unit* for the entire transit. However, this thesis will focus on road-rail intermodal transport, and ECMT´s narrower definition for the term *combined transport* might therefore be more applicable:

> "combined transport: intermodal transport, where the major part of the European journey is by rail, inland waterways or sea and any initial and/or final leg carried out by road are as short as possible."

For the road-rail solution the loading unit is either a swap-body, trailer, or a container, and we will refer to this as the *Intermodal Transportation Unit* (ITU). We will, however, use the term intermodal transport throughout this thesis for both *intermodal* and *combined transport*, since this is the term most commonly used in international literature.

1.3.2 Applying a shipper perspective

A firm's logistics system and the decisions therein can be viewed and studied from different perspectives. A model is given by Wandel et al (1992), where a logistics system is divided into three separate layers according to Figure 1.5.

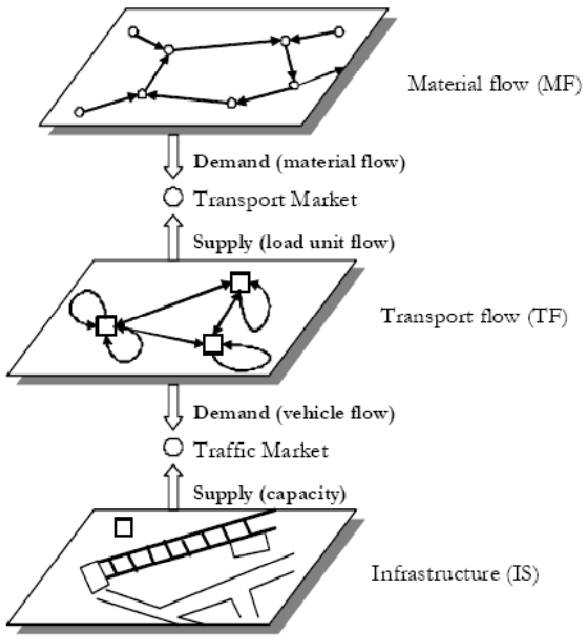

Figure 1.5. A three-layer model of logistics (Wandel et al., 1992)

The upper layer concerns the flow of the *shipper* and depicts the material flow, that is, the nodes and links that make up the logistics system of the company. The nodes are established spatial points where goods stop for storage or processing. In other words, the nodes are plants and warehouses where the organization stores materials for conversion into finished products or goods in finished form for sale to customers. The other part of the system is the links, which represent the transportation network connecting the nodes in the logistics system (Coyle et al., 1996). On this level of abstraction the arrival and departure at the different sites are of interest, not the transportation itself. Transportation is seen as a black box system merely moving stock keeping units or materials from point A to point B. In the shipper's logistics system the focus is on delivering cost efficient customer service through manipulation of system structure and planning of inventory, transport flow, and production.

The flow of material and goods create a demand for transport within the system and these are supplied from the *service providers*, or *carriers*, to a transport market. These transport service providers, e.g. DHL, Schenker, and GreenCargo, operate on the second layer where the transport flow represents the consolidated flows that these carry to the different shippers' destinations. Transports can be carried out by means of one mode (e.g. truck transport) or through multi-modal solutions (e.g. truck-ship, truck-rail), with the aim of delivering customer service to the shipper, that is, transport quality. To reach the desired level of consolidation, different network structures are set up with terminals handling the consolidation and routing of goods. Primary objectives are to keep utilization high and handling times short.

The operations of the service providers also create a demand of infrastructure which is depicted in the lowest layer. This capacity can be supplied by private or publicly owned companies but are the regulation of public bodies. It concerns highways and railroads but also information infrastructure such as internet cables or telephone lines.

It is pointed out by Kohn (2008), that the model helps pointing out that even though logistics and transport research can be performed at any of these three levels, the levels are also linked to one another. As this thesis aim at understanding the success of intermodal transports as a solution within the shipper's logistics system, the primary focus will be on the efforts of the upper layer in Figure 1.5, as depicted below in Figure 1.6. Infrastructure and the actors of the transport market will be discussed briefly however, so as to be able to get a clearer picture of possible contextual factors. These factors will all be considered constant for the duration of the thesis, since it is not the primary objective of the shippers to change these.

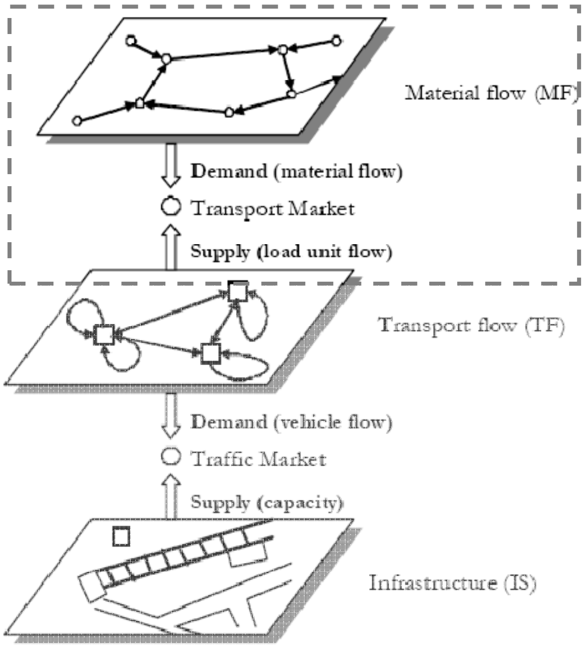

Figure 1.6. The perspective of this thesis

1.4 Structure of the thesis

A schematic view of the thesis is given in Figure 1.7 below. The introduction and methodology chapters introduce the research questions, the background to the study, and the chosen mode of procedure. After this follows a description of the current situation of intermodal transport in Sweden and in Europe as of today, as to get an orientation of how this transport solution is employed as seen from a macro perspective. Facts and figures are also given to deepen the understanding of the subject and introduce findings that can explain some of the shipper system behaviors that we aim to investigate.

The fourth chapter looks at previous studies and normative theories with the aim of forming a framework for analysis. This is made by combining well established literature on logistics management with more recent publications regarding the performance of intermodal transport. A framework for future analysis is presented at the end of the chapter.

After this, the case company reports from the five case studies follow: Arvid Nordquist, Home Retail Co, ITT W&WW, Lindex, and Volvo Trucks; and thereafter an analysis of the cases based on the findings from the frame of reference.

The findings are summed up in the conclusion chapter were we return to our initial research questions and form a discussion around the purpose of the thesis.

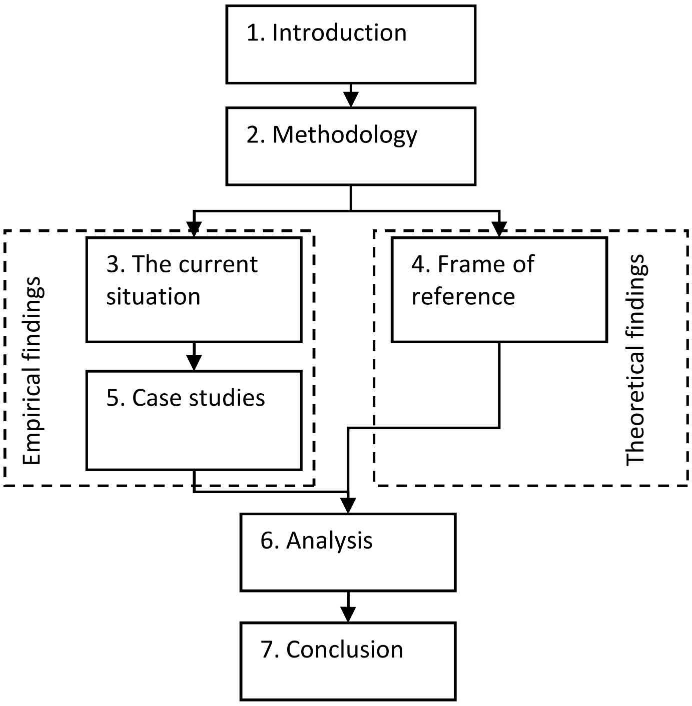

Figure 1.7. Disposition of thesis

2 Methodology

In business and in research it is essential to understand the methods and assumptions that form the context of the study to better know how to interpret the results. Methodological insight gives an audience a better understanding of previously conducted research and how to proceed in the future (Gammelgaard, 2004). The aim of this chapter can therefore be seen as twofold: (1) to describe the scientific context and assumptions of the study and (2) to describe, and motivate, our selected mode of procedure. Firstly, the Arbnor and Bjerke framework is presented, and our problem is compared to the suggestions of the model. Thereafter, a number of methods are described and our choice of the case method as mode of procedure is discussed in more detail. At the end of the chapter, a discussion of the validity and reliability of the chosen procedure is held.

2.1 Scientific approach

The choice of research method is influenced by a number of factors and is heavily dependent on the scientific approach of the researcher. Different researchers make different interpretations and assumptions of the surrounding world and view scientific work from slightly different perspectives. To fully understand the result of a study, one must know the researcher's approach.

A commonly used separation of approaches for business studies is given by Arbnor and Bjerke (1997). Their framework is based on the premise that the choice of research methods should not only be influenced by the nature of the research question, but also by the researcher's view of reality (Arbnor and Bjerke, 1997). The three approaches suggested in their framework are:

1. The analytical approach
2. The systems approach
3. The actors approach

These views have different implications on how research methods are chosen and how the research itself is conducted, as summarized in Table 2.1. Since logistics is interdisciplinary, the approach issue cannot be taken for granted. In fact, as pointed out by Gammelgaard (2004), all approaches coexist, and to better understand the continuation of this thesis, we will now discuss these three approaches in more detail.

Table 2.1.Arbnor and Bjerke framework (1997)

	Analytical approach	Systems approach	Actors approach
Theory type	Determining casue-effect relations. Explanations, predictions. Universal, time and value free laws.	Models. Recommendations, normative aspects. Knowledge about concrete systems	Interpretations, understanding. Contextual knowledge
Preferred method	Quantitative (qualitative research only for validation)	Case studies (qualitative and quantitative)	Qualitative
Unit of analysis	Concepts and their relation	Systems: links, feedback mechanisms and boundaries	People – and their interaction
Data analysis	Description, hypothesis testing	Mapping, modeling	Interpretation
Position of the researcher	Outside	Preferably outside	Inside – as part of the process

2.1.1 Analytical approach

The analytical approach is commonly seen in many fields of academia. It has its roots in Western philosophy and is closely related to the positivistic view, that is, that true knowledge is only what can be observed in reality. Gammelgaard (2004) describes the approach in the following way:

> "According to the analytical approach, there is an objective reality, in which patterns and causal relations can be investigated and disclosed through research. The researcher must stay outside the research object and refrain from interacting with it to avoid exerting an influence on the object and thus distort the reality he or she is trying to disclose." (Gammelgaard, 2004 p. 480)

Further, the summative character of an analytical approach is described by Arbnor and Bjerke (1997):

> "[The analytical approach's] assumption about the quality of reality is that reality has a summative character, that is, the whole is the sum of its parts. This means that once a researcher gets to know the different parts of the whole, the parts can be added together to get the total picture" (Arbnor and Bjerke, 1997 p. 50)

Thus, when using an analytical approach, a problem can be divided into sub-problems where the sum of the solutions to each smaller problem forms the solution to the whole. The research is quantitative and the researcher merely examines the observable reality with as little interaction as possible.

2.1.2 Systems approach

The summative character of the analytical approach is often a too general assumption, especially in business where synergies or economies of scale and scope are desired outcomes. An example from logistics is the way a change in transport frequency affects the amount of safety stock needed. A higher transport frequency increases transportation costs, but also allows for lower inventory levels which might lower the total cost (Coyle et al., 1996). If transportation costs where to be analyzed in isolation, the total logistics cost of the firm might not be optimized.

This dependency of parameters calls for a different approach, where the interrelation of the diverse parts is taken into consideration as well. Arbnor and Bjerke (1997) describe the systems approach in the following way:

> "The assumption behind the systems approach, different from the assumption underlying the analytical approach, is that reality is arranged in such a way that the whole differs from the sum of its parts. This means that not only the parts but also their relations are essential, as the latter will lead to plus or minus effects (synergy)." (Arbnor and Bjerke, 1997 p. 51)

The systems approach is holistic and relations between the parts are just as meaningful as the parts themselves. This puts the researcher in a slightly different position:

> "The researcher's task is to create an understanding of a given part of the world, to identify the system parts, links, goals and feedback mechanisms in order to improve the systems … The systems approach is pragmatic in nature, and the search for an absolute truth is replaced by the search for a problem solution that works in practice." (Gammelgaard, 2004 p. 481)

The pragmatic and systemic nature of logistics and physical distribution has made the systems approach popular among scholars in this field of academia (Gammelgaard, 2004). Case studies, with both quantitative and qualitative elements, are commonly used as a research method.

2.1.3 Actors approach

The actors approach stems from sociology and argues, in contrast to the analytical and systems approaches, that no objective truth exists. The behavior of different actors and their perception of the truth is of interest, not to find a universal truth.

2.1.4 The scientific approach in this thesis

The purpose of this thesis is to analyze how intermodal transportation affects a shipper's logistics system. This is a complex issue since causal relationships are not easily distinguishable. For example, if the changeover to a larger amount of intermodal transport has been undertaken in conjunction with other projects it may be difficult, or impossible, to isolate certain output effects to that one change. Also, the many parts of the system are interrelated and do not show a clear summative character. As pointed out by Gammelgaard (2004), logistics management is pragmatic and systemic in nature. Although certain aspects can be isolated and analyzed individually, a holistic view on the system is usually necessary and for this a systems approach is required. This is true also for our research purpose, and a systems approach is therefore chosen.

In order to fulfill the purpose, the system must first be defined and limited. Evidently, any transport solution could potentially transport goods in one out of two possible settings: 1) between two units within the same company, or 2) between two units of different companies. That is, the solution can be either internal or external. In both cases, operational changes might have to be made at both the consignor and the consignee in order for the solution to be successful. For this thesis however, the goods owning company will be the focal point in order to get a better idea of the reasoning behind the change and its effect on the initiative taking company. A schematic picture of the system under investigation is depicted in Figure 2.1 below[7]. The system can be seen as having three different levels: the company level, the logistics system level, and the specific flow level. To properly fulfill our research purpose all of these levels will have to be considered; the intermodal solution will be

[7] Compare to the discussion on perspective (section 1.3.2)

implemented for a specific flow, but what is of interest to the thesis is to analyze how this implementation affects the system and the company for which it is designed. That is, as one parameter is changed we want to investigate how other parameters (e.g. inventory holding costs, service reliability measures, marketing and sales) are affected.

The system can be considered open, meaning that it can be given input from external factors. These factors relate to macroeconomic dynamics, politics, currencies, trade traffic, the general business cycle and many other factors. These different factors are primarily dealt with in the introduction chapter and can be said to be drivers or triggers for the decision under investigation: the decision to utilize an intermodal solution for a certain part of the system. This decision is seen as the input to the system and the thesis will focus on what effect this input has on the system's three different levels as described above.

One objective of the study is to better understand how the different parts of the system are interrelated, the other objectives concern the output of the system after the implementation as measured in costs, customer service, and CO2 emissions, and what changes that has been made within the system on strategic, tactical, and operational levels.

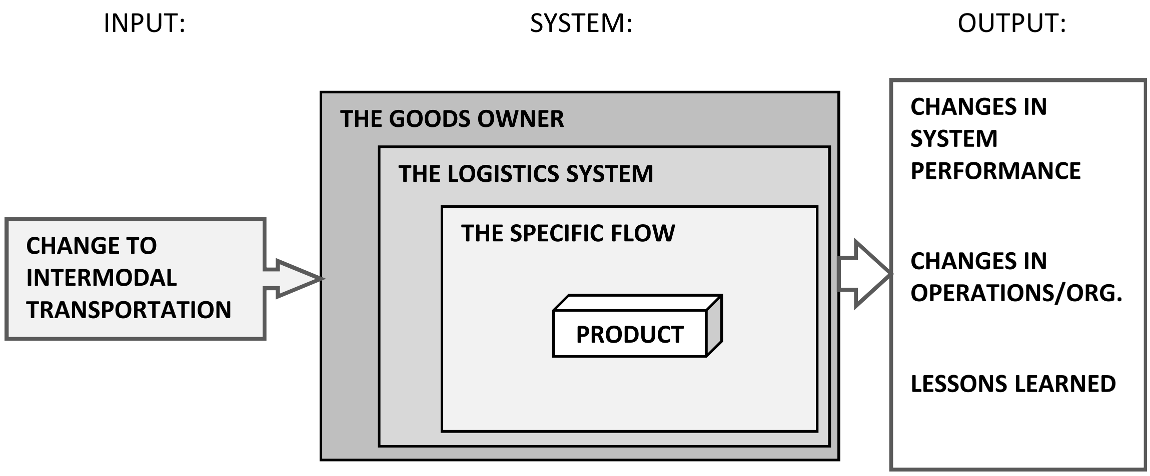

Figure 2.1. Schematic description of our studied system

2.2 Research methods

When conducting research, the choice of research method has great impact on how well the objectives of the study are met. Following, a number of different methods will be discussed.

2.2.1 Inductive, deductive, abductive methods

A commonly used distinction of research methods is the separation into inductive and deductive methods. With an inductive method, research starts with an observation and theoretical conclusions are drawn from the empirical findings. With a deductive research method, conclusions or hypotheses are drawn from theory and tested, after which the hypotheses are either discarded or accepted (Kovács and Spens, 2005).

An alternative to inductive and deductive methods is the abductive research approach. The methods under this approach are based on the fact that research seldom follows the pattern of pure induction or deduction. Kovács and Spens (2005) describe the abductive reasoning graphically in Figure 2.2. Like induction, the abductive approach starts with a real-life observation. On the surface, this does not hold for all abductive research, because researchers start out with some pre-perceptions and theoretical knowledge. Sometimes, the theory used is already determined prior to empirical observations. However, a closer examination of this starting point leads to the conclusion that even if prior theories are given, abductive reasoning starts at the point at which *an observation in the empirical research does not match these prior theories*. Kovács and Spens (2005) argue the following:

> "In this case, the theoretical framework used prior to this otherwise falsifying observation is not able to explain the anomaly of the observation itself. Therefore, a creative iterative process of 'theory matching' or 'systematic combining' starts in an attempt to find a new matching framework or to extend the theory used prior to this observation. […] The aim of this process is to understand the new phenomenon and to suggest new theory in the form of new hypotheses or propositions. The abductive approach closes with the application of these H/P in an empirical setting, however, this last step can already be characterized as a deductive part of the research."
> (Kovács and Spens, 2005 p. 138)

Roughly, abductive reasoning starts with a deviating observation (point 1 in Figure 2.2) and concludes with a hypothesis or proposition (H/P, point 3 in Figure 2.2).

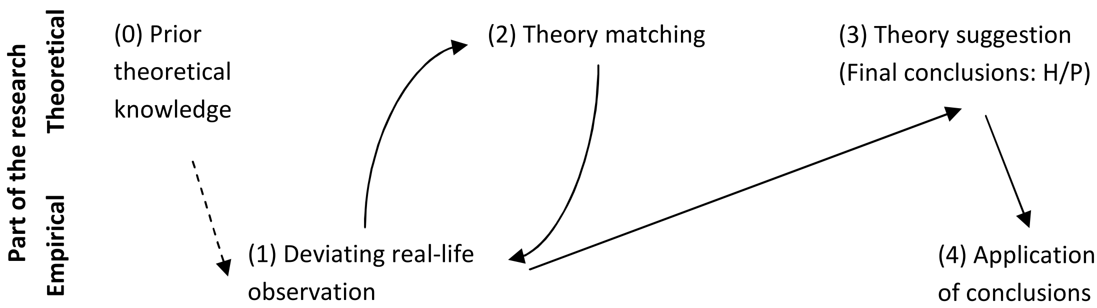

Figure 2.2. The abductive research process(Kovács and Spens, 2005)

This study was initiated by the observation that intermodal road-rail solutions are sometimes used in settings where traditional logistics theories, as well as prior transport buyer surveys, favor other modes of transportation. This raises the question of how the solution is actually employed in order to be possible and economical and whether or not these companies have reasoned in other ways than what the literature suggests.

2.2.2 Qualitative and quantitative data gathering

Two distinct types of data gathering exists, qualitatative, and quantitative. In the qualitative case, the researcher is interested in investigating unknown or insufficiently known phenomena and focuses on structures and variations. In the quantitative case the researcher investigates causal relations and relies heavily on statistical methods for analysis. The two types of data gathering processes are used for different research questions. A comparison between the two methods of analysis is given by Starrin et al (1994), as seen in Table 2.2 below.

Table 2.2. The distinction between quantitative and qualitative analysis, freely from Starrin et al (1994)

	Qualitative analysis	Quantitative analysis
Goal	To identify and determine unknown or insufficiently known phenomena, qualities, and meanings with respect to a) variations, b)structures, and c) processes	a) To investigate how predefined phenomena and their features and significances are allocated in a population or situation b) To investigate if there is a causal relation between two or more phenomena
Type of question	What does it mean? What is it about? What is characterizing this phenomenon?	Is there a relation between A and B? Is A more prevalent in C than in D?
Principle of analysis	Abduction; Exploration	Deduction; Exploration

2.3 Research strategy and design

According to Yin (2003) and Regnell et al (2006), five major research strategies can be identified, each one following its own logic. The different strategies have different advantages and dis-advantages depending on the research question and the focus of the study. In Table 2.3, the different strategies are listed with their corresponding research questions.

Table 2.3. Research strategies (Yin 2003)

Strategy	Form of research question	Requires Control of behavioral events?	Focuses on Contemporary events?
Experiment	How, why?	Yes	Yes
Survey	Who, what, where, how many, how much?	No	Yes
Archival analysis	How, why?	No	Yes/No
History	How, why?	No	No
Case study	How, why?	No	Yes

A complementing distinction is made by Ellram (1996) who group research designs based on the type of analysis (quantitative vs. qualitative) and type of data used for analysis (empirical vs. modeling). Based on these qualities, a matrix can be created as shown in Table 2.4.

Table 2.4. Basic research design (Ellram, 1996)

Type of data		**Types of analysis**: Primarily quantitative	**Types of analysis**: Primarily qualitative
	Empirical	• Survey data • Secondary data • Statistical analysis	• Case studies • Participant observation • Ethnography
	Modelling	• Simulation • Linear programming • Mathematical programming • Decision analysis	• Simulation • Role playing

For this study we have been concerned primarily with empirical data which has gone through qualitative analysis. Our research focuses on contemporary events and aim at answering "how" or "in what way" types of questions. Therefore, in accordance to the distinctions made by Ellram (1996) and Yin (2003) above, case studies have been the chosen research design for this thesis.

2.3.1 Case study design

According to Yin (2003), a frequent concern among social scientists is that case studies cannot be used for drawing general conclusions. However, case studies can, and should be, seen as quite similar to laboratory experiments. Scientific investigations are often based on a few experiments, from which general conclusions are drawn. The underlying theory can be either strengthened or weakened by the replicated experiments. Yin (2003) considers the following example:

> "For example, upon uncovering a significant finding from a single experiment, the immediate research goal would be to replicate this finding by conducting a second, third, and even more experiments. Some of the replications might have attempted to duplicate the exact conditions of the original experiment. Other replications might have altered one or two experimental conditions considered irrelevant to the finding, to see whether the finding could still be duplicated." (Yin, 2003 p. 47)

By proceeding with such replications, he argues, the original finding will be robust and worthy of continued investigation or interpretation. This approach can also be used for case studies. Case studies and experiments can be used for generalizing to theoretical patterns, but not for generalizing to larger populations. (Yin, 2003)

Four different types of case study designs exist, as shown in Figure 2.3. The design can be either single-case or multiple-case with each of these types being either holistic or embedded. The *single-case* (TYPE 1 and TYPE 2) is suitable for testing existing theory, investigating rare or unique circumstances, or to show a typical or representative case. The method is also appropriate if the case serves a revelatory or longitudinal purpose (Yin, 2003). This is often the case in clinical psychology and examination of unusual syndromes. The single case study is also common in situations of investigating patterns previously not explored.

The same case study may involve more than one unit of analysis. This occurs when, within a single case, attention is also given to a number of subunits. In this case, the resulting design is referred to as an *embedded case study design*. This could, for example, be the case in a study where a large organization or company would be analyzed, but where the analysis also includes outcomes from different operational departments. The departments would then be the embedded units. In contrast, if the case study examined only the global nature of an organization, a *holistic design* would have been used. (Yin, 2003)

When involving more than one case object, the study is defined as a *multiple-case design* (TYPE 3 and TYPE 4 below). The usage of this method has increased over recent years. One rationale for this is the conception of multiple-case studies as being a more robust design, since the higher number of objects makes it possible to test the theory several times. On the other hand, it is sometimes not possible to find more than one interesting case to investigate. When conducting a multiple-case study, it is important to choose the different cases carefully to make sure they all serve the purpose of the investigation. The cases should serve in a manner similar to multiple experiments, with similar results (a literal replication) or contrasting results (a theoretical replication) predicted explicitly at the outset of the investigation. (Yin, 2003)

	Single-case design	**Multiple-case design**
Holistic (single unit of analysis)	TYPE 1	TYPE 3
Embedded (multiple units of analysis)	TYPE 2	TYPE 4

Figure 2.3. Basic types of design for case studies

The purpose with case studies is not to follow the sampling logic, as is the case in statistical survey analysis. When this logic is applied, the respondents are believed to represent a larger population and are chosen accordingly. If the results from the different cases within a multiple-case study are similar, replication has occurred, and the tested theory is strengthened. If the analysis gives contradictory results, the theory must be modified or retested with other cases. Thus, it is of high importance to have a rich theoretical framework. The framework needs to state the conditions under which a particular phenomenon is likely to be found, as well as the conditions when it is not likely to be found. (Yin, 2003)

The development of a multiple-case study starts with theory development, case company selection and a decision on how data shall be collected. The chosen cases are then investigated separately and analyzed in isolation before a cross-case analysis is performed. The final report should include single-case analysis as well as cross-case conclusions. Each single case analysis points out the reasons to how and why different propositions were demonstrated or not demonstrated; the cross-case analysis aims at explaining why particular results were expected or not expected for the cases included.

To fulfill the purpose of the thesis, our case studies will be of TYPE 3, although this single unit (a company with intermodal transport in its logistics system) will be divided into several levels according to Figure 2.1.

2.4 Data collection

There are many types of data gathering and this phase has great impact on the final result of the research. The data for this thesis was collected from literature and interviews and carried out in a number of steps as depicted in Figure 2.4 below. Since an abductive approach was employed, the research questions and delimitations grew out of the original problem description, with the scope being narrower by every step taken. Let us discuss these steps in more detail.

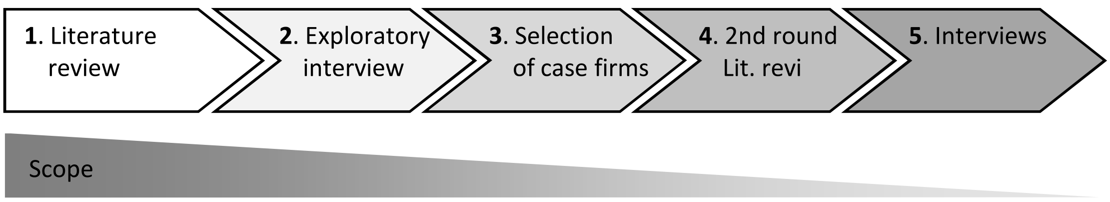

Figure 2.4. The data collection process

2.4.1 Literature review

To create an initial frame of reference to form our research question, a broad and extensive literature review was conducted as a primary step of the thesis work. To ensure high credibility, a structured keyword-based search was carried out at four major online databases: EBSCO Business Source Premier, Emerald Insight, Science Direct and Wiley Interscience. The keywords used were "intermodal transport", "supply chain management", and "sustainability" and synonyms and combinations of these, e.g. "intermodality AND sustainability".

Articles from peer reviewed scientific journals, in different fields of academia, such as *International journal of physical distribution and logistics management, Transportation research A, The international journal of production economics, Industrial marketing management* etc. were found and judged by relevance. The most relevant articles were read thoroughly and references used by these were targeted in a new search using a "snowball approach". By using this approach we were able to distinguish generally accepted ideas from more controversial.

The findings of the initial review were complemented by newspaper articles, business and transportation literature, and reports from consultancies and government agencies. Influences were sought after from a wide range of sources to give as holistic a view as possible for finding the right approach to the problem. The aim was not yet to build a strong frame of reference but merely to get acquainted to the different issues and to the subject itself.

From this, our initial research problem was refined and important delimitations were stated. In discussion with the tutors at UnitedLog and the university, the introduction chapter was written and the research questions drafted. A range of possible case companies were identified and a first contact was initiated over the phone or by email before a decision was made on what companies to include in the study.

2.4.2 Exploratory interview

To be able to break up the initial problem statements into smaller sub-problems and to gain a deeper understanding of previous and contemporary issues relating to intermodal transportation, Dr Jonas Flodén from Göteborg School of Business and Law was contacted and interviewed in person. Dr Flodén's doctoral dissertation was titled ”Modelling intermodal freight transport – the potential of combined transport in Sweden”, and he has several years of experience from research on the subject.

During the interview, Dr Flodén explained his own research, current issues and opportunities, and provided us with feedback on our initial problem description. We were also given a number of examples of shippers using intermodal transportation and Dr Flodén's own experiences from discussing the issue with service providers, forwarders, and shippers. This helped us to further focus our initial research question.

2.4.3 Selection of case companies

During the initial literature review and interview round a small number of companies had been identified as possible targets for further case research. These had all implemented intermodal solutions successfully into their logistics systems, alone or in cooperation with a logistics service provider. They were also owners of the solution, and transported goods which were not seen as the typical rail-bound kind of goods. These companies were Coop, Ica, Tetra Laval, Smurfit Kappa, Arvid

Nordquist, Home Retail[8], Lindex, ITT Water & Wastewater, Volvo Cars, and Volvo Trucks. Through telephone conversations we discussed their intermodal solutions and after consideration we decided to focus on a smaller sample of companies whose logistics systems exhibited more of the non-traditional characteristics of rail-bound transport, for example quality, service, and lead time focus. We also aimed at finding case samples from diverse industries and geographical locations. An overview of the selected companies and the prevalence of certain characteristics are shown in Table 2.5 below.

Table 2.5. Occurance of non-traditional characteristics and common denominators

	Non-traditional characteristic	Arvid Nordquist	Home Retail Co SE	ITT W&WW	Lindex	Volvo Trucks
Products	Consumer products	X	X		X	
	High value-to-weight			X	X	X
	Sensitive to impact	X	X	X		X
Logistics System	Lead-time focus				X	X
	Outbound intermodal			X	X	
Company	Quality/Service focus	X	X	X	X	X
	Common denominators					
	Has intermodal solution	X	X	X	X	X
	Owner of solution	X	X	X	X	X
	Transports non-typical products	X	X	X	X	X

2.4.4 Second round literature review

For the second round literature review, focus was primarily on the established theories on logistics management. These were to be used to construct the frame of reference and were found in four well renowned books on logistics and supply chain management: Christopher's *Logistics and supply chain management – strategies for reducing costs and improving service*, Coyle et al's *The management of business logistics*, Skjött-Larsen et al's *Managing the global supply chain*, and Lumsden's *Fundamentals of logistics.*

In books, one often finds compilations of, and synthesized, knowledge and information concerning specific areas. However, when one seeks leading edge knowledge and recent findings this might be easier obtained in recently published papers and journals (Patel and Davidson, 1994). To make sure that the frame of reference was of high reliability, the theories from the four books were complemented with conclusions from recent doctoral dissertations, official statistics and government reports, and articles from scientific journals and magazines. The focus was on the shipper's logistics system and in particular on the costs, service measures, and environmental aspects related to the decisions made in the system.

2.4.5 Case interviews and data analysis

The case company data was gathered through interviews with logistics managers or employees at other high-level positions at the five shippers' logistics functions. Since the study was qualitative in nature, we decided to conduct the interviews in person. In this way, we reasoned, we would be able to conduct more detailed interviews and also get to know the interviewee better.

[8] The company name is fabricated due to secrecy

The case interviews were conducted in a semi-structured manner and lasted for approximately two hours. Before our visit, a comprehensive list of questions was sent to the interviewee (see Appendix), and upon meeting we had an open discussion, zooming in on the issues most relevant to the system being investigated. The same interview guide was used for all companies to facilitate the cross-case analysis; however, we made some modifications during our discussion depending on the system under investigation. By conducting the interviews in this way we hoped to be able to "dig deeper" into the specifics of each of the cases, as the manager more freely could describe the solution and his or hers experiences from it. We made sure, though, to touch upon all important issues during the course of the interview. One or two employees on logistics manager position or similar were interview for every company. In addition, a questionnaire was sent out by email a few weeks after the interview, complemented by a few extra questions for clarity.

