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Export costs and service conditions in times of a global container shortage

A case study at Heineken Netherlands Supply

Key words: Export, container shortage, Detention and demurrage, HNS, case study

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Written by:

Nanninga, M.J.
Student-ID: 4450760

Supervised by:

Prof. R.R. Negenborn

TU Delft- Department of Maritime and Transport Technology

Dr. J.M. Vleugel
TU Delft - Department of Transport & Planning

Dr. W.W.A Beelaerts van Blokland
TU Delft - Department of Transport Engineering & Logistics

Stevens, P.
The HEINEKEN Company - Manager Customer Service Export & Customs

Delft University of Technology

The Netherlands

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PREFACE

This report has resulted from a case study research at Heineken Netherlands Supply, the department of Customer Service Export & Customs. It is the final work of Michiel Nanninga, in order to achieve the degree of Master of Science in the field of Transport, Infrastructure & Logistics. It is made for the course TIL5060- TIL Thesis (2021/2022) at the TU Delft and was written during the period of August 2021-February 2022.

The realization of this would not have been able without the critical eye and experience of dr. Vleugel and dr. Beelaerts van Blokland. Their supervision kept me on the right track when I drifted towards the less scientific aspects of this research. Secondly, I would like to thank professor Negenborn for taking the position of chair of the graduation committee.

Next to my supervisors from TU Delft, I would also like to thank HNS for this opportunity and more specifically Pim Stevens who, next to supervising my work took the time to make me feel at home from the minute I stepped into the office.

Zoeterwoude, 2022
Michiel Nanninga

EXECUTIVE SUMMARY

The container shipping sector has experienced big changes for the last couple of years. Trade skewness has always existed for the fact that Asia exports a lot more to Europe than the other way around for example, explaining the need of redistributing empty containers. These effects became even worse because of the COVID-19 pandemic and the Suez channel blockade. Lockdowns all over the world at different times and harbors being closed led to very uneven trade patterns, almost shutting down world trade at times and leading to heavy congestion in a lot of chains in the supply chain. A global container shortage resulted. Secondly the past years, large container shipping companies have started working together in large alliances, such as Maersk and MSC in “2M”, owning close to 35% of the market. In 2020, the ten largest shipping companies owned over 80% of the industry, leaving the opportunity for them to make pricing arrangement. All of these effects have led to a scarcity in container and vessel capacity, paired with skyrocketing exporting prices. In some trade legs, the costs of shipping a container increased by a 1000%.

These high prices have led container shippers to profit margins they had never experienced before. In a market that was characterized by overcapacity leading to low profits, the tides changed. In 2021, container shippers reached a combined EBIT (Earnings Before Interest & Taxes) of 150 billion dollars, which is more than the previous 20 years combined. Because of this, container shippers learned to not lose out any more. They did not have to compete to get their capacity sold to freight forwarders and exporters any more, but freight forwarders and exporters were competing for the aforementioned capacity. This has influenced the bargaining positions of both exporters and container shipping companies. Because of this change, contracts with exporters become less beneficial for the exporter in terms of standard tariffs, flexibility and additional terms.

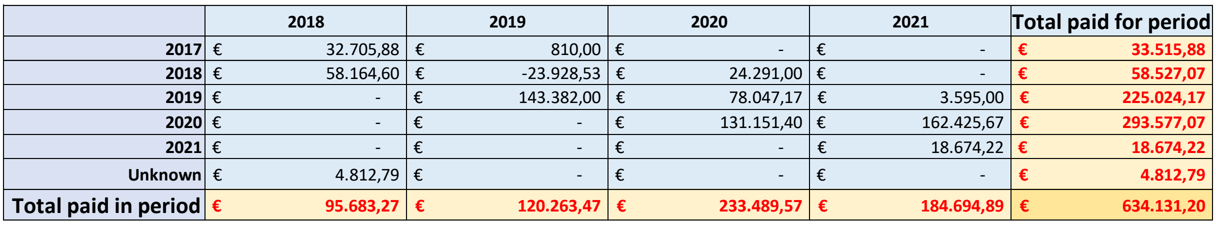
This research thesis is executed at Heineken Netherlands Supply (HNS), Customer Service Export & Customs (CSE&C). This department is engaged in export related activities and transports around 70.000 containers yearly to over 160 countries. HNS has seen an increase in transportation costs, especially in additional costs. Next to that, during negotiations for new contracts they were presented with higher prices, additional costs or less flexibility. This has led to the following research question:

‘How should large exporters like HNS weigh off transportation costs, flexibility in service conditions and environmental effects for contractual agreements in times of a global container shortage?’

The earlier stated congestion following the global container shortage has led to delays in transportation for exporters such as HNS. These delays have led to higher additional costs, of which the main part are detention and demurrage costs. These are costs associated with the usage and storage of containers. HNS has a certain amount of “free days” that they receive from the deep sea carrier to deliver the container on a boat. Every day that exceeds those free days will cost them extra money. HNS serves four trade legs for pre carriage where these costs originate from: Alphen to Rotterdam (1), Alphen to Antwerp (2), Den Bosch to Rotterdam (3) and Den Bosch to Antwerp (4). In Alpen, a container terminal is used to take out containers to be loaded at the brewery of Zoeterwoude and in Den Bosch the same for the brewery in Den Bosch. Currently, HNS has 28 free days for equipment usage per container, of which a maximum of 14 days for storage. When a container is used more than 28 days, or stored more than 14, HNS will be invoiced for those additional detention and demurrage costs. In the current situation they pay €8,- per container per day for exceeding the total amount of 28 days and €10,- per container per day for exceeding the 14 days relating to storage.

These current values have more or less been similar for the past years and congestion has led to an increase in additional costs in pre carriage. The following table shows the increase in detention and demurrage costs over the past years:

TABLE 1: TOTAL DETENTION & DEMURRAGE COSTS HNS 2021 (AUGUST, 2021)



	2018	2019	2020	2021	Total paid for period
2017	€ 32.705,88	€ 810,00	€ -	€ -	**€ 33.515,88**
2018	€ 58.164,60	€ -23.928,53	€ 24.291,00	€ -	**€ 58.527,07**
2019	€ -	€ 143.382,00	€ 78.047,17	€ 3.595,00	**€ 225.024,17**
2020	€ -	€ -	€ 131.151,40	€ 162.425,67	**€ 293.577,07**
2021	€ -	€ -	€ -	€ 18.674,22	**€ 18.674,22**
Unknown	€ 4.812,79	€ -	€ -	€ -	**€ 4.812,79**
Total paid in period	**€ 95.683,27**	**€ 120.263,47**	**€ 233.489,57**	**€ 184.694,89**	**€ 634.131,20**

The two main contributors to these effects are delays and congestion and thus longer equipment usage as well as limited visibility on container movements. Because of limited visibility, HNS cannot control their invoices for additional costs systematically, which it why they are often paid without verification. To get more grasp on the latter, HNS has explored buying their own containers. This however, turned out to not be a viable option as deep sea carriers prioritize transporting their own equipment. Because of this flexibility of operations would actually just decrease instead of increase, as well as transportation costs. However, HNS has joined the Tradelens platform recently. Tradelens is a platform designed to radically disrupt this industry by digitalizing all of the processes, making information available to all customers and affiliations to those customers at all times. Over 2021, Tradelens' partners grew, now accounting for close to 90% of container movements from HNS. This allows for the calculation of days it takes HNS to deliver their containers to the deep see terminal and how long they are consequently stored at the terminal on average:

TABLE 2: AVERAGE USAGE AND STORAGE (IN DAYS, 2021)

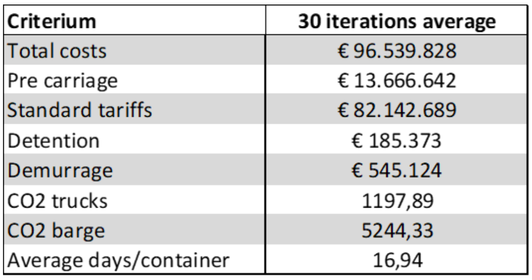
Shipping leg	Equipment Usage	Equipment storage
Alphen-Rotterdam	16,3	7,3
Den Bosch- Rotterdam	17,1	6,8
Alphen- Antwerp	18,3	10,9
Den Bosch- Antwerp	18,7	11,0

In the near future, these delays are not expected to be solved, as new vessels from carriers are only expected in the market in 2023. Not a large increase in trade volume, both of containers and in the beer sector are expected. However, the recovery of the market could still take a few years.

For that reason, HNS needs to figure out how to remain competitive in the future. On the one hand they have always strived to be a precursor in terms of sustainability and reliability to their customer. On the other hand, the current conditions and bargaining power of deep sea carriers a large impact on flexibility of their operations and transportation costs. They need to weigh off all of these effects. This study has tried to do so by creating a calculation model, indicating the effect of different contractual service agreements changes, the effect of trucking a certain percentage of containers to the deep sea terminal which are currently all transported by barge ships and the effect of altering the production division.

In the current situation (base case), the findings are as follows:

TABLE 3: RESULTS BASE CASE



Criterium	30 iterations average
Total costs	€ 96.539.828
Pre carriage	€ 13.666.642
Standard tariffs	€ 82.142.689
Detention	€ 185.373
Demurrage	€ 545.124
CO2 trucks	1197,89
CO2 barge	5244,33
Average days/container	16,94

These results were found to accurately portray the actual criteria values, except for the additional costs of detention and demurrage. The model finds higher costs for those criteria compared to real life spending. This can be explained by the fact that real life invoicing for those costs might occur in the next calendar year, whereas the model predicts values instantly. A second explanation is that the model does not include choices that are made by the deep-sea carriers. It could well be that deep-sea carriers do not send invoices for every single exceeding in terms of detention and demurrage. The model however, does assume that every exceeding is included.

A total of 18 different alternatives were modeled, all differing in terms of standard tariffs, free days, detention and demurrage fees, trucking percentages and production divisions. They entail a combination of a strategic choice that needs to be made in contract negotiations and a design choice in terms of pre carriage. The results thus measure performance in terms of costs, sustainability and throughput from the perspective of the exporter.

After this analysis, it was found that HNS should always opt for higher standard tariffs compared to less free days or higher detention and demurrage fees. Transporting by truck or altering the production division based on port of loading does not have a beneficial effect when the standard tariffs are a little higher. If HNS does not get the aforementioned strategic choice and if they have to oblige to worse service conditions because deep sea carriers simply prove to have too much bargaining power, trucking more volume than they currently do in pre carriage does have a beneficial effect on the criteria. The best course of action would then be to leave the production division as it currently is and to transport all of the containers towards Antwerp by truck, instead of by barge.

Some important limitations of the research that should be taken into account are the lack of current real data and weekly or seasonal demand fluctuations. The data that is used is currently incomplete as the used Tradelens platform is still incomplete in terms of container movements. A fraction of container movements is used to interpolate towards a full year of container movements. This might leave a slight bias in the data, as it could be that a certain part of movements from a certain carrier are not fully represented in the existing data.

The research does also not take demand fluctuations on a weekly or seasonal basis into account. In practice it does sometimes occur that an empty container is not available, even if contractually, the carrier should be providing an empty container. This is accounted for in the next week, but it does have an influence in the day to day operations and takes effort from employees to arrange. On a yearly basis, this capacity constraint does however not exist, which is why it is not considered to be a problem for this specific research, which models a year of operations as a discrete event. It should also be noted that, since all additional capacity that needs to be shipped compared to what is contractually agreed upon now is far more expensive than it used to be, planning and forecasting become far more important. If demand could be predicted more accurately on route level, this could also impact the criteria beneficially. It could be taken into account in future research to research more specifically the impact of these operational complexities on the performance criteria.

It is therefore recommended to HNS to try to negotiate higher standard tariffs with the deep-sea carriers in contrast to worse service conditions. If this strategic choice is unavailable and HNS has to comply to worse service conditions it is advised to leave the production division as it currently is and to start transporting containers with port of loading Antwerp by truck. It is also advised to look further into weekly demand fluctuations and whether weekly demand on route level can be forecasted more precisely.

GLOSSARY

Alpherium-	Inland container terminal located in Alphen aan den Rijn
BCT(N)-	Bossche Container Terminal (inland container terminal located in Den Bosch)
BBD-	Best Before Date (THT)
CCT-	Combined Cargo Terminals (operator Alpherium & Moerdijk)
CFR –	Case Fill Rate
CSE&C –	Customer Service Export & Customs
DB-	Den Bosch
DD/D&D-	Detention and Demurrage
ETA-	Estimated Time of Arrival
ETD-	Estimated Time of Departure
HBBV –	Heineken Brouwerijen BV
HNS –	Heineken Netherlands Supply
MOQ-	Minimum Order Quantity
MTO –	Make To Order
MTS –	Make To Stock
MTR -	Replenishment
POD-	Port of discharge
POL-	Port of Loading
SKU –	Stock Keeping Unit (product)
SPC –	SKU
THC –	Terminal Handling Costs
THT –	Tenminste Houdbaar Tot (BBD)
TSCP –	Tactical Supply Chain Planning
TP –	Transfer Price, the price HNS charges the customer, based on the production cost only
ZW-	Zoeterwoude

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1. INTRODUCTION

The report consists of several parts. The first part will introduce the topic and problem. It starts off with providing general information on the subject, which will eventually boil down to the concrete problem that HNS faces and will face in the following years. This way, the problem will be analyzed, defining it in several research questions.

1.1 GENERAL INFORMATION

Almost every company that operates in the logistics sector is experiencing the effects from the COVID-19 virus. The daily lives and purchasing behavior of billions of people have significantly changed in a relative short period of time. Harbors in China being closed, due to the COVID outbreaks, led to congestions in the supply chain. Next to that, the Suez Canal- responsible for about 12-13% of world trade per year- was blocked by a ship further disturbing the logistic sector (Ramos et al, 2021).

These developments have put a massive strain on the supply chain. In the export sector, the most significant effects can be noticed in the prices for container rent which have surged due to empty container scarcity. By the end of 2020, a surge of Asian imports to feed retailer restocking efforts had shipping lines rushing goods back to China, leaving equipment shortages in the U.S. (Paris, 2020). A few months later this imbalance led to the opposite effect, leaving Chinese exporters without empty containers (Xie, 2021). The price on the spot market for shipping a container from Rotterdam to South Korea for example, has multiplied by six from $2000 in September 2020 to $12000 one year later (Lalkens, 2021a). The skyrocketing prices of container usage are explained by the shipping companies as an effect of the extreme situation described above. They charge additional costs such as ‘Service disruption charge, congestion surcharge, equipment imbalance surcharge, peak season surcharge, port congestion surcharge, emergency revenue charge, environmental fuel fee and Suez incident congestion surcharge’ (Lalkens, 2021a). One of the largest and most frequent returning aspects amongst these charges are detention and demurrage costs: the costs associated with ‘renting’ a container from a shipping company. These costs are often charged a long period of time after the actual event has happened and leaves exporters with little resources to second guess these charges.

Secondly, the amount of shipping companies has decreased due to mergers. They have also started working together in three big alliances. The suspicion of abuse of power is created by the fact that the 10 largest shipping companies control more than 80% of the total market, which means they can easily make pricing agreements. In the early 2000s this number was a little over 10% (Lalkens, 2021a). The change of the past 5 years is visualized by the following diagram:

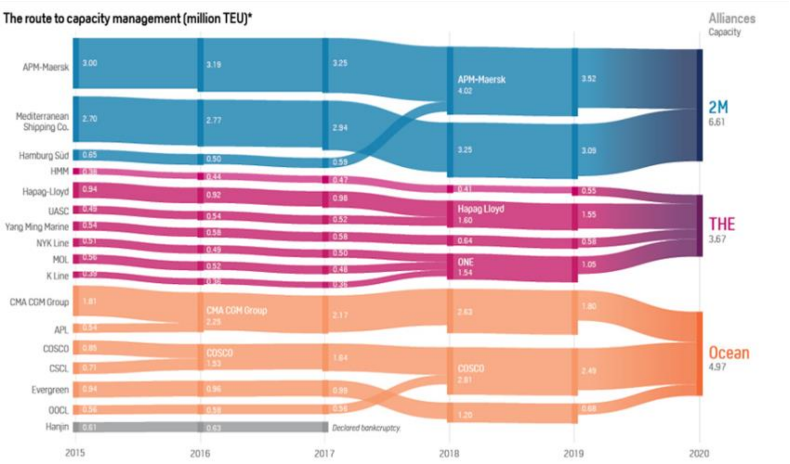


FIGURE 1: ROUTE TO CAPACITY MANAGEMENT (HICKIN & GRIFFITHS, 2020)

From the diagram, it can be seen that in 2015, 17 shippers shared a certain market share, operating in four alliances. In 2020, this number has been reduced to 9 major shippers in 3 alliances. Because of the small amount of stakeholders, price arrangements can be easily made.

This has recently led to president Biden attempting to regulate these companies, which might have prompted CMA to freeze container prices until the first of February, feeling the pressure from control organizations such as the Federal Maritime Commission (Financieel Dagblad, 2021). A second confirmation came when a South Korean regulator fined 23 container shipping companies $81 million for illegal pricing arrangements in regional shipping legs in Asia in January 2022 (Lalkens, 2022).

These effects have also affected large exporting companies such as Heineken. These companies often operate under yearly contracts with deep-sea carriers. Up until now, these contracts had very beneficial terms for larger exporters. The container demand market had always been characterized by a market of overcapacity. This means that container shipping companies did everything in their power to contract large exporters, since they would take a majority of their containers. For the past 2 years however, the market has changed to a market which is characterized by under capacity. This means that container shipping companies do not have to fight for exporters anymore since they have no problem to ship their containers. Nowadays, exporters have to fight in order to get their load transported.

This research will focus on a case study relating to Heineken Netherlands Supply (HNS). HNS is responsible for all activities relating to the three Dutch breweries and all associated supply chain activities. Its sub-department ‘Customer Service Export & Customs’ is responsible for all export related activities. They serve over 170 countries with Heineken products such as beer, packaging materials and yeast. The services they offer mainly entail the transport of finished products from the brewery, through a barge terminal and harbor to customers all over the world. Since beer is already a product with relative high distribution costs compared to other consumer goods (Madsen et al, 2016), HNS has even more incentive than others to keep these costs as low as possible to remain competitive, especially with the relative increase in detention and demurrage.

1.2 PROBLEM DESCRIPTION

In order to remain competitive in the current market, HNS needs to anticipate changes that are happening and be ready for future developments as much as possible. This section aims to define the problem as concretely as possible and to indicate the scope of the problem. This will lead to the development of the research questions that this research will try to answer.

1.2.1 PROBLEM STATEMENT AND OBJECTIVE

The container shipping market has changed from being large, cumbersome and characterized by overcapacity to a market in which container shipping companies have learned to lose out no longer. A power shift is occurring in the bargaining positions relating to contractual agreements for container shipping for large exporters. For large exporters, exporting the number of containers they want on a yearly basis is not necessarily the problem, but the prices and terms and conditions in contracts for shipping these containers are going up. The expectation is that these effects will remain, even when the currently disturbed market starts to stabilize. Large exporters such as HNS therefore need to critically evaluate their operations in order to remain competitive. Opting to minimize costs might affect the flexibility and sustainability of their operations, which are very important to large exporters such as HNS. If costs however are not considered enough, export operations might stop being profitable. This will eventually affect product prices for the consumer, which will impact the market share of Heineken.

In order to decrease transportation costs, whilst assuring flexibility and sustainability in operations, HNS should look to strategically redefine their operations relating to pre carriage to best fit the contractual changes in tariffs and terms and conditions. The objective of this research is to find out what the future bottlenecks will be in order to define possible solutions for these newly emerging problems and to assist in future contract negotiations.

1.2.2 SCOPE

Since the operations related to export are very large and involve a great number of stakeholders, the problem should be properly scoped. To include all operations in the research would simply be a far too complex problem. As stated in the previous section, the general scope will be a case study at Heineken Netherlands Supply (HNS).

Geographical scope

Export streams are very different due to a wide variety of reasons. Some examples are that each country is served by different shipping legs, has to oblige to different customs regulations and has a different demand pattern. Therefore, this research focusses on their common denominator of their export streams, which is the container flow from the breweries to the harbors of Rotterdam and Antwerp: the pre carriage. This is depicted in the figure below by the blue rectangle, meaning the geographical scope will be Netherlands and Belgium.

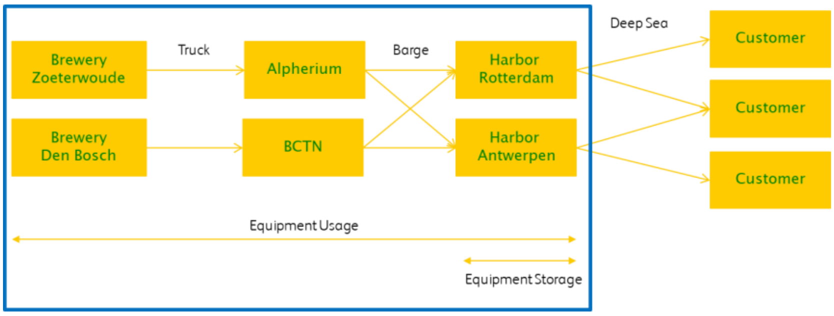


FIGURE 2: TRADITIONAL EXPORT FLOW

A large aspect within this research is detention and demurrage costs, the costs associated with 'renting' and storing a container. These costs relate to the 'equipment usage time' and 'equipment storage time', which is why these are also indicated in the figure above. Detention and demurrage costs charged to HNS should only contain costs associated with container movements within the traditional export supply chain, thus on the four pre carriage shipping legs: Alphen- Rotterdam, Alphen- Antwerp, Den Bosch- Rotterdam, Den Bosch- Antwerp. Detention and demurrage can also be charged on the receiving customer end, but these are to be paid by the customer which is why this is left outside of the scope of this research.

Scope of operations and contracts

It is important to define which operations are looked at within this research and to examine how contracts are built up and how these negotiations work.

First of all, this research focuses on deep-sea movements only. Short- sea and road transport are left outside of the scope as these processes differ from deep-sea transport. The described problem exists mainly in deep-sea transport and the largest volume (more than 80%) of all export is by deep-sea. Containers are owned by the deep-sea carriers such as Maersk, MSC, CMA-CGM etc. These containers can be rented by exporters such as HNS. First of all, HNS has two dedicated inland container terminals from which they can take out containers. The first terminal is located in Alphen for Zoeterwoude and another in Den Bosch for the brewery in Den Bosch. They also do business with CCT Moerdijk, which also serves as a container terminal for a few deep-sea carriers. If it occurs that no container is available at the required inland terminal, they can take out a container from another terminal which will then be transported to the other brewery.

As stated before HNS has contracts for each shipping leg with carriers which are tendered each year. Simplified, this means that each origin-destination pair (Rotterdam-New York for example) is up for ‘auction’ each year. Every deep-sea carrier can make an offer on each route, offering the capacity they can deliver, the price and other additional terms. For most of the routes, HNS has more than 1 carrier contracted. This means that if capacity is not available from one carrier, HNS can book containers at the other carrier. In general, HNS can always transport containers if they want on a yearly basis. They ‘buy in’ what they want to transport every year from this tender procedure and therefore do not have to cope with a lack of empty containers. This is also the case because deep-sea carriers do still value their contracted exporters for accounting for a lot of their capacity, meaning they will find an urge to serve them before the spot market, although they might make more money on the spot market. It does rarely occur that on a weekly basis, capacity cannot be served. On the work floor this causes for extra work, pulling and pushing to get that capacity recovered in the next week. Although this leads to more work for employees and because on a yearly basis the capacity bought in is not affected, it is left outside of the scope of this research.

In some cases, containers have to be shipped additional to what is ‘bought in’ in the contracts. There are two instances in which this is the case. Firstly, a mismatch between demand forecasting and actual bought in capacity. Demand is forecasted by the B2B customers as well as by HNS themselves. In many cases the actual route level demand can vary slightly to this demand. Secondly, in some cases a complete distribution network is taken over by HNS. This happened last year in Peru, which caused the need for shipping about 500 containers additional to the amount that was predefined in the contracts. In previous years, carriers would take the additional load for the low contracted prices anyway. In the current market however, this is no longer the case and additional volume has to be bought on the spot market for higher prices. The difference in price to account for is big and varies per destination, but could be 20% more expensive up until 150%. The actual shipped demand can thus be higher or lower than what is contractually bought in. In 2021 for example, only about 55.000 containers were shipped for deep sea, whereas 57.261 were bought in.

Because of the complexity and uncertainty of these numbers. This research assumes that the yearly demand is equal to the bought in amount of containers, with a 5% deviation trying to account for this uncertainty. This means that for each destination, 5% more or 5% less can be shipped. If more than the bought in amount is demanded, the price for those containers will be more expensive than the original bought in price. The price for those containers will be between 120% and 250% more expensive.

Time horizon

The time horizon for this research is a period of 1 year. This means that one year of operations will be modelled. It is however important to take a longer period into account and to see what implications certain decisions can have on future years. In 2023 new operational vessels will come into the market, which might affect the operations although not modelled in the simulation model. It will also take into account expected developments in trade volume, but only one year of operations will be modelled.

1.3 RESEARCH QUESTIONS

To concretely tackle the problems that currently occur or might develop in the (near) future, a research question was made which indicates what the research will revolve around:

‘How should HNS weigh off transportation costs, flexibility in service conditions and environmental effects for contractual agreements in times of a global container shortage?’

Since this main research question is very complex, several sub- questions are defined in order to split up the problem and go about answering the main research question step by step. The following order of sub- questions will be answered during the project:

1. *What do logistic processes, corresponding information sharing processes and contractual agreements for the export market currently look like?*
2. *What are the performance criteria for these logistic processes?*
3. *What kind of bottlenecks and challenges are present in these current processes and how are those bottlenecks expected to change in the future?*
4. *What are the constraints, design requirements and criteria relating to this logistic process?*
5. *What are possible ways of altering this logistic process to impact current and future expected challenges?*
6. *How do these different designs relate in terms of key performance indicators?*
7. *Which designs perform best base on Multi Criteria Analysis?*

1.4 METHODOLOGY AND RESEARCH APPROACH

This chapter will go into depth on the methodology and research approach of this research. First, the methodology will be put into perspective by using the research questions. After that, the specific research and design methods that will be used for each phase will be shortly elaborated on.

The methodology that will be used in this research is an adaptation of lean six sigma’s DMADV (Selvi & Majumdar, 2014). This original method is meant for a product improvement, adjustment or the creation of a new product of service. It consists of five phases: Define, Measure, Analyse, Design and Verify. This methodology will be slightly adjusted to DMADE: Define (problem definition), Measure (relevant data collection), Analyse (analyse data), Design (requirements and alternative generation) and Evaluate (Multi criteria analysis). This choice is made, as the ‘Verify phase’ is generally an ongoing phase while the product is being introduced. This research aims to present different design alternatives and their simulated score, which is why the verify phase is swapped for an evaluation phase. How the research questions fit in this methodology can be found from the table on the next page.

TABLE 4: RESEARCH QUESTIONS AND METHODOLOGY

Question	Analysis techniques and explanation	Chapter
DEFINE / MEASURE		
1	*Review of current process documentation / Literature study / Data collection* In chapter one, the problem was defined. Subquestion 1 will finalize the problem definition by performing a literature study to indicate its scientific relevance. Next to that, current processes will be studied and documented on and relevant data will be collected.	1, 2, 3
MEASURE		
2	*Data Collection / interviews* In order to map the performance criteria that are currently being used to measure the performance of the processes, data has to be collected. This, together with interviews with employees from HNS will help to find and list the performance criteria.	3
ANALYZE		
3	*Data analysis / Lean analysis tools / Scenario Analysis* The current bottlenecks and their future developments will be found in this phase, by analysing the collected data from the measure phase and lean analysis tools the wastes in the current process operations can be identified. By performing a future scenario analysis, the future developments can also be taken into account.	3, 4
DESIGN		
4	*Requirements analysis* This research question will aim to define the design requirements to which the system has to comply.	5
5	*Morphological design / interviews / Calculation model* A morphological design will be used to assist in alternative generation. The generated alternatives (including the current state design) will be modelled with a calculation model. This model will be used in order to simulate the effects of the alternatives.	6
EVALUATE		
6	*Simulation* The model will be used to generate results for all of the different designs. The results of the simulated alternatives will be compared in terms of the criteria that had been listed earlier.	7,8
7	*Multi Criteria Analysis / Recommendations* The results of the simulated alternatives will be evaluated by making use of multi criteria analysis. After the results have been compared, advice will be given to the case commissioner in terms of further steps.	9,10

1.4.1 RESEARCH METHODS

The research methods will explicitly explain how better insight into the problem can be obtained. These methods consist of: Literature review, review of current process documentation, lean analysis tools, Data collection and analysis, interviews with supervisors and employees.

Literature review

Through review of the current literature on the subject, the current state of the art will be studied. This will be used to better understand the current processes and associated subjects. The literature review will contain both scientific and non-scientific sources.

Current process documentation

In the first phase of the research, this will be the most important method. Current process documentation is very important to understand current transport flows, as well as detention and demurrage costs. With this method the studying of contractual agreements with shipping companies and incoterms with customers is also aimed at. All of this information is of the utmost importance to clearly depict the problem.

Lean analysis tools

Gemba is a Japanese terms which translates to 'on-site'. A Gemba walk is a lean method, which finds its origin in the Toyota Production System (Huijgens, 2020). Gemba walks were introduced because it was found that managers often think they know how processes are executed whereas these processes might actually be performed differntly in day-to-day operations. The idea behind the Gemba walk is that the only way to make improvements in processes is to actually go to the work floor and explore the process on-site by managers (Lange, 2019). Managers here need to stop assuming and start seeing the real practices. It might be that employees don't function in the best way possible, but they might as well have found a way to work smarter or more efficient.

To better comprehend the activities at the brewery and hence the first link in the chain, a Gemba walk will be performed. The observations of especially the loading activities will then be documented in this report, providing insights in the current warehouse process for the B2B type e-commerce orders.

In addition to the Gemba walk described in the previous subsection, an IDEF-0 diagram will be made. Integration definition for function (IDEF) is a lean method which provides a structured overview of process flows (Lightsey, 2001). In this diagram, the focus will primarily be to provide insights in the way the fysical transport flow goes through the system and what its control mechanisms as well as material or employee requirements are. IDEF is particularly useful because it is possible to easily zoom in on one of the subprocess even further. To fully understand and depict regular transport flows of container movements, an IDEF diagram is drawn in which several of the subprocesses might be further analyzed.

To gain even more insight into the specific transport flows and more specifically who is responsible for what action in the process, a swimlane diagram will be constructed. Swimlane is a process stream diagram in which the process is divided in several 'swimlanes'. These swim lanes indicate what a certain department or employee has to do in a process (Janse, 2020). All of these tools are also applied through a workshop in which all processes are documented. The results can be found in appendix A.

Interviews

One of the more important sources of information however, are interviews with the commissioner and employees. They provide the more general knowledge on current processes, billing etc. These interviews can help to strengthen knowledge gained from other analysis tools.

Data analysis

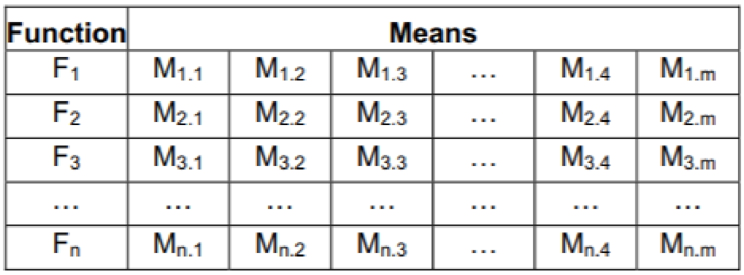
Data will be collected on container movements and will be consequently analyzed to determine what the KPI's are and where they are lacking.

1.4.2 DESIGN METHODS

To come up with different alternatives two different design methods are used. The first method is meant to help the process of computing different design alternatives, namely a morphological design. Next to that, these different designs will be modelled through a calculation model, after which they will be evaluated through multi criteria analysis.

Morphological design

Morphological Chart analysis is one of the formal design tools enabling collaborative product development. It is widely used as an effective technique for conceptual design of products, processes, and systems (Huang & Mak, 1999). The common structure of a morphological chart is depicted in the following figure:



Function	Means					
F_1	$M_{1.1}$	$M_{1.2}$	$M_{1.3}$	…	$M_{1.4}$	$M_{1.m}$
F_2	$M_{2.1}$	$M_{2.2}$	$M_{2.3}$	…	$M_{2.4}$	$M_{2.m}$
F_3	$M_{3.1}$	$M_{3.2}$	$M_{3.3}$	…	$M_{3.4}$	$M_{3.m}$
…	…	…	…	…	…	…
F_n	$M_{n.1}$	$M_{n.2}$	$M_{n.3}$	…	$M_{n.4}$	$M_{n.m}$

FIGURE 3: COMMON STRUCTURE OF A MORPHOLOGICAL CHART (RICHARDSON ET AL., 2011)

On the left side, the functions that need to be fulfilled by the system are provided, whilst the top provides the means possible to fulfill those functions. The concept of a morphological chart will be used to compute several alternatives in this research as well.

Calculation model

This study will make use of a discrete event calculation model. One input of the model- the container throughput time- is a discrete random variable which will be based on a discrete frequency distribution found by analyzing data from Tradelens which will be elaborated on in section 3. These distributions are non-uniform probability distributions with a positive skew. In this model, a full year of operations will be modelled to analyze the behavior of the system in different circumstances. The results following from this model will then be evaluated through multi-criteria analysis.

Multi criteria analysis

A multi criteria analysis is a tool that is used for decision making. Each decision is made within a certain environment and is defined as the collection of information, alternatives and most importantly: the preferences and values of the decision maker at the time of actually making the decision (Mateo, 2012). This is important as not all of the criteria have to be equally important to the decision maker. If all of the criteria were handled as such, a depiction of the results can occur that wrongfully puts one alternative in front of the other.

1.5 STRUCTURE OF THE REPORT

The report is divided in several parts that all cover a different aspect to this problem. The report will first go into depth in chapter 2, researching literature on the topic. Together with chapter 3, the current situation, sub questions 1 and 2 will be answered. Chapter 4 will provide answers on question 3, analyzing the expected future state. After that the alternative requirements will be put forward in chapter 5. Chapter 6 and 7 will then elaborate on different possibilities of filling in these design requirements. Chapter 8 and 9 will provide the implementation and results and chapter 10 and 11 will compare and evaluate those results.

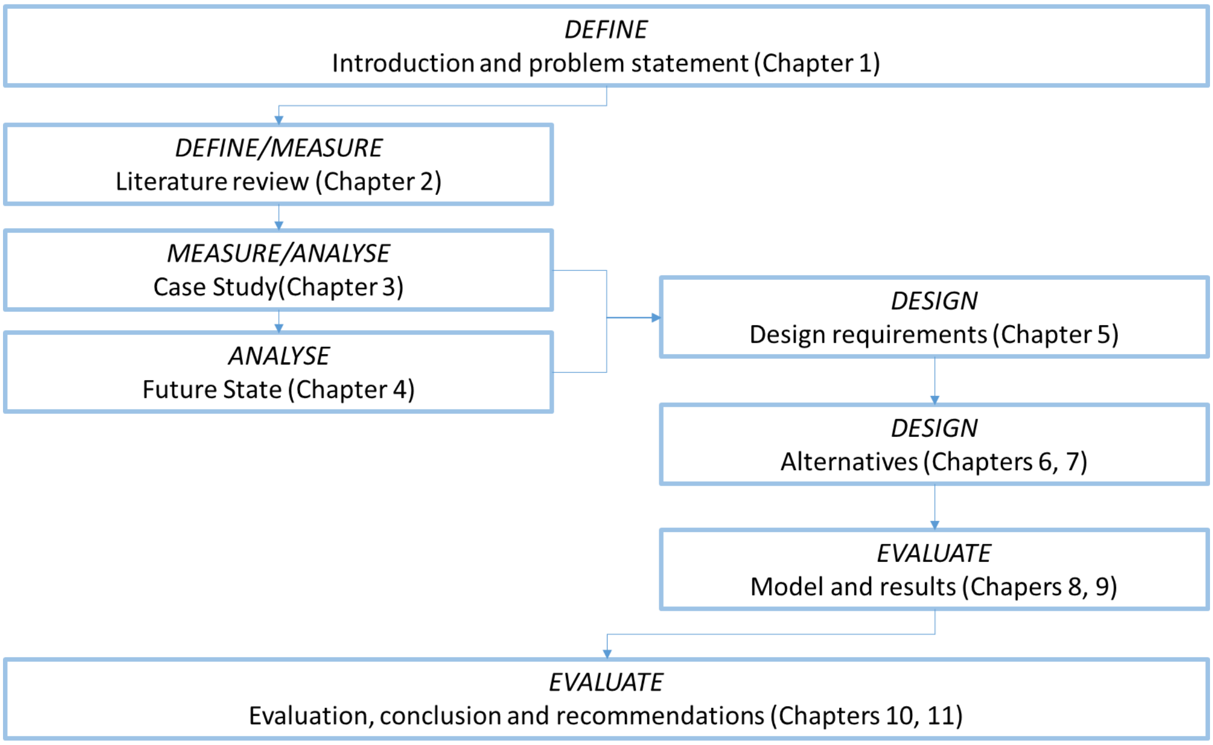


FIGURE 4: SCHEMATIC OVERVIEW OF REPORT

2. LITERATURE REVIEW

To understand the terminology, previous research and the problem space, literature will be studied. In doing so, the problem will be further defined. It will start by trying to define some of the terms that are used and how they are widely used. This section will contribute to answering research question 1:'*What do logistic processes, corresponding information sharing processes and contractual agreements for the export market currently look like?'*. It will not be able to identify a clear answer to the research question but will help analyzing the current state of the art in terms of logistic processes, information sharing processes and contractual agreements for the export market.

The Brewing industry

The brewing industry is quite unique in the way it characterizes itself by a large number of mergers or/and acquisitions. One of the main reasons behind this is the high cost of distribution compared to other consumer goods (Madsen et al, 2016). Mergers and acquisitions lead to a reduction in these high transportation costs, leaving local breweries active and offering the own brand as a premium beer at a premium price. These mergers and acquisitions started occurring more and more through time. In the early 2000's, the market share of the ten largest companies in the brewing industry started rapidly increasing due to all those mergers (Madsen et al, 2012). These ten companies now own approximately 70% to 75% of industry equaling a combined revenue of close to 160 billion USD, with a revenue of about 24 billion USD for Heineken (Bizvibe, 2020). For the top 10 companies, this means they have doubled their market share in approximately 20 years. This trend is not expected to stop, as Heineken recently acquired additional shares in India's United Breweries, gaining a majority of 61,5 percent (Giriprakash, 2021).

