Erasmus School of Economics

Small dry inland shipping in the Netherlands

A performance analysis of small dry inland shipping on the Dutch waterways

A thesis submitted to the Erasmus School of Economics (Erasmus University Rotterdam) in partial fulfilment of the requirements for the degree of

Master of Science in Economics and Business
(Urban, Port and Transport Economics)

by

Derk Johannes Hoogervorst

Student number: 429019

To be defended in public on November 12th, 2019

Supervisor:	B. Kuipers, Erasmus Centre for Urban, Port and Transport (UPT)
Second assessor:	M. Streng, Erasmus Centre for Urban, Port and Transport (UPT)
Date final version:	9 October 2019

Kennisinstituut voor Mobiliteitsbeleid | KiM

Erasmus Universiteit Rotterdam

Abstract

In this thesis, the performance of small dry inland shipping in the Netherlands is researched. Based on data of Rijkswaterstaat and CBS, five performance indicators are used to measure the performance of small dry inland shipping. Those five indicators are fleet size, waterway availability, tonkilometers, load factor and inland throughput. In addition, a fixed effects model has been run to estimate the effects of different variables on transport with a small ship. The waterway availability and the load factors did not change that much. In terms of fleet size and tonkilometers the ships of CEMT-class 0 to 3 performed negatively. The throughput at inland ports along small waterways increased. Economic growth in a region is accompanied by a decrease in the use of the small ship. The positive effect of low water levels on the use of the small ship was not found. The main conclusion of this thesis is that the small dry inland shipping sector overall performed negatively. On the other hand, there are enough possibilities for the small ship on the small waterways in the Netherlands.

Keywords: inland shipping, small dry shipping, dry goods, waterway, Netherlands, fleet, performance analysis, economic growth, low tide, fixed effects model.

Acknowledgement

Dear reader,

The document on your screen or that is in your hand right now, is my master thesis and marks the conclusion of my educational career. Started with six years of pre-university education at Veluws College Walterbosch in Apeldoorn. Then the Economics and Business Economics bachelor's degree at the Erasmus School of Economics for three years. Concluded with one-year master's degree in Economics and Business, Urban, Port and Transport Economics at the same faculty. Everything I learned during this ten-year educational period has resulted in this thesis, with the aim of successfully obtaining the degree of master’s in science (MSc.) of Economics and Business.

During my master education I decided to search for a graduation internship, to write my thesis. Via Bart Kuipers, that later became my thesis supervisor, I contacted the Netherlands Institute for Transport Policy Analysis (KiM). That institution is the independent research body of the Ministry of Infrastructure and Water Management. A research assignment about Dutch inland shipping was available, which I was interested in. The assignment was of sufficient level and was a good basis for my thesis research. From 2019 to September 2019 I worked at KiM on the assignment and on this thesis.

My interest in inland shipping arose at a young age. We sailed the Dutch waterways during domestic holidays with family. So, I was fascinated at an early age by the large inland vessels and the transport operation that I saw at the time. This early interest was later one of the reasons to follow my economics studies in Rotterdam, the port city of Europe. My choice for the master’s degree specialization in Urban, Port and Transport Economics is then not entirely surprising.

Firstly, I want to thank Martijn van der Horst, my internship supervisor, and all the other colleagues at KiM for the pleasant and interesting period I had. In specific I want to thank Martijn for his perfect guidance and assistance, not only with the research assignment, but also with my thesis research. Martijn brought me into contact with the right people at an early stage to complete this research. Without him it would not have been completed so quickly and the research would not have been so complete.

Secondly, I want to thank Bart Kuipers, my thesis supervisor. Bart helped me to find the right graduation internship and introduced me in the right way at KiM. I also want to thank him for the valuable feedback on my written thesis. Mutual trust between Bart and me has led to a pleasant and successful period, for which I am grateful.

Finally, I want to thank my parents and grandparents, because they provided me the possibilities to follow four-years of university education. In addition, I am grateful to my girlfriend and family for the unwavering support I have always had. Thank you all for making this educational period a success.

Dirk Hoogervorst
Rotterdam, October 2019

Table of contents

List of abbreviations

AIS	Automatic Identification System
ASV	Algemeene Schippers Vereeniging
AVV	Adviesdienst Verkeer en Vervoer
BIVAS	Binnenvaart Analyse Systeem
CBS	Centraal Bureau voor de Statistiek
CCR	Centrale Commissie voor de Rijnvaart
CEMT	Conférence Européenne des Ministres de Transport
CS	CEMT-shift
EC	European Commission
EICB	Expertise- en Innovatie Centrum Binnenvaart
FBB	Federatie Belgische Binnenvaart
GM	Goodtype mix
GNP	Gross national product
GRP	Gross regional product
IVR	Internationale Vereniging het Rijnschepenregister
KiM	Kennis Instituut voor Mobiliteitsbeleid
KNMI	Koninklijk Nederlands Meteorologisch Instituut
NIS	Network Information System
NL	The Netherlands
NUTS	Nomenclature of Territorial Units for Statistics
PTC	Private Transport Cooperation
RWS	Rijkswaterstaat
TEN-T	Trans-European Network – Transport
TG	Total growth
TNO	De Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek
WVL	Water, Verkeer en Leefomgeving

List of figures

List of tables

1. Introduction

In this chapter the societal and political situation and relevance of the topic will be discussed. In addition, it will have a quick look at the situation of inland shipping abroad. Thereafter, the research question will be introduced, and the corresponding sub-questions discussed. Finally, the structure and outline of this thesis are given.

1.1 Background

This thesis deals with a performance analysis for small dry inland shipping in the Netherlands. On the basis of various performance indicators and the data available, an analysis is made to give substance to the performance of small dry inland shipping in the Netherlands.

The Dutch inland waterway network is a widespread network of important transport routes, used to ship all types of goods. In 2018 a total navigable waterway length of about 5.810-kilometer crosses throughout the Netherlands and connects various regions (CBS, 2019b). Besides the natural importance of the waterways and the use for recreational purposes, the canals and rivers are sailed by a Dutch inland shipping fleet of 8,279[1] ships (Binnenvaartcijfers, 2019). By which the Netherlands has the most extensive inland shipping fleet in West-Europe (Binnenvaartcijfers, 2019). The inland waterway network consists of a few major main waterways and also smaller waterways that connect to them. The focus in economic research often lies on the major waterways (Jonkeren, Rietveld, & Ommeren van, 2007; Mihic, Golusin, & Mihajlovic, 2011), but the main waterways have this importance because of all the smaller waterways that connect to this (Bureau Voorlichting Binnenvaart, 2010). For example, for animal feed companies along small waterways, small vessels are very important for transporting their products to livestock farms throughout the Netherlands (Schuttevaer, 2017). In addition to the nautical importance, small inland waterways can also play a significant role in transport to and from urban areas. Small waterways are a congestion-free alternative to road transport, and here cooperation is essential to cover the last kilometers from a port to the final destination (Bureau Voorlichting Binnenvaart, 2010). The inland ports along small waterways have an important node function in this.

The small waterways may be important for economic development in a region and vice versa. According to the inland shipping industry, this is not always taken into account during regional planning and regional development (Binnenvaartkrant, 2014). With the right investments, local businesses and the society can benefit from a sustainable and reliable transport mode. Besides the societal interests, small inland shipping also gets a lot of interest from politics and its policy.

1.2 Policy relevance

There are two topics in the present political discussion about small inland shipping. Firstly, the European requirements of the Centrale Commissie voor de Rijnvaart

[1] Number of ships of the inland shipping fleet, sailing under the Dutch flag, at the time of writing (11th of June 2019).

(CCR) for new-build ships that have a retroactive effect on existing ships (CCR, 2019b). These requirements have been set with the aim of renewing the inland shipping fleet and making it more sustainable (Van Gurp, 2018). On its own, these requirements are in favour of the sector and encourage investments. But most of the requirements are not feasible for small inland shipping (Vinkenvleugel, 2019). On the one hand because of the financial size of the investments that are not affordable for small inland shipping entrepreneurs and on the other hand because of infrastructural obstacles. In addition, another negative effect of more requirements is that more ships stop operating. This means less supply for transport which causes higher prices and then shippers could choose other forms of transport, such as road transport (Van Gurp, 2018). However, an exploratory report from KplusV (2011) shows that the impact on small inland shipping can only be detrimental to the smallest ships (with a length of up to 56 meters). Also, a reasonable part of the regulations does not have that much impact on inland shipping as it seems.

The 'Algemeene Schippers Vereeniging' (ASV)[2] endorses the European requirements for small inland shipping (Schuttevaer, 2018a). They argue that the requirements induce a decrease in the small inland shipping fleet, which is also recognised by Evofenedex (the association of shipping and exporting companies) (Binnenvaartkrant, 2018a). The ASV calculated that this could lead to about 70.000 more trucks on the road, used for road transport[3] (Binnenvaartkrant, 2017). To prevent the end of small inland shipping, the 'Provinciale Staten van Overijssel' proposes to the 'Ministerie van Infrastructuur en Waterstaat' to exclude small inland shipping up to a certain limit from the CCR requirements (Schuttevaer, 2019a). This could be a possible solution, but there is more to politics and regulation on this topic.

The second discussion is about the investments and policy adjustments of the government, that have an impact on small inland shipping. According to the skippers' unions, the policy of local and regional authorities is increasingly focused on promoting the traffic flow on roads and railways (Vinkenvleugel, 2019). This means that bridges, for example, are opened less often and for shorter periods. According to the ASV, this does not take into account the flow of small inland shipping. While transporting goods using small inland shipping can easily keep 15 to 25 trucks off the road, for the same movement of goods. The bottom line is that inland navigation is not sufficiently under the attention of policymakers as an important transport modality, and that needs to be changed. Likewise, they also complain about the maintenance of the small waterways (Vinkenvleugel, 2019). Because the small rivers and channels are not dredged properly, small inland vessels can carry less cargo which reduces their turnover.

However, inland shipping has not completely escaped the mind of the current Minister of Infrastructure and Water management, 'Cora van Nieuwenhuizen' (June

---

[2] *"The Algemeene Schippers Vereeniging (ASV) is the trade association for private skippers. The A.S.V. strives for a private skipper to achieve a socially / economically acceptable situation in inland shipping, a proportionate distribution of burdens and benefits, undistorted competition between modes of transport and the maintenance of independence"* (Ministerie van Sociale Zaken en Werkgelegenheid, 2019).

[3] If this will happen, this would be contrary to the 'Witboek Vervoer' of the European Union, in which is agreed to transport as much as possible via the rail and the water network (Europese Commissie, 2011).

2019). The Ministry is committed to a new procedure for inland shipping skippers to request an exception to the requirements (Binnenvaartkrant, 2019b). This procedure must become more understandable and easier to apply. This should offer ship owners a way out if they cannot meet the strict technical requirements of the CCR. Besides, in the end of 2018 the minister said that she is willing to invest 5 million euros in improving the coordination of the operating times of locks and bridges in order to improve the flow of shipping traffic (ASV, 2019). Despite these investments, the ASV considers this amount of 5 million euros not enough and certainly not to accomplish a modal shift[4] from road to water. They argue as follows, 35% of domestic freight is transported by water. Only 6% of the total budget for infrastructure is used to invest in the waterways. And that is disproportionate, also in view of the fact that investments in waterways do not only benefit inland shipping (transport), but also water management (nature). In addition, overdue maintenance from the past due to retrenchment in recent years has not been taken into account. That is a reason for the ASV to argue for a different distribution of the infrastructure budget. Summarily, there are political obstacles to deal with and to be able to do this, better cooperation and understanding for each other will have to take place.

Not only in the Netherlands, also in other European countries with a widespread waterway system, small inland shipping gets attention due to developments in the industry. In for example Belgium, the 'Federatie Belgische Binnenvaart' (FBB) calls for a European incentive fund for the construction of small inland vessels. The reason for this is that the sector is about to disappear and that would mean that the small waterways will no longer be navigated over a few decades (Nicolai, 2013). Firstly, as the main causes, they state the aging skippers who quit their work because of pensions. Secondly, governments are making more and more waterways navigable for larger ships, making the smaller inland vessels superfluous. Besides, In France, the responsible minister proposes to stop shipping on the small maintenance intensive waterways and to invest the money saved with that in the larger waterways (Leeuw van Weenen, de & Geest, van der, 2016; Scheepvaartkrant, 2018). That would therefore be a disadvantageous development for small cargo shipping in France. Finally, between now and 2030, the German Minister of Transport wants to invest 25 billion euros in waterways to promote inland navigation (Mackor, 2019). This is aimed to make up for overdue maintenance and to be able to start earlier with constructing new projects. The question is whether this is also specifically advantageous for small inland shipping. In any case, the objective is to increase the modal split to inland shipping by a quarter, as a result of which 12% of the goods in Germany will be transported by German inland shipping. In short, the Netherlands is not the only country in Europe where inland shipping, and specifically the continued existence of small inland shipping, is under societal and political attention.

1.3 Research question

The above-mentioned societal importance and the political discussion leads to the motivation behind this research. With a performance analysis, a better assessment of the situation on the market can be prepared. Policy makers do not have direct

[4] *"The proportion of total trips that uses each of various specified modes of transportation".* (Bureau of Transportation Statistics, 2019)

influence on the business operations of an inland navigation vessel. However, if necessary, public goods such as waterways and other sector-wide interventions such as regulations can be decisive. The Ministry of Infrastructure and Water Management does have a role in this and therefore this research will focus on a transport performance analysis at the Dutch market for small inland shipping from the waterway perspective. This research will not analyse the business-economic aspects of the ship, because data about the inland ships companies is not available[5]. Nevertheless, many of the results of this research will have interfaces with the business economics of the sector. Some results will influence or be influenced by the earnings and costs of a ship. Based on a proper performance analysis, the question can be answered as to the role of small inland shipping in the medium and long term. Subsequently, the main research question of this research is:

How did small dry inland shipping in the Netherlands perform from a waterway perspective in the last decade and what are the expectations for the future?

During the research process it appeared that the data for the different performance indicators used, is available for different time periods. That is why the time period covered by this study is around the past decade. The main question will be answered quantitively with data of small dry inland shipping in the Netherlands. The main source for this data is Rijkswaterstaat, the executive agency for the Ministry of Infrastructure and Water Management. Together with the Centraal Bureau voor de Statistiek (CBS), which is the independent body designated for data collection and processing of data for statistical applications of the government, business and science. The assignment for this research was set up the Netherlands Institute for Transport Policy Analysis (KiM[6]). This institute request a thorough transport performance analysis of the small Dutch inland shipping sector in a waterway perspective. This means the development of the transport performance of the ships and thereby the availability and use of the waterways. Preliminary research on the future of small dry inland shipping and the available knowledge concludes that a thorough performance analysis was missing (Van der Horst & Francke, 2018).

The following sub questions have been formulated in order to answer the main question.

A. What are the main characteristics of small dry inland shipping market in the Netherlands in recent years?

The answer to this first question is an exploration of the current situation of the Dutch small dry inland shipping. This question will be answered with desk research of academic literature, grey literature and news articles.

B. How can small dry inland shipping be defined?

---

[5] Via the policy department of The Ministry of Infrastructure and Water Management is Steunpunt Binnenvaart approached for this data, but they did not want to collect it due to the enormous size of such a process.

[6] Het Kennisinstituut voor Mobiliteitsbeleid (KiM) conducts independent research and provides knowledge for the mobility policy of the Ministry of Infrastructure and Water Management (IenW) in the Netherlands (KiM, 2019).

This question will be answered with desk research comparing definitions used in different research. Including the existing designations in classes for ship size and the political and cross-border aspects.

C. What are performance indicators to measure the performance of small dry inland shipping?

This question will be based on transport economics literature. Different performance indicators used in literature will be explored and based on this, the most suitable for small dry inland shipping will be selected.

D. What are relevant data sources in the Netherlands about inland shipping that can be used for the performance analysis of small dry inland shipping?

To do a thorough quantitative analysis based on the performance indicators, which is the answer to sub question C, data must be collected. Therefore, for sub question D, the data availability will be considered and the data that is used for this research will be introduced.

After the performance of the small dry inland shipping sector is clarified, one of the goals of this research is to indicate the explanatory variables. Of course, there are many business economic variables such as price, demand and supply that determine the performance of the inland shipping sector. But more interesting for the sector as a whole and for policy makers is to clarify the non-business economic variables that have an effect on the performance of the inland shipping sector. Therefore, the fifth sub question is.

E. Which non-business economic variables have an effect on the performance of small dry inland shipping?

The effect of non-business economic variables will be tested using a fixed effects model regression with panel data. As soon as some general explanatory variables are known about the performance of the small dry inland shipping sector, it is interesting to make predictions for the future. Together with the current trends it is possible to sketch some predictions for the future of the small dry inland shipping sector.

F. What are the expectations for the performance of small dry inland shipping in the short and medium term, based on the performance analysis made and the trends in the sector?

1.4 Outline

This paper is organized as follows, in the second chapter small dry inland shipping in the Netherlands will be introduced and sub question A will be answered. In the third chapter the literature about the inland shipping sector is introduced and sub questions B and C will be answered. In the fourth chapter, the availability and origin of the data will be discussed, and the question D will be answered. Moreover, the methodology for the performance indicator results and the fixed effects panel model will be explained, with which the results can be collected. In chapter 5 the results of the main research question will be showed and discussed, and sub question E will be answered. In chapter 6 all the results will be concluded, the limitations of this research will be discussed and the trends in small dry inland shipping will be summarized. Together with the results of the explanatory variables of the performance, sub question F will also be answered. At the end, a short policy recommendation is done.

2. The current situation in the Netherlands

In chapter 1, the social relevance and the domestic and foreign political discussion of small dry inland shipping were introduced. In addition, there are other important specific characteristics that describe the situation of the sector in the Netherlands. This situation will be further elaborated on and described in this chapter. The conclusion will answer sub-question A of this study.

2.1 Company structures and aging

The skippers who run their small inland shipping companies are a different type of entrepreneur. In 2012, 98% of the companies were family businesses, consisting of men and women, with sometimes hired staff, depending on the size of the ship (Van Dijk, Van Bekkum, & Van den Boogaard, 2012). Furthermore, their entrepreneurial attitude is affected due to a market situation that has been the case for a period of 65 years. Between 1933 and 1998 the small dry inland shipping sector was regulated and the supply and demand for cargo shipping was operating under a so-called 'proportional freight distribution' (Nieuwsblad Transport, 2019). This meant that the cargo was divided equally among all the inland skippers and they were assured of a certain extent of freight transport and therefore income. This history shows that the entrepreneurial spirit of the inland skippers has changed. The small inland vessel skippers have a negative self-image because of the less stable market situation (Geerlings, et al., 2012). The question is whether this negative self-image is correct and whether small dry inland shipping is actually performing poorly.

Another important trend in the inland shipping sector is the rapid shrink of the small inland vessels fleet[7], as indicated by ASV, Evofenedex and Private Transport Cooperation (PTC). These associations emphasize this development to the minister Cora van Nieuwenhuizen in the political discussion described in chapter 1 (Schuttevaer, 2019b). The argument of the trade associations is that the decrease in the fleet of small ships is mainly due to a lack of governmental support. But the reduction of the small vessel fleet is not only due to a lack of government support and investments. Aging of skippers in the inland shipping sector also seems to be a serious issue. Young potential employees must be encouraged for the inland shipping sector and be attracted to work on vessels, is the view of the chairman of trade association for inland shipping Royal BLN-Schuttevaer (Duursma, 2019). Initiatives such as an inland shipping woman that does promotion by video's, provides an example of such an initiative (Algemeen Dagblad, 2018). In addition, experiments are being conducted with unmanned sailing, but this is still in an exploratory phase (Hegger, 2018; Rijkswaterstaat, 2019a). 'Autonomous sailing' ships could be a solution for the prevention of accidents, often caused by human errors. In addition, with better information and planning, the right speed can be sailed so as not to waste time and emissions while waiting for bridges or locks. Moreover, it is a solution for the personnel problem in the shipping sector. Sailing completely without a skipper will not be the case very soon, but the skipper will instead have a more management role on the ship (Niewold, 2017). In conclusion, inland shipping is a special sector and there are several reasons for a decrease in

[7] The figures of the inland shipping fleet will be presented in chapter 5.1.

the number of small dry inland skippers and their ships. Figures will have to show whether this is actually the case.

2.2 Modal shift and the pros and cons of inland shipping

The government has to deal with the climate goals that have been set in Paris (Rijksoverheid, 2019). These goals are about reducing CO2 emissions and of course this also applies to the transport sector. The small inland shipping sector can make an important contribution in this (RLI, 2013). Namely, inland shipping, even with a small ship, is a more environmentally friendly method of transport than for example road transport (Bureau Voorlichting Binnenvaart, 2010). As an indication, water transport emits on average 30% less emissions than road transport (Duursma, 2019). But the green image of inland shipping is getting worse because of in particular old small inland ships. For several reasons old small inland ships are not as developed in terms of sustainability (EICB, 2012; STC-Nestra, 2015). Firstly, inland vessels often have a long operating lifespan. As a result, older ships are still sailing and those are not as sustainable as the more modern ships and do not look sustainable either. Secondly, compared to other sectors relatively little investments are done in inland navigation to improve the sustainability of transport. This is mainly due to the low turnover achieved by the sector and the more modest capital accumulation. Thirdly, the price of a new energy-efficient engine is disproportionate to the value of the ship. Investing in a new engine is therefore often not possible, certainly not for the skipper with a small inland vessel.

The goal of the Dutch government is 95% less CO2 emissions in 2050 compared to 1990 (Rijksoverheid, 2019). In order to operate fully energy-neutral, inland shipping also needs to adapt technically. Small and large ships that can sail on energy power are under development and the costs of such ships will be roughly the same as those of a diesel-powered ship (Hegger, 2018). However, hydrogen is an even more sustainable fuel, but the development of hydrogen powered engines is not yet at an advanced stage. In addition, ships have a relatively long lifespan compared to other modes of transport[8], so the issues will not be solved with the development of sustainable new-build ships (Binnenvaartkrant, 2019a). Existing ships will also have to be converted in due course, but this is very expensive. Financial support from the government for inland shipping could help in this (Hegger, 2018). To transport more sustainable and to solve congestion problems on the Dutch national roads, more inland shipping can be a solution. Freight transport must be shifted from the road to the waterways in the future and the government could in turn provide financial support for making existing inland shipping vessels more sustainable (Duursma, 2019). If this does not happen and inland shipping loses its position as a sustainable transport option, the small inland shipping sector may disappear in the short term. That would ensure more road transport and more road congestion. That is why a petition from the ASV has been signed 1,500 times with the message of "Save the small inland shipping sector and retain 70,000 extra trucks on the road" (Binnenvaartkrant, 2018a).

But inland shipping as a whole not only offers opportunities for improvement and has strengths. The sector also has its weaknesses and threats. In comparison with

[8] In the results section (chapter 5.1) about the fleet data it can be deduced that some ships have been operational for more than 30 years.

the period of economic recession (around 2008), in 2017 the amount of goods transported by inland vessels increased with 8% (in tons), but the turnover has not improved and is still 10% lower than in 2008 (Van Heerde, 2018). This can be partly explained by the strong fleet growth. More supply of transport and overcapacity as a result causes a lower average price. Also, the congestion in the Port of Rotterdam does not have a good impact on inland shipping. Sea-going vessels are getting bigger and the peaks that occur upon the arrival of such a ship mean that inland vessels have to wait. Furthermore, Inland navigation is strongly depending on natural conditions and water levels. Due to persistent drought and low water levels, inland vessels were for example able to transport less cargo in 2018 (Binnenvaartkrant, 2018b). As a result, higher rates were requested, which boosted the overall turnover of 2018. The total inland shipping turnover in the fourth quarter of 2018 was 30% higher than in the same period in 2017, because of the higher rates and 'low water surcharge' that was received (Pals, 2019). This is an example of instability in the sector. Moreover, during extreme low tide, the importance of small vessels for inland waterway transport is emphasized. In such periods, it are the small inland vessels that can still transport goods via the waterways (Schuttevaer, 2018b).

To conclude, small dry inland shipping has some important characteristics that determine the current situation in the sector. First of all, the entrepreneurs in the sector are negative about their business and the position of the government and there are many complaints about that. The skipper entrepreneurs are an aging group because among others the growth of young people is low. The sector is also characterized by its flexibility in terms of geographical reach but uncertainty for the future about its green image. Small inland shipping offers sufficient possibilities for resolving transport issues but is also threatened by decreasing revenues and a lack of investments. Together this is the answer to sub question A.

3. Small dry inland shipping definition and performance indicators

This chapter reviews literature about inland shipping. By defining small dry inland shipping, sub question B will be answered. Moreover, the types of cargo that are typically transported by small inland ships and the relevant literature about small inland shipping will be discussed. The indicators of the performance analysis to answer the research question are introduced and sub question C will be answered. Lastly, possible non-business effects on inland shipping will be suggested.

3.1 Inland shipping: an overview of existing literature

The inland waterway network in the Netherlands is a widespread network of 5.810 kilometers in 2018 (Appendix Table A.1). Together with the inland waterways of Belgium, Germany and France it is an important and unique transport network. In these four major European inland shipping countries, 66% of the waterways are only accessible to small ships[9] (Buck Consultants International, 2008). The small inland waterways provide a connection by water to regions that cannot be reached via the major waterways. That also means that some companies located at inland regions can be reached by ships because of the small waterways. The small inland vessels are able to reach regions where large inland vessels cannot sail the waterways. That is one of the reasons that the small inland vessels are considered the ideal alternative for truck transport via road (Ministerie van Verkeer en Waterstaat, 2007).

The available literature about inland shipping, and specifically small dry inland shipping, performance is scarce and local. There is indeed research into the inland shipping sector, but these often contain subjects other than a performance analysis or the research is focused on local cases. For example, about fleet optimization and timing issues in the inland shipping sector (Bush, Biles, & DePuy, 2003; Swedish, 1998). Another often researched topic is traffic and accidents on inland waterways (Roeleven, Kokc, Stipdonk, & Vries, de, 1995; Talley, 2000). Lastly, there is also a lot of literature about the effects of climate and sustainability developments or goals, on inland shipping (Bloemhof, Laan, van der, & Beijer, 2011; Jonkeren O. , Rietveld, Ommeren, van, & Te Linde, 2014; Schweighofer, 2014; Zhang, Wiegmans, & Tavasszy, 2013). This limited academic literature does not correspond to the subject of the use or performance of small waterways. That is why further on in this paper gray literature will often be used to view existing knowledge about the subject.

The literature about small dry inland shipping is even more limited. Only Van Hassel (2011) specifically studied small dry inland shipping, but that study is about the North-west European market as a whole. The main conclusions about the situation in the sector are reasonably the same as what is described about the Dutch situation. The most important are; little to no new small ships are being built, the technical condition of the existing small fleet is declining and there are little to no new captains for small vessels. Moreover, the infrastructural

[9] In that report of Buck Consultants International, ships are called small if they are less than 86 meters long and have a maximum load capacity of 1.350 tons.

maintenance of the small inland waterways is insufficient and there is increasing competition from road transport. As far as foreign literature is concerned, only in China is written about the small waterways in specific. China has the world's largest inland waterway network (126,300 km) (Asian Development Bank, 2016) and they also consider inland shipping as a solution for congestion. However, Chinese studies mainly focus on (lack of) intermodal innovations, the deterioration of waterways and the social problems of skippers and their families (Asian Development Bank, 2016; Wang & Li, 2013). It is mentioned however, that a lack of proper management and investment has led to a decline in the quality and navigability of the small waterways. To conclude, the literature about small dry inland shipping is limited, whilst a decent performance analysis is also hard to come by. This makes this study relevant for the small dry inland shipping sector and the policy makers.

3.2 Definition of small dry inland shipping

For this research and to answer the research question and the sub questions it is of great importance to first define what exactly small dry inland shipping is. The term 'Small dry inland shipping' consists of three important parts that will be defined separately, small, dry and inland shipping. First 'small' ships. To define small shipping, it is useful to look at existing and extensive ship size indications that exist. The most common used European size indicator for inland vessels is the 'CEMT-class'. This system is developed to coordinate the size of all waterways in western Europe. The system is called 'CEMT' because the class division is determined by 'Conférence Européenne des Ministres de Transport' (European Conference of Ministers of Transport (ECMT), 1992). The classes are classified on the basis of a ship's length, width, height and maximum load capacity. Another size indicator that is used a lot in the Netherlands is the inland waterway fleet classification of Rijkswaterstaat consisting of the M, B and C system (Rijkswaterstaat, 2010). There, motor vessels, barges and convoy system ships have their own code starting with respectively M, B and C, followed by a number from which the size can be deduced. Both size indicator classes are described in detail in Appendix Tables B.

The most common definition for small inland shipping is ships with a maximum load capacity of 1,500 tons and a maximum length of 86 meters (ASV, 2011; Buck Consultants International, 2008; EICB, 2012; Van der Horst & Francke, 2018). So, ships sailing on waterways with CEMT class I up to and including IV). But for various reasons other definitions are also used in literature and reports. An older source of the 'Traffic and Transport Research Department' states that small ships are all ships with a maximum load capacity of up to 1,000 tons (AVV, 1999). No reason for this delimitation is given in the report. In the paper of Van Hassel (2011) he argues that small ships are ships of CEMT-class I and II and that ships of class III and IV are medium size. This distinction is made because according to the 'Alleenvaart regeling' regulation, class I and II ships are allowed to sail with only the skipper on its own and from class III onwards at least one additional sailor needs to be on the ship (Verkeer en Waterstaat, 2004). In the same way there is also a different crew requirement for the step from class IV to V. Ships of class III and IV meet the regulations with a skipper and a sailor. On ships larger than 86 meters, so class V and higher, at least a skipper, a steersman and a sailor must be present (Binnenvaartregeling, 2018). In a forecast study by research institution Panteia (De Leeuw van Weenen, Van der Meulen, & Van der Geest, 2018) small ships are referred to as ships with a maximum load capacity of 800 tons, so CEMT-class I and II. Also, in this report of Panteia no clear reason for this distinction is given. To conclude, there are a lot of different definitions used in other literature to define 'small' inland shipping (Table 3.1).

