Tutkimusraportti *Research Report* 234

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Ville Henttu & Sirpa Multaharju

Transshipment Costs of Intermodal Transport in Finnish Context

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ABSTRACT

Aim of this study is to clarify and estimate transshipment costs that occur, when intermodal loading unit is changed between different transport modes during intermodal transportation. Furthermore, costs of loading an intermodal loading unit are observed and estimated. Transport modes observed in this research report are road and rail transport. Sea and air transport are not taken into account. In some earlier studies the transshipment costs have been taken into account partly, but not on the whole. The transshipment costs have not been researched specifically in Finnish transport network. This creates a need for this research work, which studies these costs in regional aspect.

Literature review includes research articles and research studies about intermodal transport. Furthermore, articles that take transshipment costs under focus are reviewed. Aim of the literature review is to study, how transshipment costs are taken into account, and how they are defined and estimated. Main result of the literature review is that intermodal transport needs certain distance to gain better cost-efficiency than unimodal road transport. Many studies claim that intermodal transport cannot be cost-efficient in short distances. That distance is called break-even point. In addition, statistics mainly concerning rail transit traffic between Finland and Russia are reviewed and discussed.

Aim of the empirical part of this study is to create cost estimations for transshipping intermodal loading units between different transport modes. Empirical part is based mainly on two case companies. Process charts of intermodal transport processes of both case companies are created. Used resources and costs of intermodal transport are studied with help of process charts. Main focus is in transshipment costs, more specifically in terminal costs and costs that occur, when transport mode is changed from road to rail transport and vice versa. In addition, estimations of transshipment costs are calculated based on cost accounting. Furthermore, cost estimation of loading an intermodal loading unit is estimated. Two different scenarios are created for cost estimations. Transshipment costs are estimated for seaport situated company and inland situated company.

Results are based on cost estimations, which have been created based on intermodal processes of two different case companies. Results show that it is more expensive to operate in the seaport area than in seaport's hinterland. Difference in costs of transshipping ILUs can be up to 20 percent more inexpensive in inland located intermodal terminal than in seaport, if ILU is only transshipped. Difference increases to up to 30 percent, if ILU is also loaded in intermodal terminal. Difference is mainly due to salary level differences between inland located and seaport located intermodal terminals. Difference can be decreased by enhancing the level of productivity in seaport located intermodal terminal. By increasing the share of transshipments and loadings in inland intermodal terminal instead of seaport, large cost savings can be achieved.

Keywords: Intermodal transport, transshipment costs, Finnish transit traffic statistics

TIIVISTELMÄ

Tutkimuksen tarkoituksena on selvittää sekä arvioida yhdistetyn kuljetuksen kuljetusmuodon vaihdosta koituvia kustannuksia. Myös intermodaalisen kuljetusyksikön kuormaamisesta koituvia kustannuksia tarkastellaan ja arvioidaan. Tässä työssä keskitytään kumipyörä- sekä raideliikenteeseen. Lento- sekä vesiliikennettä ei ole otettu huomioon. Kuljetusmuodon vaihdosta koituvia kustannuksia on arvioitu muutamissa aiemmissa tutkimuksissa, mutta kaikkia kustannuksia on harvoin otettu huomioon aiemmissa tutkimuksissa. Suomen kuljetusverkoston kustannusrakenteella yhdistetyn kuljetuksen kuljetusmuodon vaihdosta koituvia kustannuksia ei ole aiemmin tutkittu. Tästä syntyy tarve tälle tutkimukselle.

Kirjallisuuskatsauksen kohteena ovat yhdistetyt kuljetukset sekä yhdistettyjen kuljetusten kuljetusmuodon vaihdosta koituvat kustannukset. Katsauksen tarkoituksena on selvittää, miten kuljetusmuodon vaihdosta koituvia kustannuksia on tutkittu, sekä miten kustannusten määrää on arvioitu. Kirjallisuuskatsauksen mukaan intermodaalinen kuljetus vaatii tietyn etäisyyden, jotta sen on mahdollista olla kustannustehokkaampi kuljetusmuoto kuin kumipyöräkuljetus. Useiden tutkimusten perusteella intermodaalinen kuljetus ei voi olla kustannustehokas muoto lyhyillä etäisyyksillä. Kirjallisuuskatsauksen lopussa on katsaus Suomen ja Venäjän välisen transito-liikenteen tilastoihin keskittyen pääosassa raideliikenteeseen.

Empiirisen osan tavoitteena on kehittää kustannusarvioita kuljetusmuodon vaihdosta koituvista kustannuksista. Tutkimuksen empiirinen osa perustuu pääosin kahteen case-yritykseen. Tapaus-yritysten yhdistetyn kuljetuksen prosesseista on kuvattu prosessikaaviot empiirisen osan alussa. Kaavioiden avulla on selvitetty yritysten käyttämät resurssit kuljetusmuodon vaihdon yhteydessä. Näiden avulla tutkitaan sekä määritellään, mistä terminaalikustannukset sekä kuljetusmuodon vaihdosta koituvat kustannukset muodostuvat. Lopuksi empiirisessä osassa lasketaan arviot kuljetusmuodon vaihdosta koituville kustannuksille kustannuslaskennan avulla. Lisäksi on arvioitu kustannuksia, jos mukaan otetaan intermodaalisen kuljetusyksikön kuormaaminen. Kustannusarvioille on muodostettu kaksi erilaista skenaariota. Kustannukset on arvioitu erikseen satamassa toimivalle yritykselle sekä sisämaassa toimivalle yritykselle.

Tutkimuksen tulokset ovat kustannusarvioita, jotka perustuvat kahden case-yrityksen intermodaalisen kuljetuksen prosesseihin. Tuloksena on, että kuljetusmuodon vaihdosta koituvat kustannukset ovat suurempia satama-alueella sijaitsevassa intermodaalisessa terminaalissa kuin sisämaassa sijaitsevassa terminaalissa. Kuljetusmuodon vaihdosta koituvat kustannukset voivat olla 20 prosenttia pienemmät sisämaan intermodaalisessa terminaalissa. Ero nousee noin 30 prosenttiyksikköön, jos intermodaalinen kuljetusyksikkö myös lastataan. Ero selittyy pääosin sisämaan intermodaalisen terminaalin pienemmillä palkkakustannuksilla. Ero pienenee, jos satama-alueella oleva toimija kykenee parantamaan tuottavuuttaan. Suuret kustannussäästöt ovat mahdollisia, jos kuljetusmuodon vaihtoja sekä lastauksia toteutetaan enemmin sisämaassa.

Avainsanat: Yhdistetyt kuljetukset, kuljetusmuodon vaihdosta koituvat kustannukset, Suomen transito-liikenteen statistiikka

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1 INTRODUCTION

European Union aims at increasing intermodal transport (European Commission, 2001a; European Communities, 2009). Road transport can be decreased by increasing the amount of intermodal transport. Environmental impacts of transportation sector can be decreased from current situation by decreasing use of road transport, which is the major source of pollution originating from transportation (UIC, 2009). Rail transport emits much less than road transport at same distances (LIPASTO, 2009). Another driver in addition to decreasing environmental impacts is that Russia has proposed switching 20' and larger containers completely from road transportation to rail and sea (Tekniikka&Talous, 2009). The transfer of containers from road to rail is the target of both Finland and Russia in the long-term plan (Tekniikka&Talous, 2009). This study focuses in costs of intermodal transport, in particular costs of transshipping intermodal loading unit (ILU) from one transport mode to another.

If rail transport is used, then also another transport mode has to be used for the initial or final leg of transport. In many cases initial and final legs of intermodal transport are accomplished by road transport, because road transport reaches consignee or consigner best if compared to other transport modes, because road transportation network is so extensive if compared e.g. to rail transportation network. Different transport modes than road transport can rarely be used for first or final leg of intermodal transport. Aim of this research is to estimate costs of transshipping an intermodal loading unit from one transport mode to another (road and rail transport modes are observed in this report). Furthermore, costs of loading an empty container are studied briefly, because it is part of case companies' intermodal process in intermodal terminal. Purpose of this study is to allow better understanding of full costs of intermodal transport.

Intermodal transport is transport of intermodal loading unit (ILU) with at least two different transport modes. The ILU stays untouched during the intermodal transportation. Intermodal transport is researched to be environmentally friendlier mode of transport than conventional road transport, because it uses mainly environmentally friendlier transport modes (e.g. rail or sea transport) than road transport as the main transport mode for the whole intermodal transport chain. Intermodal transport includes more different variable and fixed costs than unimodal road transport, because at least one transshipment takes place in intermodal transport, and because more than one transport modes are utilized during the transportation of ILUs. In many cases there are more than two different transport modes utilized during transportation. Intermodal transport includes various costs that occur at intermodal terminals e.g. salary costs of employees, rental costs of warehouses and storage areas and rental costs of lifting and moving machines e.g. cranes or container movers. Aim of this research is to calculate and estimate total costs of intermodal transport by defining and estimating transshipment costs. (Henttu et al., 2010; Hayuth, 1987; Rutten, 1998; Slack, 1996; Woxenius 1998)

1.1 Mobile Port Project

This research report is part of Mobile Port project in which Lappeenranta University of Technology Kouvola Unit (LUT Kouvola) is part of. The main goal of the Mobile Port project is to create an information system and research how to implement it to seaport dependent transport system. Furthermore, possible information systems used in large scale seaports are researched. LUT Kouvola is one of three different research parties. The other two are Centre for Maritime Studies, University of Turku and Kymenlaakso University of Applied Sciences. Centre for Maritime Studies is the coordinating research party for Mobile Port project. Financiers of the Mobile Port project are Tekes (the Finnish Funding Agency for Technology and Innovation), European Regional Development Fund, Cursor Oy, Port of HaminaKotka, Kymp Oy, Se Mäkinen Logistics Oy, Steveco Oy, CCC Oy, TransPeltola Oy and VR Oy. Aim of LUT Kouvola is to study the dry port concept i.e. benefits and disadvantages of it and could it be implemented cost-efficiently in the Kymenlaakso region, more specifically in the city of Kouvola. One main focus is to research environmental impacts of the dry port concept, since increasing environmental friendliness of transportation sector is one target of EU (European Commission, 2001a; European Communities, 2009). LUT Kouvola has finished its first research report for the Mobile Port project (see: Henttu et al., 2010) in summer 2010, and it concerned literature review about dry port concept and possibility of the concept to be used in city of Kouvola to support ports of

Hamina and Kotka. These ports have merged during writing process of this research report in spring in year 2011 (Port of Kotka, 2010). In addition, road and rail transport modes were compared by cost accounting. Both the internal and main external costs (external costs included are carbon dioxide, noise, accidents and congestion) were included. Cost estimations were created for both transport modes in costs per kilometer and costs per ton-kilometer. Different gravitational models were also created to compare the location of Kouvola with other city locations to find out whether or not city of Kouvola is in good location for a dry port implementation. Title of the first research report is "*Financial and Environmental Impacts of a Dry Port to Support Two Major Finnish Seaports"* and it can be found from different sources e.g.: Merikotka (2011) or LUT Kouvola (2011). Second research report created by LUT Kouvola (see: Henttu, 2011) was published in January 2011, and its title is "*Regional Survey Study from Dry Port Concept in South-East Finland"*. That research was a follow-up for the first dry port research. It aimed at explaining the opinions of logistics companies about dry port concept, intermodal transport, green values of transportation sector and information systems and also to find out, if there are more advantages or disadvantages in the concept than that was found in the first research report's literature review. In addition, the second research report studied the most important export and import cities and seaports for the respondent companies.

This research report is third and final research report of LUT Kouvola in the Mobile Port project. In the first research report (Henttu et al., 2010) LUT Kouvola studied costs of rail and road transport to compare these transport modes. The comparison was not totally realistic in the first research report, because rail transport lacked total costs of intermodal transportation including transshipment costs between rail and road or sea transport. Rail transport needs almost always at least one or two transshipment between different transport modes, because road transport is needed for the initial or final leg of transport. This research report aims at defining and estimating transshipment costs of intermodal transport, more specifically transshipment between road and rail transport. By researching this, comparison between unimodal road transport and intermodal transport is more accurate and it can be used as decision support, when choosing between unimodal road transport and intermodal transport.

1.2 Research Problem and Limitations

Aim of this research is to define different costs occurring during transshipments in intermodal transport. Furthermore, costs of transshipping ILUs e.g. containers or semi-trailers from one transport mode (two different modes used in this report are road and rail transport) to other is defined. In addition, transshipment processes are divided into smaller parts to enable more acute cost estimations. Main goal of this study is to create cost estimations of transshipping ILUs between different transport modes. Main research question is:

- What are total costs of transshipping intermodal loading unit during intermodal transport?

Main research question can be further divided into smaller sub-questions:

- What different resources are used in transshipment process?
- What costs take place in intermodal terminals?
- What costs take place, when changing transport mode of ILU between road and rail transport?
- What are cost estimations for changing transport mode between road and rail transport?
- Are there differences in cost estimations, if transshipments take place in seaport area or in hinterland of seaport?

One limitation in this study is that it takes into account only intermodal transport. ILUs discussed in this research report are containers or semi-trailers. Furthermore, transshipment between road and rail transport is considered in this research report. In addition, transshipping between same transport mode is researched e.g. between rail and rail. Transshipments between sea and road transport and sea and rail transport are not taken into account, although estimations calculated in this research can with some extend be used with mentioned transshipments, because there are many similarities between inland intermodal terminals and seaports. Main geographical scope of this research is Finland, which means that results of this study are for Finnish intermodal transport. In other countries or geographical areas these costs might vary due to e.g.

different salary levels, rental costs etc., but calculations made in this research can be used in other countries than Finland with certain caution. Environmental costs of transshipment are not taken into account, because there is only little estimation about environmental costs about transshipments between different transport modes in literature review.

1.3 Structure of the Report

Structure of this research report is as follows: Chapter 1 is the Introduction Chapter. Literature review is divided into two different Chapters, and they are Chapters 2 and 3. Chapter 2 is about a literature review of intermodal transport. Furthermore, this Chapter includes literature review about costs of intermodal transport on the whole, and costs of transshipments in intermodal transport. Chapter 3 is about transit traffic statistics in Finland. Chapter 3 mainly focuses in rail transport mode. Methodologies and data gathering are clarified in Chapter 4. Results of this study are presented in Chapter 5. The results include process charts about two Finnish logistics case companies. Process charts illustrate case companies' intermodal processes. In addition, cost estimations of transshipping ILUs in intermodal transportation is presented in Chapter 5. Final Chapter 6 summarizes conclusions of this research report.

2 INTERMODAL TRANSPORT

The definition of intermodal transport has been widely discussed by several authors (see e.g. Hayuth, 1987; Rutten, 1998; Slack, 1996; Woxenius 1998). Rutten (1998) has defined intermodal transport as transport of goods in ILUs which can be transshipped between different transport modes (e.g. road, rail, inland shipping, short-sea shipping, deep-sea shipping and air). At least two different transport modes are utilized during transportation of freight. Therefore, one or more transshipments take place between consignor and consignee. The main haulage is not carried out by road, but by rail or water. Road transportation is only used for the initial and final legs of the freight movement (Ricci & Black, 2005). Contents of an ILU must stay untouched during the shipping. The ability of carriers to provide the shipper with one bill of lading is also a crucial element of intermodal transport (Hayuth, 1987). Figure 1 is a simplified example of unimodal road transport and intermodal transport with road and rail transport modes. In the left of Figure 1 only road transport is used, whereas in the right transport between hubs A and B is accomplished by rail. Initial and final legs of intermodal transport are accomplished by road.