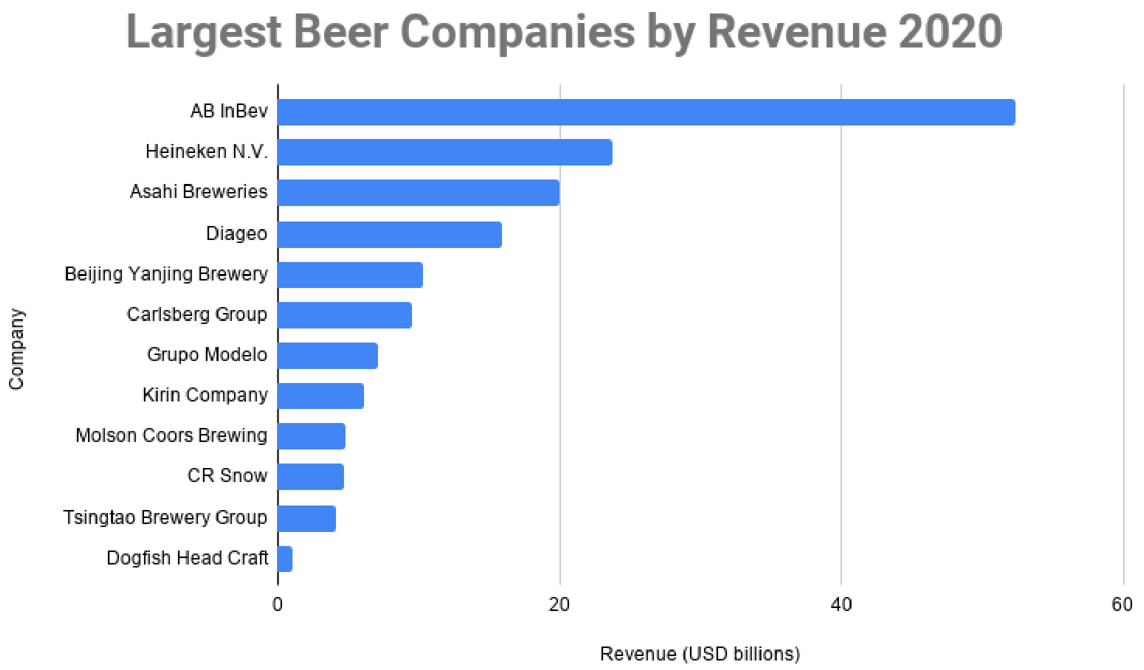


FIGURE 5: LARGEST BEER COMPANIES BY REVENUE IN 2020 (BIZVIBE, 2020)

Export and Export performance

Export and ways to measure the performance have become more and more important over the years for SMEs as well as big enterprises. Export performance can be described as being the outcome of activities that a company performs in the export sector, meaning transporting goods that have to cross borders (Katsikeas et al, 2000). The main substance of export these days is accounted for by maritime transportation. In 2016 this accounted for over 50% of the total worldwide trade volume (Yu et al, 2018). Export activities obviously greaten the market of sold goods by a company, but they also enhance organizational capabilities further boosting the firms performance (Filatotchev et al, 2009). A study summarizing export performance determinants in the period from 2006-2014, found that progress was booked on three main aspects: the use of theoretical foundations, the introduction of several new determinants of export performance and the use of advanced statistical models (Chen et al, 2016). It did however, also find that research on export performance is still characterized by divergence and discordance (Tan and Sousa, 2011). The three main major problems found by Chen and colleagues (2016) are the lack of in depth studies, the fragmentation of different models that are used and inconsistency in terms of conflicting results relating to determinants on export performance. However one important development was that interaction and indirect relationships were more and more taken into account.

For example, one of the main determinants for the export performance of any firm is innovations. Next to that it is said that user-producer interaction is a very important influencer towards innovations that succeed in the market (Beise-Zee and Rammer, 2006). This means that the indirect relations that Customer Service Export & Customs has towards the consumer become more and more important towards successful innovations and hence boosting the performance consequently profits.

Make to order (MTO)

There are two types of order markets that CSE&C serves: Make-to-order (MTO) and Replenishment. MTO is a manufacturing process where the production process is initiated when the company receives an order by a customer. It is a pull-type production method and is the opposite of push-type strategies such as make to stock or replenishment, where the company produces goods prior to an order or where the company controls the inventory stocks of a customer (Thomas, 2019). Benefits are that it helps to minimize excess inventory costs whereas limitations include for example longer lead times (Thomas, 2019).

In a production environment where products are both made to stock as well as to order complex trade-offs occur to decide whether to make to stock or make to order for a new customer/product. In such a hybrid environment, Rajagopalan (2002) states the following: *'making an item to order reduces inventory costs for that item, but might increase the lot size and inventory costs for the items made to stock. Also, lead times increase because of congestion effects, resulting in higher safety stocks for make-to-stock items and lower service levels for make-to-order items'*.

Heineken handles both types of orders and decides on the type based on several parameters such as the percentage a market represents of a specific production line/product group or packaging type and the total volume sourced from HNS (Heineken, n.d.).

In the current market, the MTO market has become increasingly more expensive. Profit margins in the brewing industry have declined and the global container crisis have put constraints on capacity, leaving the MTO market with even longer lead times and therefore higher (detention and demurrage) costs and potentially lower customer satisfaction.

Replenishment (Vendor-Managed Inventory)

The ‘service replenishment’ market that HNS serves is a production market in which Heineken provides the service of controlling stock inventory levels of their customers and delivering products accordingly. In literature this is often referred to as Vendor-managed inventory or VMI (Cetinkaya and Lee, 2000). The system was first seen about 25 years ago with Wallmart (Fry et al, 2001), but has since seen a large deployment amongst all different types of sectors (Sainathan and Groenevelt, 2019). These types of markets have often failed due to inadequate contracts coordinating the supply chain. Chrysler for example, pushed cars towards customers in the sales as well as rental business to boost their sales, but exceeded the demand, leading to underperforming financially. Other examples with the opposite happening leading to inventory drops in retail stores during promotions have also often occurred (Sainathan and Groenevelt, 2019).

Cetinkaya and Lee (2000) and Cheung and Lee (2002) posed on coordinating shipments and stock rebalancing to optimize vendor-managed inventories in close- proximity geographical systems. They found that shipment coordination lead to lower retailer costs, especially when there are many retailers in a geographical region such as major metropolitan market. Lee and Tang (2000) find that demand information sharing between vendor and retailer is also of the utmost importance in VMI systems. Internet of Things has recently been found to be incredibly important and contributing with today’s complex logistic flows, processes and increasing number of stakeholders and participants (Dasaklis and Casino, 2019).

In short, VMI markets are very complex but can be beneficial for both vendor and retailer. In order to be successful, they require adequate contracts, coordinating shipments and the inclusion of advanced data analytics systems. Also, information sharing and streamlined processes contribute to the effectivity of VMI systems.

Trade skewness and global container shortage

Empty container scarcity has always been a problem in deep sea logistics. For example in trade from Asia to Europe, where 7,5 million TEUs were transported westbound compared to 4.1 million eastbound in 2006 (Robinson, 2007). This skewness can also be seen from the following table, indicating the annual growth in (predicted) percentages of both import and export (WTO, 2021):

TABLE 5: (EXPECTED) IMPORT AND EXPORT GROWTH

Exports	2017	2018	2019	2020	2021	2022	Imports	2017	2018	2019	2020	2021	2022
North America	3.4	3.8	0.3	-8.5	7.7	5.1	North America	4.4	5.1	-0.6	-6.1	11.4	4.9
South America	2.3	0.0	-2.2	-4.5	3.2	2.7	South America	4.5	5.4	-2.6	-9.3	8.1	3.7
Europe	4.1	1.9	0.6	-8.0	8.3	3.9	Europe	3.9	1.9	0.3	-7.6	8.4	3.7
CIS$_d$	3.9	4.1	-0.3	-3.9	4.4	1.9	CIS$_d$	14.0	4.1	8.5	-4.7	5.7	2.7
Africa	4.7	2.7	-0.5	-8.1	8.1	3.0	Africa	-1.7	5.4	2.6	-8.8	5.5	4.0
Middle East	-2.1	4.7	-2.5	-8.2	12.4	5.0	Middle East	1.1	-4.1	0.8	-11.3	7.2	4.5
Asia	6.7	3.8	0.8	0.3	8.4	3.5	Asia	8.4	5.0	-0.5	-1.3	5.7	4.4

The table shows two important findings: firstly import and export in continents have always been uneven, proving the need of empty container movements. Secondly it proves an (predicted) uneven recovery, which can be felt today. Where trade grows quickly in one shipping leg, but not in the reverse shipping leg, empty container scarcity occurs. This results in imbalanced prices for shipping legs as well. This imbalance in trade growth shows in the price per container per shipping leg. For Europe, Asia, US West Coast and US East Coast, table 4 shows the increase in prices per container per shipping leg. What is important to note is that the increase in imbalances shows directly from this table. Some prices on the spot market have exploded and are now close to ten times as expensive compared to their five year average, whereas others have ‘only’ doubled. Another important note, is that contracted prices, the prices that large export companies pay, are significantly lower than the prices on the spot market. The rise in prices can thus firstly be explained by the increase in trade skewness and therefore container scarcity in several areas. The increase in prices on the spot market have alerted contracted companies as well. Since shipping companies can now profit more on the spot market, the bargaining position of large exporters becomes significantly smaller, increasing the need to take action proactively.

TABLE 6: PRICES IN $ PER 40"CONTAINER IN 2021 COMPARED TO PREVIOUS 5 YEARS AVERAGED

From	To	5 YR avg spot market	Spot Jul '21	Contracted '21
Asia	EUR	2,500	20,000	2,100
EUR	Asia	900	1,800	650
Asia	US WC	2,200	9,500	n.a.
US WC	Asia	500	1,300	n.a.
Asia	US EC	3,300	12,000	n.a.
US EC	Asia	600	1,100	n.a.
EU	US EC	2,200	6,000	1,875
US EC	EU	550	1,200	450
EU	US WC	3,200	7,000	2,830
US WC	EU	2,200	2,300	n.a.

This scarcity is further enhanced in the beer sector by very imbalanced shipping legs. Traditional supply chains focus more and more on reverse logistics, which have become more important due to sustainability goals. Reverse logistics relate to all logistics activities carried out in source reduction, recycling, substitution, reuse of materials and disposal (Gencer and Akkucuk, 2016). This often entails the return of items such as packaging materials. In the supply chains of exported beers however, most products are considered non-returnable such as cans and bottles. Sometimes this is because of expected damages such as glass breakages, but sometimes it is simply because it is not profitable. The only products that are often returned are kegs of beer, because the chances of damage to the product are low.

This means that a lot of empty containers need to be shipped back in order to meet customer demand. These imbalances have been even further strengthened by the COVID-19 pandemic and Suez Canal crisis. The introduction has already briefly mentioned the effects of the COVID-19 pandemic and the blockade of the Suez Canal and their effects on the logistics sector. Especially the pandemic and lockdowns have massively impacted the supply chain. Trade flows-although imbalanced- were usually very consistent, but once half the world goes into lockdown where the other half does not, self-reinforcing imbalance is created. This can for example be seen in the prices related with different shipping legs throughout time. By the end of 2020, a surge of Asian imports to feed retailer restocking efforts had shipping lines rushing containers back to China, leaving equipment shortages in the U.S. (Paris, 2020). A few months later this imbalance lead to the opposite effect, leaving Chinese exporters without empty containers (Xie, 2021). This can lead to massive container rent prices, leading to higher export costs. In short, the disruption of containers’ normal flow, leaving containers in the wrong location when world trade emerged again, tremendously affecting the shipping rates. This is however not the only cause influencing the global container shortage. Kuehne+Nagel, a logistic service provider offers insights in the following other causes, also relating to the disturbance of world trade (Kuehne+Nagel, 2021):

- Congested ports

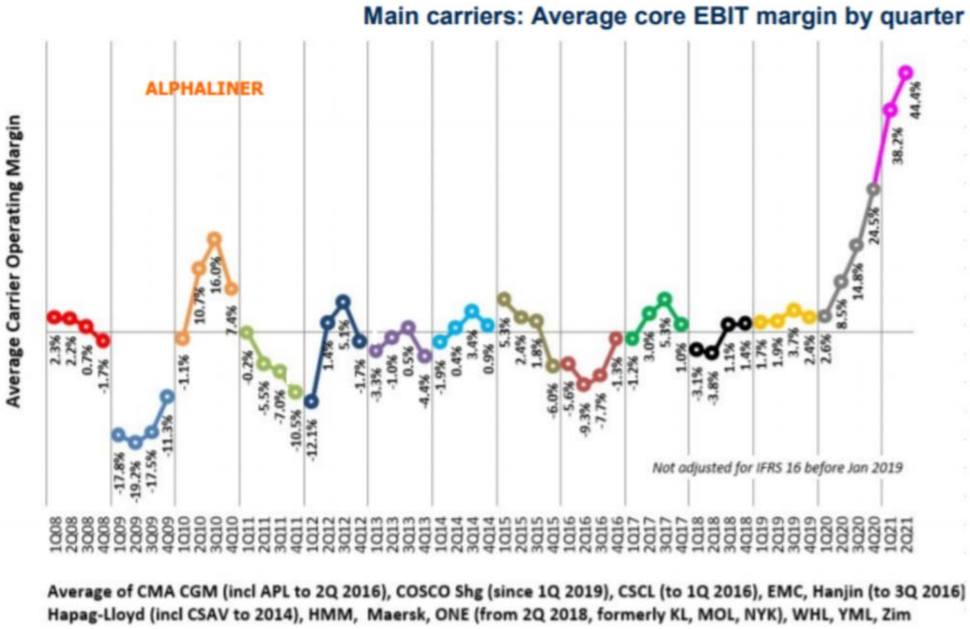
Since workforces at ports were greatly reduced during the pandemic, terminals and terminal supportive jobs have caused delays, missed sailings and constraints on loading capacity.

- Reduced number of operational vessels

Because a lot of vessels were not needed during the first waves of the COVID-19 pandamic, some of them were put into maintenance. This, together with COVID-19 outbreaks on operating vessels lead to further delays and capacity constraints.

- Unpredictable flow of goods

The buying behavior of people has been incredibly unpredictable, which made prediction on the flow of goods hard. The irregularities are said to have led to a significant increase in the cost burdens of carriers. Sea freight rates for bulk carriers have recently increased to record heights for the past eleven years (Heigermoser and Glauben, 2021). This has however, also lead to very high profit margins for shipping companies, which is fairly new to them. The following diagram shows the profit margins for shipping companies:



Average of CMA CGM (incl APL to 2Q 2016), COSCO Shg (since 1Q 2019), CSCL (to 1Q 2016), EMC, Hanjin (to 3Q 2016)
Hapag-Lloyd (incl CSAV to 2014), HMM, Maersk, ONE (from 2Q 2018, formerly KL, MOL, NYK), WHL, YML, Zim

FIGURE 6: AVERAGE CORE EBIT MARGIN BY QUARTER (ALPHALINER, 2021)

The high profit margins gained on the spot market has increased the bargaining power of these companies with contracted exporters. If contracted exporters don’t start paying more, they simply provide transport for other exporters on the spot market. The effects of this power shift can already be noticed. Exporters are sidelined by shipping companies who are forcing certain ‘standardized’ contracts on the market (Jumelet, 2021). Even more severe examples can be found in Hamburg Süd, who without reasoning left forwarders with a booking stop (Verheggen, 2021).

All of these effects combined have caused a global container shortage, leading to high export costs for global companies such as HNS. These high costs require HNS to adapt its operations in order to remain competitive.

Detention & demurrage costs

Two charges impacting container prices are detention and demurrage costs. Detention and demurrage costs can be explained simply put as being the costs for renting an empty container. Demurrage relates to container storage at the terminal and detention, relating to container usage (Bowa-Gate Global, 2020). The process differences through import and export can be seen from the following figure:

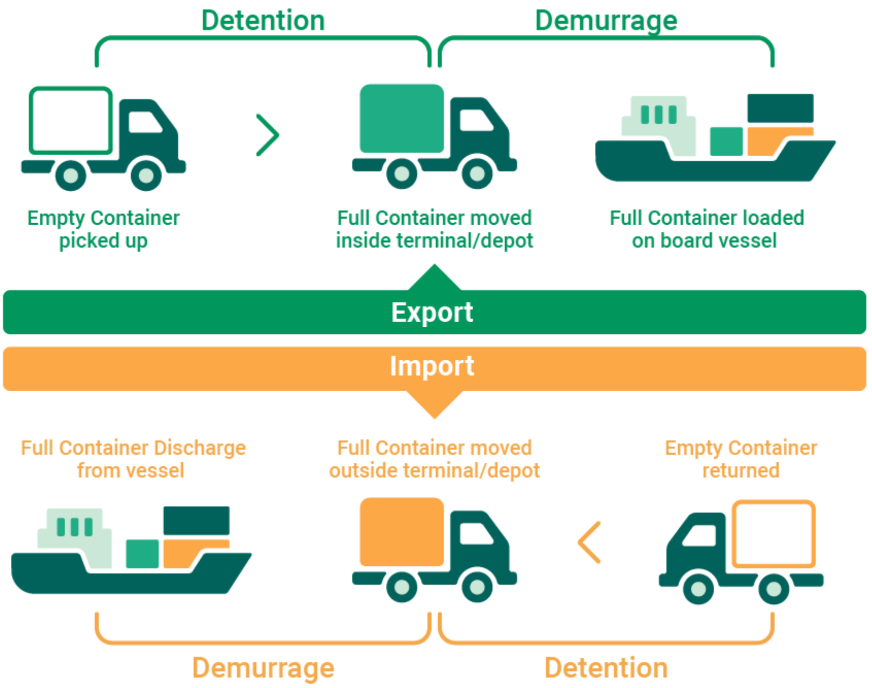


FIGURE 7: DETENTION AND DEMURRAGE

They are charged on a daily basis per container. These costs used to be close to zero, but now they could at times well accrue to over 20 times the value of the container itself (Frese, 2021). Detention and demurrage tariffs vary per container and shipping company and per country. Often a certain amount of ‘free days’, in which no fees have to be paid for the containers, are available for companies to make use of these containers, but these also vary amongst shipping companies. In the Netherlands for example, the amount of free days related to export (on the spot market) can for example be seven days for Hapag-Lloyd (Hapag-Lloyd, 2021), whereas this is twelve days for CMA (CMA CGM, 2021). The costs after that vary quite a lot but CMA for example charges €68,- for a 40’ container per day for the first week after the free days. The week after that this becomes €100,- per container per day and after that the prices go up to €135,- per container per day (CMA CGM, 2021). It quickly shows that for large exporters, these prices can stack quickly. For example, if on a yearly basis, 10.000 containers are stuck for a week after the free days, close to 5 million euro’s in extra costs could be charged for detention and demurrage on the spot market.

However, larger exporters generally work under tendered contracts for each shipping leg and have better conditions. They will often have more free days and cheaper detention and demurrage tariffs. However, these prices are also expected to go up for contracted companies, since their bargaining power is decreasing due to the higher profit margins of carriers which has been explained in an earlier section.

Information sharing

The importance of information sharing in a supply chain for the optimization of a supply chain-wide performance has been elaborately discussed in literature. Information sharing is seen as an enabler of tighter coordination leading to a better performance (Lee and Whang, 2000). Although general consensus is that a supply chain basing its choices on global information would be superior opposed to a supply chain in which separate entities make separate decisions within that supply chain, the realization of such a supply chain remains difficult (Lee and Whang, 2000). Especially in global supply chain systems challenges become bigger relating to information sharing when customers are spread out all over the world and more stakeholders become involved (Shore, 2001). Centralized management approaches where a single entity tries to optimize a global supply chain have hence become unrealistic. Each entity within a supply chain aims to optimize its own processes, although they know that a global wide supply chain collaboration would be beneficial to the global performance (Sadraoui and Mchirgui, 2014). These supply chains characterize themselves by having many phases, multiple locations, multiple accounts and payment and an increasing amount of business partners and means of transport (Pal et al, 2021). This is further enhanced by a very unstable environment due to a lack of knowledge about the timing of activities of a great amount of actors within a port system, requiring a need for information sharing when striving for an efficient supply chain (Olesen et al, 2014).

According to Chen and colleagues (2017), blockchain is a promising technology to address problems in this sector, focusing on self-interest of different parties in the supply chain. They propose a framework to assure information sharing and quality control. The framework assumes four layers, based on different functions to ensure information sharing: a IOT sensor layer, a data layer, a contract layer and a business layer. The first layer entails different IoT tools used to measure for example product locations. The second layer goes into the specific types of data. The third layer goes into contractual agreements to prevent e.g. concerns about privacy issues that will be related with data sharing. Some information could well be sensitive since competitors are active within the same supply chain (Chen et al, 2017). The fourth ‘Business’ layer entails business activities within enterprises, made able by real time data availability. The framework however, neglects the complexity between parties in the business layer and assumes that decisions are made rationally based on perfect and symmetric information. This is however not always the case with the relation between carrier, barge operator and exporter and it is often unclear through contracts who is responsible for which costs that could possibly be made within the supply chain, or exporters are incapable of controlling charges systematically, leading to additional costs.

A lot of study has been done into barge operators and how to optimize their processes in the harbor. The uncertainty from unreliable container arrivals for example was shown to have a possible impact of up to 53% of the costs (Gumuskaya et al, 2020). Similarly, Fazi and colleagues (2015) presented a decision support system for barge planning between deep-sea terminals of Antwerp and Rotterdam and an inland terminal in Veghel. This is a tool that could potentially be aimed at exporters, but is provided for barge operators. Larsen and colleagues (2021) recently proposed a real-time co-planning method to let truck operators indicate their preferred departure time without giving out any sensitive information, offering a new perspective on operations relating to container transport.

Literature thus shows that the relationship between carrier, barge operator, harbor operators and truck operators have often been researched to optimize handling of containers. One big problem relating to the previously mentioned D&D costs however, is the lack of information sharing, or information processing capabilities between the exporter and these other stakeholders. Handfield and Nichols (2002) proposed a framework on relationship management including flows of information within a supply chain. They do however define the distributive network as one layer, whereas current distributive networks can be seen as two different layers, operating with different goals, under varying contracts with the enterprise. In this case these layers can be defined as inland transportation like barge operators and deep sea carriers. The framework can be adjusted to define the missing information or information processes within the supply chain form a exporters perspective:

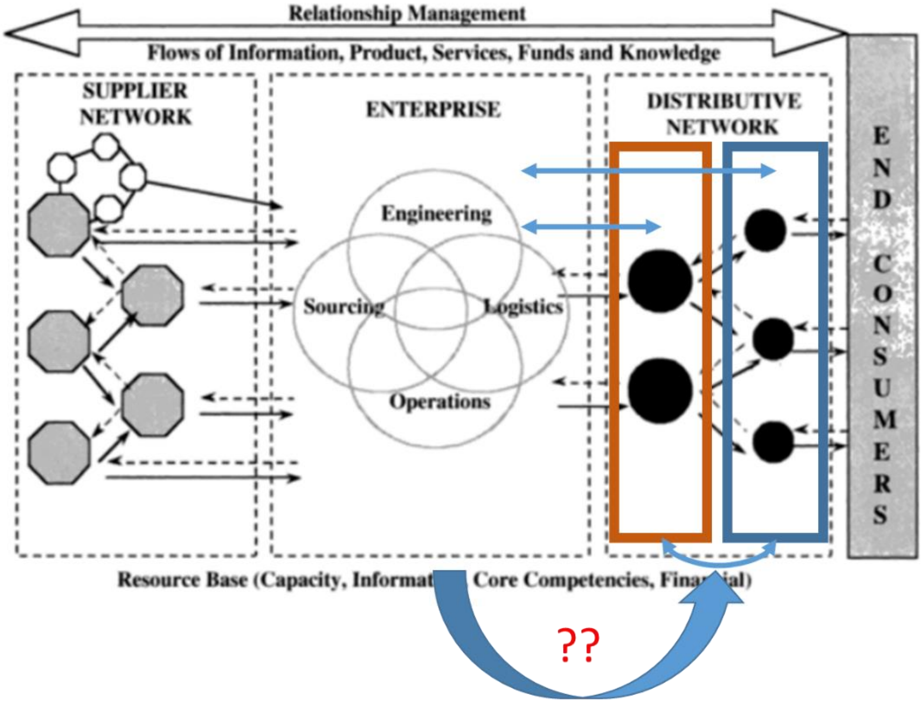


FIGURE 8: FRAMEWORK ADAPTED FROM HANDFIELD AND NICHOLS (2002)

In the adjusted framework, the barge operator are depicted by the orange rectangle and the deep-sea carriers with the blue rectangle. The arrows are associated with the contractual agreements as well as information flows. The framework indicates that the enterprise, or exporter, lacks insights into the contractual agreements and operational activities between barge operators and deep-sea carriers.

Exporters usually have contact with the barge operator and carriers separately, but have little insight into the information between barge operator and carrier. Detention and demurrage are thus often charged by the carrier in a grey area where the exporter has no clear visibility of the containers movements anymore. This information is necessary for the exporter.

Another aspect to this problem is that contractual agreements between carriers and exporters state that charges should not be charged a certain time period after the actual process happening, but practice learns that they do. Exporters have no precise insight in where containers were at that point in time, or lack information processing tools. For exporters, downstream supply chain information sharing is of the utmost importance to increase their performance. Carriers have less incentive to share information upstream, which is why D&D costs remain very unclear for exporters.

It should also be noted that this aspect of detention and demurrage have only marginally been studied in literature from the perspective of the exporter. Some operational research has been done, for example into inbound container hinterland transportation concerning the detention and demurrage (Fazi and

Roodbergen, 2018) or for decision making on free time for ocean carriers (Yu et al, 2018). The impact of information sharing on the topic between stakeholders within this aspect of the supply chain is close to non-existent.

CONCLUSION AND KNOWLEDGE GAP

The container crisis has had a significant impact on the exporters' market. Scarcity of empty containers on the desired location has led to very high shipping prices. Carriers have made more profits in 2021 than they have made in the last twenty years combined, equaling a combined EBIT (Earnings Before Interest & Taxes) of 150 billion dollars (Lalkens, 2021c). For exporters, additional costs such as detention and demurrage have increased as well due to congestion in the container shipping market. Since these additional costs had always been relatively low, they have never been researched from the perspective of the exporter. The high profits, amongst other effects such as pricing agreements have led to a power shift in bargaining. The market, that was characterized by overcapacity of containers and ships, had always left deep-sea carriers fighting for the exporters' demand. Nowadays, exporters have to fight the spot market to have their demand contracted by deep-sea carriers. Exporters are left with less beneficial contracts or no contracts at all.

Furthermore, exporters working with inland terminals and barge operators have always had limited visibility on their container movements. They used to provide the full containers to the barge operators, where containers would then enter a 'grey area'. In this area the only updates on their containers that exporters would receive came from the barge operators and carriers. Because of this, the visibility on container movements within the pre carriage part of transportation was always limited. Nowadays, data becomes more and more available to exporters, giving them more insight in that 'grey area'. The following table indicates several studies (and some other sources) and their main focus and indicates the focus of this study and how it contributes scientifically:

TABLE 7: LITERATURE GAP TABLE

	Container scarcity/ price ↑	Increasing power carriers/ contracts	Information sharing	Data usage	D&D	Exporters perspective
Robinson, 2007	●			●		●
WTO, 2021	●			●		●
Paris, 2020	●			●		
Xie, 2021	●					●
Heigermoser & Glauben, 2021		●				
Alphaliner, 2021	●	●		●		
Jumelet, 2021		●				●
Verheggen, 2021		●				●
Frese, 2021					●	●
Lee & Whang, 2000			●			●
Pal et al, 2021			●			
Olesen et al, 2014			●			
Chen et al, 2017			●			
Gumuskaya et al, 2020			●	●		
Larsen et al, 2021			●	●		
Handfield & Nichols, 2002			●			
Fazi et al, 2015			●	●		●
Fazi & Roodbergen, 2018			●	●	●	
Yu et al, 2018			●	●	●	
This study	●	●	●	●	●	●

This research will focus mainly on determining whether the insight in data relating to container movements could assist exporters in gaining more specific insights into their demurrage and detention costs and how this information can be further used to weigh off flexibility, sustainability and costs in times of a global container shortage.

3. CASE STUDY

This section will elaborate on the case study of HNS. It will try to explain in detail what the environment is in which HNS operates for the export market, what the key performance indicators are and how contractual agreements are arranged within the market. This section will provide answer to the following research questions:

1. *What do logistic processes, corresponding information sharing processes and contractual agreements for the export market currently look like?*

2. *What are the performance criteria for these logistic processes?*

It will also provide part of the answer of research question 3:

3. *What kind of bottlenecks and challenges are present in these current processes and how are those bottlenecks expected to change in the future?*

3.1 EXPORT FLOW

In order to understand how the general transportation goes, it is important to first look into the export flows of HNS. As stated before HNS handles two types of orders: make-to-order, where customers can order products when they want and replenishment, where HNS is responsible for the management of the customers' inventory. The biggest difference between these orders is the order lead time. HNS operates under a 'drumbeat'. This is the time required for Plan-Produce-Start Shipment of orders. This time is 4 weeks for MTO markets and 3 weeks for replenishment markets and is also called the frozen period in which orders cannot be changed. The lead time of MTO markets is thus one week longer.

The complete processes and responsible stakeholders can be found in Appendix A, which also goes into wastes more specifically. A strongly simplified flow of the order process relating to the main activities can be found in the following IDEF-0 diagram:

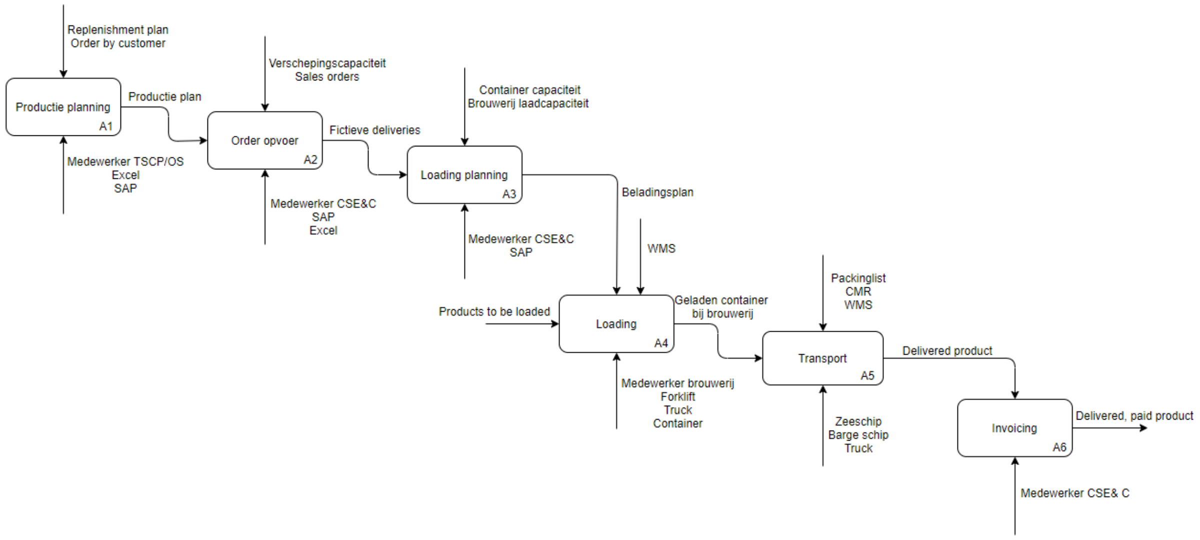


FIGURE 9: SIMPLIFIED PROCESS FLOW (OWN SOURCE)

As can be seen the process and product flow entail 6 main steps: production planning, creating orders, loading planning, the actual loading and transport and invoicing of the customer. The process steps entail the main steps and relations between HNS and the carrier. In the ‘Transport’ step, costs are made for HNS between them and the carriers and barge operators.

For deep-sea export the costs charged by carriers can be split up into two main parts: standard tariffs and additional surcharges. This report will focus mainly on the detention and demurrage surcharges and leave other, additional surcharges that occurred due to the container shortages out of scope, since they have a wide variety and are hard to put under the same denominator.

For all exported legs, HNS is responsible for the standard shipping tariffs. These are then included in the price charged to the customer. However, detention and demurrage costs are surcharged and are not included in the standard shipping tariffs. These can thus be considered extra costs that have to be paid by HNS, which is why it is important to see whether these costs can be influenced.

Another important aspect is that whether HNS or the customer is responsible for detention and demurrage costs. This is dependent on the incoterms HNS has with the customer. In general, HNS is responsible for all detention and demurrage costs that occur between the brewery and the deep-sea terminal for export and vice versa for import. On the receiving end, the customer is responsible for clearing the container and thus also for detention and demurrage on their end. This report will therefore focus on the ex- and import between the brewery and the deep-sea terminal of Rotterdam and Antwerp.

3.2 KEY PERFORMANCE INDICATORS EXPORT

Export performance at HNS is measured through a couple of KPI’s. From the perspective of the customer there are two metrics that can be associated with resilience to the container crisis a well. HNS uses the following two indicators for that:

- Do we deliver on time?
- Do we deliver in full?

These aspects rely on several other factors such as no Product Available (PA), not On Time (OT) and not In Full (IF). Now these aspects could occur for example in the following cases:

- Not IF: Breakage due to container stuffing, shortage due to physical/administrative stock differences
- No PA: Shortage due to production, production back log, production blocked, planning issue
- Not OT: Issues with priority with loading, pre carriage and the main leg of transport.

These aspects together form the KPI that is used, namely the Case Fill Rate (CFR). This metric is calculated by multiplying the percentages of PA, OT and IF. The following fictive example shows how the CFR is calculated:

- Total cases 43900
- 200 cases are not in full: 99,9%
- 1800 cases have no product availability: 95,9%
- 3400 cases are not on time: 92,2%
- CFR = 99,9% x 95,9% x 92,2% = 88,3%

The target of HNS in 2021 was a CFR of 88%. This target was not reached in 2021 of which one of the causes was the container shortage. Especially the amount of orders IF OT can be impacted by the current container crisis. If containers are not available, orders cannot be completed in full or within the previously mentioned drumbeat, leading to delays.

From the perspective of HNS, KPI’s mainly entail trade volume and associated transportation costs. The expectation is that in order to meet customer demand and thus a high CFR, HNS will have to invest more and more in their transport, leading to higher costs. These higher costs could eventually lead to lower profit margins or higher product prices.

Transportation costs can be split up into several different costs:

- Pre carriage costs
- Deep-sea costs
- Additional deep-sea costs
- Terminal handling (Port of Loading & Port of discharge)

These costs can be further summarized by costs charged by the barge operator and carrier and costs paid by HNS and by the customer. This research will focus on exactly those costs and contain of the following:

- Standard Deep-sea tariffs (sum of rates Deep-sea and terminal handling)
- Additional costs (detention and demurrage)

In the future a weigh off needs to be made between these two costs. If HNS wants to be more flexible, this will lead to an increase in the standard tariffs. If HNS wants to keep their standard tariffs low, the flexibility of their operations will decrease, possibly leading to higher additional costs because they can’t deliver containers within the free time frame to the ports.

Furthermore, costs associated with the positioning of empty containers to in-land terminals of Alphen and Den Bosch are included in the deep-sea rate of the carriers.

Admittedly, Heineken has repeatedly expressed their wish to become more sustainable and strive for an environmental friendly supply chain. At this moment and within this department however, sustainability is not something to which HNS actively measures its performance.

3.3 TRADELENS

Until recently, HNS had no clear way to trace their containers. When they left the brewery, they could be described as a black box, in which HNS was reliant on the information they received from barge operators and carriers. At the end of 2018 however, IBM and Maersk launched named ‘Tradelens’ a product that could potentially change this. Tradelens is a platform supported by block chain technology, enabling information sharing across supply chains (Tradelens, 2021). The shipping industry, being very old, cumbersome and characterized by paper document handling and personal relationships. Tradelens is a platform designed to radically disrupt this industry by digitalizing all of the processes, making information available to all customers and affiliations to those customers at all times.

Although not all carriers are in bed with Tradelens yet, Tradelens is able to represent data on 60% of the global container shipping volume. It provides near real-time information to all kinds of parties operating in the container shipping industry. HNS has recently also joined Tradelens, giving them insights in their export-related activities. This data could possibly assist in solutions towards detention and demurrage costs, although it should always be noted that the data points might be unreliable, since not all carriers are included (such as evergreen). Tradelens provides accurate datapoints since 2021. Several carriers however, have only started providing data in late 2021, meaning that the data is not as accurate as it could be. Carriers that are currently affiliated with Tradelens account for more than 90% of HNS’ container movements. Although the data might not be as accurate for 2021, the potential of this platform on visibility of container movements should not be forgotten. As Tradelens states, they can: *"Transform container logistics by freeing yourself from legacy data systems, manual document handling and poor visibility* (Tradelens, 2021)*."* The potential on visibility speaks for itself, but the digitalization of (customs) document handling can also heavily impact the supply chain. Although not the prime focus of this research, this is very important to name. Documents often get lost or delays occur because documentation is missing or delayed. The digitalization and automation of these processes can thus also influence the lead time of container movements, which have to be named.

3.4 STANDARD TARIFFS AND PRE CARRIAGE

As stated, transportation costs are build up from several different aspects. The contracts with the carriers go into those different costs and provide a total rate that needs to be paid for shipping a container. These costs entail terminal handling at origin and destination and the deep-sea tariffs in USD. Appendix D highlights all export-related shipping legs and their associated total rate. It also provides the allocation for each of the shipping legs. Sometimes the total demand is split up between different carriers. In general, prices range from $500,- up to $5000,- per container, where the shipping legs towards Asia are generally the cheapest and to North America and Africa more expensive. These differences have already been explained in section two and relate to the trade skewness and local demand and supply. From Asia towards Europe for example, demand for containers is much higher than the other way around, leading to high prices towards Europe, but low prices towards Asia from Europe.

Heineken has also explored options to buy containers themselves instead of 'renting' them with shipping companies. Several options were considered, including buying them in Europe and selling them again at the POD. In the research and negotiations with CARU, a container dealer, there were however several problems associated with this. The most important problem is that, whilst meant to be more flexible, flexibility is actually decreased by buying 'own containers'. Exporters remain fully depending on the carriers to provide them space on ships. Carriers however, have incentive to move their own equipment with priority, meaning that the exporters' containers can only travel on shipping legs where capacity is left on ships. Otherwise, exporters would have to pay even more than they would have when they would rent containers with these shipping companies. Another aspect is that the back haul of containers is less interesting for exporters since the demand on the main haul is not equal to the demand on the back haul, increasing transportation costs for the 'own containers'. Finally, own containers cannot be shipped in third world countries as much, since they often 'disappear' in these regions. For exporters this would be too expensive since they would have to use containers several times in order for them to become profitable.