Table 3.1 Definitions of small inland shipping

Source name	**CEMT-class**	**Max. length** in meters	**Max. weight** in tons	**Reference**
Note Kennisinstituut Mobiliteit	I, II, III and IV	85	1,500	Van der Horst & Francke (2018)
Algemeene Schippers Vereeniging	I, II, III and IV	85	1,500	ASV (2011)
Buck Consultants International	I, II, III and IV	85	1,500	Buck (2008)
Expertise- en Innovatie Centrum Binnenvaart	I, II, III and IV	85	1,500	EICB (2012)
Adviesdienst Verkeer en Vervoer	Unknown	73	1,000	AVV (1999)
Edwin van Hassel Antwerp University	I and II	55	650	Van Hassel (2011)
Panteia	I, II and partly III	70	800	Panteia (2018)
Non-TEN-T corridor	I, II and III	85	1,250	EC (2019)
No national policy	I, II and III[10]	85	1,250	RWS (2019d)

From political point of view there is also an important aspect for the ship size classes. The TEN-T corridors are ten corridors throughout Europe that connect important regions and cities via road, rail and waterway. The infrastructure of these corridors does get extra attention from the European parliament for infrastructural investments and developing programs. Dutch inland waterways from class IV and higher are included in these TEN-T corridors. Therefore, these waterways are, in addition to national, also under European supervision with regard to maintenance and investments (European Commission, 2019). The management responsibility of the waterways in the Netherlands does not have a clear delineation. This was discussed in a conversation with Pim Breek[11] from the Ministry of Infrastructure and Water Management on the 4th of July 2019. Basically, all main waterways (class IV and higher) are managed by the government. All other waterways are managed by local authorities such as provinces and municipalities. There are, however, exceptions such as small waterways that were considered to be of national importance in the past and therefore belong to the government portfolio. The government has attempted to transfer the management of these waterways to the provinces (Rijkswaterstaat, 1995), but no financial agreement has been reached. An example of this is the 'Wilhelminakanaal' in

[10] Without a few exceptions
[11] Pim Breek is deputy head inland waterways transport division, part of the Maritime Affairs Directorate of the Ministry of Infrastructure and Water Management.

Brabant (Rijkswaterstaat, 2019d). However, there are also class IV waterways that are not under government control, such as the 'Gouwe' and the 'Noordhollandsch-kanaal'. These are examples of waterways that are completely located within one province and have been transferred to the province because the transport on these waterways is of regional purpose.

Various ambitions have been set for the waterways of government management, generally class IV and higher, in the 'Structuurvisie Infrastructuur en ruimte' (Ministerie IenM, 2012). Meanwhile, class III and lower waterways in the Netherlands are not part of the national policy program. The policy for these waterways is in the hands of the local authorities. For example, reliable transport timing, getting rid of overdue maintenance and making certain waterways suitable for a certain size of ships are policy goals for the national waterways. These kinds of policy goals should also be applicable for the small waterways in order to maintain a vital and complete network. However, the question is whether this is also the case. By taking the beformentioned different defintions, policitcal responsibility and attention into account, the definition of 'small' is attained.

For the purposes of this study, small inland shipping is demarcated as follows; all ships of CEMT-class 0, I, II and III (Table 3.2). This is also the definition of small waterways that Rijkswaterstaat is using (Rijkswaterstaat, 2017). So, it includes all inland vessels with a load capacity up to 1,250 tons. The terminology in this study will be based on the CEMT classification, since Rijkswaterstaat has also classified the waterway network in the Netherlands based on this classification. As a result, the available data for this study is also classified in the CEMT classification. The class IV ships are not included in the definition of 'small ships', but since this category is often also defined as small, the performance of this category will be considered separately in this research. Consequently, it is also possible to determine the effect of whether or not to assign category IV vessels to the small group and the performance of small dry inland shipping.

Table 3.2 Common small inland vessel categories and characteristics

CEMT class	Name of type (Dutch) and picture	Max. length (in meters)	Max. width (in meters)	Max. draft (in meters)	Load capacity (in tons)	Average truck capacity (amount of trucks)
0	Others				1 -250	
I	Spits	38.5	5.05	2.5	251 - 400	14
						
II	Kempenaar[12]	55	6.60	2.60	401 - 650	22
						
III	Hagenaar or Dortmund-Eemskanaalschip	85	8.20	2.70	651 – 1.250	40
						

Source data: Rijkswaterstaat (2010)
Source pictures: Bureau Voorlichting Binnenvaart (2019b)

The second term that has to be defined is 'dry'. The commodities that are transported via inland shipping are often divided in four categories; dry bulk, liquids and chemicals, containers and general cargo (CBS, 2019d). For this research an image of small inland shipping is required as complete as possible. However, the liquids and chemicals category is not taken into account. This is because the liquids and chemicals category is a sector in itself within the entire sector and is highly dependent on the oil price in performance of the sector (Bückmann, Korteweg, Bozuwa, Volkerink, & Van Veen, 2008). In addition, it is also the case that this sector is not complaining and does not protest the regulations. Moreover, for the transport of liquids and chemicals, small vessels are not often used (De Leeuw van Weenen, Van der Meulen, & Van der Geest, 2018). For this research, a definition of a sector study of sea- and inland ports of Ecorys is used for the definition of 'dry' (2008). Dry goods are anything but liquids and chemicals. This means that 'dry' includes sand, gravel, ore, coal, agricultural goods, containers, break bulk and all other non-liquid cargo.

[12] This category also includes the intermediate type 'Neokemp'. This type of ship has been specially developed for the transport of containers on small waterways. The ship is 63 meters long and 7 meters wide and can transport 32 TEU containers. The wheelhouse of this ship is situated at the front, which means that the height of the ship is not as high as that of regular container ships (Wereld van de binnenvaart, 2019).

The third and last part of the term is 'inland shipping'. With inland is meant in this study; via the waterways on Dutch territory. According to the Cambridge dictionary shipping is 'the process or business of sending or transporting goods' (2019). In the context of this term 'shipping' is not the business that wants the goods to be shipped, as 'the shipper' is. For this study shipping is defined as; the process of a company that operates the transport of goods via inland waterways. To conclude, the complete definition of 'small dry inland shipping' and the answer on the sub question B is;

A. How can small dry inland shipping be defined?

The process of a company that operates the transport of sand, gravel, ore, coal, agricultural goods, containers, break bulk and all other non-liquid cargo loaded on small vessels via the small as well as major Dutch inland waterways. Here small is defined as all ships and waterways from CEMT-class 0 to III and for major ships and waterways CEMT-class IV to VIc.

To make all the figures in this study consistent, every CEMT-class has a unique colour. The colours are specified in Table 3.3.

Table 3.3 CEMT-class specific colour used in figures

CEMT-class	Colour name	Colour
0	Dark yellow	
1	Light green	
2	Dark green	
3	Light blue	
4	Dark blue	
5	Light gray	
6	Dark gray	
Total/overall	Red (dotted line)	

3.3 Cargo types of small inland shipping

To get more information about small dry inland shipping it is useful to know which types of cargo are mainly transported by this sector. The goods that are mainly transported by small inland shipping are construction products (sand and gravel) and agricultural products (AVV, 1999). In addition all kinds of ore and coal are extremely suitable for transport with small dry inland shipping ships (Policy Research Corporation, 2007). Agricultural products, which in particular include animal feed and fertilizer for the agricultural sector are mainly shipped by small ships (Harms & Willigers, 2002). There is a fixed group of shippers along small waterways that is highly dependent on small inland shipping for transporting sand, gravel and agricultural products in particular (Koninklijke BLN-Schuttevaer, 2018). Transport by road is not possible for these shippers due to large quantities of goods. The transporting parties of these commodities usually operate via one of the three following exploitation possibilities (Bu̇ckmann, Korteweg, Bozuwa, Volkerink, & Van Veen, 2008; STC-Nestra, 2015). First of all, the spot market where supply and demand come together freely and where therefore larger price fluctuations occur. Hence, the skipper has no certainty in this form. Secondly, there are inland navigation skippers who transport for a fixed shipping company or charter office. Often a contract has been drawn up here and sometimes the prices are fixed for a longer period. Lastly, there are skippers who operate in a cooperation. This means that skippers sometimes have a transport obligation and are less free in choosing their routes. On the other hand, there is more certainty in cargo supply and stability in prices over a long period. With the exception of cooperation's, the price is determined between two parties. Because nowadays there is no central pricing in the inland shipping sector anymore (Bückmann, Korteweg, Bozuwa, Volkerink, & Van Veen, 2008).

In order to improve the situation of inland shipping, it may be necessary to have more horizontal cooperation in addition to vertical cooperation. One example would be for several skippers to cooperate (EICB, 2012; STC-Nestra, 2015; Van Dijk, Van Bekkum, & Van den Boogaard, 2012). With this, for example, more contracts can be drawn up between a group of skippers and a shipper[13] to generate more certainty. This is important for the sector, because if the shipper is more committed to the skipper, the skippers will be more inclined to innovate. And more inclined to make rigorous investments that ensure sustainability. More cooperation of skippers can also provide network benefits. To be precise, the small waterways can be better utilized because there is also cooperation with small ships.

3.4 Performance indicators

To do a performance analysis for small dry inland shipping in the Netherlands, some performance indicators have to be determined. The performance indicators that will be used in this research and the answer to sub question C is depicted in the Table below (3.4). For all these performance indicators the absolute value, the growth and the growth relative to the overall inland shipping sector, will be reviewed if possible. In the following part of this paper all these performance indicators used in this study will be introduced. Relevant background information and insights from other works will be described and a hypothesis will be outlined separately for each performance indicator as an expectation on the results.

[13] The shipper is the link in the logistics chain that wants to have the goods transported and often also owns the goods (Bückmann, Korteweg, Bozuwa, Volkerink, & Van Veen, 2008).

Table 3.4 Performance indicators and its units for the performance analysis on small dry inland shipping

	Performance indicator	Unit
1	Number of small ships	Number of active small ships in the Dutch fleet
2	Availability waterways	Number of kilometers small waterways
3	Shipped cargo distance small	Amount of tonkilometers shipped by small ships on small waterways
4	Shipped cargo distance major	Amount of tonkilometers shipped by small ships on major waterways
5	Load factors	Average load factor of small inland vessels
6	Throughput inland ports	Throughput of inland ports located along small waterways

3.4.1 Development of the small inland shipping fleet

The number and growth of ships in the small inland shipping fleet is a relevant indicator of the performance of the sector. In this part the first performance indicator of this research is described, where after the theory of inflow and outflow are elaborated upon separately. Firstly, the inflow of new ships determines the future of the fleet. Not only in a positive direction because new ships entering the market has two effects. On the one hand, new ships provide new transport possibilities for the long term and probably they are also more technically advanced, which results in more sustainable ships. On the other hand, too many ships entering the market may result in overcapacity, which is negative for the existing inland shipping companies. Overcapacity can lead to a lower price level and less revenues for the inland skippers. This could also be a reason to stop the operation of sailing the small inland ship. In the research of van Hassel (2011) about the small inland waterway network, he argues that the amount of new small inland ship inflow has been limited in recent years for a number of reasons. Firstly, because of an increase in competition of other transport modes. Secondly, due to economies of scale in inland shipping, the ships that are being built are built increasingly larger which reduces the costs per ton transported. Thirdly, the lack of new skippers is a persistent problem in the sector.

There is a decreasing interest from young new employers for the inland shipping sector (Van Dijk, Van Bekkum, & Van den Boogaard, 2012), and that is disappointing because young entrepreneurs offer innovation and a boost for the sector (Geerlings, Kuipers, & Van der Horst, 2016). For the future of the inland shipping sector as a whole, it is important to increase the attractiveness for new entrepreneurs (EICB, 2012; Hubens, 2004). In addition to attractiveness, another factor also determines the inflow of new ships and entrepreneurs in the sector. The finance possibilities of new ships for new entrepreneurs has changed over the past 10 years (Geerlings, Kuipers, & Van der Horst, 2016). The traditional attitude of banks has changed, and they are not willing to finance new small ships. That is why new ideas are being devised to finance, such as crowdfunding or credit union (Sys, Van de Voorde, Vanelslander, & Van Hassel, 2017). The number of finished ships that have been delivered and the number of ships that were under construction for inland shipping was virtually the same in 2018 as in 2017, so recently there were no direct developments in this sector of area (Netherlands Maritime Technology, 2019). The question is whether this development is the same over a longer period and whether indeed fewer ships are being built. That is why the figures of the fleet size from the last 11 years are analysed for this study. This can be used to get a first idea of the performance of the sector and its attractiveness as a result.

Secondly, the number of small vessels in the fleet is not only changed by inflow but also by outflow. Between 1981 and 2003, 40% of small vessels (up to 1,500 tons) have left the market (Buck Consultants International, 2008). Two important reasons for stopping the operation of an inland shipping vessel are, firstly, aging and secondly, bankruptcies. Aging is a well-known issue in the sector because of the aging of existing skippers and the small amount of new young entrepreneurs (Van den Bossche, Van Schijndel, Van de Pol, Wester, & Sprengers, 2017). A side effect of aging is that a skipper who is about to retire is not likely to invest in his ship, which could be the cause of a ship's deferred maintenance (EICB, 2012). A solution for low accretion of human capital could be semi-autonomous sailing, but this development is not sufficiently completed yet. The other reason for small inland shipping companies to leave the market is bankruptcy. Bankruptcy is a direct reason for stopping the business, but does not reflect the situation properly, because bankruptcy is normally requested when the company can no longer fulfil its payment obligations. But small inland shipping skippers often no longer have payment obligations because their ship has already been fully repaid. Therefore, they often wait to stop the business until it is really no longer financially viable. Because the ship is not only their work but also often their home (Van Hassel, 2011).

So, there are different reasons for inflow and outflow of inland ships which makes it more interesting to analyse the development of fleet size. *Based on the above information and the news articles read, the hypothesis for the growth of the inland shipping fleet of small ships is negative.* It seems that the fleet size is decreasing over the last years. Quantitative research will show whether this is the case.

3.4.2 Inland waterway network kilometers

The second performance indicator that will be used to do a performance analysis for small dry inland shipping is the available number of kilometers small inland waterways. The Netherlands is a country with a widespread waterway network of rivers and canals that connect the seaports of Rotterdam, Amsterdam, Delfzijl en Terneuzen with almost all regions in the Netherlands. It also provides a transport network towards important industrial regions in other countries such as the Ruhr area in Germany or the Belgian hinterland. Inland waterway transport is of great importance for national and international transport (Kuipers & Streng, Binnenhavenmonitor 2015 - Economische betekenis van binnenhavens in Nederland in 2014, 2016) and inland vessels transport a large part of the total flow of goods (Van Dorsser, 2015). The Dutch waterway network had a total length of 6,297 kilometers in 2018 (CBS, 2019b). All waterways are classified in different size classes. From this it can be deduced which ships can sail on that waterway based on length, width, draft and therefore maximum weight. Based on the definition set in chapter 2.2, the number of kilometers of small waterways, from CEMT-class 0 to III will be reviewed. This number of kilometers gives an indication of the possibilities of small inland shipping. The more kilometers of small waterways that are available, the greater the importance of small shipping and the wider the market in which they operate. If transport has to take place over small waterways, this can only be done by small ships, since the large ships cannot sail on the small waterways. Therefore, the development of the number of kilometers is used as an indicator of the performance analysis for small dry inland shipping.

Since waterways are natural rivers or constructed canals, they are fixed assets. From one day to the next, a waterway does not suddenly change in length or in existence. *That is why it is expected that the number of kilometers of small waterways will not change significantly over the years.* Nevertheless, it may be that in a year, for example, a lock is widened so that larger vessels can sail on a waterway. In addition, the government may also close a waterway because they will no longer maintain it. That is why it is interesting to analyse this performance indicator. The waterway length will be considered in kilometers for this study since the data source also provides the figures in kilometers.

3.4.3 Transport performance of small vessels on small waterways

The third performance indicator of this research is about the actual transport performance. The performance will be measured via the unit tonkilometers transportation by small vessels. Small dry inland shipping is characterized by its flexibility (EICB, 2012). Flexible because small vessels can sail on more waters compared to large vessels. In comparison with road transport, small inland shipping is not flexible, because often pre-transport and post-transport is still needed before the goods transported arrive at their destination. In addition, inland shipping is also dependent on the lock and bridge service times that are sometimes limited on smaller waterways. In comparison with road transport, roads are accessible 24 hours a day, but the waterways, for example, have no traffic issues. Apart from operating times of locks and bridges, the desired speed can almost always be sailed. To utilize the flexibility of small inland shipping, a goal is to include it more and more in a synchro modal transport system (RLI, 2013). This means that the same good is transported flexible by several modalities, depending on availability and the type of good. In particular for container transport, inland shipping may fulfil a greater role in this. Containers have standard dimensions and are easy to transfer from one mean of transport to another.

Various indicators are possible to measure the actual transport performance of small dry inland shipping. The first option is the number of trips from small vessels on small waterways. However, this indicator is not sufficient since sailing with little cargo loaded is not a good performance. A second option is the amount of cargo that is transported by small inland vessels on small waterways. This indicator already provides a better indication about the performance but is still not sufficient enough. A ship that transports big quantities, but only over very small distances still does not perform very well. A third performance indicator possibility of freight transport is the revenue that is earned with it. This indicator is not used because revenue is also highly dependent on external factors and not just on the performance of small dry inland shipping. In addition, considering revenue, this research would analyse the business-economic side of a ship and the goal is a performance analysis from the ship-waterway perspective.

In general literature on transport issues, the multiplication of loaded tons and kilometers travelled with this load is often used for a performance analysis (Behrens, Gaigne, & Thisse, 2009; Bilec, Ries, Matthews, & Sharrard, 2006; Gudmundsson, 2004). This creates the unit 'tonkilometer'. Also, in other studies on other specific modalities tonkilometer is used as a performance indicator. In different studies on railway transport and in aircargo studies, tonkilometers is used (Farsi, Filippini, & Greene, 2005; Feng, Li, & Shen, 2015; Lawrence & Lin, 2006; Oum, Waters, & Yu, 1999). In studies on inland shipping you will see tonkilometer as a performance indicator in a report from Panteia on a future vision of inland shipping (De Leeuw van Weenen, Van der Meulen, & Van der Geest, 2018) and in a report from RIVM[14] on the development of inland shipping and sea shipping (Harms & Willigers, 2002). To conclude, the performance indicator tonkilometer will be used to indicate the performance of small dry inland ships on small waterways. *Based on publications from skippers' trade unions and news articles introduced in chapter 1, the hypothesis for the development of the amount of tonkilometer for small dry inland shipping is negative.*

3.4.4 Transport performance of small vessels on major waterways

Small inland vessels do not only sail on small waterways. To reach the small waterways and to reach certain destinations small ships will also have to sail on the major waterways. It could also be the case that small ships sometimes fulfil the demand or transport with origin and destination along major waterways. But because of the consulted literature and the advantages of large vessels, the latter is not expected. Namely, large vessels make use of economies of scale advantages. Because of the larger amounts of cargo that can be transported on larger vessels, certain fixed costs can be divided over a larger amount of cargo. As a result, the costs per ton or container for a large ship are lower, which means that they can offer more competitive prices. Nevertheless, it is important for this research to also consider the performance of small ships on major waterways, to get a complete overview. This will of course be done in the same way as described above in section 2.5.3. The performance is indicated on the basis of the number of tonkilometers transportation. *Based on the same publications from skippers' trade unions and news articles, the hypothesis for the development of the amount of tonkilometer for small dry inland shipping is negative.* On waterways where large vessels can also operate, the expectation for the development of transported tonkilometers is even more negative than on small waterways. This is because of the high intensity of competition.

3.4.5 Load factor of small vessels

The next performance indicator is about the load possibilities of small inland ships. The load factor will be calculated as a percentage of the loaded tons relative to the maximum load capacity. Transporting a high tonnage goods over a long distance is a good performance, but it does still not give a complete view. If the number of tonkilometers has remained constant in recent years, this is not a bad performance. But if the capacity of the small ships is much more than the number of tons transported, then the performance is not optimal. It would have been possible to perform better with the same fixed costs and sailing movements. Therefore, the calculation of the average load factor of ships is important. Load factor is defined as the number of tons transported as a percentage of the total capacity in tons of the ship. It is important to note that sailing with a very high

[14] The Rijksinstituut voor Volksgezondheid en Milieu (RIVM) is the national knowledge and research institute for public health and environment in the Netherlands, focused on promoting public health and a healthy and safe environment.

load factor is not possible, nor is it a goal in inland shipping. Because there needs to be a bit of overcapacity for transport peaks due to external circumstances (Van Dijk, Van Bekkum, & Van den Boogaard, 2012). In addition, the load factor is also considerably lower in times of low tide, because ships transport less cargo to reduce their draft. To sum up, load factor also does not provide a total picture of the performance but is an important indicator to include in this study. *Based on the literature read, no hypothesis can be made about the development of the load factor of small dry inland shipping in recent years.*

3.4.6 Throughput from inland ports along small waterways

In the Netherlands, small and large inland ports are located along many waterways for the transhipment of goods that are transported by water. The direct added value to the Dutch economy of all these inland ports together was 8 billion euros in 2014 (Kuipers & Streng, Binnenhavenmonitor 2015 - Economische betekenis van binnenhavens in Nederland in 2014, 2016). Add the indirect added value and the total added value was 12.6 billion euros. In addition, direct employment in Dutch inland ports was calculated at 66.9 thousand people employed in 2014. So, the Dutch inland ports have an important contribution to the national economy. Inland ports can be defined as a transfer point for goods or terminal as well as the business sites and activities associated with this transfer facility (TNO, 2004). In this report of TNO an inland port is described as identified with a branch in a municipality and has three important functions. A node in transport chains, a location for industry, services and part of clusters and finally a part of (international) production networks. The expectation in 2002 was that the use of small waterways will increase due to an inland shift of port activities (Harms & Willigers, 2002). This is also the case at present, due to increasing congestion in the seaports. The activities at inland terminals are increasing to protect the seaport terminals of a congested situation. An example given already in 1999 was the inland port of Tilburg and the connection Rotterdam - Tilburg (Gemeentelijk Havenbedrijf Rotterdam, 1999). Interestingly, the port of Tilburg is located on a small waterway (class II).

The inland ports along small waterways are essential for the small inland shipping sector, because most of the small inland ships do not have an onboard crane to load and unload goods to the quay. The most important function of an inland port for the inland shipping sector is the function to load and unload the shipped goods. In order to get a complete analysis of the small inland shipping sector, it is therefore also important to include the performance of the inland ports along small waterways, because they have a vital role in the process. Inland ports along small waterways are defined in this research as all the inland ports in the Netherlands that are only accessible via waterways of CEMT-class 0, I, II and III. Two important comments must be added to this. For example, if an inland port is located along a class IV waterway, but the actual port dock is only accessible for class III ships, the port is defined as a port along a small inland waterway. The other way around, if a class IV ship is able to enter a port dock, but the direct waterway towards this dock is a class III waterway, the port is also considered a port along a small inland waterway. Just because a class IV ship cannot sail towards this inland port. The performance indicator that can be used to indicate the performance of inland ports along small waterways is about throughput. Throughput volume (tons cargo) handled is used in literature about inland ports (De Langen, Nijdam, & Van der Horst, 2007; Talley, 2007) and will be used in this research as well. *The hypothesis* *for this performance indicator is that the development is negative.* Namely, if the transport of small inland shipping had decreased in recent years, the throughput volume of inland ports along small waterways would also be reduced.

To sum up, in Table 3.5 the hypothesis for each performance indicator is added in the last column. These are the expectations based on relevant background information and insights from other works described above.

Table 3.5 Performance indicators and its units for the performance analysis on small dry inland shipping

	Performance indicator	**Unit**	**Hypothesis**
1	Number of small ships	Number of active small ships in the Dutch fleet	-
2	Availability waterways	Number of kilometers small waterways	0
3	Shipped cargo distance small	Amount of tonkilometers shipped by small ships on small waterways	-
4	Shipped cargo distance major	Amount of tonkilometers shipped by small ships on major waterways	-
5	Load factors	Average load factor of small inland vessels	?
6	Throughput inland ports	Throughput of inland ports located along small waterways	-

The expected development over the past years is:
+ positive | - negative | 0 no difference | ? unknown

3.5 Effects on the share of small dry inland shipping transport

If the performance of small dry inland shipping has been sketched based on the above performance indicators, the next interesting step is to explain these developments. In the beginning, a model for CEMT-class choice would be very interesting to estimate. This would explain the choice for the type of ship that is used for the transportation. However, this is a very difficult model to estimate, for the following reasons. The choice of ship size does not only depend on origin, destination, sailing route and other regional characteristics of origins and destinations, but also especially on the type of goods and total weight that must be transported. Often it is not about one quantity of sand or coal that has to be transported once, but about a continuous flow of these goods throughout the year. So, if the choice for the first two trips is on a small ship, the next trip must be with a large ship to fulfil to the order size. This means that it is not an independent choice for each trip, but that the choice depends on other choices and these influence each other. The share of small ships in total dry transport to regions in the Netherlands, on the other hand, is a variable that can be modelled. This is relevant because such a model can provide interesting content to the developments of the performance of small dry inland shipping.

Because this study is an analysis on waterway perspective, business economic effects are not taken into account. Several non-business economic variables are mentioned in the literature that could have an effect on small dry inland shipping. The available literature and reports from the sector (Chapter 2) indicate that there are two main situations in which small inland shipping becomes important. First, in times of economic growth, when there is an increase in demand for inland shipping, the shipping sector could be dealing with shortages in terms of available ships. Second, in times of low water levels is shipping with small ships more flexible. Because the waterways are less navigable for bigger ships. That is why this research is about the effects of these two variables on the performance of small dry inland shipping. In the next four sections, the dependent variable and other relevant variables for the model will be introduced.

3.5.1 Gross regional product

The gross regional product could have an effect on small dry inland shipping. If a region has economic growth, it may be that more goods also need to be transported to that region. If the large inland vessels cannot fulfil in this need or cannot operate some smaller quantities to certain regions beneficially, the small inland vessels could set in. Besides, small inland shipping mainly transports goods to local industries and therefore regional economic development could have an effect on the performance of inland shipping (Jonkeren, Rietveld, Van Ommeren, & Te Linde, 2014). The gross domestic product (national) has no clear effect on transported inland shipping tonnage (Sys & Vanelslander, 2011). The gross regional product is more accurate and therefore it is possible that a growth of the gross regional product causes an increase in the share of transport by small inland shipping towards a certain region.

3.5.2 Water level

A second possible explanatory variable is the water level. It is clear that ships can transport less cargo when the water level is at low tide. This was for example the case in the Netherlands in 2018 (Binnenvaartkrant, 2019c). Less cargo was loaded on a ship to reduce the draft. Because less freight can be transported and supply decreases, the rates increase (Jonkeren, Rietveld, & Van Ommeren, 2007). This is therefore advantageous for inland shipping in the short term. But soon, due to the increased tariffs, shippers will choose for a different modality to transport (Krekt, et al., 2011). At this point small inland shipping demonstrates the power of the sector. The small vessels are more flexible, because of the low draft small inland vessels are more able to sail on certain waterways at low tide (CCR, 2019a). This increases the captive sailing area of small vessels, the area that can only be sailed by small vessels. Not only a low water level has an impact on inland shipping and its load capacity. High tide water level also has a curdling effect. Since the clearance height under fixed bridges is reduced in a high tide period. As a result, a waterway route can be blocked, because ships can no longer sail under fixed bridges (Bascombe, 1997; Zimmermann, 1996).

Because this research is about small dry inland shipping and the dry bulk shipping is mostly not dealing with height passage, the focus will be on draft and therefore low tide. The water level is of great importance for inland navigation on the major waterways. This has also been demonstrated in a study of the impact of climate change on the competitive position of inland waterway transport (Van Meijeren & Groen, 2010). The question now is if there is an effect on small dry inland shipping. Is it a positive or negative effect on the transport performance? This research will attempt to quantify this effect. Expected is that a low tide waterlevel will cause an increase in the share of transport with small inland ships, because those ships are more flexible.

3.5.3 Non-quantifiable effects

There are two important effects that, in theory, have an effect on small dry inland shipping but cannot be quantified directly. Firstly, regulations can be a major nuisance for small dry inland shipping. If stronger regulation is imposed that is not feasible for the small ships, as described in chapter 1, this can have an adverse effect. Skippers could choose to stop operations because requested investments are not feasible. Stricter regulation cannot be expressed in figures. However, it can be examined whether, for example, the stricter regulations imposed in the Netherlands in 2008 (De Groot, 2008) have an effect on small dry inland shipping. Only the effect here is not a one day after the other effect, but a spread effect over a period of multiple years. It will not be the case that skippers stop their business the day after the introduction of the stricter regulations. This makes the effect of regulations very difficult to investigate and therefore stricter regulations within this investigation are limited to a possible reason for stopping the business activities.

The second non-quantifiable effect is technological improvement. If companies in the sector invest in technology, this can improve the operational performance. Investments in seaports, inland ports and on inland ships themselves can have an effect on the transport performance, also of small ships. An example is improved load and unload equipment at inland ports. As a result, the turnaround time of inland vessels decreases, so that total transport time decreases (Hekkenberg, 2013). This improves the competitive position of inland shipping and can therefore also lead to more transport for small ships. If small ships do not invest in technological improvement, they could get in a race to the bottom. Less investments mean less transport, leads to less income and then again, less possibilities to do investments. So, a lack of technological improvement is an important factor for the performance of small dry inland shipping.

But technological development is also very difficult to express in figures. The development of the ‘Neokemp’ new small container ship is an example of a development in the sector. However, this category of ships is not registered separately in the available fleet data for this research. Investments in the sector are available and could be a proxy but that is too general. Investing does not always mean the technological improvement of existing equipment. Therefore, the effect of technological development on transport performance is also not taken into account in this study.

3.5.4 Control aspects

In addition to the above effects, this study also includes control aspects that may influence the effect. The first variable is the greater locational aspect. It could be that there are differences between the north, east, south and west part of the Netherlands or at provincial level in, for example, the effects of the water level. That is why differences between the various larger regions are also being researched. The second locational aspect that could influence the effect on small dry inland shipping is the location along a river. The Netherlands has two important rivers of which the water level depends on natural influences. This is the Rhine and the Maas (KNMI, 2019). In addition, the rivers Waal and IJssel also experience direct effects because these rivers are connected to the Rhine without locks. At the same time, the IJsselmeer and Markermeer function as storage of water to compensate during dry periods in the Netherlands (Rijkswaterstaat, 2019j). Waterways that cross and rivers and canals directly connected to, the Markermeer or IJsselmeer therefore have probably less problems with natural influences and low water levels in the rivers. That is why it could be that transport with small ships to regions directly along the fluctuating rivers is more strongly influenced by the water level than regions with a more stable water level. In spite of that, it happens that ships that sail to more stable regions sail over the fluctuating rivers during the trip and therefore also have to deal with the water level. Sailing a different route could then be an option. In short, it is interesting to investigate whether there are differences between these regions.

The third aspect that needs to be controlled for when researching the transport performance of small dry inland shipping is the trip distance. For long trips and larger flows of goods, it is advantageous to transport with large ships (McCann, 2001). Smaller inland shipping can play a more significant role for smaller flows at shorter distances. It is therefore expected that the average distance travelled by transportation to a region also plays a role in the share of tons transport with small ships. To conclude, possible non-business explanatory variables for the transport performance of small dry inland shipping that can be investigated are gross regional product and water level. In addition, other things can also influence the effect, such as the larger regional location, river area location and the average distance to a region. The effect of these variables will be studied and described in chapter 5. In chapter 4, the methodology for estimating the effect will be described. Sub question E can now be drafted somewhat more specifically and is as follows:

E. What is the effect of economic growth (gross regional product) and the water level on the share of tons transported by small vessels in inland shipping to a region?

