Bachelor Thesis

Slow steaming in the liner shipping industry

"To what extent is slow steaming in the liner shipping industry economically justified?"

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Naaldwijk, 19 July 2011

Acknowledgement

This thesis is written as part of the bachelor's degree in Economie & Bedrijfseconomie (Economics and Business), offered at the Erasmus University Rotterdam. The major in Urban, Port and Transport economics has encouraged my interest in maritime economics and the shipping industry. Therefore, to write a thesis related to the maritime industry was for me a logic result of this interest. 'Slow steaming' is an interesting an actual trend in the shipping industry, of which I enjoyed analysing and calculating the consequences.

I would like to thank the dedicated support of my family and friends, as well as the guidance of Dr. Bart Kuipers, supervisor of this thesis. I would also like to thank Drs. Marco Wiesehahn for his vision and knowledge during the interview.

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Erasmus Universiteit Rotterdam

July, 2011

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Executive summary

Since the extraordinary rise of bunker prices in 2008, the liner shipping industry decreases the commercial speed of their vessels to save bunker costs. With the implementation of slow steaming, they create also a method to decrease their CO2 emissions, in line with stricter emission standards and legislation in certain regions. According to the liner shipping companies, the implementation of slow steaming helps them to sustain in times of high bunker costs. Instead, shippers complain about slow steaming. They face higher costs, and longer transit times. In recent articles, the effects for shippers were not taken into consideration. This thesis will therefore create an integrated analysis of all economic consequences of slow steaming for shipping companies and shippers in terms of efficiency, effectiveness, equity and sustainability.

To calculate the efficiency of slow steaming, the consequences in bunker savings, emission savings, additional vessel costs and time costs for a certain liner service were analysed. The most efficient speed was 17 knots, which saved almost 9 % of the total economic costs of operating the loop with sailing at 25 knots. At speeds under the 17 knots, much costs were still saved but the additional costs of extra vessels and time costs for shippers increased much more, resulting in even higher total costs than a fast speed of 25 knots.

When the effects of slow steaming for shippers and shipping companies are compared, equity effects become present. At every decrease in speed, shippers face extra costs while shipping companies save millions of dollars. Moreover, supply chain costs and bunker surcharges are not considered, what would make the situation even more unfair. Shippers are not compensated by a more efficient sailing process of the shipping companies. An explanation for this situation is found in the remains of the conference-systems. This shipping company protection system could make them deal with high risks and investments. However, more transparency and service in operating a liner service would not be too risky at all.

It can be concluded from the calculations in this thesis hat slow steaming is effective in reducing bunker costs for a shipping company. $3.7 million to $12.6 million can be saved with a single speed reduction of 2 knots. This implies a 50% cost reduction (more than $30 million) when every vessel makes one roundtrip with a speed of 17 knots instead of 25 knots. This scale of cost savings in short term cannot be reached by using cheaper kinds of fuel. It can be reached by innovations in the design of the vessel, but this is a long term investment and its effectiveness should therefore not be compared with slow steaming.

Slow steaming is an economically sustainable method when bunker prices are above the $600 per ton. When these prices are lower, sailing at higher speeds involves less costs than sailing at lower speeds. However, shipping companies do already have an incentive to reduce their vessel speeds at bunker prices of $250. With their current market power, bad profit forecasts for the coming year, overcapacity and expected emission bunker levies and emission trading schemes, it is expected that slow steaming will remain implemented till bunker prices are under the $250 per ton, although this would be socially undesired. Therefore, more pressure for a fairer treatment is expected from shippers.

1.Introduction

In the years before 2008, the liner shipping industry had the tendency of increasing sailing speeds. Faster ships were designed which could sail at speeds of 25 knots. These high speeds were intended to attract new customers for the shipping companies. High speeds meant shorter transit times, which made it possible for shippers to keep their inventories as tight as possible, expressed in the Just-In-Time principle. Typically, bunker costs already represents half of the operating vessel costs for shipping companies (Notteboom, 2006). But the bunker fuel prices reached a top of $700 per ton in 2008. As a comparison, bunker prices varied in the years between 2001 and 2006 only in between the $130 and $350 per ton. Consequently, methods or techniques to reduce fuel consumption costs were quite necessary for shipping companies.

Furthermore, indications for tighter legislation in the shipping industry on the emission of green house gasses, requires shipping companies to develop methods to reduce or control their emissions. Strict emission standards are already present in some parts of the world and according to the International Maritime Organisation, more regions are expected to follow. Moreover, emission trading schemes and emission levies on bunker prices will motivate shipping companies even more to control their environmental pollution.

A method for shipping companies that contributes to less fuel costs and fewer emissions is the decrease of the commercial speed of vessels, or in other words; slow steaming. At lower speeds, less fuel is consumed by the vessel, which has also its effect on the emission of GHG's. Furthermore, the shipping industry faces overcapacity of available ships since the economic crisis. Slow steaming requires more vessels, so a solution for overcapacity was also found.

In 2007, when fuel prices were already considerably high, Maersk Line and CMA-CGM reduced their commercial speeds and added vessels to their Europe-Far East services to maintain frequency of service. In 2008, the New World Alliance followed. And nowadays, with actual bunker prices of around the $650 dollar per ton, all shipping companies on the Europe-Far East trade have implemented slow steaming on all of their services.[1]

Existent literature on the consequences of slow steaming is relatively scarce. Some papers focussed on the financial consequences for shipping companies, but most of the articles investigated slow steaming as a means to reduce green house gas emissions. However, an integrated analysis of the results of slow steaming for shipping companies, the environment and shippers is missing. Especially the consequences for shippers are not highlighted very often. Shipping companies are somewhat

[1] Nieuwsblad Transport, April 2011.

reserved to acknowledge that slow steaming might create problems for shippers, but shippers do express their discontent about slow steaming more and more.

This is the reason why this thesis aims to provide an integrated analysis of the economic consequences of slow steaming. Because the effects for shipping companies, shippers and the environment will be analysed, the economic justification of slow steaming can be judged. This results in answering the following research question;

"To what extent is slow steaming in the liner shipping industry economically justified?"

Four different sections will contribute to answering the research question. Each section incorporates another part of the economic justification to be analysed. This distribution of sections results in the following sub-questions to be answered;

1. *"How efficient is slow steaming in terms of costs and benefits?"*
2. *"Are there possible equity-effects as a result of slow steaming?"*
3. *"Is slow steaming the most effective method of reducing bunker costs?"*
4. *"To what extent is slow steaming in the liner shipping industry sustainable in the future?"*

In the first section, costs and benefits for the shipping company and the shipper as a result of slow steaming will be quantified. Some methods of existing papers will be used to analyse the costs and benefits, but the calculations and results are specific and unique. The second section will compare the consequences for the shippers and the shipping company to evaluate possible equity-effects. Moreover, an interview will provide some qualitative information about the consequences for- and the role of shippers in the implementation of slow steaming. Thirdly, the effectiveness of slow steaming as a way to reduce fuel consumption costs is measured and compared with other methods to reduce bunker costs. Finally, the factors that influence the sustainability of slow steaming will be analysed and together with predictions for the liner shipping industry, the sustainability of slow steaming can be judged in the last section.

Before the above-mentioned sections are analysed, a theoretical background is presented to discuss earlier research related to the topic. Furthermore, a description if the shipping industry is given and especially the liner shipping industry will be discussed more thoroughly. After these parts, the four sections of analysis are presented in the same order as mentioned above. The conclusion will finalise this thesis. Additional tables and an elaborated version of the interview are presented in the appendix.

2.Theoretical background

Where other trends in the shipping industry -like economies of scale in increasing vessel sizes- have already been present for some decades, the decrease of commercial vessel speed is known only since the extraordinary rise of fuel prices in 2007. As a result, academic work on the topic of slow steaming in the shipping industry has not been developed that much. However, Notteboom (2006) addresses the point of possibly great benefits from slowing down in a paper two years before we have actually seen lower speeds in the liner shipping industry. It is interesting to see that Notteboom does not introduce the relation between vessel speed and bunker costs because of slowing down, but because of "an obvious trend in the modern container ship designs towards higher speeds and increasing speed margin, primarily for maintaining a tight sailing schedule with good frequency and reliability." Notteboom further illustrates the high proportion of fuel costs in total operational costs of a ship (50%), and he gives the example of beneficially slowing down vessel speed from 23 knots to 19 knots on the trans-pacific route, because of port congestion on the US West Coast. Not yet realizing that almost the whole industry would sail at lower speeds only a few years later.

The first paper that intensively investigated the relation between high fuel costs, vessel speed and liner service design, is Notteboom and Vernimmen (2009). The paper illustrates how the management of vessel speed can control bunker consumption in container shipping. Further, the number of vessels deployed on a loop is also considered as an important variable in the service configuration of that loop. Finally, a cost comparison for several vessel sizes, bunker costs and the number of vessels for a liner service on the North-Europe- East Asia trade route has been made. Results from the comparison reveal that when carriers sail at lower speeds on that route, an extra vessel has to be added to the service. For the larger vessels (> 6500 TEU) slowing down from 24 to 20 knots, even two extra vessels are needed to guarantee the same schedule. Further, the paper questions the relative late reaction of carriers on high bunker prices. It was already profitable to slow down speeds and add an extra vessel on this particular loop when the bunker price was higher than $150 per ton. This price was already reached in most ports in 2003.[2] Possible explanations for this late reaction are; the unexpected instant rise of fuel prices, the service of remaining short transit times for customers, the need to offer stable schedules and a tight vessel capacity in the years before 2008.

The academic writing that remains to be considered are papers on how speed reductions in shipping play a role in reducing CO2 emissions. This work was not intended to look at the consequences of actual slow steaming in terms of emissions. It considers more the problematic of increasing CO2 emissions from containerships, and how lower speeds can work as a means to reduce these emissions.

[2] See table A1 in the appendix.

All papers first indentify fuel consumption in tons from a ship, or ships, with the help of a mathematic function. These functions are different from each other in each paper, but they are based on almost the same assumptions. Fuel consumption is most of the times based on distance of the trip, design speed, operational speed, main engine consumption and auxiliary engine consumption. A second function is used to calculate the CO2 emissions in kilograms. This is done by multiplying the fuel consumption in tonnes with an emission factor. The result is the amount of CO2 emissions in kg per trip.

Corbett et al. (2009), identifies the optimal speed for vessels to maximize annual profit from operating a single trade between two destinations. Given several formulas, a fuel tax of $150 per ton fuel will lead to CO2 emission reductions of 20-30%, due to lower speeds.

Psaraftis et al. (2009) address speed reductions as an effective means to reduce CO2 emissions. In their model however, to keep trip time constant, the time a ship is in the port must be decreased considerably to compensate for more time a ship is sailing at sea. For instance, for a speed reduction of 15% the time in port has to decrease with 37%. They do not consider the option of extra vessels to solve the problem of time schedules.