The contracts revolving around pre carriage are different. The carrier is not involved in this process. It is a bilateral agreement between the barge operator and HNS. The tariffs are standard for barging per container measurements and are charged to HNS by the barge operator and then to the customer by HNS. These costs are equally charged, independent from the point of loading. For all shipping legs from Alphen and Den Bosch, these are hence the same. The pre carriage costs for barging are the following:

TABLE 8: PRE CARRIAGE COST PER CONTAINER 2021 (CONTRACTUAL AGREEMENTS, ANNELIES MULDERIJ)

Container type	Costs per container
20 feet	€ 199
40 feet	€ 228

Instead of by barge, containers can also be shipped by truck to the deep-sea terminal. This is faster and is hence often used as a means to make sure that containers reach the deep-sea terminals in case of emergencies when the deep-sea vessel is leaving. Because of the higher costs associated with shipping cargo by truck, this is not used as often as barging. Also, these numbers differ for the CCT, which exploits the Alpherium and for the BCTN. For the CCT, the following average tariffs are used for 20 feet as well as 40 feet containers:

TABLE 9: ADDITIONAL PRE CARRIAGE COSTS

Container type	Extra costs per container
20 ft	€ 300 (€499)
40 ft	€ 300 (€528)

It can be seen that these tariffs are also standard uninfluenced by container type, size or shipping leg. The contractual terms for the standard tariffs relate to the year 2021 and were gathered by interviewing Annelies Mulderij, contract manager and category specialist logistics HNS. The information on the costs per container for trucking were obtained through Arjen Nederhof, finance manager CCT.

3.5 CONTRACTUAL TERMS DETENTION AND DEMURRAGE 2021

The literature review already stated that detention and demurrage costs differ on many aspects such as carrier, countries and whether a company is contracted with a carrier or rents containers on the spot market. HNS, being a relative large exporter in the market has had pretty beneficial terms for the past time. They tender each shipping leg every year towards all the carriers and practice shows that most shipping legs are generally executed by the same carrier as last year. The contractual agreements relating to service agreements slightly differ for import and export, but this research focuses solely on exported container movements. The contractual terms for free days and detention and demurrage costs relate to the year 2021 and were also gathered by interviewing Annelies Mulderij, contract manager and category specialist logistics HNS.

The amount of free days relate to the amount of days HNS has for container usage and storage, before it has to pay detention and demurrage. In case of HNS this entails the process from the moment it takes a container into usage at Alphen or Den Bosch, until a ship is planned to leave the deep sea terminal in Rotterdam or Antwerp (Estimated Time of Departure/ETD). HNS books a carrier to transport a certain container and once this booking is confirmed, the original ETD is contractually used as a cutoff. When a ship delays, HNS should not be responsible for detention and demurrage.

As stated, HNS used to have very beneficial terms with the carriers. Contracts with all carriers on all shipping legs contained the same amount of free days that HNS could make use of. For both Rotterdam and Antwerp, HNS has the following terms relating to free days:

TABLE 10: FREE DAYS HNS EXPORT

Equipment usage free days (detention)	Including maximum storage days (demurrage)
28	14

The terms thus state that HNS has 28 days from the start of equipment usage to the original ETD. Within these 28 days, containers can be stored at the deep-sea terminal for a maximum of 14 days.

However, as can be found from appendix C, carriers do not always use the right amount of days in their invoicing process, possibly leading to higher costs. If for example 14 equipment usage free days are used to calculate detention with as in appendix C, the total costs can quickly start to reach high values. It is clear that there is a lot of uncertainty in those contracts and that neither stakeholder knows the exact contractual agreements per shipping leg. There is a clear discrepancy between what HNS thinks is in the contracts and what the carriers sometimes think is listed in the contracts. An interview with Mitchell Drooduin (Global contract manager) elaborated on this. It is true that the standard request is 28/14 days, but at times exceptions could even be verbally addressed. However, the standard contractual agreement should be 28 free days for usage and 14 for storage.

DETENTION AND DEMURRAGE COSTS HNS EXPORT

Just like the amount of free days, the costs that HNS has to pay for detention and demurrage are equal amongst carriers and ports. These costs thus occur once HNS' usage of the container exceeds the amount of free days of 28 for equipment usage and 14 for equipment storage. The following costs apply to those situations:

TABLE 11: DETENTION AND DEMURRAGE COSTS HNS EXPORT

Detention costs	Demurrage costs
€8,-/container/day	€10,-/container/day

If HNS were to use the equipment for 30 days-2 days too much- for all 60.000 containers, this would mean that additional detention could easily reach one million euro's. This quickly shows that if the terms are consequently exceeded, prices could easily reach extreme heights due to the high volume of HNS.

3.6 FREE DAYS HNS

To give an indication of the amount of days it usually takes HNS to transport containers from Alphen and Den Bosch to Rotterdam and Antwerp, data from Tradelens can be used as explained in Appendix B. The data used contains container movements in 2021 from January towards September.

It is important to define which points in the process will be taken into account to define the amount of days. This is directly related to detention and demurrage costs and is elaborated on in more detail in appendix B. In short: after HNS receives a booking confirmation from the carrier they take a container into use and usage days is calculated until the original planned vessel departure time at the deep sea terminal. Storage is calculated by looking at the time a container arrives at the deep sea terminal and the planned vessel departure time.

However, not all container movements are taken into account in this data file, because of for example missing values. These missing values can occur for several reasons. The most important reason is that the data has long been incomplete. Data from CMA-CGM for example was only included in Tradelens in June of 2021, but for containers in the previous period, values do exist from the source of Heineken. Because of this, several container movements could not be fully measured in terms of equipment usage or storage. This leads to discrepancies between the amount of data points used for the equipment usage and equipment storage. The quality of the data however, should not be worse, since all of those measurements are still real data and depict actual container movements, although sometimes only the first or second half of the shipping leg.

All of the data points and their corresponding values can be found in more detail in Appendix B. The following table provides the average values in days for each of the shipping legs for both equipment usage and storage. The amount between brackets shows the amount of values used for these measurements:

TABLE 12: AVERAGE EQUIPMENT USAGE AND STORAGE PER SHIPPING LEG IN DAYS (TRADELENS)

Shipping leg	**Equipment Usage**	**Equipment storage**
Alphen-Rotterdam	16,3 (7687)	7,3 (4303)
Den Bosch- Rotterdam	17,1 (1417)	6,8 (4866)
Alphen- Antwerp	18,3 (8166)	10,9 (4817)
Den Bosch- Antwerp	18,7 (632)	11,0 (4809)

3.7 TRADE VOLUME

To be able to define relative impact of detention and demurrage costs, which will be covered in the next section, it is important to provide insight into the total amount of trade volume and associated costs. To define trade volume, the amount of containers that are shipped are taken as indicator instead of total shipped volume. This is done because detention and demurrage costs are charged for containers and not for the volume, weight or other metrics of shipped colli. The following table shows the amount that has been transported for the last couple of years. For 2021, data was available until august of this year. The number in brackets is the average per month extrapolated to the remaining four months.

TABLE 13: TOTAL TRADE VOLUME PER YEAR (FRANK KEMPER, PROCUREMENT SUPPORT OFFICER)

Year	**Exported containers (Deep-sea)**
2018	58170
2019	61341
2020	19735 DB+ 40090 ZW (59825)
2021 (January-August)	11998 DB+27308 ZW (39306 → 58959)

A very slight increase in transported volume can be found from this table. COVID-19 does not seem to have impacted the trade volume for HNS. This is supported by McKinsey, finding a global shipping volume increase of ‘only’ 5% compared to 2019 (Remes and Saxon, 2021). For the year of 2021, it seems that the eventual transported volume is close to the volume of the years before. Right now the estimation is a little under that, but September and October are usually months in which a bigger volume is transported. This could maybe account for that difference.

For 2020 and 2021, the amount of containers from both breweries is incorporated. It should be noted that the transport volume is close to 33% for Den Bosch and 67% for Zoeterwoude.

Next to the total trade volume, it is also important to define the amount of containers that are currently shipped by truck instead of by barge. As explained in an earlier section, this is generally used for containers that need to arrive very quickly at the deep-sea terminal, offering more flexibility. It is however, more expensive and less sustainable. The following percentages apply for the CCT and BCTN:

TABLE 14: PERCENTAGES OF AMOUNT OF CONTAINERS TRUCKED FOR DEEP-SEA (CURRENT)

Percentage CCT	Percentage BCTN
7,1%	5,5%

It is not clearly defined how percentages differ per container sizes. This is however also not necessary to investigate, since the costs of transport are the same for both 20 feet as well as 40 feet containers. These numbers were obtained through Arjen Nederlof (CCT) and Peter De Witte (BCTN).

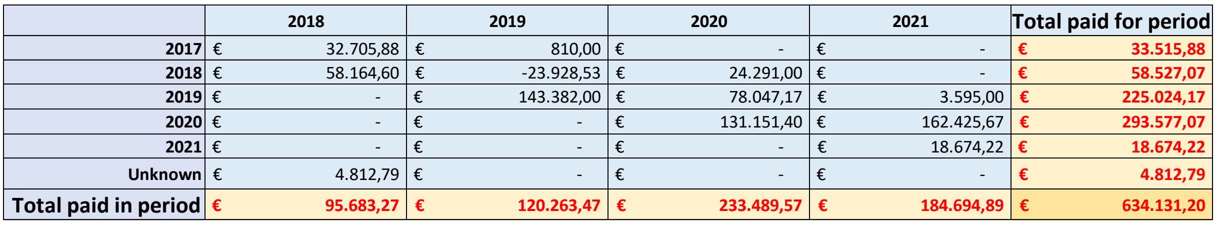
3.8 TOTAL DETENTION AND DEMURRAGE COSTS

Appendix A already tried to identify detention and demurrage costs for HNS and defined an estimation of how high these costs would be. There, the wastes in terms of costs were defined as two separate things:

- The lack of a trigger to make work of D&D costs, causing an estimated €200.000,- each year.
- The payment of D&D without verification, resulting in an estimated €50.000,- each year

To give insights into the current costs that are actually being made because of demurrage and detention, the costs of previous years have been looked at. Therefore the total period that was studied is from 2018 to august 2021. The total costs in 2021 could thus grow further towards the end of 2021. Since detention and demurrage could well be charged for events that happened two year prior, not only the amount paid per year, but also the amount paid for a year is depicted in the following table:

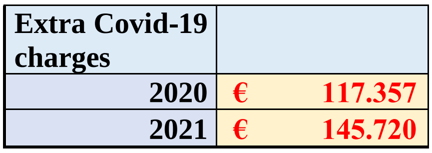
TABLE 15: TOTAL DETENTION & DEMURRAGE COSTS HNS (FLORIS PIGEAUD, BUSINESS CONTROLLER LOGISTICS HNS)



	2018	2019	2020	2021	Total paid for period
2017	€ 32.705,88	€ 810,00	€ -	€ -	**€ 33.515,88**
2018	€ 58.164,60	€ -23.928,53	€ 24.291,00	€ -	**€ 58.527,07**
2019	€ -	€ 143.382,00	€ 78.047,17	€ 3.595,00	**€ 225.024,17**
2020	€ -	€ -	€ 131.151,40	€ 162.425,67	**€ 293.577,07**
2021	€ -	€ -	€ -	€ 18.674,22	**€ 18.674,22**
Unknown	€ 4.812,79	€ -	€ -	€ -	**€ 4.812,79**
Total paid in period	**€ 95.683,27**	**€ 120.263,47**	**€ 233.489,57**	**€ 184.694,89**	**€ 634.131,20**

A clear trend is visible in the table above. The costs have drastically increased in the period of 2018 to 2021. For the period of 2017, total D&D costs were about €33.000. For 2020, these costs are currently at approximately €293.000 which might even increase further with invoices still coming in for that period. In general, deep-sea carriers provide their invoices every month for the month before. The invoices are then sent to Heineken Global Shared Services (HGSS) in Poland. They send these invoices back to CSE&C to verify detention and demurrage fees. Depending on the current workload, verifying these invoices can take up to 6 months or even a year at times. The aforementioned means that in a period of three years, a 1000% increase is seen in detention and demurrage. Furthermore, there are also additional COVID-19 charges. These can also include demurrage and detention costs, but the exact composition is unclear. The following additional covid-19 charges were charged for 2020 and 2021:

TABLE 16: EXTRA COVID-19 CHARGES



Extra Covid-19 charges	
2020	**€ 117.357**
2021	**€ 145.720**

This large increase cannot be explained by a larger transport volume as can be seen from section 3.7. Because of that, a possible explanation for these high costs can be the container crisis, caused by the COVID-19 pandemic as well as the Suez canal blockade.

3.9 CONCLUSION CASE STUDY

This section has aimed to answer the following research questions:

1. *What do logistic processes, corresponding information sharing processes and contractual agreements for the export market currently look like?*

Currently, large exporters book container transport at a deep-sea carrier. These carriers then provide a container, which is filled and delivered by HNS and a barge operator to the deep sea terminal. From these deep sea terminals containers are then shipped all over the world.

Information sharing processes mainly existed between barge operators, ports and deep sea carriers, but not with the exporter. New platforms like Tradelens provide more information on the actual location of containers and their movements and give exporters more insight in their exporting activities.

Contracts contain yearly tendered capacity on a large number of shipping lanes. Carriers all ‘offer’ on those shipping lanes, providing a certain capacity they can transport, the price for the transport and additional service conditions such as free days and detention and demurrage fees. These contracts used to be very beneficial for exporters, as the container shipping market was characterized by overcapacity, indicating low prices and beneficial service conditions.

2. *What are the performance criteria for these logistic processes?*

HNS currently measures KPI’s mostly from the perspective of the customer focusing mainly on the reliability of their deliveries being on time and in full. A second perspective are the costs that are made during the export process, which are significantly increasing. HNS does not actively measure performance in terms of sustainability, although Heineken does express the wish to become more sustainable.

3. *What kind of bottlenecks and challenges are present in these current processes and how are those bottlenecks expected to change in the future?*

Bottlenecks exist in the current container market. Congestion and delays occur, leading to significant increases in transportation costs. This is particularly the case with detention and demurrage costs, seeing a 1000% increase over the past three years. Also, exporters like HNS have always trusted on the information they received from their barge operators. Therefore, their own information processing tools were lacking. New platforms provide the opportunity for exporters to directly visualize their container movements. Next to that, HNS sees congestion towards their customer, leaving a decrease in flexibility and customer satisfaction.

Bottlenecks thus occur in controlling mechanisms due to lack in data processing tools, customer satisfaction and in general: higher costs.

4. SCENARIO ANALYSIS

Near-future developments are important to take into account as they might influence the current bottlenecks as well. This section will aim to identify future developments in terms of container scarcity and price developments, the consequences of those developments on contract negotiations and well as developments in demand in terms of containers as well as beer. This will boil down to several scenario's based on the demand of containers that need to be shipped that will be taken into account. This section will answer the following research question:

3. *What kind of bottlenecks and challenges are present in these current processes and how are those bottlenecks expected to change in the future?*

4.1 CONTAINER SCARCITY- AND PRICE DEVELOPMENT

In the current situation, container exporting prices are very high and freight carriers have made more profit than the 20 past years combined. This has increased their power in the market significantly. To see how HNS needs to adjust to this situation and how they should take action in the future to ensure their operations, developments in the (near) future need to be taken into account. These developments are two sided. On the one hand, the scarcity of empty containers and the stabilization of the market need to be looked at. On the other hand, the corresponding prices need to be analyzed. At first sight these might seem correlated but there are several causes that might prove otherwise.

CONTAINER SCARCITY

As stated before, carriers have enjoyed the benefits of the aftermath of COVID-19 and the Suez canal blockade. Because empty containers were unevenly distributed compared to the demand in each trade leg, shipping prices were able to reach prices six times as high as before this period. Another important factors for this effect were the congestion of harbors due to COVID-19 outbreaks and that during the initial COVID-19 outbreak, carriers took vessels out of operation for maintenance since at that time trade volume was very low. The assumption is that in time the market will stabilize and empty containers will thus slowly start being on the right locations again as the market recovers from these effects.

Container carriers, experiencing these effects, have ordered a record high of 229 new container vessels with a combined capacity of 2.2 million TEU over the first 6 months of 2021 (Konings, 2021). Since the building of those ships takes quite a bit of time, the new capacity is expected to be ready in the second half of 2021. The new capacity is expected to represent a 6% increase in trade capacity, which the scrapping of old vessels is not expected to disturb. This effect, combined with the market recovering itself after the COVID-19 and Suez blockade is expected to ease the capacity constraints that are present now, due to which exporters sometimes struggle to get their cargo shipped, even against the high tariffs (Konings, 2021).

CONTAINER PRICES

Another effect on the supply side that has to be taken into account is how the container prices will develop. The general economic consensus is of course that scarcity leads to higher prices, which also counts for this situation. However, once the market stabilizes the prices are not necessarily expected to decrease. There are several reasons why this might not apply in this case.

Firstly, there are fewer carriers in the market than ever before. Because of the way ocean freight carriers are divided in several very large alliances, carriers have learned to manage capacity better than ever before. This, alongside with pricing agreements between the big alliances and carriers within these alliances, mean that prices might not decrease to their old values, but remain fairly high.

A second reason for why prices might remain high in the future is the decarbonization of shipping and thus the internalization of external costs. The energy transition is happening on a large scale and on multiple facets. Also in maritime logistics, the energy transition is a hot topic. There are a terms and regulations emerging from worldwide organizations and governmental bodies which all limit the amount of polluting emissions. In maritime logistics this is slowly developing towards a situation in which the polluter pays. The external effects will somehow be internalized, meaning container shipping prices are expected to increase as well (Hoffmann, 2021).

A third and final reason is that carriers have learned not to lose out any longer. Carriers had always felt the need to decrease unit costs and invest in bigger economies of scale and more fuel efficient ships. What followed as a consequence was a market in which overcapacity only got bigger, since older ships were not scrapped (due to their high sunk costs). Freight carriers have now learned to better manage this capacity and have learned how important they are in the market (Hoffmann, 2021).

All of these reasons have shifted the bargaining power in the market. The past decades, large exporters such as HNS were holding the cards in negotiations with the carriers. The carriers were competing with each other more and the market characterized itself by the overcapacity on the supply side. Since the carriers could only profit if the capacity was used, they would heavily compete with each other for the demand that existed, leading to very low container prices. Nowadays however, the bargaining power has shifted to the carriers. There are fewer carriers on the market and the market does not characterize itself anymore by the overcapacity that has existed for the past time. If exporters such as HNS do not comply to the terms and conditions of the carrier, they will simply sell their capacity to another party who does accept the terms or even sell the capacity on the spot market, leading to even higher profit margins for the carriers.

McKinsey & Company underpin these effects as well. They highlight the robustness in demand, as covid-19 has not impacted trade volume. Although pubs for example might see a decrease in product sales, people have more savings due to lower expenses the past two years. On the supply side, they state that the instability of freight transportation prices will normalize and thus be more consistent even towards the end of this year. However, these prices would not be dropping towards pre-covid prices, but simply be less unstable. They also expect that contracts will become more long term opposed to the yearly tenders that occur now with more enforceable contracts with volume commitments in them as well (Remes & Saxon, 2021). Finally, they do expect that the market will return to its natural state of a slight overcapacity in supply.

4.2 CONSEQUENCES FOR CONTRACTS

Because the bargaining power of carriers is increasing, developments on contractual agreements need to be looked at. As stated in the case study, HNS was always able to receive beneficial service conditions relating to for example the amount of free days. However, since the carriers have become more powerful, these beneficial circumstances are expected to change. Recent developments on the tenders (which are done for each shipping leg every year) confirm this expectation. Carriers earn more money with moving containers, meaning that providing exporters with a lot of free days is cost- inefficient for the carriers. In the tenders, carriers are thus not offering the same conditions for HNS anymore. Carriers offer HNS less free days to deliver their cargo at the terminal as well as less free days to store their cargo at the terminal. If Heineken requires the old conditions, the standard tariffs are going up.

The main tradeoff occurs between costs and flexibility. If HNS can oblige to the amount of free days they receive in the new situation from the carriers, they are capable of staying with low standard tariffs.

If they require more free days then the standard tariffs are assumed to go up. This tradeoff is something Heineken is unexperienced with and should therefore be analyzed more closely.

4.3 FUTURE TRADE VOLUME SCENARIO'S

The current trade volume (defined in containers per year) has already been elaborated on in section 3. What could be seen was more or less in line with the development of trade growth in all global container shipping. The Organisation for Economic Co-operation and Development finds a slight increase of about 0,9% in trade volume for export and 0,4% for import over 2021, indicating a slight increase and thus recovery in world trade volume (ANP, 2021). The same accounts for HNS. Trade volume for deep sea has remained relatively constant, with a slight growth from 2018 to 2019, a slight decrease again towards 2020 an now an expected slight increase again in 2021. The exporting trade volume for HNS is not expected to change significantly as well, since the consumption of beer is expected to stay relatively constant. Consumers might require more bottles then kegs since they would drink more at home, but this does not significantly change the container volume. However, several reasons might still influence the amount of exported volume. Demographical effects such as population growth might influence the amount of sold products. Another effect might be changes in the legal drinking age or the effect of mergers and acquisitions which are characterizing in the brewing industry as explained in section 2, increasing the market share of Heineken compared to other breweries. Slight growth of the beer industry is also predicted for the years to come. The Global Beer Market was valued at USD 597,067 million in 2018, and is projected to reach USD 697,617 million by 2026, growing at a compound annual growth rate (CAGR) of 1.9% from 2019 to 2026 (Straits Research, n.d.). The majority of this growth is expected however in production increase in the United States, which does not indicate an increase in exported volume. It might however even have the opposite effect, leading to a slight decrease in exported volume. The main takeaway is however, that no major market disruptions are expected, so scenario's should aim at slight increases and decreases to represent real world trends as accurately as possible.

In order to account for small changes over the coming years and taking into account the relative stability of the exported trade volumes of the past years, several scenario's will be made to indicate different types of growth or decline in the future relating to the trade volume.

The following scenario's will be taken into account for the situation in 3 years, where the 'stable scenario' indicates the current situation, which is deducted from the amount of containers that have been awarded through the tender for 2021:

TABLE 17: SCENARIO'S ON FUTURE DEMAND DEVELOPMENTS

Scenario	Total export volume	Percentage increase
1: large decrease	51534,9	-10%
2: small decrease	54397,95	-5%
3: stable	57261	0%
4: small increase	60124,05	5%
5: large increase	62987,1	10%

These different amounts of trade volume will need to be considered to ensure the robustness and resilience of the export market for HNS.

4.4 TECHNICAL SYSTEM ADAPTATIONS BREWERY

In order to be able to cope with these changes in the future state and transported volumes, technical system adaptations need to be taken into account. These technical system adaptations need to be looked at for the brewery as well as in the rest of the supply chain. First of all, to be able to ship a higher volume, a higher volume has to be produced. The production capacity of the breweries in The Netherlands is not necessarily a problem. A slight problem does occur with the loading of containers at the brewery. In order to cope with the increasing demand, more operators would be required in the breweries. However, peak volumes in summer time for example have already proven that this is possible if the brewery is prepared. The brewery in Zoeterwoude has 24 docks available for export, in Den Bosch there are 12 at the brewery and 8 at the logistics center of Den Bosch. The following figure shows part of the floor plan for export. On the left side, the packaging lines are shown as well as some palletizers. In the middle there are conveyor belts or empty storage space and on the right side, 20 docking stations for trucks are shown.

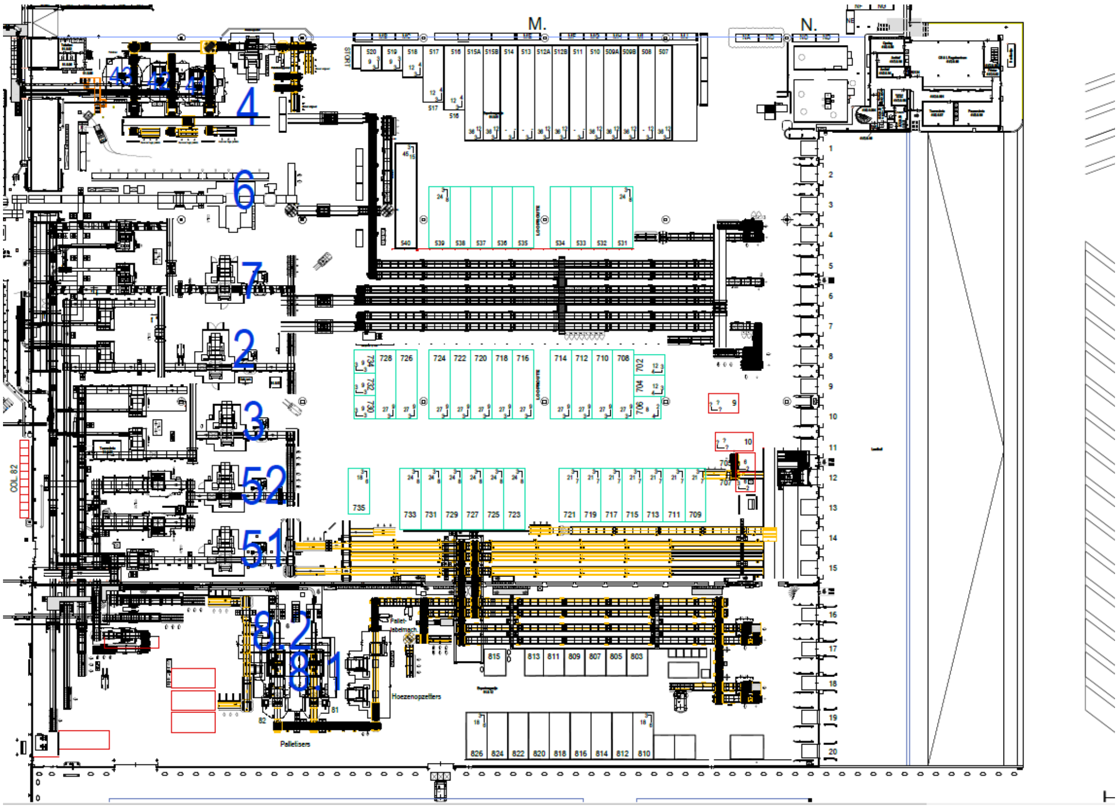


FIGURE 10: EXPORT RELATED PART OF BREWERY

The amount of production capacity, loading and docking capacity is not a problem for the expected increase in demand as described in the scenario's. Therefore, no technical adjustments have to be made at the breweries themselves. If a modal split towards more trucks would be advised, this would not change operations at the brewery as the loading there happens by trucks right now. It would however change the technical perspective on the rest of the supply chain. The following figure shows the original pre carriage plan:

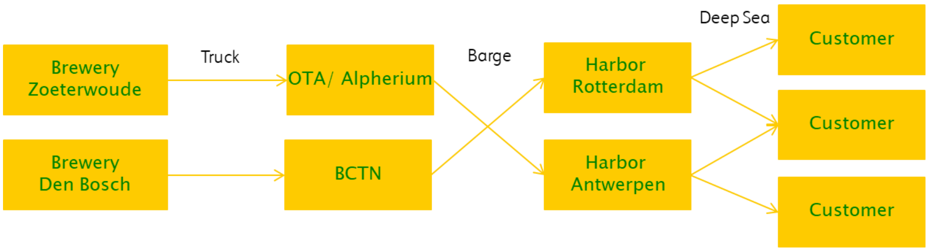


FIGURE 11: ORIGINAL PRE BARGE

For trucking movements, the containers would not have to be brought back to the Alpherium or BCTN to be transshipped onto barges, but they would be able to be driven straight to the deep sea terminals as in the following figure:

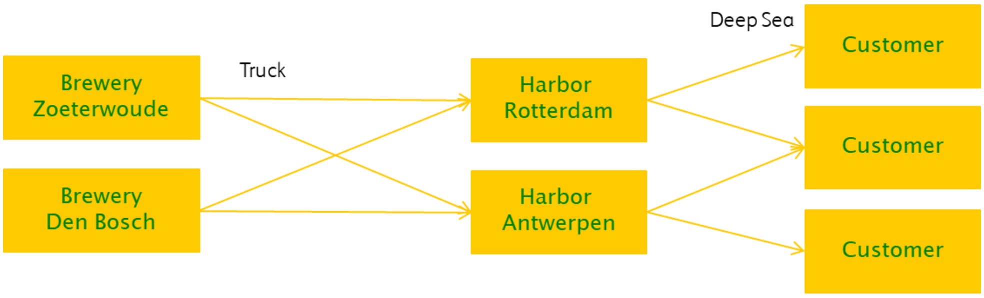


FIGURE 12: PRE CARRIAGE TRUCK

These changes mainly impact the operations at the deep-sea terminals of Rotterdam and Antwerp. The port of Antwerp transships around 12 million TEU and the port of Rotterdam transshipped 15 million TEU in 2021 (Port of Rotterdam, 2021). For that reason a possible modal shift and increase in transported volume is not expected to significantly impact operations. Also, since HNS will be able to then deliver containers with more flexibility and closer to the departure time of the ships, additional storage at the deep-sea terminals is not expected to become an issue.

4.5 CONCLUSION FUTURE STATE

This section aimed to answer the following question:

3. *What kind of bottlenecks and challenges are present in these current processes and how are those bottlenecks expected to change in the future?*

In the near future, container prices are expected to normalize, but remain higher than pre-Covid times. Next to that the trade volume is expected to remain relatively stable. It has not seen significant recent changes. The increase in bargaining power for the carriers is something that will impact the contractual agreements between exporters such as HNS and carriers. Moving containers lead to profit for the deep-sea carriers, which is why they profit from not giving exporters a lot of time to deliver containers to the deep-sea terminal. The standard tariffs are expected to increase if HNS requires the same amount of flexibility in terms of free days. If HNS obliges to less flexibility, they might be able to preserve their relatively low standard tariffs. HNS does currently not have the means to analyse what kind of service conditions they actually require. They also need to consider the decreasing customer satisfaction if congestions become worse.

5. DESIGN REQUIREMENTS

This section will provide more insights in the requirements to which the logistic process have to oblige. It will contain several hard constraints, some functional requirements and several non-functional requirements. By defining these requirements, the eventual alternative can be tested on those requirements. Finally, the section will elaborate on the criteria by which the alternatives can be evaluated. This section will answer the following research question:

4. *What are the constraints, design requirements and criteria relating to this logistic process?*

5.1 ASSUMPTIONS

Before highlighting the constraints and (non-)functional requirements, several assumptions will be highlighted in this section that should be taken into account:

1. *There are no capacity constraints in terms of empty containers.*

This has already been elaborated on in the scope in section 1. Although a global container shortage has occurred, big exporters such as HNS do not suffer as much that empty containers are not available. They do however experience this in contract negotiations where terms and conditions become less flexible and more expensive. Secondly, if they wish to transport additional volume, they will have to buy this additional capacity against higher prices on the spot market, but empty containers are available.

2. *The deep-sea terminals are considered to be two terminals: Rotterdam and Antwerp.*

HNS delivers their containers to several different terminals within the deep-sea terminals. Containers are for example delivered to BEANT-1700, BEANT-869 and BEANT-364, which are all different locations within the terminal of Antwerp, depicted in the following figure:

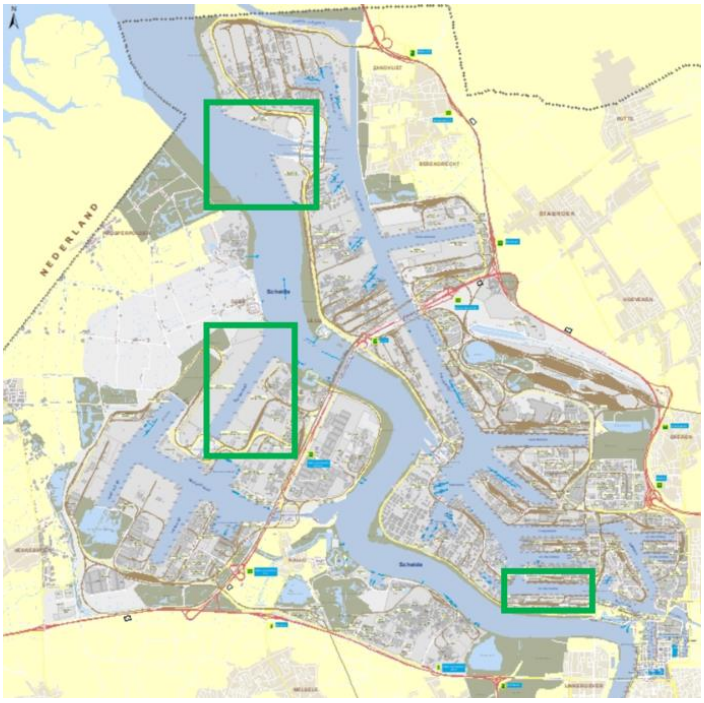


FIGURE 13:PORT OF ANTWERP WITH USED TERMINALS

In the design these are all taken as one big terminal, being Antwerp. For Rotterdam the same is applicable, but most of the terminals that are used are located at the first or second Maasvlakte. Similarly, all terminals are taken as one terminal, being Rotterdam.

3. *Containers always weigh their maximum gross mass.*

In order to be able to say anything about the sustainability of containers, these measurements are considered standard. Sometimes containers might in practice not be completely full, but they are assumed to be filled to the absolute maximum at all times.

4. *The distance between inland- and deep-sea terminals are equal for truck and barge.*

In practice these distances might differ a bit, but for this research they are considered to be equal. This way, the different transport modes can be compared better and in practice the distances do not differ as much that they would make a significant difference.

5. *The amount of containers transported is divided 67% for Zoeterwoude and 33% for Den Bosch.*

In order to determine the amount of containers per trade leg, it should be defined how many containers are transported from Zoeterwoude and Den Bosch for each trade leg. This study will assume that two thirds of all containers are transported from Zoeterwoude and one third is transported from Den Bosch. Realistically, this highly depends on the type of product and the market to which that product is served, since the breweries often brew different beverages. However, finding the exact amount for each of the 289 deep-sea trade legs would simply be too complex. It is therefore simplified, based on total amount of exported containers from each of the breweries, which approaches the numbers as described in this assumption.

6. *If containers are trucked, they are delivered to the terminal in one day, and are stored anywhere between 1 to 7 days.*

If trucking movements are contracted it is assumed that these are used for shipments relatively close to their closing (planned vessel departures). Trucking containers ensures delivery the same day. For customs reasons and terminal handling capacity, it cannot be assumed that all containers are moved onto ships the same day. Because of those reasons, the model will assume a range of values between 1 and 7 days.

5.2 CONSTRAINTS

Constraints are requirements that have to be satisfied by the system in order to properly function. They are mandatory and are considered hard yes or no questions. If an alternative does not satisfy all of the constraints, the design is rejected. Constraints are hence typically defined as what a system must do.

The system must:

1. *Deliver containers at the deep-sea terminal at all times.*

The most important constraint also relating to the KPI’s of HNS is that the system must be able to deliver containers to the deep-sea terminals at all times. This means that if barge operators stop working, alternative ways of delivering the containers must be in place.

2. *Be compatible with the way of working from Heineken Global Procurement (HGP).*

A second constraint relates to procurement. HNS must oblige to the way of working by HGP. This means that they will export under contracts that are tendered for each shipping leg each year. The purchase of containers for example, as also explained to not be feasible in section 3, is not an option in the design alternatives.

3. *Be able to cope with different container sizes.*

There are different sizes of containers that are used to ship cargo. The two sizes that are used for deep-sea shipping are 20 feet and 40 feet. They can also differ in terms of other specifications such as whether they are able to cool (or heat) the cargo. This is often indicate by letters. A 40DR container relates to a 40 feet dry container, whereas a 40RF relates to a 40 feet 'reefer'. However, these different specifications are not important within the design scope, since the sizes are the same. The system must thus be able to ship containers of 20 feet and 40 feet.

5.3 REQUIREMENTS

To score the different means on their performance in the packing system, requirements are set up. According to Robertson (2001), the requirements can be divided into two categories: the functional and non-functional requirements. This section provides an overview of both types of requirements for the design of a packing process.

5.3.1 FUNCTIONAL REQUIREMENTS

Functional requirements indicate what the system should be able to do. The functionality of the system is described by those requirements and they are not compulsory to be satisfied as the constraints are. Functional requirements are often described as what a system should have.

The system should:

1. *Reduce total transportation costs as much as possible.*

One KPI that is important to HNS is transportation costs. In order to remain competitive, the aim should be to minimize transportation costs to ensure maximum profit. The design should therefor aim to reduce transportation costs.

2. *Be as flexible as possible.*

A second requirement is that the design should be as flexible as possible. It should aim to deliver containers under all conditions and to be able to adapt to changes as much as possible.

3. *Deliver containers to the deep-sea terminal as quickly as possible.*

In order to maximize throughput and minimize transportation costs, the usage time of containers plays a big role. Because of this, the design should aim to deliver containers as quickly as possible to the deep-sea terminal.

4. *Track and trace containers at all times.*

To ensure that HNS has better understanding of the performance of their operations, track and traceability becomes very important. Therefore, the design should aim to remain control in terms of track and traceability as much as possible.

5.3.2 NON- FUNCTIONAL REQUIREMENTS

Non- functional requirements are defined in order to describe what would be nice for the system to have. They implicate the properties of a design and are also described by what a system should have.

The system should:

1. *Be as cost efficient as possible.*

In order to remain competitive, the logistic process should be as costs efficient as possible.

2. *Have back up options in case of system failures.*

If the system fails, it is important that HNS should be able to have a backup towards delivering the containers at the deep-sea terminal.

3. *Transport containers of different measurements and volume.*

There are several different container types (such as 20DR, 40DR and 40NW) which the system should be able to handle.

4. *Be as sustainable as possible.*

One requirement is that the system should be as sustainable as possible. Not only is this a wish that Heineken has expressed towards the future, but also this will become more and more important relating to the decarbonization of deep-sea logistics, where ‘the polluter pays’.

5.4 CRITERIA

In order to test and evaluate the alternatives, the criteria have to be defined. These criteria were listed by brainstorming with Pim Stevens, manager Customer Service Export & Customs. These criteria are necessary in order to compare the alternatives with each other. The main criteria are costs, throughput and sustainability, which can be split up into several different aspects:

1. *Costs*

In order to measure the efficiency of the transportation of containers the costs are very important to consider. As explained, these costs relate to several phases or parts of the transport:

   a. *Pre carriage costs*

First of all, there are pre carriage costs. These relate to the cost that is associated with the actual transport to the deep-sea terminal. This can happen either by the regular way, which is barging or by trucking straight to the deep-sea terminal. This is however much more expensive then barging.

   b. *Deep-sea standard costs*

The second aspect of costs relate to standard deep-sea tariffs associated with each shipping leg. The tariffs are explained in section 3.4 and appendix D.

   c. *Additional costs (Detention and Demurrage)*

Finally, there are additional costs, for example detention and demurrage on which this research focusses. These costs are elaborated on in earlier sections, but occur when HNS need more time to deliver containers to the deep-sea terminal then the time agreed upon with the carriers.