All interviews were transcribed and sent to the company for verification before analysis. These transcriptions can be found in the Appendix. To increase the construct validity, the interviews were complemented with financial and sustainability reports, as well as web site information, from the case companies.

The analysis was then performed by comparing the findings in each case to a proposed model based on the frame of reference. The different cases were also compared in a cross-case analysis in order to identify interesting differences and similarities between them.

2.5 Validity and reliability

There are several ways to judge the quality of case studies. According to Yin (2003), four different tests are commonly used; construct validity, internal validity, external validity and reliability. When conducting case studies it is important to consider these concepts not only at the beginning of the project, but also during later stages of the investigation (Yin, 2003). The different tests are shown in Table 2.6.

Table 2.6. Four tests for validity and reliability (Yin, 2003)

Test	Case study tactic	Phase of research in which tactic occurs
Construct validity	• Use multiple sources of evidence • Establish chain of evidence • Have key informants review draft case study report	Data collection Data collection Composition
Internal validity	• Do pattern-matching • Do explanation-building • Address rival explanations • Use logic models	Data analysis Data analysis Data analysis Data analysis
External validity	• Use theory in single-case studies • Use replication logic in multiple-case studies	Research design Research design
Relibility	• Use case study protocol • Develop case study database	Data collection Data collection

Several of the above measures have been taken into account in order to get reliable and valid results. In the case studies, several sources of evidence were used, both people interviewed (one or two per case) and written communications in the form of annual reports, the company web page, and magazine articles. Also, all interviewees were sent the interview transcription and the case report for review as to make sure that no mistakes were made regarding the information.

Replication logic was used in the research design phase, and in the data analysis phase different models were used and rival explanations were addressed. These combined measures, in the pre-study and design phases as well as the analysis phase, have secured high validity and reliability. However, there may always be a bias involved in any of the phases. This risk has hopefully been minimized the efforts described above.

3 The current situation: intermodal transport in Sweden and Europe

To get a clearer picture of how intermodal transport is used in Sweden and Europe, this chapter will provide information on mode choice and usage on an aggregated level. The purpose is to further describe how an intermodal network is designed and bring up facts and figures which will be relevant for the analysis.

3.1 The different freight modes

Firstly, we will start by describing the different modes of transports and their relative strengths and weaknesses. Below is a short summary of Lumsden's (2000) take on each of the transport modes.

Road. The small size of the truck means that the truck can be adapted to the needs of a single customer. This also means that the truck can act as an independent economic unit able to solve and adapt to problems on a low level by, for example, search locally for additional goods. The fact that a driver is accompanying the goods adds a certain amount of safety and reliability.

The flexibility of truck transport does not end with the single vehicle. Truck traffic is also capable of handling different distances ranging from local deliveries to long international transports. In addition, the mode has the advantage of being relatively fast and not bound by any specific infrastructure other than the road network.

Rail. Rail-bound traffic relies on the principle of the extremely low friction between steel wheels and steel rail. Because of this, rail cars are able to form a convoy, a train, which can be towed by a single engine with a relatively small amount of total traction and staff. The concept of forming convoys means that the train can carry very large loads and are therefore mostly suitable for large flows to achieve high fill rates. Rail transport is also somewhat slower than its main competition road due a traditional focus of energy efficient transport and the fact that it has to follow the existing infrastructure. The dependence on infrastructure also means that the rail has to rely on other means of transport (mainly road) to reach location not connected to the rail network.

Water. Transport by means of ship offers three major advantages. First of the high capacity of the large and specialized ships enables even very low-valued products such as ore and core to be transported profitably. Secondly, the free lanes that the international waters offer combined with the last factor, cheap bunker oil for propulsion, ensure low variable costs for the transport. Together, these factors give sea transports the lowest cost per ton kilometer of all modes of transport. Sea is however also the slowest of all the commonly used transport modes.

Air. In later years, trends such as Just-in-Time, centralization and wide sourcing have increased the demand for fast and reliable transports. This has benefitted air transport, as it is by far the fastest transport mode for covering long distances. Air transport is however associated with very high costs compared to all other transport modes.

A compilation made by Kohn and Huge Brodin (2007) describing the characteristics of each of the transport modes are presented in Table 3.1 below.

Table 3.1. Compilation of transport modes' characteristics

	Road	Rail	Water	Air
Cost level	Moderate	Low	Low	High
Balance fixed/variable costs	High variable; low fixed	High portion of fixed	High variable; low fixed	High variable, low fixed
Market coverage	Point to point	Terminal to terminal	Terminal to terminal	Terminal to terminal
Predominant traffic/goods	All types	Low-mod value; mod-high density	Low value; high density; large load size	High value; low-mod density; small shipments
Length of haul	Short to long	Medium to long	Medium to long	Medium to long
Speed	Moderate	Slow	Slow	Fast
Availability	High	Moderate	Low	Moderate
Delivery accuracy	High	Moderate	Low	High
Loss and damage	Low	Moderate-high	Low-moderate	Low
Flexibility	High	Moderate	Low	Low-moderate

Due to the focus of this thesis on road and rail transport we will now leave the two other transport modes be. We will instead focus on the development in the modal split between road and rail and the underlying factors.

Despite an increase in total transport work the development of rail transport has seen virtually no growth or even a decline in both Sweden and Europe in general. Instead, truck traffic has taken over market shares at the expense of rail. The development for each of the two transport modes in Europe is illustrated in Figure 3.1 below. Nelldahl (2000) argues that this is because the railway operators have neither been customer focused nor market oriented enough and that the rail transport systems have not developed in the same pace as for truck.

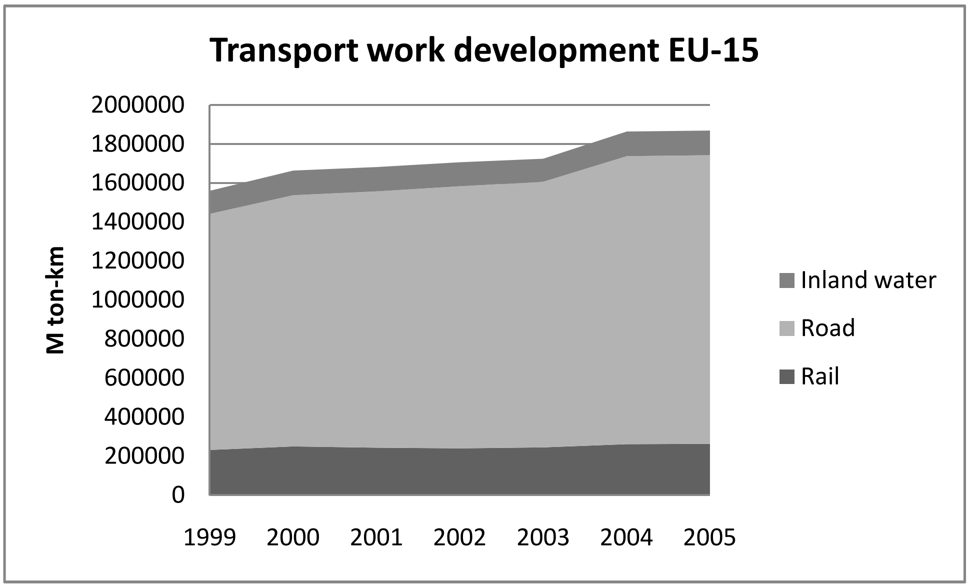

Figure 3.1. Transport work development for different modes of transport, EU-15 (Eurostat, 2009)

A major problem rail transport have when competing against road on a trans-European scale is the large differences between countries. Different electric and signal systems makes for problems when crossing borders and engines that can handle both systems are much more expensive. Another problem is the mismatched loading profiles that forces companies to adopt train cars that have a smaller profile that matches those of all other countries. But the largest obstacle is perhaps the lack of cooperation between companies where planning and sales operations are only handled on a national level. For example, if a carrier wants to buy a rail transport from Spain to Sweden it is necessary to contact six different railways just to be able to present an offer to a potential customer.

3.2 The intermodal transport network

Although the planning and execution of the transportation is the concern of the carrier, it could be of interest for the understanding of the thesis to describe – in general terms – how the solution is structured. We will therefore spend a moment describing the generic design of the intermodal transportation network.

Flodén (2007) describes the structure of an intermodal transport network as being constructed by the three following components:

- A finely distributed distribution/collection system
- A roughly distributed long-haul system
- Terminals

The relation between the components is illustrated in Figure 3.2.

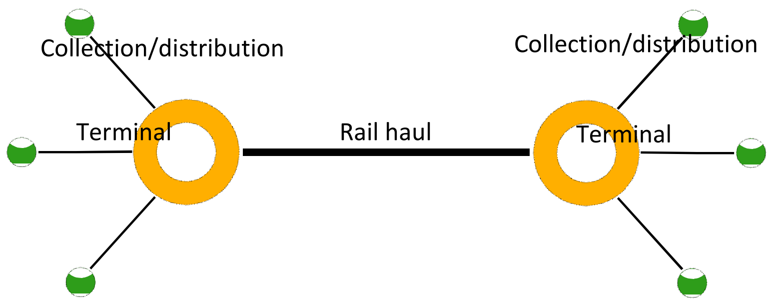

Figure 3.2. Intermodal transport network, after (Flodén 2007)

Designed this way, the intermodal transport network is able to combine the strengths of different transport modes. In the case of the road-rail transportation network the short collection/distribution part of the transport to and from terminals would be conducted by means of road traffic. This enables the network to reach more locations while offering a higher degree of flexibility. The long part of the journey between the terminals would however be on the more cost effective and environmentally friendly railway.

The goods transported by intermodal traffic in Europe follow very distinct corridors with a limited number of routes and destinations. These corridors are formed in order to maintain high volumes in the intermodal flow and are often created around a major flow in a large company's supply chain, for example a car company. The majority of the flows follow a North-South axis connecting the industrial centers in northern Italy with Austria, Switzerland, Germany and the Benelux countries. In total 70% of the intermodal transports in Europe crosses the Alps and 95% originates or terminates in Austria, Switzerland, Germany, or Italy. (Henstra and Woxenius, 2001)

An increased use of intermodal transports can also be seen in West-East corridors connecting the emerging Eastern European economies with Western Europe. These flows uses a simpler form of intermodal transport called "rolling highway" using ordinary trucks that can be rolled onto a railway car for transport. This form of transport is not cost-effective and relies on subsidiaries and road tolls to stay competitive but acts as a transition phase for when containers and swap bodies become more available in Eastern Europe. A map illustrating the main intermodal corridors in Europe is shown in Figure 3.3 below.

Figure 3.3. Most trafficked intermodal rail-bound flows in Europe, based on (UIC-GTC, 2004)

3.3 The Swedish situation

The rail market in Sweden has many similarities to that of the European market. In this section we will briefly describe what is being transported by rail in Sweden and where in the country the main flows are.

In general, rail transports are often considered a slow, cheap and damage-prone mode of transport. Traditionally, this has lead to that only products with certain characteristics have been seen as suitable for transport by means of rail. In Figure 3.4 below it is easy to see that the majority of the products transported on rail in Sweden are bulk products such paper, iron ore and timber. It is also interesting to see that the category 'Other' that includes finished goods have almost doubled its volume in the years 2001-2006.This change is a small indicator to the trends that this thesis is based upon, but more about that later.

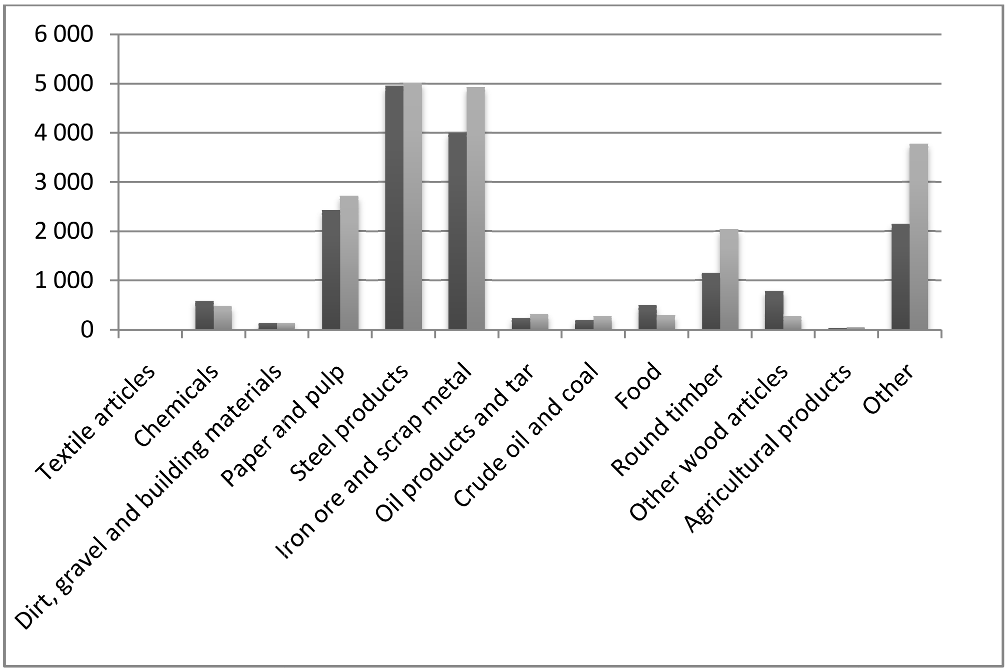

Figure 3.4. Distribution of transport work on rail (in M tonkm) in Sweden (SIKA, 2008a)

The intermodal flows in Sweden follow certain patterns just like those in the rest of Europe. In Figure 3.5 below the total amount of TEU's[9] for the intermodal terminals in Sweden is presented. As expected, much of the traffic is concentrated around the three largest cities Stockholm, Gothenburg and Malmo but also in railway nodes such as Almhult and Hallsberg. While it is preferable to have high volumes when using rail traffic it can also be associated with problems. The high volumes can cause congestion, which in turn leads to longer lead-times and difficulties with maintaining delivery precision.

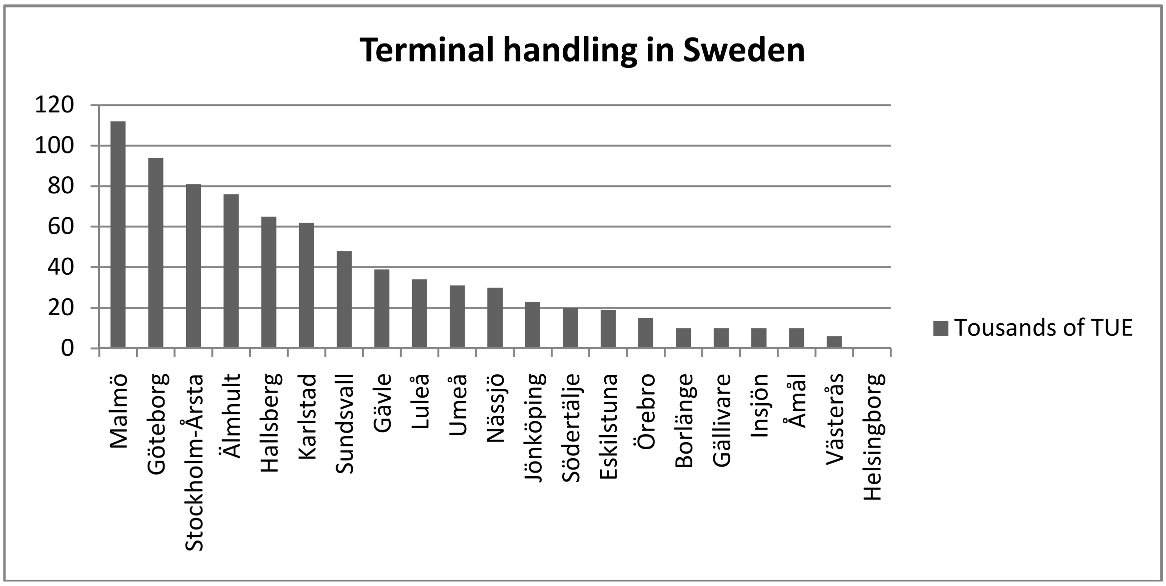

Figure 3.5. Amount of TEU's (Twenty-foot Equivalent Unit's) handled by Swedish intermodal terminals (Banverket, 2007)

[9] Twenty-foot Equivalent Unit

4 Frame of reference

In the logistics management literature, intermodal transport is often mentioned but rarely discussed in isolation. There is a wealth of normative theories regarding a shipper's logistics system, but when it comes to intermodal transportation the research is descriptive and usually from a carrier point of view. One can find many studies on the performance of the solution, but not explicitly on the systemic effects of such a solution. However, by combining these descriptive studies and apply them to normative logistics management theories, one could make a number of theoretical assumptions on system behavior. The aim of this chapter is to create a frame of reference in this way. The theories are centered around three major decision variables for the shipper: customer service, logistics costs, and environmental performance. Our starting point is that of changes and decisions in the logistics system.

4.1 Decisions and changes in the logistics system

From CSCMP's definition on logistics management, the logistics system can be defined as the system that

> "plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements." (CSCMP, 2009)

From this definition two important conclusions can be drawn. Firstly, the logistics system should deliver *customer service*, that is, making sure the customer receive the right good, service or information according to his or hers requirements. Secondly, the deliverance should be carried out in *a cost efficient way*, that is, all processes and activities from point of origin to point of consumption should be done as cost efficient as possible without compromising the ability to deliver customer service.

This captures the *role* of the shipper's[10] logistics system. All activities, functions or processes within the system should strive at delivering cost efficient customer service (Christopher, 1998; Mentzer et al., 2004).

However, when designing the logistics system, many tradeoff-decisions need to be made with regard to the firm's market, customer, product and logistical resources. Depending on a firm's strategic goals and available resources, logistics managers can choose from an array of options including direct shipping or hub-and-spoke, central warehouse or distributed network, intermodal or single mode, and third party services or private fleet (Wu and Dunn, 1995).

Fisher (1997) argues that the mix of options chosen must be aligned with the competitive strategy of the firm. Depending on *the implied demand uncertainty* of the products, he argues, the system design is made to deliver the right amount of customer service at the right total logistics cost. Essentially, two generic design strategies exist (Fisher, 1997):

1. Physically efficient design, and
2. Market-responsive design.

Logistics systems for innovative products such as mobile phones, high fashion items, or cars, should be responsive in order to respond to unpredictable demand. On the other hand, functional products such as canned soup, basic clothing, or oil and gas, require efficient and stable logistics systems to maintain high utilization rates of manufacturing (Skjøtt-Larsen et al., 2007). A comparison of important design criteria is given in Table 4.1 below.

Table 4.1. Comparison Efficient vs. Responsive structure (Fisher, 1997)

Criterion	**Efficient**	**Responsive**
Primary goal	Lowest cost	Quick response
Product design strategy	Integral design to minimize product cost	Modular design to allow postponement
Pricing strategy	Lower margins	Higher margins
Manufacturing strategy	High utilization	Capacity flexibility
Inventory strategy	Minimize inventory, centralize	Buffer inventory, close to customer
Lead time strategy	Reduce but not at expense of greater cost	Aggressively reduce if costs are significant
Supplier selection strategy	"Sufficient" quality and cost	Speed, flexibility, quality
Transportation strategy	Greater reliance on low cost modes	Greater reliance on responsive (fast) modes

Lee (2002) specifies the model further by also considering uncertainties in the *supply* process. In this manner he makes a useful distinction between responsive strategies (flexible to the *changing needs* of the customers) and *agile* strategies (flexible to the *changing demand* of the customers). Responsive strategies can be utilized by companies with fairly stable supply processes such as those in the fashion apparel or personal computer businesses. Agile strategies should be used if the supply process is evolving which is the case in the telecom and high-end computer businesses.

[10] For a definition on shipper see Section 1.3.2

Obviously, the overarching strategy can be carried out in a number of ways. When designing the logistics network, that is, the structure of links and nodes that handle the material flow, one has to find the right balance between cost and customer service. In the words of Chopra (2003), the performance of a system should be evaluated along two dimensions:

1. Customer needs that are met.
2. Cost of meeting customer needs.

A cost efficient, or lean, system focuses on the cost part whereas a responsive, or agile, system focuses on the customer service part. This is the essence of the logistics strategy. The chosen focus shapes the premises for all other decisions taken within the system and the two points above will therefore be dealt with explicitly in the following sections. Specifically, we are interested in investigating the effect on cost and service that *a change in transport mode*, from all-road transport to intermodal transport, might incur, so called *Mode Choice* (see Figure 4.1).

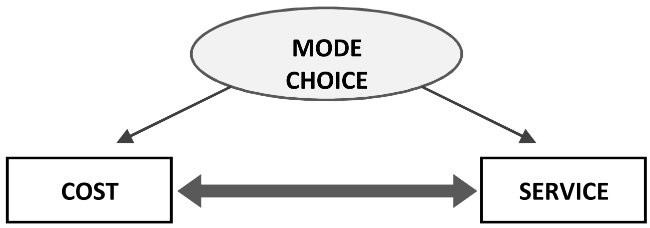

Figure 4.1. Mode choice and the Cost-Service tradeoff

It should be noted at this point though, that a change in transport mode is not a purely strategic issue. Many levels of decision-making are affected by such a change in the system, and before the impact of the modal shift is investigated further, these levels need to be clarified.

One common way to view the logistics decision hierarchy is by separating the decisions into strategic, tactical, and operational decision levels, and many frameworks for this exist (e.g. Aronsson and Huge Brodin, 2006; Chopra and Meindl, 2006; Stank and Goldsby, 2000). In Figure 4.2 a framework of the decision levels and their relation to mode choice is presented, based on the frameworks by Björnland et al (2003) and Aronsson and Huge Brodin (2006).

The framework aims at showing how every level in the hierarchy creates opportunities and set the boundaries for actions taken at a lower decision level (Aronsson and Huge Brodin, 2006), as symbolized by the ever narrower funnel. The strategic and structural decisions are long-term and involve top management. Tactical and operational decisions regard planning and day to day operations. Although decisions taken on all these levels together determine the performance of the logistics system, decisions taken at the higher levels in the hierarchy have a greater impact on the overall performance (McKinnon, 2003).

That these levels are sometimes blurred is pointed out by Aronsson and Huge Brodin (2006):

> "An example of a structural decision is whether there should be both central and regional storage of a product. Typical for such strategic decisions are that they concern the whole supply chain. One step down in the decision hierarchy is decisions primarily concerning planning and management. Typically, they concern one market or one large customer. There is not always a clear distinction between strategic/structural and tactic/management decisions, e.g. one market

might be distant enough so that it is not possible to service the market with only one central warehouse, an exception is made and another, local, warehouse is established in that market. The decision has both strategic and tactic similarities, the scope of the change(one market) indicates that it is a tactical decision and the type of decision (structural)indicates that it is a strategic decision." (Aronsson and Huge Brodin, 2006 p. 401)

Now, the impact of mode choice presents similar confusion, as the transport mode must not only be taken into account when designing the system but system design must also be taken into account when choosing transport mode (Stank and Goldsby, 2000). This decision is based on a number of criteria, and once this is done the *Carrier selection* phase is initiated, concerning what carrier to select within the chosen mode. According to Coyle et al (1996), the central criteria when evaluating mode and carrier are transit time, delivery reliability, capability, accessibility, and security. Different transport modes have different advantages and an overview of the common transport modes and their relative rank is shown in Table 4.4. Other criteria might include flexibility, information sharing, company image, regulatory elements, and equipment (Björklund, 2005).

Table 4.2. Performance rating of modes, 1=Best, lowest; 4= Worst, highest (Coyle et al., 1996)

Service component	Rail	Motor	Water	Air
Transit time	3	2	4	1
Reliability	2	1	4	3
Capability	1	2	4	3
Accessibility	2	1	4	3
Security	3	2	4	1
Cost	2	3	1	4

In this thesis we are concerned with a specific change in the logistics system – the changeover from road to intermodal transport – and the logic of Stank and Goldsby (2000) indicates that this is an iterative process that is not secluded to only one of the decision levels. Applying the four levels from Figure 4.2 to the implementation of intermodal transport, the literature suggests the following:

- **Competitive Strategy:** The competitive strategy does not deal explicitly with transportation in for a shipper. Rather, these decisions are concerned with what needs to satisfy (Chopra and Meindl, 2006). This, however, have implications for the mode choice since it specifies how efficiency, responsiveness, or environmental aspects should be prioritized.
- **Strategic**: Mode choice is often seen as a structural decision (Chopra and Meindl, 2006). With this view, the choice to use intermodal transport influences the structure of the system with the decision being long-term, often with heavy investments involved (Chopra, 2003; Coyle et al., 1996; TFK, 2005). The tradeoffs between transportation and inventory costs are addressed on structural level through network design decision.
- **Tactical**: For tactical decisions the structure is seen as fixed and transportation is chosen for a specified route between two points (Chopra and Meindl, 2006; Crainic and Kim, 2007).This is also a commonly seen view on transportation mode choice (Chopra and Meindl, 2006; Flodén, 2007). The tradeoffs between transportation and inventory costs are addressed on tactical level through planning, scheduling, and inventory policies.
- **Operational**: Operational issues are concerned with specific shipments (Chopra and Meindl, 2006), and the control and operation of these. Handling and packaging costs are dealt with on operational level.

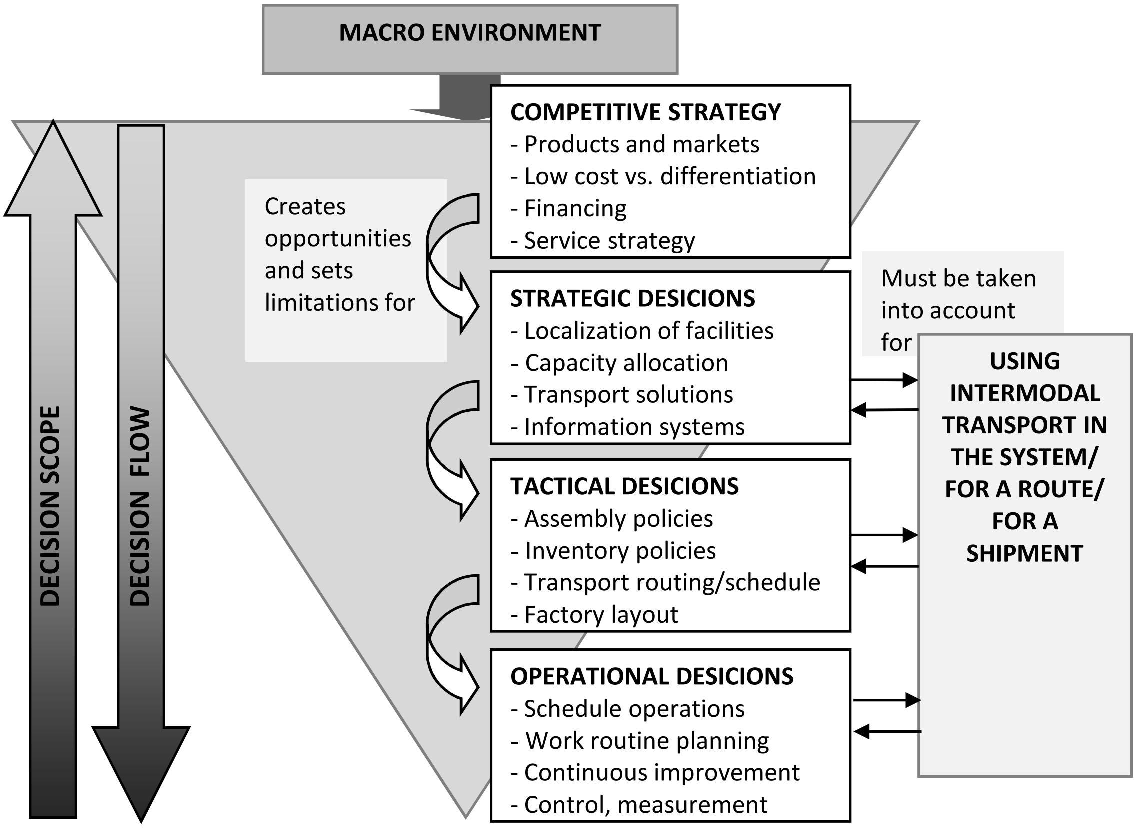

Figure 4.2.The four decision levels for the logistics system, based on (Aronsson and Huge Brodin, 2006; Bjørnland et al., 2003; Chopra and Meindl, 2006; Stank and Goldsby, 2000)

Traditional theories on logistics management suggest that changes and decisions in the logistics system, on all of the above levels, strive at either lowering cost or improving service or, in successful cases, both. Nevertheless, it has also been suggested that environmental performance should be a decision variable in its own right, owing to the tradeoffs that exist with both cost and service aspects (Aronsson and Huge Brodin, 2006; United Logistics Group, 2009). It will be discussed later how environmental efforts can be seen as both increasing and decreasing cost, as well as increasing and decreasing service, depending on the measure chosen. Therefore, for this thesis, Figure 4.1 is extended and the frame of reference will be structured around these three cornerstones of the logistics system and the impact the modal split has on each of them (see Figure 4.3).

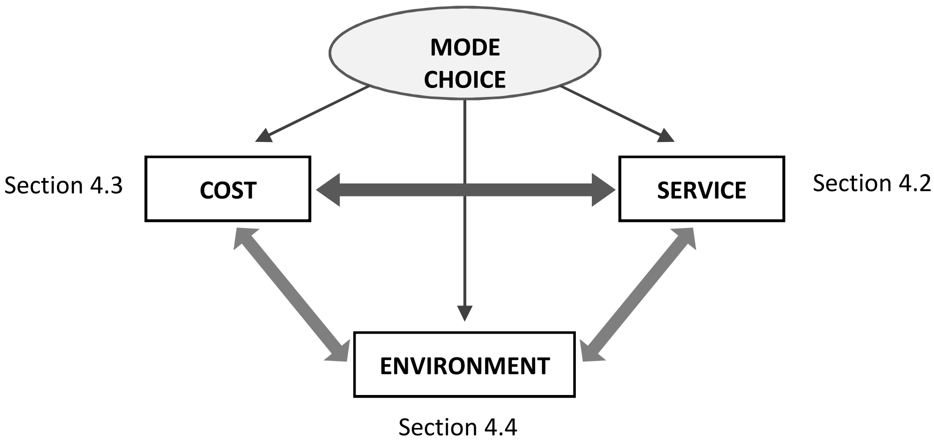

Figure 4.3. Mode choice and the three tradeoffs between cost, customer service, and environmental performance

4.2 Delivering customer service

Customer service is difficult to define and there are many different opinions on what is meant by this. According to Coyle et al (1996), customer service can be seen as having four dimensions; time, dependability, communications, and convenience. There are a multitude of measures for each of these four dimensions, but when discussing logistics structure the ones depicted in Table 4.3 are those primarily affected (Chopra, 2003).

Table 4.3. Customer Service measures affected by structural decisions (Chopra, 2003; Coyle et al., 1996)

Dimension	Measure	Explanation
Time	Response time	Time between when a customer places an order and receives delivery
Dependability	Product availability	Probability of having a product in stock when a customer order arrives
Communications	Order visibility	Ability of the customer to track their order from placement to delivery
Convenience	Product variety	Number of different products/configurations that a customer desires from the distribution network
	Customer experience	Ease with which the customer can place and receive their order
	Returnability	The ease with which a customer can return unsatisfactory merchandise and the ability of the network to handle such returns

It may seem at first that a customer always wants the highest level of performance along all these dimensions. In practice, however, this is not always the case. An example is given by Chopra (2003) who argues that customers ordering a book at Amazon.com, for example, are willing to wait longer than those that drive to a nearby book store to get the same book. On the other hand, customers can find a far larger variety of books at Amazon compared to the local book store. Further, Chopra (2003) concludes:

> "Firms that target customers who can tolerate a large response time require few locations that may be far from the customer and can focus on increasing the capacity of each location. On the other hand, firms that target customers who value short response times need to locate close to them. These firms must have many facilities, with each location having a low capacity. Thus, decrease in the response time customers desire increases the number of facilities required in the network." (Chopra, 2003 p. 125)

This is really a case of differing implied demand uncertainties – serving customers that demand shorter response times increases the uncertainty. What kind of customers the firm seeks to satisfy should be clear from the competitive strategy of the firm.

As this thesis focus on intermodal transport it is of interest to investigate the impact it has on the service delivered by the logistics system. In order to do that, a review of studies regarding shipper attitudes towards intermodal transport is conducted below. The attitudes are used to identify which of the customer service dimensions, if any, that are considered to have changed with the adoption of intermodal transport.