In Psaraftis and Kontovas (2010), a trade-off between the fleet costs of two scenarios is made. One scenario involves the maintenance of high speeds, the second scenario incorporates slow steaming from 21 to 18 knots, the extra charter costs for extra vessels and extra in-transit inventory costs. The slow steaming option could be more expensive when a high charter rate is present, or when the value of the cargo is very high, resulting in high in-transit inventory costs.

The most recent work is from Cariou (2011). The sustainability of slow steaming is investigated in this paper. When the bunker price for fuel is high enough to offset the additional costs of operating the vessel and the additional inventory costs, slow steaming will be beneficial. The formula to calculate this bunker price is applied on all major trade routes. This results in bunker break-even prices in $/ton ranging from $259/ ton for multi-trades to $568/ton for Australasia/Oceania. The differences in these prices depends on the size of the trade, rate of slow-steaming and the time at sea. Only high bunker prices make slow steaming sustainable.

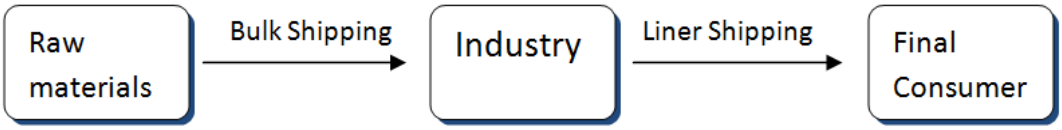
Where most of these papers only look at an efficiency scale towards slow steaming, this thesis will incorporate also equity, effectiveness and sustainability. The efficiency section in the thesis takes several assumptions and methods from above mentioned papers into account, but introduces furthermore an own, specific calculation and comparison.

3.Industry background

3.1 Liner shipping and bulk shipping.

The shipping industry is traditionally divided in two sectors; the bulk shipping industry and the liner shipping industry. To give insight in these industries, the paper by Haralambides and Veenstra (2000) is used. The bulk shipping industry is involved in the transportation of raw materials like oil, coals, grain, iron ore, etcetera. When the raw materials are transformed into final products, then the liner shipping industry takes care of the final sea transportation of the products. Figure 1 presents a rough illustration of both industries in the production process.

Figure 1, Shipping in the production process.

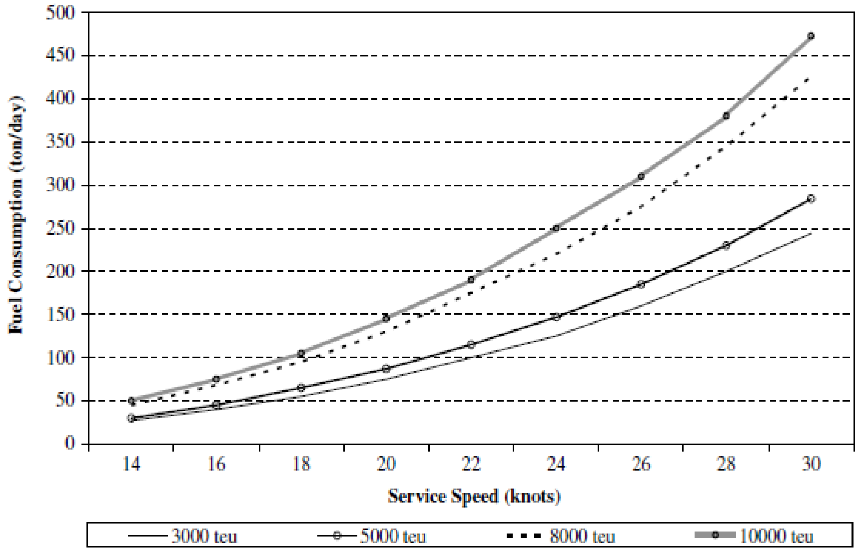


The sectors are very different from each other while looking at their market structure. In the bulk shipping industry, the commodity is transported on a contract basis between the ship owner and the cargo owner. This contract is called the charter party. The ship is chartered for a certain period (time-charter) or for one certain trip (voyage-charter). After this period or trip, the contract expires. In the liner shipping industry however, carriers offer regular services between specified ports, based on an itinerary and on prices that are known in advance. This difference makes it for the liner shipping industry necessary to have extensive infrastructure. Many vessels, cargo handling activities, equipment and coordination is needed to provide such a scheduled and global service. It follows that the entry in the liner industry is much more limited than it is for bulk shipping.

Since the start of containerization in the 1960's, the liner shipping service is mainly involved in carrying containers. Thus, the terms liner shipping and container shipping can both be used to express the same market.

This thesis only considers the effects of slow steaming in the liner shipping industry and not in the bulk shipping industry. Several reasons can be distinguished for this focus. The main reason is quite straightforward; container vessels sail at much higher speeds than bulk carriers. Containerships sail at speeds as high as 25-26 knots, while bulk carriers sail at speeds around 14-15 knots (Table A2, appendix). As figure 2 illustrates, the shape of the fuel consumption curve is much steeper at higher speeds. Therefore, slowing down four knots (for example) at speeds of 25 knots can save considerably more than slowing down from 14 to 10 knots.

Figure 2, Fuel consumption per day for four container vessels (source: Notteboom and Vernimmen 2009)



As a result of the higher speeds, the container vessels are also the biggest fuel consumers. In Table A2, a comparison is made between several types of bulk carriers and container vessels, based on calculations from the second IMO[3] Greenhouse gas Study. The only ship that came close to the consumption of fuel of containerships was the RoPax ferry, again a ship with high speeds.

Another consequence of the higher speeds of container ships is pollution. Container ships are the most polluting ships in terms of CO2 (see, Table A2). Further, emissions from these ships are expected to grow the fastest of all segments of marine shipping. (Ocean Policy Research Foundation, 2008.)

Concluding, because of the speeds, the higher fuel consumption and the degree of CO2 emissions, most costs can be saved, and most pollution can be reduced with slow steaming in the liner shipping industry. This is the reason why this thesis focuses on the liner shipping industry.

[3] International Maritime Organization

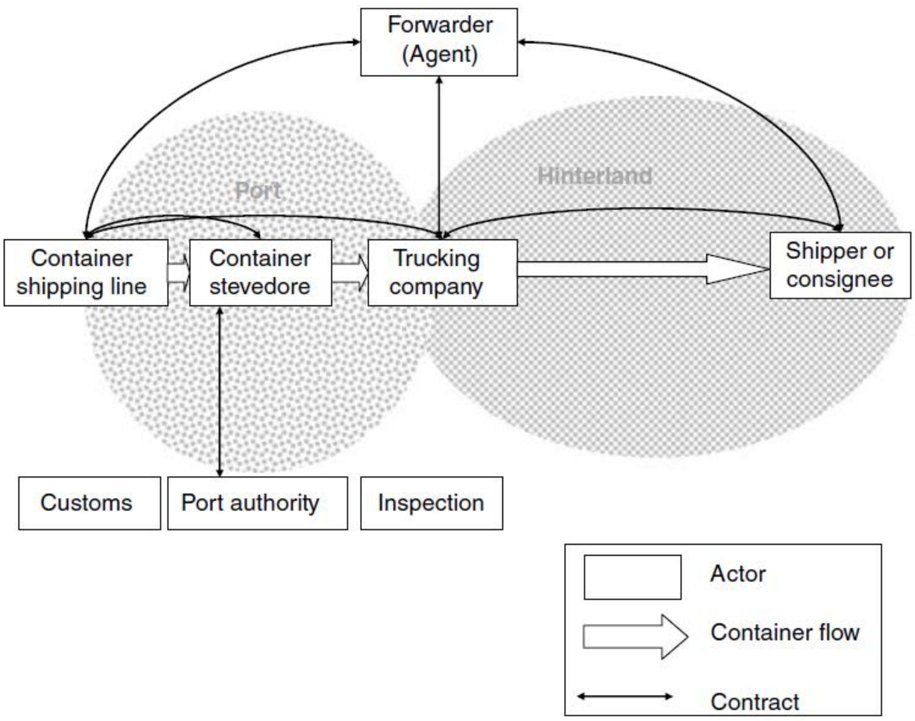
3.2 The liner shipping industry, a system description.

To gain better insight in the effects of slow steaming later in this thesis, a system description of the liner shipping industry will be introduced in this section. The aim is to understand which players interact in the liner shipping industry and how their relations are.

In figure 3, an example of a possible hinterland chain is given. The mode of transport in the hinterland is a truck. This could also have been a barge or train, but the truck- example gives the clearest view because fewer actors are involved.

First, when a shipper needs cargo to be transported over sea, he has several options. He can directly contact a shipping company to take care of the transportation. It is also possible to contact a (ship) broker. Then, shipping lines can offer a price for that specific transportation. The broker acts as an intermediate between shipping line and shipper. However, the most common way nowadays is to contact a freight forwarder (In other words: third party logistic, 3PL or NVOCC's). This agent will take care of all the logistics that is needed to bring the freight from door-to-door. As illustrated in figure 3, the forwarder has contracts with the shipper, the shipping line, and the trucking company that delivers the freight to the door of the shipper.

Figure 3, The trucking hinterland chain. (source: Van der Horst & De Langen, 2008)



A trend in the shipping line industry nowadays, is that the freight forwarders are taking over the role of shipping companies. They can also offer a door-to-door service for a shipper and are not dependent anymore of other parties. This is called freight integration. Also, terminal operators merge with transport companies to integrate in the whole supply chain. They take over the role of the freight forwarder.

Whatever the contractual arrangements are, the actors in figure 3 will be present in each case. The container shipping line takes the cargo in containers to a certain port. The containers will be handled at the terminal by the terminal operator or stevedore company. As such, contractual arrangements are present between carriers and terminal operators. At the port, the stevedoring company hires space on the terminal from the port authority. Customs and inspection can intervene at the port to check the cargo and papers. Then, the trucking company takes the container through the hinterland to the consignee.

In case of slow steaming, the shipping line and the shipper are the parties that are mainly involved in this trend. The shipping line is the party who has implemented a lower speed on their vessels and the consequences on shore are present for the shipper because it will take more time before he will receive his freight. Consequences for the terminal operator, inland transportation company and port authorities will not be of considerable size. A 'party' that cannot be defined as actor in the supply chain, but will be influenced by the implementation of slow steaming is the environment. What are the consequences in terms of pollution and CO2 emissions for the environment, due to slow steaming? This question will be answered in the section of efficiency.

Further, the relation between shipper and carrier will also be an interesting part of the hinterland chain to investigate in this thesis. Under normal conditions, the shipper will pay a freight rate to the shipping line the take care of the maritime transportation. This payment could be directly or indirectly, depending on the involvement of freight forwarders or ship brokers. But when bunker prices increase, surcharges on the freight are applied to compensate the shipping lines partially for these higher bunker prices. This is called the Bunker Adjustment Factor (BAF). The BAF is applied with different formulas and base rates among carriers and liner conferences[4]. A common way is to apply a surcharge above a certain base bunker price. In table 1, an example of BAF surcharges is given for the IFO 380 bunker price in Rotterdam. Some conferences set a fixed BAF and Maersk Line has developed in 2008 a new formula to calculate the BAF, which can be used at the internet. This has been done to create more transparency on the calculations of the BAF.