2. *Throughput*

Throughput is defined here as the average time a container needs to be delivered on the deep-sea terminal. This is used as a measure of flexibility in this research. If containers can be delivered faster to the deep sea terminal, this is assumed to be more flexible. Secondly, this could also improve customer satisfaction since the order lead time could be decreased.

3. *Sustainability*

Lastly, the sustainability should be taken into account. This can be measured by defining the distance each transport mode has to travel and the associated emissions related to that vehicle to that distance. If this is than divided by the amount of containers a transport mode carries, the amount of emission per container per distance can be measured.

5.5 CONCLUSION CASE STUDY

This section has answered the following research question:

4. *What are the constraints, design requirements and criteria relating to this logistic process?*

Three main constraints were considered. The system should at all times be able to handle different container sizes and has to comply to the way of working of HGP. This means that the ‘regular’ booking process with deep sea carriers has to be followed where HNS orders container transport at a deep-sea carrier who rents out their containers.

Design requirements mainly focus on being as flexible, efficient, quick, traceable and sustainable as possible. This naturally flows into the criteria that apply to this logistic process. The following criteria will be considered;

1. *Costs*
    a. *Pre carriage costs*
    b. *Deep-sea standard costs*
    c. *Additional costs (Detention and Demurrage)*
2. *Throughput (Time per container)*
3. *Sustainability (Emissions)*

The following section will elaborate more on the conceptual design, eventually boiling down to several design alternatives.

6. CONCEPTUAL DESIGN

The previous section has elaborated on the design requirements and criteria that are needed to evaluate different designs. This chapter will elaborate on all of the different designs and how a model will contribute to this. It will indicate how it is conceptualized and provide the mathematical modelling of the calculation tool. It will provide part of the answer to the following research question.

5. *What are possible ways of altering this logistic process to impact current and future expected challenges?*

6.1 DESIGN ALTERNATIVES

HNS has several methods to influence the criteria. All of the actions that are possible are worked out in 18 different designs which are explained in this section. The following actions are possible:

Firstly, HNS can define whether they want to ship containers (pre carriage to the terminal) by barge of by truck. This all entails the pre carriage from the breweries to the deep-sea terminals Rotterdam and Antwerp. Trucking is more expensive, but quicker than barging. Currently, it is used as an 'emergency mode' to get containers to the terminal quickly to arrive in time for the deep-sea vessel departure time. Trucking could however become more interesting in the future in terms of total costs if the amount of free days is decreased. In practice, the end solution will always entail a combination of the two and should therefore be described as a percentage of containers that will be trucked.

Secondly HNS can influence the amount of free days, standard deep sea tariffs and D&D tariffs that are contractually agreed upon with the deep-sea carriers. HNS can opt for more flexible service conditions, meaning more free days, but this will probably result in higher standard tariffs and possibly higher D&D tariffs. The opposite solution is to have less free days, but retain the lower standard tariffs. It should be noted that there is a tradeoff between those aspects. The proposed differences in alternatives for these variables are in line with actual contract negotiations between Heineken and shipping companies.

Thirdly, they can have an impact on production. What is meant by this is that all of the products that are shipped from Rotterdam will be produced in Zoeterwoude and all products that are shipped from Antwerp are produced in Den Bosch.

These three system functions can be described as follows for both the trucking percentage and the service conditions:

TABLE 18: SYSTEM FUNCTIONS: TRUCKING PERCENTAGES

Alternative conditions	Additional trucking percentage
Low truck amount(current)	0 %
Med truck amount	20 %
High truck amount	50%
Truck everything to Antwerp	100%

In the current situation, an average of 6,3% of all containers is transported by truck. These relate however, to the containers that are transported with urge, so the 'emergency containers'. These are expensive containers, since an additional amount is charged above the regular pre carriage tariffs. In the 'Med truck' case, an additional 20% of container movements to the terminal will be transported by truck, but by predefined contracts. The same applies to the 'High truck' case, where 50% of additional container movements will be done by truck. There is also the possibility to transport all containers that need to be loaded in Antwerp by truck, since these container movements generally take longer than the ones to Rotterdam. In these scenario's the amount of trucks that need to be used for emergencies is considered to remain the same.

When the trucking companies are contracted, lower prices can be achieved than with those emergency trucking movements. In the current situation road traffic contracts are used for road/short sea allocation. In these contracts, the shorter trucking movements in the Netherlands and Belgium cost approximately €300,- for both 20 and 40 feet containers. It is therefore assumed that when a truck is used, this amount will be charged.

For service conditions, as stated previously, situations are depending on the amount of free days, the standard tariffs and D&D costs. This provides the following possibilities:

TABLE 19: ALTERNATIVE POSSIBILITIES FOR SERVICE CONDITIONS

Standard tariffs	**Free days (usage-storage)**	**D&D costs in €**
Current prices	28-14	8/10
+$50,- per container	21-14	15/30
	21-7	25/50

These numbers are based on actual predicted changes in the future. In the current scenario, HNS has 28 free days for equipment usage and 14 days for equipment storage. CMA-CGM proposed, during the tender process, a decrease in free days to 21-7 if HNS wants to keep their current prices for standard tariffs. The other possibility is to pay $50,- more for each container in the standard prices. This study assumes that this effect can be generalized to all tenders for deep-sea carriers. The demurrage and detention tariffs are also deducted from current negotiations and verified by Annelies Mulderij and Pim Stevens.

The last system function that can thus be varied is alterations to production quantities. The current division is that close to two thirds of all products is produced in Zoeterwoude and one third in Den Bosch. This is assumed to be the case for all routes in this research. In practice, the different breweries are specialized in different products and what they brew heavily depends on a lot of different factors such as which country it is shipped to, how much of the product is demanded and what kind of product it is. In the alternative way of production, it is assumed that all products that travel through Antwerp are brewed in Den Bosch and that all products that are shipped from Rotterdam are produced in Zoeterwoude.

Appendix F highlights all different possibilities of designs. A total of 18 designs will be modeled over the five different demand scenarios described later in this section. They differ firstly in terms of contractual agreements: standard tariffs, free days and D&D tariffs (1-5). Secondly the designs differ in terms of modal split and production division (A-E). They can be found from the following table:

TABLE 20: DESIGNS THAT WILL BE MODELLED

Alternative	**Standard Tariffs**	**Free days**	**D&D tariffs**	**Trucking %**	**Production**
Des 0 (Base)	Current	28 & 14	€8,- & €10,-	0%	Regular
Des 1.A	Current + $50,-	28 & 14	€8,- & €10,-	0%	Regular
Des 1.B	Current + $50,-	28 & 14	€8,- & €10,-	20%	Regular
Des 1.C	Current + $50,-	28 & 14	€8,- & €10,-	50%	Regular
Des 2.A	Current	21 & 14	€15,- & €30,-	0%	Regular
Des 2.B	Current	21 & 14	€15,- & €30,-	20%	Regular

Des 2.C	Current	21 & 14	€15,- & €30,-	50%	Regular
Des 3.A	Current	21 & 14	€25,- & €50,-	0%	Regular
Des 3.B	Current	21 & 14	€25,- & €50,-	20%	Regular
Des 3.C	Current	21 & 14	€25,- & €50,-	50%	Regular
Des 4.A	Current	21 & 7	€15,- & €30,-	0%	Regular
Des 4.B	Current	21 & 7	€15,- & €30,-	20%	Regular
Des 4.C	Current	21 & 7	€15,- & €30,-	50%	Regular
Des 5.A	Current	21 & 7	€25,- & €50,-	0%	Regular
Des 5.B	Current	21 & 7	€25,- & €50,-	20%	Regular
Des 5.C	Current	21 & 7	€25,- & €50,-	50%	Regular
Des 5.D	Current	21 & 7	€25,- & €50,-	100% Antwerp	Regular
Des 5.E	Current	21 & 7	€25,- & €50,-	0%	Alternative

These designs will be further modelled in excel using 30 iterations per design to try to eliminate the randomness of container movements.

6.2 MODEL CONCEPTUALIZATION

In this section, the goal and classification of a model will be explained. This model will be used to simulate the effects of all of the aforementioned designs. This is important to consider since a simulation model is always seen as a simplification of, or abstraction from the natural, real world system (Crooltall et al, 1987) and thus serves a specific goal.

MODEL GOAL

This research aims to identify the trade-off between standard costs and additional costs for HNS as an exporter and by their predefined criteria as explained in section 5. In order to make well founded choices relating to future tender- and contractual agreements, the output of this model could be used. The output of the model will highlight how the choices that HNS makes can influence their costs, throughput and sustainability scores. The output of the model can also be evaluated by using a multi criteria analysis to better support future decision making. It should be noted that the model is by no means an exact predictor of the defined criteria, but serves as a means to compare different choices relative to each other and give an indication of costs, throughput and sustainability.

CLASSIFICATION OF THE MODEL

The model can be defined as a discrete- event calculation model. It is a discrete-event model opposed to a continuous model, since between consecutive events, no changes to the system are assumed to occur. In short, the model finds all of the (random) values independent from each others outcome.

6.3 MODEL SPECIFICATION

This section will describe the different inputs and outcomes of the model. The input variables, calculations and output criteria will be explained. The input can be defined as Scenario’s, Alternatives and Input parameters. The output of the model, as explained in the section on criteria contains costs (Total, pre carriage, standard and additional), Throughput (Amount of containers and average time in system) and the emission based on total CO2 per ton kilometer. The following figure conceptualizes a schematic representation of the model:

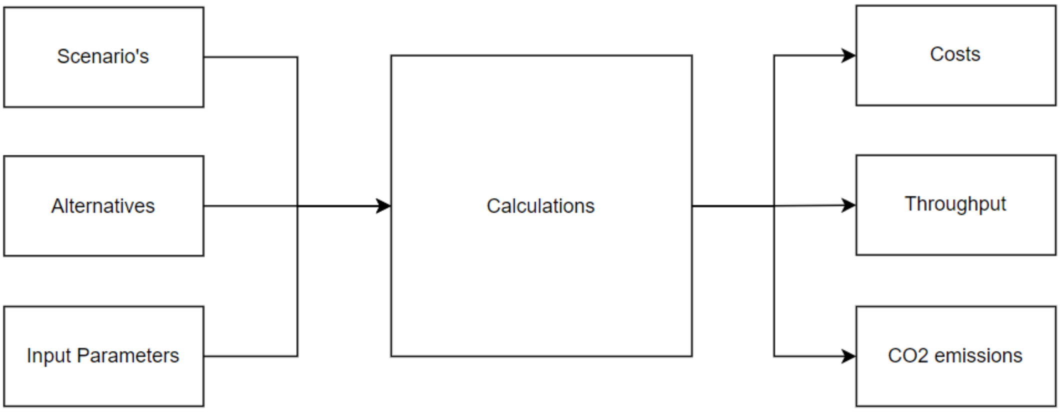


FIGURE 14: SCHEMATIC MODEL CONFIGURATION

6.4 SCENARIOS

The scenarios that will be used as input for the calculations have been elaborated on in previous sections and depend on the amount of trade volume that is demanded. There are five scenarios, including the trade volume of the current situation. The others all indicate slight increase or decrease around this volume.

The contracts of 2021 (appendix D) are used to indicate the percentages of trade volume per trade leg. An increase or decrease in total trade volume increases or decreases according to these percentages. Secondly, the assumption on production capacity comes into play here. 67% of containers are transported from Zoeterwoude and 33% is transported from Den Bosch.

All of the container movements are then calculated based on the distribution of container movements in 2021 which can be found in appendix B. This means that if there are 1000 container movements in a certain trade leg, the amount of days relating to all of those container movements for equipment usage and equipment storage is found by using the distribution relating to that trade leg.

6.5 INPUT PARAMETERS & CALCULATIONS

This section will elaborate on the input parameters that are used as input for the model calculations. The actual numbers can be found in appendix E. These inputs might differ per scenario, which will then be explained.

6.5.1 COSTS

Costs consist of three different indicators. The standard tariffs, pre carriage costs and additional costs:

$$\mathrm{C_{tot}} = \mathrm{C_{ST}} + \mathrm{C_{PC}} + \mathrm{C_{ADD}}\ (1)$$

Standard tariffs (C_{ST})

The total costs associated with standard tariffs is calculated by the container flow and associated standard tariffs. These tariffs are predetermined within contractual agreements and can vary within the different designs. Regular contractual standard tariffs per shipping leg can be found in appendix D. The following equation denotes the full calculations:

$$\mathrm{C_{ST}} = C_{STr} + C_{STa} (2)$$

These costs contain regular costs and additional costs (if a container exceeds the contractual agreed upon quantity). The regular standard costs are as follows:

$$C_{STr} = \sum_{i \in N} C_{STr_{ij}} * (x_{ij} - w_{ij}) \ \forall \ j \ in \ J \ (2.1)$$

In this equation, $C_{STr_{ij}}$ entails the regular standard tariffs for a certain shipping leg with origin i and destination j. x_{ij} entails the total flow of containers from i to j, whereas w_{ij} relates to the amount of containers that is shipped more than the contractually bought in containers. N is the set of terminals and J is the set of destinations all over the world. The costs for the additional volume is determined by the following:

$$C_{STa} = \sum_{i \in N} C_{STa_{ij}} * w_{ij} \ \forall \ j \ in \ J \ (2.2)$$

The tariffs for any additional container between origin i and destination j $C_{STa_{ij}}$ are random for each shipping leg which is denoted by the following equation:

$$C_{STr_{ij}} * 1{,}2 \leq C_{STa_{ij}} \leq C_{STr_{ij}} * 2{,}5 \ \forall \ i \ in \ N, j \ in \ J \ (2.3)$$

The tariffs for additional containers can take any value between 1,2 and 2,5 times the regular tariff for shipping a container on that same shipping leg.

Pre carriage (C_{PC})

Total pre carriage costs are determined by the amount of containers and the costs per container. The costs for pre carriage per container are one of the input parameters for the simulation model. There are two types of pre carriage: trucking and barge. The prices for carriage from the brewery to the deep sea terminal depend on the mode of transport and the container size. Trucking is currently not predefined in contracts. This means that following contracts, all container are shipped per barge. If a container is not shipped but for whatever reason needs to be trucked, the original price for barge will be charged plus the additional trucking price.

In principle, the aim is thus to transport all containers by barge at all times since its cheaper, but slower. A 20ft container will cost €199,- for example by barge. However, sometimes containers need to be transported within a very limited time frame, or they don't fit on the barges, which is why 'emergency trucking' can be used. An additional €300,- is charged for those transportation movements.

As stated in the designs, HNS can alter the amount of containers they wish to transport by truck, leading to lower delivery times, but larger costs. If HNS predefines the amount of containers that they want to truck each year in contracts, it is expected that they will be able to get sharper prices for the container transportation by truck if these do not have to be booked last minute. In case of a higher trucking amount, it is assumed that the containers can be transported for €300,- per container. This is based on current prices of trucking with similar weights, volumes and distances in the Netherlands.

The costs for pre carriage can be defined by the following equation:

$$\mathrm{C_{PC}} = \sum_{i \in N} C_{PC_{ij}^{k}} * x_{ij}^{k} \ \forall \ j \in N, \forall \ k \in K \ \ (3)$$

In equation 2, $C_{PC_{ij}^{k}}$ depicts the costs associated with pre carriage between terminal i and j for mode k. x_{ij}^{k} is the flow between terminal i and j for mode k. N is the set of terminals and K is the set of modes available.

Additional costs (C_{ADD})

To calculate additional costs, detention and demurrage are considered. Several components are important. First of all, the amount of free days relating to equipment usage and equipment storage. Once again, equipment usage relates to the time that is needed from take out at the dedicated inland container terminal until the planned (deep sea) vessel departure. Equipment storage relates to the time a container is stored on the deep sea terminal. In the base case, HNS has 28 days for equipment usage, of which a maximum of 14 days can be used for storage.

The days it takes to transport to- and store containers at the terminal are gathered from actual data as described in section 3 and appendix B. For each leg between the inland terminals and deep-sea terminals, two distributions of data points are computed based on data for usage and storage. These distributions form the input for each container movement in the model, meaning they take values for usage and storage according to- and thus behaving like- the real life data.

For detention and demurrage, the costs that are charged for using or storing a container for a longer than allowed period of time is considered (longer than the free days). If a container were to take 30 day from the take out moment until the planned vessel departure time, 2 days of detention would be charged. If from those 30 days, 15 were at storage at the deep sea terminal, 1 day of demurrage would be charged. For export-related movements, the charges per day are the same for all carriers in 2021, which are the numbers that are used for the model. For detention (usage) this is €8,- per day. For demurrage (storage) this is €10,- per day.

To calculate the amount of additional demurrage and the detention, the amount of days that each container exceeds the permitted amount through the contracts multiplied by the costs per container by that needs to be calculated. If all of these amounts are summed for all containers, the total amount of detention and demurrage can be calculated. The following equation gives the total additional costs:

$$\mathrm{C}_{\mathrm{ADD}} = C_{det} + C_{dem} \text{ (4)}$$

C_{det} relates to detention costs, whereas C_{dem} is associated with demurrage costs. The following applies:

$$C_{det} = \sum_{i \in N} x_{ij} * T_{ijx} * p_{det} \; \forall \, j \; in \; N \text{ (4.1)}$$

Equation 4.1 calculates the total detention costs. X_{ij} relates to the flow of containers from origin i to destination j. p_{det} is the price for detention, which varies throughout the designs. T_{ijx} is related to the amount of days that a container between origin i and destination j exceeds the amount of permitted free days in the system where the following applies:

$$T_{ijx} = \begin{cases} 0, & if \; T_{ij} \leq F_{det} \\ T_{ij} - F_{det}, & if \; T_{ij} > F_{det} \end{cases} \forall \, i \; in \; N, j \; in \; N \text{(4.2)}$$

Here, T_{ij} is the amount of days a certain container is in the system. The amount of free days for detention equals 28 in the base case. For demurrage costs $C_{dem,}$ the following applies:

$$C_{dem} = \sum_{i \in N} x_{ij} * S_{ijx} * p_{dem} \; \forall \, j \; in \; N \text{ (4.3)}$$

Within this equation, the amount of free days for storage, or demurrage play a role. S_{ijx} relates to the amount of days that a container between origin i and destination j exceeds the permitted amount of free days for storage where the following applies:

$$S_{ijx} = \begin{cases} 0, & if\ S_{ij} \leq F_{dem} \\ S_{ij} - F_{dem}, & if\ S_{ij} > F_{dem} \end{cases} \forall\ i\ in\ N, j\ in\ N (4.4)$$

S_{ij} relates to the amount of days a certain container with origin i and destination j is stored at a terminal. The amount of free days relating to demurrage equals 14 in the base case.

6.5.2 EMISSIONS

The second aspect of input parameters and calculations are aimed towards emissions. These exist of two aspects, the actual emissions by the transport means per containers per kilometer and the distances between the inland- and deep-sea terminals. This study focuses solely on CO2 emissions. Although nitrogen oxides (NOx) as well as particulate matter also play a role in the pollution process, the inclusion of all variables would be too complex for the model purpose. Next to that, CO2 is still considered to be the main gauge for air pollution. Thirdly, truck- and barge traffic approach each other's emission numbers in terms of NOx emissions but not in terms of CO2, making it a more relevant measure (Kennisinstituut voor Mobiliteitsbeleid, 2016).

The total emissions can be calculated by the following equation:

$$EM = \sum_{i \in N} x_{ij}^{k} * EM_{ij}^{kl}\ \forall\ j \in N, \forall\ k \in K, l \in L\ (5)$$

Em denotes the total amount of emissions. x_{ij}^{k} is the flow between i and j for mode k. EM_{ij}^{kl} relates to the emissions for mode k and container l between i and j. These values can be calculated as follows:

$$EM_{ij}^{kl} = \sum_{i \in N} d_{ij}^{k} * EMtk^{kl}\ \forall\ j \in N, \forall\ k \in K, l \in L\ (5.1)$$

Here, d_{ij}^{k} denotes the distance in kilometer between i and j and $EMtk^{kl}$ denotes the emissions per ton kilometer per mode k per container type l. Per ton kilometer, a barge ship emits 34 grams of CO2, while a truck emits 112 grams per ton kilometer (Nicolai, 2020). It is assumed, as stated in section 5, that containers always weigh there gross max, which equals 24 tons for a 20 ft container, and 30,5 tons for a 40 ft container (Emase, 2007). By multiplying those numbers, the amount of emission per container per kilometer can be calculated:

TABLE 21: EMISSIONS PER CONTAINER KILOMETER IN GRAMS CO2

Barge		**Truck**	
20ft	*40ft*	*20ft*	*40ft*
816	1037	2688	3416

The distances are taken from google maps and are assumed to be equal for both road traffic as well as barge traffic.

TABLE 22: DISTANCES PER SHIPPING LEG

Shipping leg	Distance in km
Alphen- Rotterdam	80
Alphen- Antwerp	120
Den Bosch- Rotterdam	120
Den Bosch- Antwerp	110

With these numbers the emissions for each container on each of the tradelegs can be calculated. The sum of all of those outcomes make for the emissions per year.

6.5.3 THROUGHPUT

The final aspect that needs to be considered is the throughput of the model. This is as stated previously, aimed at average throughput time per container within the system of pre carriage transport. This can be calculated by the following equation:

$$\mathrm{T} = \frac{\sum_{i \in N} T_{ij} * x_{ij}}{\sum_{i \in N} x_{ij}} \; \forall\, j \in N \; (6)$$

T denotes the throughput time per container as explained. T_{ij} denotes the time a certain container between origin i and j stays in the system. x_{ij} once again relates to the flow between origin i and destination j.

The variable T_{ij} is a random variable based on its corresponding non-uniform probability distribution as explained in appendix B.

6.6 CONCLUSION CONCEPTUAL DESIGN

This section has provided answers to the following research question:

5. *What are possible ways of altering this logistic process to impact current and future expected challenges?*

The section concluded on 18 different design alternatives that can impact the current and future bottlenecks. These designs incorporate strategic decisions by the exporter to impact the current bottlenecks. All of these designs vary firstly in terms of contractual agreements between the exporter and deep-sea carriers. Secondly, the designs vary in decisions relating to the actual pre carriage based on a modal split and production division based on geographic location of the breweries and deep-sea terminals.

All of these designs will be analyzed through a discrete event calculation model. This model will measure the performance of all of the designs in terms of the criteria from section 5.

7. MODEL BASE CASE

This section will elaborate on the results that were obtained through modelling the 'base case' scenario. It will elaborate on the results found and go into validation and verification of the model, to make sure the model represents the real situation as well as possible and that no modelling mistakes were made. The section will aim to deliver the base case results and hence contribute to the following research question:

6. *How do these different designs relate in terms of key performance indicators?*

7.1 RESULTS BASE CASE

First, the results of the model calculations will be shown which will then be further elaborated on. After 30 iterations of the model, the following averages were found:

TABLE 23: RESULTS BASE CASE SCENARIO

Criterium	30 iterations average
Total costs	€ 96.539.828
Pre carriage	€ 13.666.642
Standard tariffs	€ 82.142.689
Detention	€ 185.373
Demurrage	€ 545.124
CO2 trucks	1197,89
CO2 barge	5244,33
Average days/container	16,94

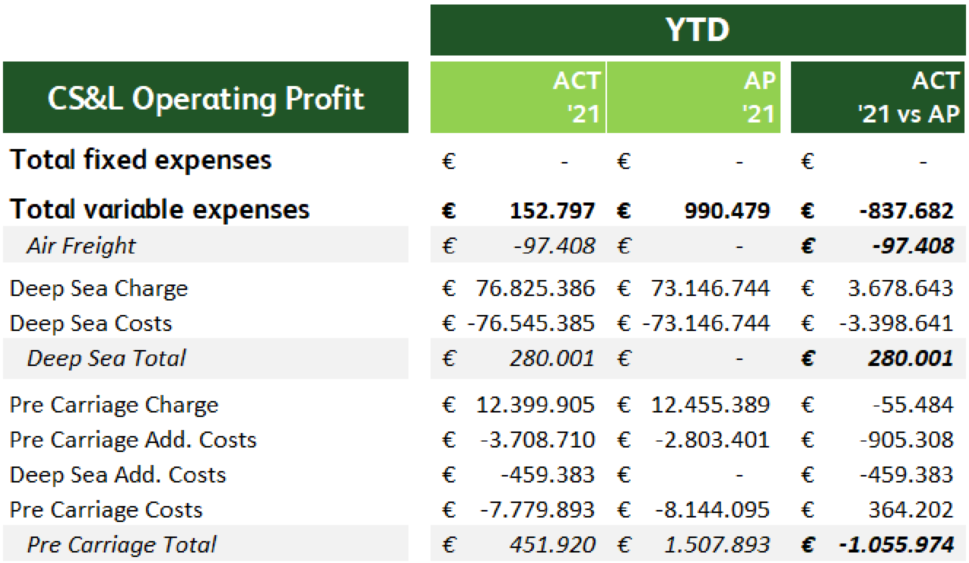
The total amount of containers that are bought in through contractual agreements is equal to 57.261. The results show that the total cost of deep-sea container transport is equal to about 96 million euro's. The majority of those costs are represented by the standard costs of container transportation. Another interesting aspect is the height of detention and demurrage. Demurrage costs are much higher than detention costs. For the emission number, it shows that the truck emissions are lower than the barge emissions, which is explicable by the fact that only a small percentage of containers are transported by truck.

7.2 MODEL VALIDATION

In order to determine whether the model fits it purpose, validation is applied. 'Validation is the process of determining the degree to which a model is an accurate representation of the real world from the perspective of the intended uses of the model' (Oberkampf and Roy, 2010). In this validation, the results found by the model will be compared with the actual system.

To do so, the expenses of 2021 until the month of November are used, information which is gathered through interviews with business controllers from Heineken Netherlands supply is used. It needs to be taken into account that an additional month (December) is missing from this data, so a small addition needs to be done to the numbers that are obtained. This yielded the following information for 2021:

TABLE 24: EXPORT EXPENSES YEAR TO DATE 2021 NOVEMBER (BUSINESS CONTROLLER HEINEKEN)



	YTD		
CS&L Operating Profit	ACT '21	AP '21	ACT '21 vs AP
Total fixed expenses	€ -	€ -	€ -
Total variable expenses	**€ 152.797**	**€ 990.479**	**€ -837.682**
Air Freight	*€ -97.408*	*€ -*	***€ -97.408***
Deep Sea Charge	€ 76.825.386	€ 73.146.744	€ 3.678.643
Deep Sea Costs	€ -76.545.385	€ -73.146.744	€ -3.398.641
Deep Sea Total	*€ 280.001*	*€ -*	***€ 280.001***
Pre Carriage Charge	€ 12.399.905	€ 12.455.389	€ -55.484
Pre Carriage Add. Costs	€ -3.708.710	€ -2.803.401	€ -905.308
Deep Sea Add. Costs	€ -459.383	€ -	€ -459.383
Pre Carriage Costs	€ -7.779.893	€ -8.144.095	€ 364.202
Pre Carriage Total	*€ 451.920*	*€ 1.507.893*	***€ -1.055.974***

From the table above the actual expenses until November can be seen. The following section will shortly go into validating all of the outcomes from the model, comparing them to the actual expenses.

STANDARD TARIFFS

The standard tariffs (Deep sea charge), including an additional month assuming the amounts are linear, add up to about 83 million euro's. The model shows slightly less, namely 82 million. This difference can be explained by the model using a certain exchange rate. The standard tariffs in the contracts are given in USD. In the model an exchange rate of 0,89 USD to Euro is used (as per 23-11-2021), but these values might differ over the year. If a value of 0,91 USD to euro's would be used the amount would for example add up to over 83 million.

PRE CARRIAGE

In terms of pre carriage, it is important to look at the costs that are charged to the customer by HNS. These costs, if once again linearity is assumed, add up to a little over 13,5 million. This is almost identical to the values found by the model. The results from the model thus represent the real word quite accurately in terms of pre carriage.

DETENTION AND DEMURRAGE (ADDITIONAL COSTS)

In terms of additional costs, the model finds a value that is significantly higher than the actual costs over 2021. Actual additional costs add up to a little over 500.000 euros, of which not everything might be considered detention and demurrage (also additional COVID charges for example as explained in section 3). The model finds a value that is closer to 730.000 euros. A possible explanation for this difference could be that these costs will only be paid by Heineken in the new year, since detention and demurrage costs can sometimes be charged months or even years after the actual event happened. The model however, charges everything instantly. A second explanation could be that the data that is used (combined from Tradelens and own data from SAP) is biased. Since the model uses this data as input, but not all container movements are included in the datafile, the missing data might influence the actual outcome. This could be because carriers like Yang Ming or Evergreen are not incorporated in Tradelens data, but these carriers only contribute to a minor piece of container movements. This effect is however not expected. A third reason could be that carriers actually often do not charge for detention and demurrage. As explained throughout this report, detention and demurrage is often a grey area in which it is unclear who should pay and when. Carriers might at times also lose track of this in practice and ‘forget’ to charge demurrage and detention in real life, whereas the model charges each and every day a container exceeds the limit. The model does not include ‘choices’ that are made by deep sea carriers.

The standard tariffs and pre carriage tariffs seem to be quite valid. It should however be noted that the model finds a higher value than the actual value that has been paid in 2021 for detention and demurrage. Although possible reasons were named in the aforementioned text, the model cannot be validated with 100% certainty. The model and designs should therefore only be used to check relative impact compared to other scenario’s and the absolute values should not be used for concrete recommendations.

For the average time in the system the comparison is made to the analyzed data from Tradelens. Equipment usage here is a little lower than the combined average of all actual shipping legs. However, there are more containers transported from Alphen than Den Bosch, and more to Rotterdam than Antwerp, which accounts for this difference. The model seems to be valid in terms of average container transportation time.

7.3 MODEL VERIFICATION

Next to validation, model verification plays an important role to make sure the model functions properly. ‘Verification is the process of determining that a model implementation accurately represents the developer’s conceptual description of the model’ (Oberkampf and Roy, 2010). Verification is often a process which happens through the modelling phase in principle, by constantly checking the formulas and outcomes. Calculations have been checked by Heineken supervisors, but to make sure the model behaves as expected, a sensitivity analysis and robustness analysis can be performed.

7.3.1 SENSITIVITY ANALYSIS

A sensitivity analysis is done to gain insights in the effect of changes in the input variables on the outcome of the model. Then, the ‘sensitivity’ of the model towards those variables can be seen and taken into account. The input variables that will be tested in the sensitivity are emergency trucking percentages (1) and barge costs and emergency trucking costs (2). To test the sensitivity of those input variables, their values will be in- and decreased by 10% and the results will be compared to the base case results.

EMERGENCY TRUCKING PERCENTAGES

For the emergency trucking percentages, 10% was added and reduced from the amounts used in the base case. This does not mean that 10% of the container volume is now added to trucking movement, but that the trucking percentage is increase and decreased by 10%. The following results showed after 30 iterations:

TABLE 25: SENSITIVITY ANALYSIS EMERGENCY TRUCKING PERCENTAGES

Emergency trucking percentage			
Criterium	**-10%**	**Base**	**+10%**
Total costs	€ 96.359.691	€ 96.539.828	€ 96.420.542
Pre carriage	€ 13.548.424	€ 13.666.642	€ 13.756.243
Standard tariffs	€ 82.082.081	€ 82.142.689	€ 81.934.820
Detention	€ 185.292	€ 185.373	€ 187.154
Demurrage	€ 543.895	€ 545.124	€ 542.325
CO2 trucks	1077,98	1197,89	1315,48
CO2 barge	5279,94	5244,33	5199,26
Average days/container	16,95	16,94	16,96

The amount of emergency trucking has no influence on the amount of containers used per day, because these trucking movements are included in the distributions that are used to predict container movements. The model behaves exactly as expected and is sensitive relating to the pre carriage costs and CO2 emissions. If a higher percentage of containers is trucked, the pre carriage costs rise and the emissions relating to trucks increases. Obviously, the emissions by barge decrease, but the total emissions increase.

BARGE COSTS AND EMERGENCY TRUCKING COSTS.

Barge costs differ slightly for each year, all depending on contractual agreements. The sensitivity of the model towards cost of barging in pre carriage is therefore something that should be looked at. This analysis will increase and decrease 10% of barge costs. It should be noted that because of this effect, the amounts paid for emergency trucking will also be increased since an additional €300,- will be charged when this mode is used. The following results are found with these scenarios:

TABLE 26: SENSITIVITY ANALYSIS BARGE AND TRUCKING COSTS

Barge costs			
Criterium	**-10%**	**Base**	**+10%**
Total costs	€ 95.255.577	€ 96.539.828	€ 97.919.269
Pre carriage	€ 12.407.510	€ 13.666.642	€ 14.933.491
Standard tariffs	€ 82.119.088	€ 82.142.689	€ 82.253.024
Detention	€ 185.391	€ 185.373	€ 185.839
Demurrage	€ 543.589	€ 545.124	€ 546.914
CO2 trucks	1197,61	1197,89	1199,28
CO2 barge	5243,00	5244,33	5250,25
Average days/container	16,94	16,94	16,95

The results show what was expected: with an increase in barge costs, the pre carriage costs increase significantly as well and vice versa. Other variables are not affected as much, but the model is quite sensitive to barge costs.

7.3.2 ROBUSTNESS ANALYSIS

Next to the sensitivity of the model, the robustness of the model will also be taken into account. The robustness is tested by altering assumptions that are made and to test the effect on the criteria. This will be done by testing two of the assumptions made for the model. In the analysis the assumptions that will be tested are the equality of distances for trucking and barging (1) and the percentages of containers from ZW and DB (2).

EQUALITY OF DISTANCES FOR TRUCKING AND BARGING

In this scenario we assume that the distances for barging are 10% closer than the distances for road traffic and vice versa. The assumptions made are that the distance stays the same for the other mode as in the base case, but the distances become 10% shorter for the tested mode. The following results highlight the effects on the emissions, where the combines total of emissions are summed to clearly depict the overall results:

TABLE 27: ROBUSTNESS ANALYSIS EQUALITY OF DISTANCES

Equality of distances			
Criterium	**Barge closer**	**Base**	**Road closer**
Total costs	€ 96.500.859	€ 96.539.828	€ 96.351.584
Pre carriage	€ 13.670.525	€ 13.666.642	€ 13.649.200
Standard tariffs	€ 82.101.399	€ 82.142.689	€ 81.970.866
Detention	€ 185.815	€ 185.373	€ 186.285
Demurrage	€ 543.120	€ 545.124	€ 545.234
CO2 trucks	1198,41	1197,89	1007,35
CO2 barge	4357,56	5244,33	5238,97
Average days/container	16,93	16,93	16,93

The results show that if the barge is closer, the total emissions drop. If road is closer, the emissions also drop, but more significantly. This is explicable by the fact that road transport is more polluting than barge transport.

PERCENTAGES CONTAINERS ZW & DB

For this robustness analysis we will shortly assume that the containers transported from either of the breweries is equal, so the distribution of containers transported from ZW and DB is considered equal. When this is done, the following results are found by the model compared to the original model outcome:

TABLE 28: ROBUSTNESS PERCENTAGES CONTAINERS ZW & DB

Percentages containers ZW & DB		
Criterium	**Base**	**50-50 scenario**
Total costs	€ 96.539.828	€ 96.506.982
Pre carriage	€ 13.666.642	€ 13.618.273
Standard tariffs	€ 82.142.689	€ 82.124.603
Detention	€ 185.373	€ 218.588
Demurrage	€ 545.124	€ 545.518
CO2 trucks	1197,89	1193,90
CO2 barge	5244,33	5472,28
Average days/container	16,94	16,99

The results show a few deviations from the base case results. For the costs criteria, standard costs remain more or less constant. The pre carriage costs decrease slightly. This can be explained by the fact that the 'emergency trucking percentage' for the BCTN is 1.6% lower than for the CCT. Since in this scenario, more containers are transported from Den Bosch, a lower amount of containers is transported by 'emergency trucking'. In terms of emissions, a short increase is can also be noticed. This change can be explained by the increased distance from Den Bosch to Rotterdam compared to the Alphen-Rotterdam trade leg.

Demurrage costs stay relatively constant and an increase in detention costs is found. This can be explained by the fact that the trucks take slightly longer from Den Bosch towards the Deep-sea terminals than from Alphen. The total costs however stay relatively constant and the model can therefore be called robust in terms of costs for this assumption.

7.4 CONCLUSIONS BASE CASE MODEL

This section has contributed to answering the following research question:

6. *How do these different designs relate in terms of key performance indicators?*

It has provided the results of the base case design alternative and provided model validation and verification for the base case model. The base case appeared valid, except for the additional costs. Possible reasons for this are that the model does not incorporate choices made by deep-sea carriers on whether or not they charge additional costs. Deep-sea carriers might sometimes not charge additional costs for reasons unknown to HNS. Secondly, the model does not incorporate the delay in payment of additional costs that does exist in real life. The model assumes that when additional costs have to be paid, they are paid instantly. Thirdly, the data might be slightly biased as it is incomplete. The results of the base case will be used to compare other designs within the next section to provide an answer to question 6.

8. MODEL RESULTS

This section aims to answer the following research question:

6. *How do these different designs relate in terms of key performance indicators?*

It will do so by providing the results several of the designs and comparing them with the base case design. The full results can be found in appendix G.

8.1 DESIGNS

This section will elaborate on the results of the simulation model. Several designs were modelled to look for tradeoffs between the service conditions and standard tariffs. Each design will be modelled for each of the scenarios stated in section 4. All of the designs and corresponding results can be found in appendix G. This section will highlight a few of the design results. In the following table, all of the designs that are highlighted will be covered in this section. In this table the brackets behind the design number show in which section the results are covered.