4. Data collection, adjustments & methodology

In this chapter the data and the calculations for the performance indicators will be introduced. For each performance indicator the data that could have been collected are described[15]. This chapter will give a description of the institutions that collect relevant data of inland shipping and waterways in the Netherlands, per performance indicator. This will also be the answer to sub question D. Moreover, the data and method will be introduced that are used to do the regression to answer sub question E.

D. What are relevant data sources in the Netherlands about inland shipping that can be used for the performance analysis of small dry inland shipping?

E. Which non-business economic variables have an effect on the performance of small dry inland shipping?

To summarize the data that is used for every performance indicator and the source of that data, the following Table 4.1 is given.

[15] Searching for data and making a plan for approaching different organizations has been in collaboration with colleagues from The Netherlands Institute for Transport Policy Analysis. These colleagues have years of experience and therefore connections in the inland shipping and freight transport sector.

Table 4.1 Overview of data per performance indicator

Performance indicator	Unit	Time period	Source
Number of active small ships in the fleet	Number of ships registered as active fleet	Moment July 2019	International association for the register of inland vessels in Europe
	Number of ships registered in traffic data as active	2007-2018	Network Information System (NIS) of Rijkswaterstaat
Availability of small waterways	Number of kilometers small waterways	2008-2018	Statistics Netherlands (CBS)
Shipped freight-distance small ships	Number of tonkilometers transported by small ships	2014-2018	Binnenvaart Analyse Systeem (BIVAS) - Rijkswaterstaat
Load factor small ships	Percentage of load relative to total load capacity	2014-2018	Binnenvaart Analyse Systeem (BIVAS) - Rijkswaterstaat
Throughput at inland ports along small waterways	In tons	2011-2018	Statistics Netherlands (CBS)

4.1 Inland shipping fleet

Information about the inland shipping fleet is collected by more than one institution. There is an important difference in register fleet and traffic fleet. With **register fleet** is meant the ships that are registered in a fleet database as active sailing ship. It does not mean that this ship is actually sailing on the Dutch waterways or is sailing at all. It could be that this ship is operating in for example Germany or that the ship is situated in a port somewhere without transporting cargo. **Traffic fleet** is data about all the ships that have been sailing on the Dutch waterways and have therefore been registered.

To clarify the differences in content and to elaborate upon the similarities and differences of the two datasets, a Venn diagram has been created (Figure 4.1).

A: Register fleet data. Contains all the Dutch registered ships that are registered as actively sailing, according to the information at the moment July 2019. The location where the ships actively sail is not included.
B: Traffic fleet data. Contains all the ships that actively sailed on the Dutch waterways in a certain year, according to traffic data. That can also be ships that are registered abroad.
C: Overlap in data. Ships that are registered in the Netherlands and are also actively sailing on the Dutch waterways appear in both datasets.

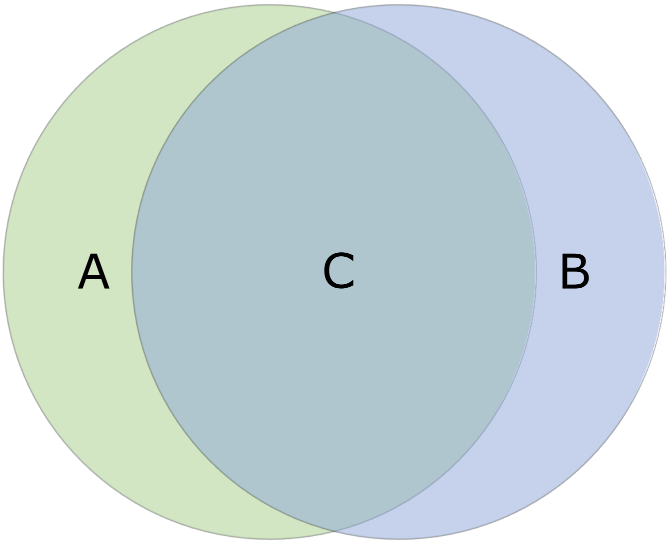


Figure 4.1 Venn diagram of fleet data sources

Both datasets are used to get results. Since there is overlap and there are no corresponding unique ship identities, this data is not aggregated, but analysed separately. Below the data of both will be described and the adjustments done explained.

Important notice: all data used in this research is classified or converted manually to CEMT-class (Appendix Tables B). CEMT-class is the classification that is both used for inland vessels as well as for the navigability of the waterways and is therefore more convenient to use. CEMT-class 7 is a special class and is the size class for a barge combination with three barges broad wise and two barges long (Appendix Table B.2). This CEMT-class is not applicable for motor vessels or for convoys. Besides, there are no waterways specified as class 7. That way of shipping is only possible on routes without locks, so from Rotterdam to the German Ruhr area for example. The combination of 6 barges with three barges broad wise is mainly used for returning empty barges to a certain location. All this together is the reason to completely disregard the results of class 7 in this study on small dry inland shipping.

4.1.1 Register fleet data

Three institutions have been contacted for the register fleet data, namely CCR, IVR and the national statistical institution of the Netherlands (CBS). IVR is the 'International association for the register of inland vessels in Europe' (IVR[16]) (IVR, 2019b). This association represents the interests of the inland shipping sector and the involved insurance companies. The European 'Central Commission for the navigation of the Rhine' (CCR) (CCR, 2019c), established during the Vienna Congress in 1815, is the organization responsible for the legal and practical regulation for shipping on the Rhine. The CCR also administrates a register fleet database and has five member states: Belgium, Germany, France, the Netherlands and Switzerland. CBS (CBS, 2019e) and the European statistical institution Eurostat (Eurostat, 2019) both also have register fleet data. Those open data sources are very general in nature and there is no distinction in ship fleet size. The CBS was asked for an updated and specified dataset for this research but a statistical research employee of CBS, answered that at short notice such a dataset was not available. The CCR provided a dataset with registered ships from 2008-2018, but this data was not elaborated on ship size class.

The secretariat of the IVR provided on the 19th of July 2019 (IVR, 2019a) a dataset in which the ship length, width and load capacity were specified, by which the CEMT-class could be determined. A disadvantage of this dataset is that it is not panel data, but data at a certain moment, July 2019. As a result, the development of the fleet over time could not be analysed. The ships in this dataset are all the registered ships in the Netherlands, so sailing with Dutch flag in July 2019. The dataset consists of 9,861 ships and is adjusted as follows. Firstly, 1,133 passenger ships, 1,058 liquid bulk ships and 1,181 tow and push ships are deleted. Tow and push ships are a special category because it includes various ships. In the case of tow and push ships active in a port that tow and push big sea-going vessels, those are service ships and no freight transport ships. In the case of push ships that push barges it could be that ships in that category facilitate the transport of dry bulk. However, it is not known what kind of barges, suitable for which type of cargo, is being pushed and this can also vary per trip. That is why tow and push ships are not included as dry shipping fleet in this study. In addition, 764 'other sailing' category ships, such as fire-fighting vessels and pleasure yachts, have been removed. Within the category dry bulk ships, 253 ships are deleted because they were specified as unknown load capacity or a load capacity of 0. Those ships cannot be classified as dry bulk transport ships. Those adjustments result in a registered dry shipping fleet of 5,725 ships. Within those dry bulk category, 83 vessels were incorrectly labelled because those are passenger ships or tankers. So, in the end the analysis was done for 5,389 dry bulk shipping vessels.

The group of dry bulk vessels mainly consists of motor vessels (2,585), dry bulk barges (2,585) and freight pontoons (1,025). Originally the data from the IVR was not classified in CEMT-class. Meanwhile, ship length, ship width, ship draft and load capacity were given, with which CEMT-class could be awarded. Based on the Rijkswaterstaat guidelines for waterways (Rijkswaterstaat, 2017), the ships are primarily classified on the basis of width. The waterway guidelines state: *"The CEMT-class of a ship is primarily determined by the width criterion. The tonnage classification is not accurate."* This is because ships may be extended or widened,

[16] Internationale Vereniging het Rijnschepenregister

and the dimensions may change as a result. Where width was not specified, classification is done on the basis of load capacity (Appendix Tables B). As CEMT-class characteristics differ between motor vessels and barges, these two groups are classified separately. Convoys do not appear in the dataset because they are registered separately as a motor vessel and barges. The results of this data are described in chapter 5.1.

4.1.2 Traffic fleet data

For the traffic fleet data, the department of 'Water, Traffic and Environment' (WVL[17]) of Rijkswaterstaat was approached. The WVL department of Rijkswaterstaat is responsible for the policy vision for the main waterway network in the Netherlands, among others (Rijkswaterstaat, 2019g). In addition, it is also the institution who monitors traffic on the waterways and, where necessary, adjusts the policy accordingly. This department provided a dataset with shipping traffic information. The data is obtained on 12th of July 2019 (Rijkswaterstaat, 2019a). The data is output of the Network Information System (NIS) of Rijkswaterstaat. NIS is the system that collects traffic data. The data is generated by the IVS 90[18] system. This is the Information and Tracking System for Shipping and is the system with which Rijkswaterstaat monitors the traffic on Dutch waterways (Rijkswaterstaat, 2019e). In this system all active ships on the Dutch waterways are registered, so also foreign registered ships that sail on Dutch waterways.

The data is originally categorized in Rijkswaterstaat M/B/C-class (Appendix Tables B). This makes it easy to assign the CEMT-class for every ship. The system operates on the basis of a report obligation for ships. All ships transporting containers or liquid bulk have this report obligation (Regeling communicatie en afmetingen rijksbinnenwateren, 2018). Which means, all ships longer than 110 meters also have a report obligation. If a ship needs to pass a lock, it also needs to report itself. It is therefore possible that a dry bulk ship of, for example, 86 meters (CEMT-class 4) sails unreported on a route without locks. This is the case, for example, on the route from Rotterdam to the Ruhr area in Germany. Using Automatic Identification System (AIS), Rijkswaterstaat is developing a new way to monitor all the inland shipping traffic, including unreported small ships. The integration of AIS took place recently, in March 2019, and therefore it is not yet possible to work with this data.

The data is structured as rows with every unique ship and for every year from 2007 to 2018 in columns a '1' if the ship actively sailed the Dutch waterways in that year. The file consists of 48,224 ships that sailed one or more times in the Netherlands. For 22,619 (46.9%) ships the Rijkswaterstaat ship class was unspecified. Also, in this dataset there is no length, width, load capacity or other form of characteristic available from which the size of the ship can be derived. After questions and consultations with employees of the Rijkswaterstaat WVL department, it became clear that there is no solution for this. Ships for which no class is specified are ships that either have not specified a type at their report or cannot be classified within a type. If no type specification is known for a ship, this is the case for the entire time period. As a result, the development over time of

[17] Water, Verkeer en Leefomgeving
[18] Informatie- en Volgsysteem voor de Scheepvaart established in 1990.

the number of ships per CEMT-class is not affected. All ships that do not transport dry cargo have been removed (5,886), leaving 19,739 dry cargo ships that have sailed on the Dutch waterways for one or more years. These ships are classified in CEMT-class. The results of the calculations with this data are described in chapter 5.1.

4.2 Inland waterway network

The data about the inland waterway network in the Netherlands could easily be deducted from CBS. There is an open dataset available with information about the waterways, among which the length in kilometers of the waterways that could be categorised in CEMT-class (CBS, 2019b) (Appendix Table A). The data did not need adjustments because it was downloaded categorised in CEMT-class and over the years 2008 to 2018. This data has been used to analyse whether the water infrastructure has changed in recent years. The results of this will be described in chapter 5.2. The CBS data does not indicate where which waterways are located. A solution for this is to use an online map of Rijkswaterstaat to view the waterway network, among other things (Rijkswaterstaat, 2019b). It is also possible to display the CEMT-class per waterway on this map.

4.3 Travel data and route statistics

Travel data of inland shipping is collected via Rijkswaterstaat, because they monitor the traffic on waterways. All travel data is deducted via the 'Inland navigation analysis system' (BIVAS[19]) (Rijkswaterstaat, 2019h). BIVAS has been developed to perform network analyses for inland shipping. In this system the routes and all related information from inland vessels are recorded. The input from BIVAS follows from the IVS 90 system, the same as is described in chapter 4.1. For the IVS 90 system, a skipper registers his ship information once and provides the load information at the start of each trip. The ship is then registered at various IVS stations, so that the route can be determined roughly (Rijkswaterstaat, 2019e).

The same issue with the report obligation of ships, as is described in chapter 4.1, is the case for this travel data. Two files with travel data were received for this study for each year from 2014 to 2018. A longer period was desirable at the beginning, but obtaining the data took too much time, taking into account the time schedule of this research. The data sets from 2014 to 2018 were almost ready for use and could therefore be sent quickly.

The first file with travel data is mainly about ship information and provides all kinds of anonymous information such as ship type, dimensions, tons loaded, type of load and load capacity. For this file all ship types have been converted to CEMT-class and all ships are classified in dry bulk, as is specified in chapter 3.2, or liquid bulk.

The second file is a file with route statistics and provides information about the same trips such as the number of kilometers travelled for a trip. In this dataset, international trips are split into two parts, the part within the Netherlands and the part outside the Netherlands. Only trips with origin and/or destination within the Netherlands are included in this dataset. Both files have been merged on the basis

[19] Binnenvaart Analyse Systeem

of a unique trip identification number (Table 4.2). Because the percentage of coverage after merging is not exactly the same for every year, this is adjusted for after calculating the output variable tonkilometers.

Table 4.2 Percentage coverage of trip data merge per year (Appendix Table E.1)

	2014	2015	2016	2017	2018
Merged	549,017	602,680	600,913	601,430	619,977
Not merged	53,020	7,347	5,811	8,981	8,704
Total	602,037	610,027	606,724	610,411	628,681
Percentage coverage	91.2	98.8	99.0	98.5	98.6

Information about the number of kilometers of a trip per waterway section was also desirable, so that tonkilometers of trips of small ships could be split into transport on small waterways and transport on major waterways (performance indicators 3 and 4). However, this was not feasible because Rijkswaterstaat does not save the exact route for every trip. There is a solution for this and that is with the online version of the BIVAS Charta software (Rijkswaterstaat, 2019h). In this online software system, it is possible to show the sum of the number of tons transported per CEMT-class on a heat map (Figure 4.2). The year 2017 is showed, because 2018 was a year with a divergent performance due to the low water levels. From Figure 4.2 can be deduced that there is not much diversion in where the small ships transport the most tons in comparison with the total fleet. In order to be able to analyse the transport performance of small ships on small waterways separately, this can be approached using throughput data from inland ports along small waterways. This will be further elaborated in chapter 4.4.

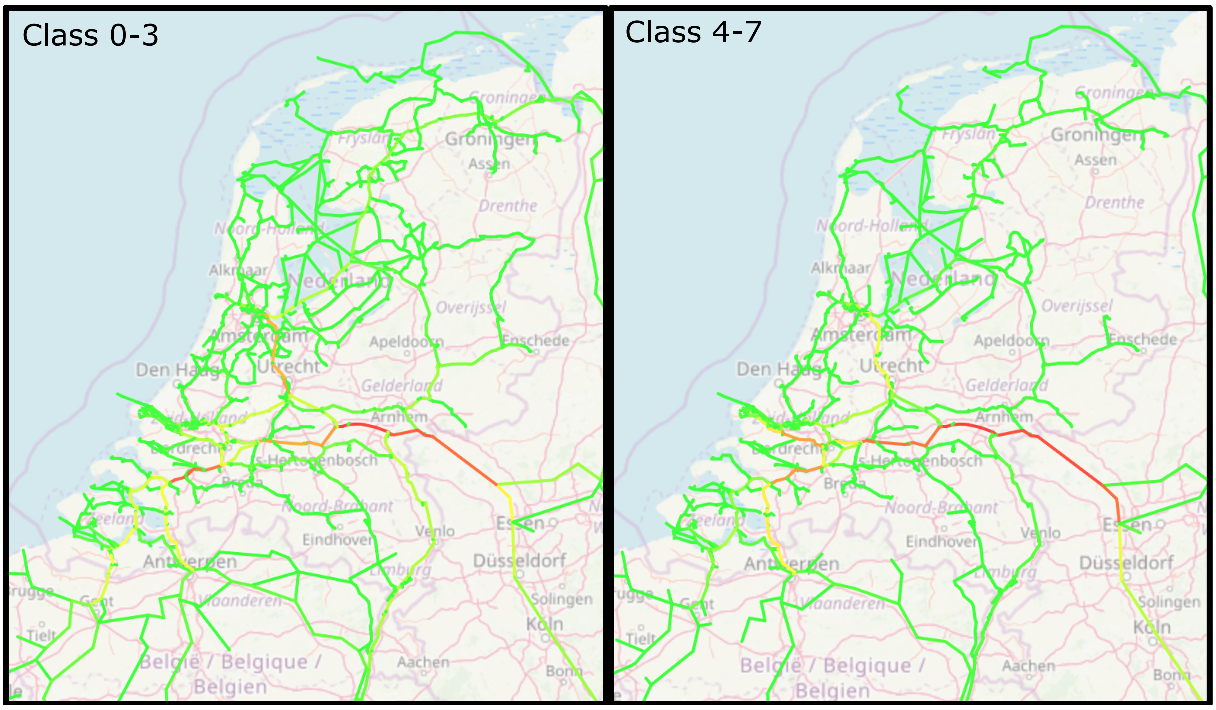


Figure 4.2 Heatmap of sum of tons shipped in the Netherlands in 2017

Source: Charta Software B.V. (2019)

With the two merged travel data files, the variable tonkilometer could be calculated for each trip.

$$Tonkilometre = Total\ tons\ transported\ (including\ packages) \times distance\ (in\ kilometre)$$

Based on the first travel file, also the load factor has been calculated for each trip[20].

$$Load\ factor\ (\%) = \frac{Total\ tons\ transported\ (including\ packages)}{Load\ capacity\ (in\ tons)}$$

The results per CEMT-class per year have been calculated for both tonkilometers and the load factor. The descriptive statistics of the relevant variables in the travel data, used to calculate the results are given in Appendix Table E.1. Remarkable about the summary statistics is that the average load capacity of all the ships is increasing over the years. This supports the economies of scale developments in the inland shipping sector.

Because the performance of the ships specifically per CEMT-class is important for this study, a shift share analysis has also been applied to the growth in the number of tonkilometers per year. The shift share analysis is done for the growth of

[20] This could not be done for 8,493 trips (0,3% of the total trips) because the load capacity of some ships is unknown.

tonkilometers of trips within the Netherlands of all dry ships from all countries. The shift share analysis (Dunn, 1960) has been developed for regional economic research. The analysis indicates the regional growth effects for a specific sector, whereby the actual growth is split into national growth, industry mix and regional shift. For this research, it is assumed that the actual growth in tonkilometers consists of the overall growth of inland shipping, growth of shipped dry goods and the specific CEMT-class shift. To use the shift share method, it is assumed that there are no growth spill over effects between different CEMT-classes.

$$\text{Actual growth per CEMT} - \text{class} = \text{Total growth (TG)} + \text{Goodtype mix (GM)} + CEMT - shift\ (CS)$$

To do the shift share analysis, the number of tonkilometers in total, dry goods and liquid goods per CEMT-class is calculated for each year (Appendix Table E.8). The total growth, good type mix and the CEMT-class shift is then calculated for each CEMT-class for each year, based on the formulas below. The results can be found in Appendix Table E.9.

$$Total\ goods = tonkilometres\ dry\ goods + liquid\ goods\ of\ all\ CEMT - classes$$

$$Dry\ total = tonkilometres\ of\ dry\ goods\ shipped\ of\ all\ CEMT - classes$$

$$Dry\ goods = tonkilometres\ of\ dry\ goods\ per\ CEMT - class$$

$$Total\ growth\ (TG) = Dry\ goods^{t-1} \times \frac{Total\ goods^{t}}{Total\ goods^{t-1}}$$

$$Goodtype\ Mix\ (GM) = \left(Dry\ goods^{t-1} \times \frac{Dry\ total^{t}}{Dry\ total^{t-1}}\right) - TG$$

$$CEMT - class\ shift\ (CS) = Dry\ goods^{t-1} \times \left(\frac{Dry\ goods^{t}}{Dry\ goods^{t-1}} - \frac{Dry\ total^{t}}{Dry\ total^{t-1}}\right)$$

The results of the tonkilometers, the load factor and the shift share analysis per CEMT-class, are described in chapter 5.3.

4.4 Throughput data inland ports

The data about throughput at inland ports is available via CBS. The data is available from 2011 to 2018 and consists of throughput data in tons and the number of containers in TEU[21] of inland vessels in inland ports in the Netherlands. Because of company-sensitive data, this is not classified per inland port but at municipality level. The throughput consists of all good types, so liquid bulk, dry

[21] Twenty-foot equivalent unit

bulk, break bulk and containers. So, the data also contains liquid bulk and that is an issue for this research.

To quantify the issue of liquid bulk in the throughput data, the register fleet data from the IVR is reviewed. Of the total number of cargo ships that can reach the Dutch inland ports located on waterways with CEMT-class 3 and lower (3,761), 10.7% of the ships are liquid bulk ships (Table 4.3). Since only 10.7% of the small ships transporting cargo in small inland ports are tankers, the performance of the liquid bulk sector cannot have a major effect on the throughput of inland ports. In addition, many of those small tankers are operating in the large seaports of Rotterdam and Amsterdam, to supply larger ships with fuel. Those ships are therefore not transporting liquids, but they are service vessels. In short, this will not lead to invalidation of the analysis of throughput of small inland ports in the Netherlands.

Table 4.3 Distribution of number of small ships among dry and liquid bulk shipping of Dutch fleet July 2019

Type of shipping		**CEMT-class 0-3**	**CEMT-class 4-7**
Dry shipping	5,725	3,360	2,365
Tank shipping	1,058	401	657
Tow and tug ships	1,181		
Passenger shipping	1,133		
Other shipping	764		
Total	9,861		

Source: IVR (2019a)

The throughput data of CBS is the total weight in tons including packaging. Because several municipal reclassifications have taken place in the Netherlands between 2011 and 2018, the figures of some municipalities have been combined. Due to shifts in municipal boundaries, it is possible that throughput numbers from the past do not entirely belong to the right municipality. This is limited to a few cases and has no negative effect on the analysis of this study. After reclassification, there are 296 municipalities in the data set. Dutch municipalities without throughput are not included in the dataset. Despite this, 10 municipalities were removed because the throughput was 0 tons over the entire period. In addition, 29 municipalities have been removed because they are not located along any waterway and therefore could not be classified according to the Rijkswaterstaat waterway information map (Rijkswaterstaat, 2019b). Why there are a few tons of throughput reported for these municipalities is unclear.

Using the same waterway information map, all other inland ports, 257, are classified in CEMT-class. The classification is based on the following criteria:

- Basically, all municipalities are assigned the CEMT-class of the waterway along which this port in the municipality is located.
- If the port entry in a municipality has a separate CEMT-class designation than the waterway, the class of the port entry is assigned.
- If a waterway has a certain CEMT-class and this waterway cannot be reached by a waterway with the same class or higher, the CEMT-class that is assigned to it is the class of the waterway with the highest CEMT-class that provides accessibility.

- If two separate ports with different CEMT-classes are located within one municipality, the highest class is assigned to the municipality. This is because, if necessary, larger ships can also reach the municipality via the other port.

The distribution of the number of inland port municipalities per CEMT-class is given in Appendix Table F.1. The results of the throughput data are described in chapter 5.4. After analysing the results, it turned out that there was an excessive increase in throughput of class 2 inland municipalities in 2014 (+104.9%). This increase was caused by the municipalities of Almere and Diemen. The Rijkswaterstaat trip data showed that many raw minerals and construction materials were transported between these municipalities, with class 3 and 4 ships. This means that this was not throughput at inland ports, but most likely transport to and from dredging works to the quay[22]. For this reason, the increase in 2014 throughput of Almere and Diemen has been removed from the dataset.

4.5 Data and methodology for effects on inland shipping

In this part the data and methodology that is used for the model to estimate the effects on the performance of inland shipping will be discussed. Starting with the dependent variable, followed by the explanatory variables and lastly the control variables. After that, the methodology is discussed and finally the summary statistics will be showed.

4.5.1 Share of tons transported by small ships

The performance of small dry inland shipping will be explained as the share of tons transported by small ships relative to the total tons transported towards a region. Many aspects are influencing the total amount of tons transported by inland shipping and when taking the share of small shipping these effects are controlled for. In the travel data of Rijkswaterstaat from 2014 to 2018 the origin and destination per trip is specified, divided into several NUTS level regions. Based on this, the number of tons transported towards a region with ships per CEMT-class can be calculated. Dry cargo, be it from all origins, is the only form of cargo included. Only destination regions in the Netherlands are considered, because this is a study into the small dry inland shipping in the Netherlands. It is assumed here that at the destination the entire freight load is unloaded, and that freight is not circulating in dry inland shipping. This may be the case with container transport and that is a limitation of the model.

Calculating with the throughput data per municipality would also have been possible, but there was no difference in ship size in this dataset, so only an analysis of the municipalities along small waterways would have been relevant for this study. In addition, the CEMT-class is manually classified per municipality and is therefore susceptible to errors. For the trip data, the 6 seaport regions in the Netherlands are not included in the model[23]. This is because throughput at those regions has mostly nothing to do with demand for goods in that region but more

[22] It is likely that a large number of tons sand was used from dredging works in the Gooimeer in 2014 for the renovations of the A1-A6 highways at Diemen.

[23] Groot-Rijnmond – Groot-Amsterdam – Zeeuwsch-Vlaanderen - Overig Zeeland – Overig Groningen – Kop van Noord-Holland

with throughput to sea-going transport. This adjustment does not change the throughput numbers in non-seaport regions of which also transport movements from and towards regions with a seaport has taken place.

For the share of small ships, the tons transported by ships of class 0 to 3 is divided by the total number of tons transported to that region. CEMT-class 0 to 3 is the definition of small as is described in chapter 2.2. The share of small ships as dependent variable also eliminates the problem of simultaneity bias. When estimating the number of tons of transported, the question is whether a higher gross regional product will lead to more transport to a region or whether more transport to a region will lead to a higher gross regional product. However, gross regional product is not directly affected by the share of small ships of total transport. As a result, the effect of gross regional product on the share of small ships can be estimated in an isolated manner.

4.5.2 Gross regional product

Gross regional product (GRP) data is obtained via open data of the Dutch national statistical institution (CBS) (CBS, 2018). This data is available from 2013 up to and including 2017 and gives the GRP in million euros[24]. Data of 2013 has also been included so that a possible effect of a lagged variable can be estimated. Data about 2018 will become available in December 2019 and has therefore been calculated based on imputation. The growth factor of the national gross product (GNP) from 2017 to 2018, is multiplied by the 2017 GRP. It is therefore assumed that there are no significant regional deviations from national economic growth. The logarithm of the GRP has also been calculated for each year in order to check for the skewed distribution of GRP. To check the results of the study of Sys & Vanelslander (2011), also for this data the effect of GNP on the share of small inland vessels was estimated. As expected, this did not produce explanatory results.

4.5.3 Water level

In order to estimate the effect of low tide on the inland shipping sector, data is requested via Rijkswaterstaat about the water level on the Rhine at the location 'Lobith'. This measurement point has been chosen because this is the general point that indicates whether the Netherlands is or will be dealing with a low water level (Rijkswaterstaat, 2019i). The tons transported to a region (dependent variable) are from all kinds of destinations and therefore it is interesting to look at the obstruction for inland shipping as a whole. This data is also available for several measuring points in the Netherlands, but then it would have to be determined separately for each region which measuring point is a good approximation of the water level in that region. Because several waterways with separate water level management, flow through one region, it was decided not to do this. This would be too difficult and will cause errors. The water level at Lobith gives a good general idea of the situation on Dutch inland waterways.

[24] 2016 and 2017 are provisional figures

The data is obtained via Rijkswaterstaat (2019k) and is about the level of the surface water in centimetres compared to Het Normaal Amsterdams Peil[25]. The data was measured every 10 minutes and the average per day was calculated, then the number of days per year that this average is below 750 centimetres is added, because if the level at the measuring point at Lobith is below 750 centimetres, Rijkswaterstaat gives a warning for low water level and the possibility of obstruction for inland shipping (Rijkswaterstaat, 2019l).

4.5.4 Locational aspects

To control for regional differences other than NUTS 3 level, the interaction with NUTS 1 level, NUTS 2 level and 'river area' is also included. NUTS 1 level divides the Netherlands into a north, east, south and west section. NUTS 2 level is a distribution of the Netherlands at provincial level. The different NUTS levels are given for each destination region in the trip data. The dummy variable river area is 1 for all regions along or through which one or more of the following rivers flow, Rhine (and its components), Maas, Waal and IJssel, as is introduced in chapter 3.5.4.

4.5.5 Average distance towards a region

The average distance travelled within the Netherlands is calculated based on the trip data from Rijkswaterstaat. The number of kilometers travelled is given for each trip and the average number of kilometers travelled with loaded trips to that region has been calculated for each destination region. Since the effect of distance travelled is not expected to be linear but increasingly marginal, the logarithm of each average has been calculated. This variable has been added to the model as a control variable.

4.5.6 Methodology

To estimate the effect of economic growth (GRP) and the water level on the share of tons transported by small vessels in inland shipping to a region, a fixed effects model is estimated. This model controls for specific characteristics of a region. In a fixed effects model the regions serve as their own controls. Time-invariant omitted variables that affect the share in transport of small ships towards a region are no issue. For example, if an inland port is of a certain size that makes it very beneficial to ship with bigger inland vessels, it is assumed that this is the case in all the years of the sample. In the model the NUTS 3 level region is the panel and year is the time variable. The following four fixed effects panel data regressions are estimated.

[25] Het Normaal Amsterdams Peil (NAP) is the general measurement point in the Netherlands for the level of water and land compared to an average sea level (Stichting NAP, 2019).

