Teemu Alila

# Rail Transportation from China to Germany, Case Company X

Metropolia

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The objective of this Bachelor's thesis was to examine which transportation mode is the most cost efficient between two specific locations. The Case Company re-evaluates the cost efficiency of different transportation methods every few years due to changes in transportation costs.

To determine this the case company provided materials and information as well as calculation tools that were modified to fit the scope of this thesis. An interview with a buyer was conducted to discover additional information. After that the theory of this topic was studied to gain further knowledge about the topic. Calculations which determine the cost efficiency were made and described. After that conclusion and suggestions for the case company were made.

The calculations point out that in this case the sea freight is the most viable and cost efficient option. Both rail and air freight do not give enough of an advantage from reduced stock levels and shorter lead times to even out the higher cost of transportation. These transportation modes may be viable in different scenarios, however, in this case they are not recommendable.

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|---|---|
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Tämän insinöörityön tavoitteena oli tarkastella, mikä kuljetusmuoto on kustannustehokkain vaihtoehto, kun kuljetetaan tavaraa kahden ennalta määrittämän paikan välillä. Yritys jolle tämä insinöörityö tehtiin tarkastaa eri kuljetusmuotojen kustannustehokkuuden tietyin väliajoin uusilla markkinahinnoilla.

Jotta kustannustehokkuus voitiin laskea, yritys antoi käyttöön kehittämänsä laskentatyökalun, joka muokattiin tähän tehtävään sopivaksi, sekä tietoa ja taustamateriaalia laskentaa varten. Alussa myös haastateltiin ostajaa lisätiedon saamiseksi. Tämän jälkeen etsittiin teoriaa ja taustatietoa asiasta sekä sovellettiin sitä työhön, minkä jälkeen tehtiin työhön liittyvät laskutoimitukset. Näistä saatiin lopputulokset.

Laskuista ilmenee, että merikuljetus on tässä tapauksessa kaikkein kustannustehokkain tapa kuljettaa juuri näitä materiaaleja ja tällä reitillä. Ilma- ja rautatiekuljetuksien lyhyemmillä kuljetusajoilla ei saataisi varastoarvoja tarpeeksi alas, jotta niiden käyttö olisi järkevää. Eri lähtöarvoilla ja tiedoilla ilma- ja rautatiekuljetukset voisivat toimia, mutta tämän työn lähtöarvojen kanssa niin ei ole.

| Avainsanat | Kuljetus, meri, rautatie, hinta, vaikutus, TCO |
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**List of Abbreviations**

| | |
|---|---|
| 20' | 20 feet |
| 40' | 40 feet |
| FCL | Full container load, when a company has enough goods to fill a container. |
| LCL | Less than a full container load, used when the company which ships the goods does not have enough to fill a container. |
| TCO | Total Cost of Ownership |
| USD | United States Dollar |
| KG | Kilogram |
| WACC | Weighted average cost of capital |
| NWC | Net Working Capital |
| FCA | Free Carrier, incoterm |

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# 1 Introduction

This thesis compares two different modes of transportation from a specific supplier in Hong Kong to the Case Company X central warehouse in Menden, Germany. The transportation modes that are examined are sea transportation and railway transportation. The thesis looks at transportation costs, delivery times and effects on warehouse levels as well as payment terms. The thesis also checks the qualifications for the packaging and different risks in each transportation modes.

The thesis only takes into account selected box build codes transported to the central warehouse and excludes all other transportations. To calculate the TCO for these codes, the Case Company X's in house developed tool called SCM Total Cost of Ownership Calculator is being used. The calculation tool has been slightly modified to fit this project's needs.

## 1.1 Choosing a transportation mode

Before making a deal with a supplier and even after the initial contract, a company needs to make an agreement with the supplier on a number of different topics. E. g. what transport mode they will use, will pallets be used and if so, what sized pallets and will the goods be stacked loose inside containers. (Rushton et al. 2010: 213.)

While logistics is an ever-changing environment, looking closely at the different transportation modes has become more important, because companies are focusing on global operations. While production is being moved to low-cost areas and companies are focusing on producing certain products only in certain areas the products are being transported from afar. Transport modes that excel in moving goods for long distances increasing their importance to companies that have the focus on operating their global logistics more efficiently.