TABLE 29: DESIGNS THAT WILL BE MODELLED

Design (section)	Standard Tariffs	Free days	D&D tariffs	Trucking %	Production
Des 0 (Base)	Current	28 & 14	€8,- & €10,-	0%	Regular
Des 1.A (9.2)	Current + $50,-	28 & 14	€8,- & €10,-	0%	Regular
Des 1.B	Current + $50,-	28 & 14	€8,- & €10,-	20%	Regular
Des 1.C (9.2)	Current + $50,-	28 & 14	€8,- & €10,-	50%	Regular
Des 2.A (9.3.1)	Current	21 & 14	€15,- & €30,-	0%	Regular
Des 2.B	Current	21 & 14	€15,- & €30,-	20%	Regular
Des 2.C (9.3.1)	Current	21 & 14	€15,- & €30,-	50%	Regular
Des 3.A (9.3.2)	Current	21 & 14	€25,- & €50,-	0%	Regular
Des 3.B	Current	21 & 14	€25,- & €50,-	20%	Regular
Des 3.C (9.3.2)	Current	21 & 14	€25,- & €50,-	50%	Regular
Des 4.A	Current	21 & 7	€15,- & €30,-	0%	Regular
Des 4.B	Current	21 & 7	€15,- & €30,-	20%	Regular
Des 4.C	Current	21 & 7	€15,- & €30,-	50%	Regular
Des 5.A (9.4.1)	Current	21 & 7	€25,- & €50,-	0%	Regular
Des 5.B	Current	21 & 7	€25,- & €50,-	20%	Regular
Des 5.C (9.4.1)	Current	21 & 7	€25,- & €50,-	50%	Regular
Des 5.D (9.4.2)	Current	21 & 7	€25,- & €50,-	100% Antwerp	Regular
Des 5.E (9.4.3)	Current	21 & 7	€25,- & €50,-	0%	Alternative

8.2 HIGHER STANDARD TARIFFS FOR BENEFICIAL CONDITIONS

In design 1.A and 1.C, standard tariffs per container are increased by $50,- to retain the beneficial service conditions of 28 and 14 free days and €8,- and €10,- detention and demurrage fees. Design 1.A does not include any additional trucking, design 1.C does include these additional trucking movements. The following results are found by the model for design 1.A:

TABLE 30: RESULTS DESIGN 1.A

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 89.102.475	€ 94.277.348	€ 99.022.401	€ 103.990.831	€ 109.448.212
Pre carriage	€ 12.285.291	€ 12.989.469	€ 13.653.263	€ 14.334.363	€ 15.062.452
Standard tariffs	€ 76.161.813	€ 80.596.697	€ 84.640.896	€ 88.893.042	€ 93.580.893
Detention	€ 166.950	€ 176.989	€ 186.653	€ 194.734	€ 204.709
Demurrage	€ 488.422	€ 514.193	€ 541.589	€ 568.692	€ 600.158
CO2 trucks	1076,84	1138,82	1196,83	1256,51	1320,34
CO2 barge	4714,47	4985,65	5239,66	5501,01	5779,70
Average days/container	16,95	16,94	16,96	16,95	16,95

In the current volume, standard tariffs are obviously a little more compared to the current situation, since the volume has gone up. Other aspects remain equal to the current situation. To indicate the effect of more trucking movements for this scenario, an additional 50% of container movements is modelled to be trucked in design 1.C:

TABLE 31: RESULTS DESIGN 1.C

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 91.079.449	€ 95.989.206	€ 100.984.870	€ 105.918.492	€ 111.412.233
Pre carriage	€ 14.398.106	€ 15.186.175	€ 15.981.294	€ 16.764.530	€ 17.609.430
Standard tariffs	€ 76.350.952	€ 80.454.583	€ 84.637.549	€ 88.770.076	€ 93.398.796
Detention	€ 84.664	€ 88.698	€ 92.899	€ 97.566	€ 102.206
Demurrage	€ 245.726	€ 259.751	€ 273.128	€ 286.321	€ 301.802
CO2 trucks	9394,39	9909,88	10429,84	10941,43	11490,93
CO2 barge	2197,10	2317,64	2439,24	2558,88	2687,30
Average days/container	10,47	10,47	10,47	10,47	10,47

In this design, costs increase as well as emissions and the throughput per container decreases. Detention and demurrage costs are too low for trucking to become beneficial.

8.3 SAME STANDARD TARIFFS WITH MEDIOCRE CONDITIONS

In these four designs, the standard tariffs will be kept equal to the current tariffs, whereas free days will be limited to 21 and 14 days and detention and demurrage fees will increase to €15,- and €30,- for the first designs (2.A & 2.C). In the latter two designs (3.A &3.C) these fees will increase even further to €25,- and €50,-.

8.3.1 MED PRICE DESIGN

For these designs (2.A & 2.C) the amount of free days is thus decreased to 21 and 14 and the detention and demurrage fees are increased to €15,- and €30,-. Design 2.A will have no additional trucking, whereas design 2.C will include 50% additional trucking movements. The results of design 2.A can be found in the following table:

TABLE 32: RESULTS DESIGN 2.A

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 88.763.301	€ 93.599.559	€ 98.474.458	€ 103.364.142	€ 108.378.825
Pre carriage	€ 12.305.656	€ 12.982.101	€ 13.653.156	€ 14.342.957	€ 15.026.377
Standard tariffs	€ 74.018.706	€ 78.048.288	€ 82.107.099	€ 86.168.220	€ 90.376.966
Detention	€ 978.581	€ 1.030.946	€ 1.084.891	€ 1.143.784	€ 1.188.978
Demurrage	€ 1.460.358	€ 1.538.224	€ 1.629.312	€ 1.709.181	€ 1.786.505
CO2 trucks	1078,58	1138,08	1196,84	1257,43	1316,89
CO2 barge	4722,12	4982,41	5239,69	5504,90	5764,67
Average days/container	16,95	16,95	16,95	16,95	16,94

The results show that with this design, costs remain lower than with the design where the standard tariffs are increased (design 1.A and 1.C). If only costs were taken into account, this design would hence be preferred to the higher standard tariffs. Demurrage and detention costs increase, but this does not weigh up to the increase in standard tariffs in the design from section 9.1. Emissions and throughput stay equal. The effects when 50% of container movements are trucked can be found from the following table:

TABLE 33: RESULTS DESIGN 2.C

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 89.718.187	€ 94.627.349	€ 99.544.435	€ 104.125.773	€ 109.673.186
Pre carriage	€ 14.402.917	€ 15.193.539	€ 15.994.584	€ 16.751.048	€ 17.601.612
Standard tariffs	€ 74.086.955	€ 78.137.145	€ 82.187.919	€ 85.955.549	€ 90.567.122
Detention	€ 487.910	€ 516.330	€ 541.468	€ 564.692	€ 597.674
Demurrage	€ 740.405	€ 780.335	€ 820.464	€ 854.485	€ 906.779
CO2 trucks	9399,42	9915,52	10439,35	10932,42	11487,95
CO2 barge	2198,26	2318,95	2441,45	2556,77	2686,60
Average days/container	10,47	10,47	10,47	10,46	10,48

In this design, emissions increase, detention and demurrage decrease whilst pre carriage and total costs increase. Finally the throughput time per container decreases. It should be noted that trucking more containers does not decrease the total amount of costs.

8.3.2 HIGH PRICE DESIGN

In these designs (3.A & 3.C) the situation is looked at where free days are still 21 and 14 days, but detention and demurrage fees increase even further to €25,- and €50,-. Firstly we look at the situation where no additional containers are trucked.

TABLE 34: RESULTS DESIGN 3.A

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 90.471.695	€ 95.318.503	€ 100.479.937	€ 105.368.338	€ 110.456.549
Pre carriage	€ 12.313.991	€ 12.979.131	€ 13.678.864	€ 14.344.662	€ 15.040.635
Standard tariffs	€ 74.083.619	€ 78.037.578	€ 82.273.168	€ 86.274.540	€ 90.424.003
Detention	€ 1.631.444	€ 1.724.815	€ 1.803.385	€ 1.896.270	€ 1.996.431
Demurrage	€ 2.442.640	€ 2.576.980	€ 2.724.520	€ 2.852.865	€ 2.995.480
CO2 trucks	1079,62	1137,84	1199,18	1257,43	1318,45
CO2 barge	4726,52	4981,38	5249,86	5504,98	5771,33
Average days/container	16,95	16,96	16,95	16,95	16,96

The first thing to notice here is that the total amount of costs is higher than in the situation where standard tariffs are increased to retain beneficial service conditions. If these service agreements follow from the tenders, transport thus becomes more expensive, which can be explained by the increase in detention and demurrage costs. The following design shows the situation in which 50% of the containers are trucked:

TABLE 35: RESULTS DESIGN 3.C

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 90.496.476	€ 95.291.767	€ 100.404.701	€ 105.203.627	€ 110.696.547
Pre carriage	€ 14.402.459	€ 15.179.402	€ 15.994.786	€ 16.763.375	€ 17.609.094
Standard tariffs	€ 74.054.034	€ 77.962.687	€ 82.147.804	€ 86.055.444	€ 90.594.501
Detention	€ 814.213	€ 851.530	€ 905.282	€ 950.118	€ 989.732
Demurrage	€ 1.225.770	€ 1.298.148	€ 1.356.830	€ 1.434.690	€ 1.503.220
CO2 trucks	9398,34	9906,10	10440,09	10939,06	11492,73
CO2 barge	2198,02	2316,75	2441,62	2558,34	2687,72
Average days/container	10,46	10,46	10,47	10,47	10,47

In this design, a certain tipping point is reached in terms of costs. For some of the demand scenarios, total costs decrease, whereas in other the total costs remain a bit higher than in the situation where no additional containers are trucked.

8.4 SAME STANDARD TARIFFS WITH BAD CONDITIONS

The most extreme situation thinkable is that the free days are cut back to 21 and 7 days and that the tariffs associated with detention and demurrage increase to €25,- and €50,-. If the demurrage and detention fees increase drastically, trucking more might decrease the total costs associated with container transport.

8.4.1 BAD CONDITIONS AND HIGH PRICES

In these designs the results of 21 and 7 free days and €25,- and €50,- detention and demurrage fees will be shown (5.A & 5.C). The first design depicts the system with no additional trucking movements:

TABLE 36: RESULTS DESIGN 5.A

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 94.797.860	€ 100.108.396	€ 105.054.124	€ 110.787.668	€ 116.495.394
Pre carriage	€ 12.291.932	€ 12.971.652	€ 13.631.795	€ 14.353.475	€ 15.060.246
Standard tariffs	€ 73.829.877	€ 77.944.808	€ 81.768.373	€ 86.258.348	€ 90.753.073
Detention	€ 1.621.329	€ 1.719.426	€ 1.809.874	€ 1.900.806	€ 2.001.480
Demurrage	€ 7.054.722	€ 7.472.510	€ 7.844.082	€ 8.275.040	€ 8.680.595
CO2 trucks	1077,22	1136,99	1194,54	1258,43	1320,27
CO2 barge	4716,25	4977,71	5229,79	5509,21	5779,32
Average days/container	16,94	16,95	16,96	16,96	16,96

The first thing to notice is that retaining the current standard tariffs for these service conditions heavily increases the total costs. Detention and demurrage costs increase significantly with these tariffs leading to high prices. To test whether trucking has an effect on this, the situation is modelled in which 50% of all container movements are trucked:

TABLE 37: RESULTS DESIGN 5.C

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 92.887.627	€ 97.801.286	€ 102.909.026	€ 108.351.776	€ 113.429.851
Pre carriage	€ 14.394.711	€ 15.168.309	€ 15.969.812	€ 16.788.691	€ 17.577.028
Standard tariffs	€ 73.966.288	€ 77.865.063	€ 81.924.311	€ 86.260.248	€ 90.324.357
Detention	€ 810.729	€ 857.536	€ 900.676	€ 953.461	€ 990.516
Demurrage	€ 3.715.898	€ 3.910.378	€ 4.114.227	€ 4.349.377	€ 4.537.950
CO2 trucks	9392,31	9898,12	10419,10	10957,21	11467,55
CO2 barge	2196,61	2314,89	2436,74	2562,57	2681,85
Average days/container	10,47	10,47	10,47	10,47	10,48

The results show that costs drop quite significantly. It does however also heavily impact emissions as more container movements are trucked and trucking is more polluting than barge transport. If more volume is trucked instead of transported by barge, the costs will thus drop down with these service conditions. Lastly, the average time it takes to transport containers to a deep- sea vessel is shorter.

8.4.2 Truck all container movements to Antwerp

Design 5.D will also explore the scenario in which the amount of free days is low and prices are high. It will evaluate what the effect is if all containers that are transported to Antwerp are transported by truck instead of by barge.

TABLE 38: RESULTS DESIGN 5.D

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 91.682.636	€ 96.113.518	€ 100.912.151	€ 105.633.284	€ 110.531.187
Pre carriage	€ 13.825.753	€ 14.272.935	€ 14.714.391	€ 15.169.734	€ 15.637.552
Standard tariffs	€ 74.175.830	€ 77.963.095	€ 82.119.568	€ 86.172.785	€ 90.392.544
Detention	€ 794.693	€ 838.744	€ 885.646	€ 929.724	€ 977.960
Demurrage	€ 2.886.360	€ 3.038.743	€ 3.192.547	€ 3.361.040	€ 3.523.132
CO2 trucks	7291,23	7662,56	8068,69	8475,28	8869,04
CO2 barge	2894,60	3051,74	3206,97	3366,82	3530,76
Average days/container	12,25	12,27	12,27	12,26	12,27

Compared to the scenario in which no containers are trucked, the costs decrease. It also shows that emissions increase and that the throughput in terms of average days per container decreases. Compared to the scenario in which 50% of all containers are trucked, costs are even lower, but the throughput time is larger.

8.4.3 Alternative production and transport

Design 5.E will, similarly to the previous designs, explore another option when the conditions are bad. This design assumed that all OD- pairs that originate in Rotterdam are served by production and containers from Zoeterwoude. All OD- pairs originating in Antwerp are hence served from Den Bosch.

TABLE 39: RESULTS DESIGN 5.E

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 95.218.554	€ 100.396.061	€ 105.756.951	€ 110.772.339	€ 116.428.903
Pre carriage	€ 12.310.705	€ 12.989.698	€ 13.671.005	€ 14.327.247	€ 15.049.641
Standard tariffs	€ 74.052.573	€ 78.038.579	€ 82.152.121	€ 86.092.545	€ 90.514.466
Detention	€ 1.633.794	€ 1.730.298	€ 1.833.213	€ 1.908.298	€ 2.006.904
Demurrage	€ 7.221.482	€ 7.637.485	€ 8.100.612	€ 8.444.250	€ 8.857.892
CO2 trucks	951,66	1007,49	1066,35	1116,32	1174,53
CO2 barge	4193,83	4437,55	4701,20	4924,82	5179,92
Average days/container	17,06	17,06	17,06	17,06	17,07

In this design, costs are slightly higher to the design in which production is ‘normal’. Throughput time is slightly longer. Emissions are lower however, which can be explained by the shorter distances on those two pre carriage legs compared to the other two pre carriage legs.

8.5 CONCLUSION MODEL RESULTS

This section aimed to answer the following research question:

6. *How do these different designs relate in terms of key performance indicators?*

The base case design scores best in terms of costs. In none of the designs, costs drop below the value that was find for the current situation. In terms of costs, designs 1.A,B,C score better than the other alternatives. In terms of costs this means that higher standard tariffs are preferred above less flexible/beneficial service conditions within contracts.

In terms of throughput, the modal split decreases the throughput times. The more container volume is transported by truck, the lower- and thus better performing- the design.

In terms of emissions the higher the percentage of trucks, the higher the emissions. This means that all x.C alternatives score relatively bad in terms of emissions. Alternative 5.D where all containers to Antwerp are transported by truck scores a little better in terms of emissions. Alternative 5.E scores well in terms of emissions, but bad in terms of costs and sustainability.

The next section will use Multi Criteria Analysis to be able to compare the results based on the decision makers preferences.

9. EVALUATION

This section will go into the evaluation of the different designs. It will do so by performing a multi criteria analysis to compare the designs with each other. A multi criteria analysis is a tool that is used for decision making. Each decision is made within a certain environment and is defined as the collection of information, alternatives and most importantly: the preferences and values of the decision maker at the time of actually making the decision (Mateo, 2012). A total of 18 designs were modelled (including the base case). In this multi criteria analysis, all of the outcomes in the ‘current volume’ scenario will be compared. This section will aim to answer the following research question:

7. *Which designs perform best base on Multi Criteria Analysis?*

9.1 CRITERIA WEIGHTS

The goal of multi criteria analysis is thus to help with decision making, taking into account relative importance of criteria. In section 5 the criteria used for the model were defined. This section will aim to give those criteria weights in terms of importance. For this analysis, the SMART (Simple multi attribute rating technique) method will be used. The SMART method contains several steps. The steps that will be performed in section 11 are the following:

1. Assignment of importance weights for each of the evaluation criteria
2. Calculation of a weighted average of the values that is assigned each of the designs
3. Provisional decision on ‘best performing designs’
4. Sensitivity analysis

First of all the importance weights have to be defined. In order to do so, Pim Stevens (manager Customer Service Export & Customs) has performed a pairwise comparison between criteria scoring them on a 9-point scale. In this scale, a 1 indicates equal importance between criteria, whereas a 9 indicates that a criterion is very much more important than the other criterion. After this is done, the scores for each column are normalized, calculating the average score for each row and thus criterion. Normalization is used in order to have comparable input on the same scale. After determining the weights of the criteria, the weights of the sub criteria will also have to be defined. Finally the ‘global’ weights of all of the criteria will be defined.

The following figures indicate how the pairwise comparison is done for both the main criteria as well as sub criteria and how these normalized results translate to the local weights assigned to each of the criteria:

TABLE 40: ASSIGNED WEIGHTS AND NORMALIZED LOCAL WEIGHTS

Criterium	Costs	Sustainability	Throughput
Costs	*1*	*5*	*4*
Sustainability	*0,20*	*1*	*0,5*
Throughput	*0,25*	*2*	*1*
Sum	*1,45*	*8*	*5,5*

Criterium	Costs	Sustainability	Throughput	***Weights***
Costs	***0,69***	*0,63*	*0,73*	***0,69***
Sustainability	*0,14*	***0,13***	*0,09*	***0,13***
Throughput	*0,17*	*0,25*	***0,18***	***0,18***
Sum	*1,00*	*1,00*	*1,00*	***1,00***

Criterium	Pre carriage	Standard tariffs	Additional costs
Pre carriage	*1*	*2*	*0,33*
Standard tariffs	*0,5*	*1*	*0,25*
Additional costs	*3*	*4*	*1*
Sum	*4,5*	*7*	*1,58*

Criterium	Pre carriage	Standard tariffs	Additional costs	***Weights***
Pre carriage	***0,22***	*0,29*	*0,21*	***0,22***
Standard tariffs	*0,11*	***0,14***	*0,16*	***0,14***
Additional costs	*0,67*	*0,57*	***0,63***	***0,63***
Sum	*1,00*	*1,00*	*1,00*	***1,00***

Now that the local weights have been defined, the global weights are needed to see how the sub-criteria relate to the other criteria. To find the global weights, the weight of the cost criterion is multiplied by the local weights of the sub criteria. This yields the following final weights for each of the criteria:

TABLE 41: NORMALIZED GLOBAL WEIGHTS

Criterium	**Costs**			**Sustainability**	**Throughput**
Weight	0,69			0,13	0,18
Sub-criterium	**Pre carriage**	**Standard Tariffs**	**Additional costs**		
Weight	0,22	0,14	0,63		
Global weight	***0,15***	***0,10***	***0,44***	***0,13***	***0,18***

These are the final weights that are assigned to the criteria and will be used to evaluate the results.

9.2 NORMALIZED RESULTS DESIGNS

Now that the weights of the criteria have been defined, the results have to be normalized. In order to do so, the range between the best and worst scoring designs per criterion has been calculated. After that the to be calculated value minus the worst scoring design is divided by the previously calculated range, giving the normalized results between 0 and 1. The following scores were found, given in two tables for clarity reasons:

TABLE 42: NORMALIZED RESULTS OF DESIGNS (PART 1)

Criterium	**Des 0**	**Des 1.A**	**Des 1.B**	**Des 1.C**	**Des 2.A**	**Des 2.B**	**Des 2.C**	**Des 3.A**	**Des 3.B**
Pre carriage	0,99	0,99	0,60	0,01	0,99	0,59	0,00	0,98	0,59
Standard tariffs	0,87	0,00	0,05	0,00	0,88	0,89	0,85	0,82	0,88
Additonal costs	0,96	0,96	0,98	1,00	0,75	0,81	0,90	0,57	0,66
Emissions	0,91	0,91	0,54	0,00	0,91	0,54	0,00	0,90	0,54
Throughput	0,02	0,02	0,41	1,00	0,02	0,41	1,00	0,02	0,41

TABLE 43: NORMALIZED RESULTS OF DESIGNS (PART 2)

Criterium	**Des 3.C**	**Des 4.A**	**Des 4.B**	**Des 4.C**	**Des 5.A**	**Des 5.B**	**Des 5.C**	**Des 5.D**	**Des 5.E**
Pre carriage	0,00	0,99	0,59	0,01	1,00	0,59	0,01	0,54	0,98
Standard tariffs	0,87	0,92	0,85	0,92	1,00	0,88	0,95	0,88	0,87
Additonal costs	0,80	0,43	0,55	0,72	0,03	0,22	0,51	0,61	0,00
Emissions	0,00	0,91	0,54	0,00	0,91	0,54	0,00	0,23	1,00
Throughput	1,00	0,02	0,41	1,00	0,02	0,41	1,00	0,73	0,00

9.3 WEIGHTED RESULTS MULTI CRITERIA ANALYSIS

Now that both the weights of the criteria and the normalized results of the designs are known, these two can be multiplied with each other, offering a weighted, normalized score on each criterion per design. The sum of those values then provides a final score of an design, indicating its performance for the decision maker. A sensitivity analysis for these results is also performed in appendix H. The following results are found:

TABLE 44: WEIGHTED RESULTS OF DESIGNS (PART 1)

Criterium	**Des 0**	**Des 1.A**	**Des 1.B**	**Des 1.C**	**Des 2.A**	**Des 2.B**	**Des 2.C**	**Des 3.A**	**Des 3.B**
Pre carriage	0,15	0,15	0,09	0,00	0,15	0,09	0,00	0,15	0,09
Standard tariffs	0,09	0,00	0,00	0,00	0,09	0,09	0,08	0,08	0,09
Additonal costs	0,42	0,42	0,43	0,44	0,33	0,35	0,39	0,25	0,29
Emissions	0,11	0,11	0,07	0,00	0,11	0,07	0,00	0,11	0,07
Throughput	0,00	0,00	0,07	0,18	0,00	0,07	0,18	0,00	0,07
Final score	**0,77**	**0,69**	**0,66**	**0,62**	**0,68**	**0,67**	**0,66**	**0,59**	**0,61**
Ranking	1	2	5	7	3	4	6	11	9

TABLE 45: WEIGHTED RESULTS OF DESIGNS (PART 2)

Criterium	Des 3.C	Des 4.A	Des 4.B	Des 4.C	Des 5.A	Des 5.B	Des 5.C	Des 5.D	Des 5.E
Pre carriage	0,00	0,15	0,09	0,00	0,15	0,09	0,00	0,08	0,15
Standard tariffs	0,09	0,09	0,08	0,09	0,10	0,09	0,09	0,09	0,09
Additonal costs	0,35	0,19	0,24	0,32	0,01	0,10	0,22	0,27	0,00
Emissions	0,00	0,11	0,07	0,00	0,11	0,07	0,00	0,03	0,13
Throughput	0,18	0,00	0,07	0,18	0,00	0,07	0,18	0,13	0,00
Final score	**0,62**	**0,55**	**0,55**	**0,59**	**0,38**	**0,42**	**0,50**	**0,60**	**0,36**
Ranking	8	14	13	12	17	16	15	10	18

Following this MCA, the base case scores best. Designs 1.A and 2.A follow, scoring almost the same score. In design 2.A, the standard tariffs are as they currently are, free days are decreased to 21 and 14 and the price for detention and demurrage is increased to €15,- and €30,-. No additional containers are trucked. In design 1.A standard tariffs are increased by $50,- to retain the same conditions as in the base case.

In general these results can be seen in blocks of three, categorized on their contractual agreements: designs 1.A, 1.B and 1.C have the same service conditions, only changing the trucking percentage. This is the same for design 2.A, 2.B and 2.C etc. What can be seen is that for designs 1.A, 1.B and 1.C and designs 2.A, 2.B and 2.C trucking more containers actually decreases the score of the designs. However, for the latter three series, the score increases when more containers are trucked, especially in the ‘worst case’ scenario of designs 5.A, 5.B, 5.C and 5.D.

It can therefore be concluded that if conditions are as bad as in designs 3 or worse, trucking starts increasing the combined score. These conditions are with current standard tariffs, free days are reduced to 21 and 14 and detention and demurrage tariffs are increased to €25,- and €50,-. This is basically the ‘tipping point’ as scores only increase very slightly for those designs, but start increasing by larger margins as the conditions get worse.

Design 5.D explored the option of trucking only containers that are transported to Antwerp. This seems to be a very good alternative to the situation, as it scores much higher than other designs with the same standard tariffs and service conditions (5.A, 5.B and 5.C). Design 5.E however, scores the worst overall score according to this MCA. This means that altering the production to OD pairs does not influence the overall performance of the system.

9.4 CONCLUSION EVALUATION

This section aimed to answer the following research question:

7. *Which designs perform best base on Multi Criteria Analysis?*

Based on the Multi Criteria Analysis, the base case performs the best. This also indicates that future bottlenecks will decrease the performance of the systems unavoidably. Next to the base case, design 1.A and 2.A perform best. In general, higher standard tariffs are preferred above worse service conditions. In designs 3,4 and 5 the performance increases when a higher volume is trucked. Altering the production division does not increase the performance of the design.

10. CONCLUSIONS AND RECOMMENDATIONS

This chapter will elaborate on the conclusions and the recommendation of this research paper. Paragraph 11.1 will provide the answers to the main research question, 11.2 will focus on future research recommendations en paragraph 12.3 will focus on some limitations.

10.1 ANSWER MAIN RESEARCH QUESTION

This research has focused on exploring the following research question: *'How should HNS weigh off transportation costs, flexibility in service conditions and environmental effects for contractual agreements in times of a global container shortage?'* This question followed from the increase in bargaining power of deep-sea carriers. In contract negotiations, stricter conditions or higher prices are demanded by deep-sea carriers. The answer to this question contains several aspects.

First of all, different designs were modeled to find possible solutions to the upcoming problems. This study has tried comparing all relevant criteria by providing a calculation model reporting on the transportation costs, flexibility and sustainability of different designs and scenario's. 18 different designs were modeled, differing in standard tariffs, free days, detention and demurrage fees, trucking percentages and a production division over different trade volumes. A tradeoff between certain variables could very well be identified. After the Multi Criteria Analysis in chapter 9, it was found that after the base case, design 1.A and 2.A score the best. In design 1.A standard tariffs are increased by $50,- compared to the base case to retain the same conditions as in the base case and no containers are trucked additionally. The production division between Zoeterwoude and Den Bosch is also kept equal to the base case scenario. In design 2.A, the standard tariffs are as they currently are, free days are decreased to 21 and 14 and the price for detention and demurrage is increased to €15,- and €30,-. Next to that, no additional containers are trucked and production division is kept equal. Both of these scenarios are likely to occur as they follow from real contract negotiations. Both of these designs score poorly in terms of throughput, but well in terms of costs and sustainability. In design 1.A, detention and demurrage costs are lower than in design 2.A, but standard tariffs are obviously higher. In this design the total costs are also lower than in design 2.A. Detention and demurrage costs are however considered to be more important by the decision maker, since these costs can often not be charged to the customer and need to be paid by HNS. Standard tariffs are charged to the customer. In these two designs, trucking more containers instead of transporting them by barge only led to worse scores. This means that the gain in throughput time does not weigh up against the sustainability effects and costs remain the same or increase.

If the conditions get any worse however (less free days or higher additional costs) trucking more containers becomes a viable option. This tipping point is reached if the amount of free days becomes lower than 21 and 14 and/or detention and demurrage fees become higher than €25,- and €50,-. Although these conditions are not expected to occur in the near future for large exporters in The Netherlands, their bargaining power could increase further in the coming years. Transporting containers by truck increases emissions, but decreases detention and demurrage costs and influences throughput time beneficially. It was also found that altering the production quantities to the deep sea terminal from where the containers need to be shipped did not have a beneficial effect on the criteria.

The answer to the weigh off in transportation costs, flexibility in service conditions and environmental effects can thus be found in the following: if HNS has the opportunity, they should in general opt for higher standard tariffs if this means they can retain the current beneficial service conditions. However, if this option does not apply because of the growing bargaining power of deep sea carriers, HNS should consider trucking additional container volume in certain conditions. If the amount of free days drop to

21 and 14 and the detention and demurrage fees increase to €25,- and €50,- trucking containers starts having a beneficial impact on the criteria. This can be seen as the tipping point. If conditions become even worse than the aforementioned, trucking becomes more and more significant. The best option for HNS would be to leave the production division as it is now and to transport all containers that are shipped to Antwerp by truck instead of by barge, whilst leaving transportation towards Rotterdam by barge as it is now. This was found to be the best scoring design if service conditions are less beneficial.

In short, HNS should opt for higher standard tariffs if the same service conditions in terms of free days and detention and demurrage fees can be retained. If for whatever reason, these conditions are non-avoidable, the best course of action is to leave the production division as it is and to start trucking containers that originate from Antwerp.

10.2 LIMITATIONS

There are some important limitations to this research that need to be taken into account. First of all the data that is used could be considered incomplete. As explained, data from the 'Tradelens' platform is used for this model study. However, Tradelens is a relatively new platform and not all deep sea carriers are affiliated with it yet. Some carriers have only affiliated themselves to Tradelens during 2021, which means that not all container movements of 2021 are taken into account. Only part of the total amount is used to interpolate a year full of container movements. This might make for a biased model, although the assumption is that enough container movements are available generalize their movements and thus that this bias, if existing, is very small.

Secondly, as stated in the section on scope, this research does not account for capacity constraints on a weekly basis. It calculates a full year of operations but models it as a discrete event. It does therefore not account for heavy fluctuations in weekly transport volume. Employees have stated that on a weekly basis it does sometimes occur that empty containers cannot be taken out. This missing capacity can almost always be accounted for in the next week, which is why on a yearly basis this is not considered to be a constraint.

Finally, the assumption on how the container distribution between breweries is made might be too much of a simplification. The model now assumes that the demand for each trade leg is divided 67%/33% for Zoeterwoude and Den Bosch. In practice these divisions are dependent on many other aspects such as product specificity and packaging material availability. All of these aspects are not taken into account in this research since the model would become to complex. Since the total amount of container movements approximates this division, this assumption is made.

10.3 FUTURE RESEARCH RECOMMENDATIONS

The model in this research is used to indicate what the impact of different strategic choices and design choices is on costs, sustainability and throughput. It should be noted that the research aims to identify which design is the 'best scoring' design for the criteria relative to other designs. As stated in the previous sections there are several limitations and assumptions that might influence the outcome. It is therefore advised to implement the best scoring designs to see their actual performance.

Secondly future research could also look at the previously described weekly fluctuations in order volume. This is a problem that is not addressed in this research, but could cause problems in day to day operations. From a business perspective, this could therefore be a reason for future research. Also, if the demand on route level could be more accurately forecasted, performance might be enhanced. This research does not take any forecasting tools into account, which is why this could be included in future research.

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APPENDIX A LOGISTIC PROCESSES

Together with IBM and Tradelens, several workshops were held in order to depict the complete processes and corresponding current pain points. To do so, the complete drumbeat (order to cash) was mapped, including the responsible parties for each activity. The following pages contain figures which depict the process for the MTO market quite detailed and are split up for visibility reasons. For replenishment markets these processes are more or less similar from the moment that CSE schedules orders, deliveries and shipments. The part before that is different since they don't have to process orders by customers but manage the inventory of customers internally.

Out of these processes, several wastes relating to detention and demurrage were identified. These are of course visible in the shipment and aftercare of the processes. Two main wastes were concluded upon relating to D&D. Also, an estimation of the expected costs and FTE's required for this waste were made:

No info/trigger in D&D (demurrage & detention) costs incurring

- Waste (costs) = 200 K per Year

Paying D&D without verification / D& D costs are not transparent

- Waste = 50 K per Year (Heineken pays too much), D&D costs are not justified
- Waste = Shipment delay costs extra for keeping the container too long
- Waste = minimum of 1 Hrs/Week for 10 CSE that does bassware (invoice system) = 10 Hrs/Week

However research has led, as can be found from for example in appendix C, to numbers that are far larger than described at paying D&D without verification. For 2021, invoices were challenged for over 250.000 euro's.