In a study on Swedish companies using intermodal solutions conducted by Ludvigsen (1999), different service aspects were rated for unimodal and intermodal transport. Six service quality dimensions differed significantly between intermodal and single-modal transport: (1) availability of tracing and tracking, (2) availability of unit load devices, (3) efficiency at trans-loading stations, (4) quality of freight handling, (5) transit time, and (6) processing of loss and damage. The results show that the Swedish users were not satisfied with the above performance elements of intermodal operators. Moreover, the overall quality standard of intermodal solutions scored lower than single-modal.

Similar results are shown in a survey presented by Woxenius and Henstra (1999). Here, the most significant differences between intermodal road-rail solutions and unimodal road are identified as transit time, reliability, flexibility, and information provision. Further, a survey by Evers and Harper (1996) shows that those companies that use intermodal transportation in their logistics system rate timeliness (transit time, reliability, directness) and availability as the most important decision variables although these score lower for intermodal transport than for all-road transport. Also here, overall intermodal quality ranks lower than that of single-modal transport. A comparison of the results from these studies is shown in Table 4.4.

Table 4.4.Quality aspects where intermodal transport lack in quality significantly compared to all-road transport according to the shippers

Transport quality aspects	**Ludvigsen (1999)**	**Woxenius and Henstra (1999)**	**Evers and Harper (1996)**
Transit time	X	X	X
Pick-up/delivery times			X
Reliability of service		X	X
Directness of service			X
Frequency of service			X
Availability at origin			X
Availability at dest.			X
Availability of equip.	X		X
Information/visibility/ communication	X	X	X
General flexibility		X	
Handling/damage	X	X	
Processing of loss and damage	X		

Only two of the abovementioned aspects are highlighted as significantly worse for intermodal transport in all three studies: *the longer transit time* and *the lack of information sharing*. These are also mentioned as problematic in the case studies performed by Kohn (2008) in a study where the effects of intermodal transport in the shipper's logistics system are investigated. The issue of *reliability* is highlighted in his study as well, an aspect mentioned in two of the studies above. Two more aspects are mentioned in more than one of the sources in Table 4.4: *availability*, and *handling and damage of goods*.

From this review, we can conclude that most of the service dimensions for the logistics system presented by Chopra (2003) are affected in some way by the use of intermodal transport, at least in the eyes of the users. The aspects with the most significant difference, *longer transit times* and *the lack of information sharing* directly affect the dimensions time and communication, all other factors considered equal. The dependability of a logistics system could also potentially suffer if the *reliability of service* decreased or the *handling and damage of goods* took a turn for the worse, especially if the system relies on Just-in-Time and time-based delivery models. The last dimension, convenience, which mainly concerns the measures product variety, customer experience, and returnability, is hard to tie to any of the issues identified in the review. Due to that fact we will not put any emphasis on that dimension.

In the following sections we will present a more detailed explanation of the impact from intermodal transport on each of the different quality dimensions.

4.2.1 Time

Lead time is a customer service measure and express the time that elapses from an order is placed until the goods are delivered to the customer. A corresponding transport quality measure is the transit time, which is the total time that elapses from the time the consignor makes the goods available for dispatch until the carrier delivers the same to the consignee (Coyle et al., 1996). This is depicted in Figure 4.4.

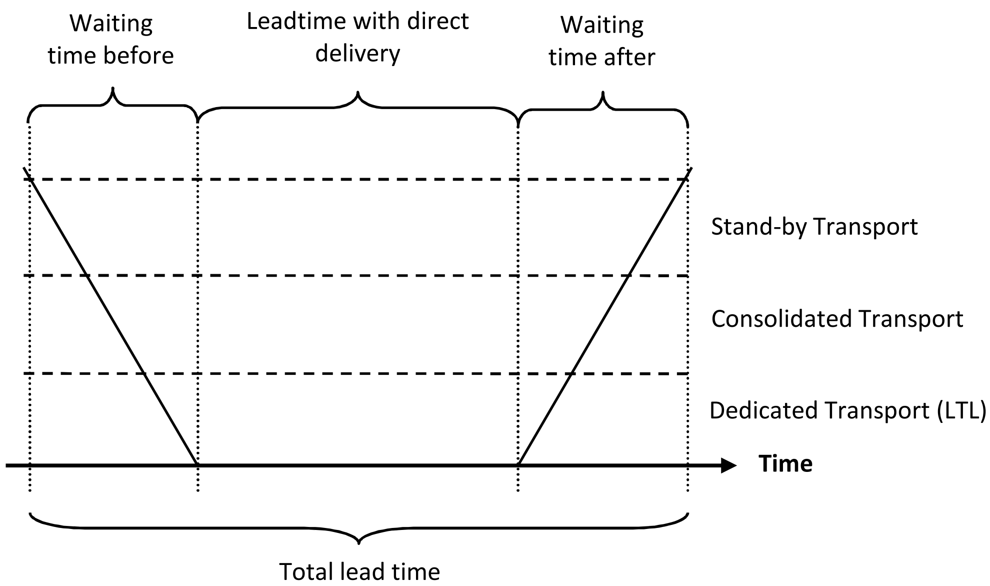

Figure 4.4. Lead time as a function of the degree of consolidation

By definition, intermodal transportation is consolidated. A collection run collects the goods by truck. The goods, or ITU's, are then transferred to a rail car and carried to a destination hub from where it is distributed by truck.

Based on these characteristics, the total transit time in an intermodal solution can be said to depend on

1. Transit time in the distribution/collection system
2. Long haul transit time
3. Time at terminal.

The speed of the local transportation is determined by a number of factors, location being one. An average estimate of the speed of truck transport is given by Björndal et al (2003) at 50-60 km per hour, with distribution/collection transportation being somewhat slower owing to shorter highway distances than long haul truck transportation. Railway transport is slower. According to Lumsden (2006), the transportation time for an average railway transport is 30% longer than for truck transportation. This is, he argues, mainly due to insufficient supply in the odd relations, which also affects the turnaround times for the goods wagons. Flodén (2007) estimates average long haul rail freight in an intermodal solution to be 12.5 % slower than all-road truck transport.

In an intermodal solution, rail freight is used only for the long haul and terminal time must be added to the total transportation time. According to Flodén (2007) the terminal handling time can be estimated to be six minutes[11] per ITU, plus the shunting time of the train at departure and arrival which is estimated to be two hours in total[12]. Assuming the train to be of maximum length[13], and every 34.2 meter car to carry four ITU's, the worst case total terminal time for an intermodal transport would be 2+18x4x0.1x2 = 16.4 hours. In reality, however, terminal handling is limited to a few hours, usually in the morning or evening hours since most freight is transported overnight (Bergqvist et al., 2007).

Now, from a shipper perspective, total transit time is of interest and not transportation time for separate operations. When a hub-and-spoke network is used the total transit time is dependent on the long haul departure times as well.

In Sweden, GreenCargo operates cargo train services to and from several destinations a few times per week. Green Cargo is the largest intermodal service provider in Sweden (Woxenius and Bärthel, 2002) and in Table 4.5 a collection of time table data on four Swedish routes is collected.

Table 4.5.Departure and arrival times for selected routes[14] (Green Cargo, 2009)

Origin	Destination	No of departures/day	Departure	Arrival (+/- 30 min.)
Malmö	Gävle	2	Before 17.00 After 17.00	06.00 after two days 06.00 after three days
Malmö	Göteborg	2	Before 17.00 After 17.00	10.00 the day after 10.00 after two days
Göteborg	Gävle	7	Before 15.00	06.00 the day after
Göteborg	Kiruna	7	Before 15.00	09.00 after three working days

The need to adjust to time tables and scheduled departures inflicts constraints on the degree of flexibility (Bontekoning et al., 2004). This, however, can be countered through planning and preventive efforts which seem to be the case among the surveyed companies as it is not regarded one of the most crucial differences between intermodal and single-modal transport.

4.2.2 Dependability

Compared to air and water freight, the reliability of intermodal road-rail transport is high. Bad weather and road congestion rarely incur any delays in the intermodal network since most of the

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11 Based on time studies at several terminals and calculated as the average of gantry crane handling (5.5 min) and truck (6.5 min).

12 This includes, according to Flodén, shunting of the train when it arrives and when it leaves, coupling and decupling of the RC line haul locomotive, relevant break tests and the transfer of the shunting locomotive to and from its depot. Note that the estimated time is for both the arriving and departing train, i.e. two shuntings of the same train at two different times.

13 Maximum length in Sweden is 650 meters, subtracting the length of the engine yields the total number of cars = 18 (18x34.2=615.6 meters)

14 Generated with the time table tool available online at http://www.greencargo.com/tidtabellapp/frmSearchTimetable.aspx, the times are only available for booking for those with contracts with Green Cargo and are only used to illustrate actual total transport times

distance is traveled with means of railway transport (Coyle et al., 1996). Intermodal transport is, however, mainly competing with all road transport (Flodén, 2007; Lammgård, 2007) and this mode of transport is, in comparison, more reliable.

Transit time precision of intermodal transport in Sweden has been studied by Sommar and Woxenius (2007). In a studied sample of 1854 arrivals over a one-month period, 606 arrived late, which corresponds to 33%. The mean delay was found to be 40 minutes, with Helsingborg being the terminal with most late arrivals (77%), see further Figure 4.5.

	No. of arrivals	**No. of late arrivals**	**Percentage of late arrivals (%)**	**Mean minutes of delay when delayed [hh:mm]**
Borlänge	147	63	43	00:47
Göteborg	209	16	8	00:29
Gävle	163	35	21	00:48
Helsingborg	175	134	77	00:36
Hallsberg	168	104	62	01:11
Jönköping	90	0	0	00:00
Luleå	163	6	4	00:11
Malmö	123	38	31	00:51
Norrköping	189	108	57	00:45
Sundsvall	98	51	52	01:22
Umeå	158	8	5	00:28
Stockholm	171	43	25	00:47
Total	1854	606	33	00:40

Figure 4.5.CargoNet's punctuality during October 2004 (Sommar and Woxenius, 2007)

This supplements the findings of Kohn (2008a), who shows that lead-time precision is a problem among the shippers, especially for material flows where arrival windows are small. Consequently, the dependability of the logistics system will suffer as the probability of stock-out increases. The unreliability of the transports could of course be countered by having larger safety stocks but with higher inventory costs as consequence.

4.2.3 Communications

With the growing popularity of logistics trends such as Just-in-Time and Time Based Competition the need for greater control in the supply chain increases. From a business-to-business point of view a delayed or lost product could have serious implications and in a worst-case scenario it could shut down the entire production. In a business-to-customer context the lack of visibility has been one of the concerns among customers that have hindered the development of e-commerce. Enter the concept of Track & Trace.

Tracking means the ability to follow a specific product through the goods flow and Tracing means locating a product that has been lost or has disappeared in the goods flow. Advancements in information technology have greatly increased a company's ability to track and trace their products through the use of GPS, Internet and RFID (Jonsson and Mattsson, 2005).

The characteristics of intermodal transport seem highly compatibible with track and trace technology. The large load carriers that go through the entire transport unbroken enable a cheap solution with a single RFID tag or GPS receiver connected to a mobile phone modem servicing an entire shipment. Despite this obvious benefit the concept of track and trace is not very extensively used in intermodal transport. This becomes even more counter-intuitive when considering that the risk of damage and misplacement of goods increases as the number of transshipments increases. The result of this is illustrated by the fact that lack of visibility is conceived by shippers as one of the major problems with intermodal transport. (Evers et al., 1996; Ludvigsen, 1999)

4.2.4 Convenience

As noted earlier, convenience is not considered a major issue when comparing intermodal to unimodal transport, when seen as a measure for the service provided to the customer of the logistics system. The product variety should not be affected in any way due to changes regarding transport mode. On the other hand, the pick-up/delivery times can be seen as a part of the customer experience, a factor noticed in the study by Evers and Harper (1996). If intermodal transport is used as the last link towards the customer, one would expect the convenience aspect to play a larger role.

4.3 Balancing logistics costs

It was previously argued that there is a tradeoff between customer service and the cost of delivering this service. The level of service is determined by the competitive strategy and once this level is chosen it can be delivered in a number of ways depending on internal and external constraints. In this section we will focus on the logistics cost of delivering the service.

Chopra and Meindl (2006) discuss logistics cost and the drivers of system performance. They identify four main drivers: *inventory, facilities, transportation,* and *information.* The customers' needs and demands can be fulfilled by different mixes of these components, which all generate costs for the system in different ways. For example, a customer may demand shorter lead times. This could be achieved through higher inventory levels closer to the customer, but it could also be achieved through a larger, centralized warehouse with lower total inventory and dedicated transportation to each customer. In the first solution, inventory and facility cost increase while transportation cost decrease; in the second solution the situation is the opposite. The same amount of service is delivered in both cases but the costs are allocated differently. Clearly, a change in any of the four drivers will affect the system output as measured in cost and service, but also, the change in one driver will affect all the others. A schematic view of this systemic nature is shown in Figure 4.6 below.

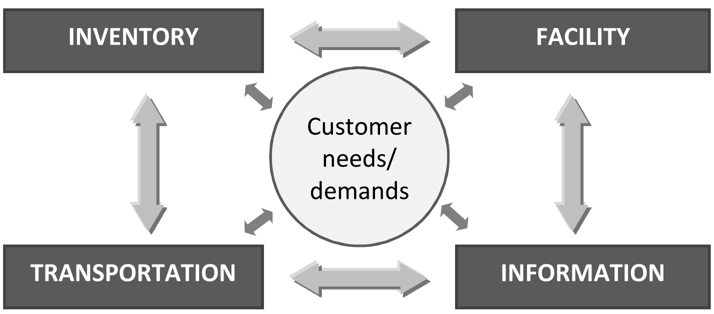


Figure 4.6. The tradeoff between the logistics cost and performance drivers. Based on (Chopra and Meindl, 2006)

When evaluating logistics design it may be convenient to think about customer service in terms of cost of lost sales (Abrahamsson, 1992; Christopher, 1998). By doing so, the customer service level is internalized as an inverted logistics cost, that is, the cost of lost sales decreases as customer service increases and cost and service can be expressed and balanced in a common model. With customer service being expressed as a cost, the structure of the network can be optimized using a total cost model with the following costs included (Abrahamsson, 1992):

- Inventory cost
- Facilities cost
- Transportation cost
- Cost of lost sales

Here, information cost is excluded. Although this, and other costs, are commonly suggested, the first three points above are generally found in most total cost models (Chopra, 2003; Coyle et al., 1996; Skjøtt-Larsen et al., 2007) and will be used in this thesis as well. Information costs do exist, but with the first three points constituting approximately 90% of the total logistics cost (Abrahamsson and Aronsson, 1999) information will not be seen as something altering the logistics structure. Also, administration, packaging, and handling are considered facility-related and will not be dealt with explicitly.

4.3.1 Inventory

Inventory exists because of a mismatch between supply and demand(Chopra and Meindl, 2006). By having inventory, the two processes are decoupled and production can be made independently of customer demand. Primarily three components of inventory exist: *cycle inventory* to satisfy demand between shipments, *safety inventory* held in case demand exceeds expectation, and *seasonal inventory* to counter predictable variety in seasonal demand. Although different in nature, the inventory cost in all instances stem from the risk and alternative cost of the capital employed (Skjøtt-Larsen et al., 2007).

Two time-oriented forces operate on the logistics system with inventory as the balancing point (Skjøtt-Larsen et al., 2007):

- *Speculation*, which is the act of producing and placing inventory close to the market at the earliest possible time to reduce cost, and
- *Postponement* which is the act of delaying changes in product form or identity until the last possible moment. This means operationally that no inventory is produced (production postponement), or that it would be held at a central location (logistics postponement, inventory aggregation).

How postponement and speculation can be used depends on not only the demand uncertainties of the products but also on design as well as manufacturing and supply aspect (Lee, 2002; Skjøtt-Larsen et al., 2007). The degree of inventory aggregation can also be said to depend on value and demand. One model for this is given by Chopra and Meindl (2006) and depicted in Table 4.6.

Table 4.6. Impact of value and demand of product on aggregation (Chopra and Meindl, 2006)

Product type	High Value	Low Value
High Demand	Disaggregate cycle inventory. Aggregate safety inventory. Inexpensive mode of transportation for replenishing cycle inventory and fast mode when using safety inventory.	Disaggregate all inventories and use inexpensive mode of transportation for replenishment.
Low Demand	Aggregate all inventories. If needed, use fast mode of transportation for filling customer orders.	Aggregate only safety inventory. Use inexpensive mode of transportation for replenishing cycle inventory.

According to the model, safety inventory should be aggregated for all products accept those of low value and high demand. Moreover, inexpensive modes of transport – for example intermodal road-rail solutions – should, according to the model, be used for replenishment of products with *high demand*.

4.3.2 Facilities

Facilities are all manufacturing or assembly plants and warehouses. The factories serve a value-adding role by refining goods or materials, but warehouses also serve a multitude of value-adding roles in the logistics system, for example: transportation consolidation, product mixing, contingency protection, and smoothing (Coyle et al., 1996).

Facility costs are those costs associated with running the facilities (e.g. rent, heating, and electricity costs).These costs are considered to be of a semi-fixed character in a shorter timeframe as they do not change in direct proportion to the amount of inventory in the distribution system. Instead, this type of cost is considered to be dependent on the number of warehouses and is expected to decrease/increase in accordance with the number of warehouses. That is to say that as the number of warehouses in a distribution system increases, so will the cost of running the facilities.

Facility costs is also comprised of operational costs such as personnel and equipment costs, and costs for transfers within a facility (Coyle et al., 1996; Skjøtt-Larsen et al., 2007). These costs are incurred by activities that vary with the amount of orders and the batch sizes in the form of packing, goods handling and order handling. As these costs are quantity-related they can be seen as variable in a short as well as long timeframe.

There are number of different techniques of organizing warehousing apart from normal storage of inventory. These include Vendor-Managed-Inventory, Merge-In-Transit, and different forms of postponement. We will not dwell into detail about these in this thesis, but one important idea for the intermodal case is that of c*ross-docking.* In this warehouse concept, the goods move right from inbound to outbound dock without ever staying in the warehouse. In this way the benefits of consolidation can be reaped without the cost of excess inventory (Chopra and Meindl, 2006).

4.3.3 Transportation

The purpose of transportation is to move the products between different stages in the logistics system and thus allow for "disintegration" (Chopra and Meindl, 2006). Two main transport flows exist in the logistics system: *inbound transports* from suppliers to the firm and *outbound transport*, usually referred to as distribution (Stank and Goldsby, 2000). Transportation costs on the distribution side involve two separate but interrelated systems: 1) a primary system of transport from production facilities to distribution centers (for example inventory replenishment) and 2) a secondary system of delivery from distribution centers to customers (Skjøtt-Larsen et al., 2007). The shipping firm may own many or few of the facilities (Chopra, 2003). See further Figure 4.7 below.

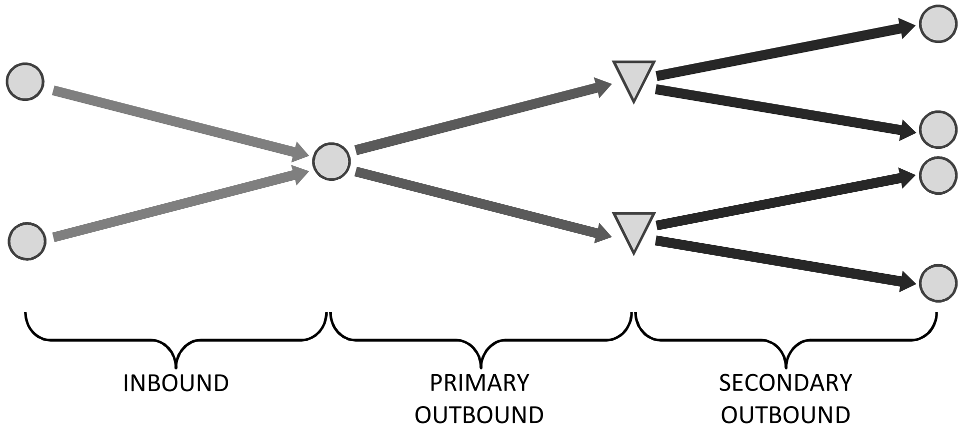


Figure 4.7. Transportation in the logistics system

The price that a shipper pays for a transport is not arbitrarily set by the carrier. The costs incurred when producing the service will directly affect the price of the transport. A factor that greatly influences the costs for the carrier is the mode of transport chosen. Chopra and Meindl (2006) has created a model to analyze the different costs related to transportation and how they affect the carriers decision. The model groups the costs depending on where they have incurred and describes their characteristics in a short and long term perspective.

Vehicle-related costs. These costs incur when a vehicle is purchased or leased from a third party. In short-term decision-making the costs are fixed and incurs whether the vehicle is used or not. In medium- and long-term planning, however, vehicle-related costs become variable as the number of vehicles purchased or leased is a choice carriers have to make.

Fixed operating costs. Costs associated with terminals, airports and gates along with labor performed whether or not a vehicle is utilized or not are classified as fixed operating costs. Just like vehicle-related costs these costs are consider fixed in a short-term but variable in the medium- and long term perspective.

Trip-related cost. This cost includes the labor performed and the fuel consumed on each trip independent of the quantity transported. The cost is always considered variable both when making strategic and operational decisions.

Quantity-related cost. Cost incurred by loading/unloading and fuel costs that vary with the amount of goods transported falls under this category. These costs are generally variable unless the labor needed for loading/unloading has a fixed work schedule independent of the work load.

Overhead cost. This category includes the cost of planning and scheduling the transportation network as well as any investment in information technology. When, for example, the trucking company invests in routing software that allows a manager to devise god delivery routes, the investment in the software and its operation is included in overhead.

The cost structure of intermodal and truck transportation differs in a number of ways. In general, intermodal transportation is characterized by high fixed costs in the form of terminals needed for the transshipment of goods. The increased complexity caused by the combination of transport modes also results in greater costs for planning and scheduling.

Truck transportation, on the other hand, has high trip-related costs. Due to the higher rolling resistance for road traffic compared to rail-bound traffic the fuel consumption is higher. In addition, each road shipment has to be accompanied by a driver in contrast to rail transport where several cars create a convoy driven by a single driver.

Because of this the competitiveness of the different transportation modes varies with the distance traveled. The high fixed costs of intermodal transports against the high variable cost of truck transport create a break-even distance that varies with the capacity of the different modes. Nelldal et al (2000) compares the costs for an intermodal solution utilizing a trailer capable of carrying 25 ton and a distance of 150 km to and from terminals with different truck solutions. The break-even distance, where rail transport becomes the most economical alternative, for each of the truck types are presented in Table 4.7 below.

Table 4.7. Nelldal et al (2000)

Truck type	Break-even
Sweden 60 ton	850 km
Sweden 51.4 ton	500 km
EU 40 ton	350 km

In an opposite manner, advancement in rail technology affects the balance between intermodal and truck transport. The maximum axel load on most rail networks in Europe today is 22.5 tons. There exist plans to increase this to 25, or even 30 tons, but the progress is slow and very costly.

Another way of increasing the relative attractiveness of intermodal transport and make the break-even distance shorter is to reduce the fixed costs that the investments in terminals bring. Bärthel and Woxenius (2003) describe a solution called Light-Combi developed by the Swedish rail operator Green Cargo, depicted in Figure 4.8.

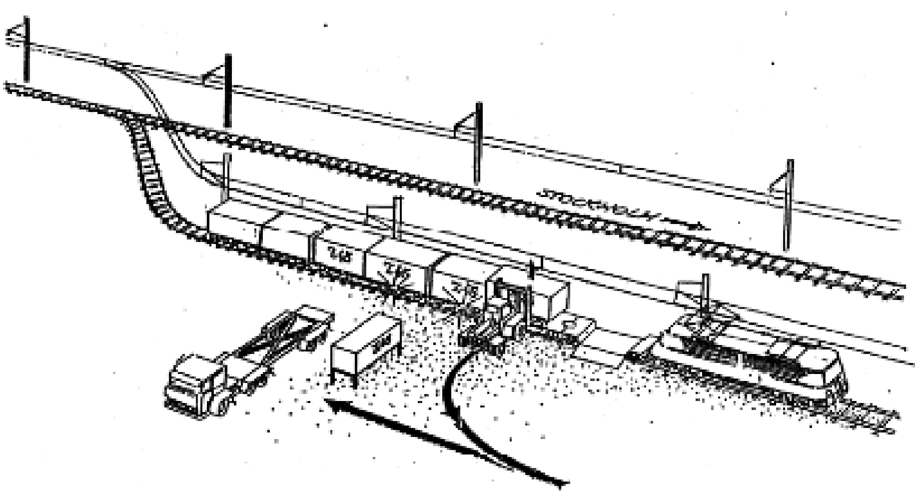


Figure 4.8.The principle of the light-combi solution (Nelldal et al., 2000)

The concept utilizes fixed train sets that make short stops at sidetrack terminals separated by as little as 100 kilometers. The train carries swap bodies that can be unloaded by means of forklift carried on-board the train and operated by the rail engine driver. Since the solution only need a relatively inexpensive rail siding to handle goods the truck transport distance can be minimized. The concept showed great potential but was cancelled due to inadequate goods flows and organizational restructuring within Green Cargo.

It can be concluded that intermodal transport may be a financially competitive alternative as long as the distance is long enough. This distance is dependent on a number of factors such as the capacity of the vehicles and the costs incurred at terminals. So far the technological advancements in intermodal transport have not been large enough to take any significant market shares from road transport. A possible reason for this is the lack of customer focus among rail operators implied by Kohn (2005). The scale of a rail network also poses a problem as the long distances traveled often involve more actors with increased complexity as a result, especially when the network stretches across national borders (Nelldal et al., 2000). However, volume is also of importance and according to Coyle (1996) the long shortest-economical-distance and the inevitable terminal handling that characterize intermodal transport call for high customer density for intermodal transport to compete with other carrier services.

4.3.4 Total logistics cost

The above discussion started from a distribution system cost perspective. However, for any intermodal solution there is always a consignor (sender of the goods) and a consignee (receiver); taking a shipper perspective, this can result in three different situations, all carrying slightly different cost components. Depending on whether the solution is used 1) within the company, 2) from a supplier to the company, or 3) within the distribution network bound for the shipper's customers, slightly different ideas are used to describe total logistics costs. A schematic view of the different cases is depicted in Figure 4.9 below.

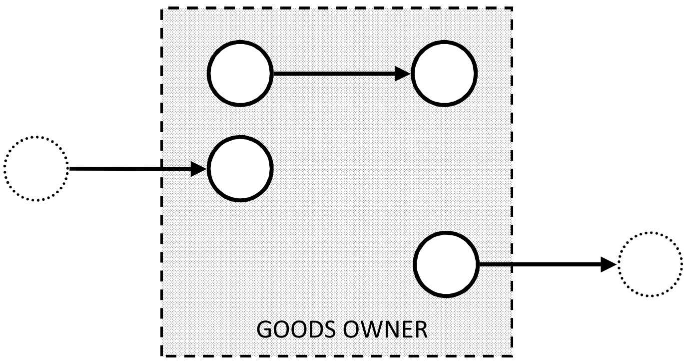


Figure 4.9. The three different cases of intermodal transportation from a shipper perspective

For the first case, when both units belong to the shipper, a common total cost model such as the one presented by Oskarsson et al (2006) can be used to calculate the logistics costs[15]:

[15] In Oskarsson et al's original model, administration is considered a separate cost, here it is included in Facility Costs

TOTAL LOGISTICS COST = IC+FC+TC

IC = Inventory Costs (consignor + consignee)
FC = Facility Cost (consignor + consignee)
TC = Transportation cost

For the sourcing case, one must also include effects from the possible restrictions on the supplier. That is, that a change in transport mode might incur costs further up the supply chain. If the logistics costs increase at the suppliers, it will eventually be reflected in the price paid by the shipper for the goods which are bought (van Weele, 2005). This is sometimes referred to as the "French fries principle", owing to the fact that potato costs tend to be transferred down the supply chain. In the cost model for this situation, one should therefore look into literature for purchasing and supply chain management. Based on van Weele (2005), the cost model for the sourcing case can be expressed as:

TOTAL SOURCING COST = P+IC+FC+TC

P = Price of goods purchased
IC = Inventory Costs
FC = Facility Cost
TC = Transportation cost

For the distribution case, the total cost model must take into account the effect the solution will have on customer service. This can be reflected through cost of lost sales, as described earlier (Abrahamsson, 1992; Christopher, 1998):

TOTAL DISTRIBUTION COST = IC+FC+TC+CLS

IC = Inventory Costs
FC = Facility Cost
TC = Transportation cost
CLS = Cost of lost sales

Usually, this cost is evaluated over the number of facilities in the distribution system.

In all of the above cases, the idea is to find the right balance between service and cost measures for the entire system. Lately, however, it has been argued that the logistics system has an environmental responsibility as well (Srivastava, 2007; Wu and Dunn, 1995). Since these efforts cannot be clearly defined as "pure" costs or a "pure" service aspects (United Logistics Group, 2009), there is a need for these to be addressed explicitly. We will now turn our attention to these.

4.4 Including environmental aspects in the decisions

In this section we will add yet another aspect to the logistics decisions: environmental performance, in particular greenhouse gas emissions. Let us start by describing why.

4.4.1 Incentives for environmental efforts

Focusing on the environmental aspects above, three major drivers for firms to aim for a more sustainable logistics system can be found in the literature (Accenture, 2009; McWilliams and Siegel, 2001; United Logistics Group, 2009):

1. Rising costs and regulation
2. Marketing advantage
3. Goodwill – corporate social responsibility

Fuel and energy prices have been rising dramatically over the last couple of years (IEA, 2009) and this has a substantial effect on the cost structure in many companies (United Logistics Group, 2009). However, as most national governments strive for more sustainable development, carbon reduction policies are being adopted in many countries. In Sweden, for example, greenhouse gas emissions are to be reduced by 40% by the year 2020 (Regeringen, 2009). Other examples are a 60% cut by 2050 in the UK and a 75% reduction in France by the same year (United Logistics Group, 2009). According to the memorandum from the Swedish government, this is to be achieved through taxes and other mechanisms that will be costly for those companies that are unwilling to adjust to the set targets. With rising fuel prices and higher taxes operational costs will increase rapidly if actions are not taken.

The *marketing* aspect is discussed in a report by LEK Consulting (2007) where consumers were surveyed on their opinion on carbon footprint information. Here, almost 40% of the respondents felt that it was the responsibility of the manufacturers and producers to reduce the carbon footprint of the products and services that are sold. Only 20% considered it to be their own responsibility. Moreover, more than 50% said that they would value information about the carbon footprint when making a buying decision; 45% claiming that they would switch to a product with lower carbon footprint that was not their first preference.

Goodwill comes from the general concept of corporate social responsibility, CSR, which is argued to create value not only to the costumers but also other stakeholders such as investors, employees, and communities (McWilliams and Siegel, 2001). By benevolent efforts value and business is created through a more favorable public opinion of the firm.

With the presented incentives in mind, "green" measures such as CO_2-reductions can be taken through numerous actions in the logistics system, on strategic as well as tactical and operational levels. This was seen in section 1.1.1 where Woxenius' critical ratios for sustainable transportation were presented (Figure 1.3). Emissions from transportation within the logistics system has also been widely analyzed by McKinnon (2006; 2003), who explicitly argues modal shift to be an environmentally sustainable measure for shippers. Let us therefore take a closer look at intermodal transport and its environmental impact.

4.4.2 Intermodal transport and the environment

Transportation often plays a large part in the environmental impact of a product. According to Aronsson and Huge-Brodin (2006) transport is responsible for 44 per cent of the total CO_2 emissions from fossil fuels. This does not mean that all transports are bad and should be kept at a minimum. The problem today is the emissions intensity of transport where the majority of the vehicles have low vehicle-kilometers to emissions ratio. The share of each mode of transport in Sweden is presented in Table 4.8 below. It can be seen that road transport has a high portion of the transport volumes in Sweden.

Table 4.8. Share of goods volume per mode of transport in Sweden (ton-km) (SIKA, 2009)

Transport mode	Percentage
Road	39.6
Rail	22.7
Sea	37.7

Kohn (2008b) has used NTM's calculation tool NTMCalc to analyze the amount of ton CO_2-emissions for different modes of transportation. The analysis is based on the transport of one ton of goods over a distance of 500 kilometers with a fill rate of 70%. The results are presented in Table 4.9.

It should be noted that the emissions for electric trains vary greatly with the source of the electricity. In this case, the numbers are based on a Swedish setting, with figures from Banverket, where hydroelectric power is used to run the trains. In another setting where a non-renewable power source would be used, the results would be much less favorable for the train.