In order to achieve this, companies need to compare the individual characteristics of sea and air freight and also rail freight where applicable. Depending on the destination, transporting the goods via road freight after using one of the other transportation modes may

still be necessary due to the location not being next to an airport, harbor or railway station. Thus, it is important to think about using a modal choice of transport when optimizing global logistics. (Rushton et al. 2010: 331.)

**Table 1. Modal choice matrix. (Rushton et al. 2010: 344)**

| | | Delivery Distance | | |
|---|---|---|---|---|
| | | Short | Medium | Long | Very Long |
| Size of order | Parcel | post/road | post/road/air | post/road/air | post/air |
| | Pallet | road | road | road/rail | air/sea |
| | 20 tons | road | road | road/rail | rail/sea |
| | 100 tons | road | road/rail | rail/sea | sea |

The above table shows a matrix for choosing a transportation mode. It comes down to deciding between cost and service. Of course, other characteristics need to be factored into the decision making but in theory the delivery distance and size of order or cargo volume make up the deciding factors when making a choice between transportation modes. (Rushton et al. 2010: 344.)

1.2    Company background [Appendix 1]

1.2.1    History [Appendix 1]

1.3    Current situation

The current situation of transportation from company X's supplier in Hong Kong to Menden, Germany consists of primarily sea freight due to the lower costs of transportation with air freight being used when needed to expedite the deliveries. The responsible buyer at the company places either sea or air freight orders on a weekly basis and the split on the freight is about 30% by air and 70% by sea.

Delivery sizes vary depending on the mode of transport, air freight's delivery sizes are irregular, while sea transportation uses either 20' or 40' containers. The supplier usually combines orders to make the deliveries into FCL containers independently to minimize freight costs. Current payment term used is 90 days FCA Hong Kong.

Current shipments from Hong Kong to the warehouse in Menden, Germany are rarely late and small delays are not noticed due to the warehouse buffers. Deliveries by sea are calculated for a 6 to 7-week delivery time while deliveries by air are approximately 2 weeks. (Interview, Buyer for Company X)

While the costs and delivery times of railway transportation have been decreasing in the past 2 years, sea transportation costs however have increased slightly. Therefore, it has become necessary to recalculate the TCO for both transportation modes. Air freight will also be calculated to get the values for comparison. The calculations will only include the 3 most ordered material codes that were included in a shipping file received from the supplier during the timespan from 25 September 2016 – 1 January 2017. The safety stocks for these 3 material codes vary depending on consumption and as such they are calculated from the average consumption during the last 12 weeks.

## 2   Logistics theory

According to Ulla Tapaninen (2013: 34), the definition of logistics is controlling the flow of materials from the source of the raw materials to the end consumer in a way that makes the product available at the right place, at the right time while minimizing the costs of all the processes and other drawbacks such as negative environmental impacts and safety risks.  In addition to the transportation and warehousing of materials, logistics also includes the planning and review of social and environmental impacts of currency and information flow. Logistics is also minimizing all of the unnecessary transportation and warehousing.

The mode of transport defines the transport type. Rail, sea, road, air and pipeline are the five transport types and each of them have their own strengths. When choosing a transport type, the cargo type, the travel distance, starting location and destination, the value of the cargo and many other things need to be considered. (Waters 2003: 310.)

One way of defining freight transport is that it is the movement of goods between areas. It allows the consumption of goods to transpire at a different place than the production of the said goods. Freight transport empowers companies to acquire goods and materials from other companies while specializing in their own core competence.

Freight carriers and freight infrastructure make up the supply part of freight transportation. While Demand is made up with companies that have the need to move goods or materials. [NCFRP. 2011.]

2.1 Maritime transportation theory

According to Rushton et al. (2010: 338) there are six core characteristics for sea freight. The first one being cost economies; sea freight is still the most economical option for most goods that are being transported globally. The second core characteristic is the availability, harbors are located in various locations so access to sea freight is widely available. Harbors usually also have the equipment to handle most types of cargo. Speed is the next core characteristic, while sea freight is a low-cost option, it is also quite slow due to the time it takes to load and unload in harbors as well as the actual transportation time between ports.

