

Managing intermodal hinterland networks

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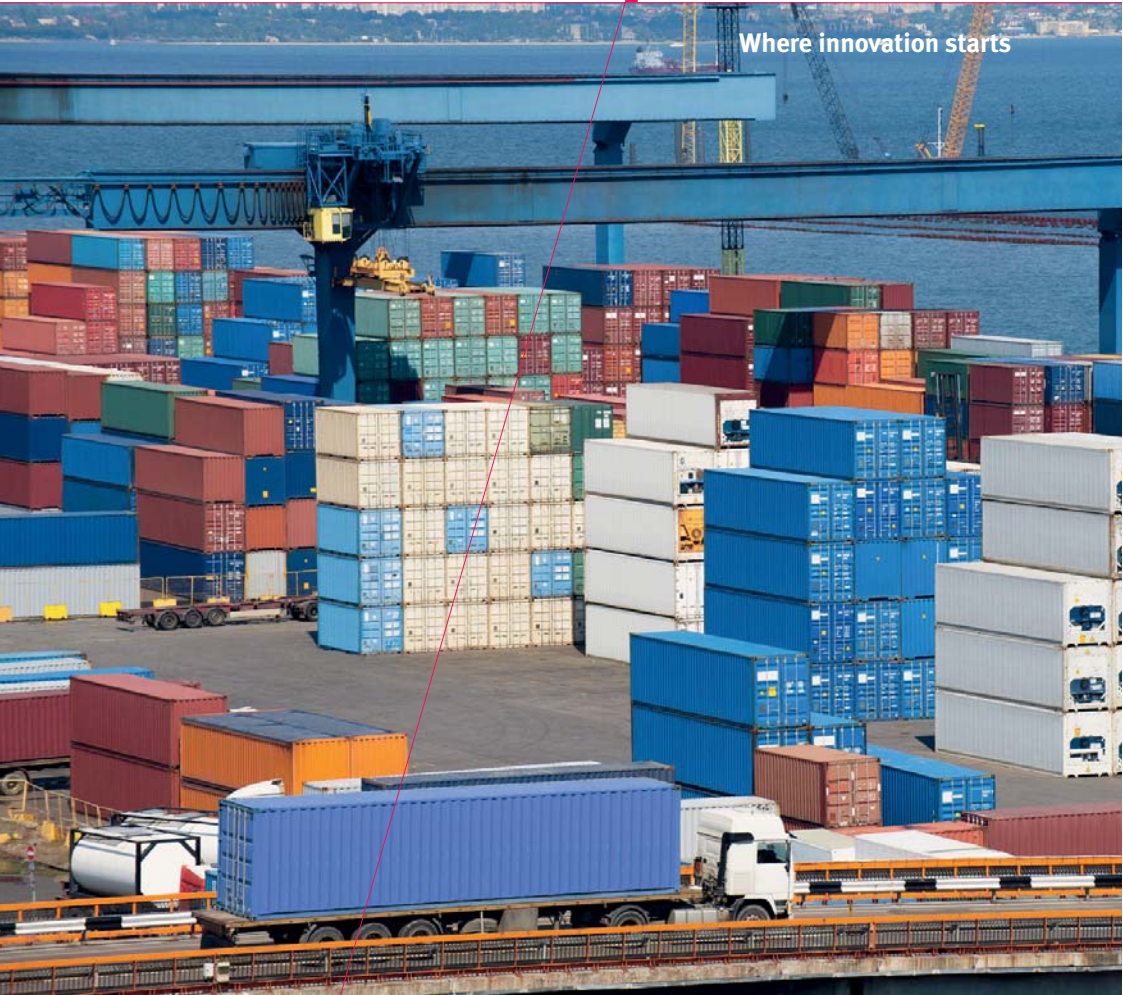
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**ESCF Operations Practices:
Insights from Science**

**Managing intermodal
hinterland networks**

Managing intermodal hinterland networks

Analyzing potential cost savings by applying cargo driven intermodal transportation in the hinterland

Concise summary of this Operations Practice

The hinterland is the inland region in connection with a port. Compared with the full distance traveled by a container from origin to destination, the distance covered in the hinterland is typically relatively small. However, this part is increasingly recognized as a key part of the overall container transportation chain, as the proportion of hinterland costs relative to the total container transportation costs ranges from 40% to 80%. In this Operations Practice, a series of new managerial insights is proposed for the management of intermodal hinterland networks at the container level. Furthermore, the study takes a look at the cargo inside the container, by examining the feasibility of on-dock transloading and cross-docking. The main results can be summarized as follows:

- Intermodal transportation projects are viable for short and medium distances if the volume is big and the origin/destination drayage distances are low.
- Shippers should request quotes that depend on the volume shipped from intermodal service companies and inland terminals.
- Coordination may be critical for successfully implementing an intermodal hinterland network even if the value of such coordination may be quite low.
- About 10% of the dry containers imported via the port of Rotterdam apply for transloading and the average saving per 40-foot container would be about € 20.
- On-dock transloading and cross-docking is of limited interest for fresh and frozen products with the current logistical settings in the Netherlands.

Key Terms

Transportation, containers, shipping, intermodal.

Relevant for

Companies that import or export goods using containers, terminal operators, third party logistics providers, companies providing intermodal services, port authorities.