Kohn (2008) points out that this analysis cannot be seen as an absolute truth, because of the host of other factors that affects the environmental performance such as weather condition, the driver's actions and the distance traveled. However, with a quick look at Table 4.9 it is easy to conclude that the slower the transport, the less polluting it is. The fast transport modes airplane and truck generates far more CO_2 than the slower modes, train and ship.

Table 4.9. Amount of CO2 emissions (kg) depending on mode of transport when transporting on ton of goods over a distance of 500 kilometers (Kohn, 2008b)

	Truck (payload 26 ton)	Truck (payload 14 ton)	Airplane (Airbus 300-B4)	Airplane (Boeing 737-300)
Excluding fuel production cycle	24	45	600	580
Including fuel production cycle	26	48	640	620

	Train (T44 diesel engine)	Train (electricity)	Ship (>8,000 dwt)	Ship (<2000 dwt)
Excluding fuel production cycle	7.9	0.0015	6.5	13
Including fuel production cycle	8.7	0.034	6.6	13

Apart from the direct reduction of CO2 emissions from a shift in transport mode to a less polluting one there is also a potential reduction in traffic intensity (European Commission, 2001). Congestion is a growing problem in many of the larger cities in Europe with pollution and more time-consuming transports as a result. If more goods could be transferred to the railway, which have the potential to transport almost 20 times[16] the load of a truck, the traffic intensity can be increased, given railway capacity exists.

[16] Avarage payload per train in Sweden: 490 tons, maximum payload per truck: 40 tons, utilization 70%. Figures from (Nelldal, 2005)

As can be seen above a shift to intermodal transport that utilize rail for the long leg of the journey would no doubt improve the environmental performance of transportation. The question is how this affects the shippers. Lammgård (2007) has examined the impact environmental aspects have on shippers and their customers. The report was performed as survey among shippers in Sweden that transport goods a minimum of 150 kilometers.

In the report Lammgård states that the environment is one of the four factors that matter for most shippers when making a decision. However, most companies focus on factors such as 'Outbound transport' and 'Load factors' and not modal choice. The problem perceived by many shippers is that a modal shift is considered to have high potential but very low feasibility. This is something that can be remedied as future advancements in intermodal technology improve the competitiveness through better flexibility, punctuality and higher speeds.

In order to identify the use of environmental arguments in marketing Lammgård (2007) examines the link between environmental aspects and modal choice. The study concludes, although somewhat vague, that companies that highly appreciate environmental considerations of their transports also value the possibility of an alternative to truck transport. This is even more so in the case of medium and large manufacturing companies. According to Lammgård (2007) this is also the segment of companies to focus the marketing of intermodal road-rail transports on.

4.4.3 Environmental tradeoffs

Modern logistics systems are designed to deliver cost efficient customer service which requires the handling of a number of tradeoffs between, for example, transit time vs. transport cost, inventory vs. transport, and customer service vs. logistics costs. This focus on cost and service has, according to Rodrigue et al (2001), led to a number of green paradoxes, one being the fact that many cost saving logistics strategies increase the negative environmental impact from the system. An example, he argues, is a system centralization, which increases total transport work and thus increase the amount of emissions produced by transportation.

Kohn and Huge Brodin (2007) argues differently, claiming that a centralization may very well reduce the amount of CO_2 emission from the system. The reason, they argue, is that the number of emergency deliveries decrease as a system is centralized while, at the same time, the replenishment can be taken care of by means of a rail or intermodal road-rail solution and thus reducing the total amount of CO_2 from the system.

Most greening initiatives within the supply chain are difficult to investigate due to similar reasons; for all initiatives tradeoffs exist with either costs or service or both. For example, a certain initiative may increase the perceived value of a product according to results from LEK Consulting (2007), but this may also increase the supply chain costs because of, for example, the need to invest in less polluting technology along the supply chain in order for the value to increase. Other efforts may reduce costs but decrease service, one example being the introduction of a slower mode of transport which reduces the customer service through the increasing lead-time.

That intermodal transport would be a ”greener” alternative than road transport is widely recognized, and the general consensus is also that the implementation would decrease total logistics costs as well but at the expense of customer service. The past years logistics trends and their impact on the development of intermodal transport are depicted in Table 4.10.

Table 4.10. Logistics trends and their effect on intermodal development, based on (Henstra and Woxenius, 2001)

Trend	Opportunity	Threat
SCM trend		
Spatial concentration/ centralization	'Thicker flows', increasing length of haul make intermodal transport relatively more attractive	
Vertical disintegration/wider geographical sourcing	Increasing length of haul make intermodal transport relatively more attractive	
Increased direct delivery/disintegration		Smaller consignment result in less consolidated flows
JIT, ECR, nominated day delivery, booking-in/timed- delivery systems		Increased service requirements (speed, precision, flexibility) increase attractiveness of road transport
Increased use of outside transport/distribution contractors	Consolidation opportunities	
Increased vehicle sizes Increase in complexity, sophistication of product, demateralization		Increased efficiency in road transport
Increased possibilities of ICT and availability at lower cost		Higher value makes road transport more attractive
Other trends		
Increased congestion on road network	Decreasing performance of road transport	
Stimulation of intermodal transport by EU and national governments	Liberalization, pricing, regulation, public investments in infrastructure in favor of intermodal transport	
Developments in propulsion technology, emission controls, alternative fuels, etc.	Cleaner intermodal transport	Cleaner road transport reduces arguments to stimulate intermodal transport
Increasing environmental awareness of customers	Using intermodal transport becomes a selling point	

4.5 Bringing it together: our framework for analysis

As seen in the previous sections, there are a number of suggestions from theory of where and how an intermodal solution is used within a shipper's logistics system. In this section, some key findings from above related to our research questions will be presented, forming a framework for our future analysis. This will be discussed on our studied system's four different levels: company (competitive strategy), logistics system (strategic), flow/link (tactical and operational), and the product level, see Figure 4.10.

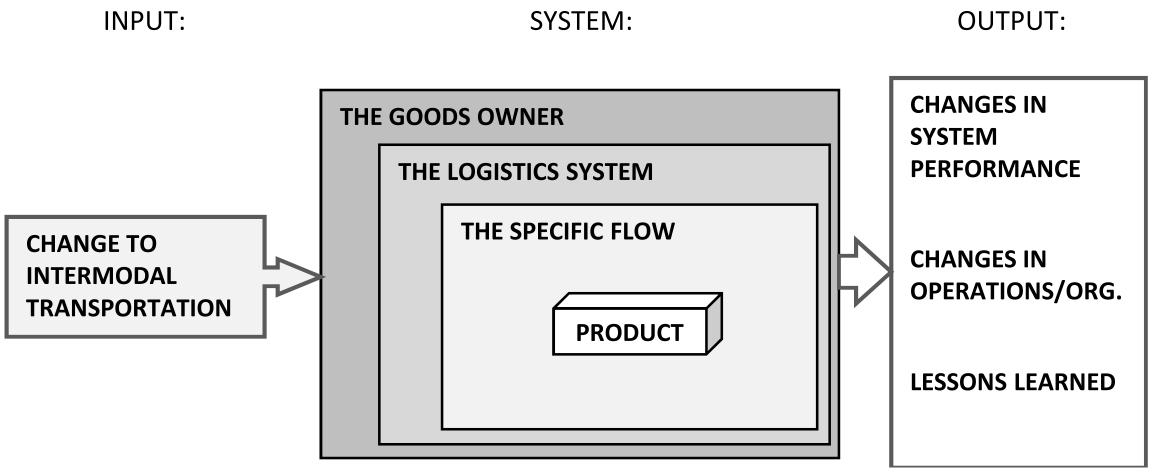


Figure 4.10. The studied system

Goods Owner (Company). Although the company level (which relates to decisions regarding competitive strategy) does not explicitly deal with logistics decisions, it sets the boundaries and decides on the amount of attention to give to logistics related issues (Aronsson and Huge Brodin, 2006). Considering the discussion regarding environmental initiatives and the pros and cons of intermodal transport above, it is reasonable to believe that environmental initiatives and policies within the company would make the implementation receive more attention and resources. Thus, it is more likely to find an intermodal solution within a company with explicit policies regarding CO2 emissions.

System. In Table 4.10 in the previous section, a number of logistics trends are mentioned as opportunities for intermodal transport. Relating these to high potential system characteristics, intermodal transport can be seen as more likely to be found in centralized logistics systems, with wide geographical sourcing, and for which 3PL providers are utilized (Henstra and Woxenius, 2001). It has also been shown in the previous sections that intermodal transport tends to be perceived as a low-cost, low-quality alternative and should therefore be more likely to be found in a system with a cost focused logistics strategy; if high service is the system focus competitiveness may be seriously jeopardized by lower transport quality.

Flow/Link. In general, intermodal transport has high fixed and low variable costs when compared to truck transports. This means that, the longer the transport, the more competitive intermodal transport is for the carrier to market to the shipper (Flodén, 2007; Nelldal et al., 2000). *How long* has been debated; a common suggestion is at least 500 km for transeuropean transportation (Nelldal et al., 2000), but both higher and lower numbers have been mentioned depending on what the underlying assumptions are (Flodén, 2007). The general consensus, however, is that the mode is not competitive for shorter distances. Also, to be able to utilize the economies of scale that comes with the consolidated rail-bound part, large total volumes for the flow are needed. This may more easily be achieved along certain established intermodal corridors that run through Europe (Henstra and Woxenius, 2001), and one may thus expect a transport link between, for example, southern Europe and Sweden to be more attractive for an intermodal solution. Since most research claim intermodal transportation to offer lower transport quality as compared to unimodal road freight (Flodén, 2007; Lammgård, 2007; Ludvigsen, 1999), it must also be deemed unlikely that the solution is used in a link for which the shipper has no control of the source or of the destination since this could potentially jeopardize the customer service. Thus, one would expect the link to be within a company.

Product. According to previous studies, goods damage is an issue for shippers using and considering intermodal transport (Henstra and Woxenius, 2001; Ludvigsen, 1999). Because of this, products which are not sensitive to damage from impact or rough handling should be more likely to be found in this type of solution. It was also argued by Chopra and Meindl (2006) that less expensive, and hence slower, modes of transport should be used to replenish products of high and stable demand and low value when designing a distribution network. These three product characteristics: low value, low sensitivity to impact, and high and stable demand, imply that intermodal transport is more likely to be found far back in the supply chain or for commodity goods for which the implied demand uncertainty is lower. Also, considering the environmental advantages of intermodal transport and the survey on customer preferences by LEK Consulting (2007), one would expect products marketed as ecological or environmentally friendly as being more prevalent in intermodal settings.

Considering the abovementioned discussion, the suggested place and use of intermodal transportation raise a number of questions for further investigation which are presented in our framework, Figure 4.11, below.

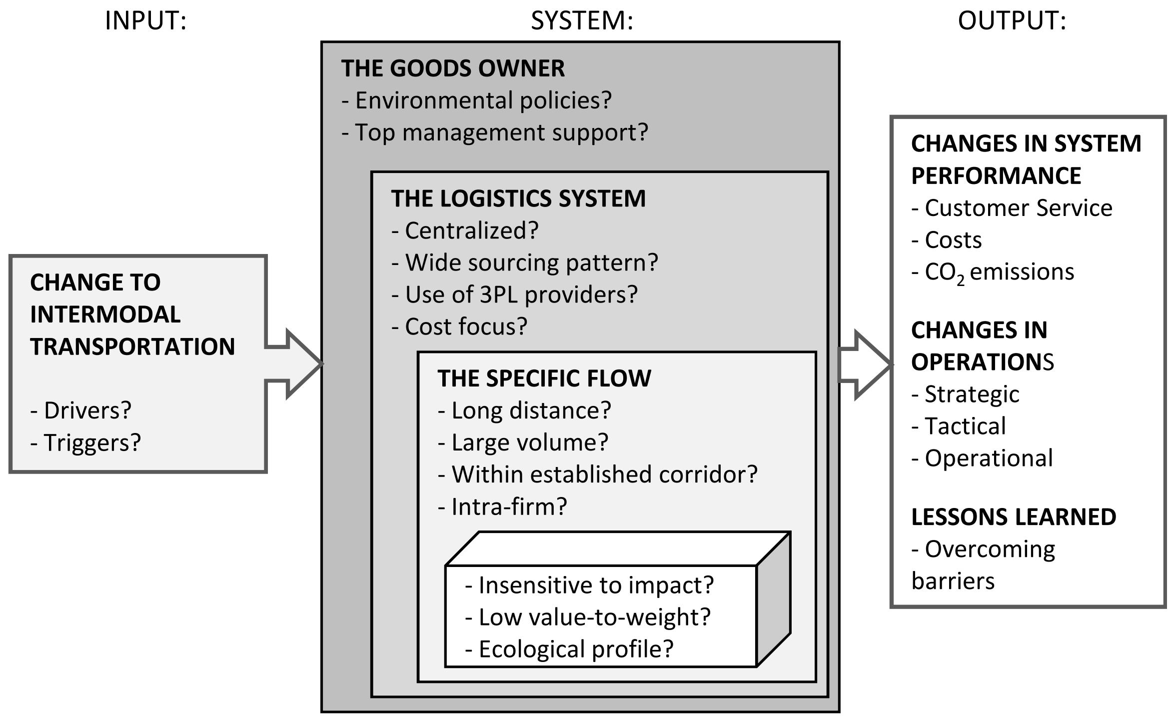


Figure 4.11. Our framework for analysis

5 The case companies

In this chapter the empirical findings from the five case companies will be presented. All of the case descriptions follow a common structure, aligned with that of our previously presented framework for analysis: company-system-flow-product. At the end of each section a summary of experienced quality and system effects are presented.

5.1 Arvid Nordquist H.A.B.

5.1.1 Company background

In 1884 Arvid Nordquist founded his first delicatessen and wine store in the central parts of Stockholm. Today, Arvid Nordquist is a family-run trading company with offices in Stockholm, Oslo, Helsinki, and Copenhagen. The company is well known for its Classic coffee, but in addition to roasting Classic coffee they also import food and drink from around the world and market it to the retail trade, work places, hotels and restaurants. Brand names include HiPP, SunMaid, DelMonte, Tabasco, and Bengt Frithiofsson Wine (Arvid Nordquist H.A.B, 2009).

Table 5.1. Arvid Nordquist H.A.B. 2008 fact box[17]

ARVID NORDQUIST H.A.B.	
Year founded	1884
Annual turnover	1,211 M SEK
Number of employees	Appr. 150
Swedish Headquarters	Solna, Stockholm
Products	Food (50%), coffee (30%), and wine (20%)
Supplier base	Global
Amount of rail-bound transport work	6.2% (within Europe 26%)

[17] As found on http://www.arvidnordquist.se

Throughout history, the company has always had a strong quality focus. On the company web site the following quote of the CEO, Anders Nordquist (third generation Nordquist), can be read:

> "Our prestige words are Quality and Tradition, and we are proud to have been Royal warrant holders for the three generations our company has existed. We strive constantly to improve upon what we do, setting our sights high when it comes to being a good employer and conscientious member of society." (Arvid Nordquist H.A.B, 2009)

The company has an environmental policy and has been ISO 14000-certified since 2003. Every year a number of environmental goals are developed, both quantitative and qualitative, for every function of the company. This also includes the Logistics function. (Skenback, 2009)

5.1.2 The logistics system

Being a small player, it is easy to get "pinched" by the much larger corporations further up or down in the grocery supply chain. A 98% service level (as measured in cartons delivered on time) is a prerequisite to qualify as a supplier for large retailers such as Ica or Coop, and Logistics is therefore considered a core competence within the company. The focus of the Logistics function is to lower logistics cost without compromising this service. Says Tomas Skenbäck, logistics manager:

> "We control sourcing, purchasing and all inventory control. We like to have this control in-house, being in a very vulnerable position we are eager to retain this expertise within the company." (Skenback, 2009)

The different product segments have slightly different logistics systems, but since the intermodal solution can be found among the food products, we will focus on the logistics system handling these products.

The logistics system for food products is shown in Figure 5.1. The deliveries from the different suppliers reach the stores in three different ways: 1) direct deliveries from suppliers, 2) through distribution from central warehouse in Arlandastad, and 3) from the Finnish warehouse (Skenback, 2009).

Goods from large suppliers such as SunMaid are delivered straight to the retailers, without intermediate storage. These represent only a small fraction, 2-3% of all transport work. Most goods go through the newly established central warehouse in Arlandastad, where it is kept in inventory and distributed through retailers and wholesalers by means of truck. The Finnish market is a special case, as this part of the business was acquired recently and distributes brands which are not available in the other Nordic countries. Therefore, a Finnish warehouse handles the distribution to the Finnish market, with deliveries from suppliers going either straight to the Finnish warehouse or through the central warehouse in Arlandastad (Skenback, 2009).

Distribution, or outbound transportation, is made by means of truck, but for the inbound transports both rail and sea freight is used as well. For the European suppliers of food products, 26% of the transport work is carried out by means of rail or intermodal road-rail solutions (Skenback, 2009).

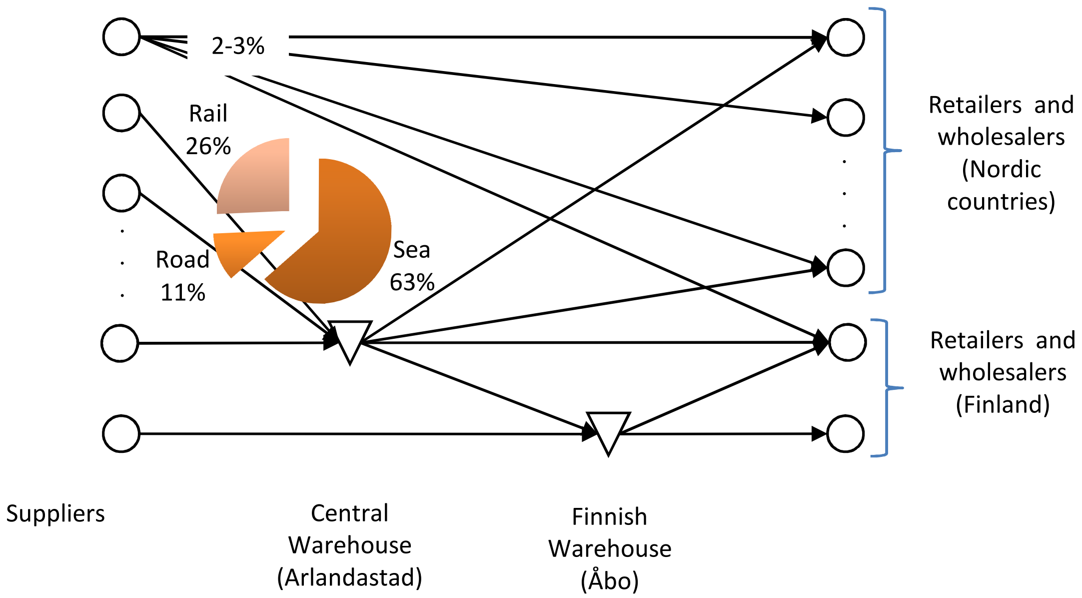


Figure 5.1. The food logistics system at Arvid Nordquist, based on (Skenback, 2009). Percentages represent amount of inbound transport work.

5.1.2.1 The new warehouse in Arlandastad

The food warehouse was previously located in Örebro. Last summer, Arvid Nordquist decided to review the total logistics structure in order to find opportunities to create a more unified structure. The business had grown quickly and the logistics system somewhat haphazardly with the expansion into new markets in the Nordic countries (Skenback, 2009).

The project was initiated in the summer of 2008 and the move took place in early 2009. With the new structure, the number of storage points within the total system was lowered and cost savings were made, even though all goods arriving by boat to Gothenburg had to travel for a longer distance by truck to reach the warehouse. However, emphasize was on finding leaner internal processes and to create a better structure while maintaining a 98% service level towards customers. Another objective was to improve cooperation between the warehouses in Sweden and Finland in order to reduce inventory, something which is yet to be realized. Environmental aspects, such as CO_2 emissions, were included as a decision variable in the analysis, as well as probable attention from the provider, IT maturity, service, and price. An environmental analysis was performed on the transport suppliers, similar to the analyses performed on all other suppliers. (Skenback, 2009)

The logistics function is measured on Service Level, Forecast Precision, and Run-out-time (time before running out of inventory), but it is still too soon to make any valid conclusions on the impact the change has had on these parameters. (Skenback, 2009)

5.1.3 The HiPP Baby food flow from Germany

HiPP baby food was introduced in Sweden in June 2002 and consists of 55 articles in the Swedish product range. Products include fruit purées as well as porridge and full meals in minced form and can be bought in glass jars ranging from 100 g to 280 g, for an example see Figure 5.2 (HiPP, 2009).

Figure 5.2. HiPP baby food (HiPP, 2009)

HiPP is profiled as an ecologically sound product. The product is produced in a plant located in Pfaffenhofen in southern Germany. The plant has its own renewable sun panels and the product is KRAV-labeled in Swedish stores. Therefore, according to Skenbäck (2009), there is an imperative from the marketing department to find environmentally sound alternatives throughout the entire product life cycle, transportation included.

After production, the glass jars must be kept in quarantine for ten days before being sold. This, and the large production batches at the Pfaffenhofen plant, puts constraints on the frequency of departure to Sweden. The geographical scope of the flow is depicted in Figure 5.3 below.

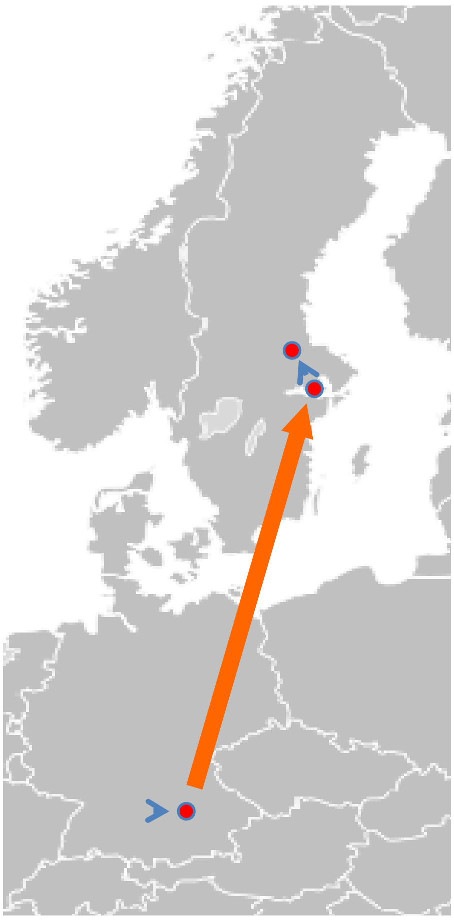


Figure 5.3. The HiPP baby food flow from Germany to Sweden.

5.1.4 Implementation of intermodal solution and the reasoning behind it

The entire HiPP product range is transported by means of an intermodal road-rail solution from the plant in Germany to the warehouse in Arlandastad. Prior to the introduction of the solution, transportation of the products was conducted by means of traditional rail freight. When the intermodal solution was presented as a more competitive advantage with regards to price and service, the company decided to switch. Says Tomas Skenbäck (2009):

> "The downside of rail freight is its problem of staying competitive pricewise. It has not improved over the last couple of years, rather the opposite. If you want economy in your solution you need full cars with at least 70 pallets. Finding these cars is also a problem due to the imbalance in rail traffic." (Skenback, 2009)

The attitudes within the company were generally positive towards the change. Transportation and logistics are usually left for the Logistics department to decide upon, and within the department there were no suspiciousness towards this type of solution. However, with the HiPP-flow, there was, as mentioned above, an interest from the marketing department that transportation should be carried out in an environmentally friendly way (Skenback, 2009).

Demanding more environmentally friendly transports is not always easily done:

> "The service providers must be better at emphasizing the positive aspects of their alternatives [when it comes to environmental performance] … For example, if HiPP, as a supplier, is far ahead when it comes to environmental work then we should take advantage of this strength when we present our products to our customers. I think the service providers should act in the same way, and give us material that we can utilize […] The service providers are deficient at giving us incentives to switch to intermodal transportation." (Skenback, 2009)

The change was made and the HiPP flow is now transported by means of a road-rail solution, for which Arvid Nordquist owns the goods the whole way (ExW). From the plant in Pfaffenhofen the jars of baby food go by truck to the hub in Hattesheim, from where it is transported to the hub in Årsta in southern Stockholm by rail. The last part is covered by means of truck, see Figure 5.4 below. Currently the solution transports 40-50 pallets about 150 times per year. The transportation is performed by Hangartner and the transit time, as measured from the plant in Pfaffenhofen to the Arlandastad warehouse, is three to four days. (Skenback, 2009)

One major flaw of the rail-bound part of the solution is the risk of unpredicted standstills. Winter time this is a problem, since the cold weather might jeopardize the products. If the food freezes the glass jars will crack and the entire transport be ruined. Therefore, winter time transportation is conducted by means of truck transportation or, when the temperature is very low, thermo truck transportation. (Skenback, 2009)

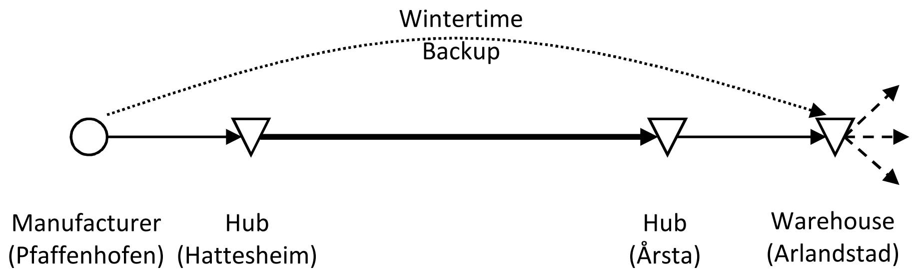


Figure 5.4. The Hipp baby food intermodal flow of goods, the bold arrow representing the rail part.

5.1.5 Experienced system effects

Generally, Skenback (2009) argues, has neither any big differences in performance nor in organization been experienced. The intermodal solution was the most competitive solution for the flow considered. Many times it is a question of market supply:

> "We rarely have any alternatives for a certain transport route. Take England for example. We want to transport the goods by boat. Then maybe we have two, or possibly three, actors and usually they are far apart pricewise. Inevitably we choose the least costly alternative. If we could choose between a multitude of transporters and different modes of transportation it would be possible to always choose the most environmentally friendly alternative." (Skenback, 2009)

Being a small player, he argues, it is hard to find the 'products' that the firm demands. This applies to inbound, trans-european transportation, as well as outbound distribution within Sweden:

> "We often hear that we are high maintenance when it comes to environmental demands. Green tons in distribution are something we usually have to nag about. The large service providers do not push this themselves. It is strange to me that a small player like AN has to drive major actors like Schenker and DHL." (Skenback, 2009)

However, intermodal transportation has been used for almost five years now by AN. The main findings on experienced system effects are presented in Table 5.2 and Table 5.3 below.

Table 5.2. Experienced quality and cost of solution

Aspect	Experienced performance as compared to before implementation	AN's Comments
Transit time	Worse	One or two day's difference as compared to road transport.
Transit time precision	No difference	This is merely related to which carrier that is chosen, not mode of transportation.
Flexibility in departure	No difference	
Flexibility in arrival	No difference	
Visibility/Traceability	No difference	
Frequency in dep.	No difference	
Goods damage/ handling	No difference	No experienced difference, however HIPP argues that the lashing is inadequate
Environmental impact	Much better	As compared to other alternatives.
Transport price	No difference	It is difficult to tell, since the price for a certain flow depends on economy, trade traffic, currencies, and politics. However, the intermodal solution is very unlikely to be more expensive.
Other transport costs	No difference	

Table 5.3. Experienced impact on logistics system performance

Aspect	Experienced performance as compared to before implementation	AN's Comments
Purchasing cost	No difference	
Inventory cost	No difference	
Facility/Administration	No difference	
Transportation costs (including damage)	No difference	
Cost of lost sales	No difference	
Other costs	No difference	

Regarding organizational issues, AN has not experienced any differences. Since the intermodal solution merely replaced another solution, no investments in information technology or education have been necessary. The only barriers identified are the standstills which have been solved with the backup transportation during wintertime (Skenback, 2009). However, he also points at one crucial aspect in the changeover:

> ”Service is of utter importance, some things just have to function. That goods arrive on time is important, but also simple things such as receiving a correct invoice. Me, and many others, have been lured by transporters offering low prices. They push prices down, and they are low, but then you do not receive any attention, your goods might be standing still, fees are sent, and you have to spend a lot of time fighting over invoices. This cost time and money. There are times when we have returned to a more expensive transporter because the relation is functioning properly.” (Skenback, 2009)

5.2 Home Retail Co. Sweden

5.2.1 Company background

Home Retail Co Sweden[18] is a subsidiary of Home Retail Co (HRC), a family owned retail company in the home and construction supply market. The parent company started in 1960 in Germany with the idea of offering everything you need for your home and garden under one roof. Over the years, the company has expanded all over Europe and is today running more than 200 retail stores in 14 countries. After Germany, Sweden is the second biggest market. Customers are private consumers as well as small firms. (HRC, 2009a)

A main part of the strategy is to keep a large assortment at each retail outlet. Each store has about 5000 SKU's and the total number of articles is close to 150 000. However, customer service in terms of treatment is also a prioritized issue. These two aspects are prioritized over price which is the third focus of the company. The company is involved in a number of social initiatives but currently lacks an environmental policy. (HRC, 2009a)

[18] The company name is fabricated due to secracy

Table 5.4. Home Retail Co. 2008 fact box (HRC, 2009a; HRC, 2009b)

HOME RETAIL CO.	
Annual turnover	N/A
Number of employees	N/A
Swedish Headquarters	Stockholm
Products	Construction materials, home and garden supplies
Suppliers	Nordic (appr. 65%), rest of Europe (20%), Asia (15%)
Amount of rail-bound transportation	Less than 10%

5.2.2 The logistics system

The main focus of HRC's logistics system is to reduce costs, mainly through large volumes that ensure low prices from the suppliers.

A large portion of HRC Sweden's suppliers are located in the Nordic countries (60-65%) serving the stores trough DDP-deliveries, meaning that the transports are handled and paid for by the suppliers. An additional 15-20% of the suppliers are located in other European countries and the majority of these are also DDP with the exception of two smaller flows from Italy and Spain, being EXW. The remaining part of the suppliers is located in Asia. (HRC, 2009b)

Most of the products are transported directly from suppliers to stores in accordance with HRC's policy of having the stocks as close as possible to the customer's in order to secure a high service level. However, in order to sustain delivery precision for products with low volumes some of the deliveries go via a central warehouse located in Norrkoping. These deliveries, which make up 12-14% of total deliveries, are somewhat unique for HRC Sweden within the HRC group and are met by a measure of skepticism from the parent company. (HRC, 2009b)

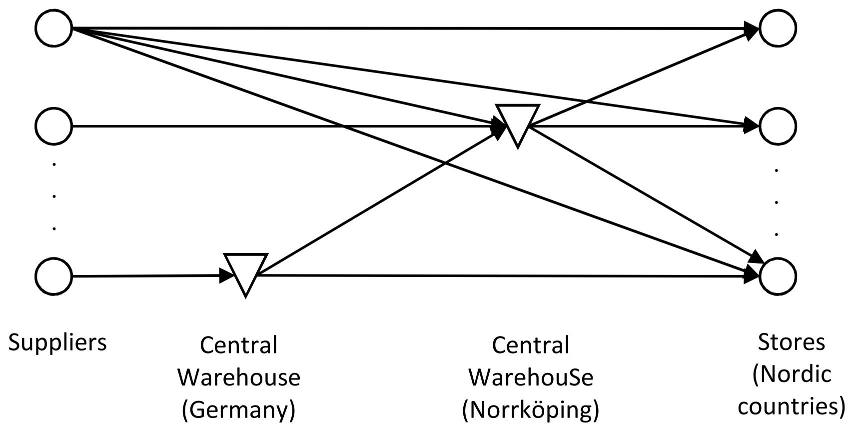


Figure 5.5. HRC's logistics system

Distribution from the central warehouse to the individual stores is made by means of truck transport. In all, direct transports and distribution transports included, each store handles approximately 12-14 incoming deliveries each day. This however is season dependant with more deliveries during the spring months. (HRC, 2009b)

In 2007 the central warehouse was moved from its former location in Denmark to Norrkoping. The rationale behind the decision, as described by HRC's Logistics Manager, was:

> "Mainly the appalling service provided by the former LSP. We also had problems with the fact that the LSP tried to control HRC and not the other way around." (HRC, 2009b)

The management also experienced that the prices were too high for the service offered.