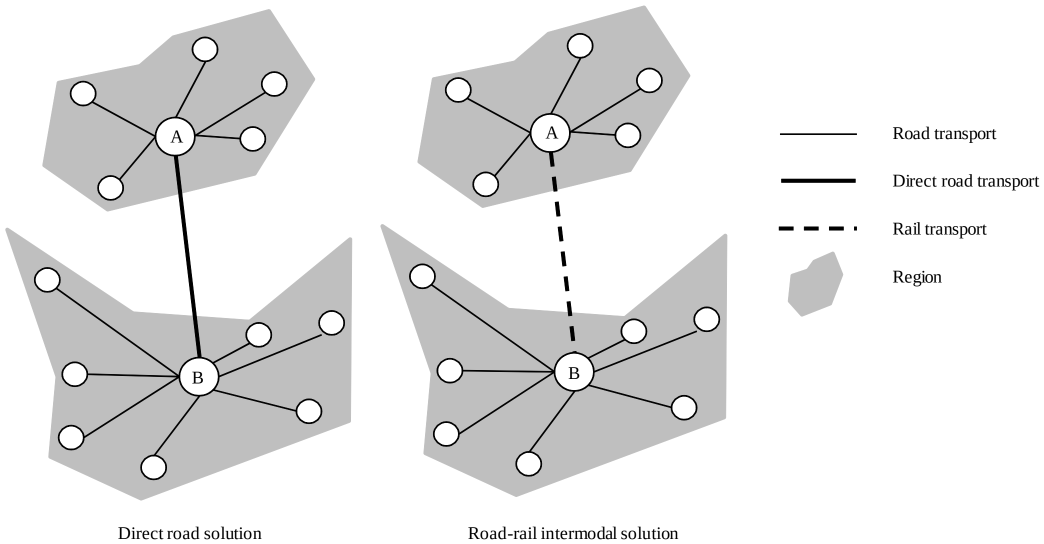


Figure 1 Visualization of direct road solution and road-rail intermodal solution (Adapted from Bergqvist, 2008)

It seems that transportation network in Figure 1 above is very similar when using either direct road solution or road-rail intermodal solution. Usually intermodal transport is much more complex to organize than conventional road transport. Main reasons for this are increased number of actors in the intermodal transportation network and increased number of transport modes. In addition, intermodal terminals during intermodal transport increase the complexity of the transportation network. Figure 2 below illustrates intermodal transport more specifically.

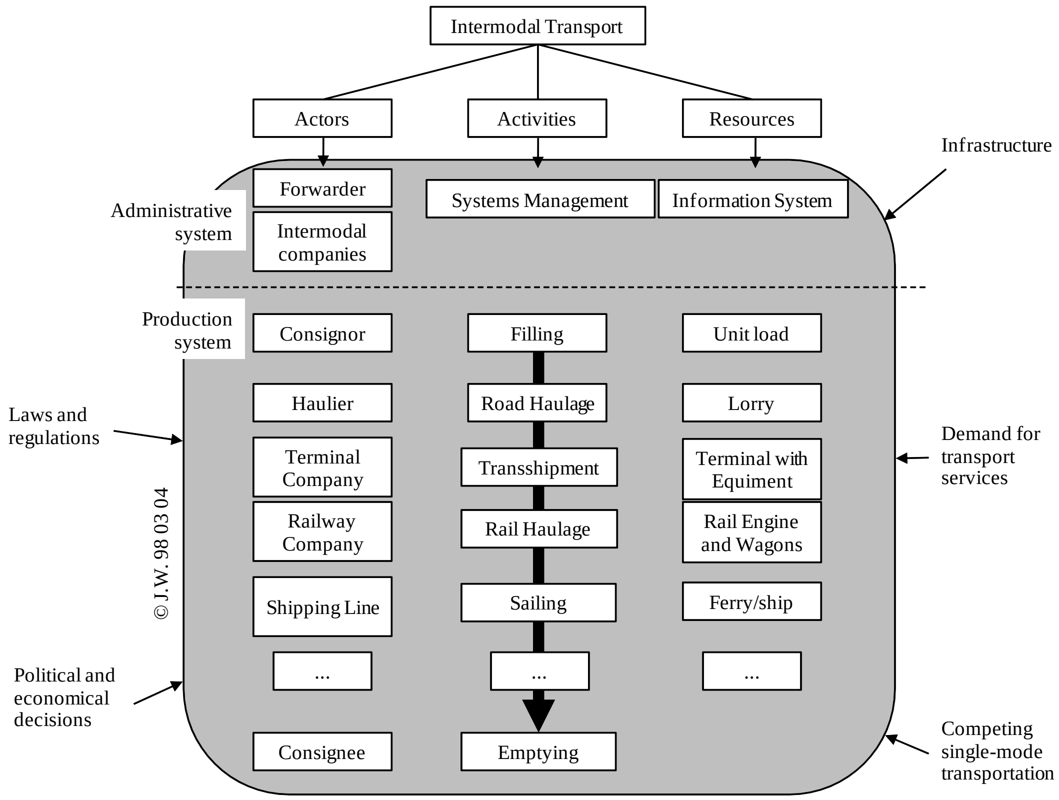


Figure 2 A reference model of intermodal transport (Adapted from Woxenius, 1998)

As can be seen from Figure 2, there are many different actors, activities and resources in intermodal transport, especially if compared to unimodal road transport, in which there can be only one actor in some situations. According to earlier survey study research on Mobile Port by LUT Kouvola (see: Henttu, 2011), many Finnish logistics companies assume that intermodal transport is more complex to organize than conventional road transport. In addition, companies believed that information flow management can become more complex, when utilizing information management in intermodal transport. Both arguments made by companies in survey seem obvious, if observing Figure 2 above, because the number of actors, activities and used resources can grow very large, especially if intermodal transport is compared with traditional unimodal road transport. According to Woxenius (1998), even in the simplest intermodal transportation with two different transport modes (e.g. road and rail transport) utilized, number of actors rise at least up to six to eight different actors, which could be e.g.:

- Forwarder
- Consignor
- Hauler
- Terminal company
- Railway company
- Terminal company
- Hauler
- Consignee

If more than two different transport modes and intermodal terminals are used during the intermodal transport, then the number of actors increase further. The simplest unimodal road transport activity can consist of only three different actors:

- Consignor
- Hauler
- Consignee

In the same way as the number of actors in intermodal transport increase, the number of activities and used resources increase. Although intermodal transport is environmentally friendlier mode of transport, companies have to be careful, when utilizing intermodal transport to gain benefits in cost-efficiencies against conventional road transport.

The most commonly used ILUs (intermodal loading units) are containers, swap bodies and semi-trailers. A container is a simple steel box with standardized measures, construction strength and fastening devices. A swap body is a detachable lorry equipped with support-legs and a semi-trailer is a lorry trailer with rear wheels (Woxenius, 1998). Containers are the most commonly used standard units for unit-load concept as they are designed for easy and fast handling of freight (Vasiliauskas & Barysiené, 2008). Weakness of semi-trailers and swap bodies is that they are more difficult to handle than containers. Semi-trailers and swap bodies cannot be piled on top of each other, whereas containers can be piled i.e. semi-trailers and swap bodies need more space. Weakness of containers is that containers always need certain machines (e.g. container movers and container reachstackers) to be transshipped between different transport modes. Figure 3 illustrates distribution of different types of ILUs used in Finnish transportation network.

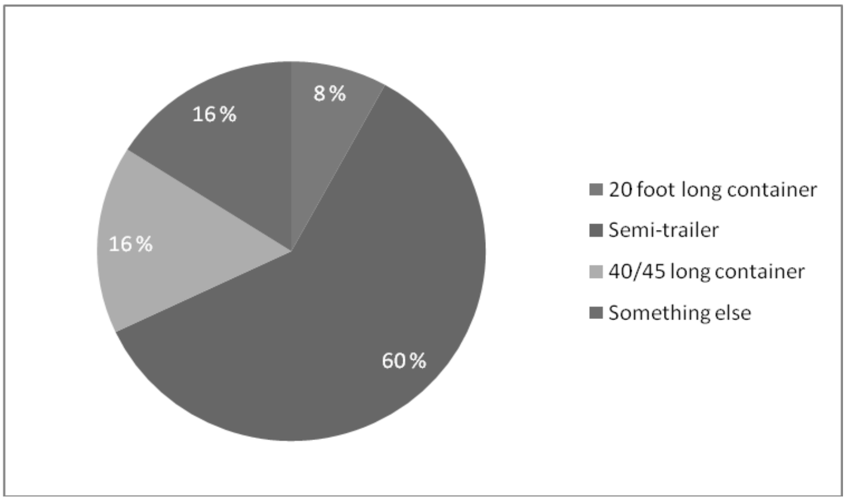


Figure 3 Container types in year 2010 according to a questionnaire research (Adapted from Sutela & Hilmola, 2010)

Figure 3 shows that semi-trailers are the most used ILUs (60 percent of respondents use semi-trailers as their main ILUs) in Finnish and Swedish transportation networks among respondents in the questionnaire (see: Sutela & Hilmola, 2010). Only about 25 percent of respondents use either 20, 40 or 45 feet long containers as their main ILUs. According to Koskinen et al. (2009), noncontainerized intermodal transport is usually industry-based concerning e.g. paper industry, which has been one of the major industries in Finland.

Containers are the most used ILUs in many geographical areas (Vasiliauskas & Barysiené, 2008), but in Finland semi-trailer is the most used ILU. Later in empirical part, created process charts do not include semi-trailers, because case companies used mostly containers as their ILUs. With containerization, transshipment time at the intermodal node is reduced due to simpler and faster handling. There is no need for stuffing and stripping at the intermodal node. Stuffing takes place before initial leg of intermodal transport, and stripping takes place after the final leg of intermodal transport. Damage to goods and packaging costs are also reduced since the packaging and disposal are eliminated at the intermodal node (Roso, 2009).

Transshipments of ILUs between different transport modes in intermodal transport take place at intermodal terminals. Such terminals can be located inland or at coastline, where seaports are usually used as intermodal terminals that have access to sea transport mode. There are many definitions and terms for an inland intermodal terminal (e.g. UN ECE, 1998; Harrison et al., 2002). UN ECE (1998), for example, has defined the inland intermodal terminal as an Inland Clearance Depot (ICD). Shapes and ranges of inland intermodal terminals differ greatly (Woxenius, 1998). The development of the inland intermodal terminal in the hinterland is aimed at contributing to a modal shift from road transport to rail and vice versa, and that is the characterizing activity for inland intermodal terminal. Inland intermodal terminal makes transshipments of freight or passengers between road and rail transport possible. Inland intermodal terminal is a facility that is equipped for the transshipment and storage of ILUs between road and rail. Inland intermodal terminals have access at least to both the road and rail network. In addition, they may have access to other transport modes such as air or inland waterways. Inland intermodal terminal can be regarded as an inland situated node in a network that improves the connectivity of the origins and destinations in a supply chain. The quality of an inland intermodal terminal can be measured by its throughput rate (Gambardella et al., 2002). Modern intermodal facilities, such as inland intermodal terminals, are one of the most space needed users of land, since they need a lot of land area for warehousing of ILUs (Slack, 1999).

A specific type of intermodal terminals has advanced around the need for connecting seaports to inland intermodal terminals (Roso, 2009). These inland intermodal terminals are in many cases called dry ports (Roso, 2009). An ideal inland intermodal terminal transfers a part of the activities inland away from the seaport, thus preventing a further overcrowding of limited seaport area i.e. these activities will not be performed again at seaport (Notteboom & Rodrigue, 2005). In a dry port concept the inland intermodal terminals offer other services in addition to transshipment and storage of load-units. The possible services are listed below:

- Consolidation
- Warehousing
- Depot
- Maintenance of containers
- Customs clearance
- Tracing and tracking of containers (Roso, 2007)

It is possible that an inland intermodal terminal has all the above services or only some of them. As it was stated earlier in this sub-chapter, the characterizing activity of an inland intermodal terminal is its ability of transshipment between different transport modes. Inland intermodal terminal that acts as a dry port has additional services in addition to transshipments between different transport modes. (Roso, 2007)

2.1 Costs of Intermodal Transport

Intermodal transportation consists of at least two different transport modes and transshipments between transport modes. There are many different actors that are part of intermodal transport (see: Figure 2 in sub-chapter 2.1). Main difference between intermodal transport and unimodal road transport is that unimodal road transport uses road transport for the whole transportation chain, whereas intermodal transport uses at least two different transport modes. Unimodal road transport can be accomplished by only one road transportation company or many different road transport companies. In many cases there are more than two different transport modes used, when intermodal transport is utilized and same transport modes can be used again later in the same intermodal transport chain. Another difference is that in intermodal transport the contents of ILU stays untouched during transportation (Hayuth, 1987; Rutten, 1998; Slack, 1996; Woxenius 1998), whereas in unimodal road transport contents can be divided or combined during transportation. Costs of intermodal transport are composed of moving freight geographically between e.g. two different cities or continents, and of transshipping freight from one transport mode to another e.g. from rail to road transport mode (Macharis et al., 2010; Macharis & Bontekoning, 2004).