To get back to the relation between shipper and carrier, the carrier will be partially compensated through the BAF, while the shipper has to pay a higher surcharge on the freight rate. Moreover, the

[4] Liner conferences are agreements on co-operation among liner companies.

shipper faces longer transit times because of the slower sailing speeds. Recent BAF surcharges for June 2011 were on average $776 per TEU[5]. This was the highest ever level according to Alphaliner[6]. With these facts in mind, it is not that odd that shippers are complaining about the implementation of slow steaming. They have to bear longer transit times and higher surcharges, while carriers save costs on slow steaming and are compensated through the BAF. The exact consequences for the shipper and carrier will be compared in this thesis in the section of equity.

Table 1, BAF percentage for several bunker prices. (source: Notteboom and Vernimmen, 2009)

IFO 380 price level(€ per ton)	BAF surcharge %	IFO 380 price level(€ per ton)	BAF surcharge %
140 (base)	2.00	216-220	6.50
141-155	2.50	221-230	7.50
156-165	3.00	231-240	8.00
166-180	3.50	241-250	8.50
181-190	4.50	251-255	9.00
191-200	5.00	256-265	9.50
201-205	5.50	266-270	10.50
206-215	6.00	271-280	11.00

[5] Average surcharges of twelve shipping line companies for the Asia-Europe trade.
[6] Source: IFW-net.com

4.The efficiency of slow steaming

After discussing the theoretical and industry background, the main analysis of this thesis will be presented from this section onwards. As described earlier, the analysis begins with the efficiency of slow steaming. A cost-benefit analysis will give insight in the economic justifiability of this trend, in terms of efficiency. This analysis will provide an answer to the following sub-question:

'*How efficient is slow steaming in terms of costs and benefits?'*

4.1 Assumptions and methodology

Before calculations can be made possible, certain assumptions are needed. These assumptions will hold for all calculations, unless noted differently. The first assumption has already been made. This thesis investigates the economic efficiency of slow steaming in the liner shipping industry, not the bulk shipping industry. A second assumption that can be made is on the level of which costs and benefits of slow steaming will be discussed. This could be done on global scale, company scale, trade scale, per liner service, etcetera. Applicability and feasibility are key criteria here. It is simply not feasible to calculate all costs and benefits from slow steaming of the whole liner shipping fleet. There are too much differences between trades and vessels to incorporate them all. Further, this thesis has limits on the range of datasets available. The global scale would require too much data. It would be definitely interesting to investigate how much a single company is saving on slow steaming, but again; this is not feasible in this thesis. The best feasible and applicable option is to discuss the effects of slow steaming of a specific liner service. Each carrier has information available on their websites about the schedules of the service and about the vessels that employ the service. Additionally, the paper of Notteboom and Vernimmen (2009) gives a nice example on how calculations on speed, vessels and transit times can be made for a specific liner shipping service.

The next step is to identify which liner service on which trade should be analysed. The answer for the latter question is quite evident. The most intensively used trade route is the Europe- Far East route[7]. This route is deployed with the largest vessels and most TEU is traded on this route. Consequently, this route is also the most attractive on which to reduce vessel speed. Because of the large distances and the size of the ships, most cost can be saved (or should be saved) on this route. This is also being seen in reality. According to data of Alphaliner, Cariou (2011) showed that almost 80% of the services on this route were implementing lower speeds in 2010. In contrast , on the second best slow steaming route, the Multi-trade route, 'only' 57 % of the services slowed down their speeds. Moreover, since

[7] See Table A3 in the Appendix

April 2011, all carriers on the Europe – Far East route participates with lower speeds[8]. Based on these facts, the most relevant trade to analyse in this thesis is the Europe- Far East route.

In June 2011, 32 liner services are deployed on the Europe- Far East route. To succeed in calculations about vessel speed, number of vessels deployed and roundtrip time, enough information about a specific liner service must be available. Exact schedules of the service, port time and information about the vessels are examples of this information. These criteria led to the selection of the NE3 service of COSCO Container Lines. Information about this service has been found at the website of COSCO and at the website of Containerisation International.

The aim of this section of the thesis is to provide a complete overview of the costs and benefits of slow steaming on a particular liner service. Because costs and benefits vary for different speeds, roundtrip times and numbers of vessels, an overview of these varying factors with the related costs and benefits must be analysed. As a consequence, two formula's relating to speed, distance, roundtrip time and the number of vessels must be kept in mind. These formula's are found in the paper of Notteboom and Vernimmen, 2009.

The total roundtrip time for a vessel to sail a round voyage can be stated as in equation 1).

1) $$T_r = \sum_{i=1}^{n} T_{pi} + \frac{D}{V \cdot 24}$$

Total roundtrip time Tr of a voyage from port 1 to n is the sum of total port time and time at sea. Tpi is port time in port i in days, distance is expressed with D in nautical miles, and speed with V in knots.

In order to maintain a frequency of service, the roundtrip time Tr cannot exceed the following threshold of equation 2).

2) $$T_r \leqslant \frac{S \cdot 7}{F}$$

F is the frequency of calls per week in each port. S is the number of ships deployed. When a loop has a weekly schedule, each port is called once a week and thus F will be one. To maintain frequency of these calls, a specified number of vessels, S, must operate the loop. Later on, this formula will be used to analyse the relation between the roundtrip time and the number of ships needed to be deployed on the loop.

[8] Source: Nieuwsblad Transport, April 2011

4.2 Analysis of the NE3 service.

The NE3 service has an Asia- Europe- Asia route with a total roundtrip time of 70 days and deployed with 10 ships. Figure 4 represents a service map of the NE3 service. All 12 ports are called on a weekly basis. This implies that equation 2) with S=10 and F=1 holds exactly. But this does also mean that the schedule is very tight and that no delays are allowed.

Figure 4, Service map of the COSCO NE3 service (source: COSCO Container Lines)

In table 2, an example of a NE3 schedule is given. The port times and distances in this table will work as a basis for further calculations. Because port time is related with the capacity of a vessel (more capacity means more time needed to load and unload the ship), the fleet of this NE3 service has to be analysed. As said before, the NE3 service is deployed with 10 vessels. The capacity of these vessels range from 8,204 TEU to 10,020 TEU. The average capacity is 8,962 TEU[9]. It follows that the port time in table 2 is based on the schedule of a vessel with the closest average capacity. This is the COSCO Korea with 8,495 TEU. Where scheduled arrival and depart are available, port time is estimated as the difference between these two times. To complete the factors which are mentioned in equations 1) and 2), the distance of the whole roundtrip must be calculated. This is done with the Dataloy Distance Tables[10]. The resulting distance of this loop is 23779 nautical miles.

[9] See table A4 in the appendix
[10] www.dataloy.com

Table 2, NE3 schedule of the COSCO Korea (8,495 TEU) based on official Cosco Container Lines schedules.

Port	Arrival	Depart	Port Time (days)	Distance (nautical miles)[1]
Xingang	May 31, 10:00	Jun 01, 04:00	0,75	199
Dalian	Jun 01, 22:00	Jun 02, 13:00	0,63	280
Qingdao	Jun 03, 08:00	Jun 04, 02:00	0,75	467
Ningbo	Jun 05, 06:00	Jun 06, 00:00	0,75	740
Yantian	Jun 07, 17:00	Jun 08, 10:00	0,71	1472
Singapore	Jun 12, 03:00	Jun 12, 19:00	0,67	8408
Rotterdam	Jul 01, 22:00	Jul 03, 22:00	2	123
Felixstowe	Jul 04, 21:00	Jul 06, 05:00	1,33	363
Hamburg	Jul 07, 07:00	Jul 09, 06:00	1,95	401
Antwerp	Jul 10, 08:00	Jul 11, 10:00	1,08	9843
Nansha	Aug 04, 09:00	Aug 05, 00:00	0,625	36
Hong Kong	Aug 05, 08:00	Aug 05, 22:00	0,58	1447
Xingang	Aug 09, 10:00			
	Roundtrip Time		**Total Port time**	**Total Distance**
	70 days		11,8	23779

[1] Distance based on Dataloy distance tables. (www.dataloy.com)

With the available information about this particular service, equation 1) can be used to calculate the average speed on which a vessel like the COSCO Korea sails the complete route. With a total roundtrip time of 70 days, total port time of 11,8 days and a distance of 23779 nm, average vessel speed V must be 17 knots[11]. A sailing speed of 17 knots is obvious a slow steaming speed. And with most of the Europe-Far East services that deploy 10 ships on similar routes with a roundtrip time of 70 days, this speed can be seen as a good average of the actual sailing speeds on the Europe-Far East route.

With these numbers about the COSCO Korea and the NE3 loop, a comparison between higher and the lower speeds, and thus the consequences of slow steaming in terms of roundtrip time and the requirement of vessels, can be made possible. Table 3 will be the guideline for this comparison.

In this table, a range of sailing speeds from 11 knots (super slow steaming) to 25 knots (maximum vessel speed) is presented. Under this row, the total roundtrip time for the varying speeds is calculated according to equation 1). In the middle column, the actual sailing speed of 17 knots results indeed in a roundtrip time of 70 days. The table makes clear what the roundtrip time could have been with 'normal speeds'. For instance, a speed of 23 knots, which was quite a normal speed a few years ago,

[11] $Tr = \sum Tp + (D/V \cdot 24)$ leads to $70=11{,}8 + (23779/V \cdot 24)$, V must be 17.02 ≈ 17 knots

results in a roundtrip time of only 54,9 days. As a consequence of slow steaming, roundtrip time has increased with 15 days, which could mean a longer transit time of 7 days for European shippers[12]. We can also see what happens when even lower speeds are made operational. The super slow steaming speed of 13 knots will imply a roundtrip time increase of even more 18 days and thus a total transit time increase of 16 days, compared to a speed of 23 knots. The costs of this transit time increase will be taken into account later on.

Table 3, Roundtrip time and number of vessels required for different speeds on the NE3 loop.