The fourth core characteristic has to do with the need to double handle the cargo. Slow handling methods are still in use for conventional sea freight. Especially when comparing the conventional sea freight to, for e. g., through transport systems. The slow cargo handling has an even larger impact on shorter sea routes. Delay problems make up the fifth core characteristic. Sea freight is vulnerable to several factors that can impact the regularity of the transport. Delays can happen before the shipment as well as the discharge port. There are also delays that are due to unexpected changes in weather or tides. The last characteristic is damage to the cargo due to the above mentioned double handling, since the more the ports have to handle the cargo, the larger the risk there is for the packaging or the goods inside to be damaged.

2.1.1 Maritime transportation costs

In the book, Handbook of Maritime Economics and Business (as sited in Merenkulun Logistiikka 2013: 39-40.) the authors mentioned that maritime transportation costs are divided into 6 parts

- Distance, the effect of distance is usually over exaggerated, as for e. g. while shipping containers, it only accounts for about a fifth of the cost difference in different transportation modes.

- The size of the shipment. The more you ship, the more the unit cost reduces. Building a bigger container ship usually costs only about half of a smaller container ship in relation to transported units while usually requiring the same amount of crew.

- Trade balance. E. g. in the container transport from Asia to Europe, due to there being less freight transported from Europe to Asia and having more space on the container ships, the freight forwarder can offer reduced prices for transportation.

- The value and type of the cargo. The more value the cargo has, the more detail should be put in the handling of the cargo and the more capital costs it will include. So, expediting the transportation is necessary. In turn, the more valuable the cargo is, the more additional delivery costs can be added to the price, without increasing the price of the product significantly.

- Transport connections and competition. The competition between different transportation modes and freight forwarders decreases the price of transportation. The price increases if there is no direct route between the starting point and destination. In these cases, the freight needs to be moved from one ship to another. E. g. from Asia to Finland the containers need to be moved to smaller container ships before entering the Baltic Sea. The freight forwarders usually have cheaper prices for the connecting transportation to aim at maximizing the capacity of the initial container ship.

- Harbors and other environments of trade. Physical infrastructure as well as working information flow and IT systems are major factors in harbor efficiency. Harbors usually try to reduce the time spent in the port thus lowering the price for the ship owners. Well-equipped and efficient harbors might have to collect increased payment for using the port to cover their initial investment costs.

### 2.1.2 Maritime transportation risks

The environment of maritime transportation has numerous risks. The weather and natural conditions are demanding enough to make even the biggest ships change course. Also, accidents can make a shipping company lose freight, ships, or crew.

Piracy has also been an issue during the last years, the Red Sea and the Indian Ocean being the two most dangerous areas due to Somali pirates operating there. Also, the South-China Sea and the nearby area of Singapore are among the most dangerous areas. Pirates usually hold the cargo or the crew for ransom while robbing anything valuable from the ship and crew. (Tapaninen 2013: 119 – 120.)

At the harbors, strikes can cause severe delays to the supply chain. These are cause by disputes with the labor force and management but e. g. in the US most of contracts are handled without a strike. (How dock strikes have effected the economy historically and today: 2012.)

The current limit of sulfur in fuel emissions for sea freight was set to 3.5% from 4.5% in 2012. As of 2020 the sulfur content has to be decreased to 0.5% in marine fuel. This will impact upcoming prices of sea freight. In comparison, North-America and northern Europe reduced sulfur to 0.1 percent in 2015 (Container lines face looming threat as 2020 low-sulfur fuel cap is affirmed. 2015)

## 2.2 Rail freight transport

The main use for railway transportation is the delivery of large and bulky goods. The railway is used for long distance transportation. The benefit of railway transportation is that the trains are capable of maintaining consistent high speeds. Trains can connect easily to other transportation modes such as ships, planes or trucks. (Waters. 2003: 310-311.)