Unhappy with these circumstances, the company decided to switch to a solution with Green Cargo as a third party logistics provider and at the same time move the central warehouse. To decide upon the location of the warehouse, HRC made a centre-of-gravity analysis weighing in factors such as economy, lead-time and environmental aspects. (HRC, 2009b)

5.2.3 The two tile flows from southern Europe

The flows we are going to focus on in this thesis are the ones mentioned above concerning inbound transports from Italy and Spain. Figure 5.6 below describes the two flows' geographical setup. Both flows transport tile from areas well known for tile making to the central warehouse in Norrkoping. To a lesser extent, the flow from Italy also includes utensils and power tools. The volumes transported each year amounts to 7000 and 2500 tons respectively for each of the flows. Demand is generated either by stores to replenish store inventory or by customers as direct orders for those articles that are not among the 50 000 SKU's. Main KPI's are lead time precision and distribution truck utilization. (HRC, 2009b)

Figure 5.6. Intermodal flow from Spain and Italy to Norrkoping. The thin arrows represent truck traffic while rail traffic is represented by bold arrows.

5.2.4 Implementation of intermodal solution and the reasoning behind it

In connection with the movement of the central warehouse and the change of logistics service provider, HRC also looked at alternative solutions to the traditional truck transports. In order to increase the general quality as well as reducing the price and environmental impact of the transport HRC decided to use intermodal transport for the flow of goods from Spain and Italy. Below is a short description for each of the two flows.

5.2.4.1 Italy

In this solution, tile from the Modena area is collected by trucks in milk runs and then consolidated in an intermodal terminal in Verona. From Verona, the goods are transported on rail to the hub by the central warehouse in Norrkoping with weekly departures of 1-6 rail cars. Also, the solution at times includes power tools from suppliers in the same area. The flow is illustrated in Figure 5.7, which also include a back-up truck transport which is used but only on rare occasions. Up until the recession last autumn the transporter had enough volume to support two departures a week. (HRC, 2009b)

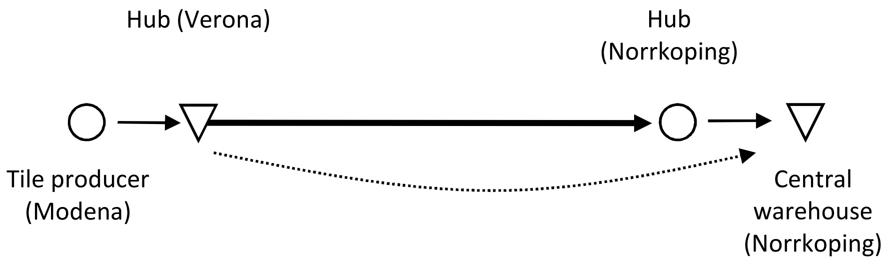


Figure 5.7.Description of goods flow from Italy to Norrkoping. The bold line represents rail traffic while the thin line represent truck. Dotted line represents back-up solution.

Green Cargo acts as a forwarder and plans the transports after the orders are sent simultaneously to them and the suppliers. This ensures that the suppliers can coordinate their production with the transports. The physical part of the transports is handled by a subsidiary of Green Cargo, Nordisk Transport Rail. The goods are transported EXW, that is, with HRC as the owner. (HRC, 2009b)

5.2.4.2 Spain

The flow from Spain is similar to the Italian flow in many ways. A truck in a milk run collects tile from the Castilian area and then consolidate the goods at a terminal in Perpignan on the Spanish-French border. The remainder of the transport is on rail to the hub by the central warehouse in Norrkoping (see Figure 5.4). Organization, operation, and ownership are identical between the two cases. The only major difference between the two flows are that the lower volumes from Spain, 2500 tons compared to 7000 tons from Italy, only allows for one train every two weeks instead of every week. (HRC, 2009b)

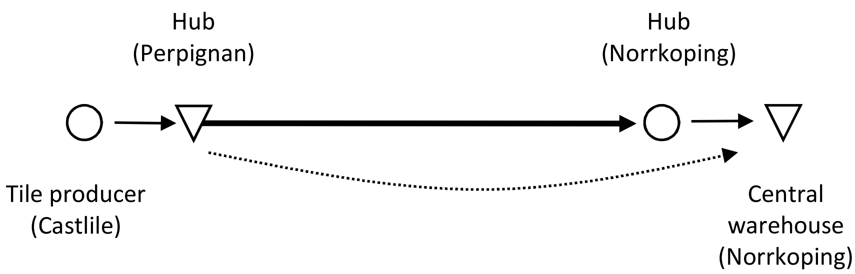


Figure 5.8. Description of goods flow from Spain to Norrkoping. The bold line represents rail traffic while the thin line represents truck. Dotted line represents back-up solution.

The lower frequency also results in longer lead-times for the individual stores. In order to counter this, HRC has a backup solution by means of truck for store costumers that are not willing to wait for their products. This solution is however rarely utilized, at a maximum of 3-4 times a year. (HRC, 2009b)

5.2.5 Experienced system effects

Prior to the implementation there were some concerns within the company regarding the performance of an intermodal solution, mainly from the stores. This attitude is also emphasized by the logistics manager as being one of the largest barriers when it comes to the implementation of intermodal transport:

> ”Quality was hard to predict before the implementation but everything pointed at that prices would be lowered […] Within the company, however, the general opinion was very skeptical before the implementation. The attitude was that trains should be used to transport pulpwood or iron ore and not consumer products.” (HRC, 2009b)

In order to come to terms, hard facts were presented and eventually the solutions were implemented for the tile flows from Italy and Spain. To ensure that the relation between the transport provider and the suppliers would not be jeopardized, a meeting was held in Italy with all suppliers and NTR, the operator. They were instructed about who to contact and how to communicate with HRC and the provider. This minimized the potential communication problems. (HRC, 2009b)

The collected experiences on systems performance is shown in Table 5.5 and Table 5.6 below.

Table 5.5. Experienced quality and cost of solution

Aspect	Experienced performance as compared to before implementation	HRC's Comments
Transit time	Worse	Slightly longer transport time
Transit time precision	Better	
Departure flexibility	No difference	
Arrival flexibility	No difference	
Traceability	Better	Increased visibility as the transporter offers updated information on a product's location trough a database.
Frequency	Better	
Goods damage/handling	No difference	Extremely small amount of goods damage. Possibly due to the tightly packed rail cars.
Environmental impact	Much better	A quick analysis made by HRC using Green Cargo's tool for calculating CO_2 emissions show a 60% decrease
Transport price	Much better	Close to 40% decrease in transport costs
Other transport costs	Better	

Table 5.6. Experienced impact on logistics system performance

Aspect	Experienced performance as compared to before implementation	HRC's Comments
Purchasing cost	No difference	
Inventory cost	Better	A new order handling system significantly helped improving inventory levels simultaneous to the implementation of the intermodal solution.
Facility/Administration	No difference	
Transportation costs (including damage)	Much better	
Cost of lost sales	No difference	Rapid orders are covered by back-up solution
Other costs	No difference	

HRC points out that the most important thing when implementing Intermodal transport is to have an extremely close dialogue with both the suppliers and the transporters in the start-up phase.

> "This is important in an early phase so that you do not find yourself with 150 new demands that the transporter cannot possibly live up to." (HRC, 2009b)

Some unpredicted events may also occur. Rail cars breaking down is one of them. If this happens the cars tend to "fall" further into the back of the shunting yard, dead locked by other cars, with increasing delays as the result. These problems have occurred more frequently than expected. At these occasions, the situation has been resolved and when it has been necessary the goods have been transferred to road transport and taken by truck. (HRC, 2009b)

Along with the changeover to intermodal transport a new order management system was implemented to optimize the supply of goods in-store. This improvement in planning countered the longer lead times and reduced the amount of working capital in store inventory. (HRC, 2009b)

HRC also points to the lack in innovation among the transport providers where much of the thinking is still concerned with bulk goods:

> "It is a problem that they [the transport providers] are deficient in fitting their offer to the customer's demands. This, however, is nothing that has affected our relation negatively; rather it has forced us to interact more closely to solve the problems together. I have seen a positive change." (HRC, 2009b)

When asked about the future for intermodal transport, both within HRC and in general, HRC's management mentions their ambition to increase the share of intermodal transport. An example of this, on the distribution side, is the newly opened store in Sundsvall. During the planning stage an intermodal solution was tried but it did not succeed because of too long lead times. The solution meant that the lead times would increase from 1 day to 2-3 days including transshipments. But, according to HRC's logistics manager:

> "The solution is by no means dead from HRC's point of view, discussions with Green Cargo continues in order to reduce lead times. As soon as I get a notice of at least similar lead times I will look in to it." (HRC, 2009b)

5.3 ITT Water & Wastewater

5.3.1 Company background

What is now ITT W&WW was founded as a company selling fans and pumps by Hilding Flygt, an engineer, in Stockholm in 1922. A few years later he came in touch with Per Alfred Stenberg, a cast-iron worker in Lindås, and production was initiated at Mr Stenberg's foundry. ITTW&WW's main markets are construction, wastewater and after market services. The facility in Emmaboda, where this study is conducted, mainly produces pumps for the first two markets. ITT is market leaders on large submersible pumps which is often custom made to fit the costumer's need and the number of variants is closer to 125 000. (ITT W&WW, 2008)

ITT is active on markets all over the world with the largest markets being Europe and the USA. Most of the sales go through their own sales offices to a wide array of customers ranging from mining and construction companies to the public sector. The customers expect ITT to deliver products of high quality but as pointed out by Perby(2009), price is usually the deciding factor. Perby (2009) also adds that a large portion of ITT's competitiveness lies in their ability to offer the customer after market support and service.

Table 5.7. ITT Water & Wastewater 2008 fact box[19]

ITT	
Year founded	1920 (ITT), 1922 (Flygt)
Annual turnover	1.6 M USD (Water & Wastewater)
Number of employees	5800 (Water & Wastewater)
Swedish Headquarters	Emmaboda
Products	Water pumps
Suppliers	N/A
Amount of rail-bound transport work	< 0.5%

The company has an environmental policy spanning the years 2009-2012 containing goals for both the company in general but also for the facility in Emmaboda. In addition, the facility has its own environmental department handling and following up the goals. The company also presents a sustainability report in the form of a brochure that among other things covers environment and transports. The environmental aspects are used in the marketing of the products through life cycle analyses especially when dealing with the public sector. (Harrysson, 2009)

5.3.2 The logistics system

The outbound side of ITT's logistics system in Europe, depicted in Figure 5.9, consists of two nodes: one in Metz, France and one at the production facility in Emmaboda. The node in Emmaboda serves both the node in Metz and deliveries to Eastern Europe as well as non-European countries. The Metz node services the area of the countries that formed the EG with the eastern border between Germany and Poland. The nodes in turn ship their products either to a sales office or directly to the customer. The aim here is to keep the stores at the sales offices at a minimum.

[19] As found on http://www.flygt.se/1220383.asp?newsid=2391917

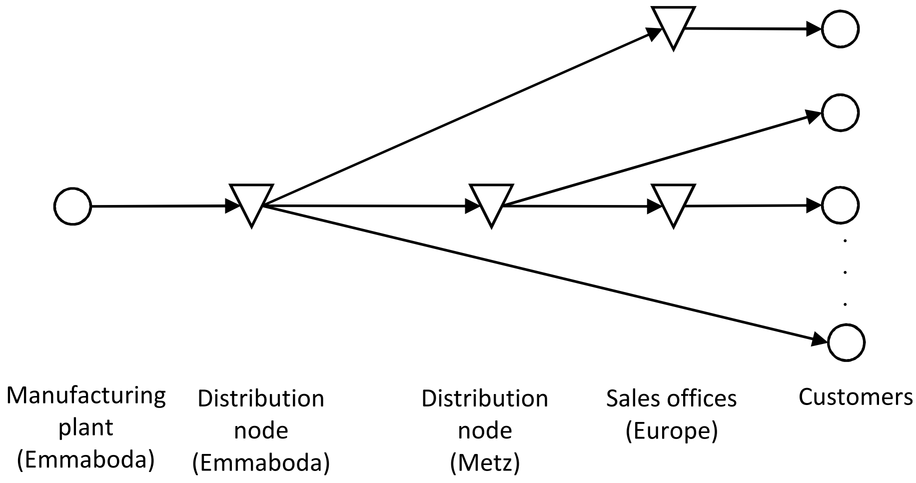


Figure 5.9. ITT's logistics system in Europe

The Key Performance Indicators of the logistics function differs somewhat depending on what type of products are being transported. Generally, delivery precision is ranked highest with availability as a close second. When it comes to spare parts, on the other hand, lead times become increasingly important (Perby, 2009).In addition to these KPI's the company also measure the emissions from transports bought through quarterly reports from transporters. These are in turn handed over to the company's environmental department, which compares them to the goals set in the company's environmental policy. In this policy there are two goals included concerning transport: a 20% decrease in air freight and an increased share of rail-bound transports. (Harrysson, 2009)

Outside of Europe much of the transports are by means of either sea or air. Within Europe the vast majority of the transports are performed by means of truck. Some minor exceptions are rail transports from Finland and Central Asian countries such as Turkmenistan, but all in all rail transports represent less than 0.5% of total transport work. (Perby, 2009)

ITT uses 4-5 large transporters and about as many smaller ones. The reasoning behind this is to build a relation to a small number of transporters to be able to control the flow both in and out of the facility. The company uses FCA for inbound and DDU for outbound meaning that they own the goods in both the flows. Logistics are handled and transports are booked from the logistics department in Emmaboda. (Harrysson, 2009)

5.3.2.1 The centralization of distribution

The current setup with two distribution nodes was developed in the years 1999-2001 and has since then been fine-tuned. The big change then was a consolidation of several smaller warehouses into two larger ones. This has lead to advantages in the form of economy of scale but also lower inventory levels and higher availability. (Harrysson, 2009)

5.3.3 The outbound flow from Emmaboda to Metz

For a period of time, ITT has tried out a few different intermodal solutions for the flow supplying the Metz node with finished goods from the manufacturing plant in Emmaboda, depicted in Figure 5.10 below.

Figure 5.10. Flow of finished goods from Emmaboda to Metz

The goods are mainly pumps for construction and wastewater handling and spare parts for these. All in all the total volume of goods transported each year amounts to about 470 swap bodies – meaning just over 2 per work day. (Perby, 2009)

The handling of inbound goods at the Metz warehouse set some constrains regarding arrival times. Because the terminal handles outbound goods in the afternoon, goods that arrive too late have to wait to the next day to be taken care of. (Harrysson, 2009)

5.3.4 Implementation of intermodal solution and the reasoning behind it

Regarding which factors that drove the development towards intermodal transport, senior transport buyer Harrysson (2009) says:

> ”I think it is the environmental factors combined with the fact that it can be competitive. […] Additionally, we care about the environment on a personal level, we who work with these questions.” (Harrysson, 2009)

In addition to this, Harrysson (2009) also notes that even though most directives from higher levels within the company concerns cost reductions the environmental factors are included under the word Responsibility in the company's vision.

Over a period of eight weeks ITT has evaluated a few intermodal solutions in cooperation with DHL. One solution involves sending a trailer on road to Gothenburg, then by boat to Ghent, Belgium and finally road transport to the warehouse in Metz. With this setup ITT saves money, in part by avoiding the costly road tolls for trucks in Germany, in addition the reducing their CO2 emissions by about 6%. (Harrysson, 2009)

In this thesis, we will however focus on the solution presented in Figure 5.11 below. The goods are transported on road from Emmaboda to Helsingborg where it is loaded onto the IKEA train solution and then taken to Ludwigshafen, Germany. The last 150 kilometers to Metz is by means of road transport. The cost savings for this solution is somewhat smaller than those of the ship solution but the emission reduction on the other hand is much larger, up to 60% according to the managers. (Harrysson, 2009)

Figure 5.11. ITT's intermodal solution

5.3.5 Experienced system effects

Due to the fact that the intermodal solution is in an evaluation phase at ITT, it can be very difficult to make any certain conclusions about the effect on the system's performance. The following section will be based on the different interviewees' observations so far in the evaluation.

One difference noticed by ITT between traditional and intermodal transport has been the lead times. Harrysson (2009) gives an example where this can be seen:

> ”Goods sent by truck on Monday would arrive in Metz Wednesday morning and with train not until the afternoon, at the latest Thursday morning. Because Metz has only outbound transports in the afternoon the lead time would be an entire day longer.” (Harrysson, 2009)

In order to match the lead-times of the traditional solution, ITT have been using intermodality for transports running over the weekends. Goods sent by ship has departed on Thursdays and rail on Fridays. In this way no effective lead-time has been lost compared to truck transport. Perby (2009) explains the effects on end customer service:

> "Products ordered from stock are not affected at all. A product made-to-order is affected but the one day longer lead is not a big issue as long as you are aware of it on beforehand. The only big issue I can see here is the emergency spare parts that cannot be planned ahead that will cause standstills in the production." (Perby, 2009)

Regarding other quality aspects, such as lead-time precision and goods damage, ITT has not been able to see any discernable changes compared to the traditional transports. In the pre-planning stage, concerns about goods damage were voiced both within the organization and from transporters. The absence of damage, Harrysson (2009) explains, depends on the fact that hub-to-hub transport does not require any shunting.

When it comes to costs the only effect that can be clearly seen this far is that the invoice from transporter is lower than before. The transporter handles everything and the pick-up of the loaded container at the production facility is done in exactly the same way as before thus incurring no further costs for loading or packaging. (Harrysson, 2009)

The largest barriers was the lead-times together with the attitude that railway is slow and inadequate for non-bulk goods. On the other hand they felt very positively surprised by the solutions offered by the transporters. The solutions were often very similar, running on the same track and only differed in price but that has more to do with the infrastructure than the transporters. (Harrysson, 2009)

The insufficient infrastructure is also a factor pointed out by Harrysson (2009) as the major obstacle to increase the share of intermodal transports within the company:

> "Regarding infrastructure I feel like Sweden is stuck in the Stone Age, there is a lot left to do there. The government has to be willing to invest in order to extend the capacity [of the railways]." (Harrysson, 2009)

He also notes that there is work to be done within the organization, especially when it comes to communication:

> "Everybody have to be aware of that the reason that it takes one day longer. That we by doing this [the intermodal solution] we can spare the environment and save money." (Harrysson, 2009)

Table 5.8. Experienced quality and cost of solution

Aspect	Experienced performance as compared to before implementation	ITT's Comments
Transit time	Worse	
Transit time precision	Worse	
Flexibility in departure	No difference	
Flexibility in arrival	No difference	
Visibility/Traceability	No difference	
Frequency in dep.	No difference	
Goods damage/ handling	No difference	
Environmental impact	Much better	
Transport price	Better	
Other transport costs	No difference	

Table 5.9.Experienced impact on logistics system performance

Aspect	Experienced performance as compared to before implementation	ITT's Comments
Purchasing cost	N/A	
Inventory cost	Worse	
Facility/Administration	No difference	
Transportation costs (including damage)	Better	
Cost of lost sales	No difference	Too early to tell, however CW may act as buffer
Other costs	No difference	

5.4 Lindex

5.4.1 Company background

With approximately 365 stores in 9 countries; Sweden, Norway, Finland, Estonia, Lithuania, Latvia, Russia, the Czech Republic and Saudi Arabia, Lindex is one of Northern Europe's leading fashion chains. The main market is Scandinavia, in particular Sweden, with 90 percent of the stores located there. The stores are owned by Lindex in all countries except Saudi Arabia where the company works according to a franchise model. In all countries, the company offers products in the areas of women's clothing, underwear, children's clothing and make-up with focus on customers looking for affordable fashion. The company has purposely migrated to a higher fashion focus, ten years ago the products offered had a much stronger price focus. (Lindex, 2009b)

This strategy can also be found on the company website:

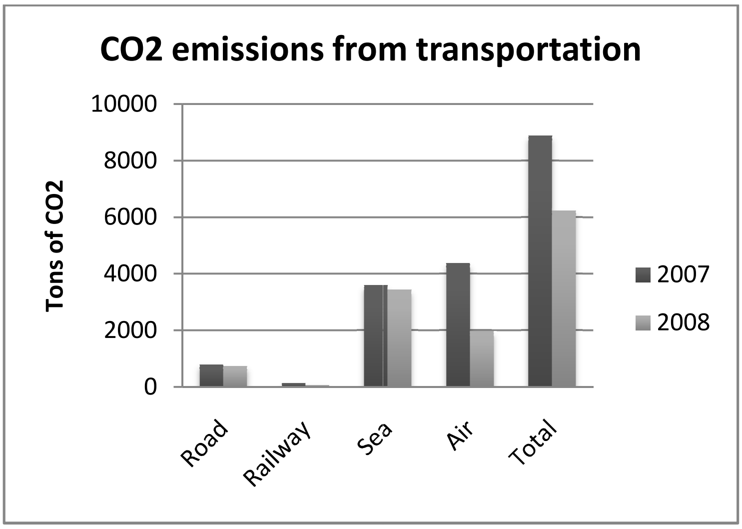
> "The overall picture is important in our selection. Our collections include garments with a high sense of fashion as well as basic garments. The fashion collections meet the requirements on choice and that it should be easy to combine and match different garments." (Lindex, 2009b)

Transformed into more tangible guidelines, a common view within the company is that the stores should feel new every 14 days (Albinsson, 2009).

Table 5.10. Lindex 2008 fact box (Lindex, 2009b)

LINDEX	
Year founded	1954
Annual turnover	5,200 M SEK
Number of employees	5000
Swedish Headquarters	Gothenburg
Products	Clothes
Supplier structure	Asia 75%, Europe 25%
Amount of rail-bound transportation	6%

Environmental aspects are not used in the direct marketing of products but that does not mean that the environment is a non-factor. Lindex works actively to build the image of a responsible company and releases a yearly CSR-report. The report covers human rights, work conditions, and corruption as well as environmental issues. An important part of the environmental work highlighted in the report is the transports with a lot of effort going in to reducing the emission of CO_2. Figure 5.12a below shows the emissions of CO_2 from Lindex's transports for each of the transport modes employed. It should be noted that the data is collected prior to the intermodal implementation and the reduction is mainly due to the decreased use of air transports.



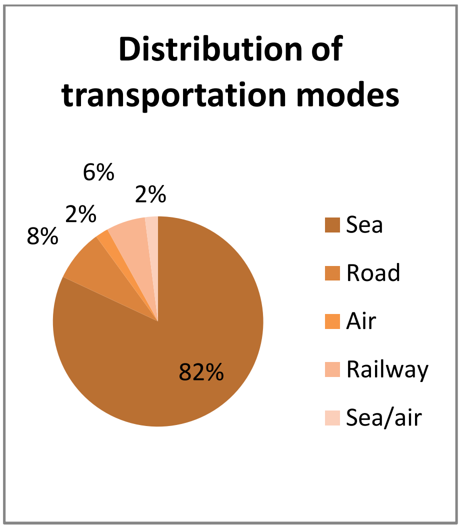


Figure 5.12a). CO_2-emissions from transport and 1b) distribution of transport modes (Lindex, 2009a)

5.4.2 The logistics system

The logistics function at Lindex has a strong lead-time focus due to the characteristics of the products. When dealing with fashion goods, decisions about quantity, color, and size should be made as late as possible (Albinsson, 2009).This does not mean that lead time is always the deciding factor or, as Albinsson (2009) puts it:

> "It is always a matter of trade-offs between service, quality and cost. It is possible to transport everything by means of airfreight from Asia, but we do not do that. We do transport a small amount this way but it is both very costly and has a high environmental impact. Lead-time affects everything we do but that does not mean we have to change mode of transport. Short lead times is not everything but also the lead-time precision. That we can make a plan and stick to it." (Albinsson, 2009)

Along with lead-time, precision in lead time is an important performance measure:

> "All products are coordinated with other products in a fashion collection, and normally there is no buffer to cover for delays. If a certain product is a part of a campaign where we have invested a lot of money into advertising it might be necessary to change mode of transportation." (Albinsson, 2009)

The logistics system of the company is depicted in Figure 5.13 below. On the inbound side of the system the majority of the products are transported from Asia, mainly from China, India and Bangladesh. These markets represent 75 percent of total sourcing while the rest are sourced Europe. Out of all transport, 82 percent are by means of pure sea transport and 4 percent by a combination of sea and air transport. The remaining 14 percent is divided about equally between truck and rail, see Figure 5.12b (Lindex, 2009a). The rail transports are mainly performed within Europe (Albinsson, 2009).

Inbound deliveries arrive either at the Bäckebol warehouse, operated by Green Cargo, or the Partille distribution center, operated in-house, depending on whether it is delivered on coat hangers or in parcel boxes. The Middle East market is excluded, since it is handled separately due to differing needs and the franchise model used on that market. At the distribution centre, about two thirds of the goods are cross-docked and sent to stores in Scandinavia, the Baltic, and the Czech Republic. The rest of the goods are stored and distributed individually when demanded by stores. 65% of the articles are new articles for which there is no reorder point. (Albinsson, 2009)

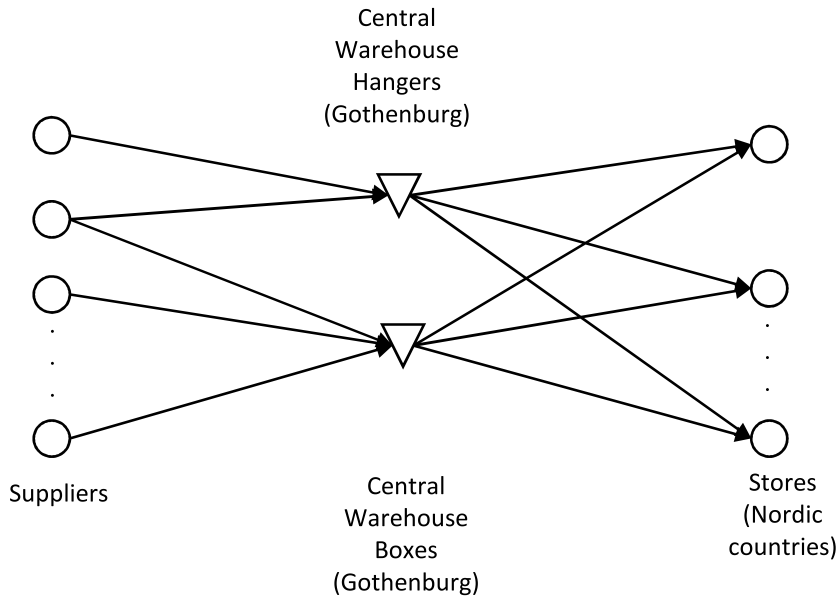


Figure 5.13.Lindex's logistics system

5.4.2.1 The new distribution center

A little more than a year ago, Lindex constructed a new distribution centre in Partille in the eastern part of Gothenburg. Prior to the construction, the company's logistics activities were outsourced to DB Schenker, but as the contract was running out questions arose whether Lindex could not handle these activities within the company. Lindex was already highly involved in the logistics planning and execution and felt that there was money to be made by controlling the logistics in-house. (Albinsson, 2009)

The distribution center was inaugurated in late 2007 as a state-of-the-art, highly automated, warehouse and cross-dock facility. The aim of the facility was to always consider the full logistics system, that is, not just optimize the operations of the warehouses and distribution centers but also considering the individual stores. If in-store-handling is complex or difficult, hours will be spent on this. By delivering the clothes complete with hangers and price tags, store handling is kept at a minimum and economies of scales are utilized. Therefore, flexibility was one issue when designing the distribution center, but also store friendliness. (Albinsson, 2009)

5.4.3 The outbound flow to Norway

The flow considered in this thesis concerns goods from Gothenburg to the 90 stores located in Norway. 98% of the goods being transported are boxed, so called flatpacks, with the rest being clothes on coat hangers such as jackets and coats. The amount of hanging goods is very season dependent with a much larger amount being transported wintertime. (Albinsson, 2009)

Each store has a small storage area but relies on daily arrivals for replenishing the shelves. The inbound arrivals are handled by the salespeople themselves and the newly arrived clothes should ideally be put into the store immediately. This means that deliveries have to be made during the stores opening hours, preferably in as narrow a time frame as possible for the activity to be properly scheduled. (Albinsson, 2009)

5.4.4 Implementation of intermodal solution and the reasoning behind it

With the move to the newly constructed central distribution center, Lindex also saw the opportunity to explore new modes of transport. They kept DB Schenker (truck) as a parcel transporter for a year but then decided to initiate a procurement process for a distribution solution for the Finnish and Norwegian markets. While doing this, they came across Green Cargo's intermodal solution which seemed to fit perfectly. The solution had the right price and could offer the quality that was required in terms of lead time and lead time precision. Further, Green Cargo already delivered hanging clothes to the Norwegian stores which meant that consolidation between the two types of shipments could be made and the number of store deliveries reduced to only one delivery per day. (Albinsson, 2009)

A main trigger to the change in transport mode was the fact that there where available resources to handle the project once the move of the distribution center was completed. That some people had available time to handle the change, in combination with the performance of the suggested solution, made the company eventually switch. Environmental aspects were not a part of the decision:

> "One always considers the total service that a supplier offers and this includes reporting, different quality measures as well as environmental aspects. However, environmental aspects may not have that much weight in our transport choices. That intermodal transports are more benign to the environment is not the reason we chose it." (Albinsson, 2009)

The intermodal solution was put into practice in September 2008. In the current setup, Green Cargo picks up flatpacks on pallets at the distribution center in Gothenburg. These pallets are sorted according to their destination store, with every store belonging to one out of five groups put together depending on store location. They go by truck to Green Cargo's terminal in Bäckebol where the goods are reloaded, consolidated with the hanging articles and clothes from other retailers, and sent on swap-body railcars to Norway. The border is crossed on three different locations and the whole trip takes about two days (to Trondheim). Deliveries are made on a daily basis. Last mile delivery is handled by means of milk-runs which are matched with the original groupings. No parallel, or back-up, solutions exist explicitly. The setup is depicted in Figure 5.14 and Figure 5.15 below. (Albinsson, 2009)

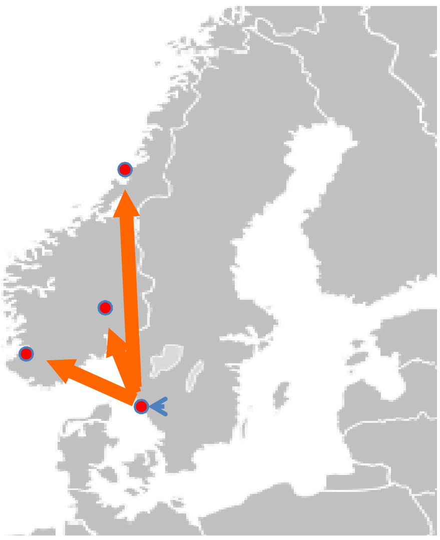


Figure 5.14. The geographic scope of the intermodal distribution at Lindex.

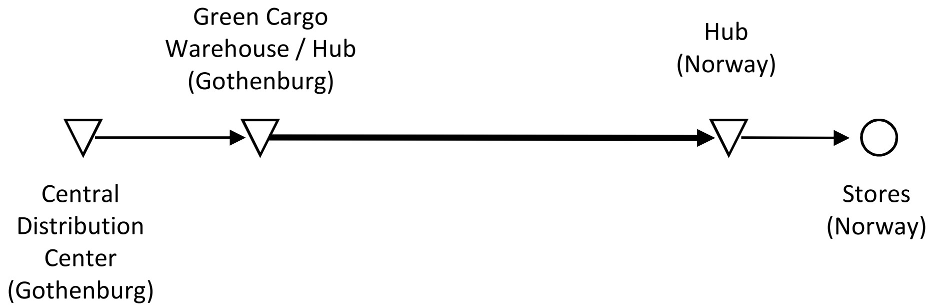


Figure 5.15. Lindex's intermodal distribution between Gothenburg and the Norwegian stores

5.4.5 Experienced system effects

The intermodal solutions effect on a number of system parameters are shown in Table 5.11 and Table 5.12 below.

Table 5.11. Experienced quality and cost of solution

Aspect	Experienced performance as compared to before implementation	Lindex's comments
Transit time	No difference	Still two days to Norway.
Transit time precision	Worse	Delivery windows have been extended from one hour to "before noon". However, precision is kept according to contract.
Flexibility in departure	Cannot be answered	
Flexibility in arrival	Cannot be answered	
Visibility/Traceability	Cannot be answered	EDI communication is a part of the deal with Green Cargo.
Frequency in dep.	Cannot be answered	
Goods damage/ handling	No difference	No problems so far.
Environmental impact	Much better	There are difficulties when it comes to quantifying the extent of the environmental impact. Firstly, the emission reports from Green Cargo are delivered on a yearly basis so the newly started project is not included in last year's figures. Secondly, Green Cargo recently changed their way to measure, which makes benchmarking unreliable.
Transport price	Better	The contractual costs have decreased.
Other transport costs	Cannot be answered	

Table 5.12. Experienced impact on logistics system performance

Aspect	Experienced effect as compared to before implementation	Lindex's Comments
Purchasing cost	N/A	
Inventory cost	Cannot be answered	Has probably not changed since lead times are identical.
Facility/Administration	Worse	The administrative costs have slightly increased due to additional border crossing for which the paper work is handled in-house.
Transportation costs (including damage)	Better	No goods damage.
Cost of lost sales	No difference	
Other costs	Cannot be answered	Handling costs in stores might have decreased since there is only one delivery per day.