COSCO Korea on the NE3 Service								
Sailing speed (knots)	11	13	15	17	19	21	23	25
Roundtrip time, Tr[13] (days)	101,9	88,0	77,9	70,1	63,9	59,0	54,9	51,4
S ≥ Tr/7	14,6	12,6	11,1	10,0	9,1	8,4	7,8	7,3
Minimum required number of vessels	15	13	12	10	10	9	8	8

Further, the number of vessels that is required to operate the loop is related with the roundtrip time and sailing speed. This relation was found in equation 2). When F, the frequency of calls per port per week, is set on 1 as assumed before, the formula can be transformed to;

3) $S \geq \frac{Tr}{7}$

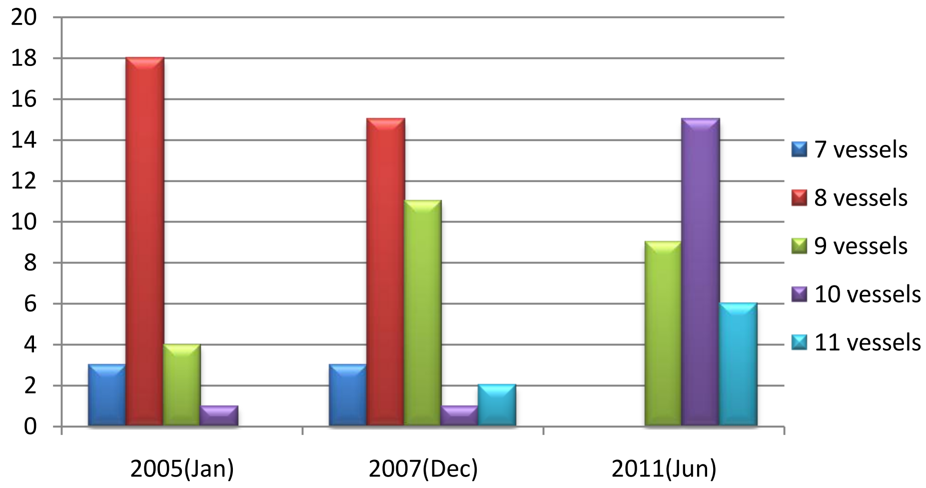
Equation 3) represents then the minimum of ships required to operate the service. The third row in table 3 shows the results of this equation when the ranging roundtrip times are implemented. The numbers are rounded up in the fourth row for the exact number of vessels required to operate the service with a certain speed.

In these days, with slow steaming speeds of around 17 knots, ten vessels are needed to deploy the loop. This is two more than under normal sailing speed conditions of 23 or 25 knots. These results are in line with the reality. While looking at figure 5, the actual shift in the number of vessels deployed on the Europe- Far East route since 2005 and 2007 can be seen. In 2007, a shift in the number of vessels can already be distinguished. But the way slow steaming has its impact on the liner services on this

[12] Assumed that the distance Far-east - Europe is half the distance of the total roundtrip.
[13] See formula 1). $Tr = \sum Tp + (D/V \cdot 24)$ leads to $Tr=11,8 + (23779/V \cdot 24)$

trade route nowadays, is striking. Where in 2007 only one service deployed ten vessels on the trade, in June 2011, these were fifteen services with ten vessels and already six services with eleven vessels.

Figure 5, Number of vessels deployed per service on the Europe – Far East route. (Source: Notteboom and Vernimmen, 2009 & Containerisation International Online, June 2011)



4.3 Cost/Benefit analysis for slow steaming.

The Cost/Benefit Analysis will be the main part of the efficiency section of this thesis. The analysis will be built with table 3 as basis for comparison. This implies that calculations are still based on the COSCO NE3 service with the Korea as operating vessel. In each paragraph, additional costs or benefits from slow steaming will be discussed. The resulting costs and benefits from slow steaming are the costs and benefits when all vessels sail one roundtrip on the loop.

4.3.1 Vessel costs without Bunker costs

The first costs of slow steaming follows from the conclusions in the previous paragraph; the additional vessels required to maintain frequency of service. Moreover, these vessels have more sailing time at sea due to the lower speeds which will also mean extra costs. There are thus two factors which provides extra costs; the additional ships and the extra time at sea. When the costs per vessel, per day are known, the total vessel costs due to slow steaming can be derived.[14] These costs do not include bunker costs. Bunker costs are analysed later on because of their fixed relation with sailing speed. Moreover, bunker costs are assumed to decline with lower speeds, while the analysis is now focussed on additional costs due to slow steaming.

Work of Cullinane and Khanna (1999) and Baird (2006) provide some basic concepts to calculate daily ship costs. Next to operational costs, the capital costs of a ship must also be taken into account. A new ship is often provided with a loan. The capital costs of a ship can then be seen as the

[14] Assumed that all vessels have the same characteristics in capacity, operations and in financial agreements.

substitution and interest costs. When the substitution and interest costs are paid annually, then this annual annuity can be allocated over the days of operation. The result will be the daily capital ship costs. The annuity can be calculated as follows;

$$4)\quad A = P \cdot \frac{i \cdot (1+i)^n}{(1+i)^n - 1}$$

The annual annuity A is a function of the newbuild price of the ship P, the annual interest rate i and the number of years n until the loan has been repaid. The daily ship costs are then easily calculated by dividing the annual annuity by the expected days of operation.

The COSCO Korea is property of Seaspan Corporation. Seaspan has ordered the Cosco Korea together with seven similar ships from shipbuilder Hyundai in May 2007. The newbuild price of these ships was $132,5 million per vessel.[15] The lifespan of the vessel is assumed to be 20 years and the interest rate is set on 6,125 %.[16] As assumed before, these factors are the same for all vessels which will be deployed on the NE3 service. According to equation 4), the annuity that represents the annual capital costs per ship will amount $11,669,454.35. When the vessels are in operation for 350 days[17], the daily capital costs per vessel are $33,341.

However, capital costs are only one part. The operational costs per container vessel is also subject to changes in the number of sailing days and the amount of deployed ships. Operational costs include manning costs, insurance costs, maintenance and repairs, ship management and administrative costs. According to studies of HSH Nordbank in 2008 and 2009, these operational costs for the larger 7500 + TEU vessels are approximately $9000 per day.[18] Together with the capital costs per vessel, ship costs would be around $42,341 per vessel per day.

Another measure of ship costs could have been the daily charter rate. But a charter rate is very fluctuating and subject to many factors in the market. This is why a charter rate does not function very well as a general measure of ship costs. Interestingly however, the daily ship costs which has been calculated above is almost equal to the daily charter rate of $42,900[19] at which COSCO Container Lines charters the COSCO Korea from Seaspan.

When the daily ship costs per vessel are applied on the results of table 3, the costs of sailing at lower speeds can be calculated. This is done in table 4.

---

[15] Source: Seaspan Corporation
[16] In line with Baird (2006)
[17] Again in line with Baird (2006)
[18] Source: HSH Nordbank, A study on operating costs of German container ships, 2008 and 2009.
[19] Source: Seaspan Corporation. Accessed by: http://www.seaspancorp.com/fleet-list.php

Table 4. Consequences of slow steaming on total ship costs.

Vessel speed (knots)	11	13	15	17	19	21	23	25
Roundtrip time (days)	101,9	88,0	77,9	70,1	63,9	59,0	54,9	51,4
Minimum required number of vessels	15	13	12	10	10	9	8	8
Total ship costs[20]	64.700.416	48.446.219	39.556.374	29.673.362	27.075.770	22.475.661	18.588.681	17.421.346
Slow steaming costs	16.254.197	8.889.846	9.883.012	2.597.592	4.600.108	3.886.981	1.167.335	

The consequences of slow steaming on the costs of the total fleet sailing one roundtrip are clear. As the roundtrip time and the number of vessels on the loop both increase, then the ship costs will increase by $42,341 per day per ship. Especially when the sailing speed goes under the 17 knots, then the costs of the whole fleet rises with enormous amounts. The slow steaming costs are the costs from slowing down 2 knots. For example, it costs $1,167,335 on ship costs to slow down from 25 to 23 knots and already $3,886,981 for slowing down from 23 to 21 knots. This identification of slow steaming costs will also be applied on the coming tables for other costs and benefits.

4.3.2 Costs of extra roundtrip time

Because the total economic efficiency of slow steaming is being analysed in this thesis, costs for shippers must also be taken into account. The shippers must wait longer on their containers because these containers are longer at sea due to the lower sailing speeds. As a consequence, shippers face higher time- or inventory costs.

These additional inventory costs because of longer transit times can be distinguished in two parts. The first part are additional opportunity costs related to the invested capital in the cargo. Secondly, economic and technical depreciation of the goods results in additional depreciation costs when goods are longer at sea. (Notteboom, 2006)

According to Notteboom (2006), opportunity costs are 3%-4% per year and economic depreciation costs of consumer goods are in between 10% and 30% per year. On average, this thesis will use 23% per year for opportunity and depreciation costs. Further, the value of one fully-laden TEU is $27,000. In previous related articles, Cariou (2011) used a value of $27,331 for a fully-laden TEU and Notteboom (2006) used a value of $40,000 for Belgian import containers and $14,000 for Belgian export containers. Because the whole loop is analysed (eats-bound and west-bound), the average of these two values should be used. This is again $27,000.

[20] Total ship costs= 42.341 * number of ships * roundtrip time.

Because not all containers are full, 70% will be used as a percentage of full containers on the ship.[21] Another assumption will be that the number of TEU's traded on the loop will be the same for every speed. More vessels are used on the loop to sail at lower speeds, however, this does not automatically mean that these added vessels means more traded containers. Only the additional days at sea influences the inventory costs and not the added vessels. This results in a total of 68,000 TEU's traded on average on the NE3 service.[22]

The average value of all these containers will then be; 68,000 · $27,000 · 0.7 = $1,285,200,000. This value of containers with 23% of inventory costs per year, divided over 365 days, results in an amount of $809,852 per extra day at sea. The resulting total time costs for shippers because of sailing at lower speeds is given in table 5.

Table 5, Additional time costs for shippers due to slow steaming.

Vessel speed (knots)	11	13	15	17	19	21	23	25
Roundtrip time Tr (days)	101,9	88,0	77,9	70,1	63,9	59,0	54,9	51,4
Total time costs[23]	82.501.218	71.278.916	63.049.228	56.755.937	51.787.549	47.765.521	44.442.976	41.652.038
Slow steaming costs[24]	11.222.302	8.229.688	6.293.291	4.968.388	4.022.028	3.322.545	2.790.938	

4.3.3 Bunker costs savings

Now the costs of slow steaming are known, the benefits can be analyzed. The largest benefit of slow steaming are the savings on bunker costs. The need for savings on fuel costs due to the high fuel prices was also the reason why liner shipping companies began to sail at lower speeds. The savings on bunker costs for slow steaming on the NE3 service with 8500 TEU vessels are calculated in this paragraph.

Fuel consumption of ships is dependent of many factors. The type of engine, the capacity of the ship, the load, the use of auxiliary engines, design speed, actual speed, weather conditions and many technical factors determine the true fuel consumption of a vessel. It is therefore difficult to determine the exact savings on fuel costs. However, a study of Notteboom and Cariou (2009) made a general model to calculate the fuel consumption of container ships for a particular liner service. This model has been made out of a sample of 2259 container ships with different characteristics. With average

[21] In line with the paper of Cariou (2011).