Regression equation 1

$$Share\ tons\ class\ 0-3_{it} = \beta_0 + \beta_1 * GRP\ (log)_{it} + \beta_2 * Av.dist.(log)_{it} + \beta_3 * Low\ tide\ days_{it} + \alpha_i + u_{it}$$

Regression equation 2

$$Share\ tons\ class\ 0-3_{it} = \beta_0 + \beta_1 * GRP\ (log)_{it} + \beta_2 * Av.dist.(log)_{it} + \beta_3 * Low\ tide\ days_{it} + \beta_4 * Low\ tide\ days_{it} * NUTS\ 1\ region_i + \alpha_i + u_{it}$$

Regression equation 3

$$Share\ tons\ class\ 0-3_{it} = \beta_0 + \beta_1 * GRP\ (log)_{it} + \beta_2 * Av.dist.(log)_{it} + \beta_3 * Low\ tide\ days_{it} + \beta_4 * Low\ tide\ days_{it} * NUTS\ 2\ region_i + \alpha_i + u_{it}$$

Regression equation 4

$$Share\ tons\ class\ 0-3_{it} = \beta_0 + \beta_1 * GRP\ (log)_{it} + \beta_2 * Av.dist.(log)_{it} + \beta_3 * Low\ tide\ days_{it} + \beta_4 * Low\ tide\ days_{it} * River\ area_i + \alpha_i + u_{it}$$

Where
- α_i (*i*=1,…n) is the unknown intercept for each region
- t is time in years (2014 to 2018)
- u_{it} is the error term

The explanatory and controlling variables used were tested for correlation issues, but this did not cause any problems (Appendix Table G.1). Thereafter a Hausman test was done to check whether the unique errors (u_{it}) are correlated with the regressors. The outcome indicated that the null hypothesis of no correlation between the unique errors and the regressors cannot be rejected. So fixed effects estimations are the most suitable to use in this case. Finally, the model was estimated with robust standard errors to check if the standard errors of the original model are homoscedastic. It turned out that they were, so there is no need to control for heteroskedasticity.

4.5.7 Summary statistics

The panel data summary statistics of the fixed effects model variables are shown in Table 4.4. The following clarifications about those statistics are needed. Firstly, after removing the regions with a seaport, 34 NUTS 3 level regions remained for the Netherlands. The trip data is available over a 5-year period from 2014 to 2018. Secondly, the high average share of small vessels per region (51.1%) is obviously due to regions that can only be reached with small vessels and therefore have a value of 1 throughout the entire time period. Thirdly, one period of time has been added for GRP (2013) to also be able to add the lagged effect. That did not yield significant results and did not improve the explanatory power of the model. Lastly, the variable low tide days varies from 0 days to 141 days. 2014 was the 'wettest' year (0) and 2018 the 'driest' year (141), with almost twice as many dry days as the average over the complete period.

Table 4.4 Panel data summary statistics of fixed effects model variables

Variable		**Mean**	**Std. Dev.**	**Min**	**Max**	**Obs.**
Share tons class 0-3	Overall	0.511	0.287	0.085	1	N = 170
	Between		0.281	0.096	1	n = 34
	Within		0.069	0.280	0.917	T = 5
GRP in million euro	Overall	15,015	12,432	2,375	70,626	N = 204
	Between		12,504	3,166	63,468	n = 34
	Within		1,439	8,755	22,172	T = 6
Low tide days	Overall	51.800	48.233	0	141	N = 170
	Between		0	51.800	51.800	n = 34
	Within		48.223	0	141	T = 5
River area	Overall	0.412	0.493	0	1	N = 170
	Between		0.500	0	1	n = 34
	Within		0	0.412	0.412	T = 5
Average distance kilometer	Overall	143.877	63.601	52.797	413.761	N = 170
	Between		63.751	68.264	381.042	n = 34
	Within		8.779	109.193	176.596	T = 5

5. Results of the small dry inland shipping analysis

In this chapter the results of the performance analysis per performance indicator and the fixed effects regression estimated effects on inland shipping will be showed and described. The first part of the main question of this research, how small dry inland shipping in the Netherlands performed will be answered. Subsequently, the answer to sub question E, which variables are influencing this performance, will be discussed.

5.1 Fleet

Table 5.1 Dutch registered shipping fleet per CEMT-class in July 2019 (created by author based on Appendix Figures C)

CEMT-class	Number of ships	Cumulative load capacity (in tons)	Percentage of total load capacity %	Peak construction year
0	1,153	145,427	2.2	1930
1	316	73,674	1.1	1962
2	555	265,898	4.0	1964
3	1,109	946,042	14.1	1965
4	741	1,036,224	15.4	1972
5	1,338	3,674,907	54.8	2008
6	177	568,156	8.5	2008
Total	5,389	6,710,328	100.0	1964

Source: IVR (2019a)

The development of both the registered and the active Dutch small inland shipping fleet has been analysed. De load capacity per class of class 0 to 2, relative to the total load capacity of all the inland ships, is very small (less than 5%). From class 3 onwards the cumulative load capacity of the class sizes is getting meaningful. Class 5 ships is the largest number of registered ships and the cumulative load capacity is also by far the biggest, more than half of the total fleet. Considering the peak construction year per CEMT-class, the year in which the most ships are built, shows an increasing trend (Table 5.1). For every CEMT-class higher, the peak year of construction also increases. This supports the expectation that on average the smaller the ship the older the ship is. This probably has everything to do with the technological development over the years to build larger ships and the economies of scale that larger ships offer. Besides, the high number of registered ships in class 0 is remarkable. This class of cargo-carrying ships with a load capacity of less than 250 tons does not seem to be the most used ship class at this time. The question is therefore whether these ships are still actively sailing.

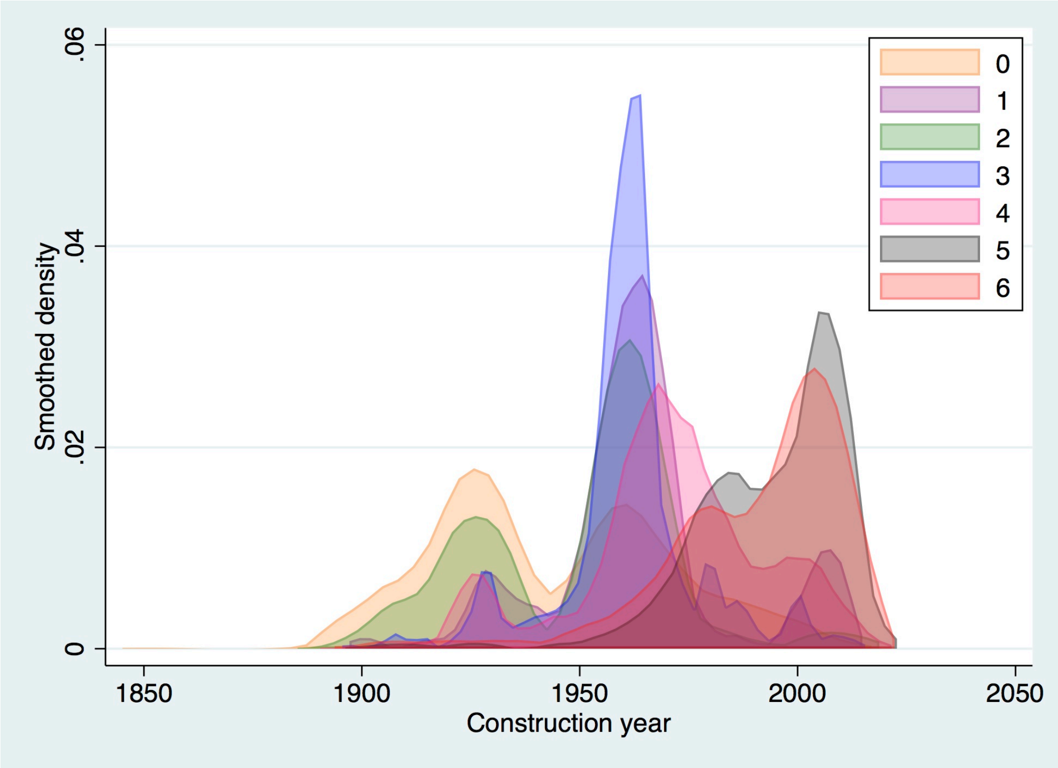


Figure 5.1 Kernel density graph of construction year of Dutch registered shipping fleet per CEMT-class (created by author)

To give an overview of the development of the year of construction of the ships from different classes, a Kernel density graph has been created (Figure 5.1). The figure shows the results of the Kernel density estimators that approximate the density of the different construction years in the dataset. It is obvious that there are a lot of ships build around 1930 in class 0 and 2. In addition, many ships of CEMT-class 1, 2, 3 and 4 were built in the 60s and 70s and in particular class 5 and 6 ships are much younger and built after 2000. The yellow and red surface clearly shows that the larger ships are much younger than the smaller ships. To express this in figures, for class 0 till 3 only 101 ships were built after 2000. For class 4 till 6, 757 ships were built after 2000. Class 4 appears to be a kind of transition class of which few ships have been built in the last 20 years.

Table 5.2 Number of active ships per year on Dutch waterways per CEMT-class and CEMT-class aggregated

	CEMT-class							
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**Total**
2007	346	651	715	1,865	1,310	1,324	875	7,086
2008	296	662	675	1,737	1,241	1,401	885	6,897
2009	311	612	651	1,665	1,229	1,418	822	6,708
2010	368	602	666	1,640	1,241	1,770	807	7,094
2011	398	576	679	1,598	1,277	1,993	1,041	7,562
2012	364	581	642	1,529	1,259	1,887	949	7,211
2013	326	522	600	1,459	1,205	1,846	928	6,886
2014	336	492	593	1,407	1,152	1,937	900	6,817
2015	316	441	581	1,338	1,172	1,839	918	6,605
2016	277	349	538	1,288	1,137	1,839	911	6,339
2017	278	359	505	1,290	1,118	1,946	840	6,336
2018	250	332	478	1,221	1,068	1,923	990	6,262

	CEMT-class aggregated and percentage of total						
	Definition 1		Definition 2		Definition 3		
	0-2	**%**	**0-3**	**%**	**0-4**	**%**	**Total**
2007	1,712	24.2%	3,577	50.5%	4,887	69.0%	7,086
2008	1,633	23.7%	3,370	48.9%	4,611	66.9%	6,897
2009	1,574	23.5%	3,239	48.3%	4,468	66.6%	6,708
2010	1,636	23.1%	3,276	46.2%	4,517	63.7%	7,094
2011	1,653	21.9%	3,251	43.0%	4,528	59.9%	7,562
2012	1,587	22.0%	3,116	43.2%	4,375	60.7%	7,211
2013	1,448	21.0%	2,907	42.2%	4,112	59.7%	6,886
2014	1,421	20.8%	2,828	41.5%	3,980	58.4%	6,817
2015	1,338	20.3%	2,676	40.5%	3,848	58.3%	6,605
2016	1,164	18.4%	2,452	38.7%	3,589	56.6%	6,339
2017	1,142	18.0%	2,432	38.4%	3,550	56.0%	6,336
2018	1,060	16.9%	2,281	36.4%	3,349	53.5%	6,262

Source: Rijkswaterstaat (2019a)

Table 5.2 shows the active fleet for the years 2007-2018. Looking at the yearly growth of number of ships per CEMT-class it is clear that the categories 0 till 4 decreased and categories 5 and 6 increased (Figure 5.2). Remarkable is that the total number of active ships also decreased by 759 ships (11.6%). Looking at the three different definitions of small dry inland shipping and the combined number of active ships, the percentage compared to the total active ships is decreasing over the years for all three definitions. The number of ships defined as small ships in this study, 0 to 3, in total decreased with 36.2%.

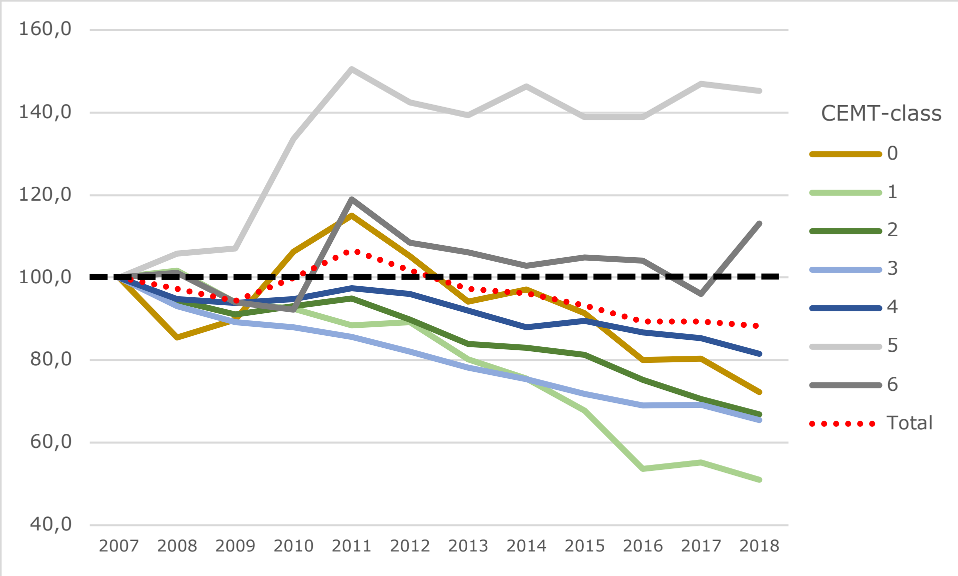


Figure 5.2 Indexed growth of number of active dry ships on Dutch waterways per CEMT-class over 2007-2018 (2007=100) (created by author based on Table 5.2)

The number of actively sailing ships of CEMT-class 1, decreased the most over the period 2007 to 2018 (Figure 5.2). Analysing the data shows that the decrease is mainly in the ship types ‘motor vessels’ and ‘convoys’ within class 1, namely a decrease of 55.3%. The number of actively sailing barges in class 1 increased over the same period, an increase of 38.2%.

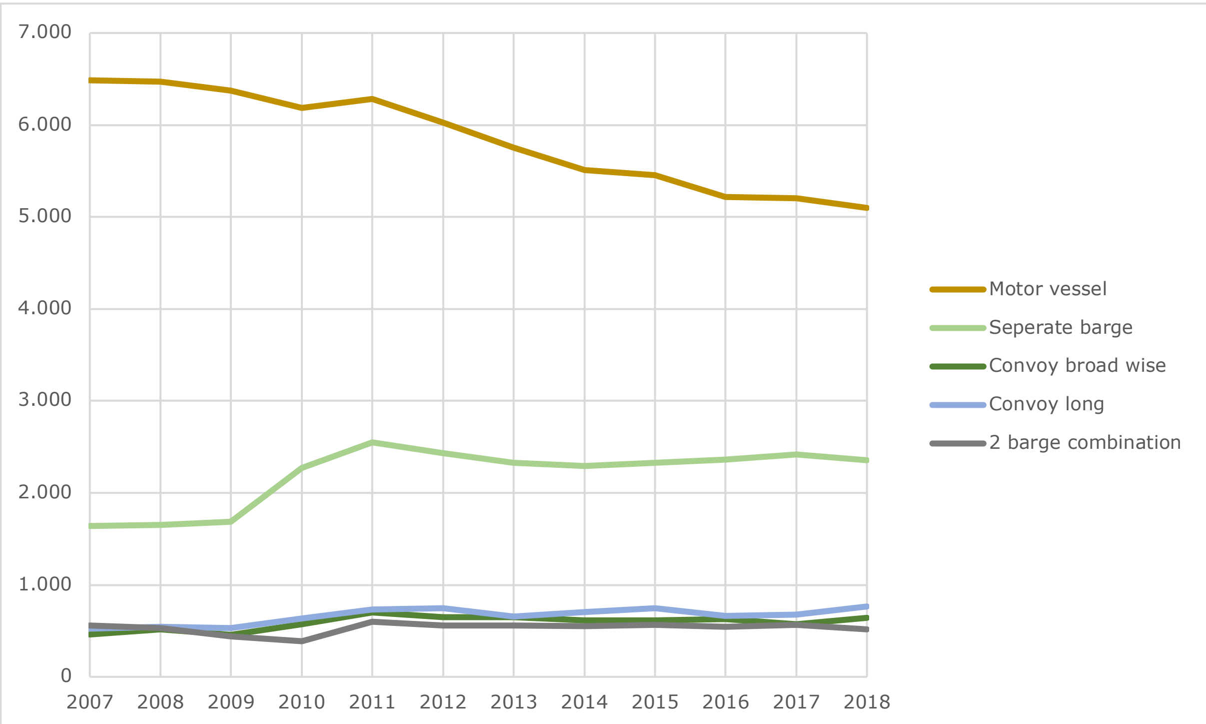


Figure 5.3 Number of ships per year per top 5 ship type 2007-2018 (created by author based on Appendix Table D.2)

In order to zoom in on the decline of the total fleet, Figure 5.3 is created. The development of the top 5 most common ship types in the data is given. These top

5 ship types cover 80.54% of the fleet data. In Figure 5.3 it can be seen that the ship type ‘motor vessel’ is by far the biggest ship type and that the decrease in fleet also occurred mainly in that ship type. Furthermore, more separate barges became active in the period 2007 to 2018. The other three smaller ship types did not have significant developments over the period. So, the decrease in the lower-class ships (Figure 5.2) is probably mainly in motor vessels.

To refer to the question that was raised because of the high number of registered ships in class 0, we have a look at Table 5.2. There are on average 322 ships of CEMT-class 0 actively sailing per year in 2007 to 2018. This means that a lot of registered ships are not actively sailing within the Netherlands. So, there are a lot of small class 0 ships active abroad or just not transporting goods. For all the other CEMT-classes the number of ships actively sailing each year is higher than the number of registered ships in that class. That means that there are of course also ships that are registered abroad, sailing on the Dutch waterways.

Based on the literature and news articles read, the hypothesis for the first indicator was that the development of the number of active small ships in the Dutch fleet was negative. Based on the results this hypothesis cannot be rejected. Looking at the number of active small ships on Dutch waterways it is demonstrated that it is decreasing. This is the case for ships of CEMT-class 0 till 4.

5.2 Waterways

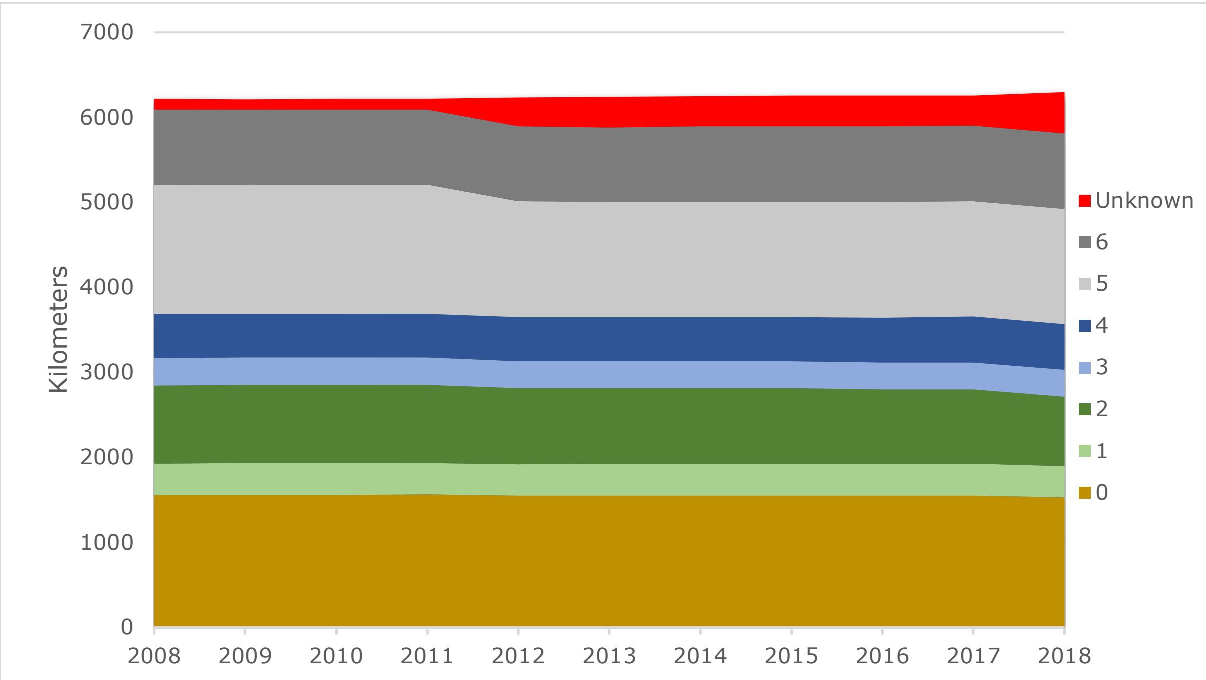


Figure 5.4 Development of total length Dutch waterways per CEMT-class 2008-2018 (created by author based on Appendix Table A.1)

The second performance indicator is the number of kilometers infrastructure that is available for small shipping. The number of kilometers waterway of CEMT-class 0 and 5 are very large in the Netherlands. An increase or decrease in the number of kilometers does not necessarily mean that canals have been constructed. This is often caused by opening up waters as waterways and/or changing the depth of waterways. Adapting locks or bridges is also an important aspect that changes the navigability of a waterway. The total length of all waterways increased by 82 kilometers (1.3%) between 2008 and 2018. The decrease in length of small waterways (classes 0 to 3) is 139 km (-4.4%) in the same time period. The largest decrease in length within the small waterways herein is in 2018 compared to 2017 in class 2, which decreased with 62 kilometers. The reason for this is unknown, but the category 'unknown' increased by 131 kilometers in 2018 and has therefore probably absorbed those kilometers. The other classes have not increased, so there was probably no widening of the waterway.

Rijkswaterstaat indicates that it is currently investigating the reason for the increase in 'unknown' in 2018 (Overheid.nl, 2019). After research on the Rijkswaterstaat website about waterways (Rijkswaterstaat, 2019b), it is striking that the Wilhelminakanaal between Oosterhout and Tilburg is unspecified at the moment. After searching online, it appears that maintenance is planned there for expansion of the waterway (Rijkswaterstaat, 2019f). After contacting the Asset Management department of Rijkswaterstaat Noord-Brabant, this was confirmed. Locks construction adjustment is taking place to widen that part of the waterway, with the aim of limiting class 4[26]. The decrease in class 5 in 2012 and 2018 is also both absorbed by 'unknown'. A possible cause of this may be that some waterways have become inaccessible or a waterway has been relocated at, for example, the IJsselmeer.

Based on the literature and news articles read, the hypothesis for the second indicator was that the number of kilometers small waterways was not changed. This hypothesis is rejected by the fact that the length of small waterways is decreased by 4.4% from 3,170 km to 3,031 km. Whether such a relatively small decrease is really a negative development for the performance of small dry inland shipping, is the question.

[26] A limiting class means that ships of that class are allowed to sail on a certain waterway but that for example the height (when stacking containers) is limited.

5.3 Transport performance and load factor

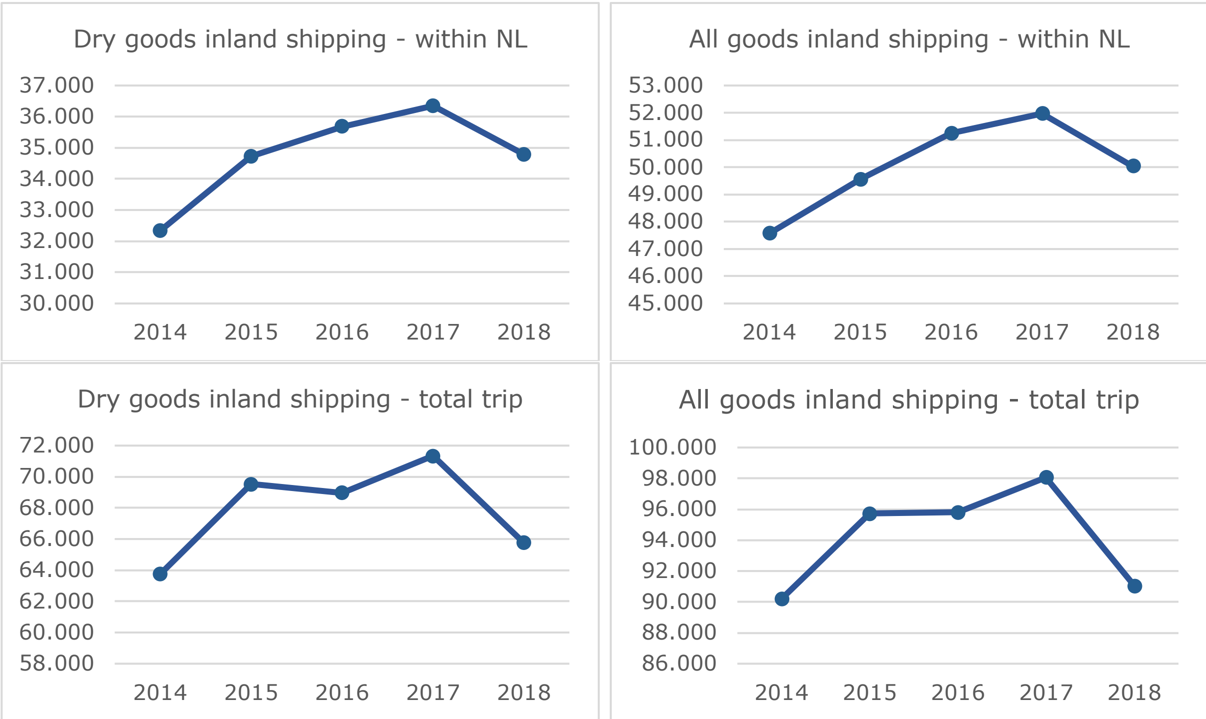


Figure 5.5 Development of total tonkilometers (in million) (created by author based on Appendix Tables E.2-E.5) – splitted in dry and all goods and trip distance within the Netherlands or total trip distance 2014-2018

First, we analyse the transport performance of the complete inland shipping sector. The results of the above-left figure (Figure 5.5), tonkilometers of dry goods shipped within the Netherlands, can be compared with the same facts of dry bulk and containers provided by CBS (Appendix Table E.6). The numbers are about the same and that is a validation of the applied method for these calculations. For all the inland shipping, the tonkilometers are shown in Figure 5.5. A distinction has been made between good type and country in which the trip took place, the kilometers within or outside the Netherlands. The shipped tonkilometers within the Netherlands increased over the years 2014-2017. In 2018 there is a rough decrease. This has all to do with the dry summer period and the resulting low water levels (Binnenvaartkrant, 2019c). Interesting is the dip in tonkilometers in 2016 when adding the total trip kilometers, of abroad. This dip is mainly because of the decrease in transport towards and in Germany (CBS, 2016). In particular, less coal and ore were transported from the Netherlands to Germany.

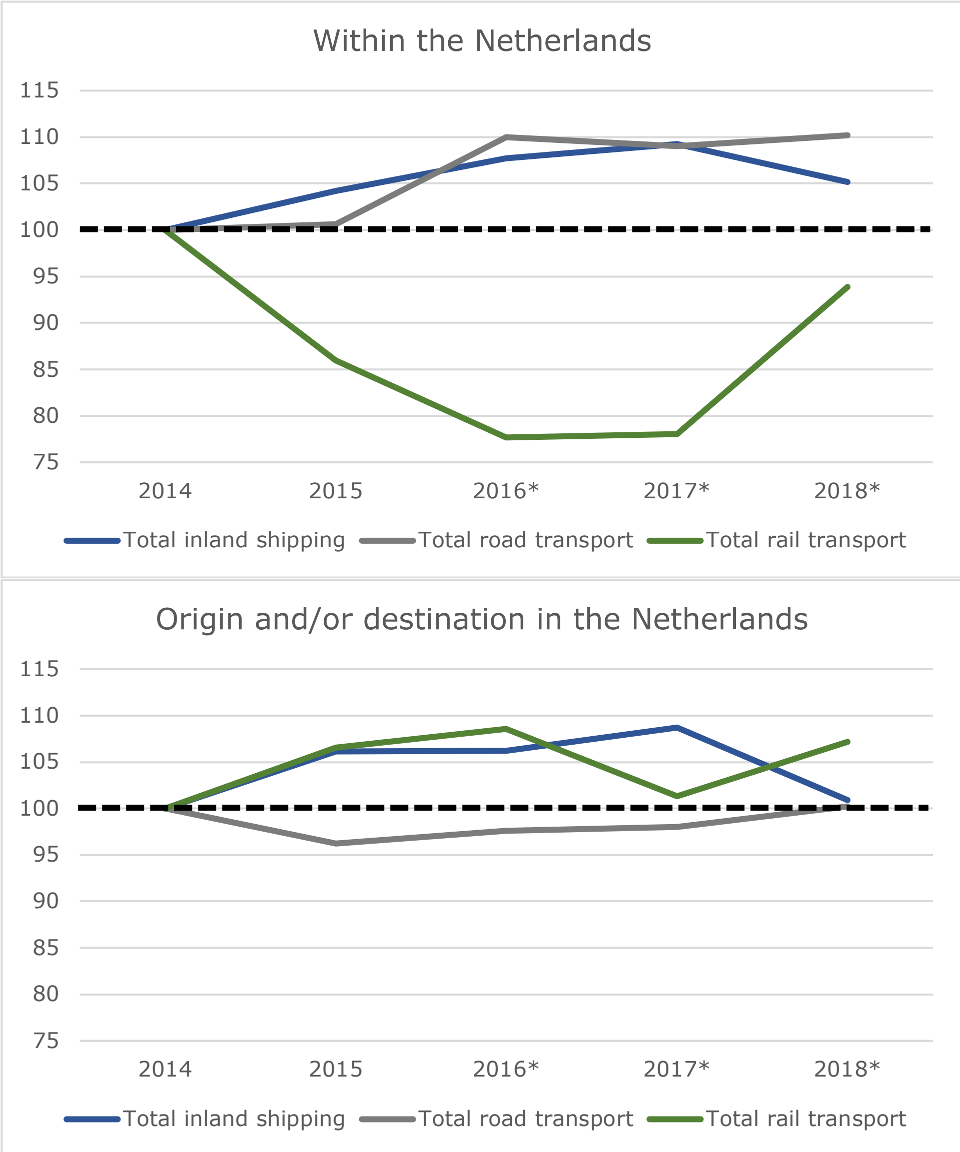


*Figure 5.6 Indexed growth (2014=100) in tonkilometers inland shipping, professional road transport and railway transport for all goods 2014-2018 (created by author based on Appendix Table E.3, E.5 and E.7) - * provisional figures*

The tonkilometers of all goods shipped for inland shipping, can be compared with the same statistics about road transport and railway transport (Figure 5.6). For transport within the Netherlands, the development of both inland shipping and road transport is kind of the same. Only in 2018 did the tonkilometers for inland shipping decrease, whilst the tonkilometers for road transport increased somewhat. Railway transport within the Netherlands did not perform very well over the same time period but increased strongly in 2018. This could mean that in a dry year as 2018 was, railway transport transports a part of the inland shipping transport tons. The tonkilometers transport via railway grew, taking also the kilometers outside the Netherlands for transport with origin and/or destination in the Netherlands. On the other hand, road transport with origin and/or destination in the Netherlands decreased over the period 2014 to 2018.