No significant IT-investments had to be made with the new solution, since a new WMS system had been introduced along with the new DC. A minor change in the interface towards the new transporter was the only difference. However, the earlier change of IT infrastructure, with the changeover from pallet to parcel handling, was an enabler for the current solution. (Albinsson, 2009)

Overall, most parameters have improved with the change:

> ”For some reason most people seem to think that things are worse with intermodal transports. But that is not the case. We have two days delivery to Norway, all the way up to Trondheim. This has not changed with the new solution. We have not renounced any demands on lead time.” (Albinsson, 2009)

The increased administration at the distribution center should be weighed against the reduction in complexity at store level. Salespeople in 90 stores now only have to consider one supplier relation (Green Cargo, daily) instead of two (Schenker, daily and Green Cargo, a few times per week in winter season) (Albinsson, 2009). Further, concludes Albinsson (2009):

> “I believe the future [of intermodal transport] is dependent upon how it is marketed, assuming no degradation in price or quality. Possibly, taxes could change the behavior but we do not see any need in trying to avoid future cost at the moment. We have looked at other types rail-bound transportation before but found it impossible to implement because of constraints on time and location. Environmental aspects are surprisingly absent in the discussion. I do not know if this is because the transporters do not believe in the sales arguments but it never comes up to discussion – neither with them nor with other firms in the business.” (Albinsson, 2009)

5.5 Volvo Trucks

5.5.1 Company background

Volvo Trucks is a subsidiary of Volvo Group which is one of the leading commercial transport solution suppliers in the world. Products range from trucks, buses, engineering vehicles and naval propulsion systems to industrial applications and parts for aircraft engines. Additionally, Volvo Group offers financial services for their customers. (Volvo Group, 2009c)

Table 5.13. Volvo Group 2008 fact box (Volvo Group, 2009c)

VOLVO	
Year founded	1927 by SKF
Annual turnover	303,667 M SEK
Number of employees	101,380
Swedish Headquarters	Gothenburg
Products	Trucks,
Number of suppliers (Europe)	2,833
Amount of rail-bound transportation (Volvo Trucks)	2%

Volvo Group employs more than 100 000 people with production facilities in 19 countries and sales in around 180 countries all over the world. The Volvo Truck brands include Volvo, Renault, Nissan Diesel, and Mack, and in Europe the company has a relative market share of 25% (Volvo Group, 2009c). Sales of products and services are conducted through both wholly owned and independent dealers. The global service network handles customer demand for spare parts and other services. For Volvo Trucks, sales increased during 2008, but a large drop has been seen recently as the world demand has halted dramatically in late 2008. The last two years' sales of trucks are depicted in Figure 5.16 below.

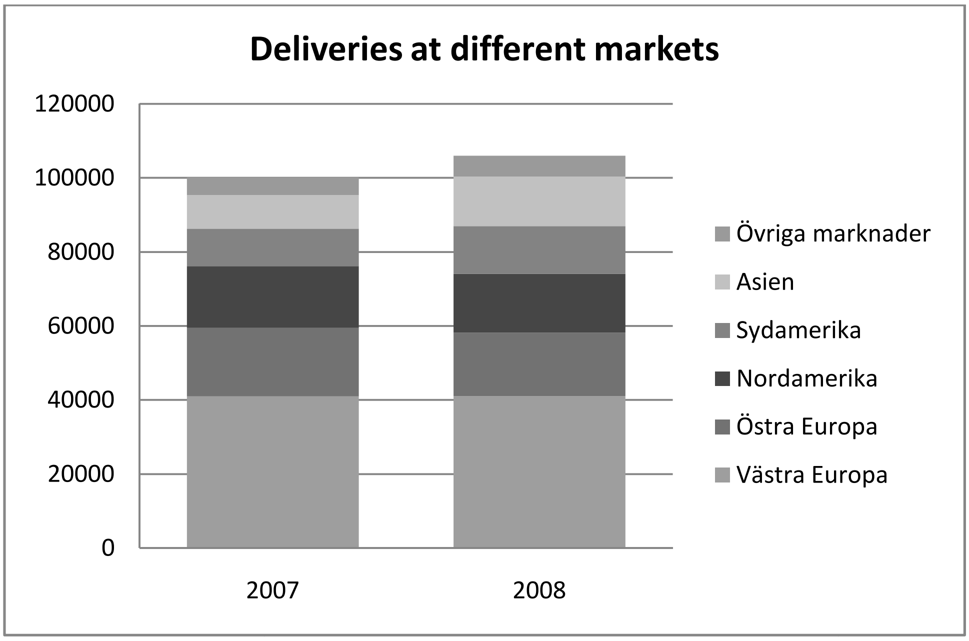


Figure 5.16. Deliveries at different markets for Volvo Trucks 2007 and 2008 (Volvo Group, 2009c).

Regarding the group's overall strategy, one can read the following in the annual report:

> "In a market characterized by intense competition, customer satisfaction is a key factor, as it represents an assurance of future sales and is a condition of good profitability [...] The products and services have high performance characteristics, quality, safety, flexibility and total economy. Customers are offered solutions adapted to their operations, regardless of whether they involve a single product or a full program involving products and financing, insurance and various service contracts." (Volvo Group, 2009c p. 10)

The Volvo Group companies also work according to a code of conduct, based on the principles in UN's initiative Global Impact. This deals with sustainability from a social as well as environmental perspective, and in different forms have these reports been presented since 1990:

> "Transports are essential for development and our responsibility is therefore to provide society with transport solutions that reduce the negative environmental impact and contribute to social development […] Environmental management is a cornerstone of the Group's efforts to promote long-term sustainability. Volvo's environmental work focuses on reducing environmental impact from both the production and the use of the products." (Volvo Group, 2009b preface)

The focus is both on the end product and the internal operations. In the current CSR program, CO_2 emissions are measured in all industrial operations, and over the last five years there has been an overall decrease. In 2006 Volvo Trucks challenged Volvo Logistics to reduce CO_2 emission by 20% between 2006 and 2010 from transports in Europe, with a long-term vision of halving their impact from goods transport by 2020. The first year, combined measures from different projects resulted in a 4% reduction of emissions. (Volvo Group, 2009b)

5.5.2 The logistics system

Within the group, logistics is handled by a wholly owned subsidiary called Volvo Logistics (VLC). The company designs, handles and develops all logistics functions such as inbound and outbound transports as well as packaging, risk management, customs and purchasing. In addition to the services provided to the Volvo Group, VLC also offers solutions to external customers, one being Volvo Car Corporation which in turn is owned by Ford Motor Company. (Olsson, 2009)

Volvo works according to a Just-In-Time strategy in production (Volvo Group, 2009c), and the prioritized focus of the logistics system is to secure availability of components at these JIT-plants (Olsson, 2009). A map of the European production facilities that these supply is depicted in Figure 5.17. Components are sourced from all over the world. In Europe, a large number of suppliers are contracted, with the biggest markets being Sweden (approximately 1200 suppliers), Germany (600), UK (300), and France (300) (Olsson, 2009). 96% of the suppliers are certified according to ISO 14000 (Volvo Group, 2009c).

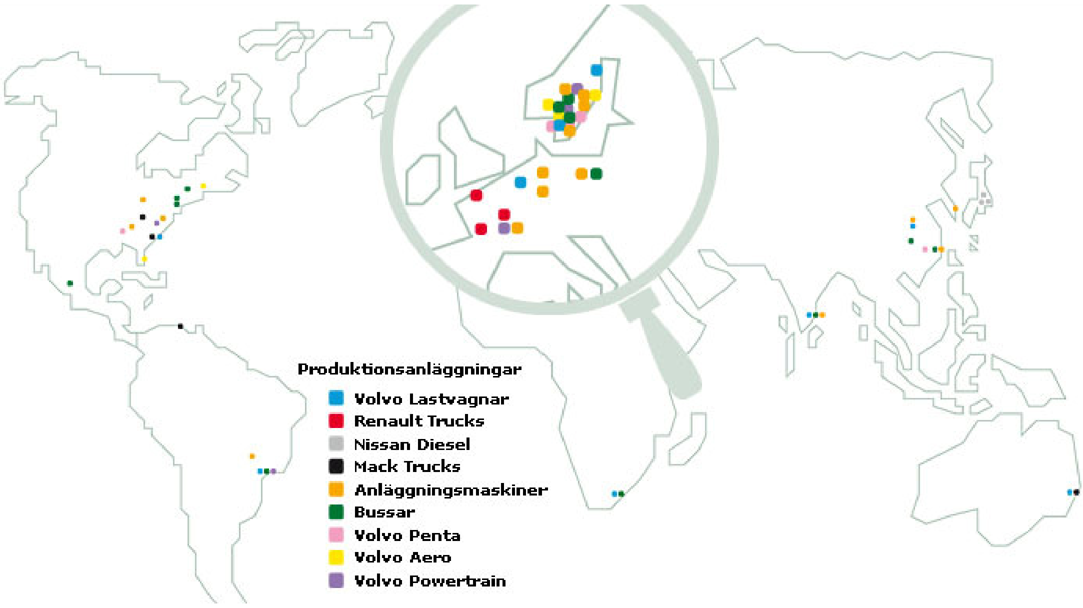


Figure 5.17. Volvo's production facilities[20]

VLC acts as a logistics service provider for the Volvo Group. Even though VLC designs, handles and develops the logistics solutions, the transports themselves are bought from a third party carrier. That is, with Volvo Group being the shipper, VLC is the service provider and carriers are external parties such as Green Cargo or DB Schenker. The transports include most of the common modes of transport such as truck, rail, and sea, excluding pipeline for obvious reasons. Transports from suppliers in Asia, mainly China, to production facilities in Europe are all but in a few cases by means of ship, with the only exception being a few tries into the Trans-Siberian railway (Olsson, 2009). At the end of 2007, around 2% of the transports from Volvo trucks were made by means of rail (Volvo Group, 2009b).

5.5.3 The Trans-European component flow

For this thesis, the focus has been on the flow concerning components and parts from the suppliers of Volvo Trucks in central Europe to the truck assembly plant in Gothenburg. The assembly plant is to be supplied according to a time controlled system, and arrival at the plant must be within a time slot, "before noon", on a daily basis. The volume is 36 trailers per day (Olsson, 2009).

5.5.4 Implementation of intermodal solution and the reasoning behind it

Before any intermodal solutions were introduced at Volvo, there was a strong skepticism against freight consolidation. "Volvo parts should be delivered with Volvo trucks at the Volvo plants" was the common conception, according to Thomas Olsson (2009).

However, Volvo has used intermodal transport for many years now in a number of different configurations. A large portion of this has been the short-sea traffic within Europe, but road-rail solutions are also commonly utilized. A well-known initiative is the Volvo 8, a road-rail solution between Olofström/Umeå and Gothenburg/Ghent, a joint effort between Volvo Cars and Volvo Trucks. For this thesis though, the focus will be on Viking Rail, an intermodal road-rail solution between Germany and Sweden. This solution is depicted in Figure 5.18 below.

[20] Screen dump generated from http://www3.volvo.com/investors/finrep/ar08/sv/vpsvartsattatt/effektivare_arbete.html

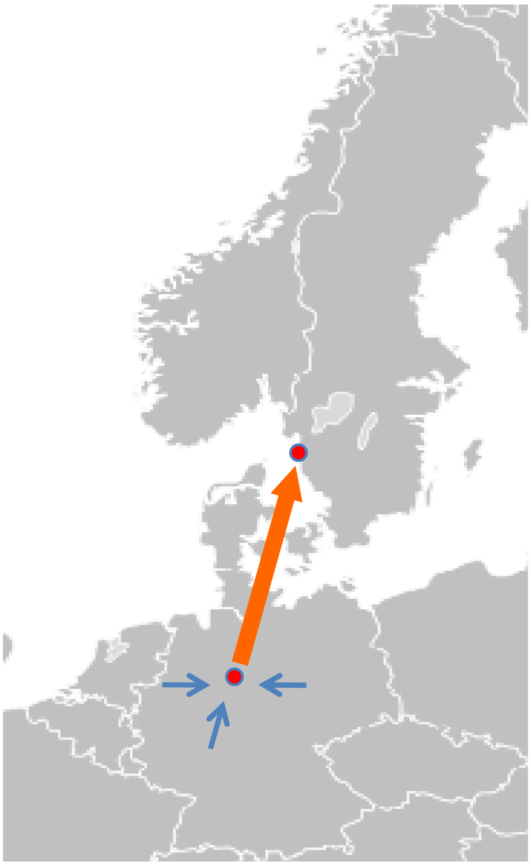


Figure 5.18. Geographic scope of Viking Rail. Thin arrows indicate truck transport within the intermodal solution, bold arrow is rail-bound transportation.

Viking Rail is an intermodal project in line with a broader environmental initiative sprung out of the climate challenge to Volvo Logistics from Volvo Trucks. The project was initiated in 2007 and launched in October 2008. One objective was to design a more “climate-smart” solution to reduce CO_2 emission, the other was to avoid costs that are likely to occur, for example road tolls or traffic taxes in different European countries. Volvo owns the train set. The solution is operated by DB Schenker and consists of trailers with components and parts from suppliers in Germany being rolled onto railway cars and carried to the assembly plant in Gothenburg, see Figure 5.18. That is, the intermodal solution handles inbound transportation in the Volvo Trucks logistics system (Figure 5.19). A number of terminals exist along the line. (Olsson, 2009)

Figure 5.19. Viking Rail positioned within Volvo's logistics system. The intermodal solution is represented by solid arrows, the bold one being the rail part and the thinner ones the truck parts.

The rail cars that are used are built low, so that standard trailers, mega trailers, or containers can be carried and easily loaded and unloaded. Thus, if the train is delayed, the goods can easily be transferred to truck and carried the remaining distance without plants having to close because of material shortage. A number of terminals exist along the line where trailers can either be loaded or unloaded if needed. Currently, the train rolls between Hannover and Gothenburg, with 36 trailers every day in both directions, and plans to expand the line to include other German cities further south, and Hallsberg further north, exist. Transit time is currently 48 hours in one direction. (Olsson, 2009)

The back-up solutions exist to hedge against strikes and unexpected events. The transportation is carried out by truck but, in very urgent matters, also by air freight. This is not, according to Olsson (2009), because rail-bound transportation is more sensitive but because a disruption here has far more serious consequences.

5.5.5 Experienced system effects

Since the solution presented above run in parallel with many other solutions, the impact on the logistics system is difficult to discuss for any one of the solutions in isolation. However, the combined effort has resulted in a number of experiences, as listed below in Table 5.14 and Table 5.15.

Table 5.14. Experienced quality and cost of solution

Aspect	Experienced performance as compared to before implementation	Volvo's comments
Transit time	No difference	
Transit time precision	No difference	Generally, there is no experienced difference between unimodal and intermodal transport, the difference lie in the selection of carriers. Different carriers deliver different quality.
Flexibility in departure	Worse	
Flexibility in arrival	Worse	
Visibility/Traceability	No difference	No discernable difference. It can be difficult to compare different modes of transport because of varying degree of complexity.
Frequency in dep.	Worse	
Goods damage/ handling	No difference	The risk of damage increases with use of rail transport as well as with the increased amount of transshipments. In Volvo's case this has meant that great effort has been put into developing packaging and lashing. Therefore no difference.
Environmental impact	Much better	Difficult to tell in isolation. Collected efforts have resulted in 4% decrease in CO_2 emissions (2007 figures), with an expected decrease of 30% until 2020.
Transport price	Worse	The system is suffering from over capacity
Other transport costs	No difference	

Table 5.15. Experienced impact on logistics system performance

Aspect	Experienced performance as compared to before implementation	Volvo's comments
Purchasing cost	No difference	
Inventory cost	No difference	
Facility/Administration	No difference	
Transportation costs (including damage)	Worse	Transportation costs are dependent on fuel prices, taxes and road tolls. However, cost avoidance has been one of the aims of the projects.
Cost of lost sales	No difference	
Other costs	No difference	

From the customer's (the assembly plants') point of view there is no major difference in the treatment as it is usually the same carrier as before that performs the last leg of the journey. Throughout the projects though, cooperation with, and persuasion of, operators and all actors along the supply chain has been crucial:

> ”There is a general conception that the manufacturing plant is in charge and everyone else should adjust to their needs. This is where we as an LSP can come in and tell them that two different alternatives exist, and we recommend this one. We believe you should behave in this way instead […] Sometimes we even demand that the manufacturing unit increases their output precision for us to be able to lower costs for the entire system.” (Olsson, 2009)

Although communication and supplier cooperation has worked out well, a major barrier has been the changing external factors. For example, when the Viking Rail project was initiated, raw oil was traded at 140 USD per barrel, in April it was hovering around 40 USD. Also road tolls and fees have changed which has altered the premises of the project (Olsson, 2009). The major change, however, is the falling world demand in the automotive industry. In one year, sales have dropped by 60% for Volvo Trucks (Volvo Group, 2009a) and this has had a tremendous impact on logistics operations for the entire group:

> ”[The utilization] is a big problem right now. The plants have stop-days and only run for two to three days per week instead of five. With these circumstances you cannot have a train departing every day. The flows halt, but it is the same with road transportation. Nevertheless, it is very complicated to run a rail-bound system with only a third of the volume it was designed for. There is no cost efficiency in that. But it is a very unusual situation […] However, the demand for Volvo's different products have not always been unison. For example, trucks and cars have for a long time been counter-cyclic.” (Olsson, 2009)

Though both projects have been extensive and thoroughly analyzed before ramp-up, some surprises have occurred. According to Olsson (2009), a surprising element was the extent to which the treatment from governmental bodies and administrative units lack in flexibility. Once a setup is designed you are committed to the solution for a long period of time. This is a disadvantage if you cannot meet your intended volumes, something which has led Volvo to search for partnering firms as world demand has soared:

> ”Now, Volvo is out there working with other shippers saying that we have a supreme system and ask if they want to join us; partly to maintain the system, partly because it is a win-win deal. Once the volume returns to normal levels we will have to find other solutions.” (Olsson, 2009)

There is also a difference in flexibility between the two solutions:

> ”For cabins or big steel details such as those on the 8, the systems are more closed, whereas Viking Rail can be expanded to include more suppliers. It is merely a question of maturity. So far only simple flows have been incorporated, now maybe more complex LTL-transports can be brought onboard.” (Olsson, 2009)

Therefore, according to Olsson (2009), if infrastructural initiatives support it intermodal transportation will be of even greater importance in the future.

6 Analysis

In this chapter the presented cases will be analyzed by using the framework presented in the frame of reference. First, all cases will be discussed on a single-case basis, thereafter a summation across all of the cases is made.

6.1 Arvid Nordquist H.A.B.

For Arvid Nordquist, many factors can be argued to be in line with the model proposed in the frame of reference. The company has indeed a strong environmental policy that sets goals for all functions of the company, including logistics. This policy is also reflected down to product level with several products with environmental certifications. The switch to intermodal transport for the studied flow of Hipp baby food were however not an initiative to reduce the environmental impact as the goods were already transported by means of pure rail. The factor that drove the decision was instead that the pure rail solution was not considered financially viable. The problem lies in the difficulty to fill a rail car with at least the 70 pallets needed as well as finding the rail cars in the imbalanced flow. We will therefore focus on the decision they made when choosing between truck or intermodal transport.

The central warehouse used by AN for all of their products ensures large and stable flows. The central warehouse could be seen as a prerequisite for their role as a distributor of imported goods using very wide sourcing. Transports running directly from suppliers all over the world to the stores in Sweden would be very unreliable and hard to plan. Their method of wide sourcing, as opposed to local sourcing, also means longer transport distances, an ideal for intermodal transport according to the suggested theories. Contradictory to the model though, AN prefers to handle all of their logistics planning in-house even for the more complex intermodal flow.

AN has, as mentioned earlier, very long transport distances for their products and even though the Hipp baby food flow is one of the shortest it is still a good 1800 km from the source in Pfaffenhofen, Germany to the destination in Arlandastad. This puts the solution way over the break-even distance of 500 km proposed in the model but then there is the question of achieving sufficient volumes. This problem can in AN's case be divided into two: first AN have to fill an entire load carrier of goods for each transport to have descent fill rate and then the transporter have to have enough volumes to be able run trains with a suitable frequency. AN handles the issue of fill-rate by not having daily departures and when it comes to the transporters part the flow follows a very distinct corridor running south to north through Germany.

Baby food, in its glass jars, is relatively heavy in relation to its value and this reduces the problem of tied-up capital caused by longer lead-times. The heavy weight is also likely to be a problem if AN decided to use trucks instead as the weight limits are much lower compared to rail cars. However, contradictory to the proposed model the glass jars is very sensitive to impact. This means that AN should experience damage on the goods during transport but no such signs has been possible to see. The only type of goods damage that AN suffered was the risk of the goods freezing and thereby ruining the contents during the winter. AN solved this by using a back-up transport for transport running when there was risk of freezing.

An importing finding regarding the product that likely has an impact on the success of the intermodal solution is its low sensitivity to time. Apart from the obvious non-perishable properties of canned goods, the baby food is also required to be quarantined for ten days before selling. This makes the transit time a smaller factor in the total lead-time.

The results of the change can be a little hard to interpret as in AN's case the change was from rail and not truck. In order to be consistent with the other cases the interviewed logistics manager was asked to compare their new, intermodal solution with a corresponding one using truck. The only difference in transport quality highlighted was longer transit time. Regarding costs, AN belongs to the second type of companies described in the frame of reference with the associated cost analysis shown in Figure 6.1 below.

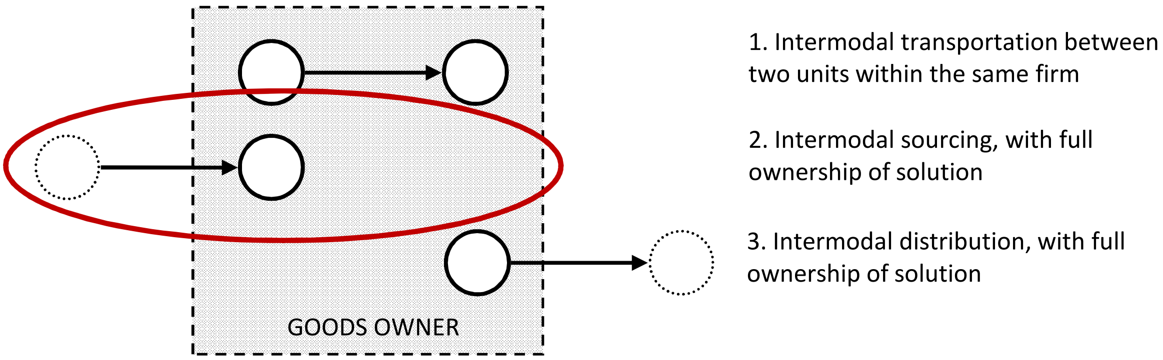


Figure 6.1. AN has an inbound intermodal solution

ΔTOTAL SOURCING COST = ΔP+ΔIC+ΔFC+ΔTC

ΔP = Price of goods purchased = 0

ΔIC = Inventory Costs =0

ΔFC = Facility Cost =0

ΔTC = Transportation cost =0

As can be seen above, the costs for the solution have not change in any way with the transport mode. This is likely due to the fact that AN's logistics system is already built around an existing rail solution so that a truck solution might not be able to benefit from the advantages of truck traffic. The CO_2 emissions have actually increased when compared to the pure rail solution but as that is not financially viable we instead compare them to those of a corresponding truck solution. The result is significant reduction in CO2 emissions. A summary of the most important findings and possible explanations is depicted in Table 6.1 below.

Table 6.1.Important findings regarding system performance and possible explanations for the AN case

Findings	Explanation/Comment	Learning
Transit time increased	In line with previous studies	The slightly longer transit time have a small impact as it is relatively small portion of total lead-time and the products are not perishable.
No change in precision, flexibility or visibility	Contradicts earlier findings, but can partly be attributed to the winter-time backup	With the right planning, the transport quality does not necessarily have to be worse; future development in rail car technology is needed in order to make them competitive all year round.
Low goods damage despite fragile products	The lack of damage contradicts the model and this despite no special measure to protect the goods.	The stresses on the goods might not be as great as model suggest.
No purchase price increase	No change as of today, but the supplier had concerns about increased need for lashing.	It is important to communicate the actual results of the change; consignor-consignee cooperation is important .
CO2 emissions decreased significantly	In line with suggestions from earlier findings	

Important factors that we consider have been essential for the success of the intermodal solution in AN is: 1) the environmental focus of the company as a whole which contribute to the attitude of the employees and ensures that the initiative receive broad support, 2) the centralized system giving the relatively small player enough volumes to keep up the frequency, and 3) the product characteristics that make the product less sensitive to longer lead times.

It is also important not to look away from the fact that AN switched from a rail solution to an intermodal as opposed to many other companies that switched from trucks. This means that they do not have to deal with one of the potentially largest barrier against intermodal transport: attitude. Coworkers and suppliers are already used to the way of working and this decreases the initial friction bound to happen with such an extensive change. A compilation of the findings of this case compared to our analysis model is presented in Figure 6.2 below.

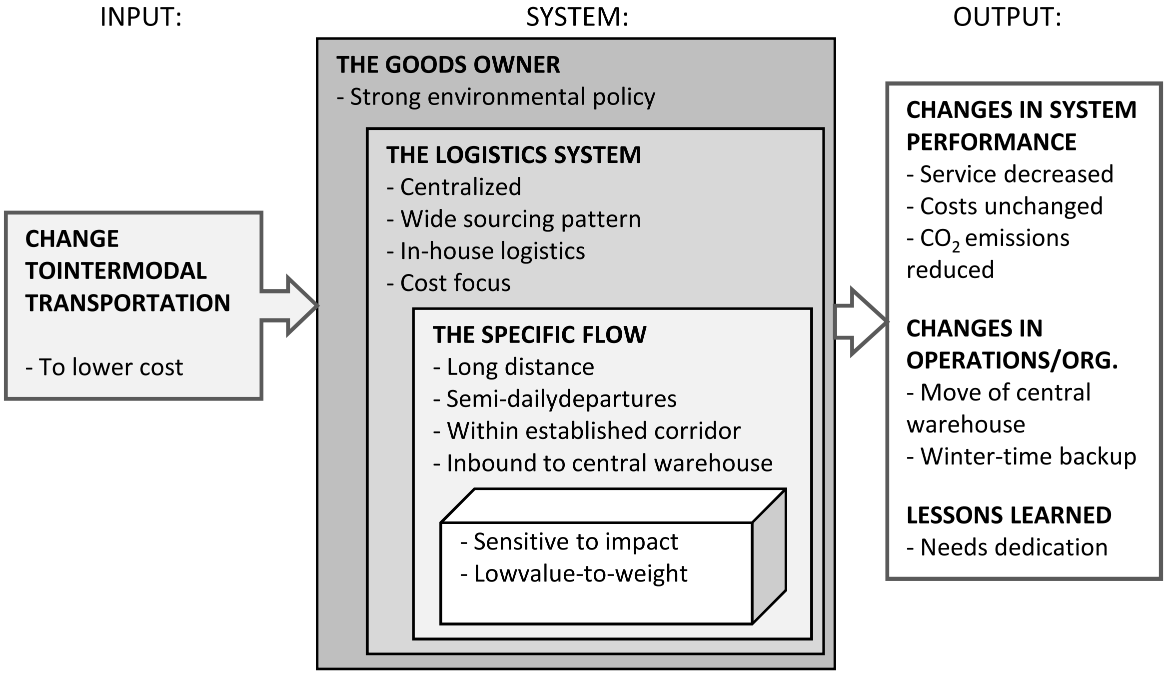


Figure 6.2. Our framework with the values of AN

6.2 Home Retail Co. Sweden

In the case of Home Retail (HRC) the implementation of the new solution was initiated to 1) lower the price paid for transport and 2) improve the quality. This is an interesting aspect, since theory suggests that a tradeoff will have to be made between the two which was never the case. Where most previous research point to the inadequacies in quality of an intermodal solution, HRC claim that almost all quality measures, including precision and visibility, has improved with the new solution. To fully understand this unique situation, we need to look at the specifics of the case. It should be noted though that the company had had problems with the former service provider and decided to make the modal change while other changes were under way, including the move of the central warehouse and the installment of the new order management software solution. These simultaneous changes make it difficult to address the success of the solution to the solution itself. Still let us have a look at the special circumstances.

At HRC, no environmental policies exist explicitly, and although the logistics manager had the support of the Swedish management, he had to fight the negative mind-sets from both store managers and corporate management when introducing the intermodal solution. That is, if it would not have been for the dedication of one person the solution would not have been likely to succeed. Just like the general consensus from previous studies, the store managers believed intermodal transport to offer lower service and that it would jeopardize the firm’s competitiveness. The newly appointed logistics manager had to put much effort into the project which shows that a major barrier to intermodal transport is the difficulty in switching. A more market-oriented approach from the intermodal service providers would have made the switch easier and thus less time consuming.

Among the many different products sold at HRC, tile from Spain and Italy were chosen to be transported by means of an intermodal setup, although these were not sourced in large volumes and often purchased and delivered on customer order. The material flow follows the established north-south corridors within Europe, but although consolidation possibilities are greater along these, frequency has had to be kept low in order to allow for the desired volumes. Potential problems in end-customer service have been countered through the utilization of a backup solution, which seem to be a good idea in order to come to terms with possible lost sales because of long lead times. The low value-to-weight also means that in order to fully utilize the volume of a trailer, weight will be very high. Since truck weight is limited to less tons per trailer in Germany than in Sweden, the utilization of each shipment can be improved significantly through an intermodal setup. In this way, the heavy trailers can be taken by means of rail through Germany, avoiding fees and road tolls, and taken the last mile by truck in Sweden were restrictions on trucking weight are more liberal. It is also shown that overall utilization has improved, from 75% in 2007 to 87% in 2008.

Further, the tile products are sensitive to impact which contradicts the suggestions from theory regarding what products are suitable for this type of transport solution. HRC has countered this by packing the rail cars tightly to prevent goods from moving while in transit. This would not be possible in an all-road solution since the high weight would not allow for a fully packed trailer.

Regarding the results, HRC has experienced positive effects in both transport quality and logistics costs. Regarding quality, transit time has decreased while precision and visibility has improved. Most likely, these positive changes are due to carrier differences, since these aspects merely depend on what additional services the provider has to offer. In this case, the visibility improvement was the joint effort between the carrier and the logistics manager and a way to involve the store managers which simplified the changeover. This, however, could have been attained even with another mode of transportation. Out of the intermodal solutions described in the frame of reference, HRC belongs to the second type (see Figure 6.3). The total cost analysis for this type of solution is shown below.

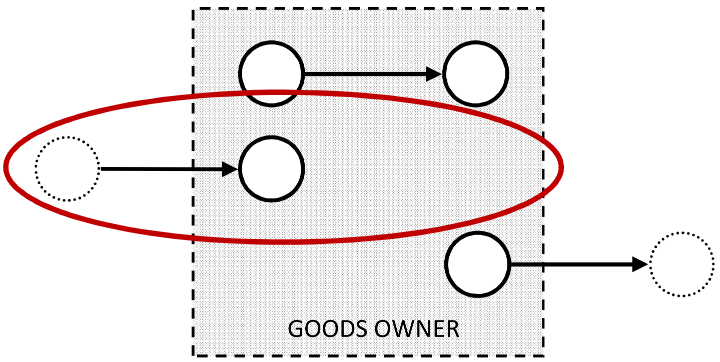


Figure 6.3. HRC has an inbound intermodal solution

ΔTOTAL SOURCING COST = ΔP+ΔIC+ΔFC+ΔTC

ΔP = Price of goods purchased = 0

ΔIC = Inventory Costs =↓

ΔFC = Facility Cost =0

ΔTC = Transportation cost =↓

The decrease in transport cost is accredited to the decrease in transport price, and the lower inventory costs are quite likely an effect of the change in order management software since transit time is longer. Planning efforts have increased but not to an extent as to increase administration costs. However, CO_2 emissions have declined by almost 60%, which must be seen as quite successful and in accordance with theory. A summary of the most important findings and possible explanations is depicted in Table 6.2 below.