Rail freight has benefited from the development of containerized systems for intermodal transportation such as the ISO containers as well as the swap-body containers (Rushton et al. 2010: 339).

### 2.2.1 Strengths and weaknesses

Trains can maintain high speeds during transit and can utilize any given width of space on land so effectively that it can move more freight than other land-based transportation modes as well as handle weather changes more effectively. Trains are very cost efficient when carrying bulk materials due to having a high cargo capacity. Effective use of energy

and the possibility to use electricity over oil-based energy sources makes trains a viable choice for green transport. Trains have a good safety record and can also possibly be made fully automated.

Financially the railway system is exposed to decline in economic activity. The traffic quantity can experience a decrease when in recession while the fixed costs of running the infrastructure will continue to be the same. Once the railway's infrastructure is built, you cannot move the rails with ease, so trains are not able to adjust to large-scale changes in industrial locations. As the infrastructure is not flexible, the railway system is most of the time an intermodal mode of transportation, meaning that the cargo will have to be moved to other modes of transportation in order to reach the destination. (Rushton et al. 2010: 392-393.)

2.2.2   Rail transportation risks

Increasing cargo volume and railway traffic create challenges to safety in transportation. To make transportation reliable, you need to ensure the safety of the transportation. Developing and securing the safety of railways transportation includes identifying and preparing for risks. Risk management should be systematic and the operation should be aware of the risks. The railway system creates a significant amount of labor, since the employees are usually part of unions the railway system is subject to actions such as strikes and as such will discourage some companies from using the railway system for their businesses. [Rushton et al. 2010: 393].

There has been a lot of research about risks on railways, but mostly for passenger traffic. In freight transportation, the focus has been on the transportation of dangerous goods. [Kallionpää et al. 2008: 8.]

Rail freight is predisposed to extreme shocks while in goods yards. This can damage the packaging or goods and will require extra attention while designing the packaging for the product. While using rail freight, you will likely have to double-handle the cargo due to road transport being used to get to and from the railway stations. It is very rare for a company to have a direct route to their premises using railway. Having this also adds costs due to the price of upkeep.

Rail freight transport has to schedule their voyage around passenger trains, making travel times longer and causing delays. It can also be unreliable in international traffic due to the need to have all train wagons that are mentioned in customs documents on one single shipment. These wagons might be coming from various locations at different times. Also, the differences in track widths and heights of bridges can cause compatibility problems while moving across Europe. (Rushton et al. 2010: 339-340)

## 2.3 Container systems

Containers play an important part in international transport in the four major transport modes as it is used in sea, air, rail as well as road transport. Intermodal transport is made possible by the development of these container systems as they make the movement of cargo from one transport mode to another fast and efficient excluding air freight as it uses different containers. When loading a container full of smaller packages, it reduces the number of units that need handling to one.  The container protects the original goods from other cargo which then reduce the insurance costs. Handling costs are also reduced due to the container being standardized, which also reduces overall travel times from the handling as well as the documentation needed being simpler.

## 2.4 Packaging requirements

The packaging of goods needs to be able to withstand a number of different transportation hazards. These hazards can also vary between the different transportation modes. There are five main hazards in transportation: shock, vibration, compression, extreme climate conditions, and altitude.

There are several reasons why shock can occur. Shock can happen both during the handling as well as while transporting it due to an impact with other packages in the shipment. The movement can cause the package to collide with other packages or fall if it is not properly secured.

When goods are being transported, the package may be predisposed to vibrations. This can happen while being moved by a forklift or while being in transit in a container. Vibration levels differ depending on the mode of transport. While being transported by a freight

plane or a container ship, vibrations tend to be of minimal amplitude. On the other hand, when being transported by road or a railcar, the packaging needs to be able to withstand much higher amplitudes.

Compression can be a static or a dynamic condition. Static compression happens when the shipment is not moving, so that the weight of the top packages affects the packages at the bottom. Once the shipment starts to move, the compression is dynamic as the forces will be both vertical as well as lateral.

The environment may subject the packaging to many different conditions. Temperature can be in range of -45 °C to 60 °C and the relative humidity inside the shipment can be 100%. This can be countered by having a temperature controlled container.