Table 5.3 Total number of trips and average tons and kilometers per loaded trip per CEMT-class dry shipping within the Netherlands 2014-2018 (created by author)

	2014	2015	2016	2017	2018	Average
CEMT-class						
			Number of trips			
0	2,288	2,764	3,195	1,926	1,800	2,395
1	4,586	4,091	3,536	3,612	3,384	3,842
2	34,475	30,341	29,602	27,148	26,424	29,598
3	79,347	84,489	85,425	82,132	81,563	82,591
4	48,167	55,923	56,623	55,697	58,061	54,894
5	62,203	77,442	77,777	80,504	88,845	77,354
6	15,294	20,697	19,935	19,679	22,326	19,586
Total	246,360	275,747	276,093	270,698	282,403	
			Tons			
0	157	203	179	218	215	194
1	293	300	304	296	297	298
2	438	460	465	464	463	458
3	811	808	814	810	788	806
4	1,186	1,137	1,152	1,161	1,124	1,152
5	1,751	1,729	1,775	1,789	1,697	1,748
6	3,931	3,755	3,947	3,875	3,308	3,763
Total	8,567	8,391	8,636	8,611	7,893	
			Kilometers			
0	66.8	76.3	58.9	72.5	72.1	69.3
1	124.0	124.3	136.2	130.3	125.5	128.1
2	105.5	112.5	110.3	112.8	112.3	110.7
3	120.5	122.5	122.3	122.0	121.1	121.7
4	135.5	133.2	137.2	138.2	134.3	135.7
5	151.9	152.5	157.2	154.8	150.3	153.3
6	153.7	157.4	155.0	158.3	157.7	156.4
Total	858.0	878.7	877.1	888.8	873.4	

In Table 5.3 the number of trips, the average tons and the average kilometers per loaded trip within the Netherlands for dry shipping are given. Analysing this data provides the insights that for class 0 to 2 the average tons increases and for class 3 to 6 the average tons decreases over the period. The number of trips decreased for class 0 to 2 ships. The bigger the ship is the more kilometers are travelled on average per trip. This also supports to control for average distance to a region in the fixed effects model discussed in Chapter 5.6. Besides, the average kilometers per trip is increasing for almost all CEMT-classes.

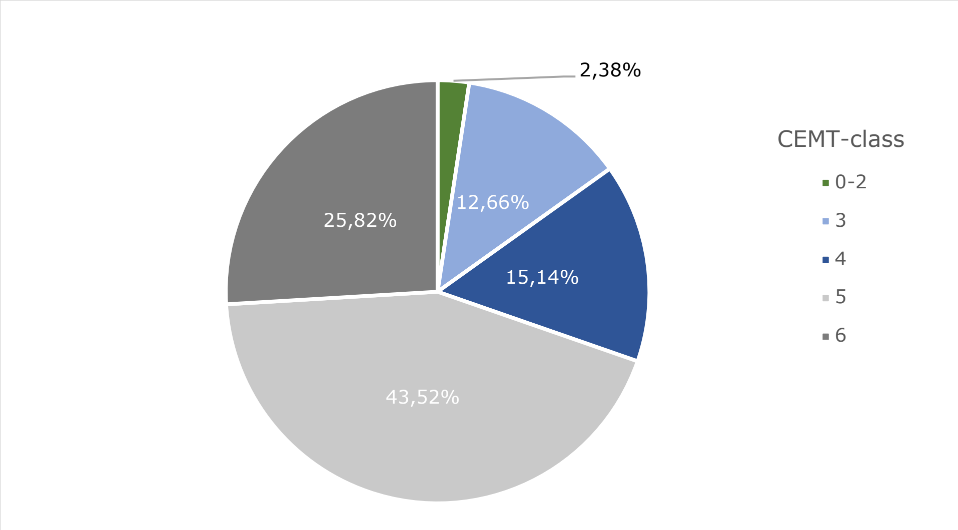


Figure 5.7 Average share in tonkilometers of total tonkilometers dry goods shipped in the Netherlands per CEMT-class 2014-2018 (created by author based on Appendix Tables E.2-E.5)

The share of tonkilometers per CEMT-class of the total tonkilometers transported varies widely. CEMT-class 0, 1 and 2 are taken together because otherwise their share is even too small to express in a figure. From class 3 and higher, the different classes have a reasonable share of the total (Figure 5.7). CEMT-class 5 is by far the largest CEMT-class in terms of share of total tonkilometers.

Figure 5.8 Average yearly growth of tonkilometers per aggregated CEMT-classes 2015-2018 (created by author based on Appendix Tables E.2-E.5)

Figure 5.8 shows the average yearly growth in tonkilometers for the different definitions of small dry shipping. First thing to notice is the lack of difference in performance between dry inland shipping and total inland shipping within the Netherlands. Only when taking the tonkilometers of all goods, the average growth rates are a bit less extreme. For example, 5.5% decrease instead of 6.7% decrease. Taking the 'smallest' definition of small dry shipping the average decrease in tonkilometers per year is the most negative. When adding respectively class 3 or class 4 to the definition of small dry shipping, the average decrease is improving. At the same time, when the definition of small dry shipping is broader, the definition of other shipping is more precise. The performance in tonkilometers of the other shipping is then improving because the best performing classes are 5 and 6. So, it is clear that small dry inland shipping is performing poorly in comparison with larger scale shipping, in terms of tonkilometers. Widening the definition of small dry shipping, can improve the negative view a bit, but still the average yearly growth in tonkilometers of small ships is decreasing over the years 2014-2018.

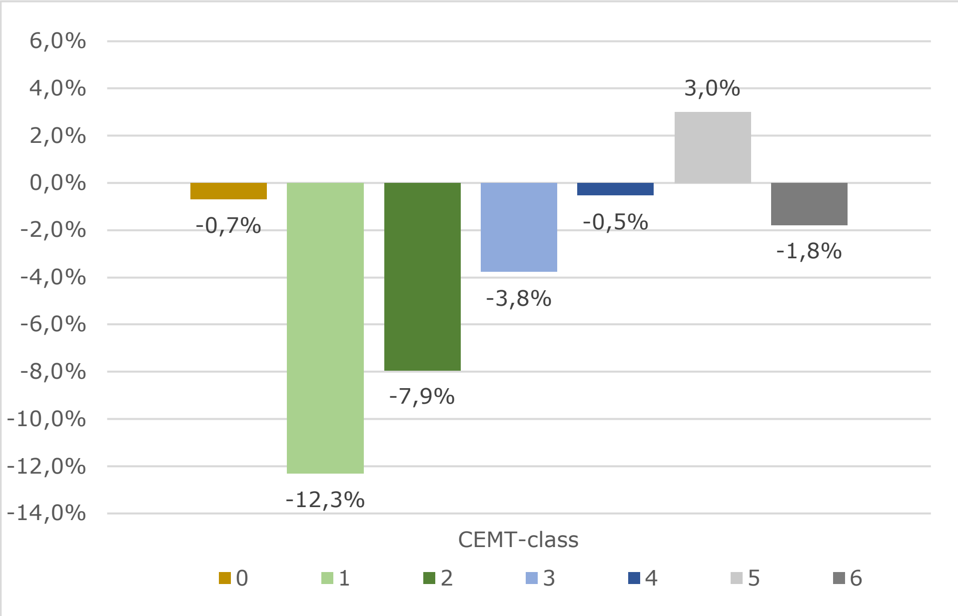


Figure 5.9 Average yearly growth 2015-2018 in share of total tonkilometers dry goods shipped in the Netherlands per CEMT-class (created by author based on Appendix Tables E.2-E.5)

To make it even more clear, Figure 5.9 shows that in particular classes 1, 2 and 3 are the ones really performing negatively, on average over the years 2014-2018. Figure 5.9 is about dry shipping within the Netherlands. Comparing with the shipping of all goods and shipping outside the Netherlands (Appendix Figure E.1) there are hardly any significant differences between these. Given that the average tons per trip for class 1, 2 and 3 did not decrease and the average kilometers per trip also did not decrease over the period. Together with the fact that the total tonkilometers for these categories is on average decreasing every year, there are less goods in total transported with ships of that size. The ships that were transporting goods were not transporting less tons or sail over a shorter distance. This development also corresponds to the decrease in active small vessels on the Dutch waterways over (chapter 5.1).

To expand the analysis of tonkilometers, it was desirable to zoom in on the development of tonkilometers per different type of goods. However, goods types in the available data are not specified for all trips. For classes 4 to 6, the type of goods is known for only about half of the trips. For classes 0 to 3, even for just about a quarter of the trips. An analysis of this would therefore give a distorted result of the actual transport performance.

Table 5.4 Shift share analysis output – CEMT-shift per CEMT-class per year (created by author based on Appendix Table E.9)

CEMT-class	2015	2016	2017	2018	Absolute average*	Tonkilometer average**	Relative average***
0	-0.23	-0.86	0.93	-0.17	-0.08	7.87	-1.0%
1	-20.06	-8.39	-2.81	-6.35	-9.40	67.71	-13.9%
2	-165.46	-41.90	-58.06	-8.14	-68.39	937.02	-7.3%
3	-397.70	-4.16	-280.65	-30.54	-178.26	4,805.26	-3.7%
4	-217.89	141.49	-66.62	25.99	-29.26	7,220.68	-0.4%
5	705.69	7.03	555.35	538.52	451.65	24,116.16	1.9%
6	217.69	-131.52	-240.97	-441.13	-148.98	12,757.82	-1.2%

* Absolute average CEMT-shift effect 2015-2018 (average of column 2-5).
** The average of tonkilometers per CEMT-class over the years 2014-2018.
*** Relative average CEMT-shift effect 2015-2018 (column 6 divided by column 7).

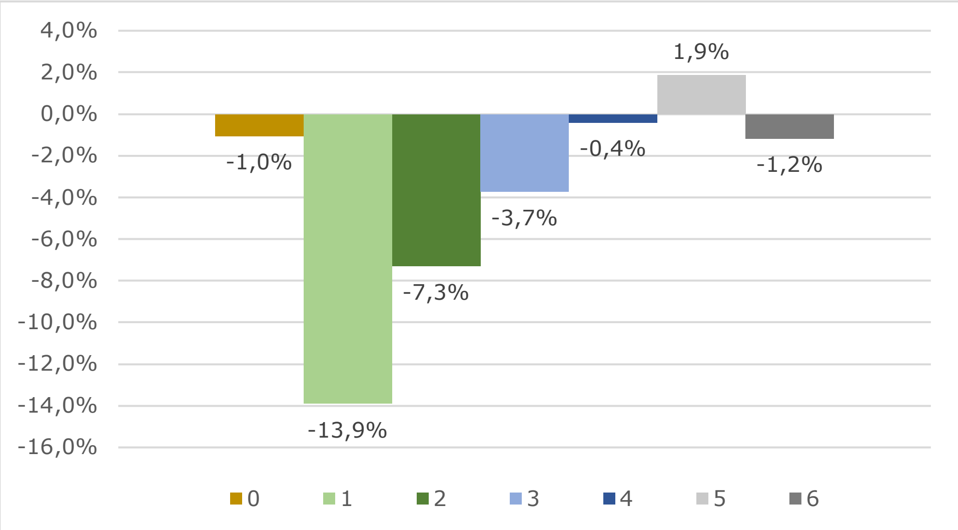


Figure 5.10 Relative average CEMT-shift effect for tonkilometers per CEMT-class 2015-2018 (created by author based on Table 5.4)

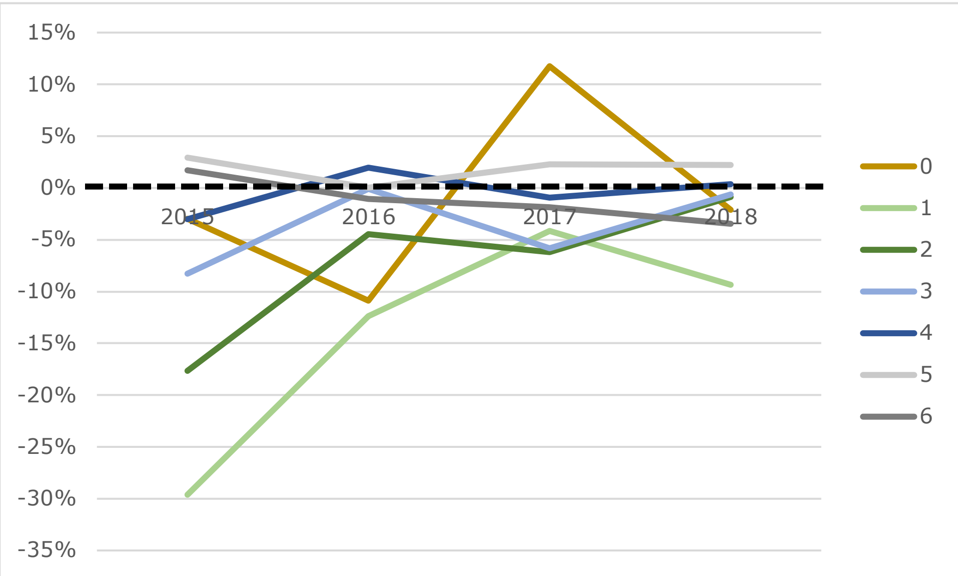


Figure 5.11 Yearly growth in CEMT-shift effect relative to average tonkilometers per CEMT-class 2015-2018 (created by author based on Table 5.4)

To get an even more reliable picture of the effect per CEMT-class, a shift-share analysis has been done for the trips within the Netherlands. Using this methodology, the specific development of growth per CEMT-class can be separated from the total growth in inland shipping and the growth of dry shipping. The results of the analysis are shown in Table 5.4. Again, classes 1, 2 and 3 are the classes that are decreasing over the years (Figure 5.10 and 5.11). The results show that classes 1, 2 and 3 are performing more worse than classes 4, 5 and 6. The CEMT-classes defined as small, 0 to 3, together have a decrease in tonkilometers of 4.4%.

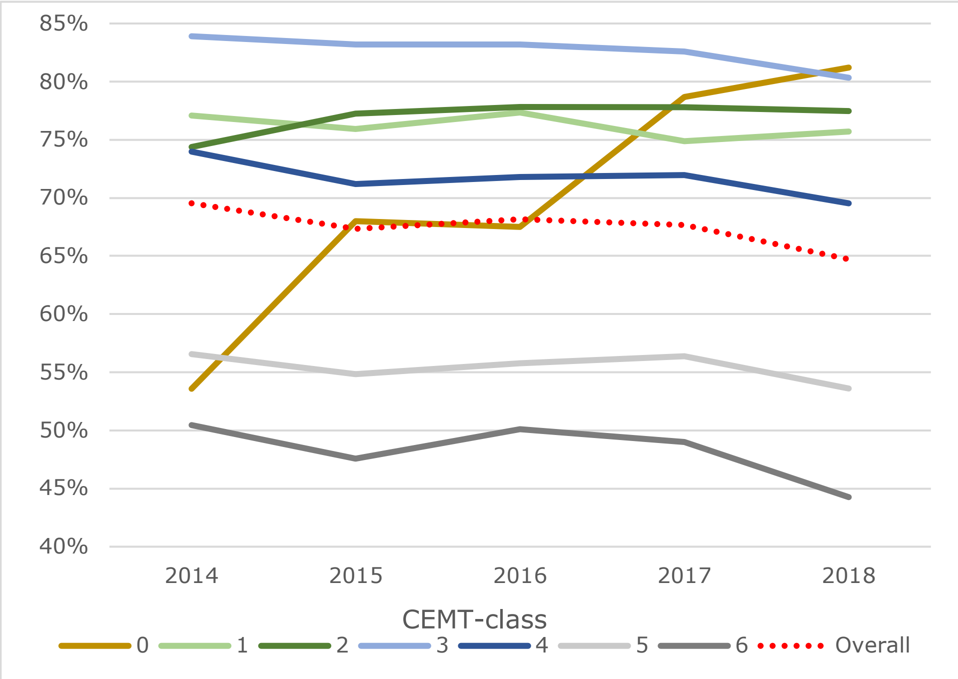


Figure 5.12 Average load factor of loaded trips dry shipping within the Netherlands per CEMT-class 2014-2018 (created by author based on Appendix Table E.11)

To find out more about the efficiency of the ships from different CEMT-classes, the development of the load factors of loaded trips is shown in Figure 5.12. The average load factor varies from 44.3% to 83.9%. Ships of CEMT-class 1 till 4 performed above average for the entire period. The load factors of class 5 and 6 are much lower. For class 5 and 6 this has probably something to do with to load capacity. The load capacity of the biggest ships is of such size that filling up everything with goods is harder than for smaller ships. The load factor of class 2 ships is the only group which had an increase in load factor over the period. For classes 1, 3, 4, 5 and 6 the load factor decreased over the period. The decrease in class 3 to 6 has a lot to do with the year 2018. This has probably to do with the low water levels discussed earlier, because less cargo could be loaded. The load factors for class 0, 1 and 2 ships did not decrease for 2018, probably because of their low draft.

Looking at the overall load factor of all trips (Appendix Figure E.2) there are possibilities for shipping cargo in the 'return' movement. More about this in chapter 6.4. In summary, the development of the number of tonkilometers for ships in classes 1 to 3 is negative, controlled for the total growth of inland shipping and the growth in dry shipping. This does not reject the hypothesis stated in chapter

3.4, in which a negative development was expected. Looking at the load factors, the performance of the small dry inland shipping sector is positive. No hypothesis could be made for the development of load factors based on the literature and news articles.

5.4 Inland ports

Table 5.5 Distribution of the number of port municipalities per CEMT-class in the Netherlands

CEMT-class	Number of municipalities	Percentage %	Cumulative %
0	17	6.6	6.6
1	7	2.7	9.3
2	44	17.1	26.4
3	22	8.6	35.0
4	34	13.2	48.2
5	88	34.2	82.5
6	45	17.5	100.0
Total	257	100.0	100.0

Source: CBS

The last performance indicator that is used the answer the main question of this research is the throughput at inland ports located along small waterways. There are many inland ports located along CEMT-class 2 waterways (17.1% of the total).

Table 5.6 Top 10 municipalities along small waterways (CEMT-class 0-3) in average throughput in tons 2011-2018 (created by author)

Rank	Municipality	CEMT-class	Average throughput 2011-2018
1	Almere	2	2.107.458
2	Nijkerk	3	795.328
3	Delft	2	631.055
4	Steenbergen	2	619.955
5	Súdwest Fryslân	3	602.797
6	Waalwijk	3	487.158
7	Schagen	3	472.596
8	Diemen	2	435.790
9	Helmond	2	393.203
10	Baarn	3	363.127

The top three throughput municipalities with ports along small waterways (CEMT-class 0-3) are Almere, Nijkerk and Delft. So, there are a lot of class 2 inland ports (17.1% of the total) and there are also 3 class 2 inland ports in the top five of small inland ports. This indicates the size and importance of CEMT-class 2 waterways and ships in the Netherlands.

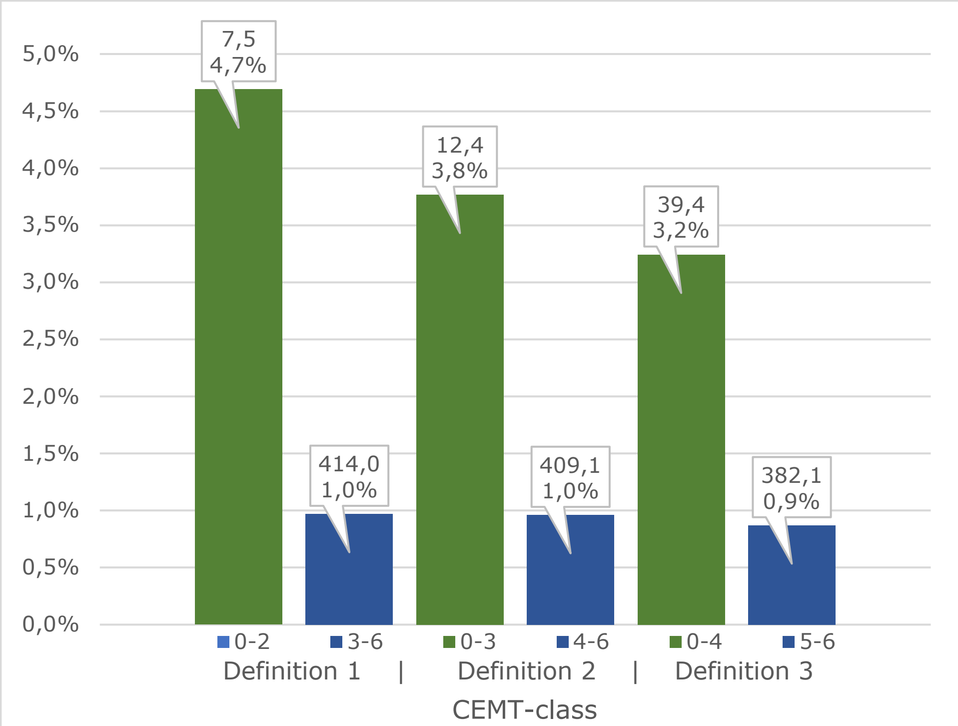


Figure 5.13 Average yearly growth of throughput in tons at inland ports in aggregated CEMT-classes 2012-2018 – above the percentage is the average number of tons throughput in millions for that category (created by author based on Appendix Table F.1)

Looking at the average yearly growth of different aggregated CEMT-classes ports, the ports located along small waterways grew the most (Figure 5.13). When making the definition of small ports wider, the average growth decreases. The positive growth in throughput of ports located along small waterways is very surprising in comparison with the tonkilometer results.

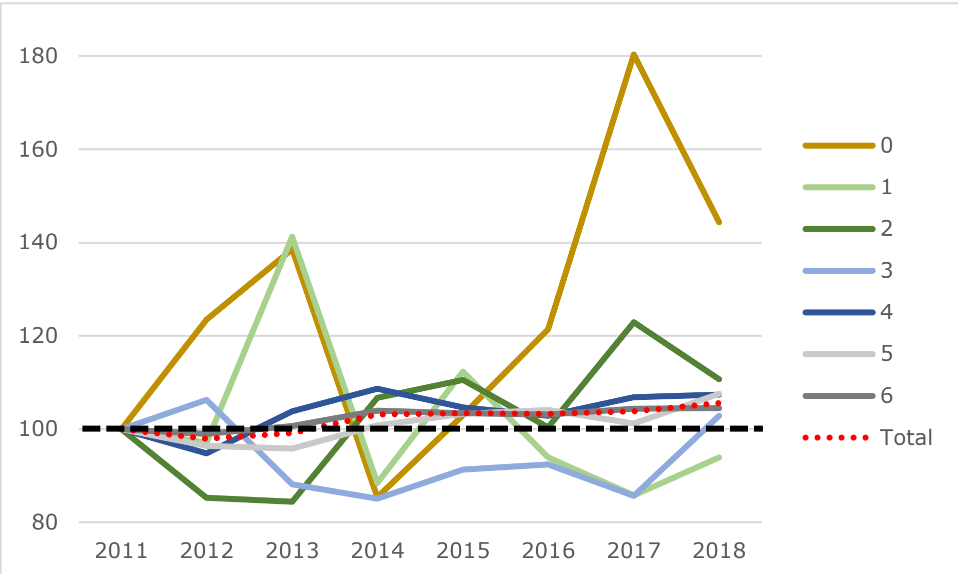


Figure 5.14 Indexed growth of total throughput of inland ports aggregated per CEMT-class over 20011-2018 (2011=100) (created by author based on Appendix Table F.1)

Analysis of Figure 5.14 shows that class 0, 1 and 2 inland ports on average performed well in increase in throughput. The throughput at class 3 inland ports clearly decreased over the period. An important note for this analysis is that the overall results for throughput of all the inland ports are in some cases determined by the performance of one or two inland ports. However, the following can be deduced from the results. If throughput in ports along small waterways increases, the location where only small ships are able to sail, but the number of tonkilometers of small ships decreases over the period, this means that more small ships actually have an origin and/or destination on small waterways. At the same time, the small ships transport less on the major waterways.

The hypothesis for the last indicator was that the development of throughput of inland ports located along small waterways was negative. This hypothesis is rejected, based on the available data. Looking at the growth of throughput at ports along small waterways it is demonstrated that it is increasing. It is even increasing much more than the throughput of ports along major waterways.

5.5 Conclusions of the performance indicators

Table 5.7 Performance indicators and its units for the performance analysis on small dry inland shipping

	Performance indicator	Unit	Hypoth.	Result
1	Fleet	Number of active small ships in the Dutch fleet	-	-
2	Waterways	Number of kilometers small waterways	0	-
3 - 4[27]	Transport performance	Amount of tonkilometers shipped by small ships	-	-
5	Load factor	Average load factor of small inland vessels	?	+
6	Inland ports	Throughput of inland ports located along small waterways	-	+

The expected development over the past years is:
+ positive | - negative | 0 no difference | ? unknown

For each performance indicator the unit, the hypothesis and the result is shown in Table 5.7. For the performance indicators 'fleet' and 'transport performance', the results are the same as the expectation was based on the consulted literature and news articles. The results of both indicators show a negative development of the performance of small dry inland shipping. For the availability of waterways, the expectation of no changes turned out to be wrong. The total length of small waterways in kilometers actually decreased somewhat. No hypothesis was set for the load factor performance indicator, the results are showing a positive performance for small dry inland shipping. Lastly, the throughput results were the most surprising, because the results were the opposite of what was initially hypothesized. However, the results of the last performance indicator are also the most sensitive in terms of interpretation.

[27] Performance indicators 3 and 4 are taken together because of data availability issues (chapter 4.3)

Now that the results of all the performance indicators are clear, the first part of the main question of this research can be answered; *How did small dry inland shipping in the Netherlands perform in a waterway perspective between 2014 and 2018?*

The performance of the small dry inland shipping in the Netherlands cannot be assessed unilaterally. Which of the performance indicators is the most important for the situation in the sector is not easy to determine. Regarding neutrality, the number of tonkilometers is the most important variable because it is not so sensitive to individual developments in the data. Yet the performance in a waterway perspective is a coherence of the above indicators. Combining the results of the five performance indicators provides the following key messages:

- In terms of fleet size, available infrastructure and shipped cargo distance, the performance of small dry inland shipping compared to overall dry inland shipping is negative.
- In terms of load factors and throughput at inland ports the performance has a positive development.
- The active fleet size is decreasing, and the load factors are increasing. That is a logical consequence if the amount of goods transported does not change. So, the load capacity of the actively sailing ships are used better.
- Average tons transported and average kilometers per trip slightly increased for small ships. The total number of trips with small ships decreased, which is the main cause of the decrease in overall tonkilometers of small ships. So, the total amount of tons transported by small ships is decreasing.
- On individual trip level, the small ships that are actively sailing are performing better, but the overall small inland shipping sector does not.
- Since throughput at inland ports along small waterways is also increasing, the actively sailing small ships are transporting more goods to ports along the small waterways and less to ports along the major waterways.
- Widening the definition of 'small' inland shipping does improve the negative performance of that sub sector.

5.6 Effects on inland shipping and inland port throughput

Now that the performance of small dry inland shipping over the years 2014 to 2018 is discussed with descriptive statistics, it is interesting to study what is affecting that performance. As is introduced in chapter 3.5 and elaborated in chapter 4.5, the effect of economic growth and the water level on the share of tons transported by small vessels is studied. First, the average share of dry tons transported towards regions by ships of class 0 to 3 per year is presented in Table 5.8.

Table 5.8 Average share of dry tons transported towards regions by ships of class 0 to 3 per year (created by author)

Year	Share of class 0-3
2014	0.582
2015	0.518
2016	0.499
2017	0.483
2018	0.474

Important to repeat is that these are the averages of the share per region, and not the overall share of small ships. Over the years, there has been a decrease in the share of small vessels, which indicates that there are factors that cause a decrease in that share. To investigate which factors, have an effect on the share of small vessels, the outcomes of the four fixed effects regressions are shown in Table 5.9.

Table 5.9 Fixed effects models on share of tons transported by ships of class 0 to 3 towards NUTS 3 regions in the Netherlands

	(1) Share tons class 0-3	(2) Share tons class 0-3	(3) Share tons class 0-3	(4) Share tons class 0-3
GRP in million euro (log)	-0.433***	-0.471***	-0.529***	-0.440***
	(0.119)	(0.121)	(0.122)	(0.120)
Average distance kilometer (log)	-0.291***	-0.285***	-0.290***	-0.292***
	(0.0767)	(0.0771)	(0.0765)	(0.0769)
Low tide days	-0.000165	-0.000469*	-0.00143**	-0.000203
	(0.000145)	(0.000228)	(0.000431)	(0.000165)
North NL * Low tide days		0		
		(.)		
East NL * Low tide days		0.000366		
		(0.000313)		
West NL * Low tide days		0.000463		
		(0.000291)		
South NL * Low tide days		0.000483		
		(0.000323)		
Groningen * Low tide days			0	
			(.)	
Friesland * Low tide days			0.00104	
			(0.000564)	
Drenthe * Low tide days			0.00161**	
			(0.000562)	
Overijssel * Low tide days			0.00149**	
			(0.000568)	
Gelderland * Low tide days			0.00137*	
			(0.000540)	
Flevoland * Low tide days			0.00112	
			(0.000755)	
Utrecht * Low tide days			0.000952	
			(0.000757)	
Noord-Holland * Low tide days			0.00131*	
			(0.000519)	
Zuid-Holland * Low tide days			0.00175**	
			(0.000523)	
Noord-Brabant * Low tide days			0.00149**	
			(0.000537)	
Limburg * Low tide days			0.00152**	
			(0.000571)	
River area * Low tide days				0.000105
				(0.000217)
Constant	5,995***	6,319***	6,881***	6,065***
	(1,170)	(1,187)	(1,192)	(1,182)
N	170	170	170	170
R^2	0.281	0.298	0.354	0.283

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

To start with the first model, in which there are no locational interaction terms included, the coefficients indicate the following. The GRP has a statistically significant negative effect on the share of small vessels. If the GRP increases by 1%, the share of small vessels decreases by 0.43%[28], ceteris paribus. This means that if a region has economic growth, fewer small ships are used to transport the goods towards that region. It should be noted that other time-varying regional factors may also have an effect on the declining share. A possible explanation could be that economic growth leads to more demand for goods, so a higher volume, making it more beneficial to ship with larger inland vessels. This result is contradictory to the expectation that economic growth leads to more use of the small inland shipping fleet. Besides, the average distance travelled to a region has also a negative significant effect on the share of small vessels. If the average kilometers travelled increase by 1%, the share of small vessels decreases by 0.29%, ceteris paribus. This is in line with the expectations that if trips to a region are on average over a longer distance, more ships of CEMT-class 4 to 6 are used. In the first model, the number of low tide days itself, has no significant effect on the share of tons transported with small vessels towards a region.

For the second model estimated, interaction terms between low tide days and the NUTS 2 level region of each region is added. This resulted in a small increase in the explanatory power of the model and no change in the magnitude or significance of the two explanatory variables. Only one of the interaction terms resulted in a statistically significant effect of low tide days on the share of small vessels. For the north part of the Netherlands the regions have a small significant negative effect on the share of small vessels. To give the coefficients of low tide days a meaning, the following is assumed. If it is a dry year in the Netherlands, such as in 2018, there are 100 dry days more than the average dry days per year. The average of dry days over the period of 2014 to 2018 was about 52 and in 2018 there were 141 dry days. So, we assume that a dry year is about the same as an increase of 100 dry days in comparison with a normal year. Then, for model 2, a dry year means a decrease in the share of small vessels by 0.047% for regions in the North part of the Netherlands, ceteris paribus, which is a small effect.