Intermodal transport is often seen as an alternative competitive transport mode for unimodal road transport. Decisive factor for decision maker is often break-even point between intermodal transport and unimodal road transport (another possible decisive factor is environmental friendliness of intermodal transport if compared to conventional road transport). The break-even point is a distance, after what intermodal transport becomes more cost-efficient than road transport i.e. intermodal transport is more inexpensive at distances longer than break-even point. Unimodal road transport is more inexpensive at distances shorter than break-even point. Intermodal transport and unimodal road transport are as expensive in the break-even point. The break-even point is simplified in Figure 4. (Macharis et al., 2010)

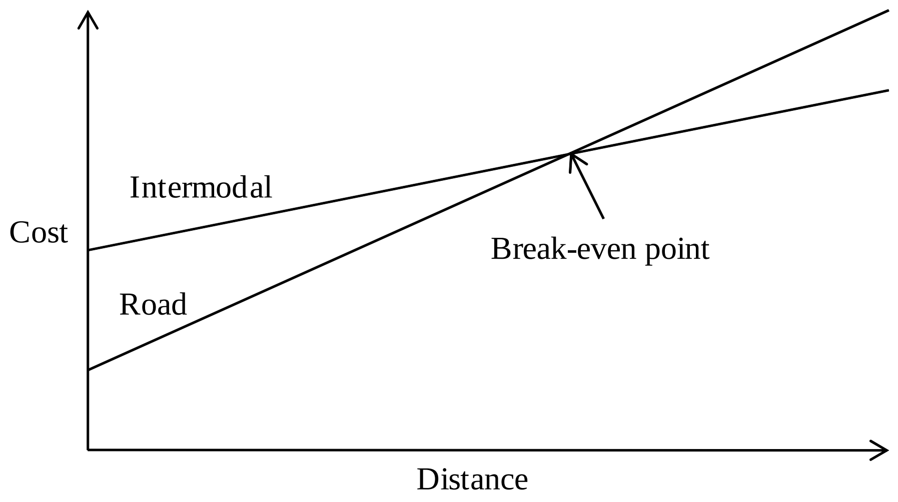


Figure 4 Demonstration of break-even point between unimodal road transport and intermodal transport (Adapted from Macharis et al., 2010)

As Figure 4 shows, unimodal road transport is more inexpensive mode of transport than intermodal transport at short distances (shorter than break-even distance). Reason is, that intermodal transport utilizes always at least two different transport modes (e.g. road, rail, sea and air transport). In current transportation structure it is cheaper to use only one transport mode than more transport modes at short distances, because transshipments between different transport modes increase total costs of intermodal transport, especially at short distances. In addition, different terminal costs at short distances increase costs percentually more than at long distances. Furthermore, short road transport distances in start and end of intermodal transport can be expensive in terms of costs per kilometer due to very short transport. After intermodal transport and unimodal road transport reach their shared break-even point, intermodal transport becomes more inexpensive mode of transport than unimodal road transport. Break-even point for environmental impacts can be achieved with very short distance, because road transport emits more than rail transport. By increasing distance after break-even point, the difference in total transport costs between intermodal transport and unimodal transport grows larger i.e. intermodal transport is more cost-efficient than unimodal road transport in long distances and the cost-efficiency can be increased by increasing total distance of intermodal transport between consignor and consignee (Arnold et al., 2004). Figure 5 below demonstrates cost differences between unimodal road transport and intermodal rail transport more specifically when increasing distance than previous Figure 4. (Arnold et al., 2004)

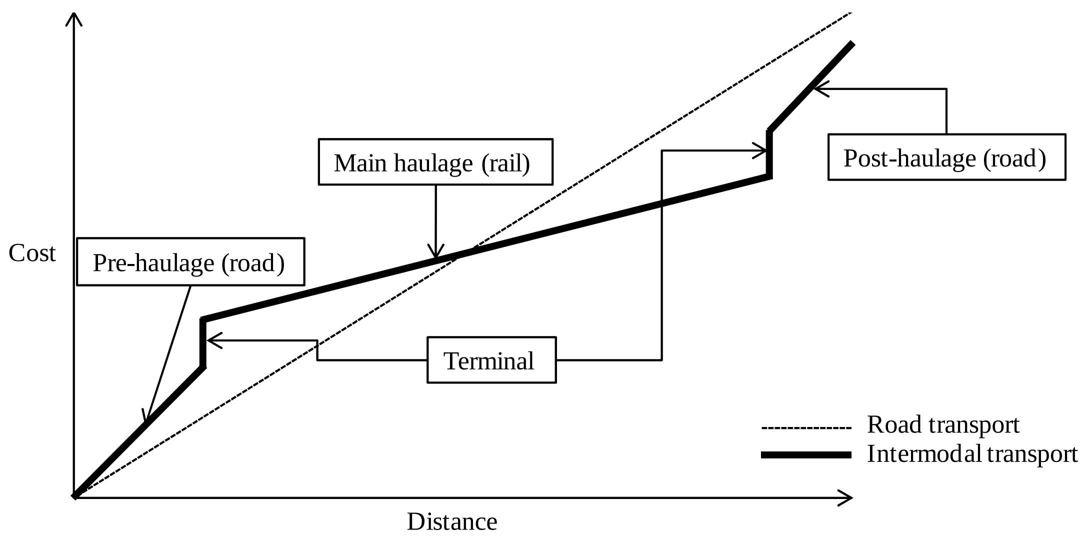


Figure 5 Cost structure of intermodal transport (Adapted from Rutten, 1998)

Pre-haulage and post-haulage in intermodal transport by road are usually relatively expensive, because initial and final legs are relatively short due to rail, sea or air being the main transport mode of intermodal transport. Costs per ton-kilometer can usually be decreased by increasing distance of transportation. Costs occurring at intermodal terminals increase costs of intermodal transport. One main cost at intermodal terminals is the transshipment cost. Transshipment costs are about changing ILU from one transport mode to another to be ready for transportation. Freight does not move geographically during transshipments. Main haulage of intermodal transport per distance or per ton-kilometer is more inexpensive than unimodal road transport, but main haulage has to be distant enough for total intermodal transport to gain better cost-efficiency in comparison with unimodal road transport. In addition, there are terminal costs including transshipment costs and post-haulage costs in the end of intermodal transport. It also has to be noted that there can be more than two different transport modes in intermodal transport. In these cases there are more transshipment costs and terminal costs during the whole intermodal transport. Example illustrated in Figure 5 utilized only two different transport modes. Road transport for pre-haulage and post-haulage and rail transport for main haulage. Figure 5 illustrates that intermodal transport includes more different cost categories than unimodal road transport, and number of cost categories increase if number of transport modes increase. Intermodal transport in Figure 5 consists of pre-haulage costs, terminal costs, main haulage costs, terminal costs and post-haulage costs. Furthermore, intermodal transport can consist of increased costs categories, if more transport modes and transshipments take place during the whole intermodal transport chain. Unimodal road transport instead consists only from road transport. In addition, operating unimodal road transport is more straightforward than intermodal transport, which gets more complicated if transport modes are added even more. (Rutten, 1998)

As can be seen from Figures 4 and 5, price of intermodal transport consists of four main elements:

- Price of pre-haulage
- Price of terminal handlings in intermodal terminals
- Price of main haulage
- Price of post-haulage

By summing all mentioned costs, total costs of intermodal transport can be calculated i.e.:

Price of intermodal transport = Price of pre/post haulage by road transport + Price of terminal handling in intermodal terminals + Price of main haulage by rail transport (Macharis et al., 2010)

Handling of the freight at intermodal terminals and initial and final haulage of intermodal transport play an important role, whether or not intermodal transport is cost-efficient mode if compared to unimodal road transport i.e. cost savings in transshipments and initial and final legs of transport can increase the cost-efficiency of intermodal transport considerable. Importance grows larger by shorter distances, because by shorter distances costs from handling freight and costs of initial and final haulage play larger role in total costs of intermodal transport. By decreasing costs of transshipments and initial and final legs of intermodal transport, the break-even point between intermodal transport and road transport can be decreased. (Konings, 1996)

In his study, Kreutzberger (2008) has divided costs of intermodal transport into direct and indirect costs. Direct costs are e.g. vehicle costs. Indirect costs are about transport quality. They increase if quality of transport for customer decreases e.g. in time of deliver. In this study intermodal transport is divided into smaller processes or parts to achieve better possibility to estimate costs of intermodal transport. Different processes are based on literature review. Different possible processes of intermodal transport are listed below (Groothedde et al., 2005; Janic, 2007; Macharis et al., 2010; Ricci & Black, 2005; Woxenius, 1998):

- Loading of ILUs
- Initial haulage (usually accomplished by road transport)
- Transshipment (e.g. from road to rail or sea transport)
- Terminal transfer
- Marshalling yard transfer
- Main haulage (usually rail, sea or air transport)
- Marshalling Yard Transfer
- Terminal transfer
- Transshipment (back to road transport)
- Final haulage
- Unloading of ILUs (Groothedde et al., 2005; Janic, 2007; Ricci & Black, 2005; Woxenius, 1998)

Processes listed above are the main processes that take place during intermodal transport. List of processes can be longer in real-life intermodal transport, if more transport modes are deployed. In those cases same processes are utilized more than one or two times. In addition, it is possible that same transport modes are used more than one or two times during the whole intermodal chain. Main aim of this research report is to focus on transshipments and costs about them. In addition, loading costs of ILUs are studied, because case company A uses loading of ILUs in their intermodal transport operations. Case company A first loads ILUs and then transships them to rail wagons.

Costs that take place, when transshipping ILUs between different transport modes are various. Different possible costs are listed below (Groothedde et al., 2005; Ricci & Black, 2005; Janic, 2007):

Possible costs that occur during transshipment process:

- Personnel costs
- Fixed assets and maintenance of assets
- Energy costs
- Stock turn costs
- Time costs
- Organization costs
- Insurance, tax and charge costs (Groothedde et al., 2005; Ricci & Black, 2005; Janic, 2007)

Different possible transshipment costs can be further divided into different more specific costs such as:

- Loading/unloading ship/rail/truck
- Rental or purchase costs of machines
    - Container mover
    - Container reachstacker
- Rental or purchase costs of warehouses or storage areas
- Salary costs
    - Supervisor
    - Terminal worker
    - Machine user (Groothedde et al., 2005; Ricci & Black, 2005; Janic, 2007)

Costs listed below are the main costs studied in the empirical part of this research report. These are the main costs of transshipments during intermodal transportation, and by estimating these costs it is possible to create accurate cost estimations concerning transshipments at Finnish transportation environment.

2.2 Similar Research Studies

Some research studies concerning costs of intermodal transport are reviewed in this sub-chapter. There are not many different research studies, which focus on full costs of intermodal transport. In many cases, costs of transshipping ILUs between different transport modes are estimated not based on real costs or not based on research.

Macharis et al. (2010) have compared unimodal road transport and intermodal transport with simulation model they created. Aim of their model was to study development in costs of both transport modes (conventional road transport and intermodal transport) between three different scenarios about fuel price. Fuel price rises in each scenario with different speed. Macharis et al. (2010) found out that intermodal transport increases its market share, if fuel price increases. The larger the fuel price increase, the more intermodal transport increases its market share. It has to be noted, that first and final leg of door-to-door intermodal transport's costs increase as the fuel price increases, because first and final legs are transported by road transport. By minimizing distance of initial and final legs, intermodal transport becomes more attractive, because consumption of fuel is minimized. In their study, Macharis et al. (2010) estimated costs of electrified rail transport. If diesel locomotives would have been used, then intermodal transport would not have been as attractive mode of transport between different scenarios as electrified locomotives were. However, diesel locomotives were more attractive than conventional road transport. Increases in fuel prices weaken competitiveness of unimodal transport in comparison with intermodal transport due to source of energy of different intermodal transport modes (e.g. rail transport's energy source in Europe is mainly electricity) (Macharis et al., 2010). In their study, Macharis et al. (2010) found out that the price of electricity in Belgium is less volatile than the price of crude oil i.e. electric trains can possibly increase their competitiveness against road transport. 83 percent of trainkilometers were carried out by electric trains in Finnish rail network in year 2008 (VR Group, 2010).

Ballis and Golias (2004) have created models that estimate transshipment costs occurring from intermodal transport. They created different models for different settings. Differences between models are e.g. number of loading units handled per day or quantity of usable cranes at intermodal terminals. Minimum costs they calculated are about 30 € per one loading unit. Maximum costs per one loading unit is somewhere between 50 to 60 € depending on how many loading units are transshipped during the whole process. Their models include investment costs about e.g. terminal buildings, whereas real market price of transshipping ILU between different transport modes usually does not take investment costs into account. Ballis and Golias (2004) remind that in real-life accepted prices are almost always about 50 percent cheaper, because their model takes investment costs into account. Many terminals and operators take only operating costs into account in their pricing system. Infrastructure is considered as “heritage” from the era of the state-owned railways, and it might skew costs under their real level.

Groothedde et al. (2005) estimated in their calculations that transshipments account for about 25-35 percent of the total transport costs of intermodal transport. Percentual amount of transshipment costs depends on the distance of intermodal transport and the number of transshipments during transportation.

In his research, Janic (2007) has created a model to estimate total costs of intermodal transport and unimodal road transport in freight transportation network. Aim of the work is to compare full costs of intermodal transport and road transport. In his model, Janic (2007) has used estimation for transshipment cost of 40 € per load. His estimation is based on calculations made by Ballis and Golias (2002) and European Commission (2001b).

3 LONGITUDINAL ANALYSIS OF FINNISH RAILWAY TRANSIT

Transit traffic is defined as transportation between two countries via third one. Transit goods are transported through transit country under its customs' control. (Widgren et al., 2000)

Finland is considered as a Gateway to Russia. To this are affected some issues such as the geographical position of Finland with shared borderline of 1,200 km with Russia, equal rail gauge (in Finland 1,524 mm, in Russia 1,520 mm; therefore bogie changing or reloading of wagons are not needed at border), long-lasting cooperation between Finnish and Russian Railways (bilateral agreement of connecting railway traffic) as well as safety and punctuality of Finnish sea ports to handle transit goods. (Sundberg et al., 2010)

Finnish Railways categorizes its international transportation to eastern, western and transit traffic (VR Group, 2011b). Finnish eastern transportation is either import from Russia or export to Russia. Finnish transit traffic is classified into westbound and eastbound traffic. As a whole, it can be noted that streams of goods through the Finnish-Russian borders by rail are much bigger westbound than eastbound (National Board of Customs, 2011a).

According to Figure 6, there are altogether five rail border stations in Finland, of which four are to Russia and one is to Sweden. In addition, there is a train-ferry connection from Turku to Stockholm and further to Scandinavia.