Altitude can be a problem while cargo travels by aircraft. The shipments can be in a cargo space that is not pressurized, but freight planes also have a pressurized cargo space. (Guide to packaging freight shipments. 2014.)

# 3   Total Cost of Ownership

The TCO calculations were made with an already existing calculation tool that was slightly modified to fit the needs of this project. Information about freight costs were taken directly from the official freight calculation tool of company X.

The TCO calculations are made to determine the full cost of owning a material, it takes into account the unit price of the material as well as the cost of all of the related operations. It considers both the direct as well as the indirect expenses caused by the ownership. Companies need to know the full cost of ownership when purchasing goods or while making investments to know the long-term costs. (Total Cost of Ownership – TCO)

## 3.1   Basic information for calculations

All the information needed for the calculation tool was supplied internally by company X. The pallet size used is a standard EUR-pallet, sized at 80 x 120 x 80 cm, since these

box builds are the same size, the EUR-pallet holds 77 units. The container used is a 40'
container holding 30 pallets.

Table 2 in appendix 2 shows the pallet freight costs for each transportation mode as well
as the material unit cost and gross unit weight. As the table shows, the sea as well as
rail transportation have set costs for pallets while the air freight cost differs due to taking
in count the weight of the materials. The costs also include the necessary road transports
from the starting location to the harbor, railway terminal or airport as well as the transport
from those three places to the final destination of the warehouse in Menden, Germany.

Figure 1 in appendix 2 shows the difference in the transport costs per pallet.

The freight calculator showed the freight prices in the unit of containers, that price then
had to be adjusted to pallet unit by dividing the container cost with the number of pallets
that fit in to the container.

Table 3 in appendix 2 shows the lead time, which is the time it takes for the material to
become available for transportation from the time the order has been placed. It also
shows how different the transit times are for each transportation mode, sea transporta-
tion taking over 4 times as much as air transportation while rail takes only double the
time of air transportation.

The domestic transit times take in count the transportation days it takes from the factory
to the respective harbor, railway station or airport in the country of origin. As well as the
transport time from the harbor, railway station or airport to the central warehouse in the
destination.

Figure 2 in appendix 2 shows the transport times in a graph form. The lead time being
the same for all three different transport modes, while the biggest differences come from
the actual transit time the domestic transit time also differs due to the time it takes to and
from the harbor.

Figure 3 in appendix 2 shows the expected stock levels for all three material codes and
separated by the different transport modes. It consists of the safety stock, the rolling
stock as well as the in-transit stock. These values are listed in number of units.

Table 4 in appendix 2 shows the safety stock levels for each material code and transportation type. These values were given from Case Company X's calculation tool. The difference in safety stocks for each material code derives from the difference in demand and statistical deviation of demand. These values are changed from number of units to days to fit the calculation tool.

Table 5 in appendix 2 shows the current stock that is in the system, current in transit stock as well as the new in transit stocks for rail and air freight. The new in-transit stocks were calculated by taking the daily demand and multiplying it by the number of in-transit days. These are used to calculate the net working capital.

## 3.2 TCO and savings calculations

The total cost of ownership is the sum of the material unit price, total transportation and logistics costs and working capital costs. The material unit price is the unit price shown in table 2 [in appendix 2].

### 3.2.1 Total transportation and logistics cost calculation for TCO

The total transportation and logistics cost is calculated with the formula below

$$\frac{Pallet\ freight\ cost}{units\ per\ pallet} + unit\ material\ cost * \frac{duties\ and\ taxes}{100}$$

Where

- Pallet freight cost is taken from table 2 [appendix 2].

- Units per pallet is a material specific amount.

- Unit material cost is taken from table 2 [appendix 2].

- Duties and taxes were a predefined percentage given by Case Company X.

- 100 is to transform the % into decimal.

### 3.2.2 The working capital cost calculation for TCO

The working capital cost is calculated by taking the company's current assets and deducting the current liabilities, but in this thesis the liabilities are not considered. The current assets are a sum of the on-hand inventory and in transit inventory. Below are the calculations for each type.