Also, for the third and fourth model the magnitude and coefficients of GRP and average distance kilometer does not change that much. So, let us focus on the interaction terms with low tide days. The third fixed effects model is constructed with an interaction term between low tide days and the NUTS 2 level region of each region. The explanatory power of the model increased substantially. The interaction terms resulted in a small significant effect for some regions, with not more than a 0.2% increase or decrease in the share of tons transported by small vessels. For the province of Groningen this effect is negative. For the provinces Drenthe, Overijssel, Gelderland, Noord-Holland, Zuid-Holland, Noord-Brabant and Limburg this effect is positive. So, when controlling for province regions there are some small positive effects of an increase in low tide days on the share of small vessels, as expected. For the fourth model estimated, an interaction term between low tide days and river area is included. This resulted in a decrease in the explanatory power of the model and both coefficients are insignificant. This means that whether a region is located along a river with strong water level fluctuations, does not affect the share of small ships transporting to that region differently.

[28] All regression interpretations done in this chapter are under 'ceteris paribus' circumstances, meaning all else equal.

To conclude, the answer to the question what the effect is of economic growth and the water level on the share of tons transported by small vessels in inland shipping to a region, is as follows. The effect of economic growth is negative, with some reservations because other time-varying factors can also contribute to the downward trend over the years. The effect of water level is somewhat less straightforward. Overall, there is no significant effect of water level on the share of small ships. When interacting with different greater regions there are mainly some small positive effects of more low tide days on the share of small ships for 8 provinces in the Netherlands. Which means more transport by small vessels if the water level is at low tide. By distinguishing between regions with a location with and without a strong fluctuating water level river, there is no significant effect.

Combining the results of the descriptive statistics (chapter 5.5) with the results of this chapter provides the following view. On individual level the actively sailing small ships are performing better, but the overall sector is not. Small ships are transporting more goods on the small waterways and less on the major waterways. Economic growth causes more use of bigger ships for shipping to regions where that is possible. So, economic growth will lead to even more shift from the major waterways to the small waterways for small ships. Only for specific provinces the small vessels can get more share in total tons transported in times of a low water level, but this effect is really small compared to the total tons shipped by inland shipping. To conclude, in regions only accessible by small waterways, the small dry inland shipping sector is performing well. On the other hand, the transport share of small shipping is decreasing for regions that can also be reached with larger ships, and this will only increase over the coming years. Assuming that the Dutch (regional) economy will develop and grow in the future.

6. Conclusion & discussion

In chapter 6, the conclusions of this study and answers to the research questions are described. Moreover, a reflection is given about important developments. Thirdly, the limitations of this research and possibilities for future research are discussed. Lastly, the important trends and future developments for inland shipping are described and sub question F will be answered.

6.1 Conclusion

This research has provided answers to the main research question and the corresponding sub question. The following is found:

A. What are the main characteristics of small dry inland shipping market in the Netherlands in recent years?

First of all, the entrepreneurs in the sector are negative about their business and the entrepreneurs are an aging group. The sector is also characterized by its flexibility in terms of geographical reach but uncertainty for the future about its green image. Small inland shipping offers sufficient possibilities for resolving transport issues but, is also threatened by decreasing revenues and a lack of investments.

B. How can small dry inland shipping be defined?

Many different definitions for small dry inland shipping are used in other literature and research. But on the basis of political interests, namely the lack of a national policy program for waterways of class 3 and lower, the following definition is used:

The process of a company that operates the transport of sand, gravel, ore, coal, agricultural goods, containers, break bulk and all other non-liquid cargo loaded on small vessels via the small as well as major Dutch inland waterways. Here small is defined as all ships and waterways from CEMT-class 0 to III and for major ships and waterways CEMT-class IV to VIc.

In this study, results are given for every CEMT-class, so that the performance of small ships can be compared with big ships. Besides that, it turned out that widening the definition of 'small' leads to a more positive performance of the sub sector.

C. What are performance indicators to measure the performance of small dry inland shipping?

Based on literature and availability, the following five performance indicators are used to measure the performance of small dry inland shipping; fleet size, waterway availability, transport performance (tonkilometer), load factor and the throughput at inland ports.

D. What are relevant data sources in the Netherlands about inland shipping that can be used for the performance analysis of small dry inland shipping?

Relevant data sources in the Netherlands about inland shipping that are used are, Rijkswaterstaat, the International association for the register of inland vessels in Europe (IVR) and CBS. Rijkswaterstaat is the institution that collects data about the actual traffic movements on the Dutch waterways, IVR is the institution that holds the ship register and CBS has more common data about waterways and regional data.

How did small dry inland shipping in the Netherlands perform from a waterway perspective in the last decade and what are the expectations for the future?

A couple of interesting observations can be made based on the five performance indicators used. Firstly, based on the transport performance expressed in tonkilometer small dry inland shipping loses its position on the major waterways (-2.8%), but seems to perform well on the small waterways, based on throughput at inland ports along small waterways (+3.8%). Secondly, the study shows that the active fleet size is decreasing expressed in numbers of ships (-36.2%), and the load factors for small ships that are still sailing are increasing. That means that the load capacity of the ships that continue their operation are better used and therefore the income per trip for the skippers probably increases.

Thirdly, the total number of tonkilometers of the small ships decreased and this was caused by less transport by small ships overall. Surprisingly, the individual average tons transported and average kilometers per trip did not decrease. So, on an individual trip level, the small ships that are actively sailing are performing better, but the overall small inland shipping sector does not. Since throughput at inland ports along small waterways is also increasing, the actively sailing small ships are transporting more goods to ports along the small waterways and less to ports along the major waterways. The operational focus of the small ship will be more on the small waterways and that is also the market and location where the opportunities for the future are.

E. Which non-business economic variables have an effect on the performance of small dry inland shipping?

The effect of economic growth on the performance of small dry inland shipping is negative, with some reservations because other common time-varying factors can also contribute to the downward trend over the years. Besides the previously mentioned argumentation, for 8 out of the 11 provinces of the Netherlands, the results turned out that there is a positive effect of a dry year on the share of small ships in total transport towards a region. But this effect is minimal, not more than 0.2% increase in share. Combining this with the results of the performance indicators, the transport share of small shipping is decreasing for regions that can also be reached with larger ships, and this will only increase over the coming years. Assuming that the Dutch (regional) economy will develop and grow in the future.

F. What are the expectations for the performance of small dry inland shipping in the short and medium term, based on the performance analysis made and the trends in the sector?

The answer to the above sub question will be given in section 6.4.

6.2 Reflection

Besides the above described results found in this study, there are a few other developments that are probably influencing the performance analysis. Those developments are not specified in facts or figures but just gave the author the impression during the research that they are of influence. Firstly, the location of the small ships is interesting. There are examples of skippers with a small ship that do not sail anymore on the Dutch waterways, but they only sail on the small waterways of France, where they service in small transportations. This kind of ships are influencing the shipping fleet results in the Netherlands negatively. Secondly, in several news reports about the issues in small dry inland shipping, the skippers are asked about the freight type they are transporting. It turns out that a lot of small inland ship skippers have a preffered freight type, for example animal feed, and that they are not willing to transport other kinds of freight. This personal preference limits the use of the ship and that has an effect on transport performance of the small shipping sector.

Thirdly, the small ships are serving more and more the transport from and to locations along small waterways. It appears that the skippers thereby have fixed shippers of cargo, whereby those suppliers and buyers are rather bound to transport by water. This means that there is some certainty of transport with small ships for these suppliers and buyers. Finally, there is another important point regarding the investment opportunities and the age of the skippers. As the average small ship skipper is getting older, it may be that they are less willing to make investments since they know that they will stop sailing within, for example, 10 years. There may be opportunities for investments, but the incentive is then not high enough.

6.3 Limitations & future research

There are three limitations in the data and calculations of the transport performance indicator tonkilometer. Firstly, not all ships have a report obligation for the IVS 90 system as described in section 4.1.2. This means that there are ship movements that have not been included in the analysis. The solution for this is the Automatic Identification System (AIS), but Rijkswaterstaat is still working on integrating this way of monitoring and therefore it is not yet possible to work with the AIS data. Secondly, there may be differences in the actual route of shipping trips and the route modelled by the BIVAS system. The sailed distances are calculated by BIVAS on the basis of the most advantageous route, given the permitted ship dimensions on the waterways. The actual route may therefore have been different. Lastly, for more than half of the ship movements, it was not known in detail which goods were transported on the trip. With this a more detailed analysis of the tonkilometer and the load factor could have taken place, divided by type of goods.

Besides the limitations for the transport performance calculations, there are two limitations in the inland port throughput analysis. First of all, the throughput data of the municipalities also includes throughput of liquid goods. A split into goods categories would give an even more detailed view of the situation on the market. Additionally, the analysis shows that individual growth developments by municipalities in the smaller classes of inland ports have a major effect on the overall outcome of that class. This makes it difficult to draw conclusions for the entire group of inland ports of such as class.

Finally, there are two limitations in the fixed effects panel model that must be described. First, it is assumed that the cargo being transported to a region is actually unloaded in that region. However, the data set also includes container transport. It is known that in some cases containers circulate and that probably has an effect on the number of tons that are transported to a region. Second, it was decided to calculate with the water level at Lobith as an overall indicator for the water level in the Netherlands. Section 4.5.3 explains why this choice was made. Despite that, it is a generalizing method and for the exact effect of the water level a more detailed analysis per waterway would be required.

Building on the above limitations, there are two major recommendations for further research. Firstly, more detailed data on good type categories would make the study more accurate. Various developments in trip data and throughput data could be analysed even better if a detailed good type overview is available. Secondly, it would be very interesting and relevant to also be able to study the business performance of the small ship. Unfortunately, revenue developments are available with the distinction between liquid and dry transport, but not available per ship size class (CBS, 2019c). In the future, this would be a perfect next step or addition to this research.

6.4 Trends & future possibilities for small dry inland shipping

In this section the trends and future developments for small dry inland shipping are described. Together with the conclusions of this study, the last sub question can be answered.

The trends in transport & logistics and the future possibilities for small dry inland shipping are described below separately in opportunities and threats for the sector. To start with threats the most important trend is about the economies of scale in the sector. More and more class 5 or 6 ships are used for inland shipping. Apart from the fact that the larger ships already have a cost advantage over the smaller ships, there is also an important indirect effect. More larger ships also lead to overcapacity in the sector sometimes. This is paired with lower rates, making operating a small ship less profitable. This further reduces the number of small ships and it ends up in a vicious circle. In addition, a forecast report from Panteia outlines the following for transport with small ships up to 900 tons capacity (De Leeuw van Weenen, Van der Meulen, & Van der Geest, 2018). The transport of goods from the Netherlands to abroad with small ships will decrease, because more waterways abroad will be made suitable for larger ships, in particular in Belgium and France.

Thirdly, the developments in the agricultural and construction sector could influence the use of the small dry inland ships negatively in the future. The agricultural sector is increasingly being encouraged towards circular business operations (Wageningen University & Research, 2019). The supply of fertilizer or animal feed with a small ship could therefore become less important. Small dry inland shipping could also contribute in the supply of raw materials to construction locations. But the construction sector may also be inhibited in the future, due to environmental issues about nitrogen at the moment (Pak, 2019). Lastly, policy at provincial level could be a threat for small dry inland shipping in the future. For example, in Noord-Brabant an important lock in the Wilhelminakanaal will be widened (Rijkswaterstaat, 2019f). The small ship then loses a monopolistic catchment area (Tilburg). Another example is the province of Friesland where the accessibility of inland ports is considered important. That is why there are plans to make the Van Harinxmakanaal suitable for class 5 ships, as an alternative to the Prinses Margrietkanaal in times of obstruction (Provincie Fryslân, 2019). This also reduces the importance of the small ship.

On the other hand, there are also opportunities in the future for small dry inland shipping. This mainly concerns the requirements of shippers, specific objectives of transport, the role of the small ship in the city and XXL distribution centres. These four promising trends will be described separately below. To start with the requirements of the shippers (the clients), they stick to traditional requirements such as price, quality, service, innovation and responsiveness. In addition, they will increasingly attach importance to sustainability, flexibility and reliance in the future (Ploos van Amstel, 2012) (Ruijgrok, 2012). Small inland shipping can play a role here due to their flexible options in waterway navigability and, for example, using LNG as fuel (Kuipers, 2016). This is also in line with the results from this study of no major changes in the availability of small waterways. Secondly there will always be specific objectives of transport for which small inland shipping can be used. An example is the import of limestone from Wallonia (De Leeuw van Weenen, Van der Meulen, & Van der Geest, 2018). Due to less marlstone extraction in Zuid-Limburg, more is imported from Wallonia, where the waterways are not wide enough for 11,45 meters wide barges. Small barges therefore have a positive future for this specific objective of transport.

Thirdly, there is a role for the small dry inland ship in the urban distribution and circular economy (Becker & Kuipers, 2018). The four major cities in the Netherlands (Amsterdam, Rotterdam, The Hague and Utrecht) all have small waterways that reach into or near the city centre. The traffic in these cities is congested and therefore the small ship can play a role in urban distribution. In addition, all cities are working to a better circular economy system in the future. Waste and recycle products, such as steel and paper, are extremely suitable to be transported from the city centre with a small ship to an industrial area (Buck Consultants International, 2008). Appendix Figure E.2 also shows that there is enough load capacity available in return trips. Finally, E-commerce is a rapidly growing sector in which companies operate XXL distribution centres in regions where goods from seaports could be transported towards that region with small ships. Examples of those kind of distribution centres are, Coolblue (Tilburg – class 2 waterway), Heyle group (Almelo – class 4), Lidl (Weert – class 2), Bol.com (Waalwijk – class 3) and Primark (Roosendaal – class 4). The study shows that small ships seem to perform well on small waterways and at inland ports along small waterways. Along with the call for more urban distribution, there are opportunities here for the small ship.

F. What are the expectations for the performance of small dry inland shipping in the short and medium term, based on the performance analysis made and the trends in the sector?

The expectation for the performance of small dry inland shipping in the short and medium term is a smaller share in terms of total transport. This is due to increasing competition from larger ships on major waterways. The skipper with a small ship will have to focus on transport on small waterways and there are plenty of opportunities for the future here. Some examples are the requirements of shippers, specific objectives of transport, the role of the small ship in the city and XXL distribution centers. In short, enough options and opportunities for the small ship on small waterways exist.

7. Reference list

Algemeen Dagblad. (2018, July 21). *'In mijn vlogs wil ik laten zien dat de binnenvaart hip is'*. Opgehaald van AD.nl: https://www.ad.nl/rotterdam/in-mijn-vlogs-wil-ik-laten-zien-dat-de-binnenvaart-hip-is~aaed8b05/

Asian Development Bank. (2016). *Promoting inland waterway transport in the people's republic of China.* Manila, Philippines: Asian Development Bank.

ASV. (2011). *Kleine binnenvaart, de moeite waard.* Rotterdam: Algemeene Schippers Vereeniging.

ASV. (2019). *ASV nieuwsbrief april 2019.* Rotterdam : ASV.

AVV. (1999). *Toekomstperspectief kleine schepen.* Rotterdam: Adviesdienstverkeer en Vervoer.

Bu̇ckmann, E., Korteweg, A., Bozuwa, J., Volkerink, B., & Van Veen, M. (2008). *Sectorstudie van zee- tot binnenhaven - Marktwerking in het goederenvervoer over water.* Rotterdam: ECORYS.

Bascombe, A. (1997). Europe's 'green' arteries. *Containerisation International, 30(6)*, pp. 77-81.

Becker, E., & Kuipers, B. (2018). *De potentie van watergebonden bedrijventerreinen in de Metropoolregio Rotterdam-Den Haag.* Rotterdam: Erasmus Universiteit Rotterdam | UPT.

Behrens, K., Gaigne, C., & Thisse, J. (2009). Industry location and welfare when transport costs are endogenous. *Journal of Urban Economics, 65(2)*, pp. 195-208.

Bilec, M., Ries, R., Matthews, H., & Sharrard, A. (2006). Example of a hybrid life-cycle assessment of construction processes. *Journal of Infrastructure Systems, 12(4)*, pp. 207-215.

Binnenvaartcijfers. (2019, June 11). *Samenstelling Nederlandse vloot - aantal schepen*. Opgehaald van Binnenvaartcijfers.nl: https://binnenvaartcijfers.nl/samenstelling-nederlandse-vloot/

Binnenvaartcijfers. (2019, September 17). *Vlagverdeling West-Europese binnenvaart*. Opgehaald van Binnenvaartcijfers.nl: https://binnenvaartcijfers.nl/vlagverdeling-west-europese-binnenvaart/

Binnenvaartkrant. (2014, March 14). *'Kleine binnenvaart is impuls voor regionale economie'*. Opgehaald van Binnenvaartkrant.nl: https://binnenvaartkrant.nl/kleine-binnenvaart-is-impuls-voor-regionale-economie

Binnenvaartkrant. (2017, December 9). *ASV vindt voorstel geluidseisen schijnoplossing*. Opgehaald van Binnenvaartkrant.nl: https://binnenvaartkrant.nl/ASV-vindt-voorstel-geluidseisen-schijnoplossing

Binnenvaartkrant. (2018a, May 30). *ASV ontmoet medestander in evofenedex voor behoud kleine binnenvaart*. Opgehaald van Binnenvaartkrant.nl: https://binnenvaartkrant.nl/asv-ontmoet-medestander-in-evofenedex-voor-behoud-kleine-binnenvaart

Binnenvaartkrant. (2018b, December 24). *Wat heeft binnenvaart gemeen met campings en cafés?* Opgehaald van Binnenvaartkrant.nl: https://binnenvaartkrant.nl/wat-heeft-binnenvaart-gemeen-met-campings-en-cafes

Binnenvaartkrant. (2019a, April 24). *Groene binnenvaart = kleinere CO2-voetafdruk*. Opgehaald van Binnenvaartkrant.nl: https://binnenvaartkrant.nl/41261-2

Binnenvaartkrant. (2019b, July 7). *ASV heeft hoop op betere procedure hardheidsclausule*. Opgehaald van Binnenvaartkrant.nl: https://binnenvaartkrant.nl/asv-heeft-hoop-op-betere-procedure-hardheidsclausule

Binnenvaartkrant. (2019c, July 16). *CBS: minder per binnenvaart vervoerd in 2018*. Opgehaald van Binnenvaartkrant.nl: https://binnenvaartkrant.nl/cbs-minder-over-water-vervoerd-in-2018

Binnenvaartregeling. (2018, October 7). Opgehaald van Wetten.overheid.nl: https://wetten.overheid.nl/BWBR0025958/2018-10-07/#Bijlage5.1

Bloemhof, J., Van der Laan, E., & Beijer, C. (2011). Sustainable Inland Transportation. *International Journal of Business Insights & Transformation, 3*, ISO 690.

Buck Consultants International. (2008). *Een goede toekomst voor het kleine schip - Visie en actieplan.* Rotterdam: Buck Consultants International.

Bureau of Transportation Statistics. (2019, June 13). *Definition Of: Modal Split*. Opgehaald van Transportation-dictionary.org: http://www.transportation-dictionary.org/Modal_Split

Bureau Voorlichting Binnenvaart. (2010, July 15). *Drijvende kracht; kleine binnenvaart, grote klasse*. Opgehaald van Youtube.com: https://www.youtube.com/watch?v=tgfsdPTIQ6s

Bureau Voorlichting Binnenvaart. (2019b, June 25). *Scheepstypen*. Opgehaald van Bureauvoorlichtingbinnenvaart.nl: https://www.bureauvoorlichtingbinnenvaart.nl/downloads/

Bush, A., Biles, W., & DePuy, G. (2003). Waterway, shipping, and ports: iterative optimization and simulation of barge traffic on an inland waterway. *In Proceedings of the 35th conference on Winter simulation: driving innovation*, pp. 1751-1756.

Cambridge Dictionary. (2019, June 25). *Meaning of shipping*. Opgehaald van Dictionary.cambridge.org: https://dictionary.cambridge.org/dictionary/english/shipping

CBS. (2016). *CBS Jaarmonitor Goederenvervoer.* Sector Verkeer en Vervoer (SVV).

CBS. (2018, December 13). *Regionale kerncijfers; nationale rekeningen*. Opgehaald van Opendata.cbs.nl: https://opendata.cbs.nl/statline/#/CBS/nl/dataset/84432NED/table?ts=1566222946491

CBS. (2019a, March 6). *Wegvervoer; kerncijfers*. Opgehaald van Opendata.cbs.nl: https://opendata.cbs.nl/statline/#/CBS/nl/dataset/83077NED/table?ts=1565783715669

CBS. (2019b, March 22). *Lengte van vaarwegen; vaarwegkenmerken, provincie*. Opgehaald van Opendata.cbs.nl: https://opendata.cbs.nl/statline/#/CBS/nl/dataset/71531ned/table?ts=1559555401130

CBS. (2019c, July 15). *Bedrijven; bedrijfstak*. Opgehaald van Opendata.cbs.nl: https://opendata.cbs.nl/statline/#/CBS/nl/dataset/81589NED/table?ts=1519308104241

CBS. (2019d, July 19). *Binnenvaart; goederenvervoer; vervoerstroom; soort lading*. Opgehaald van Opendata.cbs.nl:

https://opendata.cbs.nl/statline/#/CBS/nl/dataset/83019NED/table?ts=1565083250728
CBS. (2019e, August 15). *Geregistreerde en actieve binnenvloot; 1997 - 2002*. Opgehaald van Opendata.cbs.nl: https://opendata.cbs.nl/statline/#/CBS/nl/dataset/37761/table?ts=1565858263836
CBS. (2019f, September 5). *Spoorvervoer; ladinggewicht, ladingtonkilometer, treinkilometers*. Opgehaald van Opendata.cbs.nl: https://opendata.cbs.nl/statline/#/CBS/nl/dataset/80429ned/table?ts=1567762308601
CCR. (2019a). *Market Insight - Europese Binnenvaart.* Straatsburg: Centrale commissie voor de Rijnvaart.
CCR. (2019b, June 12). *Technische voorschriften voor binnenvaartschepen*. Opgehaald van CCR-ZKR.org: https://www.ccr-zkr.org/12020200-nl.html
CCR. (2019c, August 15). *Organisation*. Opgehaald van CCR-ZKR.org: https://www.ccr-zkr.org/11000000-en.html
Charte Software B.V. (2019, August 15). *Scenario's*. Opgehaald van Bivas.chartasoftware.com: https://bivas.chartasoftware.com/Scenarios
De Groot, L. (2008, September). *De overgangsbepalingen van de technische regelgeving in de binnenvaart*. Opgehaald van CBRB.nl: https://www.cbrb.nl/publicaties/50-thema-s/themas/400-de-overgangsbepalingen-van-de-technische-regelgeving-in-de-binnenvaart
De Langen, P., Nijdam, M., & Van der Horst, M. (2007). New indicators to measure port performance. *Journal of Maritime Research, 4(1)*, pp. 23-36.
De Leeuw van Weenen, R., & Van der Geest, W. (2016). *Versterking Marktobservatie Binnenvaart Middellange Termijn Prognoses voor het ladingvolume periode 2016 - 2020.* Zoetermeer: Panteia.
De Leeuw van Weenen, R., Van der Meulen, S., & Van der Geest, W. (2018). *Middellange Termijn Prognoses voor de binnenvaart - Vervoer in relatie tot Nederland, periode 2018 - 2022.* Zoetermeer: Panteia.
Dunn, E. (1960). A statistical and analytical technique for regional analysis. *Papers in Regional Science, 6(1)*, pp. 97-112.
Duursma, M. (2019, March 26). *"Toekomst van de binnenvaart is goud"*. Opgehaald van NRC.nl: https://www.nrc.nl/nieuws/2019/03/26/toekomst-van-de-binnenvaart-is-goud-a3954638
EICB. (2012). *Plan van Aanpak Kleine Schip.* Rotterdam: Expertise en InnovatieCentrum Binnenvaart.
European Commission. (2019, June 24). *Mobility and Transport TENtec Interactive Map Viewer*. Opgehaald van Ec.europa.eu: http://ec.europa.eu/transport/infrastructure/tentec/tentec-portal/map/maps.html
European Conference of Ministers of Transport (ECMT). (1992, June 24). *New Classification of Inland Waterways.* Parijs: CEMT/CM(92)6 Final. Opgehaald van Bureauvoorlichtingbinnenvaart.nl: https://www.bureauvoorlichtingbinnenvaart.nl/over/basiskennis/vaarwegen
Europese Commissie. (2011). *Stappenplan voor een interne Europese vervoersruimte – werken aan een concurrerend en zuinig vervoerssysteem.* Brussel: SEC.
Eurostat. (2019, August 15). *Inland waterways transport database*. Opgehaald van Ec.europa.eu: https://ec.europa.eu/eurostat/web/transport/data/database

Farsi, M., Filippini, M., & Greene, W. (2005). Efficiency measurement in network industries: application to the Swiss railway companies. *Journal of Regulatory Economics, 28(1)*, pp. 69-90.
Feng, B., Li, Y., & Shen, Z. (2015). Air cargo operations: Literature review and comparison with practices. *Transportation Research Part C, 56*, pp. 263–280.
Geerlings, H., Kuipers, B., & Van der Horst, M. (2016). *Vaarroute naar succesvol binnenvaartbeleid voor de provincie Zuid-Holland.* Rotterdam: Erasmus Universiteit Rotterdam.
Geerlings, H., Van der Horst, M., Kort, M., Kuipers, B., Quispel, M., & Visser, H. (2012). Beschrijving huidige binnenvaart en eerste probleemanalyse, Deliverable 1.1. *Impuls Dynamische Verkeersmanagement (RWS)*.
Gemeentelijk Havenbedrijf Rotterdam. (1999). *2020: Integrale Verkenningen voor haven en industrie; werkdocument Verkeer en Vervoer.* Rotterdam: Gemeentelijk Havenbedrijf Rotterdam.
Gudmundsson, H. (2004). Sustainable transport and performance indicators. *Issues in environmental science and technology, 20*, pp. 35-63.
Harms, L., & Willigers, J. (2002). *Binnenvaart en Zeescheepvaart - Volume- en ruimtelijke ontwikkelingen.* Bilthoven: RIVM.
Hegger, F. (2018, January 11). *Hollands glorie: elektrisch binnenvaartschip gaat in de zomer het water op*. Opgehaald van RLTNieuws.nl: https://www.rtlnieuws.nl/nederland/artikel/3808946/hollands-glorie-elektrisch-binnenvaartschip-gaat-de-zomer-het-water-op
Hekkenberg, R. (2013). Inland Ships for Efficient Transport Chains. *Technische Universiteit Delft*.
Hubens, A. (2004). *Continuïteit en ambitie: Onderzoek naar de toekomst van gezinsbedrijven in de binnenvaart.* Den Bosch: AHA Data.
IVR. (2019a). Dutch registered inland shipping fleet. *Internationale Vereniging het Rijnschepenregister*.
IVR. (2019b, August 15). *Organisatie*. Opgehaald van IVR-EU.com: https://www.ivr-eu.com
Jonkeren, O., Rietveld, P., & Van Ommeren, J. (2007). Climate Change and Inland Waterway Transport - Welfare Effects of Low Water Levels on the river Rhine. *Journal of Transport Economics and Policy, Volume 41, Part 3*, pp. 387–411.
Jonkeren, O., Rietveld, P., Van Ommeren, J., & Te Linde, A. (2014). Climate change and economic consequences for inland waterway transport in Europe. *Regional environmental change, 14(3)*, pp. 953-965.
KiM. (2019, June 25). *Home*. Opgehaald van Kimnet.nl: https://www.kimnet.nl
KNMI. (2019, August 29). *Uitleg over hoogwaterberichten*. Opgehaald van KNMI.nl: https://www.knmi.nl/kennis-en-datacentrum/uitleg/hoogwaterberichten
Koninklijke BLN-Schuttevaer. (2018). *De toekomst van de binnenvaart.* Zwijndrecht: Strategy Works.
KplusV organisatieadvies. (2011). *Onderzoek en beleidsadvies overgangsbepalingen binnenvaart Probleem -en gevolgenanalyse van ROSR in Nederland.* Arnhem The Netherlands.
Krekt, A., Van der Laan, T., Van der Meer, R., Turpijn, B., Jonkeren, O., Van der Toorn, A., . . . Groen, T. (2011). *Climate change and inland waterway transport: impacts on the sector, the port of rotterdam and potential solutions.* Utrecht, Netherlands: Research Project HSRR08, National

Research Programme Knowledge for Climate, Secretariat of the Knowledge for Climate Programme, University of Utrecht.

Kuipers, B. (2016). *Scenario's voor inzet van LNG in de binnenvaart.* Rotterdam: Erasmus Universiteit Rotterdam | UPT.

Kuipers, B., & Streng, M. (2016). *Binnenhavenmonitor 2015 - Economische betekenis van binnenhavens in Nederland in 2014.* Rotterdam: Regionale Economie, Haven- en Vervoerseconomie (RHV).

Lawrence, W., & Lin, E. (2006). Performance Measurement for Railway Transport: Stochastic Distance Functions with Inefficiency and Ineffectiveness Effects. *Journal of Transport Economics and Policy, 40(3)*, pp. 383–408.

Mackor, R. (2019, May 16). *Duitse verkeersminister: 25 miljard naar vaarwegen*. Opgehaald van Nieuwsbladtransport.nl: https://www.nieuwsbladtransport.nl/binnenvaart/2019/05/16/duitse-verkeersminister-25-miljard-naar-vaarwegen/

McCann, P. (2001). A proof of the relationship between optimal vehicle size, haulage length and the structure of distance-transport costs. *Transportation Research Part A: Policy and Practice, 35(8)*, pp. 671-693.

Mihic, S., Golusin, M., & Mihajlovic, M. (2011). Policy and promotion of sustainable inland waterway transport in Europe – Danube River. *Renewable and sustainable energy reviews, 15(4)*, pp. 1801-1809.

Ministerie IenM. (2012). *Structuurvisie Infrastructuur en Ruimte: Nederland concurrerend, bereikbaar, leefbaar en veilig.* Den Haag: Ministerie van Infrastructuur en Infrastructuur.

Ministerie van Binnenlandse Zaken en Koninkrijksrelaties. (2019). *NUTS-3 Regio's*. Opgehaald van Regioatlas.nl: https://www.regioatlas.nl/indelingen/indelingen_indeling/t/nuts_3_regio_s

Ministerie van Sociale Zaken en Werkgelegenheid. (2019, June 12). *Algemeene Schippers Vereeniging (ASV)*. Opgehaald van Arboportaal.nl: https://www.arboportaal.nl/externe-bronnen/brancheorganisaties/algemeene-schippers-vereeniging-asv

Ministerie van Verkeer en Waterstaat. (2007). *Varen voor een vitale economie - Een veilige en duurzame binnenvaart.* Den Haag: Drukkerij Albani.