[22] At full speed, 8 vessels with a capacity of 8500 TEU were used on the loop. This means that each vessel carries on average 8500 TEU's from port-to-port. 8*8500=68,000 TEU.

[23] Total time costs= $809852*Roundtrip time

[24] Again, the costs from slowing down 2 knots. So it costs $4,968,388 in time costs for slowing down from 19 to 17 knots.

numbers out of this sample, a model has been constructed which can be applied on vessels with different characteristics. This model is used to estimate the fuel consumption of the COSCO Korea on the NE3 service.

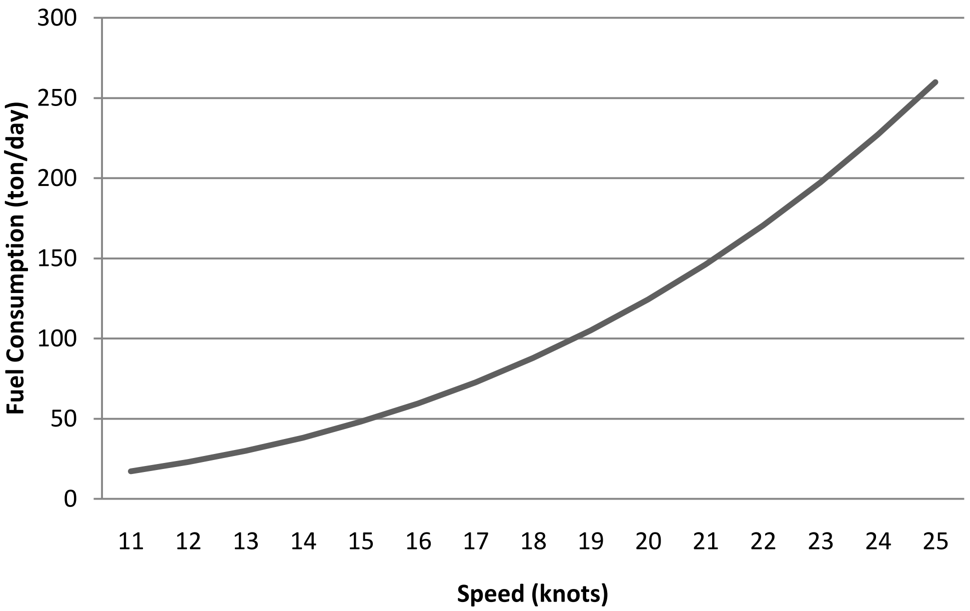
In the model, the following averages are used to calculate the fuel consumption in tons per day for ships with a capacity between the 8000 and 9000 TEU; the average load factor is 80%, 97% uses a two-stroke slow speed engine of which the average specific fuel oil consumption (SFOC) is171 g/kW h. Further, the mean design speed is 24,9 knots and the engine power was on average 64353 kW. These numbers result in an estimation of the fuel consumption for 8000-9000 TEU vessels of 260 tonnes per day when sailing at the design speed. To calculate the consumption for true commercial speeds, the following formula can be used according to Notteboom and Cariou (2009):

5) $FC\ at\ V1 = FC\ at\ V0\ \cdot (\frac{V1}{V0})^{3.3}$

With FC as fuel consumption in tonne per day, V1 as commercial speed and design speed V0.

When equation 5) is applied for speeds ranging from 11 to 25 knots, then the fuel consumption per day is as illustrated in figure 6. To calculate total fuel costs, the price per metric ton of fuel is needed. An average price of the IFO380 at Rotterdam is used. Although the price in Rotterdam is often relatively cheap, total bunker costs savings from slow steaming will therefore not be extraordinary high. In the last three months (since march), the price per mt in Rotterdam varied from $590/mt to $660/mt. Therefore, an average price of $625/mt is used in this thesis. The total savings on bunker costs due to slow steaming are presented in table 5.

Figure 6, Fuel consumption at different sailing speeds for 8000-9000 TEU vessels.



The first column that has been added in table 5 is the fuel consumption in tons per day per ship. These are the same data as presented in figure 6 above and the results are logical; a lot of fuel consumption is saved when all the ships in the loop are sailing at lower speeds. When a vessels on the NE3 service sails at a speed of 17 knots, the fuel consumption is almost reduced by 70% as it was at a speed of 25 knots.

Table 6, Savings on total fuel costs for various speeds

Vessel speed (knots)	11	13	15	17	19	21	23	25
Roundtrip time (days)	101,9	88,0	77,9	70,1	63,9	59,0	54,9	51,4
Minimum required number of vessels	15	13	12	10	10	9	8	8
Fuel consumption per vessel[25] (Tons/day)	17,31	30	48,2	72,8	105	146,25	197,5	260
Total fuel costs[26]	16.531.911	21.453.594	28.143.779	31.887.248	41.965.173	48.520.723	54.191.925	66.861.167
Slow steaming savings	4.921.683	6.690.185	3.743.468	10.077.925	6.555.550	5.671.202	12.669.242	

This reduction of fuel consumption has its impact on the total fuel costs of the whole fleet on the NE3 service. Although roundtrip time increases and more vessels are required to maintain frequency, the savings are still of considerable size in each step of lower sailing speeds. It can be seen from table 5 that especially the step from 25 to 23 knots and the step from 19 to 17 knots made a lot of savings.($12.6 million and $10 million) It looks quite reasonable from this point of view that the actual sailing speed of the COSCO Korea is on average 17 knots, as calculated before. An integrated overview of all costs and benefits will provide more answers later.

4.3.4 Savings on CO2 reductions

The second positive consequence of reducing the sailing speed of containerships is the environmental contribution. In line with the decrease of fuel consumption, the emission of Green House Gasses (GHG's) will also decline with slow steaming. According to several green house gas studies of the IMO, liner shipping is the most polluting shipping segment of all. And where the IMO and the European Commission have plans to make stricter emission standards for the shipping industry, a policy that reduces GHG emissions in the liner shipping industry is welcome. It is therefore not surprising that liner shipping companies emphasizes the reduction of emissions as major advantage of slow steaming. However, the true scope of this advantage should be investigated.

[25] Derived from formula 5) and with 260 as FC at V0.
[26] Total fuel costs = price/mt * FC per vessel * number of vessels * roundtrip time.

With CO_2 as by far the most polluting GHG in liner shipping[27], this section will focus for this reason only on the consequences of slow steaming on CO_2 emissions. Further, a life-cycle approach where emissions from the scrapping and building of ships are taken into account, will not be dealt with.

CO_2 emissions are directly related with fuel consumption of vessels. Because the latter has already been calculated in an earlier section, the relation between CO_2 and fuel consumption must only be specified to calculate the consequences of slow steaming for CO_2 emissions. This relation can be found in a CO_2 emission factor. The most commonly used emission factor for CO_2 is 3.17 (Psaraftis and Kontovas, 2010). This means that for each ton of bunker fuel, 3.17 ton of CO_2 is emitted. In table 7, this emission factor is multiplied with total savings in fuel consumption to come to the total CO_2 emission savings of the NE3 loop for different speeds.

In addition, the EU Emission Allowance (EUA) spot price is used to make the CO_2 savings quantifiable. According to Bluenext the actual spot price for one ton of CO_2 is €14.6. Furthermore, a euro/dollar rate of 1,44 (IEX.nl) is used. [28]

Table 7, Savings in CO2 emissions due to slow steaming.

Vessel speed (knots)	11	13	15	17	19	21	23	25
Roundtrip time Tr (days)	101,9	88,0	77,9	70,1	63,9	59,0	54,9	51,4
Minimum required number of vessels	15	13	12	10	10	9	8	8
Fuel consumption per vessel (tons/day)	17,31	30	48,2	72,8	105	146,25	197,5	260
Total CO2 emissions[29] (ton)	83.850	108.813	142.745	161.732	212.847	246.097	274.861	339.120
Slow steaming savings[30]	524.817	713.399	399.180	1.074.647	699.043	604.741	1.350.968	

As table 7 presents, the total emitted CO_2 on the NE3 service can be reduced by 50% by reducing sailing speed from 25 knots to 17 knots. This is not surprising, because this reduction resulted also in a 50% decrease of fuel consumption (table 6). The savings in CO_2 emissions from slow steaming in USD are not of the same range as the earlier mentioned costs and savings of slow steaming. Still, it is an acceptable advantage that will be more important in the future when legislations on ship pollution might be tightened.

[27] See table A5 in the appendix.
[28] Both rates obtained on 22 June 2011.
[29] Total CO2 emissions= 3,17*Fuel consumption per vessel per day*number of vessels*number of days
[30] Slow steaming savings= ΔTotal CO2 emissions*Emission Allowance Spot Price (4.16)*euro/dollar rate (1,44)

4.4 Conclusion

In the main part of the thesis, the efficiency of slow steaming in terms of costs and benefits has been discussed. A specific liner service is analysed and several speeds are implemented to see what consequences slow steaming has on the liner service design and liner service costs. Of course, each Far-East service is different and only one service is analysed in this thesis. However, the route of this service will not differ that much of all others. Furthermore, most assumptions on port time, vessel size, capacity, ship costs and fuel consumption are based on general and average numbers. This analysis of the NE3 route should therefore be easy to generalise. Analysis of slow steaming on other services will not provide very different outcomes.

It has been shown that slow steaming brings considerable costs with itself. To maintain frequency of service, extra vessels need to be added on the loop. This is costly in terms of capital and operational costs. Furthermore, shippers face additional time costs. On the contrary, large savings are made on bunker consumption costs, which also ensures benefits for the environment. These consequences are analysed one by one but to come to a final conclusion about the efficiency of slow steaming, an overlooking view is needed. This view is given by table 8 and figure 7.

Table 8, Final results of slow steaming with costs and savings in million $.

Vessel speed (knots)	**11**	**13**	**15**	**17**	**19**	**21**	**23**	**25**
Total costs	165.5	143.5	133.8	121.7	125.3	123.9	123	133
% of full speed	124,37%	107,82%	100,52%	91,47%	94,17%	93,14%	92,44%	
Total ST costs	27.5	17.1	16.2	7.6	8.6	7.2	4.0	
Total ST savings	5.5	7.4	4.1	11.1	7.3	6.3	14.0	
Net[31]	-22.0	-9.7	-12.1	3.5	-1.3	-0.9	10.0	

Table 8 has added each cost component that has been discussed previously, resulting in total cost of the NE3 service when each vessel makes one roundtrip. For all different speeds, the total costs are given. In this way, each step of operating at a lower speed can be analysed in its effectiveness. Further, the total costs of slow steaming and the total savings are also given for each speed. The results indicate that the most effective speed for this service is 17 knots. This is because the total costs for this speed are the smallest of all possible speeds. The step from sailing at 25 knots to 23 knots is also effective, as total costs are decreased, but not as much as at the speed of 17 knots. As calculated before, the actual speed of the analysed COSCO Korea was indeed around 17 knots. This loop is thus operated very efficiently.