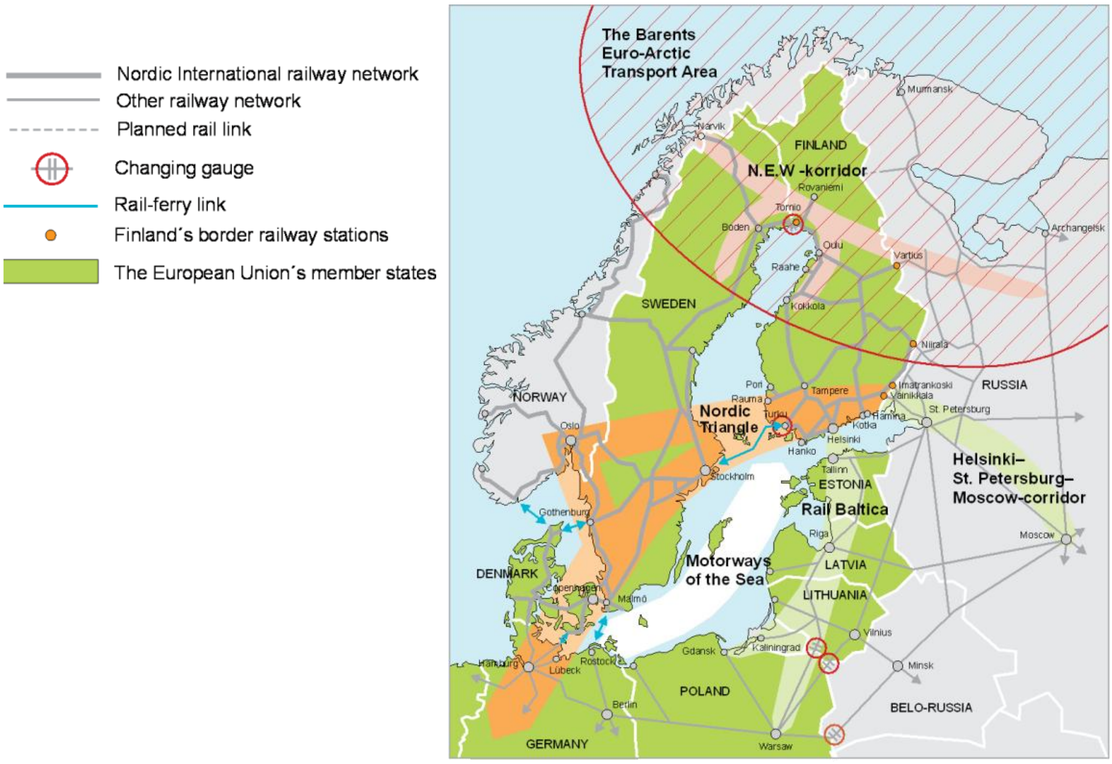


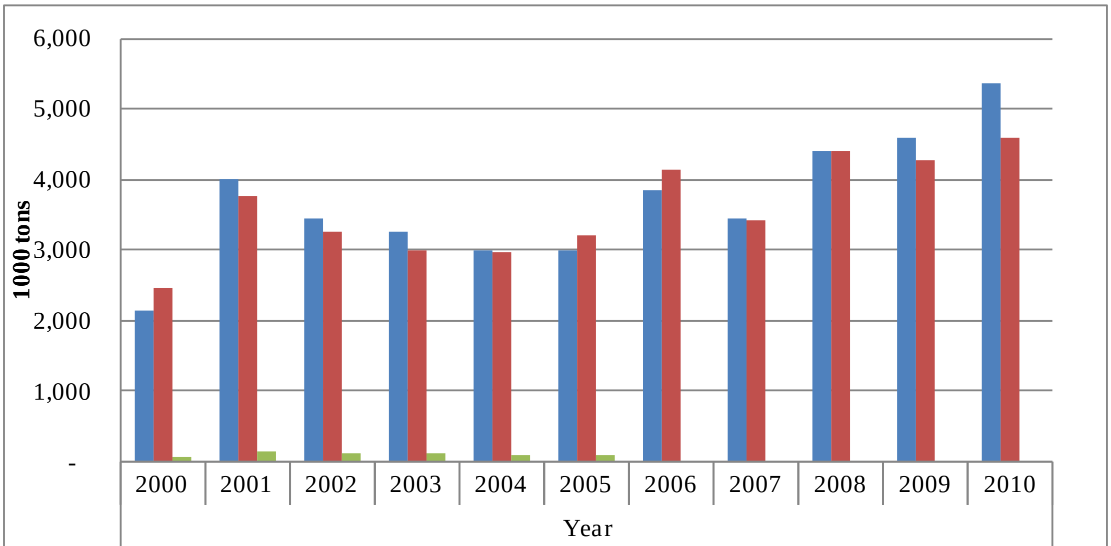
Figure 6 International connections of Finland. The Finnish border stations in rail traffic (Adapted from Finnish Transport Agency, 2011d)

Rail traffic border stations from Finland to Russia are (from south to north) Vainikkala – Buslovskaya, Imatrankoski – Svetogorsk, Niirala – Värtsilä and Vartius – Kivijärvi. Vainikkala is the largest border station and the only passenger train connection to Russia. All kind of wagon loads, containers, oversize loadings as well as dangerous goods are transported via Vainikkala-Buslovskaya border crossing. Imatrankoski-Svetogorsk operates mainly westbound with timber wood. So far, eastbound wagon loads cannot be transported via Imatrankoski-Svetogorsk, but recently this possibility has been under discussion between Finnish and Russian authorities. Via Niirala-Värtsilä wagonloads can be transported both westbound and eastbound, oversize loadings have to be agreed between Finnish and Russian Railways in advance. The main volume of Vartius-Kivijärvi border station traffic is about the iron pellet transportation from Kostamus to Kokkola port. Dangerous goods and oversize loadings have to be agreed between Finnish and Russian Railways in advance. (VR Transpoint, 2011a)

3.1 *Finnish Transit Traffic in General*

Finnish transit traffic originates from the beginning of 1970, when transportation of containers between Europe and Japan via Finland and the Soviet Union started. This route considered to be safer than the long sea route. Very soon after that, in year 1976, Finnish Railways and Soviet forwarding agency, V/O Sojuzhvnestrans, made a transport agreement of transit goods through Finland. In addition, in 1980 to this agreement was joined also V/O Sojuztransit, which had been established for forwarding activities of transit goods through the Soviet Union. Previously mentioned years have been starting point for Finnish transit traffic, which has grown threefold during its thirty years history if considering all transportation modes sea, rail and road. Thus in Finland, the total volume of transit goods in year 1980 was about 2.5 million tons, whereas it was 8.4 million tons in 2008. Due to global economic recession, transit volume decreased 25 percent (6.3 million tons) in year 2009 if compared with volume of 2008. (Sundberg et al., 2010)

As seen in Figure 7, economic recession had no impact in westbound transit traffic, which increased in 2009 in comparison to volume of 2008. Westbound transit volumes are formed mainly of bulk goods such as liquid chemicals, iron pellets and fertilizers. (Finnish Transport Agency, 2011b)

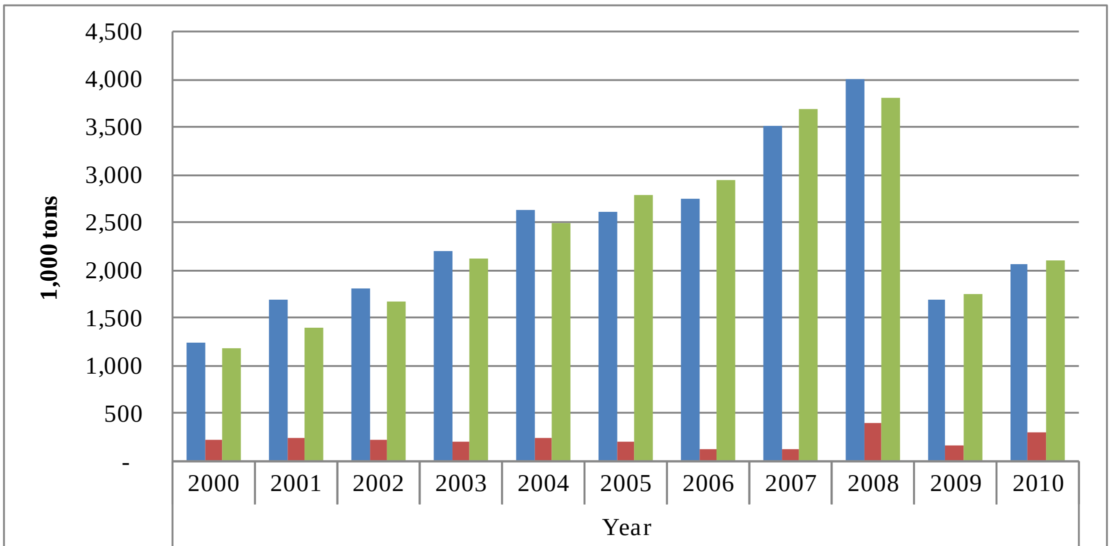


	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Sea	2,132	3,991	3,431	3,262	2,992	2,988	3,837	3,439	4,395	4,599	5,349
Rail	2,450	3,771	3,250	2,992	2,967	3,192	4,130	3,430	4,400	4,260	4,600
Road	57	130	127	116	101	86	-	-	-	-	-

Figure 7 Westbound transit by different transport modes during years 2000 to 2010 (National Board of Customs, 2011a; Finnish Transport Agency, 2011b; Sundberg et al., 2010; VR Group, 2011a)

It can be noticed in the Figure 7 that amount of westbound sea transportation is practically equal to westbound rail volume. That is because westbound rail transit goods continue through Finnish ports further to Europe by ferries. Small differences in westbound sea and rail figures derive from possible intermediate storing of transit goods at sea ports before shipping onwards. Thus, the incoming from east and outgoing to west transit goods might have been compiled statistics on different periods. Westbound transit by roads does not exist or it is minimal as well as transit transportation by rail via Tornio-Haaparanta –border (to Sweden) in the north, is minor. (Finnish Transport Agency, 2011b; National Board of Customs, 2011a)

In contrast to westbound traffic, eastbound transit volumes slumped in 2009, as can be noticed in Figure 8. This was a consequence of economic decline in year 2008. Decreased volume was mostly road transit to Russia. Transportation of passenger cars slumped extremely: 78 percent (570,000 cars less) in 2009 compared with 2008 volume. Furthermore, decrease of electronics was considerable.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Sea	1,234	1,689	1,814	2,207	2,638	2,612	2,740	3,517	3,996	1,682	2,053
Rail	223	237	211	202	234	197	120	120	400	165	300
Road	1,182	1,402	1,664	2,127	2,490	2,780	2,947	3,694	3,802	1,744	2,100

Figure 8 Eastbound transit by different transport modes during years 2000 to 2010 (National Board of Customs, 2011a; Finnish Transport Agency, 2011b; Sundberg et al., 2010; VR Group, 2011a)

However, eastbound transit figures have turned to growth after the crisis in 2010. This trend seems to continue in 2011, when in the first quarter transit traffic through Finnish ports increased about 17 percent, mainly eastbound. (Finnish Transport Agency, 2011c)

A data gathering about standard sized containers through Port of HaminaKotka was obtained to gain knowledge about the use of different sized containers in Finnish seaport related transit traffic. The distribution of different sized containers through Port of HaminaKotka is as represented in Figure 9. Sample consists of 23,125 containers, and it contains container sea vessels that have travelled through Port of HaminaKotka in April 2011.

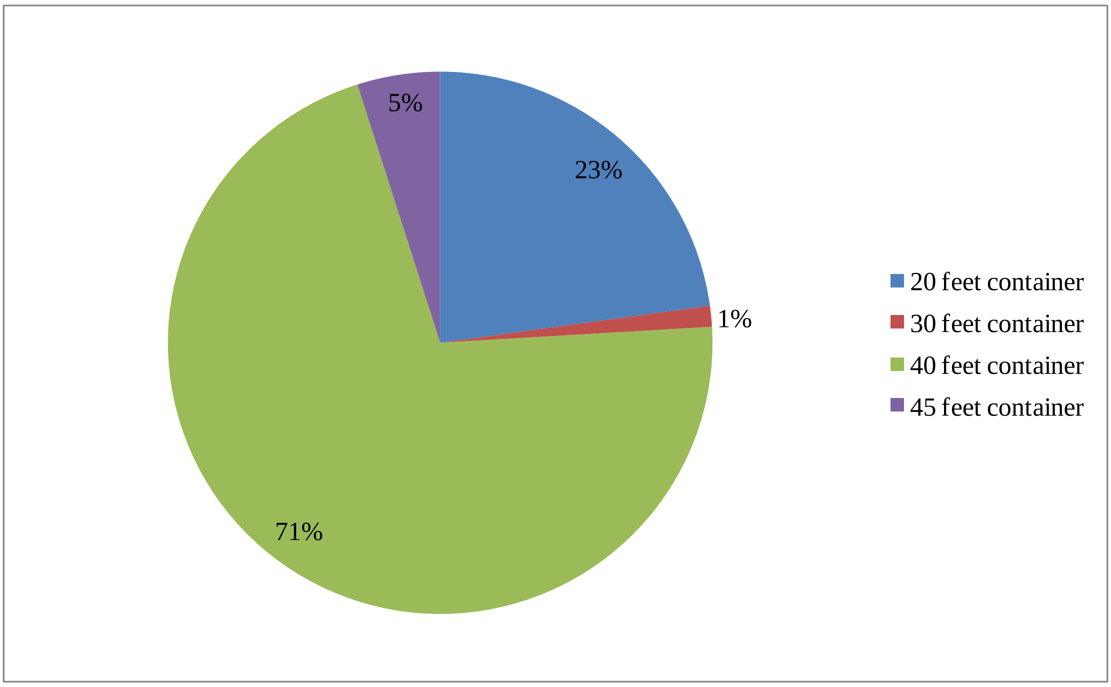


Figure 9 Distribution of different sized containers through Port of HaminaKotka in April 2011 (Port@Net, 2011)

40 feet container is the most used container type through Port of HaminaKotka in April 2011. Approximately 71 percent of all containers are 40 foot containers. Second most used container type is 20 feet container with use of about 23 percents. 30 and 45 feet containers are used rarely, 1 percent of containers are 30 feet containers, and 5 percent of containers are 45 feet containers.

3.2 Finnish International Rail Transportation

The largest amount of international railway freight traffic is *import* from Russia or from third countries via Russia. It is comprised mainly of bulk raw material, such as natural fuels; gas, oil, coal and coke, lubricants, chemicals and wood. The import of timber wood to Finland decreased in 2009 due to hiked export duties for wood in Russia and the decline of Finnish forest industry as well as its large inventories of wood raw material (Jutila et al., 2010). According to National Board of Customs (2011a), in 2010 import volume by rail was 6.5 million tons (see: Figure 10). *Export* from Finland to Russia or via Russia to third countries is consisted of manufactured products such as paper and cardboard in forest industry, machines and appliances and products of chemical industry e.g. polyethylene and colors. This volume was 1.2 million tons. Total volume of *Transit* was 4.8 million tons of which westbound transit (wb) covers 4.3 million tons and eastbound (eb) transit forms 0.5 million tons. *Westbound transit* goods are mainly liquid chemicals by tank wagons and dry bulk such as iron pellets and fertilizers. *Eastbound transit volume* covers refined products, large investment deliveries, oversize loadings, machines and appliances via Finnish sea ports to Russia, the other [1]CIS countries and to third countries. (National Board of Customs, 2011a; VR Group, 2011a)

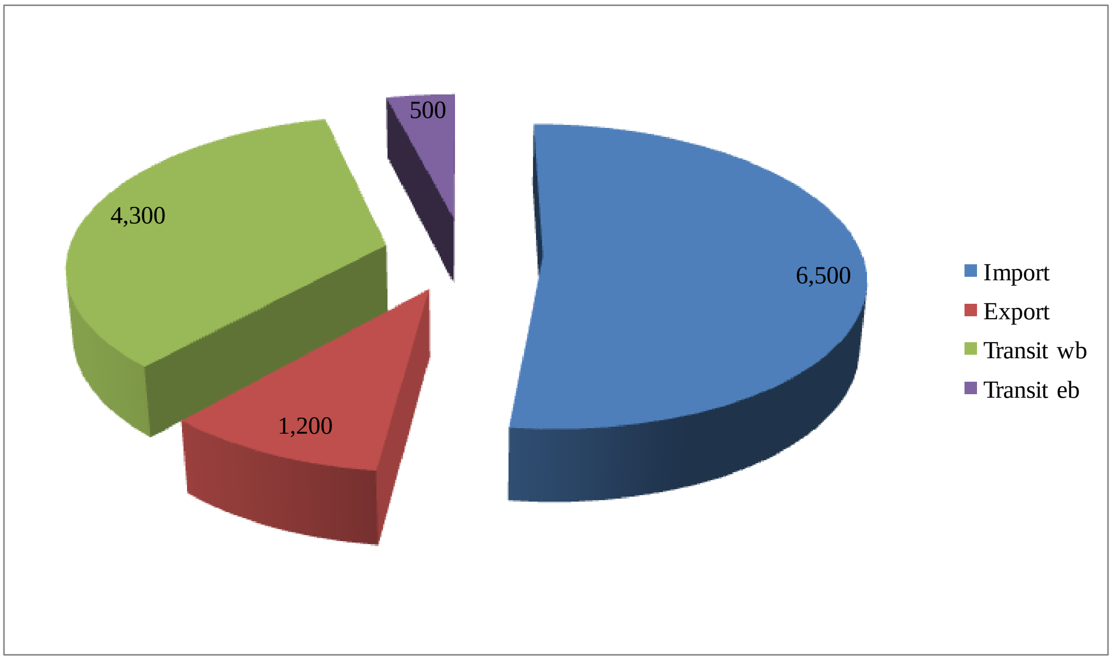


Figure 10 Volumes of rail traffic through eastern borders in year 2010 (thousand tonnes) (National Board of Customs, 2011a)

3.2.1 Container Transportation

Earlier, containers from the Far East were transported along the Trans-Siberian Railway route (TSR) to Finland (see: Figure 11).