Intermodal transport in the hinterland

To achieve economies of scale in ocean transport, sea vessel sizes are increasing, as this enables saving fuel and labor cost. This increase in vessel size, illustrated in Figure 1, leads to a concentration of the volumes in major ports. In addition to this, the total container volume is growing as a global trend.

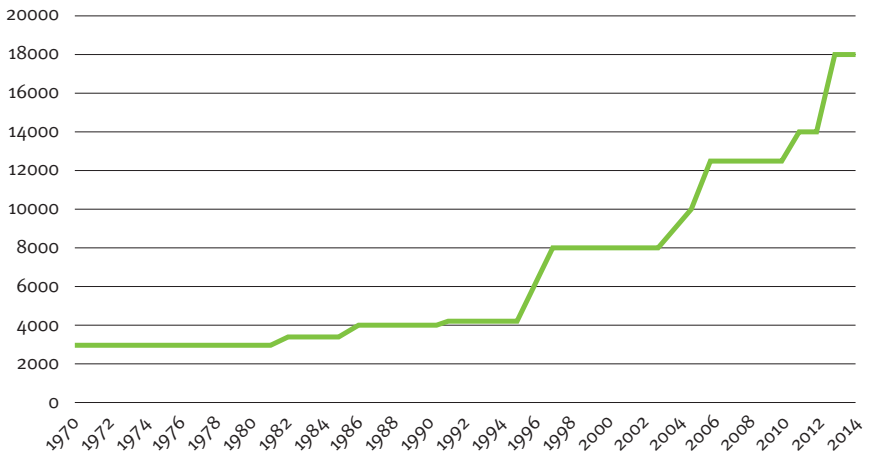


figure 1

The biggest available container vessel

These developments put much pressure on deep-sea terminals and ports, and moreover, highlights issues such as hinterland congestion and resulting safety and environmental concerns. Hence, there is a requirement for more capacity for hinterland transportation, together with a better use of the existing transport alternatives. For instance, the container terminals of Maasvlakte 1 and the new terminals of Maasvlakte 2 in the port of Rotterdam can only be accessed by a single motorway. With the growth in volumes handled at Maasvlakte, accessibility of the Port of Rotterdam by road will become increasingly difficult. This creates a need for a better use of intermodal transportation solutions.

Intermodal transportation involves using several modes of transport to deliver the container to its final destination. In the context of the hinterland, the idea behind

intermodal transportation consists in having the container leaving the port by barge or train to reach an inland terminal and to use trucks for final delivery. The segment from the port to the inland terminal is referred to as the linehaul (carried out by barge or train). In addition, drayage is often required from the inland terminal to the final destination (carried out by truck). Drayage is the term used for truck pickups from, or delivery to: a seaport, border point, inland port, or intermodal terminal, within the same area.

In this best practice, we compare direct shipment by truck with intermodal transportation. In the latter case, barge or train is used in the linehaul, and this leads to an increased efficiency. On the other hand, drayage is required in case of intermodal transportation, and this often increases the total distance traveled. This is the basic tradeoff that will be investigated. Figure 2 depicts the classical journey of a container from origin to destination. Upon arrival at the deep-sea terminal, the container typically needs to wait some time, which is referred to as the dwell time. Subsequently, the container is transported into the hinterland (either by truck-only transport or by intermodal transport) until it reaches the final destination. The container is unloaded and delivered back to the port or a depot.

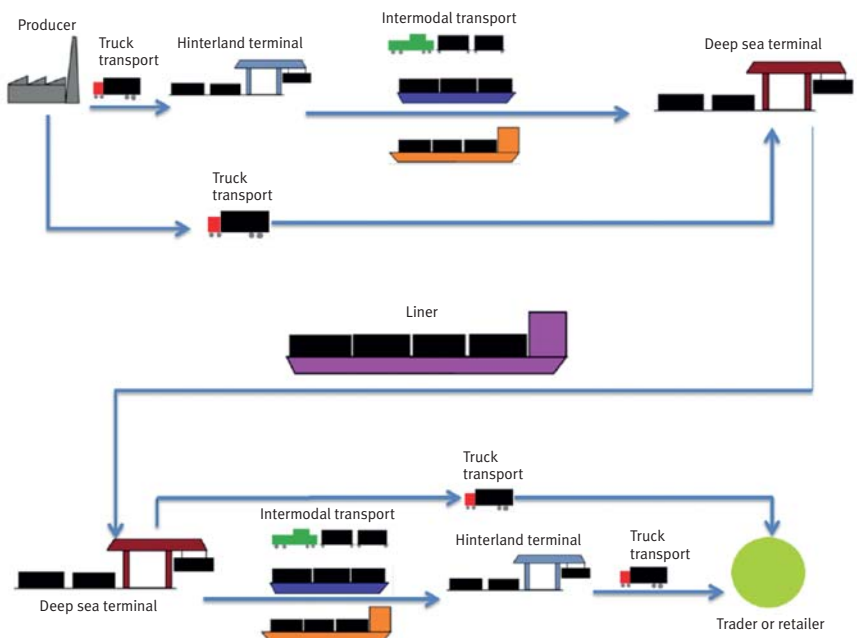


figure 2

The container supply chain

Figure 3 displays some inland terminals connected to the Port of Rotterdam. As can be seen, the intermodal network is well developed in the hinterland of the Port of Rotterdam. In order to improve the efficiency and reliability of hinterland transportation, the dynamics of intermodal transportation needs to be better understood, so that existing and new solutions can be evaluated.