Table 6.2. Important findings regarding system performance and possible explanations for the HRC case

Findings	Explanation/Comment	Learning
Transit time increased	In line with previous studies	It is difficult to compete with dedicated truck transport
Precision was improved	Contradicts earlier findings, but could be attributed to the specific carrier	Carrier Selection is probably of greater importance for transport quality than Mode Choice
Visibility was improved	Partly depends on the initial situation which was “appalling”, could also be explained by the software change	The perceived success of intermodal transport is dependent on the performance of the initial solution
Inventory costs decreased	Contradicts theory but is difficult to relate to the mode shift, since both centralization and system implementations were made in conjunction	Other simultaneous changes might be of great importance to enable a successful change
No purchase price increase	The improved quality of transport and the clear communication meant no cost increases for suppliers	Communication is important in the mode change process
CO2 emissions decreased significantly	Significant increase in utilization as measured in volume	Consumer goods with low value-to-weight benefit from the combination of rail capacity and road flexibility

The HRC case contradicts previous findings on intermodal quality, but the success of the solution is hard to attribute to the solution itself, since it was implemented along with larger structural changes. Possibly, these changes enabled the success of the solution for two reasons: 1) resources were allocated to drive improvement projects within the logistics function, and 2) it created a structure in which intermodal transports were more likely to succeed. However, the solution works well even though the products transported are sensitive to impact, which stresses the importance of lashing and packaging.

Throughout the mode switch, HRC has kept a tight dialogue with both service providers and suppliers. Although friction has been present from within the company, the open communication has been a key issue to ease the implementation and prevent goods prices from increasing despite demands on suppliers. The success of the solution is likely to depend upon this and: the dedication of the new logistics manager, the change of system structure, and the new order management software. One should keep in mind though, that the improvement is dependent upon the situation *before* the change, which was, in the words of HRC, appalling. The findings of the HRC are collected in Figure 6.4 below.

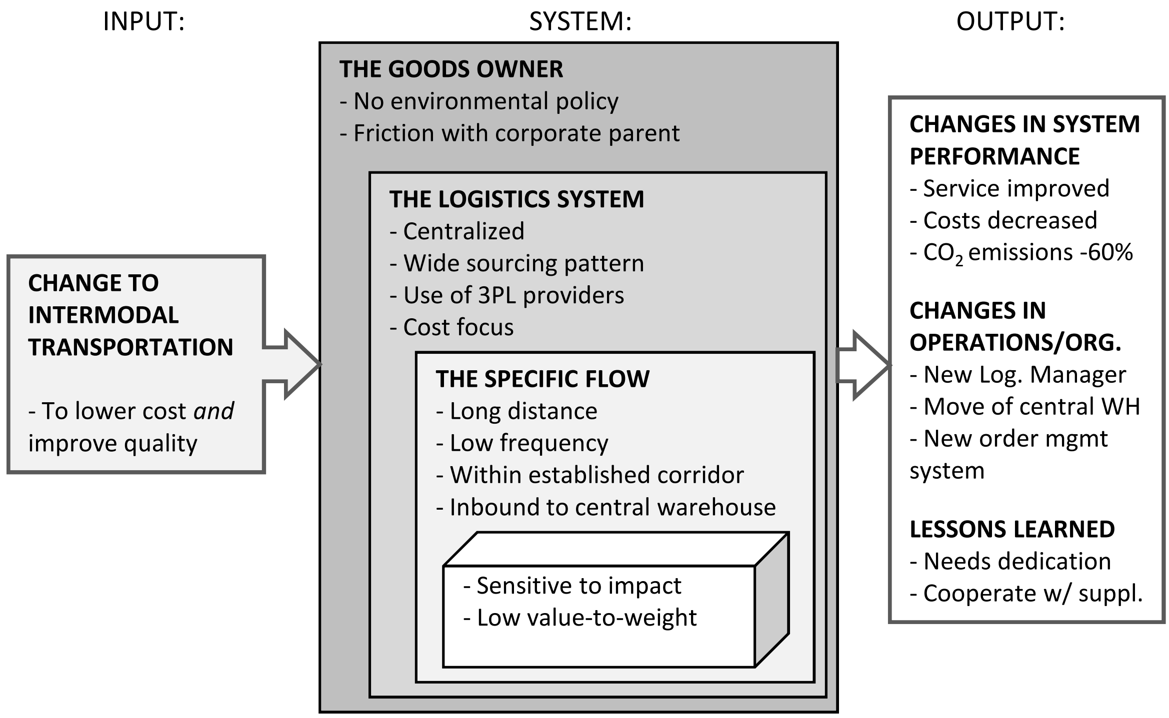


Figure 6.4. Our framework with the values of Home Retail SE

6.3 ITT Water & Wastewater

In 2001 ITT introduced their new distribution system where many smaller warehouses where consolidated into two larger nodes that supplied the entire world market. With this change, ITT also built a new distribution centre in Metz, France supplied by trucks from the manufacturing facility in Emmaboda. Now a few years have passed and ITT have begun to look into alternative modes of transport for this high-volume link in the supply chain with a new senior transport buyer leading the project. The aim of the project is, in addition to reducing costs, to decrease the impact on the environment that the transports have. Both the nodes of the flow is within the company and this means that they a high degree of control of the flow improving the potential of an intermodal solution. Even though only a small part of the flow is included in the intermodal solution as of today there is a enough capacity to fill two trailers a day giving the solution great potential volume.

Some of the characteristics that ITT's products possess speak against the general conception of which products to transport by intermodal transport. First of the products are to a high degree custom made to fit the customer's demands and it is therefore hard to build up buffers to alleviate any negative effects of a modal shift. This is even more so in the case of spare parts where delays can have serious consequences and given ITT's strong after market focus it is important that they can keep up the service. Despite this, ITT have not received any specific complaints from customers regarding the quality of the intermodal transport. An explanation to this is likely that customers that order a custom made product might be more accepting of longer lead-times and the one day longer transit time does not matter all that much. Another factor that contradicts the use of intermodal transport is that the products have a high value to weight ratio that makes the transport costs relatively small compared to the total cost of the products rendering savings in transportation costs to some degree negligible. This can in turn be explained by the fact that the change was not primarily to reduce but rather to reduce the environmental impact.

In addition to this it should also be noted that ITT have not used the solution on a full scale but instead only for smaller test runs. To reduce the effect of longer transit times ITT have used the intermodal solution for transports running over the weekend giving the transport two extra days to reach its destination. What happens when, or even if, the solution goes full scale is yet to be seen but one can expect both new problems and benefits of a larger scale emerging. It can for example be problems when they are unable to do “cherry-picking” as in the case of weekend transports.

ITT describes the change to intermodal transport as being relatively friction-less with no further facility costs incurred neither at consigner nor consignee side of the transport. ITT has simply used the same system of filling up trailers and then sending them away when full. It is possible that this is an area of potential improvement as smarter production planning can mean that the intermodal solution can match the truck solution, if not in precision, at least in transit time. As mentioned earlier, the intermodal solution is between two nodes within the company and the cost analysis is thereby as presented in Figure 6.5below.

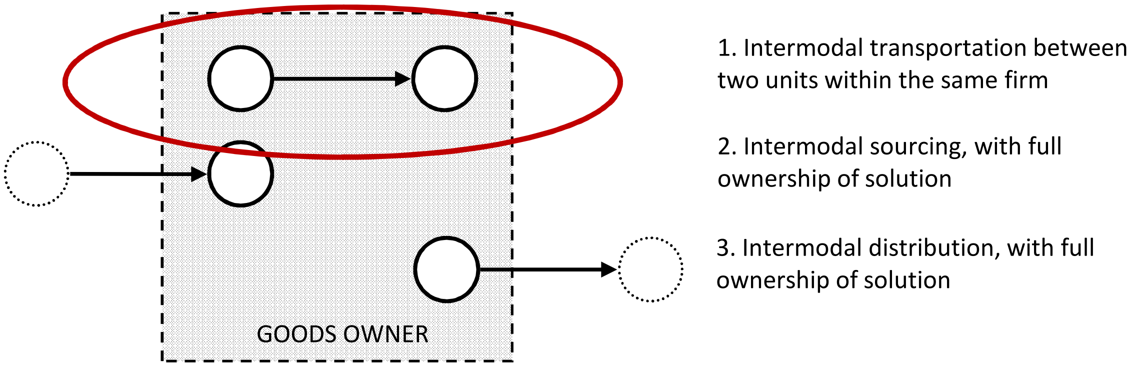


Figure 6.5. ITT's solution is intra-firm

ΔTOTAL LOGISTICS COST = ΔIC+ΔFC+ΔTC

ΔIC = Inventory Costs (consignor + consignee) = 0 + ↑

ΔFC = Facility Cost (consignor + consignee) = 0 + 0

ΔTC = Transportation cost = ↓

During the test period, ITT have not experienced any changes to their facility costs neither at the consigner nor the consignee simply because they have not changed their way of working. Regarding the Inventory costs it is possible to see a small difference as ITT have been forced to hold a slightly larger safety stock at the consignee. This is out-weighed by the reduced price that ITT pays for the transport and in total the logistics costs have gone down. A quick calculation made by ITT shows that the CO_2 emissions for this transport solution can be reduced by as much as 60% and this has to be seen as success. A presentation of the systems performance is presented in Table 6.3below.

Table 6.3. Presentation of the system performance and possible explanations in the ITT case

Findings	Explanation/Comment	Learning
Transit time increased slightly	In line with theory but can be explained partially by a mismatch between arrival times and delivery window.	With better planning and communication with Metz it is possible to match transit times of trucks.
The transport price has gone down	In line with theory	
End-customer service intact	Even though the transit times were longer no complaints were made by customers	Customers might not be as sensitive to lead-time changes for products with already relatively long lead-times
CO2 emissions decreased	In line with previous findings	CO2 emissions were a driving force for the implementation; environment can be a deciding factor and be used in marketing.

To summarize the findings in the ITT case one has to consider that ITT is only in a pre-phase to the actual implementation but the experience so far has been positive. Costs have gone down and the primary goal of reducing CO2 emissions has been achieved. The quality has in some cases suffered but as it is very early in the process to draw any certain conclusions. This is in line with the theories previously presented in our frame of reference and a comparison of our model and the ITT case can be seen in Figure 6.6below.

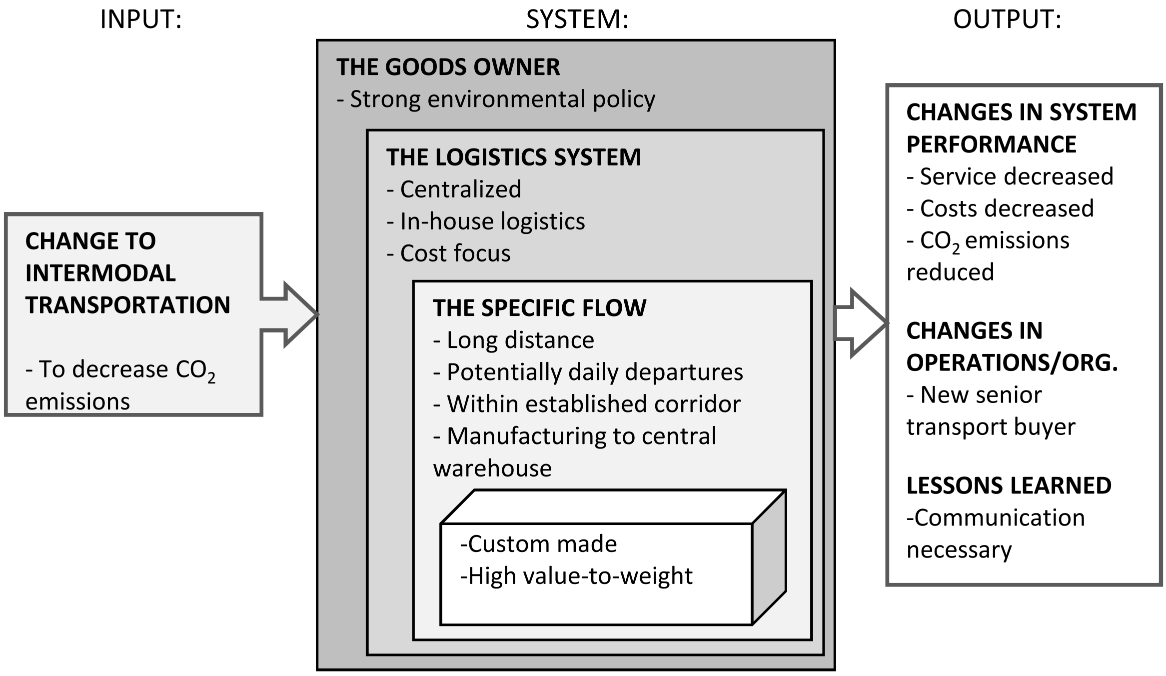


Figure 6.6. Our framework with the values of ITT W&WW

6.4 Lindex

The intermodal solution at Lindex was implemented closely after their new distribution center in Gothenburg had been inaugurated. One of the key enablers of the mode change was that resources were free to take care of a procurement process; another was the new structure and management of the distribution center. What finally triggered the process was the running out of a third-party-logistics-provider contract for which a new provider had to be found. For the company though, the *mode shift* in distribution was never an active decision, but merely a choice of the one alternative that offered the best price/quality mix out of the offers received in the procurement process. That is, without any major changes in their current operations, an intermodal transport solution offered the best price among the competition. According to previous studies, it is no surprise that the price was lower for the intermodal solution. More surprisingly, most quality parameters were the same or even better with the new solution, something that definitely seem to contradict previous findings. Let us investigate why.

Being a fashion retail chain, Lindex went against the common conception of how to deliver cost efficient customer service when they decided to use intermodal transportation for their distribution. The product life cycles are short in fashion and the demand uncertainty is very high and sensitive to trends and seasonal changes. Further, the value-to-weight ratio is high which indicates that transportation costs are only a small fraction of the total cost of goods sold. With all of these product and market aspects put together: short life cycle, volatile demand, and high-value-to-weight, one would expect the fastest possible mode of transport to be utilized and according to theory this is not intermodal road-rail transport. The company has a strong lead-time focus, for inbound as well as outbound goods, but with the change to the intermodal solution lead-time *did not change*. After implementation, transit time was equal to that of the previous road transport. This contradicts previous studies, but a couple of possible explanations exist. One is that the answer lies in the consolidation efforts of the LSP; other fashion retail chains, with stores in Norway close to those of Lindex, utilize the same solution and by doing so volumes are kept higher and frequency can be kept at the same rate as for truck transport. Another explanation could be the geography; Norway might be a special case because of infrastructure, typography, and the physical narrow-and-long shape of the country which might reduce the competitiveness of truck transport. This would be supported by the fact that truck transport was chosen for the Finnish market in the same process in which the intermodal solution for Norway was agreed upon. However, according to the statistics presented, no major intermodal flow goes in this direction which would imply that the advantages are not considered high enough by many other firms. The most likely explanation is a combination of the two points: that the transit time is kept on all-truck levels because of 1) the efficiency in LSP operations and 2) the lower relative competitiveness of truck for the given route.

Looking at the key enablers discussed above, it is clear that by controlling the central warehouse and the stores themselves it was less of an effort for Lindex to adapt to the few changes that had to be made in order to utilize the intermodal solution that was offered. Although transit time was kept constant, delivery windows at the stores had to be expanded and a larger amount of administration had to be taken care of at the DC. The reasoning was that the costs that stem from the decrease in transport quality would be outweighed by the time savings for the stores along with the transport price. That is, Lindex experienced some negative transport quality aspects which affected both the consignor and the consignees, but reasoned that the costs these quality deficits would incur would be won in price decrease and improved store-friendliness. As long as the one parameter most important to them (i.e. lead-time) was not affected negatively they were willing to make the tradeoff. Out of the different intermodal setups described in the frame of reference, Lindex belongs to the first type (see Figure 6.7). The total cost analysis for this type of solution is shown below.

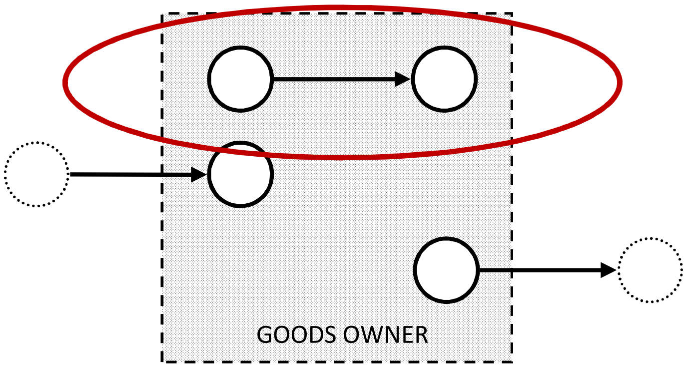


Figure 6.7.Lindex's solution is intra-firm

ΔTOTAL LOGISTICS COST = ΔIC+ΔFC+ΔTC

ΔIC = Inventory Costs (consignor + consignee) = 0 + 0
ΔFC = Facility Cost (consignor + consignee) = ↑+ 0
ΔTC = Transportation cost = ↓

The increase in consignor facility costs stem from the increase in administration that was incurred with the new solution with regards to customs clearance. This cost however, was countered by the decrease in transport price and the fact that store personnel only had to deal with one incoming delivery per day. CO_2 emissions have decreased but it is not certain yet to which extent although this is well in line with the suggestion from theory. It should be noted though that total emissions was never a decision criteria for the shift. A summary of the most important findings with regards to system performance is presented in Table 6.4 below.

Table 6.4. Important findings regarding system performance and possible explanations for the Lindex case

Findings	Explanation/Comment	Learning
Transit time did not change	Contradicts theory but could possibly be explained by the lower quality of Norwegian roads	Relative time-competitiveness of road is important; transit time must not change to the worse
Daily departures remained	The high frequency despite the relatively low volume was possible through the consolidation efforts of the LSP	Consolidation between competitors within the same industry enable high responsiveness also for an intermodal distribution solution
Delivery windows were extended	The less precise delivery windows is in line with previous findings, however precision was kept within the time frame and the store deliveries per day decreased from two to one	One must consider the tradeoffs at both consignor and consignee: there is a tradeoff between stand-by-time and precision in stand-by-time
CO2 emissions decreased to some extent	In line with previous findings and can be attributed to the mode shift which also reduced the number of store deliveries	CO2 emissions does not have to be a decision criteria in order for intermodal transport to be chosen
Administration costs increased at consignor	In line with theory	Administration at consignor might increase with an intermodal solution

The fact that transit time has not increased with the change to intermodal transport contradicts earlier findings, and shows that the slower service is not necessarily the case when shifting from all-road to road-rail transportation. If only utilization and frequency can be kept high enough this can be countered, and in Lindex's case the LSP solved the issue by consolidating the shipments with competitors of the company. A part from this, the case is well in line with theory and the suggestion that there is a clear quality-price tradeoff when choosing a more CO_2 efficient transport mode. Our framework, complete with the values of Lindex, is shown in Figure 6.8.

Regarding the changeover, it took the dedication of a procurement project team to make the change. This does not necessarily mean that an intermodal solution is difficult to procure, but indicates that a large change in distribution setup might be necessary for an intermodal solution to work successfully. Also, other changes were made in close conjunction to the intermodal project, a fact that supports this statement.

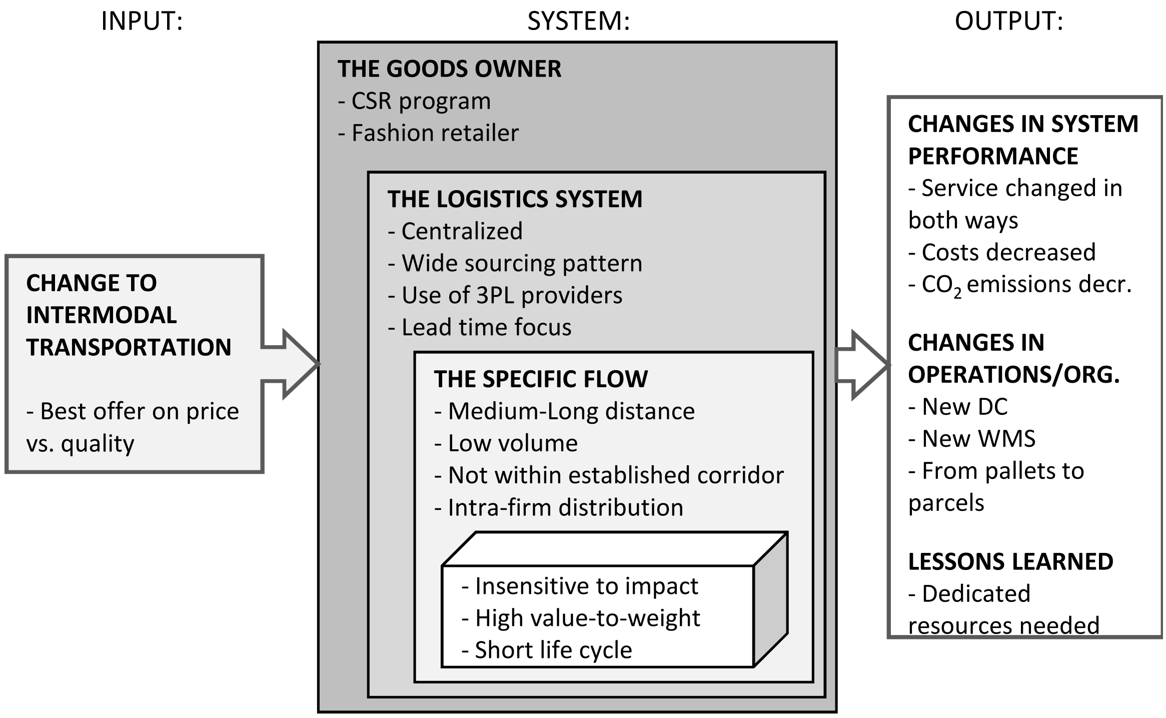


Figure 6.8. Our framework with the values of Lindex

6.5 Volvo Trucks

Volvo Group has a strong environmental profile and the initiation of the Viking Rail project was triggered by a climate challenge to reduce CO2 emissions and avoid future costs related to this. Evidently, there is a strong top management support for the solution even as capacity utilization has declined with the shrinking automotive world demand. Volvo's plants also work according to a time-based JIT-strategy, which puts very special time constraints on the performance of the solution. With previous research pointing to intermodal transportation's quality problems with regard to transit time and transit time precision, the decision to utilize this type of transport seem counter-intuitive. To understand how this is possible we need to think of the premises of the solution for a moment.

Volvo Trucks is a large company and can excerpt great power on the other actors of the supply chain. When the Viking Rail project was initiated, this relation of power could be seen as plants were forced by the Group to improve output precision in order to lower total logistics cost for the whole solution. This is a complex issue, since the supplier network is large and intricate and structured in many tiers, something which speaks against intermodal transport that, according to theory, is more likely to be found in a centralized, simpler, system. Although Volvo Logistics excerpts central control, the relations are many. However, because of the bias of power, the solution was eventually realized; consolidation between the different suppliers could be achieved resulting in large volumes and the possibility to transport these volumes in daily deliveries. The sheer scale of the company and the solution made the time-based system possible; the company owned the train set and was big enough to get priority when the slot times for rail traffic were set. This is well in line with the suggestions of theory, which claim that volumes need to be large. Also, despite the decentralized structure of the system, the large number of suppliers within viable distance of a north-south transeuropean intermodal corridor made the consolidation possible. Referring to theory, the geographical dispersion was low, something which, in combination with long distance and large volume, speaks for intermodal solution. So to sum up, the JIT-strategy could be realized because of 1) the scale of the solution, 2) the central control, and 3) the amount of suppliers close to an established corridor.

Despite the scale and frequency of the solution, problems occur and when they do it is of importance to fix these if the plant delivery windows are to be met. To avoid and prevent the problems of standstills, the solution is built so that the trailers easily can be transferred to truck at the many terminals along the way. That is, Back-up transports by truck exist. To avoid damage of the components at these situations, or when shunting trains at the rail yard, Volvo Logistics has put effort into lashing and packaging. Since sensitive products are regarded unfitting for the transport type, this is a possible action that must be made in order for the solution to work properly for products sensitive to impact. This also shows that some of the aspects regarding the nature of the product can be slightly modified in order for an intermodal solution to be more suitable for the specific product. That is, design actions can increase the intermodal suitability of a product.

What has become more of a problem though are the changes in the external forces on the solution. According to theory, intermodal transport would be a solution of with lower price under the circumstances presented. However, the drop in world market demand has decreased the utilization of the whole solution, which was designed for the volumes that were produced in early 2008. With a 60% drop in sales, production volumes has shrunk accordingly. This volume drop becomes a problem because of the high fixed nature of the transport type which was seen in the frame of reference; utilization decreases and the solution becomes less competitive as compared to road freight. This has also been the case at Volvo Trucks, and it is claimed by Volvo Logistics that the intermodal solution has become more expensive as compared to all-road transport since the flexibility in volume is much lower. Flexibility in departure times is also said to be lower, however with the strict time-based control this is not of disadvantage to total costs. But although theory suggests that transport price and cost would decrease, external factors dragged down utilization and increased transport cost per unit. To some extent it has been countered by cooperation with competitors. To achieve this, using an established corridor should be advantageous.

Out of the intermodal solutions described in the frame of reference, Volvo belongs to the second type (see Figure 6.9). The total cost analysis for this type of solution is shown below.

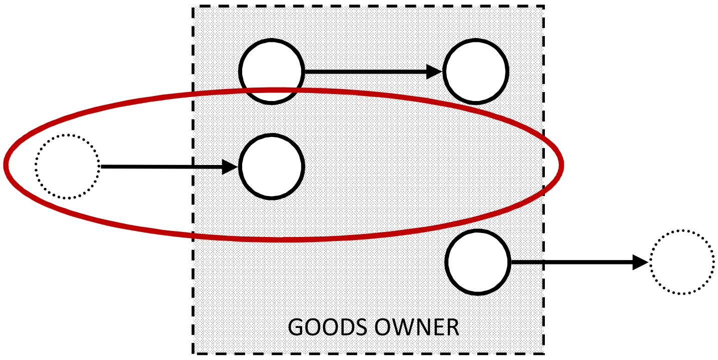


Figure 6.9. Volvo truck has an inbound intermodal solution

ΔTOTAL SOURCING COST = ΔP+ΔIC+ΔFC+ΔTC

ΔP = Price of goods purchased =0
ΔIC = Inventory Costs =0
ΔFC = Facility Cost =0
ΔTC = Transportation cost = ↑

The rise in transportation cost is dependent on the price paid for transport which has increased while capacity utilization has, at the same time, decreased. That the solution is still running, despite the various cost issues, is attributed to its purpose of decreasing the greenhouse gas emissions from the Volvo Trucks' supply chain. To some extent it has also been successful. Before the drop in demand, total CO_2 emissions had decreased by 4%, partly due to the change to intermodal transport. A summary of the most important findings with regards to system performance is presented in Table 6.2 below.

Table 6.5. Important findings regarding system performance and possible explanations for the Volvo Trucks case

Findings	Explanation/Comment	Learning
Transit time did not change	Contradicts earlier findings, but the scale of the solution and the size of Volvo created large volumes and slot time priority along with high frequency	Transit time must not change for the worse, it is advantageous to be a big player in order to get prioritized
Transit time precision was kept at acceptable levels	This is secured through the back-up solution and cannot for sure be attributed to the intermodal solution	Back-up might be needed in order for intermodal transportation to work seamlessly in a time-controlled system
Transport price increased	Contradicts theory but is based on a per unit rate which increased with the decrease in utilization	The financial performance of an intermodal solution is sensitive volatility in demand
CO2 emissions decreased	In line with theory, albeit a small change	It may be harder to achieve large emissions savings in a time-controlled system due to back-up system

The tradeoff that is suggested in theory regarding transport time vs. price is somewhat contradicted in the Volvo case. Also, the system is not physically centralized which, according to theory, should be a prerequisite to create a successful solution. However, both of these aspects can be attributed to the size of the company and the scale of the solution, creating large volumes and owing large negotiation power with authorities. These volumes are not likely to be met by many other Swedish companies. However, the small decrease of CO2 emissions also suggests that the back-up solution is utilized frequently, highlighting the sensitivity of the system. The collected findings are presented in the framework in Figure 6.10 below.

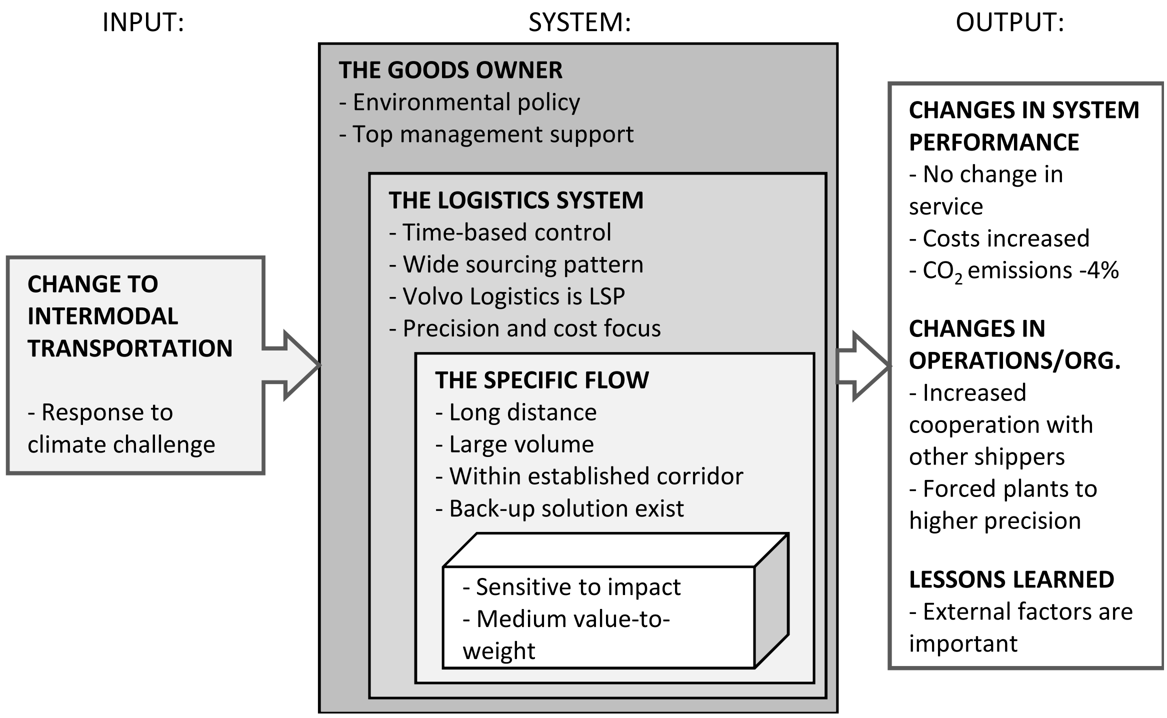


Figure 6.10. Our framework with the values of Volvo Trucks

6.6 Summary of analyses

In this section the findings from the single-case analyses will be discussed and compared with one another and our frame of reference. First, let us look at the drivers and triggers of the implementation of intermodal transport.

6.6.1 Change to intermodal transport

The first area of comparison between the different cases is depicted in Figure 6.11 below.

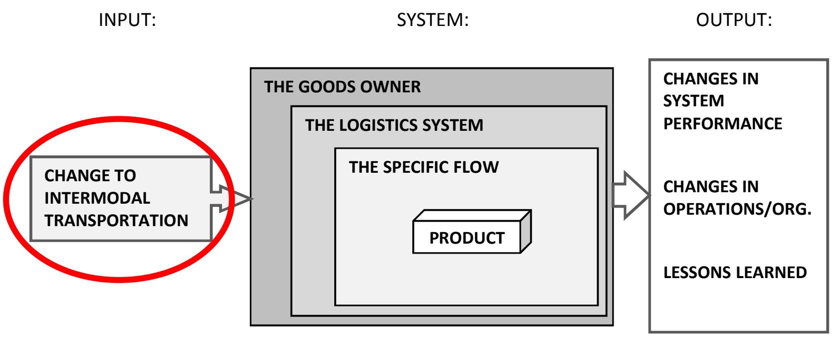


Figure 6.11. This section's relation to our framework for analysis

According to theory, the main advantage of intermodal transportation is its possibility to lower costs while increasing the logistic system's environmental performance as measured in CO_2 emissions. One would therefore expect one or both of these characteristics to be the main driver of the change. Looking at the different case companies, this suggestion cannot be discarded. Although the increase of quality is mentioned by one of the case companies as the primary objective, this is combined with a desire to lower costs. A collection of the different drivers and triggers are shown in Table 6.6 below.

Table 6.6. Collection of drivers and triggers of the mode shift

Drivers and/or triggers of mode shift	Arvid Nordquist	Home Retail	ITT W&WW	Lindex	Volvo Trucks
To lower/avoid costs	X	X			X
To increase quality		X			
Best offer on price vs. quality				X	
To decrease CO2 emissions			X		X

It should be noted that only two of the case companies claim environmental aspects to be a main driver of the change, something we will have reason to get back to.