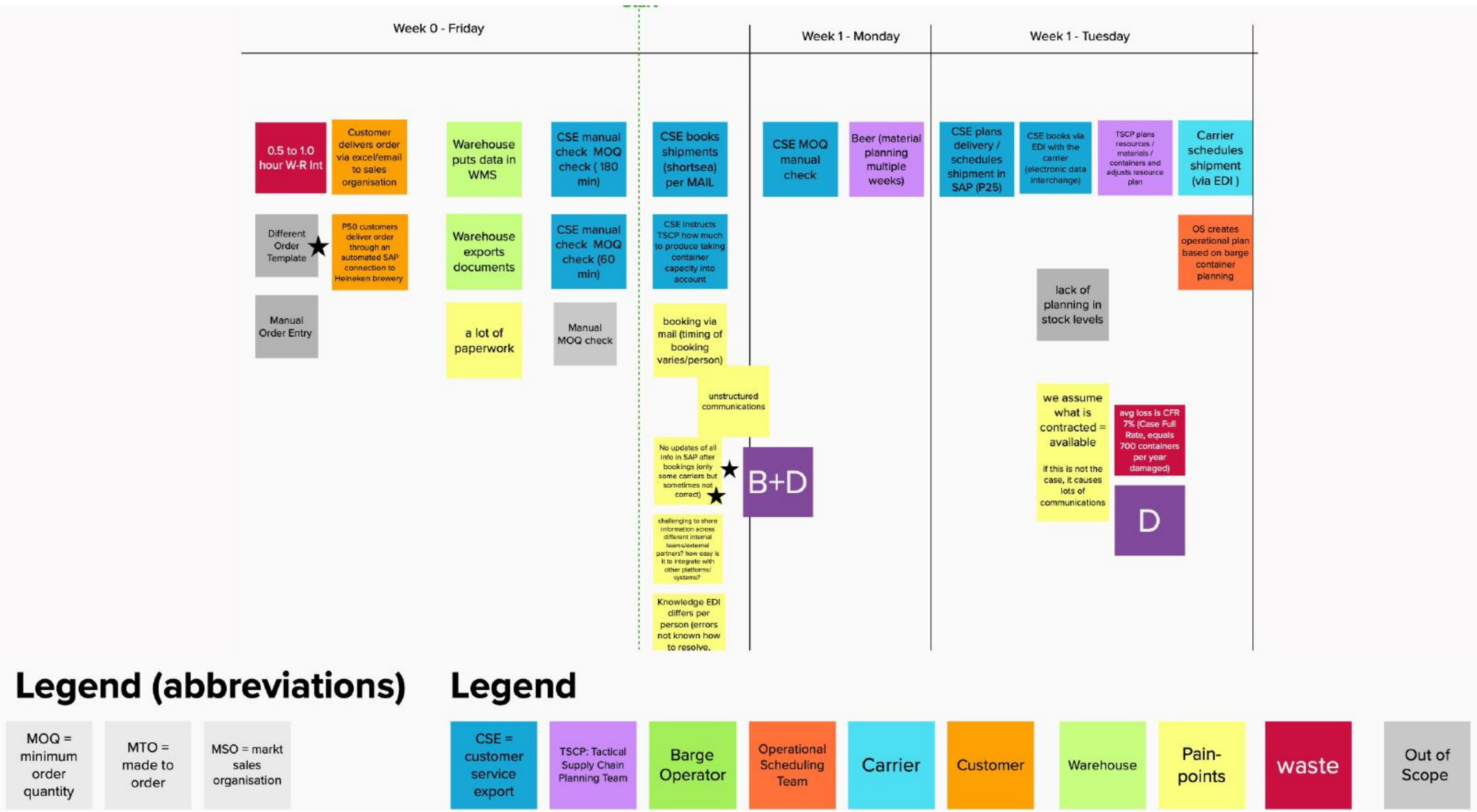


FIGURE 15: PROCESSES MTO 1

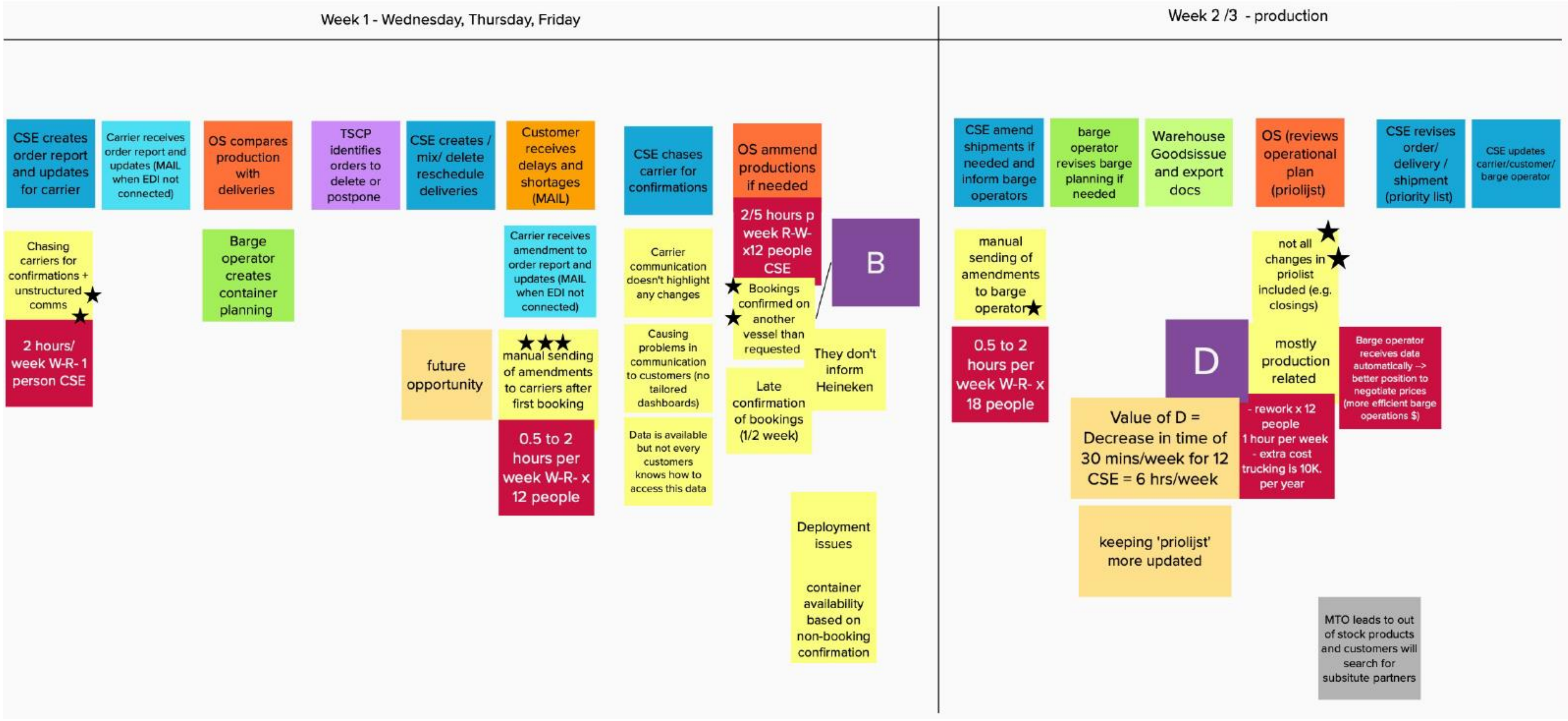


FIGURE 16: PROCESSES MTO 2

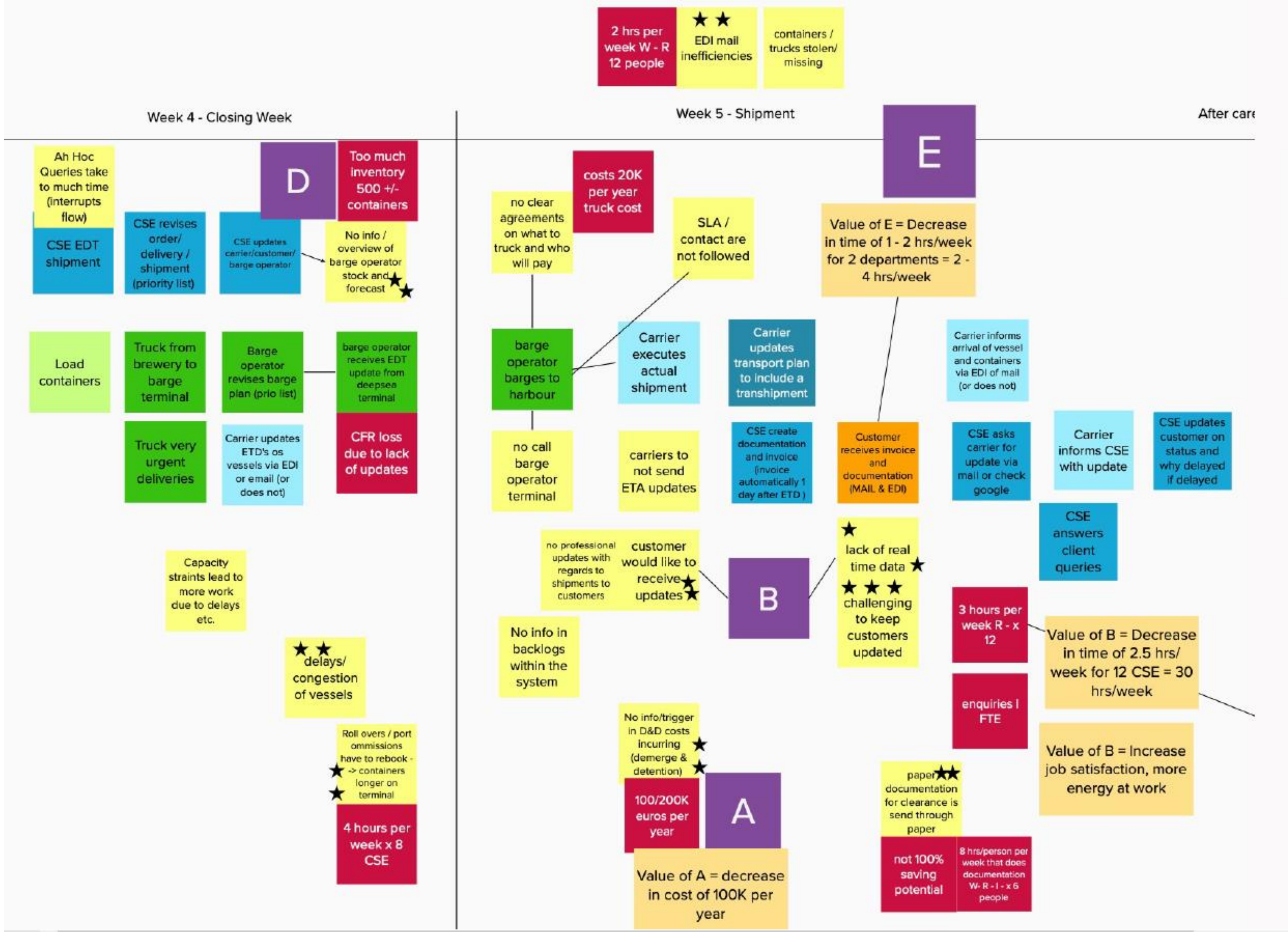


FIGURE 17: PROCESSES MTO 3

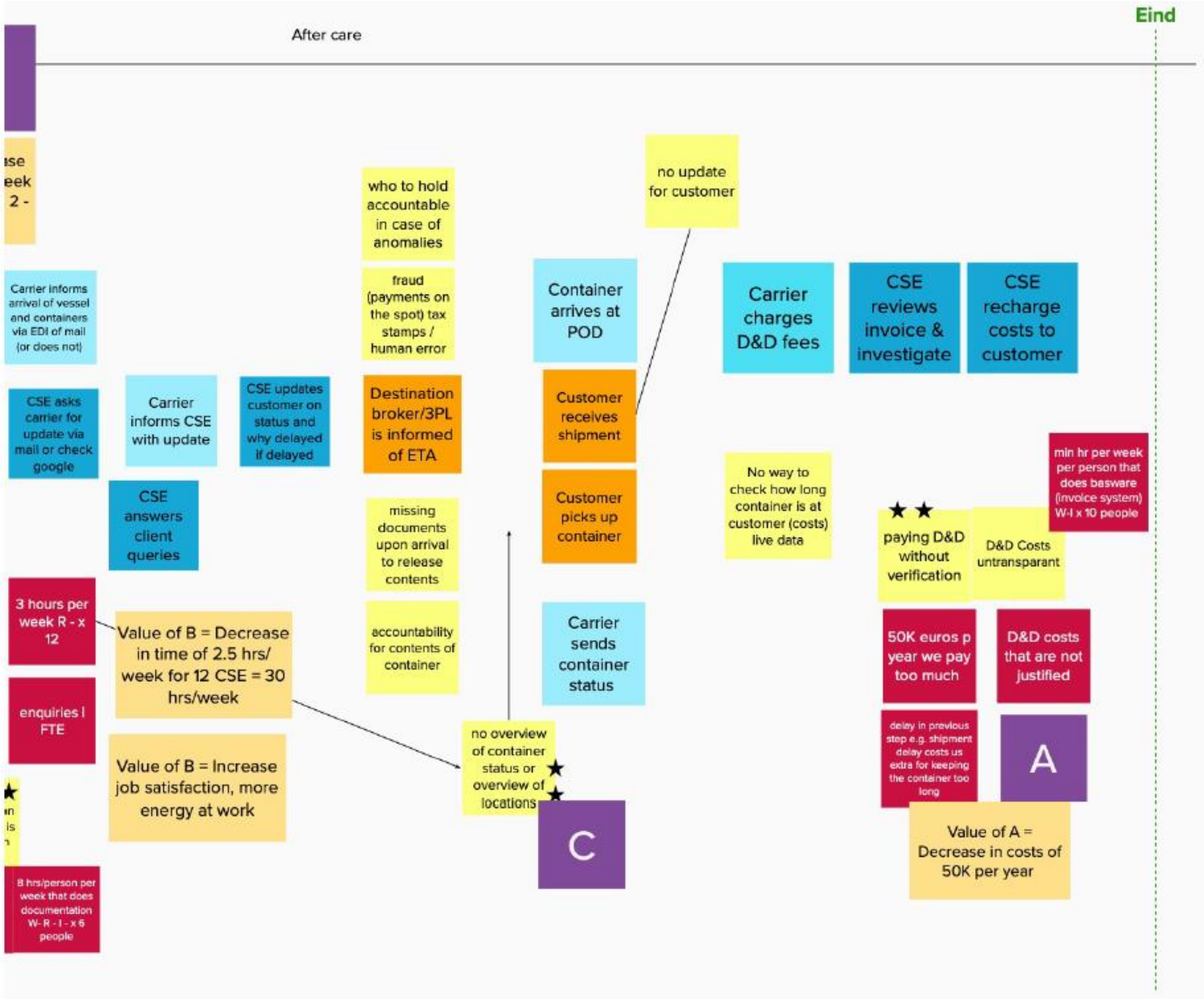


FIGURE 18: PROCESSES MTO

APPENDIX B: EQUIPMENT USAGE AND STORAGE HNS

To give an indication of the amount of days it usually takes HNS to transport containers from Alphen and Den Bosch to Rotterdam and Antwerp, data from Tradelens can be used as explained in **Error! Reference source not found.**. The data used contains container movements in the first half year of 2021. Not all container movements are taken into account in this data file, because of for example missing values. It is important to define which points in the process will be taken into account to define the amount of days. This is directly related to detention and demurrage costs. After HNS receives a booking confirmation from the carrier the following events are important to consider:

- Actual moment container is taken into use, relating to the moment a container is taken out of storage and into use at the terminal of Alphen or Den Bosch
- Actual barge arrival and unloading at the deep-see terminal
- Original estimated vessel departure time. If a carrier delays a vessel, the estimated vessel departure time changes. It is therefore important to look at the original estimated vessel departure time at the time of the booking confirmation. **However:**
- This only applies if shipments are delayed by the carrier. If shipments are delayed by HNS for whatever reason (production delays, pre carriage delays etc.), HNS will have to pay accordingly. Therefore, also data from SAP is used, where employees from HNS have to put in a reason for a delay such as: Main leg, pre carriage, planning issue etc. This data is incorporated in the analysis as well.

Equipment usage (detention) than equals the amount of days between the actual moment a container is taking into use and the original estimated vessel departure time. Equipment storage (demurrage) is the amount of days between the barge arrival/unloading and the original estimated vessel departure time.

There are four different shipping legs that exist until the deep-sea terminal. These are from Alphen to Rotterdam, Den Bosch to Rotterdam, Alphen to Antwerp and Den Bosch to Antwerp.

ALPHEN- ROTTERDAM

In this shipping leg for equipment usage, 7687 usable container movements were found. The average equipment usage time was close to 16,3 days, with a median of 15. The following figure highlights all the occurrences compared to the amount of days:

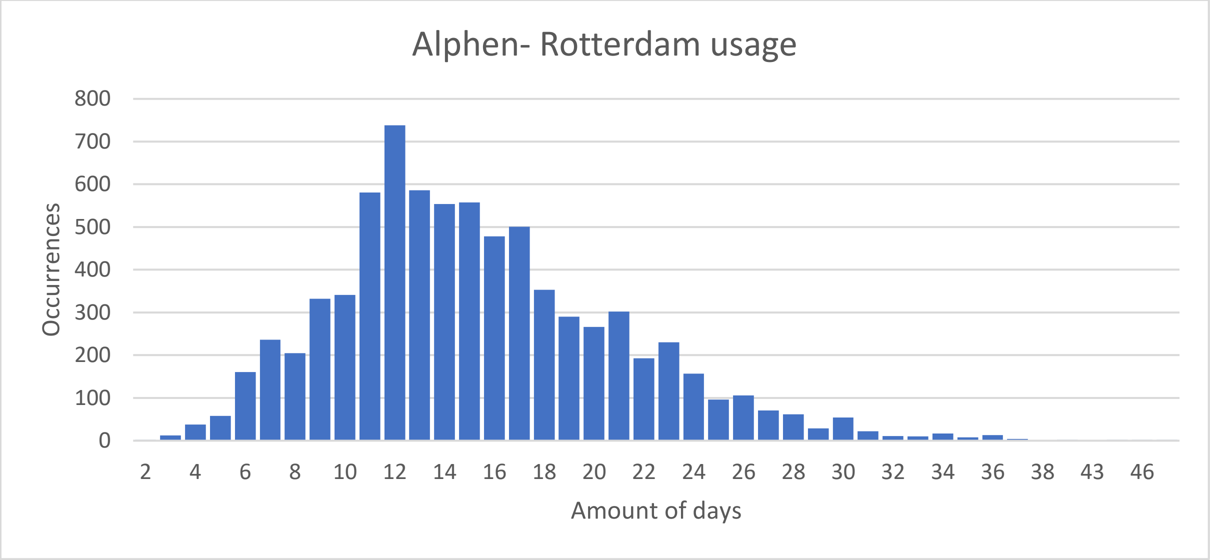


FIGURE 19: EQUIPMENT USAGE ALPHEN-ROTTERDAM

Equipment storage can thus be found by calculating the amount of days between the barge arrival/unloading and the original estimated vessel departure time. For this dataset, 4303 datapoints were available. The data had a mean time of 7,3 days and a median value of 6. The following figure highlights all occurrences compared to the amount of days:

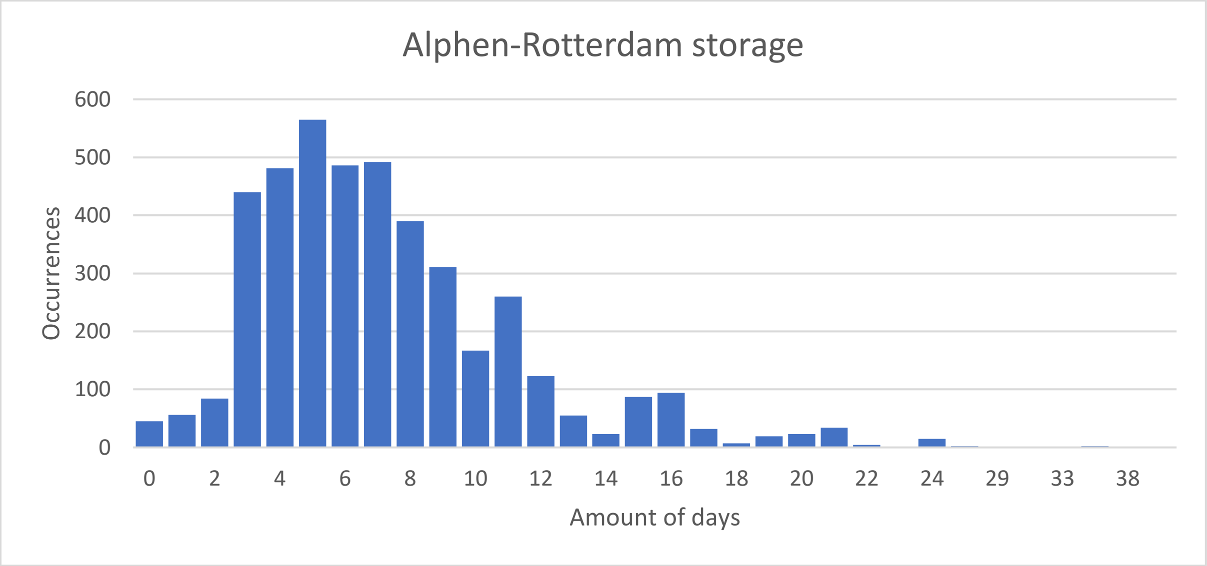


FIGURE 20: EQUIPMENT STORAGE ALPHEN-ROTTERDAM

DEN BOSCH- ROTTERDAM

In this shipping leg for equipment usage, 1417 usable container movements were found. The average equipment usage time was 17,1 days, with a median of 15 days. The following figure highlights all the occurrences compared to the amount of days:

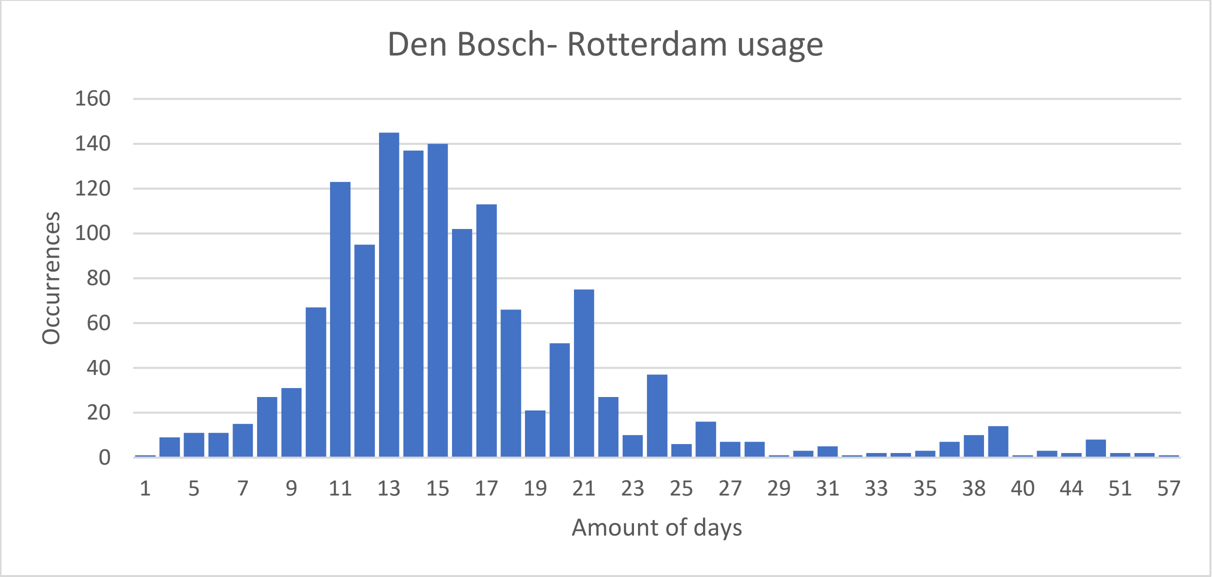


FIGURE 21: EQUIPMENT USAGE DEN BOSCH-ROTTERDAM

The data relating to equipment storage contained 4866 data points, with a mean time of 6,8 days and a median value of 6. One thing to note here, is that the amount of days containers are stored at the deep-sea terminal is quite similar for both shipping legs to Rotterdam. This makes sense since it is the same terminal handling the containers. The following figure highlights all of the occurrences:

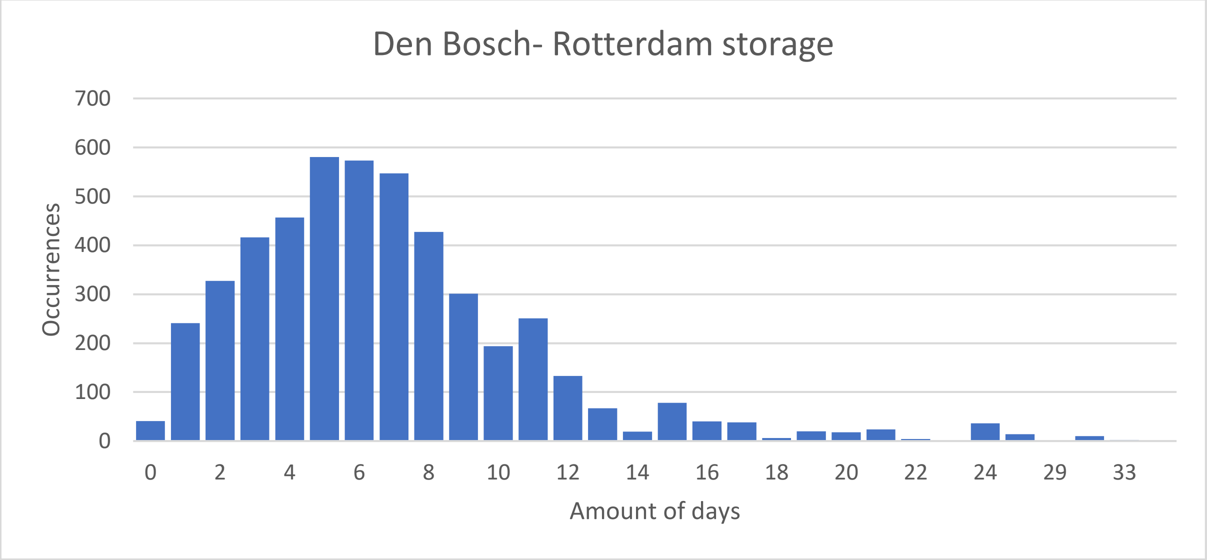


FIGURE 22: EQUIPMENT STORAGE DEN BOSCH- ROTTERDAM

DEN BOSCH- ANTWERP

The data relating to equipment usage from Den Bosch to Antwerp contained 632 usable values. The mean of the amount of days here was 18,7 days with a median of 17 days. The datasets in The Netherlands contained a long tail already. The dataset from Den Bosch to Antwerp characterizes itself with a similar long tail, but also quite a lot of data points in this tail relative to the other shipping legs:

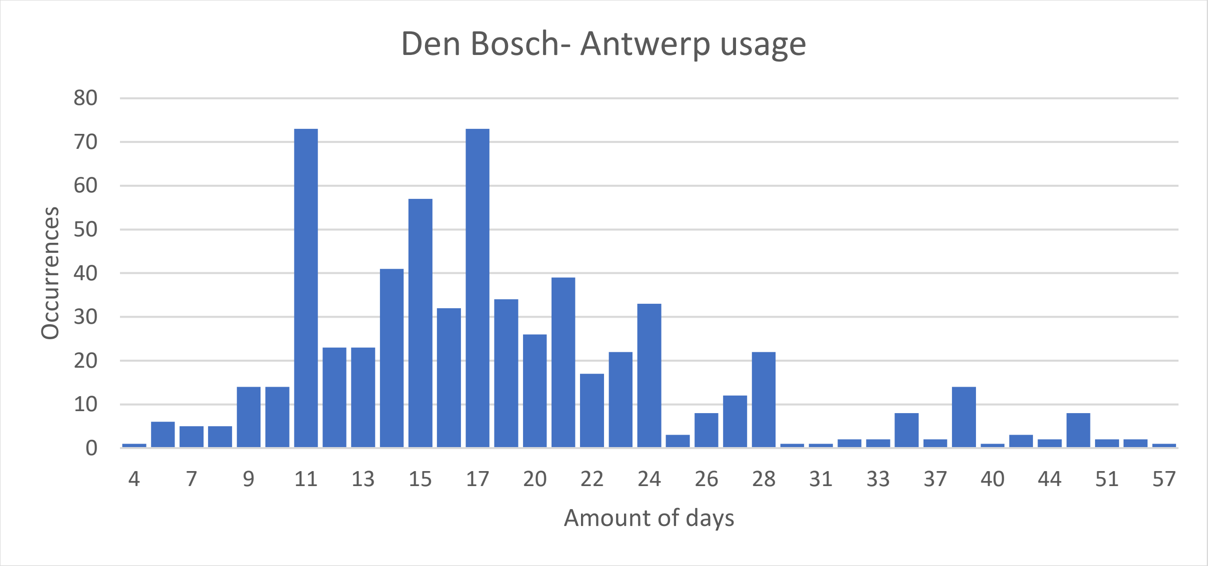


FIGURE 23: EQUIPMENT USAGE DEN BOSCH- ANTWERP

For the storage containers in this shipping leg, 4809 usable values were found. The average time containers were on the terminal of Antwerp was 11,0 days, with a median of 8 days. This dataset also contains a long right sided tail:

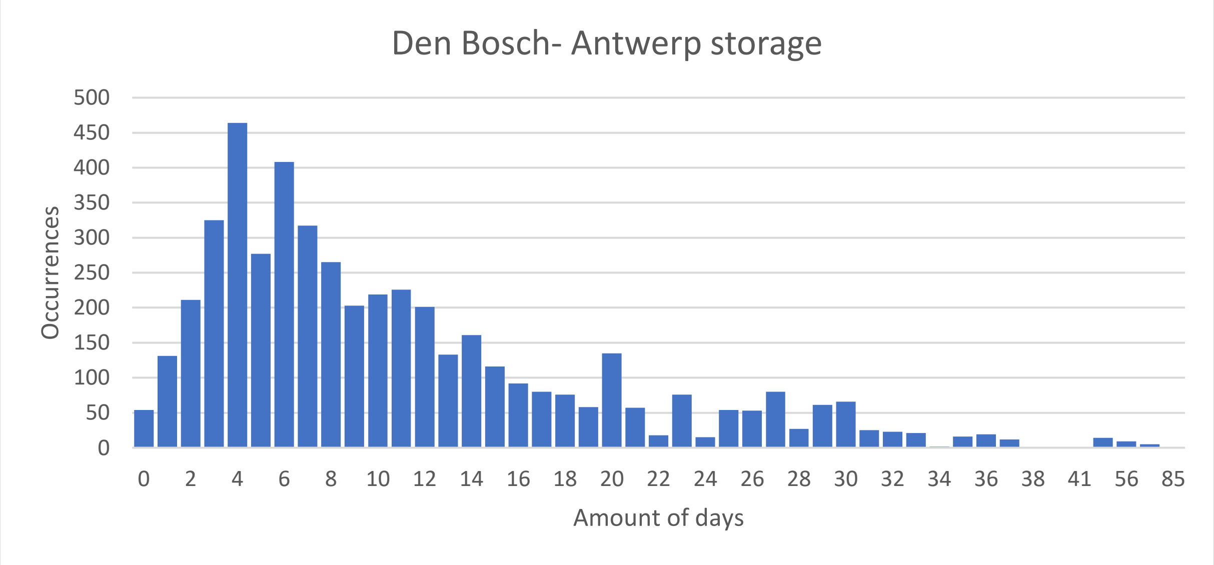


FIGURE 24: EQUIPMENT STORAGE DEN BOSCH- ANTWERP

ALPHEN- ANTWERP

The data set contained 8166 values that were usable. In this shipping leg the equipment usage time is a bit larger compared to the others. One possible explanation is that the distance is longer. A second reason could be that in this shipping leg, smaller terminals in Antwerp are also used, which HNS only ships to once a week. If a barge is then missed, this will lead to longer delays. These reasons are of course only applicable if the equipment storage is similar to the other Antwerp shipping leg. The dataset had a mean value of 18,3 days and a median of 17 days.

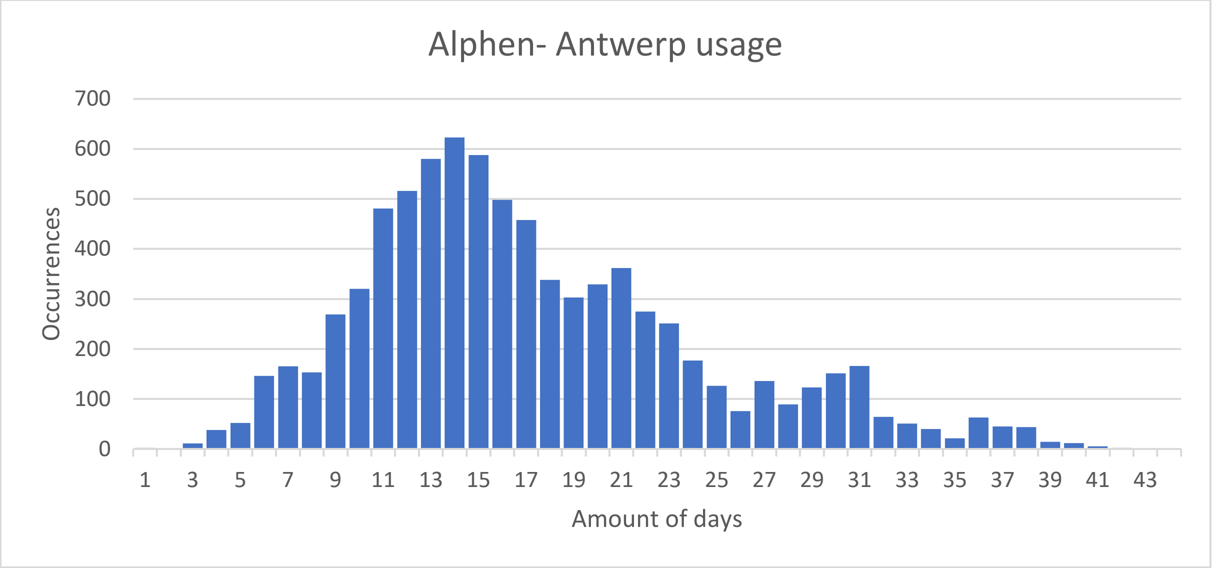


FIGURE 25: EQUIPMENT USAGE ALPHEN-ANTWERP

Relating to Equipment storage, 4817 usable values were found. The average value is 10,9 days and the median value is 8. These values are relatively close to the storage of the other containers in Antwerp which could mean that the assumptions relating to the longer equipment usage make sense. Once again, the figure shows a long tail.

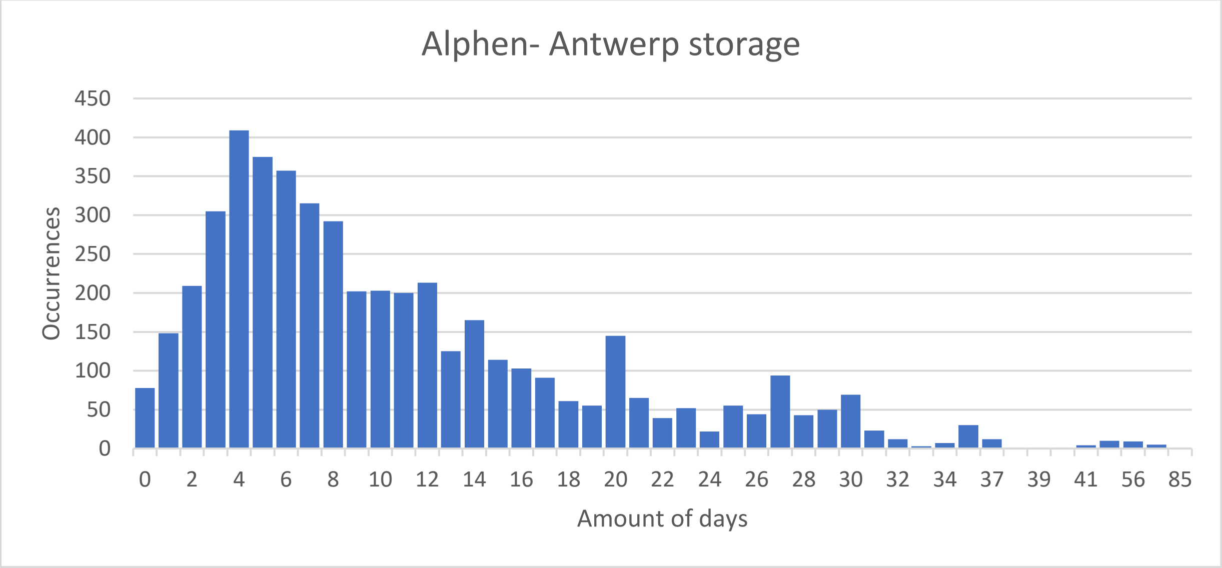
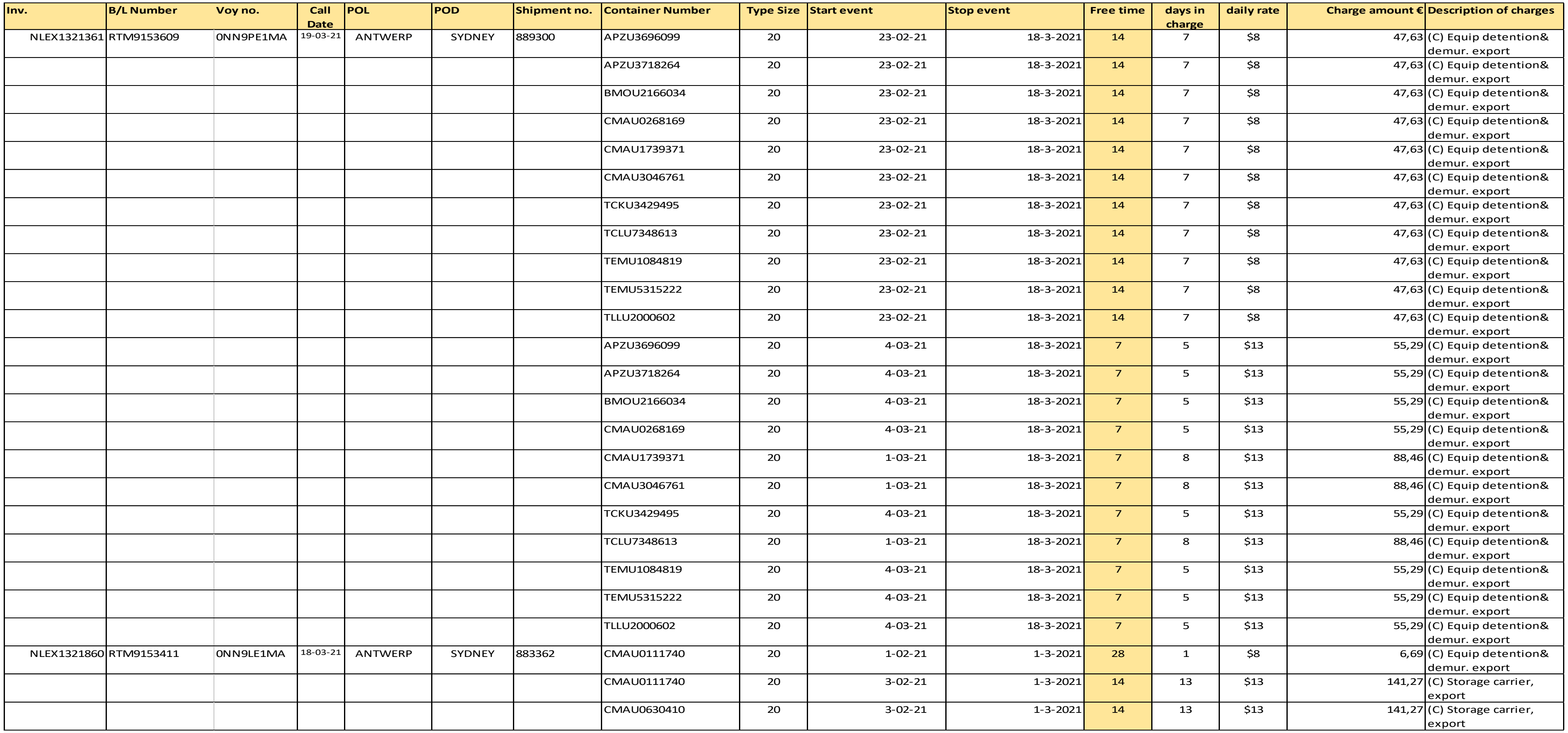


FIGURE 26: EQUIPMENT STORAGE ALPHEN- ANTWERP

APPENDIX C: EXAMPLE INVOICE DETENTION AND DEMURRAGE

The following figure shows part of an actual invoice sent by CMA-CGM relating to detention and demurrage. The conditions on which CMA-CGM bases these costs relating to free days can be found in the marked column. Interestingly enough they provide different amount of days for the same shipping leg (Antwerp-Sydney), whilst they should be the same. On the first booking the amount of 14 days for usage and 7 for storage are used, whereas another booking (last three rows) provide the amount of days of 28 and 14, which should be the conditions used.



Inv.	B/L Number	Voy no.	Call Date	POL	POD	Shipment no.	Container Number	Type Size	Start event	Stop event	Free time	days in charge	daily rate	Charge amount €	Description of charges
NLEX1321361	RTM9153609	0NN9PE1MA	19-03-21	ANTWERP	SYDNEY	889300	APZU3696099	20	23-02-21	18-3-2021	14	7	$8	47,63	(C) Equip detention& demur. export
							APZU3718264	20	23-02-21	18-3-2021	14	7	$8	47,63	(C) Equip detention& demur. export
							BMOU2166034	20	23-02-21	18-3-2021	14	7	$8	47,63	(C) Equip detention& demur. export
							CMAU0268169	20	23-02-21	18-3-2021	14	7	$8	47,63	(C) Equip detention& demur. export
							CMAU1739371	20	23-02-21	18-3-2021	14	7	$8	47,63	(C) Equip detention& demur. export
							CMAU3046761	20	23-02-21	18-3-2021	14	7	$8	47,63	(C) Equip detention& demur. export
							TCKU3429495	20	23-02-21	18-3-2021	14	7	$8	47,63	(C) Equip detention& demur. export
							TCLU7348613	20	23-02-21	18-3-2021	14	7	$8	47,63	(C) Equip detention& demur. export
							TEMU1084819	20	23-02-21	18-3-2021	14	7	$8	47,63	(C) Equip detention& demur. export
							TEMU5315222	20	23-02-21	18-3-2021	14	7	$8	47,63	(C) Equip detention& demur. export
							TLLU2000602	20	23-02-21	18-3-2021	14	7	$8	47,63	(C) Equip detention& demur. export
							APZU3696099	20	4-03-21	18-3-2021	7	5	$13	55,29	(C) Equip detention& demur. export
							APZU3718264	20	4-03-21	18-3-2021	7	5	$13	55,29	(C) Equip detention& demur. export
							BMOU2166034	20	4-03-21	18-3-2021	7	5	$13	55,29	(C) Equip detention& demur. export
							CMAU0268169	20	4-03-21	18-3-2021	7	5	$13	55,29	(C) Equip detention& demur. export
							CMAU1739371	20	1-03-21	18-3-2021	7	8	$13	88,46	(C) Equip detention& demur. export
							CMAU3046761	20	1-03-21	18-3-2021	7	8	$13	88,46	(C) Equip detention& demur. export
							TCKU3429495	20	4-03-21	18-3-2021	7	5	$13	55,29	(C) Equip detention& demur. export
							TCLU7348613	20	1-03-21	18-3-2021	7	8	$13	88,46	(C) Equip detention& demur. export
							TEMU1084819	20	4-03-21	18-3-2021	7	5	$13	55,29	(C) Equip detention& demur. export
							TEMU5315222	20	4-03-21	18-3-2021	7	5	$13	55,29	(C) Equip detention& demur. export
							TLLU2000602	20	4-03-21	18-3-2021	7	5	$13	55,29	(C) Equip detention& demur. export
NLEX1321860	RTM9153411	0NN9LE1MA	18-03-21	ANTWERP	SYDNEY	883362	CMAU0111740	20	1-02-21	1-3-2021	28	1	$8	6,69	(C) Equip detention& demur. export
							CMAU0111740	20	3-02-21	1-3-2021	14	13	$13	141,27	(C) Storage carrier, export
							CMAU0630410	20	3-02-21	1-3-2021	14	13	$13	141,27	(C) Storage carrier, export

TABLE 46: (PART OF) INVOICE CMA-CGM DETENTION AND DEMURRAGE

APPENDIX D: STANDARD TARIFFS PER SHIPPING LEG 2021

This appendix shows all of the different shipping legs and the total rate that has to be paid (in USD) for each container shipped on that leg relating to the standard tariffs. These conditions apply to the contracts as agreed upon for the year of 2021.