On hand inventory:

On hand inventory is calculated by taking the safety stock and multiplying it by the unit material price that has been divided by 365 and multiplying that by the inventory valuation.

The safety stock is the amount of extra quantity of goods kept in storage to act as a buffer as sometimes the sales volume spikes. In this calculation, it is measured in days, as in how many days the average consumption can take from the safety stock before it runs out. The safety stock can also be measured in e. g. units or weeks. (What is safety stock.)

$$safety\ stock * \frac{unit\ material\ price}{365} * Inventory\ valuation$$

Where:

- Safety stock is from table 4 [appendix 2].

- Unit material price is from table 2 [appendix 2].

- 365 are the days in a year.

- Inventory valuation is a predetermined value given by Case Company X.

In transit inventory:

In-transit inventory is calculated by taking both the transit time as well as the domestic transit time and multiplying those by the unit material price that has been divided by the

days in a year. And finally multiplying those by the annual weighted average cost of capital.

The weighted average cost of capital, or WACC is a calculation of a company's capital cost where all of the capital categories have been weighted. For each euro the company finances, the debt can be determined.  (Weighted Average cost of Capital – WACC)

$$(Transit\ time + Domestic\ transit\ time) * \frac{unit\ material\ price}{365} * Annual\ WACC$$

Where:

- Transit time is taken from table 3 [appendix 2].

- Domestic transit time is taken from table 3 [appendix 2].

- Unit material price is from table 2 [appendix 2].

- 365 are the days in a year.

- Annual WACC is a predetermined percentage given by Case Company X.

### 3.2.3   Calculation results

The total cost of ownership calculation was made and showed clear differences between different transportation methods and materials. In this case the transportation by air was always more expensive than the other two options, while sea transportation was still the cheapest even when factoring in the changes in warehouse stock.

Figure 4 in appendix 3 shows the total cost of ownership results per 1 unit, this is the cost of owning 1 piece from ordering to the delivery point.

Table 6 in appendix 3 shows the total cost of ownership for a full container of each material. The price varies for each material, and the mode of transportation also has an effect to the price.

The annual transportation costs shown in table 7 in appendix 3 were calculated by taking the transport cost of 1 piece and multiplying it by the quantity ordered in a year. This was carried out for all material codes and transportation modes. The price differences of each transportation mode were calculated from these numbers, showing that when going from sea to rail freight, the transportation cost increased significantly for all three material codes. While going to air transportation the costs rose even more for all three materials.

The formula for net working capital is:

$$Current\ transit\ inventory\ (sea) + current\ average\ inventory \\ - new\ transit\ inventory\ (rail) - new\ average\ inventory$$

These values were calculated in USD.

Table 8 in appendix 3 shows the savings in stock when switching from sea to rail freight and from sea to air freight. As seen, the price difference between material codes varies due to differences in amounts of goods in the warehouse.

The total price difference can be calculated by taking the increased transportation costs and deducting the decreased amount that comes from minimizing the safety stock and in transit stock.

Table 9 in appendix 3 shows the total price difference when switching from one transportation mode to another. The amounts for all material codes increase when switching from sea freight to air or rail freight.


## 4   Conclusions

To sum up, with the current price levels, it can be seen that using the railway would not be a viable option. Sea freight offers lower prices, and with proper emphasis placed on production planning, the correct warehouse levels can be predicted with high accuracy. Sea freight can be complimented with ordering by air, for goods that need to be delivered faster. If railway prices continue to decrease, it might be useful to do these calculations again.

At this moment, the rail freight price has to drop by about half to be considered a viable option. If sea freight prices suddenly increase due to the upcoming low-sulfur regulations, and railway freight traffic increases between China and Europe, the possibility of switching from mainly transporting goods by sea freight to using rail freight as the main option could be feasible.

The risks for both railway and sea freight are quite similar, both have their unique aspects but that does not make a big difference in the final outcome.

The prices need to be calculated for each material code separately, the changes in order volume as well as order frequency differ too much to make conclusions on just a sample size.

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**Company background**

**Tables and figures**

**Calculation results**