figure 3

Inland terminals connected to the Port of Rotterdam

Demurrage and detention

The classical flow of containers is depicted in Figure 4. When the shipping line that does the sea transport is also responsible for delivering the container to the final destination (carrier haulage setting), it will make sure that the containers used for transport are recovered from the destination as fast as possible, and the client pays a fixed fee which is independent from the time the container spends in the hinterland. However, when the shipping line is only responsible for the ocean transport (merchant haulage setting), the client pays a variable *demurrage* and *detention* fee, in function of the time the container spends in the hinterland. Demurrage represents the charge for the time the container overstays at the deep-sea terminal, and detention applies to the time the container stays outside the sea terminal, in the hinterland.

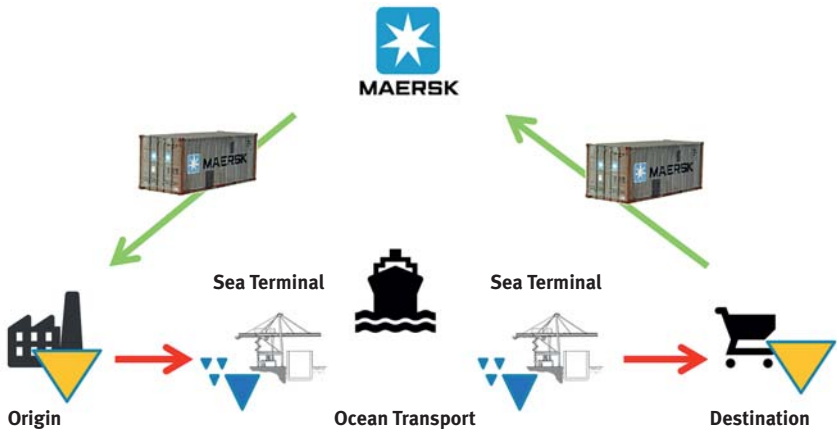


figure 4
Container transport flow

The rationale for the shipping line to charge such fees are not only related to generating local revenue, as they also include the following aspects:

- Control – the shipping line needs to carefully plan the flow of containers and the shorter the time the container is in the hinterland, the more control the company has over the container.
- Utilization – the containers owned by the shipping line are an important asset and these must be utilized as good as possible.
- Promoting own transport services – by charging demurrage and detention, the shipping line can stimulate its clients to also use the hinterland transportation services of the shipping line company (i.e. to move from merchant haulage to carrier haulage).
- Avoid storage – some clients might be tempted to use containers as a means to store inventory. The shipping line wants to discourage its clients from doing so, as this would mean that the shipping line needs much more containers.

Hinterland operations at the cargo level

The increase in competition between terminals in the port of Rotterdam caused by the opening of Maasvlakte 2 also challenges the terminal operating companies to explore solutions that may improve their competitive advantages. In this Operations Practice, we explore the advantages of “looking inside the box”, i.e., to manage hinterland transportation at the cargo level (in addition to the classical management at the container level). Two practices are studied, i.e., transloading and cross-docking. In case of transloading, the goods from one maritime container are moved as a whole into a trailer or a continental container. In case of cross-docking, goods from various maritime containers are combined, mixed and loaded into a trailer or a continental container. Transloading and cross-docking can be carried out on-dock (i.e. at the deep-sea terminal), close to the dock in the port’s area (near-dock), or at an inland terminal.

The idea behind cargo-driven intermodal transportation consists in opening the maritime containers on-dock or in the vicinity of the port. This allows for recombining the load as well as for using continental containers or trailers for delivery to the final destinations. Maritime containers are not optimized for hinterland transportation, as the dimensions of such containers do not allow for utilizing their capacity fully when the cargo consists of euro pallets. A 40-foot maritime container has a capacity of 26 euro pallets compared to 33 euro pallets for a trailer or a continental container. Second, the shipping lines who generally own the containers apply detention and demurrage fees when the container is kept for too long in the hinterland. Detention and demurrage fees may negatively impact the matching between import and export, leading to more movement of empty containers. If the maritime containers are opened on-dock or in the vicinity of the port, they can be sent back quickly to the shipping line, thereby avoiding detention fees. The cargo can be transloaded into a continental container or a trailer with higher capacity, leading to a more efficient use of the existing intermodal transportation capacities. In addition to transloading, cross-docking operations may be performed. Cross-docking implies that several import maritime containers loaded with a single type of cargo for several destinations are recombined into continental containers or trailers with several types of cargo and a single destination. The assumed benefits of transloading and cross-docking are:

- An increase in the modal shift from road to barge and rail
- Attracting additional cargo flow through the port of Rotterdam
- A reduction of empty container transport

In this best practice, the dynamics of hinterland intermodal transportation are analyzed. Subsequently, the potential of on-dock transloading and cross-docking is modelled and the results are presented.