Group ID	Name Carrier	Port Name (POL)	Port Name (POD)	Equipment Type	Award nr of containers	Total Rate [USD]
4	Central Shp	Antwerp	San Juan PR	40 NOR	1168	1200
5	CMA-CGM	Rotterdam	Gustavia	20 DR	26	2700
6	Independent Container Line Ltd.	Antwerp	Hamilton (BM)	20 DR	94	3704
7	CMA-CGM	Antwerp	George Town	20 DR	2	1916
8	CMA-CGM	Antwerp	George Town	40 DR	54	2701
10	CMA-CGM	Rotterdam	Degrad des Cannes	20 DR	461	2736
11	Hapag Lloyd	Rotterdam	Singapore	20 DR	66	480
12	MSC	Rotterdam	Noumea	20 DR	2	1450
13	Cosco	Antwerp	Mersin	20 DR	50	620
14	Maersk	Rotterdam	Port Louis	20 DR	82	1031
15	CMA-CGM	Rotterdam	Charlotte Amalie-St Thomas	40 DR	55	3192
17	Maersk	Rotterdam	Reunion	20 DR	510	991
18	Maersk	Rotterdam	Freetown	20 DR	19	1511
19	Hapag Lloyd	Antwerp	Abidjan	20 DR	69	877
20	Hapag Lloyd	Rotterdam	Djibouti	20 DR	27	847
21	CMA-CGM	Antwerp	Libreville	20 DR	174	1140
22	Nile Dutch	Antwerp	Matadi	20 DR	5	1817
23	MSC	Rotterdam	La Guaira	20 DR	2	2080
24	Maersk	Rotterdam	Port au Prince	20 DR	2	1582
25	Hapag Lloyd	Rotterdam	Hong Kong	20 DR	27	588
26	Hapag Lloyd	Rotterdam	Hong Kong	40 DR	330	767
27	Hapag Lloyd	Rotterdam	Manzanillo (PA)	40 NOR	53	1574
29	MSC	Rotterdam	Longoni	20 DR	91	1700
31	CMA-CGM	Antwerp	Pointe a Pitre	20 DR	410	1520

32	OOCL	Antwerp	Dakar	20 DR	117	690
33	MSC	Rotterdam	Aqaba	20 DR	26	1050
34	MSC	Antwerp	Monrovia	20 DR	52	1391
35	CMA-CGM	Antwerp	Fort de France	20 DR	370	1700
36	Hapag Lloyd	Rotterdam	Posorja	20 DR	2	882
37	Maersk	Rotterdam	Callao	40 NOR	48	670
38	MSC	Antwerp	Conakry	20 DR	121	1391
39	CMA-CGM	Rotterdam	Christiansted	40 DR	30	3427
41	CMA-CGM	Antwerp	El Guamache	20 DR	5	2151
42	Maersk	Rotterdam	Dar es Salaam	20 DR	699	921
43	MSC	Antwerp	Cotonou	20 DR	27	1131
44	CMA-CGM	Rotterdam	Road Town-Tortola	40 DR	41	3112
45	CMA-CGM	Rotterdam	Road Bay	40 DR	2	3597
53	Maersk	Rotterdam	Bissau	20 DR	5	1858
54	Hyundai	Rotterdam	Busan	20 DR	693	480
54	ONE	Rotterdam	Busan	20 DR	1039	473
54	Maersk	Rotterdam	Busan	20 DR	1732	428
55	Hapag Lloyd	Rotterdam	Puerto Limon	20 DR	2	1571
57	CMA-CGM	Rotterdam	Paramaribo	40 NOR	409	1717
58	Maersk	Rotterdam	Auckland	20 DR	24	1343
59	CMA-CGM	Rotterdam	Port of Spain	20 DR	5	1437
60	CMA-CGM	Antwerp	Sydney	20 DR	445	1143
61	CMA-CGM	Antwerp	Fremantle	20 DR	48	1129
62	Maersk	Rotterdam	Brisbane	20 DR	80	1143
63	Hapag Lloyd	Rotterdam	Ho Chi Minh City	20 DR	319	489
66	Nile Dutch	Antwerp	Luanda	20 DR	15	1202
67	CMA-CGM	Antwerp	Douala	20 DR	25	1168
68	Nile Dutch	Antwerp	Pointe Noire	20 DR	66	1002
69	Hapag Lloyd	Rotterdam	Hamad	20 DR	133	1066
70	Hapag Lloyd	Rotterdam	Sohar	20 DR	60	803
71	Hyundai	Rotterdam	Jebel Ali	20 DR	313	650

72	Hapag Lloyd	Rotterdam	Bahrain	20 DR	125	843
81	Hapag Lloyd	Rotterdam	Ajman	20 DR	417	823
81	Maersk	Rotterdam	Ajman	20 DR	225	2117
84	Maersk	Rotterdam	Mombasa	20 DR	816	831
86	Maersk	Rotterdam	Toamasina	20 DR	17	831
88	MSC	Rotterdam	Asuncion	40 NOR	750	1235
88	CMA-CGM	Rotterdam	Asuncion	40 NOR	500	1172
90	Hapag Lloyd	Rotterdam	Providenciales	20 DR	12	3552
95	Hapag Lloyd	Rotterdam	Grand Turk	20 DR	5	3430
96	MSC	Rotterdam	Nassau	20 DR	3	2025
99	Maersk	Rotterdam	Ashdod	20 DR	138	1011
100	Hapag Lloyd	Rotterdam	Shanghai	20 DR	335	395
101	CMA-CGM	Rotterdam	Philipsburg	40 NOR	234	2807
104	Hapag Lloyd	Rotterdam	Oranjestad	40 DR	116	2378
106	Hapag Lloyd	Rotterdam	Willemstad	40 DR	211	2278
107	Hapag Lloyd	Rotterdam	Kralendijk	40 DR	74	3167
108	CMA-CGM	Rotterdam	St John's	20 DR	20	2857
112	Maersk	Rotterdam	Barranquilla	40 DR	31	1620
114	Hapag Lloyd	Antwerp	Veracruz	40 DR	2	1551
123	CMA-CGM	Rotterdam	Santos	40 NOR	2	617
135	MSC	Antwerp	Baltimore	40 DR	1674	2091
135	ACL	Antwerp	Baltimore	40 DR	1274	1740
135	Maersk	Antwerp	Baltimore	40 DR	692	1785
139	Hapag Lloyd	Antwerp	Houston	40 DR	1698	1415
139	MSC	Rotterdam	Houston	40 DR	1698	1801
139	CMA-CGM	Rotterdam	Houston	40 DR	746	2108
140	Hapag Lloyd	Rotterdam	Long Beach	40 DR	881	2792
140	ONE	Antwerp	Long Beach	40 DR	745	2599
140	MSC	Antwerp	Long Beach	40 DR	1626	2916
140	CMA-CGM	Rotterdam	Long Beach	40 DR	136	3500
141	MSC	Rotterdam	Miami	40 DR	2587	1961

141	CMA-CGM	Rotterdam	Miami	40 DR	1586	2129
143	Maersk	Rotterdam	New Orleans	40 DR	10	1316
144	MSC	Antwerp	New York	40 DR	3819	2091
144	Evergreen	Rotterdam	New York	40 DR	1964	1600
144	OOCL	Rotterdam	New York	40 DR	1309	2400
144	Maersk	Rotterdam	New York	40 DR	1855	1650
145	Maersk	Rotterdam	New York	40 NOR	314	2166
146	Hapag Lloyd	Rotterdam	Oakland	40 DR	120	2707
146	MSC	Rotterdam	Oakland	40 DR	120	2666
147	MSC	Antwerp	Honolulu	40 DR	454	5766
148	MSC	Antwerp	Savannah	40 DR	1411	1591
148	Evergreen	Rotterdam	Savannah	40 DR	706	1400
148	CMA-CGM	Rotterdam	Savannah	40 DR	706	1537
149	MSC	Rotterdam	Seattle	40 DR	633	2666
151	Hapag Lloyd	Antwerp	Montreal	40 DR	20	3864
152	Hapag Lloyd	Rotterdam	Vancouver	40 DR	6	4268
154	Hapag Lloyd	Antwerp	Montreal	40 DR	5	4137
155	Hapag Lloyd	Rotterdam	Vancouver	40 DR	100	3478
156	Hapag Lloyd	Antwerp	Montreal	40 NOR	10	4305
157	Hapag Lloyd	Rotterdam	Vancouver	40 NOR	2	4968
159	Hapag Lloyd	Rotterdam	Vancouver	40 DR	208	2838
160	Hapag Lloyd	Rotterdam	Vancouver	40 NOR	80	4258
216	Hapag Lloyd	Antwerp	Montreal	40 DR	2	2264
246	Maersk	Rotterdam	Port Victoria	20 DR	80	1041
434	CMA-CGM	Antwerp	Bar	40 DR	122	1400
499	Hapag Lloyd	Rotterdam	Caucedo	40 NOR	181	1147
575	Maersk	Rotterdam	Los Angeles	40 DR	10	2336
765	MSC	Rotterdam	Puerto Cortes	20 DR	5	1150
769	Hapag Lloyd	Rotterdam	Huangpu	20 DR	5	576
771	Hapag Lloyd	Rotterdam	Colombo	20 DR	6	791
775	CMA-CGM	Antwerp	Fremantle	40 DR	5	1771

779	MSC	Rotterdam	Acajutla	20 DR	25	1415
785	Maersk	Antwerp	Baltimore	40 NOR	66	2437
999	Hapag Lloyd	Antwerp	Montreal	20 DR	2	2250
1017	Hapag Lloyd	Antwerp	Montreal	40 DR	8	3017
1063	Yang Ming	Rotterdam	Kaohsiung	20 DR	951	375
1063	Evergreen	Rotterdam	Kaohsiung	20 DR	951	450
1064	Evergreen	Rotterdam	Taichung	20 DR	672	550
1064	Maersk	Rotterdam	Taichung	20 DR	672	425
1065	Hyundai	Rotterdam	Taoyuan	20 DR	214	700
1065	ONE	Rotterdam	Taoyuan	20 DR	101	681
1065	Evergreen	Rotterdam	Taoyuan	20 DR	219	550
1066	Evergreen	Rotterdam	Kaohsiung	40 DR	27	650
1067	Evergreen	Rotterdam	Taichung	40 DR	15	750
1068	Evergreen	Rotterdam	Taoyuan	40 DR	5	800
1081	Hapag Lloyd	Rotterdam	Vancouver	40 RF	95	3971
1082	Hapag Lloyd	Rotterdam	Vancouver	40 RF	10	4315
1196	CMA-CGM	Rotterdam	Piraeus	40 DR	1	1528
1252	Yang Ming	Rotterdam	Tokyo	20 DR	3	750
1253	Yang Ming	Rotterdam	Tokyo	40 DR	2	1075
1266	OOCL	Antwerp	Tema	20 DR	219	863
1267	Maersk	Rotterdam	Lome	20 DR	307	1253
1367	Hapag Lloyd	Antwerp	Istanbul	20 DR	113	251
1566	Evergreen	Rotterdam	Nhava Sheva	20 DR	17	700
2646	MSC	Rotterdam	Casablanca	20 DR	47	660
2649	Hapag Lloyd	Rotterdam	Castries	40 NOR	2	3553
2938	MSC	Rotterdam	Maputo	20 DR	5	1682
2943	Hapag Lloyd	Rotterdam	Shanghai	40 DR	430	535
2944	Hapag Lloyd	Rotterdam	Xiamen	40 DR	5	546
2945	Hapag Lloyd	Rotterdam	Huangpu	40 DR	5	842
2980	Maersk	Rotterdam	Auckland	40 DR	174	1818
3119	Maersk	Rotterdam	Melbourne	20 DR	51	1143

3120	CMA-CGM	Antwerp	Adelaide	20 DR	30	1129
3233	Hapag Lloyd	Antwerp	Montreal	20 DR	2	1680
4658	Evergreen	Rotterdam	Wenzhou	40 DR	5	850
4667	Hapag Lloyd	Rotterdam	Ajman	40 DR	12	1498
4667	Maersk	Rotterdam	Ajman	40 DR	109	3275
4668	Hyundai	Rotterdam	Jebel Ali	40 DR	339	810
5079	Evergreen	Rotterdam	Manila	20 DR	90	800
5230	Maersk	Antwerp	Haifa	20 DR	5	970
5234	CMA-CGM	Antwerp	Limassol	40 DR	2	1304
5540	CMA-CGM	Rotterdam	Paranagua	40 NOR	2	742
5847	Maersk	Rotterdam	Matadi	20 DR	5	8038
5851	MSC	Rotterdam	Puerto Cortes	40 DR	24	1860
5859	Hapag Lloyd	Rotterdam	Xiamen	20 DR	47	407
5908	CMA-CGM	Rotterdam	Degrad des Cannes	40 NOR	3	4593
5910	MSC	Rotterdam	Salalah	20 DR	2	1350
5911	MSC	Rotterdam	Salalah	40 DR	2	1655
6006	Hapag Lloyd	Rotterdam	Hamad	40 DR	20	1561
6008	Hapag Lloyd	Rotterdam	Sohar	40 DR	10	1438
6018	Maersk	Rotterdam	Umm al Qaiwain	20 DR	5	1271
6094	Hapag Lloyd	Rotterdam	Montreal	40 RF	3	3245
6189	CMA-CGM	Antwerp	Kingston	20 DR	2	1256
6265	Hapag Lloyd	Rotterdam	Santiago de Cuba	40 DR	83	2372
6266	Hapag Lloyd	Rotterdam	Mariel	40 DR	167	2402
6432	Hapag Lloyd	Rotterdam	Bahrain	40 DR	19	1274
6436	CMA-CGM	Antwerp	Male	20 DR	2	1985
6812	CMA-CGM	Antwerp	Pointe a Pitre	40 DR	2	2690
6813	Maersk	Rotterdam	Colon Free Zone	20 DR	62	1122
6814	MSC	Rotterdam	Colon Free Zone	40 DR	8	1650
6815	Maersk	Rotterdam	Iquique	20 DR	5	1382
6816	CMA-CGM	Rotterdam	Montevideo	40 DR	11	1038
6817	Hapag Lloyd	Rotterdam	Posorja	40 DR	24	1240

6818	Maersk	Rotterdam	Georgetown	20 DR	5	1749
6819	Maersk	Rotterdam	Georgetown	40 DR	5	2640
6820	MSC	Antwerp	Algeciras	20 DR	6	2055
6821	MSC	Antwerp	Algeciras	40 DR	2	2657
6824	Hyundai	Rotterdam	Keelung	20 DR	662	675
6824	ONE	Rotterdam	Keelung	20 DR	147	681
6824	Evergreen	Rotterdam	Keelung	20 DR	662	650
6825	Evergreen	Rotterdam	Keelung	40 DR	32	750
6829	MSC	Rotterdam	Aqaba	40 DR	16	1350
6830	Maersk	Antwerp	Ashdod	40 DR	152	1308
6831	MSC	Rotterdam	Casablanca	40 DR	5	780
6833	Hapag Lloyd	Rotterdam	Houston	40 DR	9	3138
6834	Maersk	Rotterdam	New Orleans	40 DR	5	1711
6835	Hapag Lloyd	Rotterdam	New York	40 DR	10	2971
6895	Maersk	Rotterdam	San Antonio CL	40 NOR	12	920
6898	MSC	Rotterdam	Beira	20 DR	5	1682
6969	CMA-CGM	Antwerp	Manzanillo (MX)	40 NOR	2	1215
7024	Hapag Lloyd	Rotterdam	Caucedo	20 DR	2	1078
7108	CMA-CGM	Rotterdam	Montevideo	20 DR	52	686
7123	CMA-CGM	Antwerp	Limassol	20 DR	22	987
7124	Evergreen	Rotterdam	Nhava Sheva	40 DR	5	900
7125	CMA-CGM	Antwerp	Sydney	40 DR	3	1766
7249	Maersk	Rotterdam	Nukualofa	20 DR	2	3593
7250	Maersk	Rotterdam	Lautoka	20 DR	2	1873
7286	CMA-CGM	Antwerp	Beirut	20 DR	124	849
7295	MSC	Rotterdam	Houston	20 DR	5	1650
7310	Maersk	Antwerp	Moroni	20 DR	96	2491
7318	Cosco	Antwerp	Mersin	40 DR	420	850
7464	Yang Ming	Rotterdam	Port Kelang	20 DR	5	440
7585	WEC LINES	Rotterdam	Mombasa	40 DR	8	1645
7585	Maersk	Rotterdam	Mombasa	40 DR	2	1087

7636	Evergreen	Rotterdam	Manila South Harbour	20 DR	5	800
7684	Maersk	Rotterdam	Puerto Cabello	20 DR	5	2080
7740	Hapag Lloyd	Rotterdam	Montreal	40 RF	10	3734
7741	Hapag Lloyd	Rotterdam	Montreal	40 RF	10	4602
7748	Maersk	Rotterdam	Incheon	20 DR	4	818
7749	Maersk	Rotterdam	Incheon	40 DR	4	1627
7838	Hapag Lloyd	Rotterdam	Puerto Limon	40 DR	22	2032
7846	Hapag Lloyd	Rotterdam	Papeete	20 DR	2	2416
7944	Hapag Lloyd	Rotterdam	Papeete	40 DR	2	3761
7946	CMA-CGM	Rotterdam	Guam	20 DR	31	3420
7956	CMA-CGM	Rotterdam	Little Bay	20 DR	12	2780
7996	Maersk	Rotterdam	Corinto	40 DR	2	1867
7999	Maersk	Rotterdam	Puerto Cabezas	20 DR	2	3122
8010	Hapag Lloyd	Rotterdam	Willemstad	20 DR	2	1829
8014	Maersk	Rotterdam	Brisbane	40 DR	5	1968
8015	Maersk	Rotterdam	Melbourne	40 DR	5	1918
8016	CMA-CGM	Antwerp	Adelaide	40 DR	5	1778
8048	Hapag Lloyd	Rotterdam	Shuaiba	20 DR	5	1302
8049	Hapag Lloyd	Rotterdam	Shuaiba	40 DR	5	1370
8075	CMA-CGM	Rotterdam	Riga	40 DR	20	821
8086	Maersk	Antwerp	Mutsamudu	20 DR	2	1951
8101	Hapag Lloyd	Antwerp	Montreal	40 DR	80	3017
8102	Hapag Lloyd	Antwerp	Montreal	40 DR	12	2486
8148	MSC	Rotterdam	Izmir	20 DR	1	750
8149	MSC	Rotterdam	Izmir	40 DR	55	850
8238	Hapag Lloyd	Rotterdam	Halifax	40 DR	87	1784
8254	Evergreen	Rotterdam	Sihanoukville	20 DR	2	800
8275	Evergreen	Rotterdam	Hakata	20 DR	2	900
8413	Evergreen	Rotterdam	Shimizu	20 DR	5	850
8423	Hapag Lloyd	Antwerp	Veracruz	20 DR	5	989

8446	OOCL	Antwerp	Tema	40 DR	2	1380
8484	CMA-CGM	Antwerp	Dili	20 DR	2	2875
8485	WEC LINES	Rotterdam	Arrecife	40 DR	5	2341
8487	WEC LINES	Rotterdam	Las Palmas	40 DR	92	1491
8491	Maersk	Rotterdam	Manzanillo (MX)	20 DR	2	1452
8492	Yang Ming	Rotterdam	Port Kelang	40 DR	2	800
8493	Hyundai	Rotterdam	Busan	40 DR	150	575
8493	ONE	Rotterdam	Busan	40 DR	150	604
8494	Maersk	Rotterdam	Port au Prince	40 DR	36	1991
8495	Hapag Lloyd	Rotterdam	Laem Chabang	20 DR	5	484
8496	Maersk	Rotterdam	Timaru	40 DR	61	2818
8561	CMA-CGM	Antwerp	Beirut	40 DR	2	1020
8602	Hapag Lloyd	Rotterdam	Punta Arenas	20 DR	2	2480
8614	MSC	Rotterdam	La Guaira	40 DR	5	3120
8615	Maersk	Rotterdam	Puerto Cabello	40 DR	5	3080
8676	WEC LINES	Rotterdam	Santa Cruz de Tenerife	40 DR	5	1491
8729	Maersk	Rotterdam	Umm al Qaiwain	40 DR	5	1581
8735	Hapag Lloyd	Rotterdam	Bridgetown	20 DR	1	2114
8757	CMA-CGM	Rotterdam	Miami	20 DR	5	1649
8758	CMA-CGM	Rotterdam	Paramaribo	20 DR	2	2157
8759	CMA-CGM	Antwerp	Benghazi	20 DR	2	1350
9040	Evergreen	Rotterdam	Taipei	20 DR	5	650
9133	CMA-CGM	Antwerp	Kribi	20 DR	290	1193
9193	Maersk	Rotterdam	Tughlakabad	20 DR	5	1101
9194	CMA-CGM	Antwerp	Beirut Free Zone	20 DR	2	939
9196	Hapag Lloyd	Rotterdam	Doha QA	40 DR	20	1761
9235	CMA-CGM	Rotterdam	Poti	40 DR	4	1890
9459	Hapag Lloyd	Antwerp	Montreal	40 DR	5	4136
9465	CMA-CGM	Antwerp	Tripoli LY	20 DR	2	1270
9471	Hapag Lloyd	Rotterdam	Xiamen	20 DR	5	532

6892	MSC	Rotterdam	Durban	40 DR	120	1572
6892	Maersk	Rotterdam	Durban	40 DR	180	1449
6893	MSC	Rotterdam	Durban	20 DR	15	960
6893	Maersk	Rotterdam	Durban	20 DR	15	835
40	CMA-CGM	Rotterdam	Valletta	20 DR	176	710
6828	CMA-CGM	Rotterdam	Valletta	40 DR	7	1053
5077	Hapag Lloyd	Rotterdam	Lat Krabang	20 DR	5	559
144	ONE	Rotterdam	New York	40 DR	982	1600
144	CMA-CGM	Rotterdam	New York	40 DR	982	1574
9554	Hapag Lloyd	Rotterdam	Reykjavik	20 DR	8	2665
9559	CMA-CGM	Antwerp	Douala	20 DR	2	1218
9710	CMA-CGM	Antwerp	Benghazi	40 DR	5	1950
9711	CMA-CGM	Antwerp	Tripoli LY	40 DR	5	1950
8488	MSC	Rotterdam	Maputo	40 DR	20	2700
8489	MSC	Rotterdam	Beira	40 DR	10	2700
9334	CMA-CGM	Antwerp	Douala	40 DR	3	2920
6996	Maersk	Rotterdam	Cape Town	20 DR	5	835
9790	Hapag Lloyd	Rotterdam	Asuncion	20 DR	6	1440
9866	CMA-CGM	Antwerp	Nassau	40 DR	50	4257

APPENDIX E: INPUT PARAMETERS

All of the input parameters that are used in the base case can be found from the following table. Together with input from the contracts (Appendix D), calculations are done.

TABLE 47: MODEL INPUT PARAMETERS

	CCT	BCTN
Trucking	7,1%	5,5%
Barge	92,9%	94,5%
Kosten barge 20 ft		€ 199,00
Kosten barge 40 ft		€ 228,00
	Extra	Totaal
Kosten 20ft	€ 300,00	€ 499,00
Kosten 40ft	€ 300,00	€ 528,00
	Additionele truck bewegingen	
Kosten 20ft en 40ft	€ 300,00	
Contracted trucking percentage	0%	
	Detention	Demurrage
D+D	€ 8,00	€ 10,00
	Usage	Storage
Free days	28	14
Amount of containers	57261	
	Barge	Truck
Emission 20 ft (grams CO2)	816	2688
Emission 40 ft (grams CO2)	1037	3416
	Distances (km)	
Alphen-RTM	80	
Alphen- Antwerp	120	
Den Bosch- RTM	120	
Den Bosch- Antwerp	110	
Production percentage	Zoeterwoude	Den Bosch
	67%	33%
	USD to Euro	
Exchange rate	0,89	(23-11-2021)

APPENDIX F: DESIGN ALTERNATIVE GENERATION

In this appendix, all of the possible solutions are listed. It should be noted that not all different combinations of service conditions are taken into account. Bearing in mind that the bargaining position of deep-sea carriers is getting stronger, a combination between low standard tariffs and high amount of free days for example is simply not realistic to take into account, which is why it is left outside of the scope of this research.

	A	**B**	**C**	**D**
Standard tariffs	Current	Current + $50,-		
Free days	28 & 14	21 & 14	21 & 7	
D&D tariffs	€8,- & €10,-	€15,- & €30,-	€25,- & €50,-	
Precarriage (Truck/Barge)	0% additional trucking	20% additional trucking	50% additional trucking	100% additional trucking to Antwerp
Production	Current division	ZW-Rotterdam, DB-Antwerp		

FIGURE 27: MORPHOLOGICAL CHART FOR DESIGN GENERATION

TABLE 48: LIST OF DESIGNS AND CORRESPONDING VALUES

Design	Standard Tariffs	Free days	D&D tariffs	Trucking %	Production
Des 0 (Base)	Current	28 & 14	€8,- & €10,-	0%	Regular
Des 1.A	Current + $50,-	28 & 14	€8,- & €10,-	0%	Regular
Des 1.B	Current + $50,-	28 & 14	€8,- & €10,-	20%	Regular
Des 1.C	Current + $50,-	28 & 14	€8,- & €10,-	50%	Regular
Des 2.A	Current	21 & 14	€15,- & €30,-	0%	Regular
Des 2.B	Current	21 & 14	€15,- & €30,-	20%	Regular
Des 2.C	Current	21 & 14	€15,- & €30,-	50%	Regular
Des 3.A	Current	21 & 14	€25,- & €50,-	0%	Regular
Des 3.B	Current	21 & 14	€25,- & €50,-	20%	Regular
Des 3.C	Current	21 & 14	€25,- & €50,-	50%	Regular
Des 4.A	Current	21 & 7	€15,- & €30,-	0%	Regular
Des 4.B	Current	21 & 7	€15,- & €30,-	20%	Regular
Des 4.C	Current	21 & 7	€15,- & €30,-	50%	Regular
Des 5.A	Current	21 & 7	€25,- & €50,-	0%	Regular
Des 5.B	Current	21 & 7	€25,- & €50,-	20%	Regular
Des 5.C	Current	21 & 7	€25,- & €50,-	50%	Regular
Des 5.D	Current	21 & 7	€25,- & €50,-	100% Antwerp	Regular
Des 5.E	Current	21 & 7	€25,- & €50,-	0%	Alternative

APPENDIX G: FULL RESULTS

I. HIGHER STANDARD TARIFFS FOR BENEFICIAL CONDITIONS

In this design, standard tariffs per container are increased by $50,- to retain the beneficial service conditions of 28 and 14 free days and €8,- and €10,- detention and demurrage fees. The following results are found by the model:

TABLE 49: RESULTS DESIGN 1.A

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 89.102.475	€ 94.277.348	€ 99.022.401	€ 103.990.831	€ 109.448.212
Pre carriage	€ 12.285.291	€ 12.989.469	€ 13.653.263	€ 14.334.363	€ 15.062.452
Standard tariffs	€ 76.161.813	€ 80.596.697	€ 84.640.896	€ 88.893.042	€ 93.580.893
Detention	€ 166.950	€ 176.989	€ 186.653	€ 194.734	€ 204.709
Demurrage	€ 488.422	€ 514.193	€ 541.589	€ 568.692	€ 600.158
CO2 trucks	1076,84	1138,82	1196,83	1256,51	1320,34
CO2 barge	4714,47	4985,65	5239,66	5501,01	5779,70
Average days/container	16,95	16,94	16,96	16,95	16,95

In the current volume, standard tariffs are obviously a little more compared to the current situation, since the volume has gone up. Other aspects remain equal to the current situation. To indicate the effect of more trucking movements, an additional 20% of container movements is modelled to be trucked:

TABLE 50: RESULTS DESIGN 1.B

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 89.584.730	€ 94.981.594	€ 99.669.552	€ 104.828.176	€ 109.835.672
Pre carriage	€ 13.106.978	€ 13.865.263	€ 14.579.494	€ 15.307.513	€ 16.045.140
Standard tariffs	€ 75.953.127	€ 80.558.162	€ 84.506.127	€ 88.908.871	€ 93.146.474
Detention	€ 133.518	€ 141.279	€ 149.653	€ 155.506	€ 163.025
Demurrage	€ 391.107	€ 416.889	€ 434.278	€ 456.286	€ 481.033
CO2 trucks	4393,07	4647,90	4886,75	5133,17	5377,44
CO2 barge	3701,86	3916,58	4117,85	4325,45	4531,15
Average days/container	14,36	14,37	14,37	14,36	14,36

The results show that when demurrage and detention conditions are beneficial, trucking more containers increases the total amount of costs. It cuts back on demurrage and detention costs but increases more on the pre carriage costs. Also, the amount of emissions increases and containers move through the system about 4,5 days quicker than usual. If even more containers are trucked, the following results are yielded:

TABLE 51: RESULTS DESIGN 1.C

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 91.079.449	€ 95.989.206	€ 100.984.870	€ 105.918.492	€ 111.412.233
Pre carriage	€ 14.398.106	€ 15.186.175	€ 15.981.294	€ 16.764.530	€ 17.609.430
Standard tariffs	€ 76.350.952	€ 80.454.583	€ 84.637.549	€ 88.770.076	€ 93.398.796
Detention	€ 84.664	€ 88.698	€ 92.899	€ 97.566	€ 102.206
Demurrage	€ 245.726	€ 259.751	€ 273.128	€ 286.321	€ 301.802
CO2 trucks	9394,39	9909,88	10429,84	10941,43	11490,93
CO2 barge	2197,10	2317,64	2439,24	2558,88	2687,30
Average days/container	10,47	10,47	10,47	10,47	10,47

In this design, costs increase as well as emissions and the throughput per container decreases. Detention and demurrage costs are too low for trucking to become beneficial.

II. SAME STANDARD TARIFFS WITH MEDIOCRE CONDITIONS

In these two designs, the standard tariffs will be kept equal to the current tariffs, but free days will be limited to 21 and 14 days and detention and demurrage fees will increase to €15,- and €30,- for the first design. In the second design we will look at the results for an even further increase to €25,- and €50,-.

I. MED PRICE ALTERNATIVE

For this design the amount of free days is thus decreased to 21 and 14 and the detention and demurrage fees are increased to €15,- and €30,-. The results of this design can be found in the following figure:

TABLE 52: RESULTS DESIGN 2.A

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 88.763.301	€ 93.599.559	€ 98.474.458	€ 103.364.142	€ 108.378.825
Pre carriage	€ 12.305.656	€ 12.982.101	€ 13.653.156	€ 14.342.957	€ 15.026.377
Standard tariffs	€ 74.018.706	€ 78.048.288	€ 82.107.099	€ 86.168.220	€ 90.376.966
Detention	€ 978.581	€ 1.030.946	€ 1.084.891	€ 1.143.784	€ 1.188.978
Demurrage	€ 1.460.358	€ 1.538.224	€ 1.629.312	€ 1.709.181	€ 1.786.505
CO2 trucks	1078,58	1138,08	1196,84	1257,43	1316,89
CO2 barge	4722,12	4982,41	5239,69	5504,90	5764,67
Average days/container	16,95	16,95	16,95	16,95	16,94

The results show that with this design, costs remain lower than with the design where the standard tariffs are increased. If only costs were taken into account, this design would hence be preferred to the higher standard tariffs. Demurrage and detention costs increase, but this does not weigh up to the increase in standard tariffs in the design from section G.1. Emissions and throughput stay equal. The effects when 20% of container movements are trucked can be found from the following figure:

TABLE 53: RESULTS DESIGN 2.B

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 89.100.621	€ 93.953.486	€ 98.874.358	€ 103.716.555	€ 108.984.611
Pre carriage	€ 13.143.897	€ 13.857.918	€ 14.599.222	€ 15.314.931	€ 16.074.823
Standard tariffs	€ 73.994.687	€ 78.028.348	€ 82.091.892	€ 86.123.837	€ 90.506.942
Detention	€ 781.962	€ 824.347	€ 870.411	€ 908.280	€ 957.991
Demurrage	€ 1.180.075	€ 1.242.873	€ 1.312.833	€ 1.369.507	€ 1.444.855
CO2 trucks	4406,26	4646,52	4893,29	5133,82	5388,45
CO2 barge	3712,98	3915,37	4123,35	4326,03	4540,39
Average days/container	14,36	14,36	14,37	14,35	14,37

In this design the emissions increase. Secondly the pre carriage increases and the demurrage and detention costs decrease. Total costs however slightly increase and containers go through the system faster as expected. If even more containers are trucked, the following results show:

TABLE 54: RESULTS DESIGN 2.C

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 89.718.187	€ 94.627.349	€ 99.544.435	€ 104.125.773	€ 109.673.186
Pre carriage	€ 14.402.917	€ 15.193.539	€ 15.994.584	€ 16.751.048	€ 17.601.612
Standard tariffs	€ 74.086.955	€ 78.137.145	€ 82.187.919	€ 85.955.549	€ 90.567.122
Detention	€ 487.910	€ 516.330	€ 541.468	€ 564.692	€ 597.674
Demurrage	€ 740.405	€ 780.335	€ 820.464	€ 854.485	€ 906.779
CO2 trucks	9399,42	9915,52	10439,35	10932,42	11487,95
CO2 barge	2198,26	2318,95	2441,45	2556,77	2686,60
Average days/container	10,47	10,47	10,47	10,46	10,48

In this design, the same effects as in a slight increase of trucking movements can be seen. Emissions increase even further, detention and demurrage decrease whilst pre carriage and total costs increase. Finally the throughput time per container decreases even further.

II. HIGH PRICE ALTERNATIVE

In this design the situation is looked at where free days are still 21 and 14 days, but detention and demurrage fees increase even further to €25,- and €50,-. Firstly we look at the situation where no additional containers are trucked:

TABLE 55: RESULTS DESIGN 3.A

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 90.471.695	€ 95.318.503	€ 100.479.937	€ 105.368.338	€ 110.456.549
Pre carriage	€ 12.313.991	€ 12.979.131	€ 13.678.864	€ 14.344.662	€ 15.040.635
Standard tariffs	€ 74.083.619	€ 78.037.578	€ 82.273.168	€ 86.274.540	€ 90.424.003
Detention	€ 1.631.444	€ 1.724.815	€ 1.803.385	€ 1.896.270	€ 1.996.431
Demurrage	€ 2.442.640	€ 2.576.980	€ 2.724.520	€ 2.852.865	€ 2.995.480
CO2 trucks	1079,62	1137,84	1199,18	1257,43	1318,45
CO2 barge	4726,52	4981,38	5249,86	5504,98	5771,33
Average days/container	16,95	16,96	16,95	16,95	16,96

The first thing to notice here is that the total amount of costs is higher than in the situation where standard tariffs are increased to retain beneficial service conditions. If these service agreements follow from the tenders, transport thus becomes more expensive and if a choice is available and costs are the only criterion, HNS should opt for higher standard tariffs. If costs are the number one priority this could possibly provide reasoning to ship more containers by truck. The following design shows the situation in which 20% of the containers are trucked:

TABLE 56: RESULTS DESIGN 3.B

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 90.305.122	€ 95.424.175	€ 100.338.020	€ 105.210.858	€ 110.671.931
Pre carriage	€ 13.133.672	€ 13.870.593	€ 14.595.677	€ 15.303.635	€ 16.076.251
Standard tariffs	€ 73.893.993	€ 78.107.156	€ 82.112.178	€ 86.099.047	€ 90.597.396
Detention	€ 1.302.517	€ 1.375.932	€ 1.448.902	€ 1.520.864	€ 1.589.229
Demurrage	€ 1.974.940	€ 2.070.495	€ 2.181.263	€ 2.287.312	€ 2.409.055
CO2 trucks	4402,52	4649,67	4892,94	5130,09	5388,48
CO2 barge	3709,82	3918,07	4123,05	4322,89	4540,45
Average days/container	14,37	14,37	14,37	14,37	14,36

In these results total costs increase very slightly. Emission effects increase as expected, similar to the decrease in throughput time per container. If more containers are trucked in this design, total costs are thus not decreased. If even more containers are trucked, the following results can be found:

TABLE 57: RESULTS DESIGN 3.C

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 90.496.476	€ 95.291.767	€ 100.404.701	€ 105.203.627	€ 110.696.547
Pre carriage	€ 14.402.459	€ 15.179.402	€ 15.994.786	€ 16.763.375	€ 17.609.094
Standard tariffs	€ 74.054.034	€ 77.962.687	€ 82.147.804	€ 86.055.444	€ 90.594.501
Detention	€ 814.213	€ 851.530	€ 905.282	€ 950.118	€ 989.732
Demurrage	€ 1.225.770	€ 1.298.148	€ 1.356.830	€ 1.434.690	€ 1.503.220
CO2 trucks	9398,34	9906,10	10440,09	10939,06	11492,73
CO2 barge	2198,02	2316,75	2441,62	2558,34	2687,72
Average days/container	10,46	10,46	10,47	10,47	10,47

The results indicate similar effects. Total costs slightly increase due to the increase in pre carriage costs, which does not weigh up to the decrease in detention and demurrage costs. Also emissions increase further and throughput is quicker.

III. SAME STANDARD TARIFFS WITH BAD CONDITIONS

The most extreme situation thinkable is that the free days are cut back to 21 and 7 days and that the tariffs associated with demurrage and detention increase to €15,- and €30,- , consequently €25,- and €50,-. If the demurrage and detention fees increase drastically, trucking more might decrease the total costs associated with container transport.