[31] Net savings or losses from slowing down 2 knots each time. As example, it saves $10 million in total from slowing down from 25 to 23 knots, but it costs $1,3 million for slowing down from 21 to 19 knots.

However, costs savings are in total not of that considerable size as people might have expected. The most efficient speed (17 knots) saves only 8,5% of the costs of sailing at full speed. Furthermore, an operating speed of 23 knots seems to be more saving than sailing at 21 or 19 knots. Apparently, not all lower speeds are also more beneficial. This is even more the case for speeds under 17 knots. Costs of slow steaming rise very fast in that range of speeds and the final costs of sailing at 15, 13 or 11 knots are higher than for sailing at full speed. Thus, slow steaming is not efficient with speeds under 17 knots, for this specific service.

Figure 7, Total costs and its components of providing the NE3 service with several speeds.

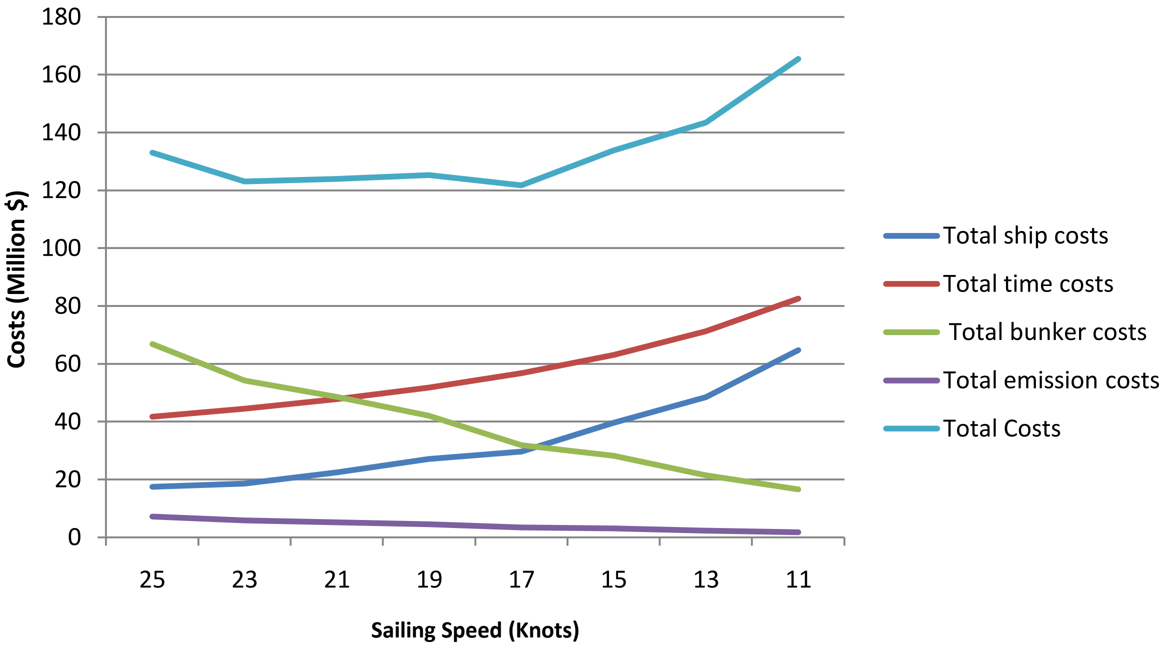


Figure 7 has been made to show how the different aspects of the total costs are behaving at lower speeds. It can be seen that bunker costs decline sharply as the speed decreases. But at a speed of 21 knots and lower, the time costs for shippers starts to rise more and more. Further, at speeds lower than 17 knots, costs for having additional ships on the route are also rising significantly. These two costs make slow steaming not efficient at speeds lower than 17 knots. Savings on emission costs are not very considerable.

To conclude, the following sub-question has to be answered;

‘*How efficient is slow steaming in terms of costs and benefits?*’

Slow steaming is efficient in terms of costs and benefits, but the efficiency is limited to some speeds. Not more than 10% can be saved in totality, when also costs and benefits for the shippers and the environment are taken into account. Super slow steaming speeds of under the 17 knots are not efficient because the shippers inventory costs and the vessel’s costs will become too high. Furthermore, long term effects as a global shortage of containers, reorganisations in the supply chain of shippers due to longer transit times and the inefficiency of the ship engine when it is operated at lower speeds, will make slow steaming even less efficient.

5.Equity-effects as a result of slow steaming

All relevant costs and benefits of slow steaming have been discussed in the previous section. It has shown that slow steaming is apparently not that efficient as many shipping companies would say it was. This is mainly a result of the additional costs for shippers, which is of considerable size. Further, in more and more media, shippers try to make clear that they are treated unfairly. They state that shipping companies save lots of money on slow steaming, while they face higher transit times and are not compensated. A hypothesis that follows from the previous section and from these shippers' critiques is; shippers bear the costs of slow steaming, while the shipping companies benefit. This interesting hypothesis about equity-effects will be analysed in this section of the thesis to come to a better understanding of the economic justification of slow steaming. Therefore, the following sub-question is formulated;

'Are there possible equity-effects as a result of slow steaming?'

Calculations from the efficiency-section are used to compare the shippers' and the shipping companies' situation. Moreover, an interview[32] with drs. Marco Wiesehahn, policy advisor at EVO, has been conducted to gain more insight in the slow steaming consequences for shippers. In this way the above mentioned sub-question will be answered.

5.1 Comparison between the consequences of slow steaming for shippers and shipping companies.

To gain insight in the possible equity-effects of slow steaming, an analysis between the consequences for shippers and shipping companies can already make some things clear. Table 9 illustrates this comparison.

Table 9, Consequences of slow steaming for shippers and shipping companies.

Shippers	Shipping companies
Costs: -Transit time -Consequences for the shippers' process and supply chain	Costs: -Ship costs for additional vessels
Benefits: -Emission savings	Benefits: -Bunker savings -Emission savings

[32] The complete interview is added in the appendix, part B.

Most consequences that are stated in table 9 have already been discussed. The consequences for the production process of the shipper and the supply chain of the product are not discussed thoroughly before because these costs were hard to make quantifiable. However, the interview with Mr. Wiesehahn made clear what these effects could actually be like. Because the whole production process is designed on specific lead times, there is a huge impact on this production process when the process can only start a couple of weeks later, due to the longer transit times of ships. As a consequence, the whole supply chain must be organised and structured with other lead times, which is involved with costs for the shipper.

On the other hand, shippers are also benefitted with the savings on CO2 emissions. Next to shipping companies, there will be more and more pressure on the shippers to build a CO2-profile that is environmentally justified. Slow steaming will help them doing so because the supply chain part of maritime transportation will be less pollutant.

While looking at table 9, the impression of an unfair situation could arise. It seems to be that shippers face more costs than benefits, while shipping companies have more benefits than costs as a result of slow steaming. Of course, the real amounts of costs and benefits are not given. This will be needed to make a fair comparison. With previous calculations, this is done in table 10. Only the costs on the shippers' process and supply chain are not taken into account because of the complex character of these costs. Again, these are costs and savings from slowing down 2 knots each time. Thus, it costs shippers $3,9 million for slowing down from 19 to 17 knots but the shipping company saves almost 9 million with this step.

Table 10, Costs comparison between shippers and shipping company in USD.

Vessel speed	**11**	**13**	**15**	**17**	**19**	**21**	**23**
<u>Shippers</u>							
Time costs	11.222.302	8.229.688	6.293.291	4.968.388	4.022.028	3.322.545	2.790.938
Emission savings	524.817	713.399	399.180	1.074.647	699.043	604.741	1.350.968
Net result	*-10.697.485*	*-7.516.289*	*-5.894.111*	*-3.893.741*	*-3.322.985*	*-2.717.804*	*-1.439.969*
<u>Shipping company</u>							
Ship costs	16.254.197	8.889.846	9.883.012	2.597.592	4.600.108	3.886.981	1.167.335
Bunker savings	4.921.683	6.690.185	3.743.468	10.077.925	6.555.550	5.671.202	12.669.242
Emission savings	524.817	713.399	399.180	1.074.647	699.043	604.741	1.350.968
Net result	*-10.807.696*	*-1.486.261*	*-5.740.364*	*8.554.980*	*2.654.484*	*2.388.963*	*12.852.875*

Table 10 reveals the equity effects of slow steaming. With every drop in 2 knots vessel speed, the shippers face extra costs. Actually, the more speed is reduced, the more it costs the shippers. Where a speed reduction from 25 to 23 knots will cost the shippers[33] almost $1,5 million, a reduction from 19 to 17 knots will cost them already $4 million. On the contrary, the shipping company (COSCO Container Lines in this case) has indeed considerable benefits from slow steaming. Until 17 knots, costs will be saved. Only with speeds under the 17 knots, slow steaming will cost the shipping company money. Additional ship costs are then higher than the savings on bunker costs.

Assumed that COSCO will not operate their vessels under the 17 knots, because they will lose money with those speeds, slow steaming has indeed equity-effects. Looking at the net results, the shipping company saves a lot of money on this method, while their clients only face increasing costs. Moreover, the costs for shippers on their production process and supply chain are even not considered here, even as the BAF surcharge. Because the BAF is not directly a consequence of slow steaming, it was not taken into account. But with the high bunker prices these days, the shipping companies are also compensated with the BAF, while the shipper pays this surcharge. This makes the actual situation with high bunker prices and slow steaming even more unfair for the shippers.

5.2 The shipping market itself as origin for unfair situations.

Additional to the fact that equity effects are present due to slow steaming, it would be interesting to analyse how these effects can exist. What is the origin of this unfair situation where shipping companies seems to have the power to keep all the benefits from slow steaming for themselves? At the EVO office in Zoetermeer, Marco Wiesehahn tried to give answer on this question. The following explanation for the unfair situation between shippers and shipping companies is based on the conversation with Mr. Wiesehahn.

In a 'normal' free market, prices are determined by the laws of demand and supply. Competition is assumed to be high and therefore, prices cannot be set too high. Any way in which costs are saved by the suppliers will be translated in lower prices. Otherwise, competitors will do so. When these conditions are applied in the shipping market, the costs savings that are made because of slow steaming, will be translated in a lower freight rate. In this way, shippers will also benefit from the slow steaming method. However, as illustrated before, this is not the case. Additional costs (in bunker) for the shipping company are passed through enthusiastically on the shippers (BAF), while more efficient or at least less costly processes for the shipping company will not benefit the shipper.