Understanding the dynamics of hinterland intermodal transportation

The dynamics of hinterland intermodal transportation at the container level needs to be understood, to assess the impact of transloading and cross-docking. Although the scientific literature may help in selecting models, we noted that for industrial partners, it was difficult to apply such models to practice. Therefore, new models have been developed to understand the dynamics of the hinterland supply chain, when intermodal transportation is considered as an option. Two main aspects are investigated in these models:

1. The impact of modal shifts on costs and carbon emissions.
2. The interaction between actors in the hinterland logistics sector – the extended gate concept.



1. The impact of modal shift on costs and carbon emissions

Intermodal transport and drayage

Intermodal freight transportation is often presented as a green practice by default, as trains and barges, which are the typical modes in this case, emit less carbon emissions than heavy duty trucks. Consequently, it can be stated that when intermodal transportation can compete against trucks regarding costs, the objective would be to maximize the number of ton.km shifted from the road. In promoting intermodal freight transportation, the objective is therefore typically expressed as the amount or percentage of ton.km shifted from the road. In line with this, the objective of the European Commissions is that “30% of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050” (EC, 2011).

However, intermodal transportation often leads to an increase in the distance travelled, due to origin and destination drayage. As a result of drayage, the carbon intensity of intermodal transportation can be higher than for direct truck transportation (see also Craig et al., 2013). This is not only due to the increase in the distance travelled, but also a consequence of the fact that older trucks are often used for drayage transportation, and these emit more carbon.

Efficiency gain and distance travelled

We focus on the tradeoff between the efficiency gain in the linehaul and the increase in the distance traveled. More specifically, the optimal inland terminal location will be determined, as this determines the increase in distance traveled. This will be done by analyzing the total costs and carbon emissions for intermodal transportation. Figure 5 depicts the total cost and Figure 6 the total carbon emissions for an intermodal train/truck transportation in the Netherlands. As it can be seen, the cost function is composed of three terms:

1. The cost of truck transportation depends on the volume and on the average distance traveled.
2. The fixed train transportation cost depends on the distance traveled by train and is independent of the volume. It represents the fixed cost of running the service.

- The linear train transportation costs depends on the distance traveled by train and on the volume. It represents the additional cost of shipping an extra container on a train.

The carbon emissions share the same structure of the cost with different parameters. According to Figure 5 and Figure 6, the terminal is optimally situated at 228 km from the port when optimizing emissions and at 130 km when optimizing cost. The fixed train emissions are comparatively less important than the fixed train cost, and this explains why the terminal is located closer to the port when optimizing cost.

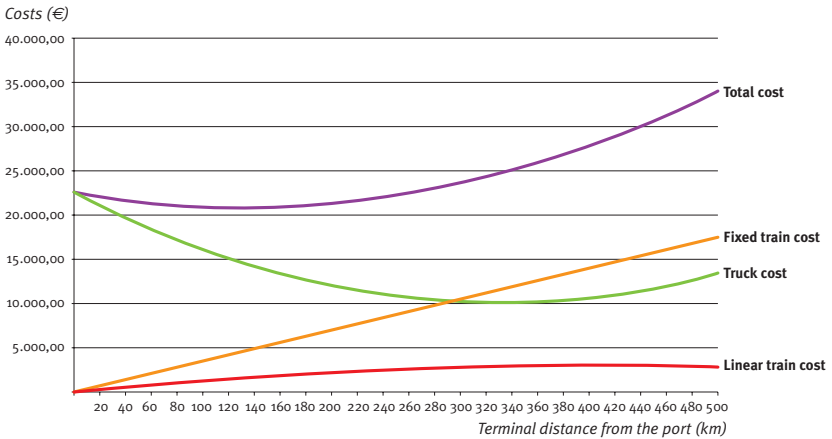


figure 5
Cost analysis

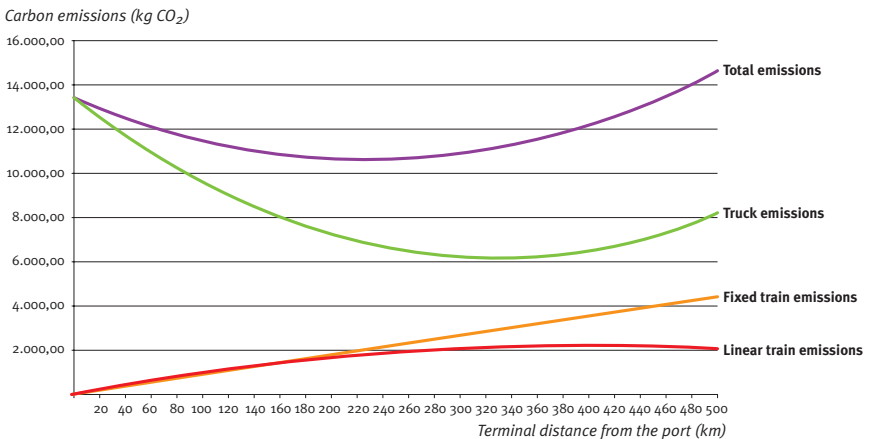


figure 6
Carbon emissions analysis

Figure 7 depicts the variation of the modal shift in function of the terminal location. The modal shift is expressed as the percentage of ton.kilometers shifted from the road compared. This graph, which shows the modal shift in function of the distance from the port to the terminal, is driven by two conflicting elements:

- A. The volume for intermodal transportation is decreasing, when the terminal is located further from the port.
- B. The distance used for train transportation is increasing, when the terminal is located further from the port.