[1] CIS-countries (Commonwealth of Independent States): Russia, Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Tajikistan, Turkmenistan, Ukraine, Uzbekistan. Later, Georgia (2008) and Turkmenistan (2005) have withdrawn from the CIS and are now classified as the associate members. (National Board of Customs, 2011b)

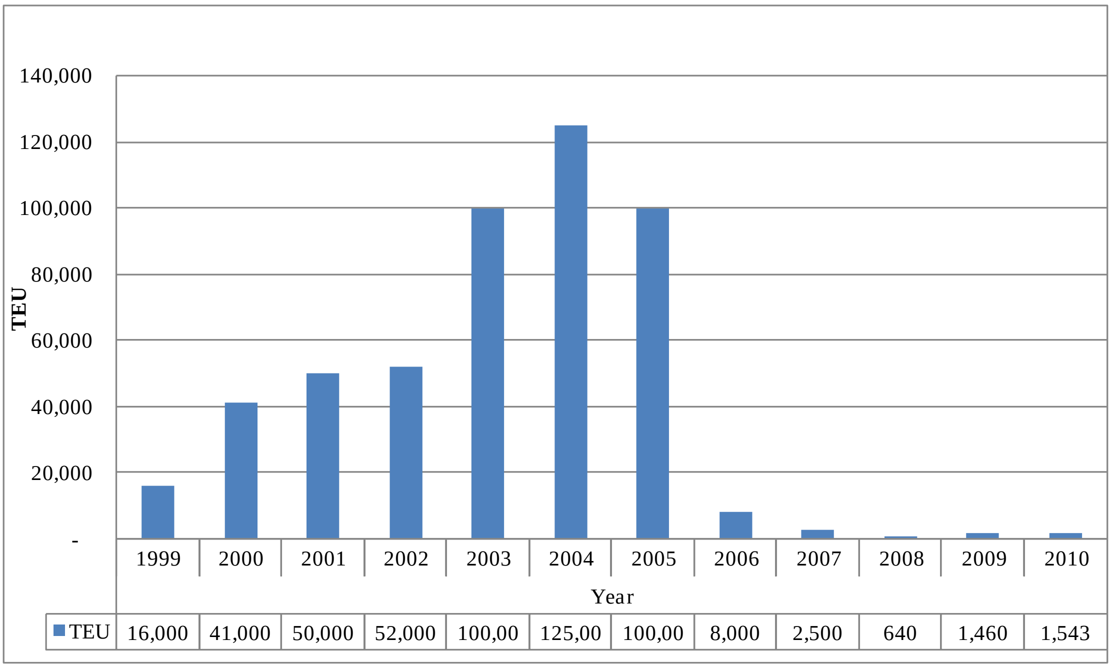


Figure 11 Container volumes between Russia's Far East ports and Finland by rail during 1999-2010 (Sundberg et al., 2010; VR Group Ltd, 2011)

In its biggest this volume was in 2003-2005, when more than 100,000 containers were transported annually to Kouvola. This traffic was Finnish transit, and containers left from Kouvola mainly back to Russia mostly by trucks. In 2006, the Russian Railways changed its policy on defining freight charges for transit and domestic transportation (Inkinen & Tapaninen, 2009) and after that, container volumes on TSR route to Finland fell drastically down, when the majority of containers from the Far East were switched to arriving in Russia via its own Baltic sea ports. (Hilmola et al., 2007)

The main problem with the TSR transit route is much more expensive freight rates than those of sea vessel transportation. Even though Russian Railways (RZD) decreased the tariffs for TSR containers about 30 percent in 2007, containers have not returned to the TSR route as can be perceived in Figure 11. That is because after the price fluctuations of containers in TSR route in 2006-2007, customers lost their confidence in the action of authorities of Russia. (Sundberg et al., 2010; Panova, 2011)

However, transport time from Asia to Europe is shorter by rail than by sea; it takes only 8-10 days from the Russia's Far East ports along TRS-route to Sankt Petersburg or Moscow, whereas it takes 30-50 days by sea to Europe, depending on the chosen route; via Suez Channel or around Africa. This time saving by using TSR-landbridge leads to smaller price erosion and decrease inventory holding costs and thus it can decrease also the final cost of transportation. (Ivanova et al., 2006; Hilletofth et al., 2007; Sundberg et al., 2010)

In addition to shorter lead time, there are some more advantages, when using TSR route, such as lower greenhouse gas emissions and lower climatic strains on products compared with sea vessel transport (Sundberg et al., 2010).

Concerning container transportation to Russia generally, in 2008 there were 200 000 TEU of containers transported to Russia via Finland by road but only 7 000 TEU by rail (Vihavainen-Pitkänen, 2009). Russia has now proposed switching 20' and larger containers completely from road transportation to rail and sea. That probably resulted from the development of the Russian Customs and moving customs declaration procedures closer to the frontiers. Anyhow, in summer 2009 Russia changed its first proposal, by making an addition under which 20' and larger containers can also be imported into Russia by road, but strictly within permitted quotas. This draft statute is currently being circulated for comments in Russia. However, the transfer of containers from road to rail is the target of both Finland and Russia in the long-term plan. (Vihavainen-Pitkänen, 2009; Tekniikka&Talous, 2011)

3.2.2 Other Finnish Rail Transit

As noticed earlier, westbound traffic covers the main part of Finnish rail transit traffic, when eastbound transportation both export from Finland and transit through Finland are minor (see: Figure 12). Accordingly, total transit volume by rail has steadily increased during its history (growing trend line), though not as much as transit traffic as a whole in relation to all transportation modes. In its biggest the rail transit was after the collapse of Soviet Union in the early 1990’s, when present Russia switched its liquid export transportation from the Baltic States (at that time seceding from the Soviet Union) to the Finnish route. Nevertheless, it was temporary arrangement and volume was moved back to Baltic route after couple of years.

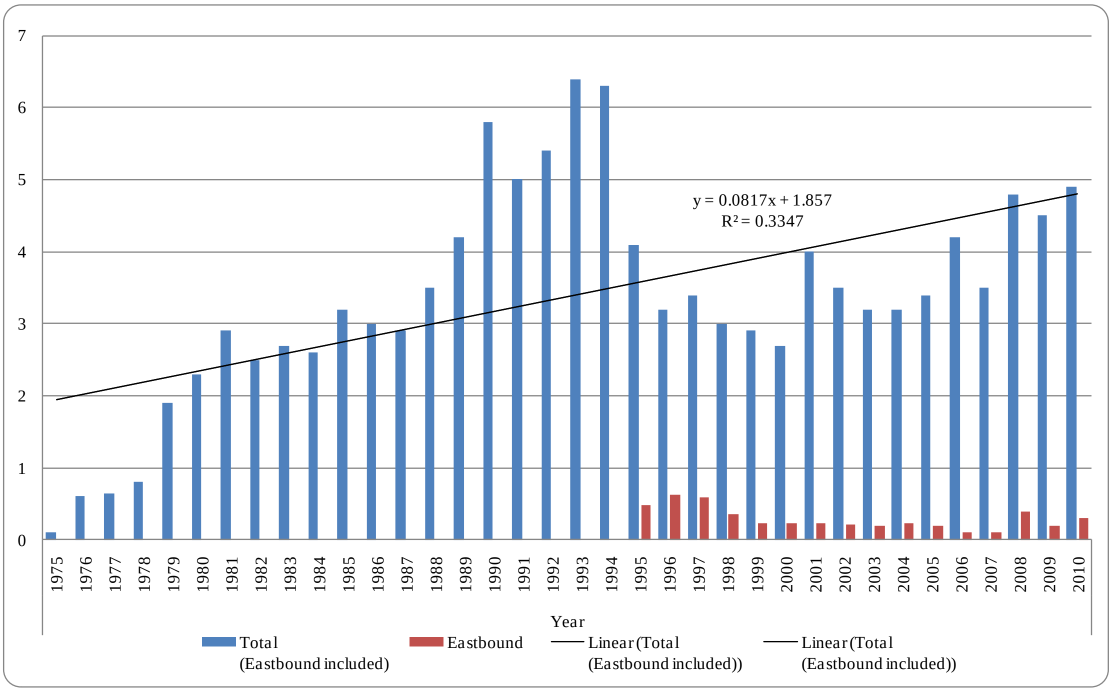


Figure 12 Transit volumes through the eastern border crossings in Finland by rail (VR Group, 2011a)

There occur two main problems in rail transportation in Finnish eastbound traffic. First is customs declaration in the destination station in Russia and the other is lack of adequate wagons for refined goods of eastbound transportation. (Sundberg et al., 2010)

In Russia, there is a two-stage customs clearance system, where incoming goods by rail are preliminarily declared at the customs point of departure (at the border station entry), then goods are transported under the customs' control to the customs point of destination (often same as destination station) for final customs declaration. After that, the goods are released for free circulation. Nevertheless, consignees often like to carry out final customs formalities at the customs point, where they have been registered ("home customs point") instead of customs point at destination station. That means moving the goods under the customs control, commonly by truck, from destination station (rail)terminal to consignee's "home customs point". This system is more complex especially in container traffic compared with road transportation. (Federal Customs Service, 2011; Sundberg et al., 2010)

The other challenge is shortage of wagons suitable for loadings of refined goods. Concerning transportation between Finland and Russia, this has always been an eternal question. Because transportation is implemented only by wagons registered in Russia or in the other CIS countries (based on bilateral agreement of rail traffic between Finland and Russia), availability of the covered wagons especially, has fluctuated depending on their needs for domestic transportation. Wagons' sufficiency for Finnish traffic have been a challenge especially before year 2003, when Russian Railways owned all the freight wagons used in traffic between Finland and Russia. During the Railway Structural Reform Program 2001-2010 in Russia, amount of private owned wagons has increased annually. Since May 2010, only private owned wagons are used in this traffic. In addition to private wagon owners, the subsidiaries of Russian Railways, TransContainer and First Freight Company, have founded joint companies with Finnish Railways for container and wagonload transportation. (Sundberg et al., 2010; Laisi, 2010)

As mentioned earlier, westbound transportation covers mostly raw material such as liquid, dry bulk and wood, meanwhile eastbound mainly refined products and valuables are transported. A consequence of that can be realized in Figure 13 below. Since the nature of transported goods is dissimilar westbound than eastbound, different wagon types are needed for them. Thus, the incoming laden wagons; gondolas (open wagon with high edges, e.g. for wood), stanchion wagons (for round timber), hoppers (closed wagon e.g. for fertilizer) and tank wagons (for liquid), after unloading in Finland, return back to Russia mostly as empty. At the same time, numerous of covered (box) wagons as well as platforms for containers are ordered as empty from Russia for loadings in Finland, because there is lack of incoming laden wagons of these "eastbound –needed" wagon types.

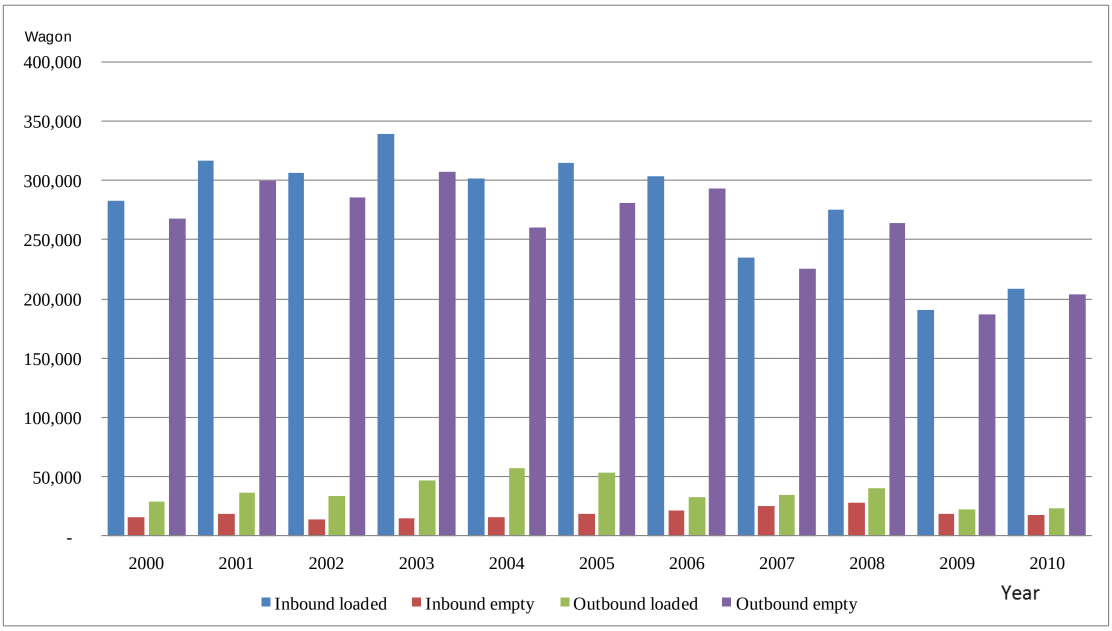


Figure 13 Imbalance of railway wagons in traffic between Finland and Russia (Adapted from Finnish Transport Agency, 2011c)

In rail traffic between Finland and Russia, only private owned wagons are used since May, 2010. Regarding the shipments from Finland to Russia, wagon owners commonly cannot find return freight at the same (destination) station. This has resulted in phenomenon that wagons are transferred as empty to the next loading station in Russia or back to Finland. In order to encourage the wagon owners to search return freight at the destination station area, RZD has increased the charges for transferring empty wagons. Until now, VR Group in Finland includes one empty hauling (either from a border to a loading point or from an unloading point back to a border) in freight rate. However, to haul empty wagons is not efficient, neither from cost viewpoint nor from usage of wagons viewpoint. (Morvesti, 2010; VR Transpoint, 2011b)

From efficiency improvement viewpoint, multi-use of railway wagons can be an alternative model for returning wagons as empty to Russia. According to the research of Saranen (2009), the efficiency improvement in railway transportation can be achieved by combining timber transportation from Russia with container flows from Finland, in certain circumstances. After unloading of timber, idle wagon capacity could be utilized on container transportation to Russia instead of returning wagons as empty. Accordingly, current eastbound container volume could be transported totally and environmentally friendly by rail thus eliminating container congestions from the roads of South-East Finland. In addition, this model would be in line with the European Union's policy of switching road transportation to rails, as well as with the target of both Finland and Russia to transfer containers from road to rail in the long-term plan. (Saranen, 2009; Vihavainen-Pitkänen, 2009)

When considering container traffic figures via and from Finland to Russia in 2010, by road were transported about 200,000 TEU (The Finnish Port Association, 2011; The National Board of Customs, 2011b) and respectively by rail 12,225 TEU (VR Group, 2011c), in total about 212,225 TEU eastbound. Assuming that typical block train to Sankt Petersburg or Moscow is comprised of 55 platforms which take about 120 TEUs, it means about 1770 block trains per year, 34 block trains per week and about 7 block trains per working day. Using the model of multi-use of wagons, the concept could save the empty traction costs of 97,350 wagons per annum.