I. MED PRICE ALTERNATIVE

In this design the results of 21 and 7 free days and €15,- and €30,- detention and demurrage fees will be shown. The first design depicts the system with no additional trucking movements:

TABLE 58: RESULTS DESIGN 4.A

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 91.545.172	€ 96.600.381	€ 101.455.167	€ 106.554.950	€ 111.900.698
Pre carriage	€ 12.305.051	€ 12.987.783	€ 13.649.208	€ 14.337.368	€ 15.034.525
Standard tariffs	€ 74.021.239	€ 78.105.918	€ 82.010.537	€ 86.119.503	€ 90.477.554
Detention	€ 973.546	€ 1.033.192	€ 1.083.698	€ 1.140.876	€ 1.195.840
Demurrage	€ 4.245.336	€ 4.473.488	€ 4.711.724	€ 4.957.203	€ 5.192.780
CO2 trucks	1078,72	1138,31	1196,49	1256,72	1317,70
CO2 barge	4722,65	4983,60	5238,13	5501,92	5768,20
Average days/container	16,94	16,95	16,95	16,95	16,95

In this design the costs are higher than when the standard tariffs are $50,- more expensive. This is explained by the increase in detention and demurrage fees. In the next figure the situation with 20% additional trucking movements can be found:

TABLE 59: RESULTS DESIGN 4.B

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 91.410.472	€ 96.295.840	€ 101.498.997	€ 106.398.769	€ 111.756.730
Pre carriage	€ 13.150.253	€ 13.858.816	€ 14.598.054	€ 15.308.632	€ 16.061.296
Standard tariffs	€ 74.024.665	€ 77.962.540	€ 82.186.873	€ 86.148.419	€ 90.507.231
Detention	€ 781.706	€ 824.285	€ 869.393	€ 912.759	€ 956.612
Demurrage	€ 3.453.848	€ 3.650.199	€ 3.844.677	€ 4.028.959	€ 4.231.591
CO2 trucks	4408,17	4645,36	4894,52	5132,23	5382,65
CO2 barge	3714,58	3914,44	4124,35	4324,68	4535,55
Average days/container	14,36	14,37	14,37	14,37	14,37

The results show that a slight decrease in costs can be noticed, meaning that when more containers are trucked the total costs are decreased. The reduction in detention and demurrage outweighs the increase in pre carriage tariffs. If even more movements are trucked the following results show:

TABLE 60: RESULTS DESIGN 4.C

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 91.039.240	€ 95.965.815	€ 100.967.054	€ 105.990.917	€ 111.583.530
Pre carriage	€ 14.389.700	€ 15.182.857	€ 15.971.896	€ 16.749.867	€ 17.615.702
Standard tariffs	€ 73.923.136	€ 77.914.583	€ 81.985.920	€ 86.085.195	€ 90.633.836
Detention	€ 489.401	€ 513.441	€ 540.842	€ 567.619	€ 593.979
Demurrage	€ 2.237.003	€ 2.354.935	€ 2.468.397	€ 2.588.236	€ 2.740.013
CO2 trucks	9390,92	9905,87	10421,99	10931,02	11493,88
CO2 barge	2196,28	2316,71	2437,40	2556,46	2688,01
Average days/container	10,47	10,47	10,46	10,47	10,47

Here, we find that the total costs decrease even further, whilst the emissions increase further. Similar to previous designs, the amount of days per container also decreases.

II. HIGH PRICE ALTERNATIVE

The following results follow from the designs and the scenarios where detention and demurrage fees are increased even further to €25,- and €50,-:

TABLE 61: RESULTS DESIGN 5.A

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 94.797.860	€ 100.108.396	€ 105.054.124	€ 110.787.668	€ 116.495.394
Pre carriage	€ 12.291.932	€ 12.971.652	€ 13.631.795	€ 14.353.475	€ 15.060.246
Standard tariffs	€ 73.829.877	€ 77.944.808	€ 81.768.373	€ 86.258.348	€ 90.753.073
Detention	€ 1.621.329	€ 1.719.426	€ 1.809.874	€ 1.900.806	€ 2.001.480
Demurrage	€ 7.054.722	€ 7.472.510	€ 7.844.082	€ 8.275.040	€ 8.680.595
CO2 trucks	1077,22	1136,99	1194,54	1258,43	1320,27
CO2 barge	4716,25	4977,71	5229,79	5509,21	5779,32
Average days/container	16,94	16,95	16,96	16,96	16,96

The first thing to notice is that retaining the current standard tariffs for these service conditions heavily increases the total costs. Detention and demurrage costs increase significantly with these tariffs leading to high prices. To test whether trucking has an effect on this, the situation is modelled in which 20% of all container movements are trucked:

TABLE 62: RESULTS DESIGN 5.B

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 94.301.735	€ 99.225.341	€ 104.539.428	€ 109.473.566	€ 115.345.136
Pre carriage	€ 13.148.261	€ 13.849.416	€ 14.596.669	€ 15.290.897	€ 16.078.619
Standard tariffs	€ 74.077.859	€ 77.926.041	€ 82.104.724	€ 85.970.083	€ 90.620.251
Detention	€ 1.301.978	€ 1.375.663	€ 1.449.158	€ 1.519.235	€ 1.596.339
Demurrage	€ 5.773.637	€ 6.074.222	€ 6.388.877	€ 6.693.350	€ 7.049.927
CO2 trucks	4409,00	4642,30	4894,06	5125,33	5389,57
CO2 barge	3715,24	3911,86	4123,96	4318,90	4541,36
Average days/container	14,36	14,37	14,36	14,36	14,37

The results show that in this design, the cost are decrease when more containers are shipped per truck. Next to that the emission scores for truck and in total increase as expected. If even more containers are trucked (50%), the following results show:

TABLE 63: RESULTS DESIGN 5.C

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 92.887.627	€ 97.801.286	€ 102.909.026	€ 108.351.776	€ 113.429.851
Pre carriage	€ 14.394.711	€ 15.168.309	€ 15.969.812	€ 16.788.691	€ 17.577.028
Standard tariffs	€ 73.966.288	€ 77.865.063	€ 81.924.311	€ 86.260.248	€ 90.324.357
Detention	€ 810.729	€ 857.536	€ 900.676	€ 953.461	€ 990.516
Demurrage	€ 3.715.898	€ 3.910.378	€ 4.114.227	€ 4.349.377	€ 4.537.950
CO2 trucks	9392,31	9898,12	10419,10	10957,21	11467,55
CO2 barge	2196,61	2314,89	2436,74	2562,57	2681,85
Average days/container	10,47	10,47	10,47	10,47	10,48

The results show that costs drop down even further with increasing emissions. If more volume is trucked instead of transported by barge, the costs will thus drop down with these service conditions.

The following design explores a different possibility to trucking percentages. Within this design, only containers that are shipped through Antwerp are transported by truck instead of by barge. Containers that are shipped through Rotterdam are still transported by barge:

TABLE 64: RESULTS DESIGN 5.D

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 91.682.636	€ 96.113.518	€ 100.912.151	€ 105.633.284	€ 110.531.187
Pre carriage	€ 13.825.753	€ 14.272.935	€ 14.714.391	€ 15.169.734	€ 15.637.552
Standard tariffs	€ 74.175.830	€ 77.963.095	€ 82.119.568	€ 86.172.785	€ 90.392.544
Detention	€ 794.693	€ 838.744	€ 885.646	€ 929.724	€ 977.960
Demurrage	€ 2.886.360	€ 3.038.743	€ 3.192.547	€ 3.361.040	€ 3.523.132
CO2 trucks	7291,23	7662,56	8068,69	8475,28	8869,04
CO2 barge	2894,60	3051,74	3206,97	3366,82	3530,76
Average days/container	12,25	12,27	12,27	12,26	12,27

The results show a large decrease in costs. Next to that, emissions are larger than in design 5.B, but smaller than in design 5.C. In terms of throughput the results indicate a faster throughput than in design 5.B, but slower than in design 5.C.

The final design explores an alteration in the production division based on the geographic location of the terminals. It is assumed that all containers that are shipped through Rotterdam are produced in Zoeterwoude and all containers that are shipped through Antwerp are produced in Den Bosch. This yielded the following results:

TABLE 65: RESULTS DESIGN 5.E

Criterium	-10%	-5%	Current	+5%	+10%
Total costs	€ 95.218.554	€ 100.396.061	€ 105.756.951	€ 110.772.339	€ 116.428.903
Pre carriage	€ 12.310.705	€ 12.989.698	€ 13.671.005	€ 14.327.247	€ 15.049.641
Standard tariffs	€ 74.052.573	€ 78.038.579	€ 82.152.121	€ 86.092.545	€ 90.514.466
Detention	€ 1.633.794	€ 1.730.298	€ 1.833.213	€ 1.908.298	€ 2.006.904
Demurrage	€ 7.221.482	€ 7.637.485	€ 8.100.612	€ 8.444.250	€ 8.857.892
CO2 trucks	951,66	1007,49	1066,35	1116,32	1174,53
CO2 barge	4193,83	4437,55	4701,20	4924,82	5179,92
Average days/container	17,06	17,06	17,06	17,06	17,07

Results show increasing costs, especially in terms of detention and demurrage. Next to that, slight improvements in terms of emissions and deteriorations in terms of throughput are found compared to design 5.A.

APPENDIX H: SENSITIVITY ANALYSIS MULTI CRITERIA ANALYSIS

Underneath a sensitivity analysis is performed in order to validate the multi criteria analysis. To do so, equal weights for each of the criteria are assumed.

Normalized and weighted:

Criterium	**Des 0**	**Des 1.A**	**Des 1.B**	**Des 1.C**	**Des 2.A**	**Des 2.B**	**Des 2.C**	**Des 3.A**	**Des 3.B**
Pre carriage	0,15	0,15	0,09	0,00	0,15	0,09	0,00	0,15	0,09
Standard tariffs	0,09	0,00	0,00	0,00	0,09	0,09	0,08	0,08	0,09
Additonal costs	0,42	0,42	0,43	0,44	0,33	0,35	0,39	0,25	0,29
Emissions	0,11	0,11	0,07	0,00	0,11	0,07	0,00	0,11	0,07
Throughput	0,00	0,00	0,07	0,18	0,00	0,07	0,18	0,00	0,07
Final score	**0,77**	**0,69**	**0,66**	**0,62**	**0,68**	**0,67**	**0,66**	**0,59**	**0,61**
Ranking	1	2	5	7	3	4	6	11	9

Criterium	**Des 3.C**	**Des 4.A**	**Des 4.B**	**Des 4.C**	**Des 5.A**	**Des 5.B**	**Des 5.C**	**Des 5.D**	**Des 5.E**
Pre carriage	0,00	0,15	0,09	0,00	0,15	0,09	0,00	0,08	0,15
Standard tariffs	0,09	0,09	0,08	0,09	0,10	0,09	0,09	0,09	0,09
Additonal costs	0,35	0,19	0,24	0,32	0,01	0,10	0,22	0,27	0,00
Emissions	0,00	0,11	0,07	0,00	0,11	0,07	0,00	0,03	0,13
Throughput	0,18	0,00	0,07	0,18	0,00	0,07	0,18	0,13	0,00
Final score	**0,62**	**0,55**	**0,55**	**0,59**	**0,38**	**0,42**	**0,50**	**0,60**	**0,36**
Ranking	8	14	13	12	17	16	15	10	18

Assumption of equal weights:

Criterium	**Des 0**	**Des 1.A**	**Des 1.B**	**Des 1.C**	**Des 2.A**	**Des 2.B**	**Des 2.C**	**Des 3.A**	**Des 3.B**
Pre carriage	0,20	0,20	0,12	0,00	0,20	0,12	0,00	0,20	0,12
Standard tariffs	0,17	0,00	0,01	0,00	0,18	0,18	0,17	0,16	0,18
Additonal costs	0,19	0,19	0,20	0,20	0,15	0,16	0,18	0,11	0,13
Emissions	0,18	0,18	0,11	0,00	0,18	0,11	0,00	0,18	0,11
Throughput	0,00	0,00	0,08	0,20	0,00	0,08	0,20	0,00	0,08
Final score	**0,75**	**0,58**	**0,52**	**0,40**	**0,71**	**0,65**	**0,55**	**0,66**	**0,62**
Ranking	1	10	16	18	2	5	12	3	6

Criterium	**Des 3.C**	**Des 4.A**	**Des 4.B**	**Des 4.C**	**Des 5.A**	**Des 5.B**	**Des 5.C**	**Des 5.D**	**Des 5.E**
Pre carriage	0,00	0,20	0,12	0,00	0,20	0,12	0,00	0,11	0,20
Standard tariffs	0,17	0,18	0,17	0,18	0,20	0,18	0,19	0,18	0,17
Additonal costs	0,16	0,09	0,11	0,14	0,01	0,04	0,10	0,12	0,00
Emissions	0,00	0,18	0,11	0,00	0,18	0,11	0,00	0,05	0,20
Throughput	0,20	0,00	0,08	0,20	0,00	0,08	0,20	0,15	0,00
Final score	**0,53**	**0,65**	**0,59**	**0,53**	**0,59**	**0,53**	**0,49**	**0,60**	**0,57**
Ranking	13	4	9	14	8	15	17	7	11

The best scoring designs are still the base case and design 2.A. However, design 1.A,B &C become significantly less interesting. This is explicable since additional costs are relatively low in these designs. As this criterion becomes less important due to equal weights, their relative score becomes lower. A second trend aspect is that per scenario, as more containers are trucked, the ranking drops. This is also attributed to the fact that additional costs become less important, whereas emissions became more important.

APPENDIX I: SCIENTIFIC PAPER

Export costs and service conditions in times of a global container shortage

A case study at Heineken Netherlands Supply

M.J. Nanninga[1], dr. J. M. Vleugel[1], dr. W.W.A. Beelaerts van Blokland[2], MSc P. Stevens[3], Prof. R.R. Negenborn[2]

Abstract

Covid-19, the Suez canal blockade and a decreasing amount of larger shipping companies have changed the container shipping industry. A power shift from the exporter towards the shipping companies is occurring, paired with capacity constraints and surging container transportation prices indicating a global container shortage. Exporters of large volume mainly experience this with contract negotiations and are left with a choice for higher prices or less flexibility in contractual service conditions whilst striving to become more sustainable. This study answers the following research question: 'How should large exporters like HNS weigh off transportation costs, flexibility in service conditions and environmental effects for contractual agreements in times of a global container shortage?'. This study poses several designs through the DMADE methodology to anticipate the aforementioned changes. It does so by modelling several designs based on contract variables, a modal shift and a production division based on geographical locations of breweries for Heineken Netherlands Supply. The study found that higher standard tariffs for container transportation should be preferred above less flexibility. Next to that a modal shift towards road transport is advised if the service conditions in contractual agreements become less flexible.

1. INTRODUCTION

The container shipping sector has experienced big changes for the last couple of years. The COVID-19 pandemic and the Suez channel blockade massively impacted world trade. Lockdowns all over the world at different times and harbors being closed led to very uneven trade patterns, almost shutting down world trade at times and leading to heavy congestion in a lot of chains in the supply chain. A global container shortage resulted. Secondly the past years, large container shipping companies have started working together in large alliances, such as Maersk and MSC in "2M", owning close to 35% of the market. In 2020, the ten largest shipping companies owned over 80% of the industry, leaving the opportunity for them to make pricing arrangement. All of these effects have led to a scarcity in container and vessel capacity, paired with skyrocketing exporting prices. In the most extreme cases, the spot market prices for container transport increased by over 1000%. The market, which used to be characterized by overcapacity and very low prices and profit margins changed completely due to these aforementioned effects. Exporters of large volumes used to benefit of the overcapacity and had shipping companies fighting for them. Nowadays a power shift has occurred and exporters have to compete with each other to have their product shipped. In contract negotiations exporters are left with higher prices or less flexibility, leaving the urge to examine the effects of the container shortage.

LITERATURE REVIEW

The changes that are occurring in the current container shipping market are essential for the relevance of this paper. Uneven trade recovery leading to an increase in the skewness of import and export movements is proven (Robinson 2007|WTO 2021). The aftermath of the COVID-19 pandemic and the Suez canal blockade including congested ports, a reduced number of operational vessels and an unpredictable flow of goods further strengthen the increase in skewness (Paris, 2020|Xie, 2021|Kuehne nagel, 2021). Because of this, a scarcity of empty containers at the necessary places was created, leading to skyrocketing container transportation prices (Heigermoser & Glauben, 2021). This in its turn led to record profits for container shipping companies. They reached a combined EBIT

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[1] Faculty of Civil Engineering and Geosciences, Delft University of Technology.

[2] Faculty of Mechanical, Maritime and Materials Engineering, Delft University of Technology.

[3] Customer Service Export & Customs, Heineken Netherlands Supply, The HEINEKEN company.

(Earnings Before Interest & Taxes) of 150 billion US dollars, which is more than the last 20 years combined. This has influenced the bargaining power of shipping companies towards large exporters leaving them with less beneficial contracts (Jumelet, 2021) or in extreme cases even refusing transport (Verheggen, 2021).

Relative high increases relating to costs can be found in additional costs for exporters such as detention and demurrage costs. These costs have been researched focusing on inbound container hinterland transportation (Fazi and Roodbergen, 2018) or as a strategy for ocean carriers decisions relating free detention time (Yu et al, 2018). It has not been studied from the perspective of the exporter as much. Additionally, it is widely known that information sharing throughout global supply chains enables tighter coordination, yielding a better performance (Lee and whang 2000). The realization of such information mechanisms however, proved difficult in a supply chain where each entity makes choices to improve on their individual profits instead of system-wide profits (Lee and whang, 2000|Shore, 2001|Sadraoui and Mchirgui, 2014). The loss of global profits is further enhanced by the shipping environment, which is very unstable due to a lack of knowledge about the timing of activities of a great amount of actors within a port system, requiring a need for information sharing when striving for an efficient supply chain (Olesen et al, 2014). Information sharing mechanisms between deep-sea carriers and barge operators are studies in literature proving the high impact of uncertainty relating to costs (Gumuskaya et al, 2020) and suggesting a real-time co planning method to let truck operators indicate their preferred departure time without giving out any sensitive information, offering a strategy where co-planning and information protection can lead to a good alternative for current systems in place (Larsen et al, 2021). Once again, the exporter is often left out of these information sharing mechanisms. The containers used to enter a ‘grey area’ once handed to the barge operator, leaving them dependent on the information they received from barge operators and deep-sea carriers. Recently however, third party logistics platforms such as ‘Tradelens’ provide data on all container related activities performed by exporters, barge operators, ports, deep-sea carriers and customers.

This paper scientifically contributes by studying the possibilities of this newly available information sharing mechanism to analyze the changing market characteristics and corresponding detention and demurrage costs from the exporters’ perspective.

RESEARCH QUESTION

Literature shows that the market characteristics are changing. Current research has not yet anticipated this change. Larger exporters need to react to this by examining their operations. This paper will focus on a case study at Heineken Netherlands Supply, the supply chain division of one of the largest beer brewery’s in the world. The goal of this paper revolves around the following research question: *‘How should HNS weigh off transportation costs, flexibility in service conditions and environmental effects for contractual agreements in times of a global container shortage?’.*

METHODOLOGY

This study follows an adaptation to the lean six sigma DMADV methodology: the DMADE methodology. The methodology contains five different research stages: Define, measure, analyze, design and evaluate. It swaps the verify phase out for an evaluation phase. It revolves around analyzing the current state, KPI’s and bottlenecks and consequently how these bottlenecks are expected to change in the (near) future. After clearly identifying the main bottlenecks, the study will pose several design alternatives. These designs will consequently be modelled through a discrete event calculation model indicating the effects of the proposed designs on the identified KPI’s. The results will be evaluated by means of a multi-criteria analysis, weighing criteria according to the decision makers’ assigned importance.

STRUCTURE

The remainder of this paper is as follows. Firstly, the case study will be described, including the current operations at Heineken Netherlands Supply and corresponding bottlenecks and KPI’s as well as expected (near)-future changes. After that, the paper will elaborate on design requirements and the following designs. It will present the calculation model and relevant results. Finally, concluding remarks relating to the research question will be made as well as some limitations and recommendations for future research.

2. CASE STUDY

This study is performed at the department of Customer Service Export & Customs of Heineken Netherlands Supply. This department is responsible for all B2B customer related activities and export-related container transportation. They currently operate under contracts with the deep-sea carrier. These contracts are tendered yearly for all of the shipping routes that HNS sails. Within these contracts, standard tariffs and additional service conditions are agreed upon such as the amount of free days and detention and demurrage fees. The actual transport consists of multiple phases: the pre carriage, terminal handling, the main haul and terminal handling at the receiving end. This study will focus mainly on the pre carriage. The pre carriage of export activities for HNS considers four shipping legs and currently fully considers barge ship movements. Only if containers have to be transported with urgency they are sometimes transported by truck. This applies to the following shipping legs:

- Alphen- Rotterdam
- Alphen- Antwerp
- Den Bosch- Rotterdam
- Den Bosch- Antwerp

Containers are taken out from a dedicated inland container terminal in Alphen or Den Bosch, are filled at the breweries in Zoeterwoude or Den Bosch and then transported by barge to the deep-sea terminals of Rotterdam or Antwerp. The transportation is composed of several costs. Firstly HNS pays a standard tariff to the deep-sea carrier, depending on the destination. Secondly, the pre carriage transport has to be paid for. Both of these costs are charged to the B2B-customer. Thirdly, HNS pays additional detention and demurrage charges to the deep-sea carrier, based on delays in the pre carriage phase. The latter cannot be charged to the customer, as they are charged months or even years after the actual event. In 2021, HNS had 28 free days for equipment usage and 14 days for equipment storage at the deep-sea terminals. Free days considers the maximum amount of days an exporter receives from the deep-sea carrier to deliver a container to the deep-sea vessel and the amount of days an exporter can store the container at the deep-sea terminal. Each excess leads to extra costs of €8,- for detention and €10,- for demurrage. In the past years HNS experienced significant increases in these additional costs:

TABLE 1: DETENTION AND DEMURRAGE COSTS PER YEAR

Year	D&D costs
2017	€ 33.515,88
2018	€ 58.527,07
2019	€ 225.024,17
2020	€ 293.577,07

The increase in additional costs is explained by increasing congestion in the supply chain following from the pandemic and Suez blockade. The increase cannot be explained by an increase in transported volume as this has stayed relatively constant over the past years (~60.000 deep-sea containers).

To determine the amount of days it takes HNS on average to deliver containers to the terminal and the average amount of days containers are stored on the terminal, data from 'Tradelens' was analyzed. In doing so, the following amount of days were found for each of the pre carriage shipping legs:

TABLE 2: AVERAGE DAYS PER CONTAINER PER SHIPPING LEGS

Shipping leg	Equipment usage	Equipment storage
Alphen-Rotterdam	16,3	7,3
Den Bosch- Rotterdam	17,1	6,8
Alphen- Antwerp	18,3	10,9
Den Bosch- Antwerp	18,7	11,0

The results show that on average, HNS does stay within the boundaries of their permitted free days. Next to that, shipping legs towards Antwerp take slightly longer, both in usage and storage compared to shipping legs towards Rotterdam.

KEY PERFORMANCE INDICATORS

Performance relating to export is currently measured in two main KPI's. One is focused on customer satisfaction whereas the other is purely related to costs. The first metric is called the Case Fill Rate (CFR). It considers the percentages of product availability and whether HNS delivers on time and in full. All of these percentages multiplied with each other provide the CFR percentage. The second metric as stated concerns transport volume and its related transportation costs. This paper focuses on the transportation costs, whilst adding two other metrics. First, it includes CO2 emissions as a KPI to indicate the sustainability of operations. This is done because Heineken has expressed its wish to become more sustainable, but HNS does not measure its performance in terms of sustainability yet on this subject. Next to that, it also specifies the throughput time of containers within the pre carriage. The throughput metric is added to indicate more flexibility. It could also contribute to a better customer satisfaction or CFR. This is included as they can focus more on the pre carriage, whereas the existing CFR metric is less specific and considers all transport related phases.

FUTURE DEVELOPMENTS

The aftermath of COVID-19 and the Suez blockade is not expected to be solved quickly. Empty container scarcity and more specifically vessel shipping capacity will remain in the next two to three years, paired with high transport prices. For large exporters like HNS this is affecting contract negotiations as well as the shipping of additional container volume. In previous years, HNS could transport additional (not concluded upon in contracts) volume against the same beneficial conditions as what was agreed upon within the contracts. In the current and future market, this volume will have to be bought for high- and increasing- prices on the spot market. Within contract negotiations, deep-sea carriers demand higher standard tariffs for container shipping, or less flexible service conditions for the exporter in terms of free days and detention and demurrage fees. These effects are expected to become worse and worse in the coming years from the exporters perspective. Trade volume, both in container transport and the beer sector is expected to remain relatively constant. This paper will hence also take small deviations in transport volume into account (±5/10%), but will not consider large volume deviations as these higher deviations are not likely to occur.

DESIGN CONSTRAINTS & REQUIREMENTS

The main future bottlenecks thus relate to the increasing bargaining power of deep-sea carriers within contract negotiations. The designs relate to strategic decisions for HNS within contract negotiations, a modal split and an alteration of production quantities between breweries. There are three constraints to which the designs have to comply:

1. *Deliver containers at the deep-sea terminal at all times.*
2. *Be able to cope with different container sizes*
3. *Be compatible with the way of working from Heineken Global Procurement (HGP).*

Next to that, the requirements for the designs are split up in functional and non-functional requirements. The functional requirements are as follows:

1. *Reduce total transportation costs as much as possible.*
2. *Be as flexible as possible.*
3. *Deliver containers to the deep-sea terminal as quickly as possible.*
4. *Track and trace containers at all times.*

The non-functional requirements are:

1. *Be as cost efficient as possible.*
2. *Have back up options in case of system failures*
3. *Transport containers of different measurements and volume.*
4. *Be as sustainable as possible*

3. MODEL FORMULATION

The schematic conceptualization of the model can be found in the following overview:

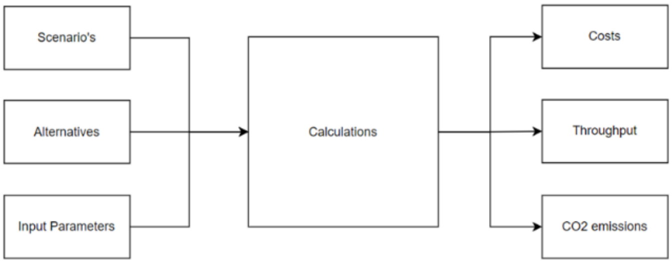


FIGURE 1: SCHEMATIC MODEL CONCEPTUALIZATION

Input is provided by scenario's based on demand, design alternatives and input parameters. The design alternatives are a set of 18 designs varying in standard tariffs, free days, detention and demurrage fees, percentages transported by truck and the production division as follows:

TABLE 3: DESIGN ALTERNATIVES

Design	Standard Tariffs	Free days	D&D tariffs	Trucking %	Production
Des 0 (Base)	Current	28 & 14	€8,- & €10,-	0%	Regular
Des 1.A	Current + $50,-	28 & 14	€8,- & €10,-	0%	Regular
Des 1.B	Current + $50,-	28 & 14	€8,- & €10,-	20%	Regular
Des 1.C	Current + $50,-	28 & 14	€8,- & €10,-	50%	Regular
Des 2.A	Current	21 & 14	€15,- & €30,-	0%	Regular
Des 2.B	Current	21 & 14	€15,- & €30,-	20%	Regular
Des 2.C	Current	21 & 14	€15,- & €30,-	50%	Regular
Des 3.A	Current	21 & 14	€25,- & €50,-	0%	Regular
Des 3.B	Current	21 & 14	€25,- & €50,-	20%	Regular
Des 3.C	Current	21 & 14	€25,- & €50,-	50%	Regular
Des 4.A	Current	21 & 7	€15,- & €30,-	0%	Regular
Des 4.B	Current	21 & 7	€15,- & €30,-	20%	Regular
Des 4.C	Current	21 & 7	€15,- & €30,-	50%	Regular
Des 5.A	Current	21 & 7	€25,- & €50,-	0%	Regular
Des 5.B	Current	21 & 7	€25,- & €50,-	20%	Regular
Des 5.C	Current	21 & 7	€25,- & €50,-	50%	Regular
Des 5.D	Current	21 & 7	€25,- & €50,-	100% Antwerp	Regular
Des 5.E	Current	21 & 7	€25,- & €50,-	0%	Alternative

The output will be measured in several KPI's of which the most important calculations will be elaborated on.

COSTS

Costs are calculated on several aspects, namely standard tariffs, pre carriage costs and additional detention and demurrage as explained in equation 1.

$$\mathrm{C_{tot}} = \mathrm{C_{ST}} + \mathrm{C_{PC}} + \mathrm{C_{ADD}} \ (1)$$

Standard costs are calculated by summing the regular standard costs (C_{STr}) and additional standard costs (C_{STa}) as in equations 2 to 2.3.

$$\mathrm{C_{ST}} = C_{STr} + C_{STa} \ (2)$$

Now we let x_{ij} denote the total flow of containers between origin i and destination j and w_{ij} the flow of containers above the 'bought' in amount of containers through contracts. N relates to the set of terminals, whereas J considers the set of destination ports:

$$C_{STr} = \sum_{i \in N} C_{STr_{ij}} * (x_{ij} - w_{ij}) \ \forall \ j \ in \ J \ (2.1)$$

$$C_{STa} = \sum_{i \in N} C_{STa_{ij}} * w_{ij} \ \forall \ j \ in \ J \ (2.2)$$

$$C_{STr_{ij}} * 1{,}2 \leq C_{STa_{ij}} \leq C_{STr_{ij}} * 2{,}5 \ \forall \ i \ in \ N, j \ in \ J \ (2.3)$$

Next to standard costs, pre carriage costs ($\mathrm{C_{PC}}$) are calculated by taking the sum of both barge and trucking costs. These are calculated by multiplying the amount of containers that are transported per mode with the associated pre carriage costs per container for that mode as in equation 3 where we let $C_{PC_{ij}^k}$ denote the costs related to pre carriage for a container that is transported between origin i and destination j per mode k. x_{ij}^k denotes the flow from origin i to destination j per mode k. K denotes the set of modes k.

$$\mathrm{C_{PC}} = \sum_{i \in N} C_{PC_{ij}^k} * x_{ij}^k \ \forall \ j \in N, \forall \ k \in K \ \ (3)$$

Lastly, additional costs ($\mathrm{C_{ADD}}$) are calculated by summing detention (C_{det}) and demurrage costs (C_{dem}) as in equation 4.

$$\mathrm{C_{ADD}} = C_{det} + C_{dem} \ (4)$$

For detention costs (equation 4.1 & 4.2) we define T_{ij} as the amount of days a container is in the system and T_{ijx} as the time in days a container is in the system longer than permitted by the amount of free days for detention (F_{det}). We also define p_{det} as the price for detention.

$$C_{det} = \sum_{i \in N} x_{ij} * T_{ijx} * p_{det} \ \forall \ j \ in \ N \ (4.1)$$

Where T_{ijx} takes a value according to equation 4.2.

$$T_{ijx} = \begin{cases} 0, & if \ T_{ij} \leq F_{det} \\ T_{ij} - F_{det}, & if \ T_{ij} > F_{det} \end{cases} \ \forall \ i \ in \ N, j \ in \ N (4.2)$$

Similarly, demurrage costs are calculated by equations 4.3 and 4.4 where S_{ij} denotes the time in days a container is stored at the terminals and S_{ijx} as the time in days a container is in the system longer than permitted by the amount of free days for detention (F_{dem}). We also define p_{dem} as the price for demurrage.

$$C_{dem} = \sum_{i \in N} x_{ij} * S_{ijx} * p_{dem} \ \forall \ j \ in \ N \ (4.3)$$

Where S_{ijx} takes a value according to equation 4.4.

$$S_{ijx} = \begin{cases} 0, & if \ S_{ij} \leq F_{dem} \\ S_{ij} - F_{dem}, & if \ S_{ij} > F_{dem} \end{cases} \ \forall \ i \ in \ N, j \ in \ N (4.4)$$

CO2 EMISSIONS

For CO2 emissions we define EM as emissions. Emissions are calculated by equation 5 and 5.1. Here we define EM_{ij}^{kl} as the emissions for mode k from origin i to destination j and container type l. We let L denote the set of container types. Also d_{ij}^k is defined as the distance between origin I and destination j for mode k. Lastly $EMtk^{kl}$ is defined as the emissions per ton kilometer for mode k and container type l. All of these definitions lead to equations 5 and 5.1.

$$EM = \sum_{i \in N} x_{ij}^{k} \ast EM_{ij}^{kl} \;\forall\, j \in N, \forall\, k \in K, l \in L \;(5)$$

$$EM_{ij}^{kl} = \sum_{i \in N} d_{ij}^{k} \ast EMtk^{kl} \;\forall\, j \in N, \forall\, k \in K, l \in L \;(5.1)$$

THROUGHPUT

Lastly, the throughput of containers is calculated in equation 6. T denotes the average throughput time per container. Other variables have already been defined for other equations.

$$T = \frac{\sum_{i \in N} T_{ij} \ast x_{ij}}{\sum_{i \in N} x_{ij}} \;\forall\, j \in N \;(6)$$

The model is validated by comparing the base run for 2021 with the actual spending of HNS in 2021 and proved to be valid for most criteria, except for detention and demurrage fees, as the model finds a higher value than the actual spend.

4. RESULTS

To indicate the most significant differences between different variables, the results of design 0, 5.A and 5.D will be given. The base case (Design 0) found the following results:

TABLE 3: RESULTS DESING 0

Criterion	Global weight
Pre carriage costs	€ 13.666.642
Standard tariffs	€ 82.142.689
Additional costs	€ 730.497
Sustainability (emissions)	6442,23
Throughput	16,94

In comparison, design 5.A- where only contractual variables are altered- gives the following results:

TABLE 4: RESULTS DESIGN 5.A

Criterion	Global weight
Pre carriage costs	€ 13.631.795
Standard tariffs	€ 81.768.373
Additional costs	€ 9.653.956
Sustainability (emissions)	6424,33
Throughput	16,96

One significant difference stands out: additional costs. If service conditions become as bad as in design 5.A, an increase in additional costs can be seen. As stated, a modal shift can be proposed to impact the predefined criteria. One example of this modal shift from barge towards truck can be found in design 5.D, where all containers towards Antwerp are trucked. This yields the following results:

TABLE 5: RESULTS DESIGN 5.D

Criterion	Global weight
Pre carriage costs	€ 14.714.391
Standard tariffs	€ 82.119.568
Additional costs	€ 4.078.193
Sustainability (emissions)	11275,66
Throughput	12,27

Although an increase in pre carriage costs is experienced, the total costs drop since the additional costs drop significantly. Since more containers are trucked, more emissions are noticed as well as a shorter throughput time.

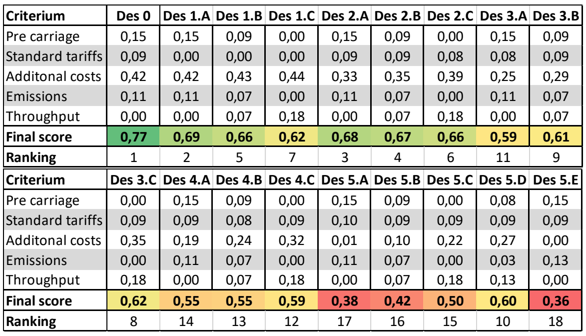
All of the results are measured by performing a multi criteria analysis. This makes it possible to score criteria according to the decision makers' preferences. The weights for each of the criteria are determined by scoring them on a 9 point scale and normalizing the global weights. This yielded the following criteria weights:

TABLE 4: CRITERIA WEIGHTS

Criterion	Global weight
Pre carriage costs	0,15
Standard tariffs	0,10
Additional costs	0,44
Sustainability (emissions)	0,13
Throughput	0,18

Multiplying these weights with the normalized outcomes of the modeled designs and summing the scores per criterion gives the performance of each of the designs. The following scores between 0 and 1 were found, where 1 would mean that a design scores the best possible for all of the criteria:

TABLE 4: MCA RESULTS



Criterium	Des 0	Des 1.A	Des 1.B	Des 1.C	Des 2.A	Des 2.B	Des 2.C	Des 3.A	Des 3.B
Pre carriage	0,15	0,15	0,09	0,00	0,15	0,09	0,00	0,15	0,09
Standard tariffs	0,09	0,00	0,00	0,00	0,09	0,09	0,08	0,08	0,09
Additonal costs	0,42	0,42	0,43	0,44	0,33	0,35	0,39	0,25	0,29
Emissions	0,11	0,11	0,07	0,00	0,11	0,07	0,00	0,11	0,07
Throughput	0,00	0,00	0,07	0,18	0,00	0,07	0,18	0,00	0,07
Final score	**0,77**	**0,69**	**0,66**	**0,62**	**0,68**	**0,67**	**0,66**	**0,59**	**0,61**
Ranking	1	2	5	7	3	4	6	11	9

Criterium	Des 3.C	Des 4.A	Des 4.B	Des 4.C	Des 5.A	Des 5.B	Des 5.C	Des 5.D	Des 5.E
Pre carriage	0,00	0,15	0,09	0,00	0,15	0,09	0,00	0,08	0,15
Standard tariffs	0,09	0,09	0,08	0,09	0,10	0,09	0,09	0,09	0,09
Additonal costs	0,35	0,19	0,24	0,32	0,01	0,10	0,22	0,27	0,00
Emissions	0,00	0,11	0,07	0,00	0,11	0,07	0,00	0,03	0,13
Throughput	0,18	0,00	0,07	0,18	0,00	0,07	0,18	0,13	0,00
Final score	**0,62**	**0,55**	**0,55**	**0,59**	**0,38**	**0,42**	**0,50**	**0,60**	**0,36**
Ranking	8	14	13	12	17	16	15	10	18

With these results, a ranking of 1 indicates the best performing design, whereas a ranking of 18 indicates the worst performing design.

The most important findings are as follows:

- The base case performs the best
- Higher standard tariffs are preferred over bad service conditions.
- As service conditions become worse, trucking larger volumes of containers starts to improve the performance.
- Especially if all containers to Antwerp are trucked an increase in performance shows (5.D).
- Altering the production division does not improve the performance.

5. CONCLUSIONS

This paper aimed to answer the following research question: *'How should HNS weigh off transportation costs, flexibility in service conditions and environmental effects for contractual agreements in times of a global container shortage?'.* It contributes scientifically by studying the possibilities of newly available information sharing mechanisms to analyze the changing market characteristics and corresponding detention and demurrage costs from the exporters' perspective. Insights into additional costs provides exporters with an important extra decision- making criterion. Also, the changing market has made contractual service conditions a more important input variable for planning container movements than they used to be.

The answer to the main research question entails a strategy based on contract negotiations and a modal split proposition. Firstly, HNS should aim to retain their beneficial service conditions, even if standard tariffs are increased. If in the future however, these conditions become worse after all, it is advised to transport a larger volume by truck instead of by barge. More specifically, containers that are shipped to Antwerp should be transported by truck. The gain in costs and throughput time starts to outweigh the loss of sustainability related to this modal split.

LIMITATIONS AND RECOMMENDATIONS

There are some limitations to this research that should be names. Firstly, this paper has used data from the 'Tradelens' platform as input for the model study. This data however, is not complete. Not all container movements for 2021 are registered, since not all deep-sea carriers are affiliated to the platform or only became affiliated during 2021. Although a large number of container movements were used to extrapolate to a full year of container movements, the data could potentially be biased. Secondly, this research assumes no capacity constraints on a yearly basis. Although this is quite accurate, capacity constraints on a weekly basis do occur, leading to operational complexities that are not taken into account in this study.

Future research should look into ways of incorporating the weekly complexities. It could also look at more accurate forecasting methods, to make sure that the demand that is bought in through contracts better matches actual demand.

Finally, future research should look into ensuring less dependency on large deep-sea carriers. Deep-sea carriers' power is only expected to increase even further. To become less dependent on these giants, exporters could for example explore producing locally so that transportation costs can be better managed.

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