These two factors yield an optimal value in terms of modal shift, when the terminal is located at 333km from the port. However, locating the terminal at such distance would imply increasing the cost and the carbon emissions compared to the carbon optimal terminal location (i.e., locating the terminal at 228 km from the port).

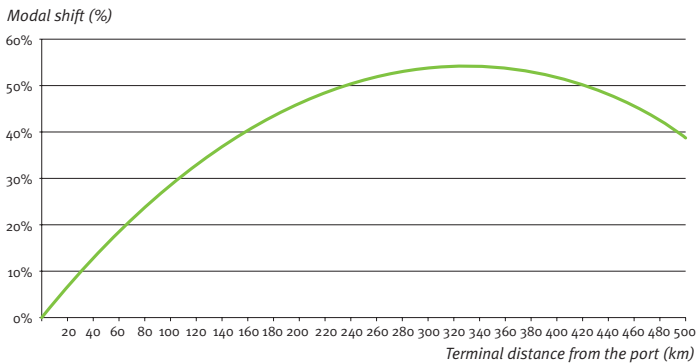


figure 7

Modal shift analysis

Reducing carbon emissions

In practice, measuring the carbon emissions from intermodal transportation is not an easy task. This requires intensive data gathering and making many approximations. The modal shift is consequently often used as a proxy for carbon emission reduction. For instance, the Marco Polo program supported by the European Commission was subsidizing intermodal projects based on the modal shift achieved. However, the results we present here show that this may be misleading: there is an optimal level for modal shift regarding carbon emissions. At other levels, making the modal shift will be harmful for the environment.

In addition, our results show that intermodal transportation may be viable for short distance as the cost optimal terminal location consists in using intermodal transportation for only 130 km. This result seems contradictory with the current European Commission's guideline that targets shipment over 300 km. Our model indeed takes economies of scale into account and, in addition, we consider that the volume shipped by intermodal transportation is decreasing in the distance from the port to the inland terminal. This feature is consistent with current trends in Europe: only 11% of the volume is transported over a distance greater than 300 km for road transport in Europe (Tavasszy & van Meijeren, 2011). We conclude that intermodal transportation projects are viable for short and medium distances if the volume is large and the origin/destination drayage distances are low. This insight is consistent with industry examples in the Netherlands, which show that intermodal transportation can be efficient even for short and medium distances when volumes are large when there is no origin drayage.

The common practice for estimating intermodal transportation cost is to share the fixed train transportation cost between the users by dividing this cost by the average number of containers shipped, leading to costs per container.km or per ton.km. When focusing on carbon emissions, the methodologies for estimating carbon emissions from transportation typically accounts for an average load factor and end up with average carbon emissions intensity per container.km or per ton.km. Our model allows for a more precise analysis by splitting the train transportation factor in two terms: 1) the impact of running the train empty (i.e., running the service) and 2) the impact of adding one container to the train. If we assume that thirty 40-foot containers are loaded on the train on average, we can obtain a new optimal terminal location that minimizes the modified carbon emissions function (that is based on the average load factor). We obtain that the optimal terminal location is situated at 280 km from the port, i.e., quite close from the optimal location in terms of modal shift.

Estimating intermodal transportation cost and emissions based on average utilization leads a biased focus on long distances and a maximized modal shift. Our results show that considering flow dependent economies of scale is of crucial importance when assessing an intermodal transportation project.

2. Interaction between actors – the extended gate concept

Container dwell time at deep-sea terminals is a major key performance indicator for most ports worldwide. A long dwell time causes issues such as a shortage of container storage capacity and a decrease in terminal efficiency. Table 1 shows the average container dwell times in some major European ports in 2003. Based on discussion with experts, it is noticed that the average container dwell times tend to increase compared to 2003. This trend may partly be explained by shippers' behavior: they increasingly use deep-sea terminals as cheap storage locations. This implies that high dwell times are no longer necessarily an indication of poor connection between the port and its hinterland.

Characteristics	Bremen	Hamburg	Rotterdam	Antwerp	La Spezia	Gioia Tauro
Import dwell vessel-truck	6,4	6,4	6,4	6,4	7,4	7,4
Export dwell truck-vessel	4,6	4,6	4,6	4,6	5,6	5,6
Import dwell vessel-train	6,5	6,5	6,5	6,5	7,5	7,5
Export dwell train-vessel	4,7	4,7	4,7	4,7	5,7	5,7
Import dwell vessel-berge	4,1	4,1	4,1	4,1	5,1	5,1
Export dwell berge-vessel	4,3	4,3	4,3	4,3	5,3	5,3
Transshipment dwell	–	–	–	–	–	5,3

table 1

Average dwell times in European ports in 2003 (expressed in days) (source: Rodrigue and Notteboom, 2009)

A mitigating strategy for the deep-sea terminals could consist in transferring the temporary storage function to inland terminals where land availability is less of an issue. This strategy may help increasing terminal throughput as the size and fill rate of the yard has an effect on operations efficiency. This strategy may be implemented via the concept of the extended gate.