[33] All shippers of the 68000 TEU on the NE3 service. (see part 4.3.2)

Of course, the shipping industry is a difficult one. Shipping companies must make incredible investments and face large fixed costs. Therefore, the industry has a legitimate reason the be prevented from any kind of destructive competition. Too much (destructive) competition will break the industry down. (Haralambides, 2007) But can the prevention of the shipping industry be seen as benefitting the shipping companies and harming the shippers? The way in which shipping companies benefit from slow steaming is probably a form of too much protectionism. And certainly the way in which shipping companies provide (no) customer service towards the shippers while implementing slow steaming, is far from decent. As Mr. Wiesehahn told, shipping companies were unable to inform their customer support division about the implementation of slow steaming and they could also not notify the shippers when the vessels with their goods would arrive instead of the arranged time before slow steaming.

As said before, the rigid shipping market has its origin in protectionism. This can be found in the conference-system, where shipping companies could legally make price-agreements on tariffs with each other. Wiesehahn: “This system is still present in United States, South –America and Asia, where shipping companies make agreements about the implemented capacity, trying to have some control over the prices in this way. This has been banned in Europe since 2008. That is then the explicit cartel idea of making price-agreements, officially. But this will not say that this does not happen. There are enough signals that the game is still not played within the rules. The fact that the EU has recently done some investigations in particular shipping company offices says enough. It is not a transparent and free operating market. Shipping companies are not forced by the market to pass efficiency benefits through on the price to make competition advantages. They can easily keep those benefits for themselves.”

The solution for the equity-problems of slow steaming is thus straightforward but hard to achieve; a transparent and free market. Wiesehahn: “At that moment, the benefits from more efficiency in shipping companies will merit that parties that have the right to benefit.” To arrive at such a situation, institutions like EVO and ECS can put some pressure on shipping companies with an aggregated shipper sound, hoping that shipping companies will realise that more transparency is needed in the market.

5.3 Conclusion

There are equity-effects present between shippers and shipping companies due to slow steaming, as a comparison between the consequences for both parties has shown. At every speed reduction, shippers face more costs while shipping companies benefit considerably. The reason for this ‘unfair’ situation is the old conference-system in the maritime industry. Shipping companies are able to keep all the benefits from slow steaming for themselves because they are still too protected and operate not as transparent as possible.

6.The effectiveness of slow steaming

The third criterion that analyses the economic justifiability of slow steaming in the liner shipping industry is the effectiveness of slow steaming. As the aim of slow steaming was mainly to reduce the bunker costs of the liner shipping company, this section will analyse how effective slow steaming has been in reducing these costs. The following sub-question will be investigated;

'Is slow steaming the most effective method of reducing bunker costs?'

Furthermore, other methods to reduce bunker costs will also be investigated in its effectiveness to decide whether slow steaming is the most effective method. This section will focus on the effectiveness in reducing fuel costs. However, the environmental aspects of each method will also be taken into account because of the rising importance of environmental awareness in the shipping industry.

6.1 Slow steaming as an effective method to reduce bunker costs

In part 4.3.3, the effectiveness of slow steaming to reduce fuel consumption costs have actually already been discussed. Table 6 provided the savings that were made in bunker costs for having all vessels on the loop operating at lower speeds. For every decrease in vessel speed, savings were made varying from \$3.7 to \$12.6 million for the whole fleet that made one roundtrip on the NE3 service. More than 50% can be saved by decreasing the speed from 25 to 17 knots. Thus, without a doubt, slow steaming is effective on the NE3 service to reduce fuel costs. Because fuel consumption depends on many factors such as ship size, engine power, load factor, etcetera, the amount of savings on other services will be different. However, it can be assumed that each ship that slows down, will consume less fuel.(see formula 5) Moreover, the analysis of the NE3 service is based on plausible and average assumptions which makes the analysis applicable to every Far-east trade and easy to generalise. Therefore, slow steaming in general can be seen as an effective measure to reduce fuel consumption costs. The most important factor that could influence the amount of savings considerably is the fluctuating bunker price. The influence on this factor will be discussed more thoroughly in the following section; sustainability.

6.2 Other methods to reduce bunker costs

Two other initiatives can be distinguished to reduce the bunker costs for liner shipping companies. Both were indicated by the paper of Notteboom and Vernimmen (2009), as well as by Mr. Wiesehahn. The two methods are; shifts in the type of fuel used and actions in vessel design.

6.2.1 Shifts in bunker fuel type

Several types of bunker fuel exists in the shipping industry. The main used type is the IFO 380, which has been used in this thesis for earlier calculations on bunker cost savings. Other types of IFO, Intermediate Fuel Oil, are the IFO 420, 500, 600 and 700. Each value represents the kinematic viscosity (in centistokes) of the residual fuel at 50ºC. These higher viscosity fuel types are rougher, but cheaper. As a consequence, using these fuel grades in liner shipping would reduce fuel costs.

According to Notteboom and Vernimmen (2009), the IFO 500 is around $7-11 cheaper per ton than the IFO 380. The IFO 700 savings will be around $16 per ton. When these savings are applied on the fuel consumption of the eight vessels on the COSCO NE3 service, sailing at a speed of 25 knots, then the savings for the whole fleet sailing one roundtrip will be as given in table 11.

Table 11. Bunker cost savings on different fuel types.

Bunker fuel type	$ price (ton)	Total bunker costs $*	Savings $
IFO 380	625	66.861.167	
IFO 500	614-618	65.643.968 - 66.071.616	1.217.199-789.551
IFO 700	609	65.109.408	1.751.759

* based on the assumptions made in section 4.3.3; 8 ships sailing 51,4 days with consumption of 260 tons/day.

As table 11 presents, the savings of using higher viscosity types of fuel exist but are not considerably large. Where the fuel cost savings of slow steaming varied from $3.7 to $12.6 million, the use of other fuel grades only represents savings that vary from $0.8 to $1.7 million. Furthermore, the use of these rougher types of fuel has also its complications. Older ships are not able to deal with these types of fuel and the environment will not be benefitted with these rougher fuel types. To sum up, slow steaming can be seen as more effective than the shift in fuel types to reduce bunker costs and CO2 emissions.

6.2.2 Vessel design

The design of a ship is very important for the fuel consumption of a vessel. Propulsion systems, the hull and engines are constantly optimized to improve the ship's efficiency. Therefore, it cannot be seen as simple method that can be implemented by shipping lines to reduce fuel costs, as slow steaming and the use of other fuel grades are. It is more a type of research and development in which shipping lines can invest or benefit from. Moreover, it is assumed that shipping companies and shipyards should invest and concentrate constantly in the improvement of the design of a vessel. In this way, the design of a vessel as a method to reduce bunker costs has a different character but not less valuable to consider. It will remain an important factor in the fuel consumption and costs of a vessel. Therefore, some examples of how vessel design could reduce the bunker costs of a liner shipping company will be analysed in this section.

The first example will show how ship-owners are constantly searching for optimal vessel efficiency. In this case, the ship-owners Schulte Group and Costamare Inc. requested a design review from FutureShip[34] and design office Maric for their 9000 TEU vessels.[35] In the optimization procedure that followed 15,000 various hull design were analysed on computational fluid dynamics. This resulted in an optimal hull with lower resistance and the instalment of a smaller main engine. This improvement would reduce fuel consumption by 10% per day so the costs of optimization should be earned back within a few days of operation. The first of the ordered six ships is delivered in 2013.

A second, more conceptual example comes from Det Norske Veritas (DNV). This conceptual design of a next-generation containership of 6,210 TEU will eventually reduce capital, operational and fuel costs by 14%. The design can be seen as aerodynamic, as figure 8 shows. A wider deck, wave breaker, wind deflector, fibre reinforced plastics and an electric propulsion system are some of the innovations that will reduce the fuel costs.

Figure 8. Conceptual containership design. (source: ship-technology.com)

The last example of an innovative way to reduce fuel costs is probably the most remarkable: SkySails. The idea is simple; reduce fuel costs and emissions by letting a giant kite pulling the ship forwards (see figure 9). In 2007, the first commercial containership with SkySails installation, the MS Beluga SkySails, set sail. The savings in fuel costs would be up to 20%. (source: SkySails). However, the SkySails are not yet a trend that is regularly seen in the shipping industry.

Figure 9. SkySails (source: skysails.info)

[34] Part of Germanischer Lloyd.

[35] Source: article Germanischer Lloyd; Containership Optimization Yields Major Fuel Savings

When the above-mentioned innovations are implemented in the shipping industry, these might be more effective in reducing fuel costs than slow steaming does. Fuel savings of 10%, 14% and 20% are considerable percentages. However, as mentioned before, the character of vessel design is very different than a 'simple' method as slow steaming. Therefore, both should not be compared too enthusiastically with each other. Another point is that slow steaming could still be implemented on the more efficiently designed ships. Vessel design should thus be seen more as a long term investment than a short-term method to reduce fuel costs.

6.3 Conclusion

Slow steaming can be seen as the most effective method to reduce fuel costs for a liner shipping company in the short term. It has been shown that slow steaming saves considerable amounts of money in fuel consumption. $3.7 to $12.6 million can already be saved by decreasing 2 knots in speed in one loop with each ship having one roundtrip. Which is a saving of $30 million by sailing at 17 knots instead of 25 knots. This amount cannot be reached by using other types of fuel, which has also more side-effect for the environment. Furthermore, ship design is important for fuel efficiency, but more on the long term. Investments in research and development of ships is needed to be efficient and environmentally responsible in the future. Some examples of innovations in recent years has shown how ship design could play a role in reducing fuel costs and emission.

7.The sustainability of slow steaming.

The final issue considering slow steaming that will be analysed in this thesis is the sustainability of this trend in the liner shipping industry. It has been shown that slow steaming is an effective way to reduce costs, but certainly not ideal for shippers. When the costs for shippers were taken into account, the costs savings were lower than expected. Because of the negative sides of slow steaming and the limited economic efficiency in costs and benefits, the following sub-question will be interesting to investigate;

'To what extent is slow steaming in the liner shipping industry sustainable in the future?'

To answer this question, the factors on which the sustainability depends must be identified. The most obvious one is the bunker price. Because the incredible rise of bunker prices last years, slow steaming has been implemented. The sustainability of slow steaming is therefore very much dependent on the bunker price. Secondly, environmental concerns are also an important trigger for slow steaming. As shippers and shipping companies are forced by increasing legislation on emissions and pollution to stick to tighter emission standards, then this will have its influence on the importance of methods to decrease CO2 emissions.

This section will analyse the influence of both factors on the incentive to decrease speeds in the liner shipping industry. Future perspectives on the shipping market will then be used to analyse the sustainability of slow steaming.

7.1 Bunker prices as a determinant for slow steaming.

Earlier research has shown that there will be certain break-even points in oil prices for which a reduction in vessel speed will be sustainable or not. Cariou (2011) did this for the most important trade routes in the world. He incorporated bunker savings, operational vessel costs and inventory costs to determine the break-even points for each trade. This point varied from $259 for the multi-trade routes to $568 for the Australasia and Oceania trade. The latter is that high because of the fewer time at sea on this trade, so less time to save fuel costs. He compared these break even prices with recent bunker prices and concluded that an environmental tax levy of $50 would be enough for slow steaming to be sustainable on all trades.