6.6.2 The different system characteristics

In the following section we collect the findings from the fives cases regarding in which setting intermodal transport is used. These findings are compared to those of the framework presented in the frame of reference. The area of investigation is shown in Figure 6.12.

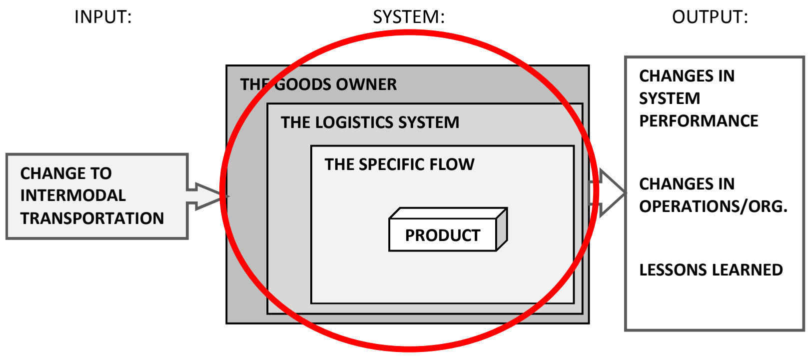


Figure 6.12. This section in relation to our framework for analysis

Our system was previously defined as being in four levels: company, logistics system, flow, and product. All of these carry different characteristics that together form the context of the intermodal solution. In the frame of reference, a framework was developed, highlighting certain key characteristics that were to be examined since these characteristics, according to previous research, would shape the context of a successful solution. Starting with the company level, the characteristics from the frame of reference is compared to the findings of the case companies in Table 6.7.

Table 6.7. Collection of characteristics on the company level

Goods owner	Arvid Nordquist	Home Retail	ITT W&WW	Lindex	Volvo
Environmental policies	X		X	X	X
Top management support			X		X

The first factor present in the framework regarding the characteristics of the goods owner was that they in some form had an environmental strategy or policy. This was indeed found in four out of the five case companies with Home Retail being the only company missing one. In the frame of reference, the reasoning was that an environmental policy would create incentives to increase the amount of low emission intensive modes of transport. This could be connected to the findings in the previous section; translated into actual drivers for implementation of intermodal transport, Volvo and ITT were the only companies that explicitly mentioned environmental consideration as a main reason for the modal shift. In the Volvo case it was the sole driver and in the ITT case a part of the decision while the remaining three companies saw it mostly as a positive side effect. It could therefore be concluded that although environmental policies might drive the solution, companywide policies is by no means a necessity for a firm to be willing to choose the transport type. It will however *increase the chances of the firm being willing to sacrifice other performance measures in order to decrease CO_2 emissions*, similar to the case of Volvo. Regarding top management support it can be seen that only two companies had explicit top management support for the intermodal solution. These are the same companies, Volvo and ITT, which had emissions reduction as the objective for the change. However, it is also shown that an intermodal solution can work perfectly without any interference or top management attention, if the solution is performing well. In the case of HRC, the pure performance alone convinced the skeptical parent to accept the solution albeit with some concerns.

Moving on to the next level, characteristics describing the different case companies' logistics systems are depicted in Table 6.8.

Table 6.8. Compilation of findings with regards to the logistics systems

The logistics system	Arvid Nordquist	Home	ITT W&WW	Lindex	Volvo
Centralized	X	X	X	X	
Wide sourcing pattern	X	X	N/A	N/A	X
Use of 3PL providers	X	X	X	X	X
Cost focus	X	X			X

Studying the compilation of the results regarding the goods owner's logistics system a number of observations can be made:

- All companies but Volvo uses a centralized logistics system
- In the cases where the intermodal solution is used for sourcing all of the companies utilizes a wide sourcing strategy
- Third party logistics providers (3PL's) are used in all cases for the physical movement of goods

It is evident that centralization has been an important factor for creating the larger flows needed for the intermodal transport to lower unit transport cost and be competitive. The system of the examined companies has in all but Volvo's case either recently adapted a centralized logistics system or has been using one for a while. In Volvo case, one can argue that the already large volumes of a company of that size are enough to support an intermodal solution between two units without the need of a central warehouse or distribution centre.

The wider sourcing trends among shippers were described in the frame of reference as a potential opportunity for intermodal transportation since flows became longer and thus relatively more competitive to truck transportation. This finding cannot be applied to the cases though, since it considers the whole structure whereas the intermodal flow is merely used for a link. One could however turn the argument around: if a shipper was not to have wide geographical sourcing, there would be no flow with long enough distance to be competitive with an intermodal solution.

The rationale behind the use of 3PL as being a success factor was that this would increase consolidation and thus the cost and eventually the price for a transport route. In all case companies, transports are taken care of by another part. One can therefore conclude that these are all in line with theory. This however concerns only the physical movement; system control is kept in-house in all cases but Volvo Trucks.

Of greater interest is the specific flow for which the intermodal solution is utilized. Many of the previously mentioned characteristics from the analysis framework were reasoned to be likely factors for a successful context since they established greater likelihood for certain flow-specific characteristics. For example, a central system was considered a high potential system characteristic since it enabled larger flow volumes because of consolidation. In Table 6.9, the four characteristics from the frame of reference are compared with the findings of the cases. Also, two more characteristics, which were found to be prevalent among many of the cases, are depicted under the bold line.

Table 6.9. Collection of flow-specific characteristics from the case companies

The specific flow	Arvid Nordquist	Home	ITT W&WW	Lindex	Volvo
Long distance	x	x	x		x
Large volume			x	X	x
Within established corridor	x	x	x		x
Intra-firm			x	x	
Shared solution	x	x	x	x	x
Back-up solution	x	x	N/A		x

From this table, the following can be said:

- Under certain circumstances long distances are not necessary for the relative competitiveness of an intermodal solution
- Not all shippers need to have large volumes, however consolidation in one way or another is crucial
- The flow must not follow an established corridor, although it simplifies consolidation efforts

In accordance with theory and the previous findings of wide sourcing strategies most companies in the study employs their intermodal solution on flows with long distances. The exception of this is Lindex, but we have seen in earlier analysis that this case shows very special circumstances since it distributes to the Norwegian market. One should also note that relative competitiveness depends on both the intermodal solution and the all-road-solution. The finding is thus that *long distances is not a prerequisite for relative competitiveness but an enabler;* the longer the distance the more likely to be competitive.

Large total volume was shown not to be a necessity for an intermodal solution. Large volume per shipment, though, was prevalent in every case and that this would be a key flow characteristic is supported by theory stating that it is important to keep utilization high. If total volume is low, high volume per shipment can still be reached by a decrease in departure frequency. This was the case for Home and AN, for which the total yearly volumes are not close to those of, for example, Volvo. In both these cases, though, product value is low, which implies that the inventory carrying costs incurred in the waiting period (between the departures at consignor and as cycle inventory at consignee) is of less importance. Thus, *volume per shipment should be kept high, and this can be obtained by firms with smaller total yearly volumes by lowering frequency and increasing inventory given that this does not increase total costs*. The importance of high volume per shipment was also shown in the Volvo case, where this eventually had to be achieved through consolidation with other shippers.

It should also be noted all the flows of the case companies are characterized by either long distances or large volumes or both.

The last system level of the framework considers the product moved by the solution. The findings from the case companies are found in Table 6.10 below.

Table 6.10. Collection of product characteristics from the case companies

Product	Arvid Nordquist	Home Retail	ITT W&WW	Lindex	Volvo
Insensitive to impact			x[21]	x	x[22]
Low value-to-weight	x	x			
Ecological profile	x				

Interesting to note here is the nonexistent connection between environmental arguments in marketing and environmental efforts in operations; the only product for which environmental arguments are used in the marketing is the baby food for which costs was the main driver of the mode shift.

Considering that the cases cover a number of different product types, weights, values, and features, it can be concluded that none of these aspects seem to hinder the feasibility or financial viability of an intermodal solution. Further, *the suitability of an intermodal solution cannot be judge on product characteristics alone, it must be judged based also on packaging and lashing*.

6.6.3 Experienced changes in system output

With these different systems characteristics in mind, let us look at the changes in system output, see Figure 6.13.

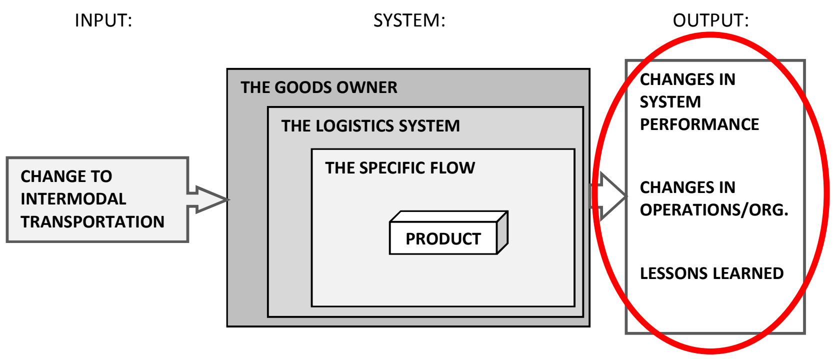


Figure 6.13. This sections relation to the framework for analysis

A logistics system is made up of nodes connected by links. To fully understand the effect on system performance, as measured in system output, we need to first understand the experienced quality of the solution used in one of the many links. In Table 6.11 below, the different companies' perception of change in transport quality is presented. That is, how they have experienced the transport quality of the specific link for which intermodal transport was introduced.

[21] Low-Medium sensitivity
[22] do

Table 6.11.Summary of experienced quality and price of solution. A= ArvidNordquist, H = Home, I = ITT W&WW, L = Lindex, V=Volvo

Aspect	**Much Worse**	**Worse**	**No Difference**	**Better**	**Much Better**
Transit time		AHI	LV		
Transit time precision		IL	AV	H	
Flexibility in departure		V	AHI		
Flexibility in arrival		V	AHI		
Visibility/Traceability			AIV	H	
Frequency in dep.		V	AI	H	
Goods damage/ handling			AIHLV		
Environmental impact					AHILV
Transport price		V	A	IL	H
Other transport costs			AIV	H	

From this table, a number of interesting findings can be made. Especially, all firms agree to three things:

- no quality parameter has become *much worse* after the change to intermodal transport,
- none of companies have experienced any difference in goods damage with the new solution,
- all have experienced *much better* environmental performance.

Let us take a look at these proposals. Firstly, that no quality parameter is considered to have become much worse is natural, seeing to the selection of case companies. Only those who had successfully implemented such a solution were chosen, and one might doubt that the solution would be considered successful if any of the parameters were much worse than before the introduction. It could also be suspected that the interviewee had a bias towards the success of the solution seeing how he or she is ultimately responsible for the solution's performance.

Goods damage is one of the parameters often highlighted in theory as a problem. Despite this, none of the case companies experienced any difference in goods damage in conjunction to the modal shift, even though many of them transported products quite sensitive to impact. This could mean either that 1) goods damage is less of a problem than the models suggests, or 2) the case companies have put solid effort into the packaging and lashing in order for goods damage not to be a problem. Both explanations can be found in the cases: Arvid Nordquist takes no measure, whereas Volvo Trucks works extensively with lashing. What can be said is that goods damage can be avoided by the right preventive actions which seem to be more of an effort for this mode as compared to road transport.

That environmental performance, as measured in CO_2 emissions, has become much better should be interpreted carefully. What a firm chooses to consider a large improvement is relative, and while for some cases the emissions have decreased significantly as measured in absolute tons, the change is more modest as counted in percent change. However, as compared to theory it is unlikely that emissions would increase with the intermodal solution, something which is clearly seen among the case companies.

From Table 6.11 one can also make some other interesting findings:

- Overall, the quality differences between before and after the implementation are small
- The quality of the solution seem to be heavily dependent on the context, there is no clear bias towards good or bad quality among the cases
- Among the problematic areas, transit time and precision are most prevalent, although not present in all cases, sometimes they are not even a problem

All of these findings on transport quality should be put into relation to the findings on system performance, which is presented in Table 6.12 below.

Table 6.12.Experienced effect on system performance. A= ArvidNordquist, H = Home, I = ITT W&WW, L = Lindex, V=Volvo Trucks

Aspect	**Much Worse**	**Worse**	**No Difference**	**Better**	**Much Better**
Purchasing price			AHV		
Inventory cost		I	AV	H	
Facility/Administration		L	AHIV		
Transportation costs (including cost of goods damage)		V	A	IL	H
Cost of lost sales			AHILV		
Other costs			AHIV		

For none of the cases has the solution led to any service problems neither on the outbound side as measured in cost of lost sales, nor on the inbound side as measure in purchasing price changes. When it comes to purely internal cost measures though, there is a wide spread on experienced performance. It can therefore be concluded that the total cost of an intermodal solution is dependent upon the premises for the solution. This analysis should therefore be made on a case to case basis[23].

In close conjunction with the change to intermodal transport, many of the firms went through other changes. These are not grouped into “before” or “after” changes, since many of the changes are carried out in projects more or less simultaneously with the investigated mode shift. In Table 6.13, these operational and organizational changes are collected. The different changes can be seen as having being long, medium, or short term, and are grouped accordingly.

[23] See sections 6.1 to 6.5

Table 6.13. Collection of operational or organizational changes in conjunction with the mode shift

Operational or organizational change at the goods owners		Arvid Nordquist	Home Retail	ITT W&WW	Lindex	Volvo Trucks
Long term	Move of/new construction of distribution center/central warehouse	X	X		X	
	Installment of new logistics manager/transport buyer		X	X		
	Implementation of new WMS/order management software		X		X	
Medium term	Introduction of back-up solution	X				X
	Change from pallets to parcels				X	
Short term	Increased cooperation with other shippers					X
	Forcing of plants to increase output precision					X
	Increased lashing/packaging efforts	X				X

Three changes were seen in more than one of the cases, and can all be classified as being long-term: the recent change of central warehousing, the implementation of new WMS/order management software, and the installment of new logistics and purchasing management. It should be noted that out of the two case companies not having gone through the centralization process, ITT already had a centralized system since eight years back, as described above. Thus, only Volvo lacked a physical centralization but had, on the other hand, central control through Volvo Logistics. Relating to this, it should be considered likely that centralization enables a shift to intermodal transport by creating the volumes needed, something which is in line with previous findings.

Among the cases, one can also find changes made at the consignor and consignee side of the transport route for the solution to be possible and financially viable. A collection of these are found in Table 6.14 below.

Table 6.14. Collection of changes made at consignor and consignee side of the intermodal solution

Change made		Arvid Nordquist	Home Retail	ITT W&WW	Lindex	Volvo
Consignor	Increase in output precision			X		X
	Increase in planning efforts and administration	X			X	X
Consignee	Increase in cycle inventory	X		X		
	Increase in safety stock			X		
	Extension of delivery windows				X	

Further, in many of the cases, the dedication of a manager or a project team has been crucial to the success of the solution. This suggests that *barriers are still high and the cases suggests that these are both internal (resistance from management or employees) and external (offerings from service providers).* A list of the perceived barriers and how these were overcome is depicted in

Table 6.15. Collection of barriers and how these were overcome

Barrier	Was overcome by
Negative attitudes from within the company	Showing convincing figures
Negative attitudes from suppliers	Information sharing and cooperation
Lack of thermo cars	Introducing back-up solution winter time
Lack of offers from LSP’s	Nagging
Longer lead-times	Communication with customers, safety stock increase
Sensitivity to demand volatility	Cooperation with other shippers

7 Conclusions

In this final chapter we return to our initial research questions and discuss our findings with respect to these. We also form a general discussion around the findings of the thesis and their relation to the overall purpose of the thesis. At the end, suggestions are made for future research.

7.1 Returning to the purpose of the thesis

In the introduction chapter it was concluded that there is a mismatch between the policy-makers' intentions and the actions of the individual firms. The willingness to address the problem of climate change was low among shippers, as many of the measures were perceived as threatening their ability to deliver service in a cost efficient manner and thereby jeopardizing their competitiveness. The same was said to be true for intermodal transport, which has been suggested by both policy-makers and researchers as a possible measure to come to terms with the growing CO_2 emissions caused by transports. It was also shown that there is an interest, but not much action. As one of the reasons might be that no research exists on the actual cost and service effects such a solution have had on a shipper's logistics system, the purpose of this thesis was to *discuss and analyze when, why, and how an intermodal solution has been successfully integrated into a shipper's logistics system and what consequences this has had on the system's performance.*

Let us therefore take a look at the research questions that we posed.

7.2 Conclusions

The first research question was concerned with the context of the solution:

"How and where is intermodal transportation used in shippers' logistics systems?"

It can be concluded from the case studies that no single aspect with regard to "how" and "where" alone is determining the success of an intermodal solution, at least could no such common denominator be found among the studied case companies as both "how's" and "where's" showed a wide spread between the cases. Rather, it was seen, *intermodal transportation works well* *independently of the products and logistics strategy of the shipper*. That is, even if the firm follows a responsive strategy, intermodal transport can be employed successfully, lowering costs and CO_2 emissions, as long as the context with regards to other aspects is close to what is perceived as optimal according to theory. In fact, it was shown that even a time-controlled system may utilize intermodal transport without jeopardizing the service at the consignee. In this setting, however, a back-up solution is still necessary, and one should keep in mind that a too extensive use of a back-up solution will hamper the decrease in total emission from the solution.

Although no "how" or "where" can be deemed as the most optimal, it can be said that an intermodal solution is likely to be implemented without any negative consequences if, currently:

- the shipper is using a 3PL provider to transport the goods, in a non-dedicated fashion
- shipment volumes are large (high utilization) and over a distance that exceeds 500 km
- the flow is in conjunction to one of the intermodal corridors

It should also be noted that the relative competitiveness of an intermodal solution in a specific flow is dependent on the properties of the alternative (truck) solutions for the flow. A flow were truck transports are in a disadvantage through geographical, legal, or other factors, the constraints of minimum distance and volume of the intermodal solution can be relaxed. An example of this is the Lindex case were the inadequate road network and narrow-and-long physical shape of Norway enables the company to run intermodal transports as short as 300 km competitively.

It was also observed that *shippers of consumer goods with low-value-to-weight, and low risk of obsolescence, transported through Europe, benefits significantly from an intermodal solution*. For these products, transport costs are high in comparison to inventory costs seen on a per unit basis. For this reason, a shipper of these types of products benefits from consolidation in time, collecting a large amount of goods and sending it in a single shipment. This was seen in both the case of Home Retail and Arvid Nordquist. Road tolls and fees in central Europe make consolidation of heavy goods impossible if transportation is to be made by means of truck transport, but with an intermodal solution, a much larger amount of goods can be sent *in a single shipment*, increasing inventory costs at consignor and consignee but lowering total costs due to the decrease in transportation costs. In addition to this, we have been able to identify that if the lead-time of a product is already long, a possible increase in lead-time through an increase in transit time may be more acceptable.

Further, it can be concluded that products which are suggested to be inappropriate for any type of rail-bound transport; perishable items (glass jars), goods with news value (fashion), and spare parts (ITT W&WW) can indeed be successfully used in a road-rail solution. The intermodal solution is however sensitive to high volatility because of the high fixed costs, something which was seen to cause a lot of trouble in the case of Volvo Trucks as market demand shrunk dramatically.

The second question concerned the performance tradeoffs:

> *"How are tradeoffs regarding cost, customer service, and CO_2 emissions dealt with in the implementation process?"*

To be able to answer the question we need to first look at the transport quality. Although, in general, transport quality with regards to transit time and delivery precision was somewhat lower, it was evident from the study that the perceived quality of the intermodal solution was not as low as suggested by previous findings. In fact, many of the firms claimed the intermodal solution to be better. This contradicts previous research but could be interpreted in more than one way:

- The initial truck solution was underperforming. This could explain for example the simultaneous increase in almost all quality parameters in the Home Retail case.
- The case companies are rare exceptions with unique circumstances with regards to, for example, geography and consolidation opportunities. This could be the case with the Norway distribution in the Lindex case.
- The findings are in line with theories suggesting that those shippers that use intermodal transport are more positive to this type of solution than those that do not, hence real quality was lower while perceived was high.
- The current prevailing theory is outdated and transport quality has significantly improved since the previous studies were conducted. This could be supported by the fact that intermodal transport has seen a lot of research and improvement over the last few years and supply and demand has increased.

As in most cases, the truth is likely to be a mixture of the points above. It is likely however, that things have actually changed over time and that theory should be updated. This could be supported by the fact that intermodal transport has seen a lot of research and improvement over the last few years and supply and demand has increased simultaneously. From the studied cases, a number of conclusions can be drawn:

The relative quality is more of a carrier selection issue than a mode choice issue. The relationship to the logistics service provider is stressed by most firms as an important success factor. It is clear that quality may vary just as much in between two truck carriers as between a truck carrier and an intermodal carrier. For example, the tile retailer experienced an increase in almost all transport quality measures, something which could in most cases be attributed to the carrier and not the chosen mode of transport. It is the carrier who is ultimately responsible for the quality and the solving of situations when this fails. This will be the case independently of the transport mode.

Transit time and precision must not decrease with the implementation of an intermodal solution. As described above, the common perception among shippers is that transport quality, as measured in transit time or precision, will decrease if the firm shifts to an intermodal solution. It was seen among many of the firms that this is not necessarily the case. The reason for this varies, and to some extent depends on the initial solution, but the point is that one will have to make a thorough assessment before making any assertions. An intermodal solution may, contrary to popular belief, improve system performance.

Tradeoffs tend to be more about purchasing convenience vs. price than transport quality vs. price or customer service vs. cost. In traditional logistics management theory, the major tradeoff a firm has to consider when making decisions is that of customer service vs. cost. That is, offering a higher level of customer service increases logistics costs. For a transportation decision this would be translated to a tradeoff between transport quality vs. transport price. In the studied companies, this was never the major tradeoff. Instead, the major tradeoff was that of purchasing convenience vs. transport price, that is, it was not the performance of the solution that was lacking, but the ease of purchasing and switching.

Process and planning changes may be needed at both consignor and consignee, but their relation to total costs is ambiguous. In many of the cases minor changes had to be made at the consignor and/or consignee side of the solution. For example, in the fashion retail case, the delivery windows had to be expanded, and at the consignor the administration increased. In the baby food distributor case somewhat larger inventories were needed at the consignee side in order to cover for the slightly longer and less reliable transit time. We were not able to judge whether or not these changes affected total costs negatively. In the fashion retail case the small delivery windows turned out to be a service which was not demanded and the expansion was thus not seen as problematic.

Total CO_2 emissions are most likely to decrease when switching from an all-road to an intermodal solution. The five cases reassure the underlying assumption that a shift from all-road to intermodal transport will decrease the amount of CO_2 emissions from the logistics system. The scale of the decrease varies among the companies, from 6-40%, but a decrease is nevertheless shown. The actual amount of the decrease depends on many aspects, with the amount of back-up transport being a major variable.

Lastly, we were interested in:

> *"What changes need to be made in the shipper's logistics system in order for intermodal transport to be economical and possible?"*

In the study, we have been able to observe that the shift to intermodal transport in many cases have been accompanied by other major changes in the logistics system, operationally or organizationally. The changes can sometimes be accredited for supporting the modal shift, as in the case where centralization brings larger, more consolidated volumes to a certain link in the system. They may also be seen as consequences of the modal shift, as in the case of the forcing of supplier plants to increase output precision.

Looking at changes made at the consignor and at the consignee, it can be seen that changes may have to be made with regards to planning and precision increasing efforts at the consignor, and inventory and delivery windows increases at the consignee.

What was also seen among the case companies was that *other, unrelated, major changes in the goods owner's logistics system will facilitate the modal shift*. Among the cases convenience has been shown to be a large barrier; a shift of transport mode, independently of how fruitful it may be in terms of costs or service, is more complicated than a shift in carrier. Many of the firms complain about the low degree of customer orientation from the transport supply side, arguing that more environmentally friendly alternatives are not commonly offered. For this reason, any change that sets aside resources at the shipper will simplify the mode shift, since comfort becomes less of any issue if a person or team is dedicated to the task.

As many barriers exist, internally as well as externally, the findings from the cases suggests that these can be overcome by:

- Dedication – resources must be dedicated to drive the implementation project
- Communication – clear communication and information exchange with employees, customers, and suppliers about the results and quality of the solution in order to avoid negative attitudes

- Cooperation – to reach the right levels of consolidation, cooperation with suppliers, customers, transport providers, and competitors will be important

7.3 Discussion and suggestions for future research

It was stated in the introduction that the thesis was to be written from a shipper, or goods owner perspective. Having performed the study, a number of new questions have arisen and new angles appear as interesting. For one, it would be of interest to apply a supply chain perspective, further and more thoroughly investigating incentive and contract issues as companies strive for more environmentally friendly logistics. How do firms, for example, handle the costs and benefits of an intermodal solution when both control part of the solution?

This thesis has focused exclusively on the shipper perspective, but the modal shift is highly dependent upon other parties. There is still, however, a lock of research of the interrelation between these different actors. Of interest for future research would be to investigate further both the Carrier perspective (customer orientation, information sharing), the Climate policy perspective (removing barriers for capacity flexibility, average speed, and capacity expansion), and the systemic relation these areas will have to the shippers.

It would also be of interest to conduct a number of scenario analyses, investigating the robustness of the solutions under possible future scenarios with regards to increasing carbon taxes, increasing reliability of service or significantly faster lead-times. What would be the effect of such changes and what is the likelihood of them occurring?

As new policies are adopted by legislative bodies around the world, firms are more or less forced to find new ways to innovate their logistics systems in order to decrease environmental impact while at the same time delivering cost efficient customer service. Intermodal transport is just one of many possible solutions. There are plenty of opportunities for interesting research in the area.

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Appendix (In Swedish)

In this chapter the interview guide and the complementary survey are collected.

Intervjuguide för fallföretag

Del 1. Kontextuella faktorer

1. **Bakgrund – marknadssidan**
   a. Vilka marknader anser ni att företaget är aktivt på (geografi/produkt)?
   b. Vad är de främsta kundkraven/ordervinnarna/orderkvalificerarna på dessa marknader?
   c. Vilka kundserviceaspekter efterfrågas från kunderna?
   d. Hur viktigt tolkar ni att ett lågt pris är för era kunder?
   e. Vad är er uppfattning om miljö som säljargument till era kunder? (framför allt CO2-utsläpp)
   f. Finns företagsgemensamma miljömål?
2. **Logistiksystemet utseende**
   a. Är er logistik in-house eller outsourcad?
   b. Vem köper ni transporter av? Vem utför dessa?
   c. I vilka regioner finns era inköpsmarknader, produktionsanläggningar och distributionslager?
   d. Vilka transportsätt använder ni er av, i huvudsak, för att frakta varor och material mellan dessa? (ungefärlig fördelning)
   e. Har ni genomfört några större förändringar i logistiksystemets struktur under de senaste åren? Om ja: vad var anledningen? Har detta påverkat andelen av de olika transportslagen i logistiksystemet?
   f. Vad har varit huvudsakligt fokus för logistikfunktionen den senaste tiden (ex. minska ledtider, sänka kostnader, öka flexibilitet, standardisera etc.)?
   g. Har miljöfrågor lyfts in i beslutsfattandet kring logistiksystemet? Om ja: på vilket sätt?
   h. Hur mäter ni logistiksystemets effektivitet?
   i. Mäter ni, och sätter mål för, CO2-utsläpp i logistiksystemet?
3. **Den intermodala lösningens karaktär**
   a. Mellan vilka geografiska platser använder ni er av intermodala transporter? Mellan vilka platser sker järnvägstransporten?
   b. Vilken del i logistiksystemet motsvarar detta?
   c. Vem är avsändare respektive mottagare?
   d. Vem utför transporterna?
   e. Vad transporteras (vilka varor/komponenter/material)?
   f. Hur ofta sker transport och i vilka volymer?
   g. Använder ni er av parallella lösningar på den sträcka som använder intermodala transporter? Om ja: på vilket sätt och varför?

Del 2. Transportlösningens påverkan på systemet

4. **Hanteringen av tradeoffs vid beslutet**

a. Var införandet av intermodala transporter en del av en större strukturförändring eller endast något som ersatte en annan typ av transporter på en viss sträcka? Anpassades strukturen efter lösningen eller lösningen efter strukturen?
b. Vad var det, i huvudsak, som gjorde att ni valde att använda er av intermodala transporter?
c. Hade några individer extra stor påverkan vid beslutet och i genomförandet?
d. Vilka transportkvalitetsaspekter vägde tyngst vid beslutet?
e. Fanns miljöpåverkan i form av CO_2-utsläpp med som beslutsvariabel? Om ja: hur kvantifierades detta?
f. Vad var er uppfattning om intermodala transporter innan ni valde att använda er av denna transporttyp?
g. Har denna uppfattning förändrats efter införandet?

5. **Transportkvalitet och logistikkostnad före och efter**
   a. På vilket sätt har följande kvalitetsparametrar förändrats i och med införandet av intermodala transporter:
      i. Transporttid
      ii. Leveransprecision
      iii. Spårbarhet under transport
      iv. Godsskador
      v. Övriga parametrar (flexibilitet, tider för hämtning/lämning, bemötande etc.)
   b. Hur har förändringen i dessa parametrar påverkat följande kostnader:
      i. Lagerhållningskostnader för omsättningslager och säkerhetslager?
      ii. Administrativa kostnader?
      iii. Kostnader för packning, hantering och skadat gods?
      iv. Övriga kostnader?
   c. Vad blev skillnaden i transportkostnad?
   d. Hur påverkades lager i båda ändar efter införandet?
   e. Tillkom kostnader som ni inte räknat med? Om ja: vilka och varför?
   f. Om ni mäter miljöprestanda: hur har denna påverkats av lösningen?
   g. Har införandet krävt investeringar i till exempel IT-system eller utrustning?

6. **Kundservice före och efter**
   a. Upplever ni någon skillnad i följande kundserviceparametrar (mot era kunder):
      i. Ledtid
      ii. Servicenivå (lagertillgänglighet)
      iii. Spårbarhet av order
      iv. Mjuka parametrar (kundupplevelse, bemötande, byråkrati etc.)
   b. Har ni använt miljöaspekter i marknadsföring mot kund? Om ja: hur har kunder reagerat på detta?
   c. Vad är den generella uppfattningen,från er och era kunder, om lösningens påverkan på er förmåga att leverera kundservice?
   d. Förbättrades/försämrades några kundserviceparametrar på ett sätt som ni inte hade förutsett? Om ja: vilka och varför?

Del 3. Övriga synpunkter

7. **Era åsikter**

a. Vad anser ni krävs för att kunna införa intermodala transporter på ett lyckat sätt? (produkter, kunder, flödesvolymer, sträckor, geografi etc.)
b. Vad anser ni har varit de avgörande faktorerna för att ni lyckats med införandet? (planering, organisation, investeringar, lagernivåer, IT-stöd, parallell hantering, relationen till transportören, flexibilitet etc.)
c. Vad har varit svårast?
d. Vad anser ni är de största fördelarna med Intermodala Transporter?
e. Vad anser ni är de största nackdelarna?
f. Vad krävs för att ni ska använda transporttypen i större grad i framtiden:
    i. Förändringar i kundkrav och efterfrågan
    ii. Förändringar i kostnader och transportkvalitet
    iii. Förändringar i utbud och säljande företag
    iv. Förändringar i infrastruktur
    v. Förändringar i politiska beslut
    vi. Något ytterligare?
g. Vad tror ni om framtiden för intermodala transporter?

Kompletterande survey

Q.1

Namn?

First Name

Last Name

Q.2

Hur upplever du att följande parametrar påverkats efter införandet av intermodala transporter (jämfört med före införandet)?

	Mycket sämre	Sämre	Ingen skillnad	Bättre	Mycket bättre	Går ej att svara på
Transporttid	☐	☐	☐	☐	☐	☐
Ledtidsprecision	☐	☐	☐	☐	☐	☐
Flexibilitet i avgång	☐	☐	☐	☐	☐	☐
Flexibilitet i ankomst	☐	☐	☐	☐	☐	☐
Spårbarhet	☐	☐	☐	☐	☐	☐
Frekvens i avgång	☐	☐	☐	☐	☐	☐
Miljöpåverkan	☐	☐	☐	☐	☐	☐
Godsskador/hantering	☐	☐	☐	☐	☐	☐
Transportpris	☐	☐	☐	☐	☐	☐
Övriga transportkostnader	☐	☐	☐	☐	☐	☐
Lagerhållningskostnader (kapital i lager)	☐	☐	☐	☐	☐	☐
Kostnader för skadat gods	☐	☐	☐	☐	☐	☐
Administration	☐	☐	☐	☐	☐	☐
Övriga kostnader	☐	☐	☐	☐	☐	☐