An extended gate is an inland terminal connected to a deep-sea terminal by a direct rail and/or barge connection where the shippers may pick-up and leave their containers in the same conditions as at the deep-sea terminal, i.e. with the

same services provided, such as custom clearance. The deep-sea terminal controls the flow of containers to and from the extended gate (Veenstra et al., 2012). The concept is currently developed in Europe but this one may also be of interest in other regions. Figure 8 illustrates the extended gate concept: the squares represent origins and destinations served by the port. These locations can be served either directly by using truck transportation or they can pick-up and leave their containers directly at the extended gate and thus use intermodal transportation (rail and truck, or barge and truck). The shippers decide whether or not to use the extended gate.

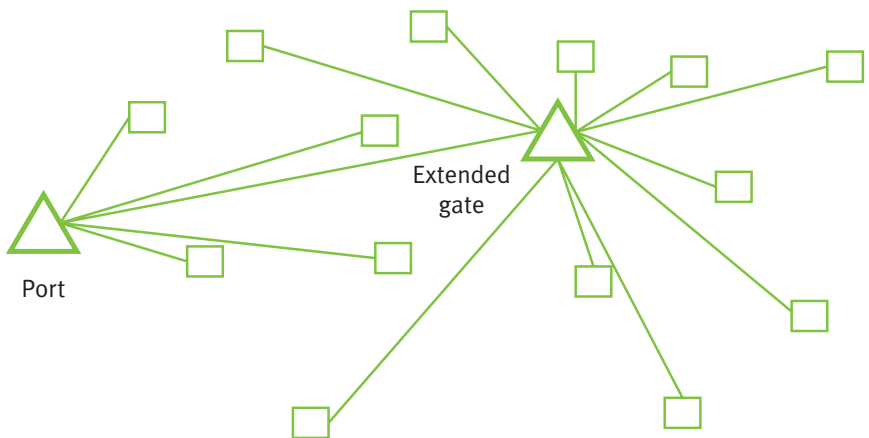


figure 8

The extended gate concept

Suppose that a deep-sea terminal operator wants to increase its throughput by opening an extended gate. The operator needs to decide on where to locate the extended gate – generally among a set of potential inland terminals. The customers of the gate are of major importance for successful implementation, as they will decide whether or not they will use this service. So the reasoning in creating extended gates can be summarized as follows:

1. The terminal operator decides on where to locate the extended gate.
2. The shippers decide if they want to collect their containers at the deep-sea terminal or at the extended gate.
3. In case they decide to use the extended gate, they pay for train transportation and extra handling costs.
4. Hence, the goal of the terminal operator is to select a gate location that creates a profitable situation for both the operator and the shipper.

The study analyses the extended gate location problem focusing on import flows, but the results also apply to export situations. Another assumption in the analysis is that the extended gate is connected to the deep-sea terminal by rail, and again, the results also hold for other modes of transportation such as barges.

We consider two objectives for the location decision made by the terminal operator.

1. Minimizing the total cost
2. Maximization of the extended gate utilization

Several models were developed to assess if the total cost minimization and the extended gate utilization maximization lead to the same location decisions. In most of the cases, the two objective functions lead to different optimal solutions: the extended gate tends to be located closer to the port when the terminal operator aims at maximizing its utilization. Based on the results presented in the previous section, we conclude that extended gates may be located at less than 100 km from the port.

In addition, the models allow us to get insights into the dynamics of hinterland network design decisions with multiple actors. We focus on non-urgent deliveries as the shippers will tend to use direct truck transportation from the deep-sea terminal for urgent deliveries. In this context, the shippers are primarily focused on minimizing the transportation and handling costs incurred from hinterland deliveries. We model flow dependent economies of scale for train transportation and for transshipment at the extended gate.

When considering flow-dependent economies of scale, the optimal decision made by one shipper depends on the other shippers' decisions. For example, when multiple shippers will use train transportation, the price per container will decrease. We study the structural properties of what would be called a non-cooperative game in game theory, and we develop an algorithm that enables identifying all the possible outcomes. It turns out that the results are very sensitive to the fact that multiple actors interact. Not considering the multiple actor setting generally leads to being overly optimistic in terms of cost and extended gate utilization. This may even lead to misleadingly considering a project as viable. Understanding the dynamics of intermodal hinterland networks at the design phase of the extended gate project is challenging but pivotal.

In the base case, we assume that the shippers do not cooperate (multiple actors setting). This could lead to sub-optimal solutions, as compared to a fully coordinated system. However, full coordination would imply an increase in cost for at least one shipper, and a bigger decrease in cost for another one. We compare the results of the base case with the optimal solution in case of full cooperation, i.e. when the shippers coordinate all their decisions to minimize the total cost, as this would be the case if a single actor takes all the decisions.

The models allow for estimating the value of coordination, by comparing the results obtained with the multiple actor setting to the results obtained in case of full coordination (i.e. similar to the single actor setting). We show that coordination may be critical for successfully implementing an extended gate even if the value of coordination may be quite low.