More widely, there are several issues to be solved concerning multi-use of wagons between Finland and Russia, e.g. requirements of customs and the other authorities, train safety and the loading orders of different types of wagons. Nevertheless, to make railway transportation more effective, the characters of wagons are worth to be developed for multi-use purposes as well as the Terms of Transport in Rail Traffic between Finland and Russia and related Loading Orders so that multi-use of rail wagons could factually be implemented. It would allow the wagon owners to find various backfreight, suitable for wagons which are unloaded at destination stations in Finland or Russia.

4 METHODOLOGY AND DATA GATHERING

Trustworthiness of a research is traditionally described with terms of validity and reliability. Reliability refers to repeatability of the research i.e. if the results of the research remain alike - when the research is repeated – the research's reliability is high and vice versa. Validity refers, how well the research measures the phenomena, what it is supposed to measure. There are several types of validity that contribute to the overall validity of the research. Two main types are internal and external validity. Internal validity is the approximate truth about inferences regarding cause-effect or causal relationships. External validity concerns with the degree to which research findings can be applied to the real world. (Metsämuuronen, 2006)

Empirical part of the study is based on two different Finnish logistics case companies. Trustworthiness of this study could have been increased with additional case companies. Both companies have terminals with rail connections, which means that they can operate in intermodal transport with both the road and rail transportation. Both intermodal terminals were visited to see what kind of operations there are. First case company was visited in October 2010. The other was visited in May 2011. In addition, professional staff of both corporations was interviewed during the visitations. Observations mainly concerned transshipment process of intermodal transport. The author was allowed to see operational activity of both case companies in their intermodal terminals and nearby areas. Observations and interviews were used in creation of process charts of both companies' intermodal processes. In total three different process charts were created to describe transshipment and intermodal transport processes. Process charts were sent to both case companies, to verify that they are correct. In addition, it was important that process charts were not too accurate so that chosen corporations cannot be identified from process charts. Some minor corrections were made in two of the process charts. All three different process charts were used to continue research by doing cost accounting about case companies' intermodal transport. Process charts are mainly used to find out, what different resources companies need, when transshipping ILUs between different transport modes. In addition, resources needed for loading if ILUs were identified. Cost accounting is further developed to estimate costs for one container or one ton of freight. There are cost estimations for transshipping ILUs between different transport modes (transport modes in this research report are road and rail) in the end of empirical part of this study. Furthermore, loading of ILUs is taken into account in more advanced cost accounting. Goal of this study is to calculate cost estimations specifically for Finnish transport network for intermodal transport.

Reliability of the research is on good level. Creating process charts of case companies was straightforward. In addition, charts were verified with case companies, and some minor corrections were made. Reliability of the study decreases a little in transshipment cost estimations, since cost estimations for different actors that are part of transshipments are estimations based on knowledge of author of the work, his supervisor and estimations according to Internet. Some estimations were verified from case companies. Estimations are assumed to be prober, because in Finland salary levels between different employees are very transparent to interest groups and actors in the field. Reliability of the transshipment cost model is at least at average level, because cost model is very simple. It calculates costs of different cost groups together and gives an estimate for transshipping one ILU between one transport mode to another. Another cost model takes loading of ILUs into account. This model is more complex than previous model that only considers transshipment costs. Reliability of the more complex model is lower. Total reliability of the whole study is not excellent, but good, because there are three main stages, in which reliability can suffer a bit.

Aim of this study is to estimate the costs of transshipments. There are numerical costs estimations in the end of this research report. Internal validity of this research report is high, because main conclusions of this study are same that were supposed to be researched in the start of the whole process. External validity is at good level. It is not totally perfect, because costs are estimated in some states of the process. It can lead to small differences, if compared to real world transshipment costs.

Research can be categorized into two detached types: qualitative and quantitative. The former involves data such as words, pictures or objects, while the latter involves analysis of numerical data. Qualitative means a non-numerical data collection (Amaratunga et al., 2002). Quantitative research is based on a positivistic or post positivistic ideal of science. Qualitative research is instead based on an existential phenomenology and hermeneutics philosophy of science (Metsämuuronen, 2006).

Data gathering has been conducted by three main forms: Literature review, interviews with personnel from case companies and observations in case companies' terminal buildings. The empirical part of the research is mainly based on case study about two Finnish logistics companies. This study is mainly qualitative research, because it is based mainly on interviews and observations. There are cost estimations for transshipping ILUs between different transport modes and loading of ILUs. That is why part of this study is in quantitative form.

5 TRANSSHIPMENT COSTS OF INTERMODAL TRANSPORT

Aim of this study is to estimate transshipment costs during intermodal transportation. Transshipment costs are costs that occur, when ILUs are transshipped from one transport mode to another. Empirical part of this study creates process charts about case companies' transshipment processes. In addition, process of loading ILUs is included in the process charts. Process charts are created by observing case companies' loading and transshipping processes. Furthermore, supervisors of case companies have been interviewed and the process charts has been clarified by case companies' logistics experts. Different needed resources are identified with help of process charts to be able to estimate costs of transshipments. Cost estimations of transshipping ILU between transport modes are presented in the end of this Chapter.

Transshipment costs in this study are about the costs that occur, when ILU (e.g. container or semi-trailer) is transshipped from rail to road transport or vice versa. In addition, transshipping between same transport modes (in this study: rail and rail, and road and road) is studied, since both case companies tranship ILUs between same transport modes. Case company A transships between rail and rail transport mode, whereas case company B transships between rail and rail, road and road, and road and rail transport modes. Transshipment processes are alike if ILUs are transshipped between same or different transport modes. Costs occurring from transporting freight geographically from point A to B by rail or road are not taken into account in this research. These costs are researched earlier by LUT Kouvola in their first research report in Mobile Port project (see: Henttu et al., 2010). Aim of this study is to complete estimation of total costs of intermodal transport by estimating transshipment costs to allow better comparison between intermodal transport and unimodal road transport. In the previously mentioned research report (see: Henttu et al., 2010) the costs of transporting ILU geographically was only taken into account, transshipment costs were not included. If only costs of moving freight by rail is considered, rail transport seems as very attractive transport mode in terms of costs and environmental impacts. External costs (e.g. costs of carbon dioxide emissions, noise, accidents and congestion) are not taken into account in this research. It seemed that rail transport is always more inexpensive than road transport, if transshipment costs are not taken into account. It has to be noted that rail transport can almost never be used as the only transport mode during the whole transportation chain between consignor and consignee, because road transport has to be used as initial and final leg of transportation. In addition, sea transport and air transport has to be used in some cases e.g. when crossing seas or oceans.

Shorter rail transport distance enlarges percentual amount of transshipment costs and road transport distance of whole intermodal transport chain, and decreases cost-efficiency of the whole intermodal transportation between consignor and consignee. Longer rail transport distance decreases percentual amount of transshipment costs and road transport distance of the whole intermodal transport, and increases cost-efficiency of the intermodal transport. In short distances unimodal road transport can be more cost-efficient mode than intermodal transport and vice versa. By increasing distance of intermodal transport chain after break-even point, cost-efficiency difference between intermodal transport and unimodal road transport grows wider.

5.1 Process Charts

There are in total two different case companies included in this research. Both are logistics companies that have intermodal terminals with rail and road transport connection. Process charts of case companies' intermodal transport processes are presented in following sub-chapters 5.1.1 and 5.1.2. Case company A has one main process chart, whereas case company B has two different main process charts included in this research report.

5.1.1 Case Company A

Estimating costs of transshipment were started by interviewing expert of case company A. In addition, process about terminal work and transshipping ILUs between different or same transport modes was observed with same expert. Case company A's terminal process at intermodal terminal includes other smaller processes than transshipping. Case company A receives freight from customers by rail. Case company A has two rail lines. The first one is used to receive freight from customers and the other is used to receive empty ILUs. The other is furthermore used to load full ILUs on to rail wagons, from where full ILU train leaves to its destination. The whole terminal process chart of the case company A is presented in Figure 14 below.

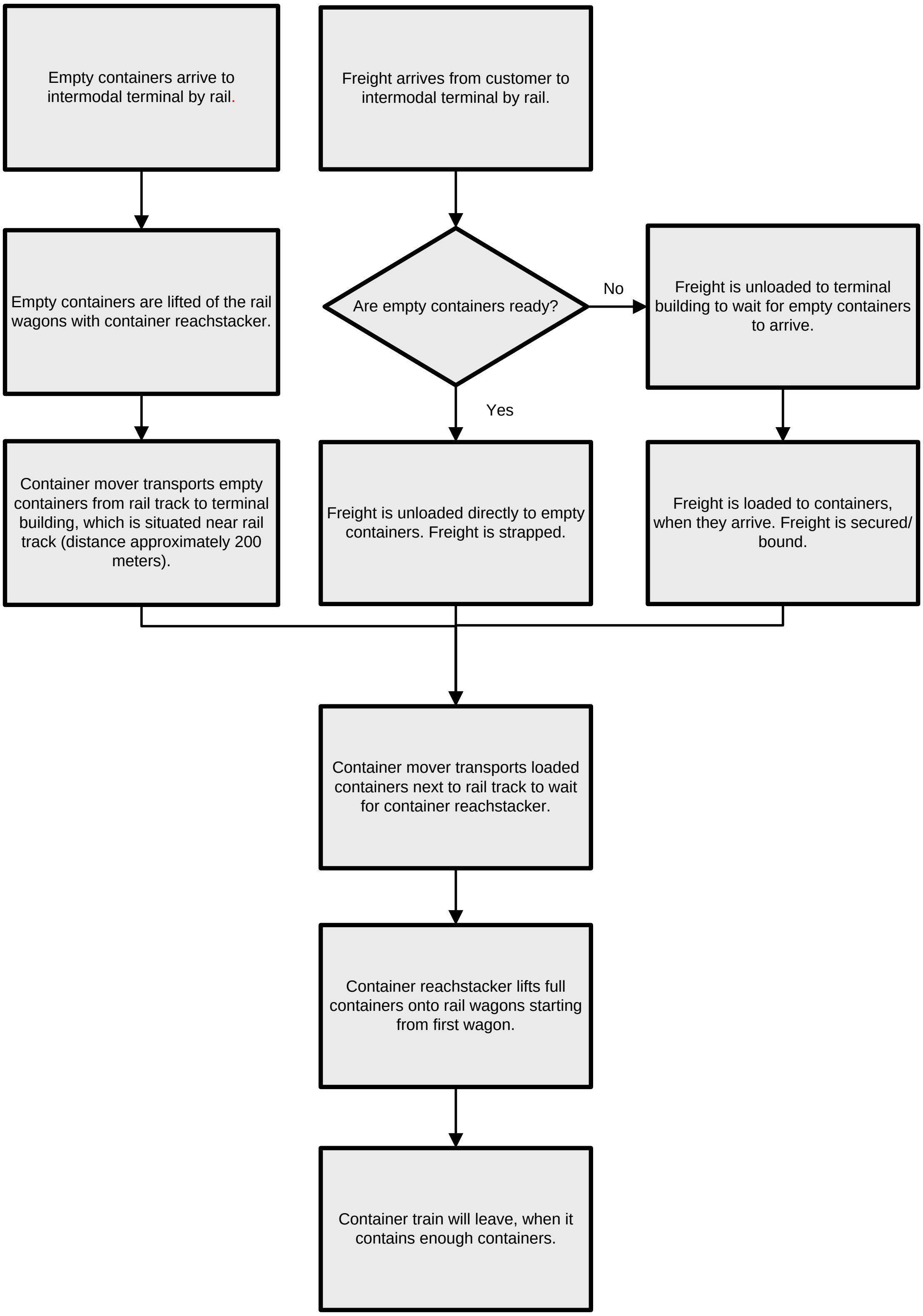


Figure 14 Transshipment process of case company A.

Transshipment is about changing transport mode from one to another. Transshipment is considered as part of intermodal transport chain. Contents of ILUs stay untouched during transshipment process. In some cases transshipment is accomplished between same transport modes, and that is the case of case company A. Case company A uses rail-rail transshipments. Process illustrated in Figure 14 contains additional tasks to transshipment process, which are about loading empty ILUs. Loading of empty ILUs is also included in estimating costs of intermodal transport. In total two different cost models are created for two different scenarios based on both case companies' process charts later in this study. First type of cost model includes only costs about transshipping ILUs between transport modes, and the other includes all costs that are created in the case company A's process. Furthermore, two different scenarios about the location of company are created. In the first scenario the company is situated in seaport area, and in the second scenario company is situated in inland terminal in hinterland of Finland.

As can be seen from Figure 14, intermodal transport process in case company's terminal area includes 10 main phases. The whole process is described more specifically below. Case company has two rail connections. The first rail connection is used for customers to send their freight in case company's intermodal terminal. The other rail connection is used for arriving of empty containers and later loading full containers. In the end of the process this rail is used to send ILU train to its destination point with loaded ILUs. ILUs are unloaded in their destination. Process starts by customers sending their freight by rail to case company's intermodal terminal. Freight arrives in wagons, which are not ILUs. That is the reason, why wagons are first unloaded, and after that freight is loaded in ILUs. Case company unloads freight either directly to ILUs or to terminal building, in case that empty containers have not yet arrived. According to expert supervisor of case company, about 50 percent times empty containers arrive in time, which means that every other time freight has to be unloaded inside terminal building to wait for empty containers to arrive. Empty containers arrive to other rail track. Empty containers are lifted off the rail wagon by container reachstacker. It lifts them next to rail wagon, where from container mover picks containers up and transports them inside terminal building, which is located about 100-200 meters from rail wagon. When both the customer's freight and free containers are ready in terminal building, the freight is loaded in containers. Freight is secured/bound in containers to able moving without content being able to move inside container during transport. Freight binding rules are much stricter, if ILUs are transported by rail instead of sea transport. According to supervisor, securing freight takes three times longer, when using rail transport instead of sea transport. Loaded ILUs are transported back next to rail track with container mover. After that container reachstacker lifts containers onto empty rail wagons starting from wagon that is next to locomotive. Wagons are fulfilled in that order. Train will leave, when there are enough loaded container wagons. Case company rents both the container mover and container reachstacker from different company. Problem in renting is that in some cases containers or freight from customer arrives at different time than was originally planned, and in these cases rented machines usually has to be transported to other companies that have rented them. In this case, case company has to wait until it can rent machines again. Benefit is that case company does not have to invest full cost of container mover or reachstacker. Cost of used machines varies between 30,000 and 240,000 € according to Europe-Machinery (2011).