Netherlands Maritime Technology. (2019). *Sectorjaarverslag 2018.* Rotterdam.

Nicolai, F. (2013, October 8). *Belgische binnenvaart wil fonds voor kleinere schepen*. Opgehaald van Nieuwsbladtransport.nl: https://www.nieuwsbladtransport.nl/binnenvaart/2013/10/08/belgische-binnenvaart-wil-fonds-voor-kleinere-schepen/

Nieuwsblad Transport. (2019, June 20). *Evenredige vrachtverdeling*. Opgehaald van Nieuwsbladtransport.nl: https://www.nieuwsbladtransport.nl/glossary/evenredige-vrachtverdeling/

Niewold, M. (2017, November 30). *Rijkswaterstaat zet in op zelfvarende schepen*. Opgehaald van RTLNieuws.nl: https://www.rtlnieuws.nl/economie/artikel/3747406/rijkswaterstaat-zet-op-zelfvarende-schepen

Oum, T., Waters, W., & Yu, C. (1999). A survey of productivity and efficiency measurement in rail transport. *Journal of Transport economics and Policy, 33(1)*, pp. 9-42.

Overheid.nl. (2019, August 16). *Lengte van vaarwegen; vaarwegkenmerken, provincie*. Opgehaald van Data.overheid.nl: https://data.overheid.nl/dataset/53929-lengte-van-vaarwegen--vaarwegkenmerken--provincie

Pak, V. (2019, June 20). *Tientallen bouwprojecten dreigen te sneuvelen door stikstofuitstoot*. Opgehaald van Elsevierweekblad.nl: https://www.elsevierweekblad.nl/nederland/achtergrond/2019/06/verstikking-nederland-dreigt-door-stikstof-694617/

Pals, B. (2019, March 11). *Binnenvaart boekt sterkste omzetstijging van deze eeuw*. Opgehaald van Nieuwsbladtransport.nl: https://www.nieuwsbladtransport.nl/binnenvaart/2019/03/11/binnenvaart-boekt-sterkste-omzetstijging-van-deze-eeuw/

Ploos van Amstel, W. (2012). *Integrale visie op transport en logistiek in 2040: Welke kansen zijn er voor chemie, agrofood en High Tech?* Vrije Universiteit Amsterdam/TNO Mobiliteit.

Policy Research Corporation. (2007). *Beleidsstrategie Binnenvaart - Een landelijke markt- en capaciteitsanalyse.* Antwerpen / Rotterdam: Ministerie van Verkeer en Waterstaat.

Provincie Fryslân. (2019, September 4). *Vaarwegen in Fryslân*. Opgehaald van Fryslân.nl: https://www.fryslan.frl/beleidsthemas/wegen_3640/item/vaarwegen-in-fryslan_9298.html

Regeling communicatie en afmetingen rijksbinnenwateren. (2018, December 1). Opgehaald van Wetten.overheid.nl: https://wetten.overheid.nl/BWBR0010360/2018-12-01

Rijksoverheid. (2019, June 12). *Klimaatbeleid*. Opgehaald van Rijksoverheid.nl: https://www.rijksoverheid.nl/onderwerpen/klimaatverandering/klimaatbeleid

Rijkswaterstaat. (1995). *Handboek Beheersoverdrachten Waterstaatswerken.*

Rijkswaterstaat. (2010). *Binnenvaartvloot Classificatie.*

Rijkswaterstaat. (2017). *Richtlijnen Vaarwegen 2017 - Kader verkeerskundig vaarwegontwerp Rijkswaterstaat.* Rijkswaterstaat Water, Verkeer en Leefomgeving (WVL).

Rijkswaterstaat. (2019a). Active fleet inland shipping on Dutch waterways 2007-2018. *Rijkswaterstaat - Water Verkeer en Leefomgeving*.

Rijkswaterstaat. (2019b). *Vaarwegen en Objecten*. Opgehaald van Vaarweginformatie.nl: https://vaarweginformatie.nl/frp/main/#/geo/map?layers=FAIRWAY&sublayer=NAVIGABILITY

Rijkswaterstaat. (2019c, June 13). *Smart Shipping: experimenten met vergaand geautomatiseerd varen*. Opgehaald van Rijkswaterstaat.nl: https://www.rijkswaterstaat.nl/water/wetten-regels-en-vergunningen/scheepvaart/scheepvaartverkeerswet-vergunningen/smart-shipping.aspx

Rijkswaterstaat. (2019d, June 27). *Vaarwegenoverzicht*. Opgehaald van Rijkswaterstaat.nl: https://www.rijkswaterstaat.nl/water/vaarwegenoverzicht

Rijkswaterstaat. (2019e, August 8). *IVS90*. Opgehaald van Rijkswaterstaat.nl: https://www.rijkswaterstaat.nl/zakelijk/verkeersmanagement/scheepvaart/scheepvaartverkeersbegeleiding/ivs90/index.aspx

Rijkswaterstaat. (2019f, August 9). *Wilhelminakanaal: herbouw Sluis II en afbouw nieuwe Sluis III*. Opgehaald van Rijkswaterstaat.nl: https://www.rijkswaterstaat.nl/water/projectenoverzicht/wilhelminakanaal-verbreding-verdieping-en-nieuwe-sluis/index.aspx

Rijkswaterstaat. (2019g, August 15). *Rijkswaterstaat Water, Verkeer en Leefomgeving*. Opgehaald van Rijkswaterstaat.nl:

https://www.rijkswaterstaat.nl/over-ons/onze-organisatie/organisatiestructuur/water-verkeer-en-leefomgeving/
Rijkswaterstaat. (2019h, August 15). *Home*. Opgehaald van Bivas.chartasoftware.com: https://bivas.chartasoftware.com/Home
Rijkswaterstaat. (2019i, August 21). *Waarom meten we de waterstanden bij Lobith en wat doen we met deze kennis?* Opgehaald van Rijkswaterstaat.nl: https://www.rijkswaterstaat.nl/nieuws/2019/08/waarom-meten-we-de-waterstanden-bij-lobith-en-wat-doen-we-met-deze-kennis.aspx
Rijkswaterstaat. (2019j, August 29). *Verdeling water bij droogte*. Opgehaald van Rijkswaterstaat.nl: https://www.rijkswaterstaat.nl/water/waterbeheer/droogte-en-watertekort/verdeling-water-bij-droogte/index.aspx
Rijkswaterstaat. (2019k, August 29). *Waterinfo*. Opgehaald van Waterinfo.rws.nl: https://waterinfo.rws.nl/#!/nav/index/
Rijkswaterstaat. (2019l, August 29). *Waterhoogte Oppervlaktewater*. Opgehaald van Waterinfo.rws.nl: https://waterinfo.rws.nl/#!/details/publiek/waterhoogte-t-o-v-nap/Lobith(LOBI)/Waterhoogte___20Oppervlaktewater___20t.o.v.___20Normaal___20Amsterdams___20Peil___20in___20cm
RLI. (2013). *Nederlandse logistIek 2040 - Designed to last.* Den Haag: Raad voor de leefomgeving en infrastructuur.
Roeleven, D., Kokc, M., Stipdonk, H., & Vries, de, W. (1995). Inland waterway transport: modelling the probability of accidents. *Safety Science, 19(2-3)*, pp. 191-202.
Ruijgrok, K. (2012). *Innovatie en duurzaamheid in de logistiek. Uitdagingen en ontwikkelingsmogelijkheden voor de periode tot 2040.* Preadvies voor de Raden voor de leefomgeving en Infrastructuur.
Scheepvaartkrant. (2018, February 13). *Frankrijk gaat minst gebruikte kanalen niet meer bedienen voor de binnenvaart*. Opgehaald van Scheepvaartkrant.nl: https://www.scheepvaartkrant.nl/nieuws/frankrijk-gaat-minst-gebruikte-kanalen-niet-meer-bedienen-voor-de-binnenvaart
Schuttevaer. (2017, December 28). *Zorgen over het kleine schip*. Opgehaald van Schuttevaer.nl: https://www.schuttevaer.nl/nieuws/vervoermarkt/2017/12/28/zorgen-over-het-kleine-schip/
Schuttevaer. (2018a, March 21). *ASV: Vijf voor twaalf voor kleine schepen en vaarwegen*. Opgehaald van Schuttevaer.nl: https://www.schuttevaer.nl/nieuws/varend-bestaan/2018/03/21/asv-vijf-voor-twaalf-voor-kleine-schepen-en-vaarwegen/
Schuttevaer. (2018b, October 23). *ASV: 'Koester kleine schepen voor tijden van laag water'*. Opgehaald van Schuttevaer.nl: https://www.schuttevaer.nl/nieuws/varend-bestaan/2018/10/23/asv-koester-kleine-schepen-voor-tijden-van-laag-water/
Schuttevaer. (2019a, January 25). *Overijssel wil kleine schepen vrijwaren van CCR-eisen*. Opgehaald van Schuttevaer.nl: https://www.schuttevaer.nl/nieuws/vervoermarkt/2019/01/25/overijssel-wil-kleine-schepen-vrijwaren-van-ccr-eisen/
Schuttevaer. (2019b, May 16). *Nieuwe poging om krimp vloot kleine schepen te stoppen*. Opgehaald van Schuttevaer.nl: https://www.schuttevaer.nl/dossiers/klein_schip/2019/05/16/nieuwe-poging-om-krimp-vloot-kleine-schepen-te-stoppen/

Schweighofer, J. (2014). The impact of extreme weather and climate change on inland waterway transport. *Natural hazards, 72(1)*, pp. 23-40.
STC-Nestra. (2015). *Inventarisatie milieuprestaties bestaande binnenvaartvloot West-Europa.* Rotterdam: STC-Nestra i.s.m. Rebel en EICB.
Steunpunt Binnenvaart. (2015, June 22). *In elke tonnageklasse enorme verschillen in bruto omzet*. Opgehaald van Steunpuntbinnenvaart.nl: http://www.steunpuntbinnenvaart.nl/index.php/publicaties/30-in-elke-tonnageklasse-enorme-verschillen-in-bruto-omzet
Stichting NAP. (2019, August 29). *Wat betekent het NAP?* Opgehaald van Normaalamsterdamspeil.nl: https://www.normaalamsterdamspeil.nl/nl/wat-is-het-nap/
Swedish, J. (1998). Simulation of an inland waterway barge fleet distribution network. *In 1998 Winter Simulation Conference, (2)*, pp. 1219-1221.
Sys, C., & Vanelslander, T. (2011). *Future Challenges for Inland Navigation – A Scientific Appraisal of the Consequenses of Possible Strategic and Economic Developments up to 2030.* University Press Antwerp.
Sys, C., Van de Voorde, E., Vanelslander, T., & Van Hassel, E. (2017). *De binnenvaart: traditionele modus, innovatieve toekomst?* Antwerpen: Universiteit Antwerpen - Department of Transport and Regional Economics.
Talley, W. (2000). Oil spillage and damage costs: US inland waterway tank barge accidents. *International journal of maritime economics, 2(3)*, pp. 217-234.
Talley, W. (2007). Devolution, Port Governance and Port Performance Ch. 22: Port Performance: an Economics Perspective. *Research in Transportation Economics, Vol. 17*, pp. 499–516.
TNO. (2004). *Functiebepaling Nederlandse binnenhavens.* Rotterdam/Delft: Ministerie Verkeer en Waterstaat.
Van den Bossche, M., Van Schijndel, M., Van de Pol, G., Wester, M., & Sprengers, L. (2017). *De Nederlandse Maritieme Cluster - Monitor 2017.* Rotterdam: ECORYS.
Van der Horst, M., & Francke, J. (2018). *Toekomst Kleine droge ladingvaart: een verkenning van kennis en onderwerpen - Interne notitie.* Den Haag: Kennisinstituut voor Mobiliteitsbeleid.
Van Dijk, G., Van Bekkum, O., & Van den Boogaard, K. (2012). *Marktwerking en Samenwerking in de Binnenvaart.* The Netherlands Institute for Cooperative Entrepreneurship.
Van Dorsser, J. (2015). Very long term development of the Dutch Inland Waterway Transport System: Policy analysis, transport projections, shipping scenarios, and a new perspective on economic growth and future discounting. *TRAIL Research School*.
Van Gurp, T. (2018, June 11). *Tweede Kamer wil af van onhaalbare eisen binnenvaart*. Opgehaald van Mainport.com: https://www.mainport.com/2018/06/11/tweede-kamer-wil-af-van-onhaalbare-eisen-binnenvaart/?gdpr=accept
Van Hassel, E. (2011). *Developing a Small Barge Convoy System to reactivate the use of the small inland waterway network.* Antwerpen: University of Antwerp - Faculty of applied Economics - Department of transport and regional Economics.
Van Heerde, J. (2018, January 16). *De binnenvaart groeit, maar de opbrengst niet*. Opgehaald van Trouw.nl: https://www.trouw.nl/home/de-binnenvaart-groeit-maar-de-opbrengst-niet~a9214c91/

Van Meijeren, J., & Groen, T. (2010). *Impact of climate change on the competitive position of inland waterway transport.* TNO.
Verkeer en Waterstaat. (2004). *Alleenvaartregeling Jaarbericht Inspectie.* pp. 33.
Vinkenvleugel, S. (2019, April 17). *'De kleine binnenvaart wordt uitgeroeid'*. Opgehaald van RTVDrenthe.nl: https://www.rtvdrenthe.nl/nieuws/146394/De-kleine-binnenvaart-wordt-uitgeroeid
Wageningen University & Research. (2019, October 8). *Kringlooplandbouw*. Opgehaald van WUR.nl: https://www.wur.nl/nl/Dossiers/dossier/Kringlooplandbouw.htm
Wang, J., & Li, J. (2013). Inland waterway transport in the Pearl River Basin, China. *L'Espace géographique 2012/3 (Tome 41)*, pp. 196-209.
Wereld van de binnenvaart. (2019, July 26). *Neokemp*. Opgehaald van Wereldvandebinnenvaart.nl: https://wereldvandebinnenvaart.nl/schepen/11/neo-kemp?lang=nl
Zhang, M., Wiegmans, B., & Tavasszy, L. (2013). Optimization of multimodal networks including environmental costs: a model and findings for transport policy. *Computers in industry, 64(2)*, pp. 136-145.
Zimmermann, C. (1996). Perspektiven im Containerverkehr. *Binnenschiffahrt, 51(13)*, pp. 21-28.

8. Appendix

Appendix A
Data of Dutch waterways length

Table A.1 Length of waterways in the Netherlands in total and based on CEMT-class in kilometers 2008-2018

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
CEMT-class	6,215	6,214	6,220	6,219	6,237	6,242	6,251	6,261	6,256	6,257	6,297
0	1,556	1,559	1,560	1,562	1,551	1,553	1,553	1,553	1,553	1,553	1,531
1	372	372	372	372	371	371	371	371	371	371	369
2	920	920	920	920	893	893	893	893	876	876	814
3	322	322	322	322	318	318	317	317	317	317	317
4	516	515	515	515	515	514	515	515	530	538	537
5	1,518	1,519	1,519	1,517	1,363	1,360	1,359	1,359	1,357	1,356	1,354
6	886	886	886	886	886	870	889	889	889	889	888
Unknown	125	121	126	125	340	362	352	362	362	356	487

Source: CBS (2019b)

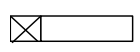
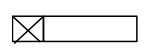
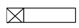
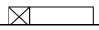
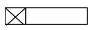
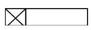
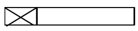
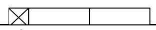
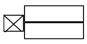
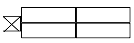
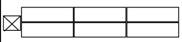
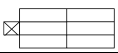
Appendix B
Overview of ship size class CEMT and RWS characteristics and classification

Table B.1 Overview ship size class CEMT and RWS – Motor vessels

CEMT Class	Motor vessels							Clearance height * incl. 30 cm spare height
	RWS Class	Characteristic normative ship**				Classification		
		Name	Width	Length	Draft (loaded)	Load capacity	Width and length	
			m	m	m	t	m	m
0	**M0**	Other				1-250	B<= 5.00 or L<= 38.00	
I	**M1**	Spits	5.05	38.5	2.5	251-400	B= 5.01-5.10 and L>=38.01	5.25*
II	**M2**	Kempenaar	6.6	50-55	2.6	401-650	B=5.11-6.70 and L>=38.01	6.1
III	**M3**	Hagenaar	7.2	55-70	2.6	651-800	B=6.71-7.30 and L>=38.01	6.4
	M4	Dortmund Eems (L < = 74 m)	8.2	67-73	2.7	801-1,050	B=7.31-8.30 and L=38.01-74.00	6.6
	M5	Verl. Dortmund Eems (L > 74 m)	8.2	80-85	2.7	1,051-1,250	B=7.31-8.30 and L>=74.01	6.4
IVa	**M6**	Rijn-Herne Schip (L <= 86 m)	9.5	80-85	2.9	1,251-1,750	B=8.31-9.60 and L=38.01-86.00	7.0*
	M7	Verl. Rijn-Herne (L > 86 m)	9.5	105	3.0	1,751-2,050	B=8.31-9.60 and L>=86.01	7.0*
Va	**M8**	Groot Rijnschip (L <=111 m)	11.4	110	3.5	2,051-3,300	B= 9.61-11.50 and L=38.01-111.00	9.1*
	M9	Verlengd Groot Rijnschip (L >111 m)	11.4	135	3.5	3,301-4,000	B= 9.61-11.50 and L>= 111.01	9.1*
VIa	**M10**	Maatg. Schip 13.5 * 110 m	13.50	110	4.0	4,001-4,300	B=11.51-14.30 and L=38.01-111.00	7.0* only for class IV convoy
	M11	Maatg. Schip 14.2 * 135 m	14.20	135	4.0	4,301-5,600	B=11.51-14.30 and L>= 111.01	9.1*
	M12	Rijnmax Schip	17.0	135	4.0	>= 5,601	B>= 14.31 and L>= 38.01	

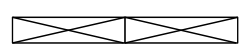
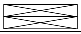
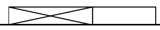
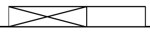
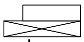
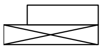
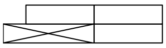
Source: Rijkswaterstaat (2010)

Table B.2 - Overview ship size class CEMT and RWS – Barges

CEMT Class	Barges								Clearance height * incl. 30 cm spare height
	RWS Class	Characteristics normative barges **				Classification			
		Combination	Width	Length	Draft (loaded)	Load capacity	Width and length		
			m	m	m	t	m		m
0									
I	BO1		5.2	55	1.9	0-400	B<=5.20 and L= all		5.25*
II	BO2		6.6	60-70	2.6	401-600	B=5.21-6.70 and L=all		6.1
III	BO3		7.5	80	2.6	601-800	B=6.71-7.60 and L=all		6.4
	BO4		8.2	85	2.7	801-1,250	B=7.61-8.40 and L=all		6.6 6.4
IVa	BI	Europe I barge 	9.5	85-105	3.0	1,251-1,800	B=8.41-9.60 and L=al		7.0*
Va	BII-1	Europe II barge 	11.4	95-110	3.5	1,801-2,450	B=9.61-15.10 and L<=111.00		9.1*
	BIIa-1	Europe IIa barge 	11.4	92-110	4.0	2,451-3,200	B=9.61-15.10 and L<=111.00		9.1*
	BIIL-1	Europe II Long 	11.4	125-135	4.0	3,201-3,950	B=9.61-15.10 and L=111.01-146.00		9.1*
Vb	BII-2l	2-barges long 	11.4	170-190	3.5-4.0	3,951-7,050	B=9.61-15.10 and L>=146.01		9.1*
VIa	BII-2b	2-barges broadwise 	22.8	95-145	3.5-4.0	3,951-7,050	B=15.11-24.00 and L<=146.00		7.0* only for class IV convoy
VIb	BII-4	4-barges (incl. 3-barges long) 	22.8	185-195	3.5-4.0	7,051-12,000 (7,051-9,000)	B=15.11-24.00 and L=146.01-200		9.1*
VIc	BII-6l	6-barges long (incl 5-barges long) 	22.8	270	3.5-4.0	12,001-18,000 (12,001-15,000)	B=15.11-24.00 and L>=200.01		9.1*
VIIa	BII-6b	6-barges broadwise (incl. 5-barges broadwise) 	34.2	195	3.5-4.0	12,001-18,000 (12,001-15,000)	B>=24.01 and L=all		9.1*

Source: Rijkswaterstaat (2010)

Table B.3 - Overview ship size class CEMT and RWS – Convoys

CEMT Class	RWS Class	Convoys: Characteristics normative convoys**				Convoys: Classification		Clearance height * incl. 30 cm spare height
		Combination	**Width**	**Length**	**Draft (loaded)**	**Load capacity**	**Width and length**	
			m	**m**	**m**	**t**	**m**	**m**
I	**C1l**	2 spitsen long 	5.05	77-80	2.5	<= 900	B<= 5.1 and L=all	5.25*
	C1b	2 spitsen broadwise 	10.1	38.5	2.5	<= 900	B=9.61-12.60 and L<= 80.00	5.25*
IVb	**C2l**	Class IV + Europe I long 	9.5	170-185	3.0	901-3,350	B=5.11-9.60 and L=all	7.0*
Vb	**C3l**	Class Va + Europe II long 	11.4	170-190	3.5-4.0	3,351-7,250	B=9.61-12.60 and L>=80.01	9.1*
VIa	**C2b**	Class IV + Europe I  broadw.	19.0	85-105	3.0	901-3,350	B=12.61-19.10 and L<=136.00	7.0* only for class IV convoy
	C3b	Class Va + Europe II broadw. 	22.8	95-110	3.5-4.0	3,351-7,250	B>19.10 and L<=136	9.1*
VIb	**C4**	Class Va + 3 Europe II 	22.8	185	3.5-4.0	>=7,251	B>12.60 and L>=136.01	9.1*

Source: Rijkswaterstaat (2010)

Remarks to Appendix B, C and D:
* For classes I, IV, V and higher, the clearance heights have been adjusted for 2 and 3 and 4-layer container traffic, respectively (headroom on channels relative to normative high water = 1% exceedance / year).
** The characteristics of the normative ship have a margin of ± 1 meter in length and a width of ± 10 cm.
1. A normative ship is a ship whose dimensions determine the dimensions of the waterway and the locks and bridges therein.
2. For new construction or waterway expansion, the largest normative ship within a CEMT class is assumed.
3. Class M3, M4, M6, M8, M10 and M11 may only be used for the renovation of existing waterways, locks and bridges.
4. The smallest dimensions of a normative ship form the lower limit for classifying a waterway in a certain standardized class.

Appendix C
Frequency histograms of construction year of registered Dutch shipping fleet in July 2019 per CEMT-class (figures created by author)

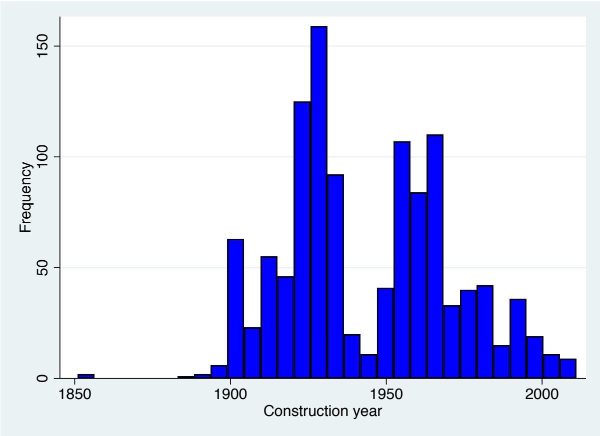


Figure C.1 – CEMT-class 0

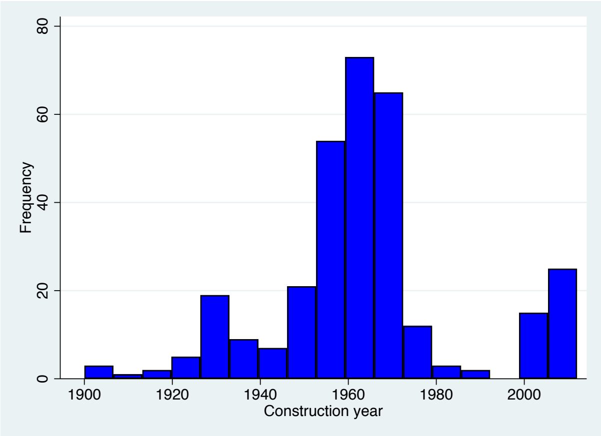


Figure C.2 – CEMT-class 1

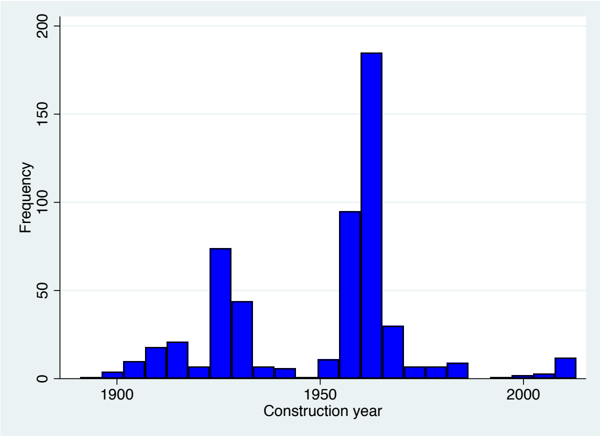


Figure C.3 – CEMT-class 2

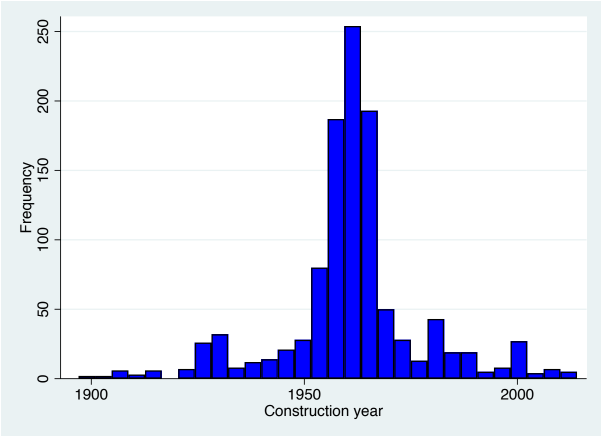


Figure C.4 – CEMT-class 3

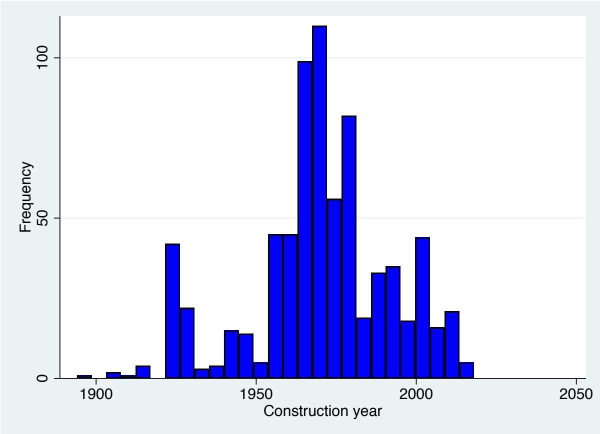


Figure C.5 – CEMT-class 4

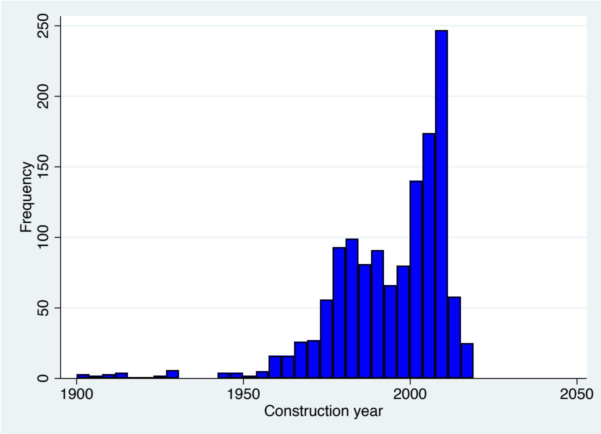


Figure C.6 – CEMT-class 5

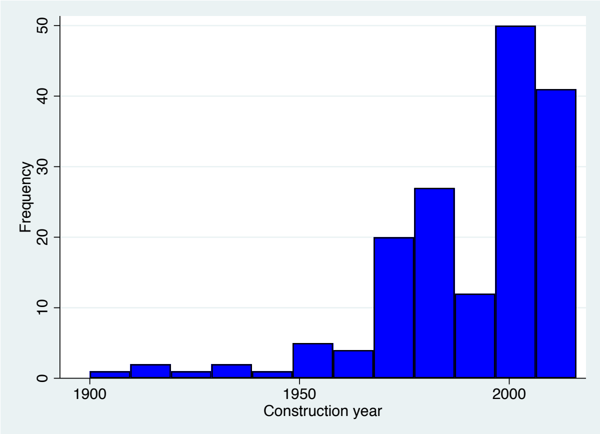


Figure C.7 – CEMT-class 6

Appendix D
Data of active ships on Dutch waterways

Table D.1 - Frequency of number of unique ships active on Dutch waterways in the period 2007-2018 per Rijkswaterstaat ship type

Ship type RWS	**Frequency**	**Percentage %**
Motor vessel	12,888	39.17
Separate barge	6,026	18.31
Convoy broad wise	3,081	9.36
Convoy long	2,310	7.02
2 barge combination	2,199	6.68
Tug ship with freight capacity	1,906	5.79
1 barge combination	1,200	3.65
Special transport	1,077	3.27
Containership	760	2.31
3 barge combination	639	1.94
4 barge combination	334	1.02
Barge with containers	148	0.45
6 barge combination	108	0.33
5 barge combination	87	0.26
Towed object	82	0.25
7 barge combination	31	0.09
Tugged freight ship	19	0.06
8 barge combination	9	0.03
Total	32,904	100.00

Source: Rijkswaterstaat (2019a)

Table D.2 - Number and yearly growth of active ships sailed on Dutch waterways per top 5 ship type 2007-2018*

Ship type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Motor vessel	6,485	6,469	6,375	6,185	6,279	6,027	5,751	5,508	5,457	5,215	5,201	5,098
Separate barge	1,640	1,651	1,684	2,274	2,549	2,429	2,327	2,295	2,329	2,361	2,414	2,354
Convoy broad wise	461	514	457	574	700	650	649	616	613	628	569	645
Convoy long	524	543	530	636	730	746	657	707	743	661	676	765
2 barge combination	555	532	437	387	599	556	556	553	563	542	564	515
Total	9,665	9,709	9,483	10,056	10,857	10,408	9,940	9,679	9,705	9,407	9,424	9,377
Motor vessel		-0.2%	-1.5%	-3.0%	1.5%	-4.0%	-4.6%	-4.2%	-0.9%	-4.4%	-0.3%	-2.0%
Separate barge		0.7%	2.0%	35.0%	12.1%	-4.7%	-4.2%	-1.4%	1.5%	1.4%	2.2%	-2.5%
Convoy broad wise		11.5%	-11.1%	25.6%	22.0%	-7.1%	-0.2%	-5.1%	-0.5%	2.4%	-9.4%	13.4%
Convoy long		3.6%	-2.4%	20.0%	14.8%	2.2%	-11.9%	7.6%	5.1%	-11.0%	2.3%	13.2%
2 barge combination		-4.1%	-17.9%	-11.4%	54.8%	-7.2%	0.0%	-0.5%	1.8%	-3.7%	4.1%	-8.7%
Total		0.5%	-2.3%	6.0%	8.0%	-4.1%	-4.5%	-2.6%	0.3%	-3.1%	0.2%	-0.5%