Two case studies on the benefits of on-dock transloading/cross-docking

Case study 1: Fresh and frozen products

In this case study, we focus on on-dock transloading and cross-docking for fresh and frozen products in the port of Rotterdam. We started by estimating the total number of reefer (refrigerated) containers imported to the port of Rotterdam for 2015. This estimation was developed by combining several sources of information. The number of reefer containers imported to Rotterdam for 2015 gives us an estimation of the potential volumes that could be considered for transloading. Subsequently, we identified the main destinations of the cargo inside these containers. A key point when focusing on fresh products is the common presence of traders who act as intermediaries between the producer and the retailer. The traders who are receiving containers from the port of Rotterdam are mainly located in the Netherlands, i.e. the Westland region, Barendrecht and Venlo. As these traders are close to the port, the opportunity of transloading containers prior to their arrival at the traders seems limited. However, opening an on-dock transloading and cross-docking facility may also enable the traders to modify their business models. In this case, the cargo could be directly shipped from the port of Rotterdam to the retailers. In this analysis, we consider both options, i.e., the location of the traders as well as the location of the retailers receiving the cargo.

The effect of transloading cargo into continental containers (or into trailers designed for intermodal transportation) has been analyzed in the study, by first considering that the cargo inside one maritime container is transloaded into one continental container. This solution could be viewed as superfluous as it has no effect on transportation costs and implies extra handling costs. However, our analysis shows that transloading may be beneficial if the reefer containers require staying in the hinterland for at least 5 days. This calculation does not include the positive effects of such practice on empty containers repositioning and potential savings from reduction in inventory at the retailers. The analysis shows that the detention fees are the main drivers towards transloading.

We further investigate the potential of transloading maritime containers into 45-foot pallet wide containers or into trailers. This option offers 20% more volume. However, our results show that the extra volume provided may often not be

utilized because of weight limitations for truck and intermodal transportation. We conclude that transloading to 45-foot pallet wide containers result in marginal gains for fresh and frozen products. Finally, our study also shows that the impact of cross-docking seems marginal for fresh and frozen products.

We conclude that on-dock transloading and cross-docking is of limited interest for fresh and frozen products with the current logistical settings in the Netherlands, as most of such containers reach their destination within the 5 days window. The benefits of cross-docking and transloading – avoiding demurrage and detention – are proportional to the time the container spends in the hinterland, which is relatively short for fresh and frozen products. However, this case study provides very interesting insights for dry cargo: we can expect huge cost savings by transloading dry cargo (that does not require refrigeration) into continental containers as the average dwell times at the port of Rotterdam is currently around 7 days.

Case study 2: Analysis of on-dock transloading and cross-docking for dry cargo

This section summarizes the main findings of a case study performed in collaboration with a deep-sea terminal operator located in the port of Rotterdam. The main goal of this case study was to analyze what could be the outcomes of transloading the maritime containers on-dock, just after they are unloaded from the deep-sea vessel.

The practice of transloading the maritime container after their unloading from the deep-sea vessel (either on-dock or in the vicinity of the port) is common in the USA. A study estimates that 19% of all the containers imported from Asia to the USA should be transloaded from a total logistics cost perspective (Leachman, 2008). The study shows that this practice enables the large nation-wide retailers to apply postponement: they are able to postpone the decision of allocating the cargo to a specific distribution center, to the moment the cargo arrives in the USA, instead of the moment the cargo is loaded in China. The referred study estimates that this practice leads to a net saving of about 1.1 billion \$ per year for the US economy, by reducing the inventory levels at the retailers.

In addition to this saving in inventory, transloading may favor intermodal transportation solutions and may also reduce empty container repositioning. Detention fees charged when keeping the maritime containers inland for too long restrict the development of intermodal transportation solutions, as these may induce longer leadtimes. Furthermore, detention fees limit the possibilities to find

an export match for the containers and thus they might go back empty to the port. Figure 9 provides the inland traffic share by modes of transportation for the ports of Los Angeles and Long Beach in 2004. About one-third of all the long-distance freight carried out of the San Pedro Bay ports is transloaded into domestic containers. Long distance freight represents 66% (16+13+13+22+2) of the total volume handled and 22% of that total volume goes through a transloading facility while being destined to non-local destination.

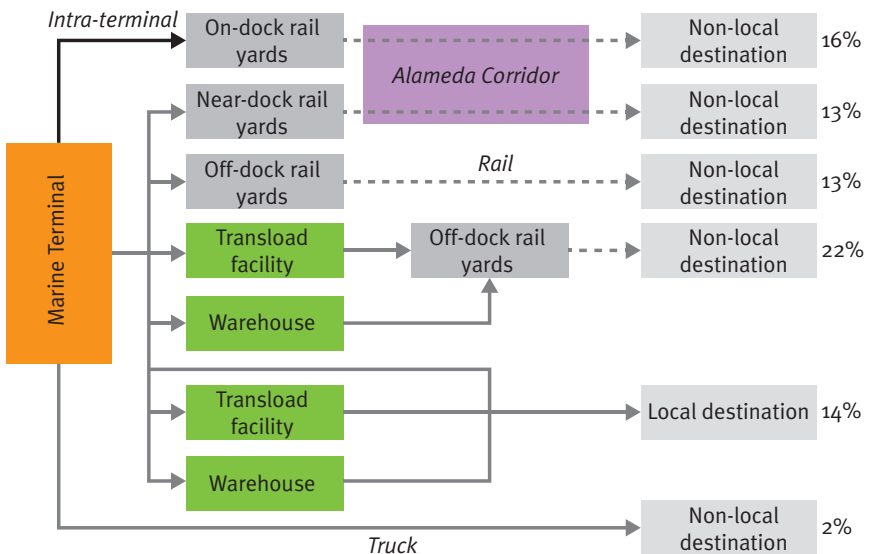


figure 9

Inland traffic share by modes for the ports of Los Angeles and Long Beach

Even if the situation faced in Europe is quite different from the USA (the distances are not comparable and the maximum capacity allowed for a continental container is less), we explore here if the idea of transloading the maritime containers may be efficiently applied for optimizing hinterland transportation in Europe. In addition to transloading, other activities such as cross-docking may occur once the container is opened. Cross-docking may for instance enable mixing local production flow with international cargo.