Process about case company A described above utilizes different resources listed below:

- Warehouse workers
    - Forklift users
    - Freight securers/binders
    - Other workers inside terminal building
    - Supervisor
- Container mover worker
- Container reachstacker worker
- Terminal building
- Two rail tracks
- Two or three forklifts

Case company A uses mainly rail-rail terminal. Freight from customers is transported by rail to terminal. There is no large distance drayage in the case company’s rail-rail intermodal transport operation, except container move from rail to terminal and back, which is circa 200 meters in one way. Forklift users, freight securers/binders and other workers inside terminal building are assumed to have similar salaries. Supervisor is assumed to have a little bit higher salary.

5.1.2 Case Company B

Case company B is a logistics company that has intermodal terminal located inland in Finland. Terminal has access to both road and rail connection, and it uses both transport modes efficiently. Rail connection goes through intermodal terminal, which improves loading and unloading freight. Freight can be loaded or unloaded straight inside intermodal terminal. Rail connection is such that there can be wagons inside terminal building waiting for new locomotive to pick them up. In addition, the new locomotive can bring new wagons inside intermodal terminal and pick ready wagons up, when leaving terminal i.e. same locomotive can bring new wagons inside terminal building and left terminal with ready wagons.

Two different process charts of intermodal transport can be defined of case company B. Some freight arrives in intermodal terminal by rail wagons. Some freight arrives by trucks. First process chart is illustrated below in Figure 15. Process chart is about case company B’s rail-rail transshipment.

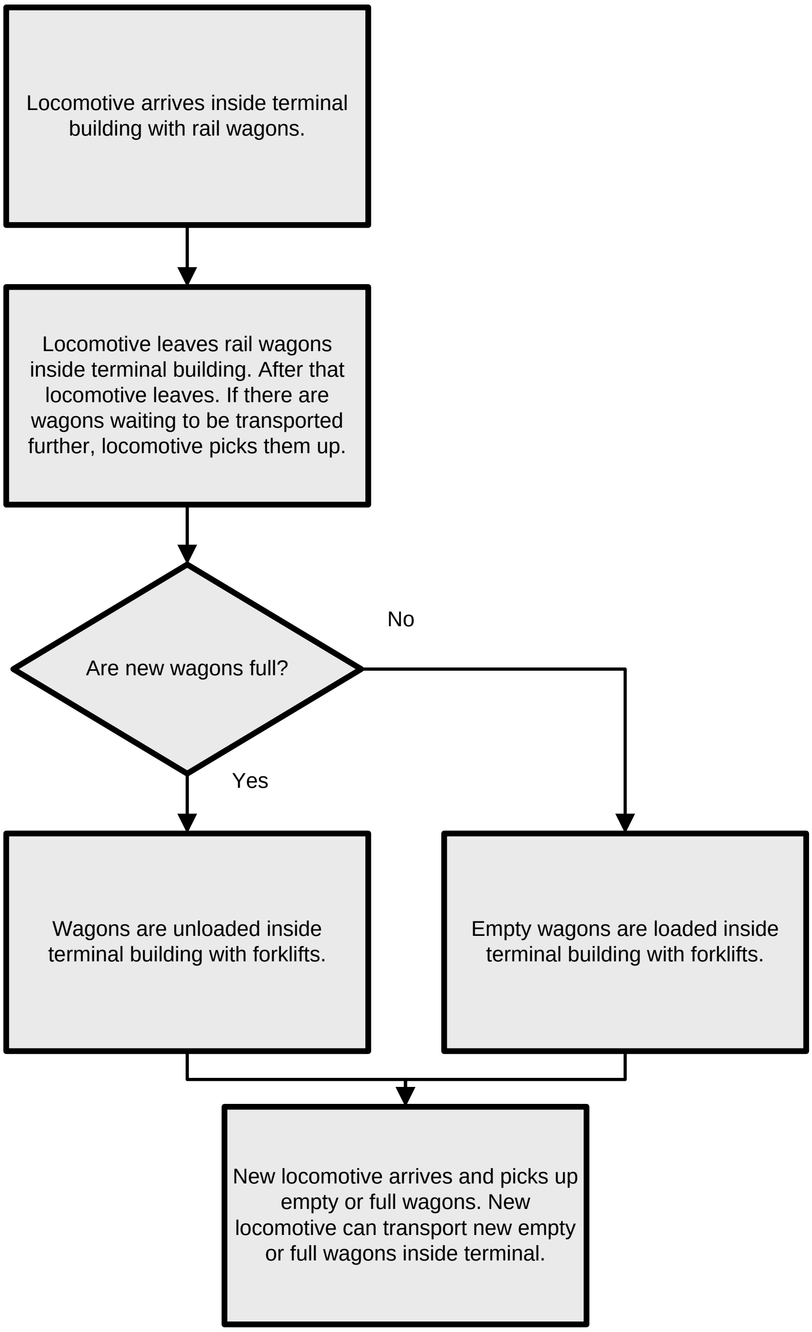


Figure 15 Rail-rail intermodal transport process in case company B.

Rail-rail transshipment process starts, when locomotive arrives inside intermodal terminal. Locomotive transports new wagons inside the terminal building, and leaves wagons there. Wagons are either empty or full of freight. After transporting new wagons inside terminal building the locomotive leaves. If there are wagons ready waiting to be transported further to their destination inside intermodal terminal, then locomotive picks them up and transports further. If new wagons are empty, they are loaded with freight that is situated inside terminal building. Freight is usually waiting inside terminal ready to be loaded inside wagons. In addition, freight is secured/bound if needed. After that ready wagons wait for new locomotive to pick them up. If new wagons are full, then they are unloaded inside terminal building. Unloaded freight will be transported to their destination later by rail or road. Freight will wait inside terminal building until they are transported further. Figure 16 illustrates example of intermediate storing of transit freight in bonded warehouse in case company B.

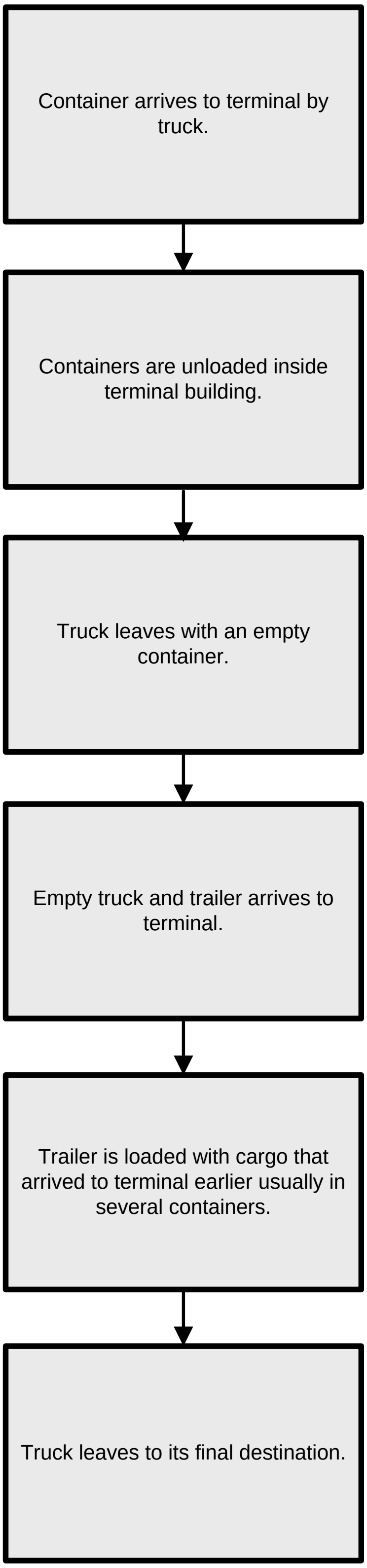


Figure 16 Process chart of intermediate storing of transit freight in bonded warehouse in case company B.

Process described in Figure 16 is pretty straightforward. The process is about road-road intermodal solution. It is part of larger intermodal chain, where in addition sea transport is included earlier. Freight by road transport is arrived at intermodal terminal usually in containers. Containers are transported by trucks. Containers are unloaded inside terminal building mainly by forklifts. There are usually one to three workmen unloading containers. Container truck leaves intermodal terminal after it is totally unloaded. In other words, empty container is transported to its next destination by same truck. Freight waits inside terminal building until it is transported further to its destination. New truck arrives with empty trailer to terminal building. The trailer is loaded with freight that has arrived earlier in terminal in several containers. Trailer truck leaves intermodal terminal when the trailer is loaded. As can be seen from case company B's both process charts, the intermodal terminal is mainly used as intermediate storing. In road-road process, the terminal is used as intermediate storing of transit freight in bonded warehouse.

Both processes by case company B described above utilize different resources listed below:

- Warehouse workers
    - Forklift users
    - Freight securers/binders
    - Other workers inside terminal building
    - Supervisor
- Terminal building
- Rail track
- Two or three forklifts

Resources used in case companies A and B are used later in this research report to create cost estimations about transshipping ILUs between different transport modes. Cost estimations will be the final results of this study.

5.2 Cost Categories and Used Resources during Transshipment

Different cost categories and used resources are identified with help of previously created process charts and discussions with case companies' experts. Transshipment costs can be divided to two different cost categories, which are terminal costs and costs that occur directly, when transport mode of ILU is changed from one to another e.g. from road to rail transport mode or vice versa. Transshipment costs of transshipping ILU between same transport modes are also taken into account, since both case companies transship ILUs between same transport modes (rail-rail and road-road transshipments). Same equipments and machines (e.g. container movers and container reachstackers) can be used, when transshipping freight between road and rail, road and road, and rail and rail transport modes. Terminal costs include e.g. salary costs of terminal workers and rental costs of terminal machines and terminal area. Transport mode change costs occur only, when ILU is moved from one transport mode to other. Two different cost estimations are created in this study. First one is about estimation of transshipment costs, and the other one is about loading empty ILU and transshipping it to rail transport mode. The first one is more straightforward and creates less costs, whereas the second one is more complicated with increased resources and cost categories. In addition, two different scenarios are used in this research. In first scenario the logistics company is situated in seaport area, which in Finland is more expensive in rental costs and especially in salary costs. Logistics company is situated in inland terminal in the other scenario, where especially salary levels are much lower than in the first scenario. Aim of different scenarios is to compare differences in transshipment costs in these two scenarios.

Terminal costs occur at every terminal no matter if it is an intermodal terminal or unimodal road or rail transport terminal. Different terminal costs used in empirical part of this study, when estimating costs of transshipping ILUs between different or same transport modes are listed below:

- Salaries of employees
    - Salaries of terminal workers
    - Salaries of machine users
    - Salaries of supervisors
- Rentals
    - Rental costs of machines
    - Rental costs of terminal area and terminal building
- Investment costs
    - Terminal area and terminal building investments
    - Machine investments

In Finland salaries are often higher at seaports than inland intermodal terminals. Because of that, intermodal transport that uses inland intermodal terminals can become more cost-efficient than intermodal transport that uses only seaports as intermodal terminals.

Costs included in estimating terminal costs in this research are salaries and rents. Investment costs are not taken into account, since in this research report it is assumed that machines and terminals are rented, not purchased, as is the case of case company, which rents equipment and machines (container mover and container reachstacker) for terminal work and transshipment work.

5.3 Transshipment Cost Estimation

Table 1 below represents different resources and costs that are taken into account, when estimating transshipment costs. Different resources and costs included in Table 1 are only about transshipping loaded or unloaded ILUs between same or different transport modes. Loading or unloading of ILUs are not included in Table 1. All the resources and costs presented in Table 1 are based on interviews with case companies' experts and process charts of case companies created earlier in this study. Table 1 is based on both case companies.

Table 1 Estimation of transshipment costs in seaport area.

Salaries		
Machine users	hourly wage	25
Number of machine users		2
Working hours		4
Rentals		
Rental of container mover	hourly rental	50
Rental of container reachstacker	hourly rental	50
Rental of terminal	per containei	5
Number of containers		18
Weight of loaded container	ton	15
Salary costs per day		
Machine users		200
Social costs	50%	100
Rental costs per day		
Container mover		200
Container reachstacker		200
Terminal costs		90
Total costs		**790**
Costs per container		**44**
Costs per ton		**2.9**

Different main cost categories are salaries and rentals. Only machine user salaries are included in transshipment cost estimations. Different rental costs include rentals of container mover, container reachstacker and rental costs of terminal building.

Case company A estimated that it can load and tranship about 17 or 18 ILUs a day with resources listed above in Table 1. That estimation is used in cost estimations created in this study. Total costs of transshipping 18 ILUs are estimated to cost circa 790 €. According to case company A’s supervisor, company is able to tranship 18 containers a day, which means that 790 € is spent a day. Costs per one container are approximately 44 €, and costs per one ton are circa 2.9 €. Two machine users are needed in transshipping. First uses container mover and second uses container reachstacker. In transshipping ILUs, there is no need for loading of ILUs. Loading of

ILUs will be taken into account in next cost estimation. Hourly wage for machine user is estimated to be about 25 €. In monthly payment it is about 4,000 €. Machine users are assumed to work 4 hours a day for direct transshipping. They will spend other four hours in other terminal operations e.g. securing/binding contents of containers or loading empty ILUs. Hourly rental costs for container mover and container reachstacker are based on investment costs of used machinery (Europe-Machinery, 2011). Terminal rental costs are based on warehousing costs of one container in Port of HaminaKotka (Port of HaminaKotka, 2011). Earlier ports called Port of Kotka and Port of Hamina still have their own prices for different operations. Prices will be common from start of year 2012 (Port of HaminaKotka, 2011). Weight of loaded container is estimated to be around 15 tons. Social costs including e.g. holidays and taxes are about 50 percent of the salary. Salary costs a day for these settings is in total 300 € (social costs are taken into account in this sum). Rental costs of container mover and container reachstacker is 200 € each, and in total 400 €.

Maximum number of ILUs stuffed and transshipped at case company A’s terminal per one day is about 17-18 ILUs. In this research it is assumed that 18 ILUs are transshipped during one day. Working hours of using container mover and container reachstacker is assumed to be circa four hours. Main part of working time is spent stuffing ILUs. Transporting them between terminal and rail track takes less time. Estimation presented in Table 2 includes whole process of case company A including loading of ILUs and transshipping them to rail wagons. In addition, process charts of case company B are reviewed and included in Table 2, if needed so that both case companies are part of estimations in Table 2.

Table 2 Estimation of stuffing and transshipment costs in seaport area.

Salaries			
Terminal workers	hourly wage		25
Supervisors	hourly wage		30
Machine users	hourly wage		25
Number of supervisors			1
Number of terminal workers			4
Number of machine users			2
Working hours	hours		8
Rental hours of machines	hours		4
Rentals			
Rental of container mover	hourly rental		50
Rental of container reachstacker	hourly rental		50
Rental of terminal	per container		5
Number of containers			18
Weight of empty container	tons		3
Weight of loaded container	tons		15
Salary costs per day			
Terminal workers			800
Machine users			400
Supervisors			240
Social costs		50%	720
Rental costs per day			
Container mover			200
Container reachstacker			200
Terminal costs			90
Total costs			**2650**
Costs per container			**147**
Costs per ton			**9.8**

There are additional resources and costs included in Table 2, if compared to Table 1. There are in total seven people working during one day. One of them is supervisor, and the other groups are terminal workers and machine users. Main difference between Tables 1 and 2 is the number of workers. In Table 1 there were two machine workers working five hours a day. All the other costs are similar in Tables 1 and 2 with only minor differences.