* The yearly total active ship differs from table 6.3 because in this rank the ships with unspecified CEMT-class are also included.
Source: Rijkswaterstaat (2019a)

Appendix E
Tonkilometer (tonkm) data and calculations per CEMT-class 2014-2018

Table E.1 – Summary statistics of the variables that are used in the transport performance analysis (created by author)

	Year	Observations	Mean	Minimum	Maximum
Ship length (in meters)	2014	549,017	92.800	0	270
	2015	602,680	95.497	2	346
	2016	600,913	95.863	2	346
	2017	601,430	96.672	1	392
	2018	619,977	97.974	1	365
Ship width (in meters)	2014	549,017	10.047	0	34.35
	2015	602,680	10.268	2.5	46.00
	2016	600,913	10.286	2	37.80
	2017	601,430	10.379	1	45.60
	2018	619,977	10.473	1	45.00
Load capacity (in tons)	2014	549,017	2,274	0	28,444
	2015	602,680	2,409	0	54,835
	2016	600,913	2,429	0	19,593
	2017	601,430	2,478	0	31,472
	2018	619,977	2,521	0	36,521
Total transported (tons)	2014	549,017	934.214	0	31,366
	2015	602,680	941.602	0	22,400
	2016	600,913	976.702	0	17,356
	2017	601,430	992.711	0	29,000
	2018	619,977	926.026	0	17,027
Distance travelled (kilometers)	2014	549,017	138.567	0.010	3,540.606
	2015	602,680	148.540	0.016	4,469.779
	2016	600,913	141.485	0.016	3,418.635
	2017	601,430	143.213	0.001	3,474.570
	2018	619,977	139.850	0.016	3,555.386
Loading 1 = loaded 0 = unloaded	2014	549,017	0.603	0	1
	2015	602,680	0.609	0	1
	2016	600,913	0.606	0	1
	2017	601,430	0.614	0	1
	2018	619,977	0.608	0	1
Dry cargo 1 = dry shipping 0 = other cargo	2014	549,017	0.659	0	1
	2015	602,680	0.670	0	1
	2016	600,913	0.668	0	1
	2017	601,430	0.663	0	1
	2018	619,977	0.667	0	1
Dutch trip 1 = inland trip 0 = foreign	2014	549,017	0.656	0	1
	2015	602,680	0.658	0	1
	2016	600,913	0.663	0	1
	2017	601,430	0.656	0	1
	2018	619,977	0.658	0	1
Tonkilometers	2014	549,017	149,829	0	8,119,473
	2015	602,680	156,931	0	13,517,231
	2016	600,913	157,843	0	18,166,666
	2017	601,430	160,596	0	30,790,960

	2018	619,977	144,800	0	13,385,848
Load factor % (loaded tons / load capacity)	2014	547,868	0.416	0	2.002
	2015	600,781	0.403	0	2.210
	2016	598,608	0.410	0	1.681
	2017	599,943	0.410	0	1.744
	2018	618,324	0.383	0	1.961

Table E.2 – Tonkilometer (tonkm) data and calculations for dry inland shipping within the Netherlands (created by author)

	CEMT-class	2014	2015	2016	2017	2018	Average over years
Coverage ratio trip and route data		91.2%	98.8%	99.0%	98.5%	98.6%	
Tonkm (in million) corrected for coverage ratio	0	4.10	4.17	3.43	4.42	4.06	
	1	83.55	69.66	63.20	61.57	52.57	
	2	873.27	772.18	751.68	707.68	669.10	
	3	4,499.12	4,433.09	4,551.77	4,356.26	4,138.34	
	4	5,000.46	5,151.20	5,435.42	5,470.47	5,261.14	
	5	13,244.01	14,926.05	15,346.67	16,189.08	16,031.22	
	6	8.,427.48	9,266.44	9,391.67	9,326.38	8,484.07	
	7	203.23	96.17	137.15	232.55	144.36	
	Total	32.335	34.719	35.681	36.348	34.785	
Tonkm (in million) corrected CEMT-class aggregated	0-2	960.92	846.01	818.30	773.66	725.73	
	3-7	31,374.30	33,872.95	34,862.69	35,574.74	34,059.13	
	0-3	5,460.04	5,279.10	5,370.07	5,129.92	4,864.07	
	4-7	26,875.18	29,439.86	30,310.91	31,218.48	29,920.80	
	0-4	10,460.50	10,430.31	10,805.50	10,600.39	10,125.21	
	5-7	21,874.72	24,288.66	24,875.49	25,748.01	24,659.65	
Average growth of tonkm CEMT-class aggregated	0-2		-12.0%	-3.3%	-5.5%	-6.2%	-6.7%
	3-7		8.0%	2.9%	2.0%	-4.3%	2.2%
	0-3		-3.3%	1.7%	-4.5%	-5.2%	-2.8%
	4-7		9.5%	3.0%	3.0%	-4.2%	2.8%
	0-4		-0.3%	3.6%	-1.9%	-4.5%	-0.8%
	5-7		11.0%	2.4%	3.5%	-4.2%	3.2%
Share of total tonkm*	0-2	3.0%	2.4%	2.3%	2.1%	2.1%	2.4%
	3	13.9%	12.8%	12.8%	12.0%	11.9%	12.7%
	4	15.5%	14.8%	15.2%	15.1%	15.1%	15.1%
	5	41.0%	43.0%	43.0%	44.5%	46.1%	43.5%
	6	26.1%	26.7%	26.3%	25.7%	24.4%	25.8%
	7	0.6%	0.3%	0.4%	0.6%	0.4%	0.5%
Yearly growth of share of total tonkm	0		-5.3%	-20.0%	26.5%	-4.0%	-0.7%
	1		-22.4%	-11.7%	-4.4%	-10.8%	-12.3%
	2		-17.7%	-5.3%	-7.6%	-1.2%	-7.9%
	3		-8.2%	-0.1%	-6.1%	-0.7%	-3.8%
	4		-4.1%	2.7%	-1.2%	0.5%	-0.5%
	5		5.0%	0.1%	3.6%	3.5%	3.0%
	6		2.4%	-1.4%	-2.5%	-4.9%	-1.6%
	7		-55.93%	38.77%	66.44%	-35.13%	3.54%

* The CEMT-classes 0, 1 and 2 are aggregated because of the low share per class

Table E.3 – Tonkilometer (tonkm) data and calculations for all inland shipping within the Netherlands (created by author)

	CEMT-class	2014	2015	2016	2017	2018	Average over years
Coverage ratio trip and route data		91.2%	98.8%	99.0%	98.5%	98.6%	
Tonkm (in million) corrected for coverage ratio	0	8.48	7.90	7.27	8.04	7.66	
	1	86.46	72.50	64.92	61.96	52.73	
	2	1,059.06	952.18	925.86	891.20	856.83	
	3	5,028.96	4,869.64	4,968.18	4,727.04	4,432.48	
	4	7,041.23	7,046.06	7,370.87	7,444.62	7,200.61	
	5	22,427.91	23,605.67	24,444.10	25,306.32	24,796.80	
	6	11,713.43	12,908.33	13,323.08	13,297.20	12,547.08	
	7	203.23	96.17	137.15	232.55	144.36	
	Total	47,569	49,558	51,241	51,969	50,039	
Tonkm (in million) corrected CEMT-class aggregated	0-2	1,154.00	1,032.58	998.05	961.19	917.22	
	3-7	46,414.76	48,525.87	50,243.38	51,007.73	49,121.33	
	0-3	6,182.96	5,902.22	5,966.23	5,688.24	5,349.70	
	4-7	41,385.80	43,656.23	45,275.20	46,280.69	44,688.85	
	0-4	13,224.19	12,948.27	13,337.10	13,132.85	12,550.31	
	5-7	34,344.57	36,610.17	37,904.33	38,836.07	37,488.24	
Average growth of tonkm CEMT-class aggregated	0-2		-10.5%	-3.3%	-3.7%	-4.6%	-5.5%
	3-7		4.5%	3.5%	1.5%	-3.7%	1.5%
	0-3		-4.5%	1.1%	-4.7%	-6.0%	-3.5%
	4-7		5.5%	3.7%	2.2%	-3.4%	2.0%
	0-4		-2.1%	3.0%	-1.5%	-4.4%	-1.3%
	5-7		6.6%	3.5%	2.5%	-3.5%	2.3%
Share of total tonkm*	0-2	2.4%	2.1%	2.0%	1.9%	1.8%	2.0%
	3	10.6%	9.8%	9.7%	9.1%	8.9%	9.6%
	4	14.8%	14.2%	14.4%	14.3%	14.4%	14.4%
	5	47.2%	47.6%	47.7%	48.7%	49.6%	48.2%
	6	24.6%	26.1%	26.0%	25.6%	25.1%	25.5%
	7	0.4%	0.2%	0.3%	0.5%	0.3%	0.3%
Yearly growth of share of total tonkm	0		-10.6%	-11.0%	9.1%	-1.0%	-3.4%
	1		-19.5%	-13.4%	-5.9%	-11.6%	-12.6%
	2		-13.7%	-6.0%	-5.1%	-0.2%	-6.2%
	3		-7.1%	-1.3%	-6.2%	-2.6%	-4.3%
	4		-4.0%	1.2%	-0.4%	0.5%	-0.7%
	5		1.0%	0.2%	2.1%	1.8%	1.3%
	6		5.8%	-0.2%	-1.6%	-2.0%	0.5%
	7		-54.6%	37.9%	67.2%	-35.5%	3.8%

* The CEMT-classes 0, 1 and 2 are aggregated because of the low share per class

Table E.4 – Tonkilometer (tonkm) data and calculations for dry inland shipping for complete trip in the Netherlands and abroad for trips with origin and/or destination in the Netherlands (created by author)

	CEMT-class	2014	2015	2016	2017	2018	Average over years
Coverage ratio trip and route data		91.2%	98.8%	99.0%	98.5%	98.6%	
Tonkm (in million) corrected for coverage ratio	0	11.64	7.85	5.44	8.11	7.04	
	1	346.64	271.80	213.47	236.72	201.05	
	2	1,268.36	1,177.71	1,104.38	1,065.32	982.71	
	3	8,186.29	8,045.45	7,906.13	7,774.19	7,159.22	
	4	10,268.60	10,536.59	10,664.96	11,069.80	10,098.75	
	5	29,512.81	33,974.08	32,940.78	35,007.26	33,018.76	
	6	13,863.06	15,383.48	15,936.31	15,852.83	14,095.56	
	7	290.02	136.47	196.03	329.16	205.35	
	Total	63,747	69,533	68,968	71,343	65,768	
Tonkm (in million) corrected CEMT-class aggregated	0-2	1,626.64	1,457.36	1,323.29	1,310.16	1,190.79	
	3-7	62,120.77	68,076.07	67,644.21	70,033.24	64,577.63	
	0-3	9,812.93	9,502.81	9,229.42	9,084.34	8,350.01	
	4-7	53,934.48	60,030.62	59,738.08	62,259.05	57,418.42	
	0-4	20,081.53	20,039.40	19,894.38	20,154.14	18,448.76	
	5-7	43,665.88	49,494.02	49,073.12	51,189.25	47,319.67	
Average growth of tonkm CEMT-class aggregated	0-2		-10.4%	-9.2%	-1.0%	-9.1%	-7.4%
	3-7		9.6%	-0.6%	3.5%	-7.8%	1.2%
	0-3		-3.2%	-2.9%	-1.6%	-8.1%	-3.9%
	4-7		11.3%	-0.5%	4.2%	-7.8%	1.8%
	0-4		-0.2%	-0.7%	1.3%	-8.5%	-2.0%
	5-7		13.3%	-0.9%	4.3%	-7.6%	2.3%
Share of total tonkm*	0-2	2.6%	2.1%	1.9%	1.8%	1.8%	2.0%
	3	12.8%	11.6%	11.5%	10.9%	10.9%	11.5%
	4	16.1%	15.2%	15.5%	15.5%	15.4%	15.5%
	5	46.3%	48.9%	47.8%	49.1%	50.2%	48.4%
	6	21.8%	22.1%	23.1%	22.2%	21.4%	22.1%
	7	0.5%	0.2%	0.3%	0.5%	0.3%	0.3%
Yearly growth of share of total tonkm	0		-38.2%	-30.1%	44.2%	-5.9%	-7.5%
	1		-28.1%	-20.8%	7.2%	-7.9%	-12.4%
	2		-14.9%	-5.5%	-6.8%	0.1%	-6.8%
	3		-9.9%	-0.9%	-4.9%	-0.1%	-4.0%
	4		-5.9%	2.1%	0.3%	-1.0%	-1.1%
	5		5.5%	-2.3%	2.7%	2.3%	2.1%
	6		1.7%	4.4%	-3.8%	-3.6%	-0.3%
	7		-56.9%	44.8%	62.3%	-32.3%	4.5%

* The CEMT-classes 0, 1 and 2 are aggregated because of the low share per class

Table E.5 – Tonkilometer (tonkm) data and calculations for all inland shipping for complete trip in the Netherlands and abroad for trips with origin and/or destination in the Netherlands (created by author)

	CEMT-class	2014	2015	2016	2017	2018	Average over years
Coverage ratio trip and route data		91.2%	98.8%	99.0%	98.5%	98.6%	
Tonkm (in million) corrected for coverage ratio	0	17.62	11.96	9.66	12.15	11.01	
	1	352.35	275.73	215.49	237.21	201.21	
	2	1,502.02	1,412.03	1,325.52	1,299.41	1,225.68	
	3	8,995.43	8,761.22	8,642.08	8,444.57	7,669.83	
	4	14,066.92	14,161.31	14,310.19	14,737.12	13,634.93	
	5	47,249.17	51,257.31	50,467.23	52,393.51	49,187.62	
	6	17,722.43	19,711.79	20,641.82	20,604.79	18,911.61	
	7	290.02	136.47	196.03	329.16	205.35	
	Total	90,196	95,728	95,808	98,058	91,047	
Tonkm (in million) corrected CEMT-class aggregated	0-2	1,871.98	1,699.72	1,550.66	1,548.76	1,437.89	
	3-7	88,323.97	94,028.10	94,257.34	96,509.15	89,609.33	
	0-3	10,867.41	10,460.94	10,192.74	9,993.33	9,107.72	
	4-7	79,328.54	85,266.88	85,615.26	88,064.58	81,939.51	
	0-4	24,934.33	24,622.24	24,502.93	24,730.45	22,742.64	
	5-7	65,261.62	71,105.58	71,305.07	73,327.46	68,304.58	
Average growth of tonkm CEMT-class aggregated	0-2		-9.2%	-8.8%	-0.1%	-7.2%	-6.3%
	3-7		6.5%	0.2%	2.4%	-7.1%	0.5%
	0-3		-3.7%	-2.6%	-2.0%	-8.9%	-4.3%
	4-7		7.5%	0.4%	2.9%	-7.0%	0.9%
	0-4		-1.3%	-0.5%	0.9%	-8.0%	-2.2%
	5-7		9.0%	0.3%	2.8%	-6.8%	1.3%
Share of total tonkm*	0-2	2.1%	1.8%	1.6%	1.6%	1.6%	1.7%
	3	10.0%	9.2%	9.0%	8.6%	8.4%	9.0%
	4	15.6%	14.8%	14.9%	15.0%	15.0%	15.1%
	5	52.4%	53.5%	52.7%	53.4%	54.0%	53.2%
	6	19.7%	20.6%	21.5%	21.0%	20.8%	20.7%
	7	0.3%	0.1%	0.2%	0.3%	0.2%	0.3%
Yearly growth of share of total tonkm	0		-36.0%	-19.3%	22.9%	-2.4%	-8.7%
	1		-26.3%	-21.9%	7.6%	-8.7%	-12.3%
	2		-11.4%	-6.2%	-4.2%	1.6%	-5.1%
	3		-8.2%	-1.4%	-4.5%	-2.2%	-4.1%
	4		-5.2%	1.0%	0.6%	-0.4%	-1.0%
	5		2.2%	-1.6%	1.4%	1.1%	0.8%
	6		4.8%	4.6%	-2.5%	-1.2%	1.5%
	7		-55.7%	43.5%	64.1%	-32.8%	4.8%

* The CEMT-classes 0, 1 and 2 are aggregated because of the low share per class

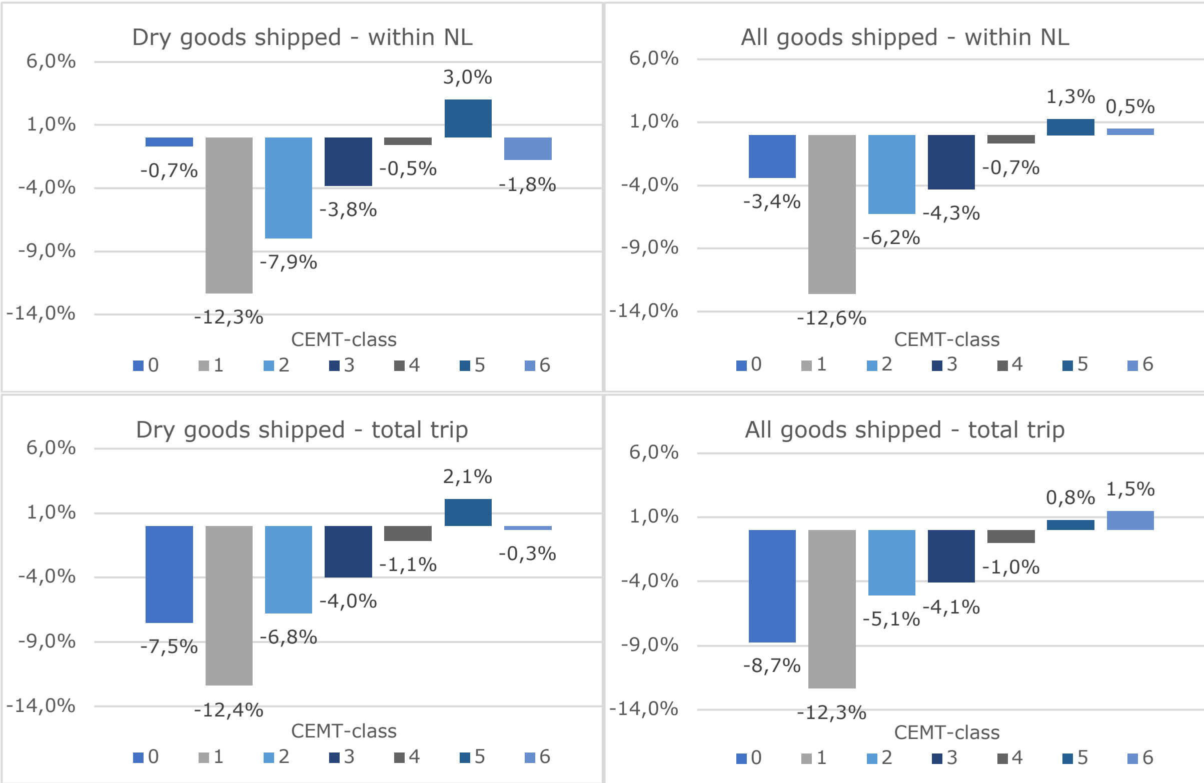


Figure E.1 – Average yearly growth in share of total tonkilomtres per CEMT-class (created by author based on Appendix Tables E.2-E.5) - splitted in dry and all goods and trip distance within the Netherlands or total trip distance 2015-2018

Table E.6 – Tonkilometers (in million) of inland shipping in the Netherlands per good type 2014-2018

	2014	**2015**	**2016**	**2017***	**2018***
Total	49,425	48,535	48,799	48,998	47,244
Dry bulk	28,807	27,936	27,370	27,255	26,169
Liquid bulk	13,863	13,929	14,369	14,316	14,162
Containers	6,756	6,671	7,060	7,427	6,913
Dry and container**	35,563	34,607	34,430	34,682	33,082

* Provisional figures
** Definition of dry shipping used in this research
Source: CBS (2019d)

Table E.7 – Tonkilometers (in millions) of professional road transport and rail transport of trips within the Netherlands and trips with origin and/or destination in the Netherlands 2014-2018

		2014	**2015**	**2016***	**2017***	**2018***
Road transport	Within NL	25,033	25,197	27,529	27,286	27,585
	O and/or D in NL	54,195	52,155	52,905	53,136	54,318
Railway transport	Within NL	542	466	421	423	509
	O and/or D in NL	5,402	5,756	5,865	5,475	5,790

* Provisional figures
Source: CBS (2019a) & (2019f)

Table E.8 - Data of shift share analysis for tonkilometers of trips within the Netherlands of ships from all countries (created by author)

Good type	CEMT-class	2014	2015	2016	2017	2018
Dry bulk	0	4.10	4.17	3.43	4.42	4.06
	1	83.55	69.66	63.20	61.57	52.57
	2	873.27	772.18	751.68	707.68	669.10
	3	4,499.12	4,433.09	4,551.77	4,356.26	4,138.34
	4	5,000.46	5,151.20	5,435.42	5,470.47	5,261.14
	5	13,244.01	14,926.05	15,346.67	16,189.08	16,031.22
	6	8,427.48	9,266.44	9,391.67	9,326.38	8,484.07
	7	203.23	96.17	137.15	232.55	144.36
	Total	32,335.22	34,718.96	35,680.99	36,348.40	34,784.86
Liquid bulk	0	4.38	3.73	3.84	3.62	3.60
	1	2.90	2.84	1.72	0.39	0.16
	2	185.79	179.99	174.18	183.52	187.73
	3	529.84	436.55	416.41	370.78	294.14
	4	2,040.77	1,894.85	1,935.44	1,974.15	1,939.47
	5	9,183.90	8,679.62	9,097.44	9,117.24	8,765.58
	6	3,285.96	3,641.90	3,931.41	3,970.82	4,063.01
	7	0.00	0.00	0.00	0.00	0.00
	Total	15,233.54	14,839.48	15,560.44	15,620.52	15,253.68
Total	0	8.48	7.90	7.27	8.04	7.66
	1	86.46	72.50	64.92	61.96	52.73
	2	1,059.06	952.18	925.86	891.20	856.83
	3	5,028.96	4,869.64	4,968.18	4,727.04	4,432.48
	4	7,041.23	7,046.06	7,370.87	7,444.62	7,200.61
	5	22,427.91	23,605.67	24,444.10	25,306.32	24,796.80
	6	11,713.43	12,908.33	13,323.08	13,297.20	12,547.08
	7	203.23	96.17	137.15	232.55	144.36
	Total	47,568.76	49,558.45	51,241.43	51,968.92	50,038.54

Table E.9 - Calculations of shift share analysis for tonkilometers of trips within the Netherlands of ships from all countries (created by author)

Calculation of	CEMT-class	2015	2016	2017	2018
Total goods growth		1.042	1.034	1.014	0.963
Total growth (TG)	0	4.27	4.31	3.48	4.25
	1	87.05	72.02	64.09	59.28
	2	909.80	798.41	762.35	681.39
	3	4,687.31	4,583.64	4,616.40	4,194.45
	4	5,209.62	5,326.14	5,512.59	5,267.27
	5	13,797.98	15,432.93	15,564.55	15,587.74
	6	8,779.98	9,581.12	9,525.01	8,979.95
Dry total growth		1.074	1.028	1.019	0.957
Goodtype mix (GM)	0	0.13	-0.03	0.02	-0.03
	1	2.66	-0.44	0.28	-0.36
	2	27.85	-4.83	3.39	-4.15
	3	143.49	-27.71	20.52	-25.57
	4	159.48	-32.20	24.50	-32.11
	5	422.38	-93.30	69.18	-95.04
	6	268.77	-57.92	42.34	-54.75
Dry goods growth	0	1.02	0.82	1.29	0.92
	1	0.83	0.91	0.97	0.85
	2	0.88	0.97	0.94	0.95
	3	0.99	1.03	0.96	0.95
	4	1.03	1.06	1.01	0.96
	5	1.13	1.03	1.05	0.99
	6	1.10	1.01	0.99	0.91
CEMT-shift (CS)	0	-0.23	-0.86	0.93	-0.17
	1	-20.06	-8.39	-2.81	-6.35
	2	-165.46	-41.90	-58.06	-8.14
	3	-397.70	-4.16	-280.65	-30.54
	4	-217.89	141.49	-66.62	25.99
	5	705.69	7.03	555.35	538.52
	6	217.69	-131.52	-240.97	-441.13

Table E.10 – Average load factor of all trips dry shipping within the Netherlands per CEMT-class 2014-2018 (created by author)

CEMT-class	2014	2015	2016	2017	2018
0	5.8%	7.6%	7.9%	11.1%	11.6%
1	35.7%	34.3%	33.1%	33.2%	31.8%
2	36.6%	36.5%	37.0%	36.9%	36.5%
3	43.9%	43.6%	43.7%	43.1%	42.1%
4	43.6%	42.2%	42.8%	43.2%	41.3%
5	40.4%	38.6%	39.0%	40.0%	36.9%
6	41.4%	35.5%	38.3%	37.8%	32.2%
Overall	**41.1%**	**40.0%**	**40.5%**	**40.7%**	**38.6%**
Missing values	1,149	1,899	2,305	1,487	1,653

Table E.11 – Average load factor of loaded trips dry shipping within the Netherlands per CEMT-class 2014-2018 (created by author)

CEMT-class	2014	2015	2016	2017	2018
0	53.6%	68.0%	67.5%	78.7%	81.2%
1	77.1%	75.9%	77.3%	74.9%	75.7%
2	74.4%	77.2%	77.8%	77.8%	77.5%
3	83.9%	83.2%	83.2%	82.6%	80.3%
4	74.0%	71.2%	71.8%	72.0%	69.5%
5	56.6%	54.8%	55.8%	56.4%	53.6%
6	50.5%	47.6%	50.1%	49.0%	44.3%
Overall	**69.5%**	**67.3%**	**68.2%**	**67.7%**	**64.7%**
Missing values	1,149	1,899	2,305	1,487	1,653

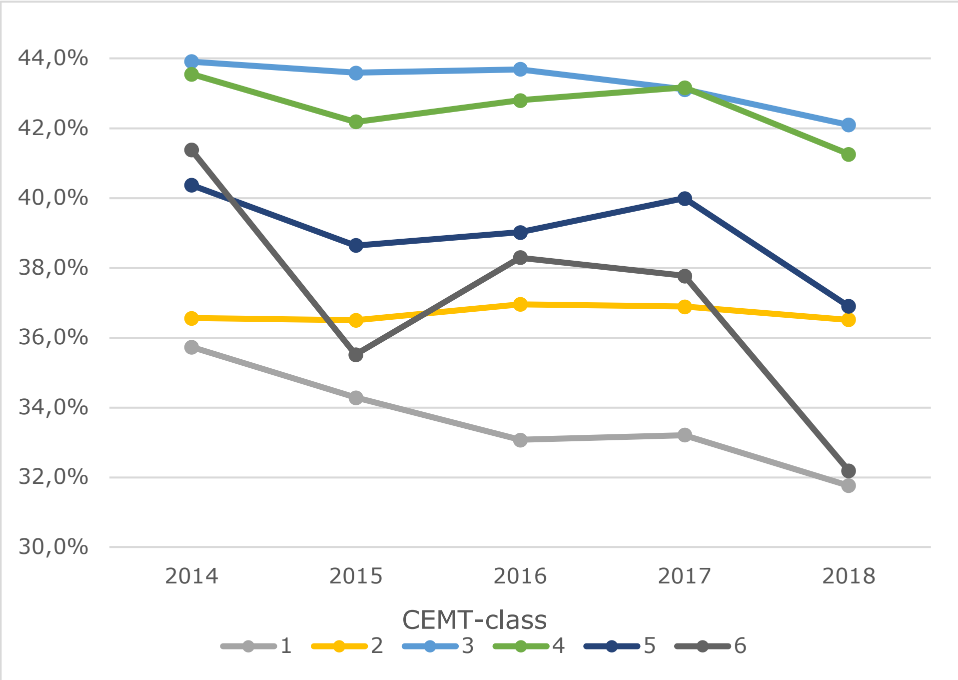


Figure E.2 - Average load factor of all trips dry shipping within the Netherlands per CEMT-class 2014-2018 (created by author based on Appendix Table E.10) – without class 0 because of a totally different scale

Appendix F

Throughput data and calculations of inland ports per CEMT-class 2011-2018

Table F.1 - Throughput in million tons and yearly growth for all inland ports per CEMT-class 2011-2018 (created by author)

CEMT-class	2011	2012	2013	2014	2015	2016	2017	2018	Average growth
0	0.22	0.28	0.31	0.19	0.23	0.27	0.40	0.32	
1	0.30	0.29	0.42	0.27	0.34	0.28	0.26	0.28	
2	6.69	5.70	5.64	7.14	7.39	6.71	8.22	7.40	
3	5.27	5.60	4.64	4.48	4.81	4.87	4.51	5.41	
4	25.93	24.58	26.93	28.17	27.12	26.67	27.71	27.85	
5	106.28	102.46	101.82	107.17	109.79	110.63	107.62	114.30	
6	267.22	264.42	268.82	277.58	276.43	275.70	278.76	279.20	
Total	411.91	403.32	408.59	424.99	426.10	425.13	427.48	434.77	
0		23.4%	12.2%	-38.4%	20.7%	17.8%	48.6%	-20.0%	9.2%
1		-2.9%	45.4%	-37.4%	27.0%	-16.5%	-8.6%	9.5%	2.4%
2		-14.7%	-1.1%	26.5%	3.5%	-9.2%	22.5%	-10.0%	2.5%
3		6.2%	-17.1%	-3.4%	7.3%	1.2%	-7.4%	20.1%	1.0%
4		-5.2%	9.6%	4.6%	-3.7%	-1.7%	3.9%	0.5%	1.1%
5		-3.6%	-0.6%	5.2%	2.4%	0.8%	-2.7%	6.2%	1.1%
6		-1.0%	1.7%	3.3%	-0.4%	-0.3%	1.1%	0.2%	0.6%
Total		-2.1%	1.3%	4.0%	0.3%	-0.2%	0.6%	1.7%	0.8%

Appendix G
Correlation table of variables used in the fixed effects model

Table G.1 – Correlation table of variables used in the fixed effects model (created by author)

	GRP in million euro (log)	**Low tide days**	**River area**	**Average distance km.**
GRP in million euro (log)	1.000			
Low tide days	0.055	1.000		
River area	0.325	-0.000	1.000	
Average distance km	-0.392	-0.002	-0.372	1.000