Based on publicly available detention and demurrage fees applied by a major shipping line and estimations of transloading and continental container rental costs, we were able to estimate what could be the potential savings from transloading. From a pure detention and demurrage fees perspective, transloading

would be beneficial when the dry container requires at least 13 days before being back to the port or to the empty depot (including dwell time which is 7 days on average in Rotterdam, as stated above). We conclude that about 10% of the dry containers imported via the port of Rotterdam apply for transloading and the average saving per 40-foot container would be about € 20. This calculation is a first order estimate based on actual dwell times in one of the main terminals in Rotterdam and estimates of the time the containers spend in the hinterland.

Volume is a key issue for efficient implementation of a transloading solution, as transloading and cross docking operations needs to be set up and must benefit from scale effects. This study shows that there is enough potential to attract sufficient volume, and thereby make this a feasible solution. Additionally, there will be positive effects on inventory levels and on empty container repositioning, which have not been included in the calculations. An aspect that might make cross-docking and transloading more beneficial for dry cargo, is that some cargo does not utilize the maritime container completely, and some of such cargo has a low density, which makes transloading and cross docking more feasible.

Lastly, the estimation of the cost of on-dock transloading is based on classic solutions for cross-docking. New solutions such as compact cross-docking systems (Zaerpour and de Koster, 2015) may help reduce the costs and therefore may amplify the cross docking potential.

It should be stated here that the results are very sensitive to the detention and demurrage cost structure applied by the shipping line. The fees applied by different shipping lines differ significantly, whereas this study focuses on data from a single shipping line. In addition, the fees charged to the shippers might be different from the official fees, as an outcome of negotiations between shipping lines and shippers.

Summary of the results

This study investigated the potential of taking a cargo perspective for managing the hinterland part of the container supply chain. We start by analyzing the dynamics of intermodal hinterland networks at the container level and we derive a series of new managerial insights. Then, we take a look at the cargo inside the box by examining the feasibility of on-dock cross-docking for fresh and frozen cargo and we extend our findings to dry containers. Our main results may be summarized below.

i) Intermodal transportation projects are viable for short and medium distances if the volume is big and the origin/destination drayage distances are low.

This implies that shippers need to identify other parties located in the same area to get enough volume for intermodal transportation (this implication is in line with the principle of co-location for logistics activities). The parties identified need to be willing to share information and to commit to guaranteed minimum volume shipped by intermodal transportation. An agreement may be hard to obtain according to the experience of the companies surveyed.

The policy makers and port authorities may thus need to serve as a platform for enhancing information sharing and commitment on guaranteed volumes among shippers. In addition, policy makers interested in developing intermodal transport solutions should put more attention on hinterland projects.

ii) Estimating intermodal transportation cost and emissions based on average utilization leads to a biased perception of its potential, by focusing on long distances and maximizing modal shift.

This implies that shippers should request quotes that depend on the volume shipped from intermodal service companies and inland terminals. According to the companies surveyed, this practice is quite developed for dedicated services but need to become more common for shared services.

iii) Coordination is critical for successfully implementing an intermodal hinterland network, which might be challenging when the value of such coordination may be low for some participants. However, there might be other coordination benefits such as reducing congestion, limiting the impact on the environment, improving service, adhering to the port authority strategy.

This implies that the company that has insight in the cost structure of intermodal transportation should lead the process. This company can be the terminal operator, the intermodal service company or the inland terminal operator depending on each specific situation. This also implies for shippers that collaboration means taking a risk that does not necessarily lead to huge cost savings from a pure transportation perspective. However, intermodal transportation may imply other types of savings such as an improvement of company image and/or an increase in responsiveness if the containers dwell at an inland terminal closer from the customer (compared to having the container dwelling at the deep-sea terminal).

iv) On-dock transloading and cross-docking is of limited interest for fresh and frozen products with the current logistical settings in the Netherlands.

This implies that on-dock transloading makes no sense for fresh products in the current settings of the port of Rotterdam as the traders are located too close for the port. On a long term perspective, on-dock transloading may become interesting when traders relocate their activities closer to their customers. As the gravity center of demand will move more to eastern Europe, such relocation of trading activities may occur in the future.

v) About 10% of the dry containers imported via the port of Rotterdam apply for transloading and the average saving per 40-foot container would be about € 20.

This implies that transloading may already be interesting now, even if more studies should be performed to ensure this is a profitable option. From a longer term perspective, the containers are expected to stay longer in the hinterland, the detention and demurrage fees are expected to increase and the maximum permissible load for intermodal transportation are also expected to increase. This leads us to consider transloading as an option with huge potential for the future of hinterland transportation in Europe.

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