According to case company A’s supervisor, case company can load and tranship about 18 ILUs a day by using six terminal workers (these include all needed workers e.g. machine workers, ILU loaders etc.). Cost estimation for loading of ILUs and further transshipping them based on case companies is about 2,650 € per one day. Costs per one container is approximately 147 €, and costs per one ton is circa 9.8 €. In these cost estimations four terminal workers, two machine users and one supervisor is used. Each one works eight hours to load and tranship 18 containers. Hourly wages for terminal workers and machine users are 25 € as was in previous cost estimation. Hourly wage for supervisor is assumed to be 30 €. It is again assumed that case companies need to rent container mover and container reachstacker for four hours each, and hourly rental costs for both machines is 50 €. With these settings, salary costs per day for terminal workers are 800 €. Salary costs for machine users are 400 €, and salary costs for supervisor are 240 €. Social costs in total for all workers including supervisor are 720 € a day. Rental costs for one machine a day are 200 €. Rental costs of terminal for containers a day is about 90 € and by summing all rental costs, the sum is a little less than 500 €.

Above costs are estimated for seaport related location. Another alternative is that same process is done in inland intermodal terminal that has no sea transport connection i.e. not in seaport. Advantages of transshipping and stuffing inland are possible decreases in salaries of terminal workers and decreased terminal rental costs of vehicles and terminal building. Estimation of costs is presented below in Table 3 and Table 4. Table 3 includes costs of transshipping ILUs. Both tables are based on case companies and their process charts.

Table 3 Estimation of transshipment costs in inland intermodal terminal.

Salaries		
Machine users	hourly wage	15
Number of machine users		2
Working hours		4
Rentals		
Rental of container mover	hourly rental	50
Rental of container reachstacker	hourly rental	50
Rental of terminal	per container	3
Number of containers		18
Weight of loaded container	ton	15
Salary costs per day		
Machine users		120
Social costs	50%	60
Rental costs per day		
Container mover		200
Container reachstacker		200
Terminal costs		54
Total costs		**634**
Costs per container		**35**
Costs per ton		**2.3**

Used resources are the same in Tables 1 and 3. Main difference in cost estimations between Tables 1 and 3 is that salary level of terminal workers is lower in Table 3. In Table 1 hourly wage was assumed to be 25 €, whereas in Table 3 it is assumed to be 15 €. Another smaller difference is that in inland located cost estimation rental of terminal is assumed to be 2 € less per container. In Table 1 rental costs per container were 5 €, and in Table 3 three €. Total costs estimation a day in company that is situated in inland are 634 €. In seaport related scenario total costs were 790 €. Decrease in total costs is 156 € a day. Costs per container in inland terminal related transshipment are 35 €, and per one ton 2.3 €. Decrease in costs per container is from 44 to 35 €. Decrease is about 20 percent.

Similar cost estimations are created in Table 4. It has similarities with Table 2. Difference is the same as in previous example. Company is assumed to be located inland in Table 4, which leads in decreased costs, especially in decreased salary costs of terminal workers.

Table 4 Estimation of stuffing and transshipment costs in inland intermodal terminal.

Salaries			
Terminal workers	hourly wage		15
Supervisors	hourly wage		25
Machine users	hourly wage		15
Number of supervisors			1
Number of terminal workers			4
Number of machine users			2
Working hours	hours		8
Rental hours of machines	hours		4
Rentals			
Rental of container mover	hourly rental		50
Rental of container reachstacker	hourly rental		50
Rental of terminal	per container		3
Number of containers			18
Weight of empty container	tons		3
Weight of loaded container	tons		15
Salary costs per day			
Terminal workers			480
Machine users			240
Supervisors			200
Social costs		50%	460
Rental costs per day			
Container mover			200
Container reachstacker			200
Terminal costs			54
Total costs			**1834**
Costs per container			**102**
Costs per ton			**6.8**

Used resources are again the same as in seaport related transshipping. Difference is that salary levels are lower than in seaport related company. Another smaller difference is that rental of terminal is assumed to be lower in inland intermodal terminal than in seaport area located terminal. Total costs of loading 18 ILUs and transshipping them to container train are circa 1,834 € a day. If costs are divided for each container, then they are about 102 € per container. Costs per one ton are 6.8 €.

These costs are estimated for a logistics company that is situated inland instead of in seaport area. Main difference in Table 4 compared to results in Table 2 is that salary costs in Table 4 are less. Hourly wage for terminal workers in Table 4 is 15 €, and hourly wage for supervisor is 25 €. In seaport related company in Table 2 hourly wage for terminal worker is 25 €, and for supervisor 30 €. Total costs for one day in seaport related company are estimated to be 2,650 €, whereas in inland related company they are estimated to be around 1,834 € a day. Percentual decrease is approximately 31 percent.

5.4 Sensitivity Analysis

Sensitivity analysis is accomplished by changing productivity. It is increased and decreased by about 30 percent, which is five containers less or more a day in different scenarios. Productivity is 13 containers a day, when productivity is decreased by 30 percent, and 23 containers, when productivity is increased by 30 percent. All the other parameters (e.g. salary levels) are kept unchanged. Table 5 includes sensitivity analysis of transshipment costs. Seaport situated transshipment costs are showed in the upper part of Table 5, and inland situated transshipment costs are showed in the lower part of Table 5.

Table 5 Sensitivity analysis of transshipment costs, if productivity is increased or decreased.

Seaport situated company			
30 percent increase in productivity			
Total costs	790	→	815
Costs per container	44	→	35
Costs per ton	3	→	2
30 percent decrease in productivity			
Total costs	790	→	765
Costs per container	44	→	59
Costs per ton	3	→	4

Inland situated company			
30 percent increase in productivity			
Total costs	634	→	649
Costs per container	35	→	28
Costs per ton	2	→	2
30 percent decrease in productivity			
Total costs	634	→	619
Costs per container	35	→	48
Costs per ton	2	→	3

Costs per container can be decreased from 44 to 35 € in seaport situated company, if container handling per day can be increased from 18 to 23 containers. In inland situated company the decrease in transshipment costs per one container is from 35 to 28 €. Difference in original results between seaport situated company and inland situated company is 9 € (44 € - 35 €). If productivity is increased by 30 percent, then the difference becomes 7 € (35 € - 28 €). Result is that difference in costs of transshipment between seaport and inland related company can be decreased by increasing productivity i.e. cost efficiency of logistics company can be enhanced by increasing productivity. If productivity is decreased by 30 percent to 13 containers a day instead of 18 containers a day, then costs per one container in seaport situated company increases from 44 to 59 €. In inland situated company the increase is from 35 to 48 €. Table 6 includes sensitivity analysis of loading and transshipment costs, if productivity is increased or decreased by 30 percent.

Table 6 Sensitivity analysis of loading and transshipment costs, if productivity is increased or decreased.

Seaport situated company			
30 percent increase in productivity			
Total costs	2,650	→	2,675
Costs per container	147	→	116
Costs per ton	10	→	8
30 percent decrease in productivity			
Total costs	2,650	→	2,625
Costs per container	147	→	202
Costs per ton	10	→	13

Inland situated company			
30 percent increase in productivity			
Total costs	1834	→	1,849
Costs per container	102	→	80
Costs per ton	6.8	→	5
30 percent decrease in productivity			
Total costs	1834	→	1,819
Costs per container	102	→	140
Costs per ton	6.8	→	9

If both the loading costs of ILU and transshipment costs are taken into account, then seaport situated company can decrease costs per container from 147 to 116 € by increasing productivity by 30 percent. Inland situated company can decrease same costs from 102 to 80 €. If the productivity is decreased by 30 percent, then costs in seaport situated company increase from 147 to 202 €, and the costs in inland situated company increase from 102 to 140 €.

6 DISCUSSION AND CONCLUSIONS

Intermodal transport consists of at least two different transport modes, and in some cases there are three to four different transport modes. Same transport modes can be used one or more times during the same intermodal transportation chain. Total costs of intermodal transport is not only about transporting freight geographically from point A to B with road, rail, sea or air transport. Part of costs in intermodal transport is born in intermodal terminals mainly from transshipping ILUs from different transport mode to another or between same transport modes. Transshipment costs of intermodal transport need to be considered, when comparing intermodal transport with conventional road transport to achieve more accurate comparison. Intermodal transport often seems more attractive alternative transport mode, because transshipment costs are not taken into account on the whole or they are taken into account partly. More transparent view of total costs of intermodal transport is important for those, who are making decisions between unimodal road transport and intermodal transport. Transshipment costs of intermodal transport are under main focus in this research report. Aim of this study is to estimate transshipment costs of intermodal transport, and these estimations are represented later in Chapter 6 (see: Table 7).

Transshipment costs consist of different parts e.g. salaries of workers, rental of machines and storage or terminal area or buildings. Transshipment costs can differ at different geographical locations. A good example in Finland is difference in salaries between terminal workers at seaports and inland intermodal terminals. Salaries at seaports can be as much as supervisors’ salaries, whereas in inland intermodal terminals salaries can be 50-80 percent of the salaries of seaport workers. i.e. salary level is higher in logistics companies, which are situated in seaport area. In addition, rental costs of terminal building and terminal area are higher in or near seaport area than in hinterland. Rental costs can be lowered by using inland intermodal terminals. By shifting transshipments inland it is possible to decrease break-even distance of intermodal transport in Finland. Results concerning transshipment cost estimations are represented in Table 7 below.

Table 7 Summary of cost estimations for transshipping ILUs and loading ILUs and transshipping them.

		Seaport situated company	Inland situated company
Costs of transshipping ILUs	Total costs	790	634
	Costs per container	44	35
	Costs per ton	2.9	2.3
Costs of loading ILUs and transshipping	Total costs	2,650	1,834
	Costs per container	147	102
	Costs per ton	9.8	6.8

If ILUs are only transshipped between different or same transport modes, then approximate for costs per container are 35 to 44 € depending on the salary and rental levels. Salary levels in seaport areas are usually much higher than in inland terminals in Finland. In summary, costs of transshipping a container are about 35 to 44 €. Approximate costs per container are 100 to 150 €, if company also loads ILUs and afterwards transships them. Differences are larger, because percentual amount of salaries are higher in this case. In summary, costs of loading a container and afterwards transshipping it are about 100 to 150 €.

Main conclusion of this study is that intermodal transport always needs certain distance to be more cost-efficient than road transport. In short distances, transshipment costs are percentually very large, if compared to total costs of intermodal transport, and that is why unimodal road transport is more inexpensive in short distances. Critical distance is named as break-even point between unimodal road transport and intermodal transport. Shorter distances than break-even point are more cost-efficient to accomplish by conventional road transport, and longer distances are more cost-efficient utilizing intermodal transport. Break-even point can be moved to left by decreasing pre-haulage and/or post-haulage of intermodal transport. It can also be moved to left by decreasing transshipment costs. Reason for this is that main haulage of intermodal transport per certain distance is more inexpensive than unimodal road transport per same distance. There is always certain break-even distance, which gives information about transport modes. Intermodal transport is more cost-efficient transport mode after break-even distance, whereas unimodal road transport is more cost-efficient if the distance is under break-even distance. Break-even point for Finnish transport network can be estimated by using cost estimations for road and rail transport (see: Henttu et al., 2010), and cost estimations of transshipping ILU in seaport situated and inland situated company. All the estimations include costs per ton or per ton-kilometer. Table 8 summarized break-even point for two different scenarios.

Table 8 Break-even points for two different scenarios in Finnish transportation network.

Overall distance	Unimodal road transport with no additional transshipments	Intermodal transport with one additional transshipment	Intermodal transport with two additional transshipments
50 km	5.8 € / ton	8.3 € / ton	10.6 € / ton
100 km	8.3 € / ton	9.7 € / ton	12.0 € / ton
157 km	11.2 € / ton	11.2 € / ton	13.5 € / ton
200 km	13.4 € / ton	12.4 € / ton	14.7 € / ton
255 km	16.2 € / ton	13.9 € / ton	16.2 € / ton
500 km	28.6 € / ton	20.5 € / ton	22.8 € / ton
1000 km	53.9 € / ton	34.0 € / ton	36.3 € / ton

The used cost estimations for road and rail transport are 0.0506 and 0.0270 € / ton-kilometer respectively (see: Henttu et al., 2010). The used values for transshipping ILU in tons are summarized on Table 7 (2.9 € for seaport situated company and 2.3 € for inland situated company). ILU is transshipped one additional time in first scenario and two additional times in second scenario. The first scenario is for container traffic in unimodal road transport, whereas the second scenario is for semi-trailer traffic in unimodal road transport. Difference is that semi-trailers can be handled more easily by trucks in the seaport area, and that decreases transshipment costs during unimodal road transport i.e. intermodal transport includes one transshipment more than unimodal transport in the first scenario, whereas in second scenario intermodal transport includes two additional transshipment compared to conventional road transport. The break-even point in first scenario is about 157 km. Under that distance the intermodal transport is more expensive, but by longer distance it is cheaper way of transporting freight. This result supports results of other studies that have estimated the needed distance for intermodal transport to be profitable (see: e.g. Roso, 2009). If unimodal road transport is compared with intermodal transport with two additional transshipments, then break-even point is about 255 km i.e. in shorter distances than 255 km conventional road transport is more cost-efficient, and in longer distances it is more cost-efficient to utilize intermodal transport.

Possible cost benefits of using inland intermodal terminal instead of seaport related terminal is estimated next. Effect of moving handling of 200,000 and 400,000 TEU to inland intermodal terminal instead of seaport related intermodal terminal is estimated based on cost estimations presented in Table 7. It is estimated that 70 percent of containers are only transshipped between different transport modes, and 30 percent of containers are first loaded in intermodal terminals and after that transshipped to rail transport mode. Table 9 summarizes possible cost benefit estimations.

Table 9 Possible cost benefits of handling 200,000 or 400,000 TEU in inland intermodal terminal instead of seaport situated intermodal terminal.

Seaport situated company

Amount of TEU	Costs of transshipping ILUs	Costs of loading and transshipping ILUs	Total costs in seaport situated company
200,000	6,144,444	8,833,333	14,977,778
400,000	12,288,889	17,666,667	29,955,556

Inland situated company

Amount of TEU	Costs of transshipping ILUs	Costs of loading and transshipping ILUs	Total costs in seaport situated company
200,000	4,931,111	6,113,333	11,044,444
400,000	9,862,222	12,226,667	22,088,889

Possible cost benefits

Amount of TEU	Difference of costs
200,000	3,933,333
400,000	7,866,667

Calculation of possible cost benefits is straightforward. By handling one container transshipment in inland intermodal terminal instead of seaport situated intermodal terminal 9 € can be saved (see Tables 7 and 8). By loading and transshipping one container in inland intermodal terminal 45 € can be saved. Potential cost benefits with 200,000 TEU can be up to about 4 million €, and cost savings can be up to 7.8 million €, if 400,000 TEU are handled in inland intermodal terminal instead of seaport situated terminal. Cost benefits are mainly possible, because of higher salary levels in seaport terminal. In fact, VR-Group has plans to increase combined rail-road transports to Russia by investing in intermodal loading platform in city of Kouvola (Yle.fi, 2011). Aim of VR-Group is to start weekly combined rail-road transports from Kouvola to Russia.

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