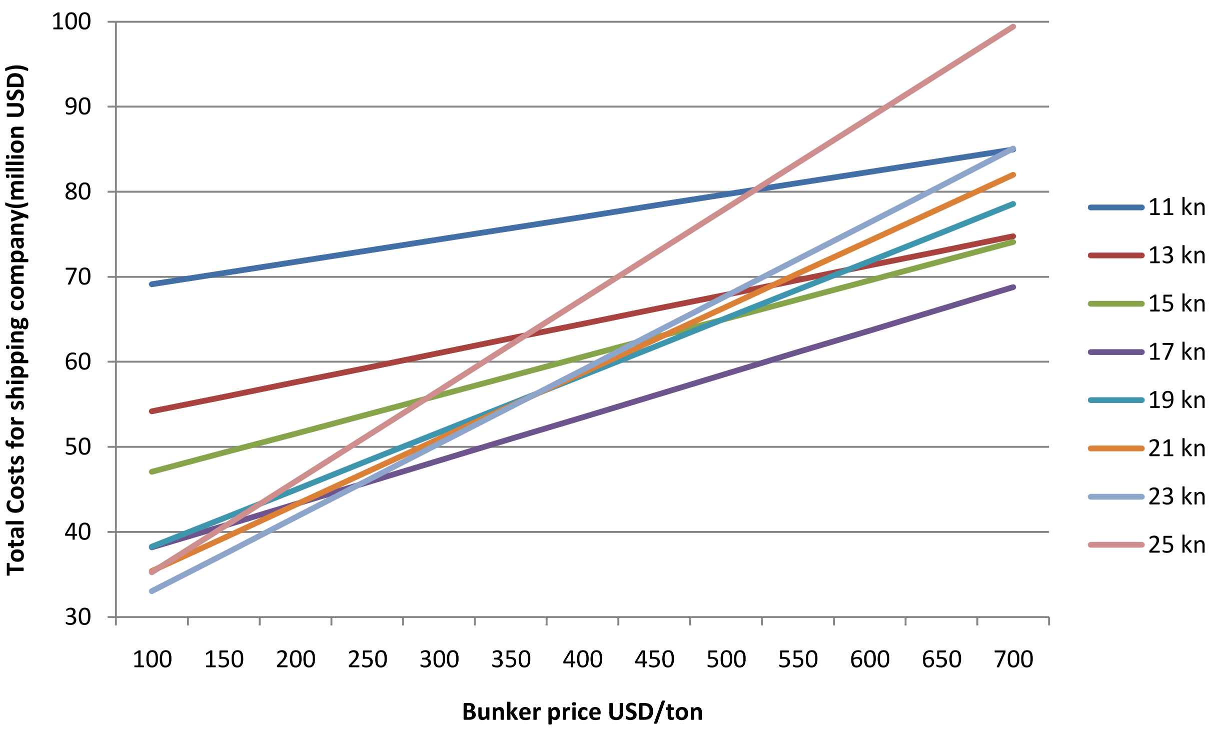
Notteboom and Vernimmen (2009) made a similar cost-benefit analysis for a single liner service as this thesis does. However, they did not incorporated the costs for shippers into their analysis, as well as emission savings. The break-even bunker price of $125 was determined for decreasing 3 knots and having 1 extra vessel to be beneficial on a specific liner service.

A similar analysis as Notteboom and Vernimmen can be applied in this thesis. However, this analysis will take more slow steaming speeds, costs for shippers and environmental savings into account, where the latter paper only considers costs for the shipping company.

In the efficiency section, bunker costs, vessel costs, inventory costs and emission costs were calculated for slow steaming on the COSCO NE3 service. The calculations on bunker costs savings were based on a bunker price of $625, an average of the previous 3 months. To see what happens with those costs when the price of oil changes, figures 10 and 11 are made.

In figure 10, only the costs for the shipping company are taken into account. This means that time costs for shippers are not included. The most efficient speeds for the shipping company can now be identified at every oil price.

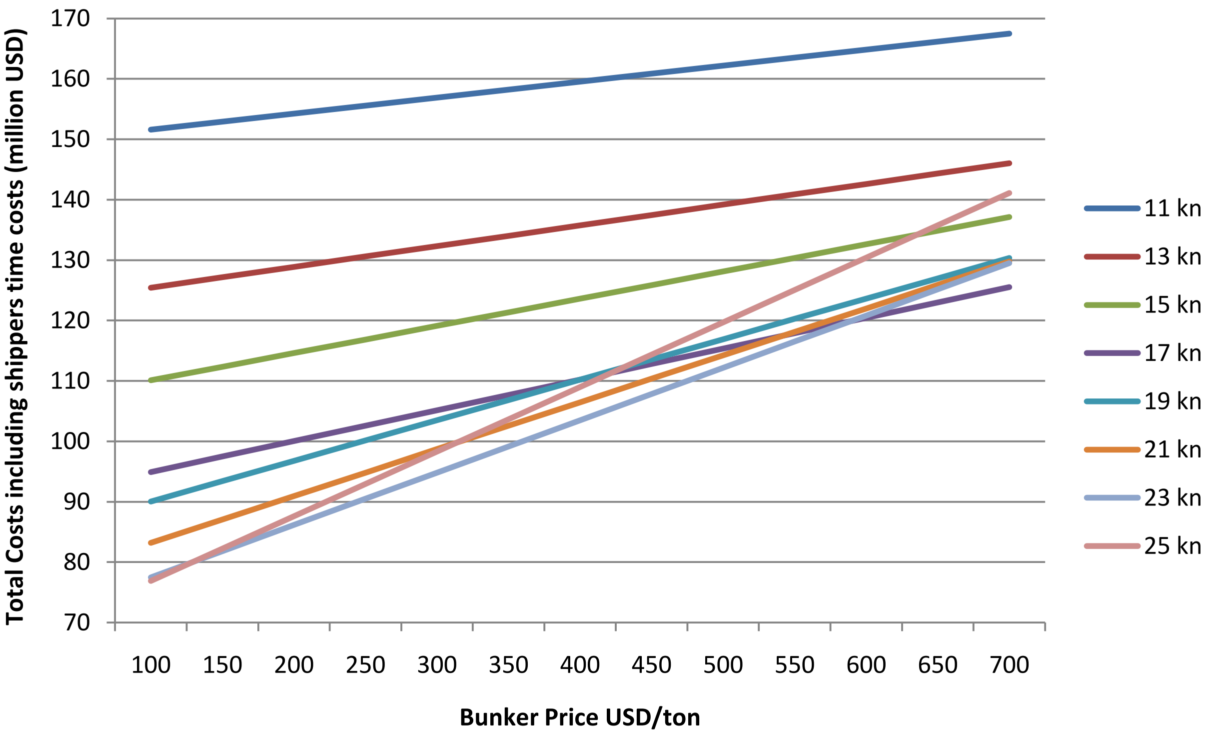
Figure 10, Total costs for the shipping company for different speeds and oil prices.



As the figure shows, the break-even point of slow steaming lies at a bunker price of $250 per ton. At that price and higher, a speed of 17 knots requires less costs than a speed of 23 knots. At prices lower than $250 per ton, a higher speed of 23 knots is the most beneficial for the shipping company. Remarkable is the speed at which the costs of sailing at 25 knots increases with rising oil prices. Only at a price of 100 dollar per ton, a speed of 25 knots is interesting, but still not the cheapest. The picture reveals further that not every lower speed is directly beneficial when high fuel prices are present. Even when fuel prices are around the $700 per ton, sailing at a super slow steaming speed of 11 knots is very expensive, due to the high costs of additional vessels. It would even be cheaper to sail at higher speeds of 19 an 21 knots in that case.

When the sustainability of slow steaming depends only on fuel prices, slow steaming will be present in the shipping industry until prices fall beneath the $250 per ton. However, this is only a look through the eyes of the shipping company. When the time costs for shippers are included, the picture changes as figure 11 shows.

Figure 11, Total economic costs for different speeds and bunker prices.



When shippers are also considered in the total costs of operating the NE3 service, sailing at faster speeds remains beneficial until the bunker price reaches an amount of $600 per ton. Then, a speed of 17 knots saves the most costs. At lower prices, a speed of 23 knots is the most efficient speed and even a speed of 25 knots can be the most efficient when prices are under the $100 per ton. Speeds of 11 and 13 knots are the most inefficient and are not likely to be implemented.

There is thus a striking difference in the bunker prices which are sustainable for shipping companies and when the interest of shippers are also considered. Shipping companies would actually implement slow steaming at a price of $250 per ton while it would be socially more justified when this would be done at prices only higher than $600 per ton. Pressure from shippers and organizations on shipping companies is expected when prices are under the $600 and slow steaming is still implemented.

The latter is also expected by Mr. Wiesehahn. He expects pressure from shippers on shipping lines to implement faster services again, possibly next to slow steaming services; "Slow steaming can be sustainable, but not as the only option for shippers."

Although, it remains questionable whether shipping companies will react on this. The last time bunker prices were at the level of $250 was in 2005 (table A1 appendix) and this level will not be reached again in reasonable time. Furthermore, the forecasts for the liner shipping industry in the coming year(s) is bad. Shipping lines are almost unable to full the whole capacities on their ships to the Far-East, spot rates are very low, economic growth is affected by the high bunker prices, and overcapacity is expected with the rising delivery of mega-vessels.[36] Already 5 Far-East services ceased operation in 2011 because of the losses they made.[37] With these facts in mind, it is expected that slow steaming stays implemented to save costs in the nearby future. On the long term, pressure from the side of shippers might influence the supply of slow steaming services but as long as bunker prices remain high, faster speeds should not be expected.

7.2 Environmental legislation as an influence on slow steaming.

As described earlier, slow steaming has its impact on the emission of GHG. Therefore, stricter legislation on these emissions is in favour of the sustainability of slow steaming. According to the IMO, there are various options of policies to reduce or limit GHG emissions from ships. These are; an emission trading scheme, emission levies, levies based on operational efficiency, levies based on design efficiency and fuel levies (Buhaug et al, 2009).Even when bunker prices might fall, these GHG reduction policies might create enough incentives to keep the vessel-speeds low. This has also been acknowledged by Mr. Wiesehahn in the interview.

The only option that will not influence the commercial speed of vessels are the levies on design efficiency because speed has no influence on this degree of efficiency. For emission trading schemes and emission levies, a reduction in emissions will be worth money for the shipping company and this reduction in emissions could be achieved by slow steaming. This holds also for operational efficiency levies. And when fuel levies are implemented, what makes the price for bunker fuel higher, then the same reasoning follows as introduced in figure 10 and 11. A higher bunker price increases the incentive for slow steaming.

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[36] Source: Nieuwsblad Transport; http://www.nieuwsbladtransport.nl/Modaliteiten/Article/tabid/85/ArticleID/17726/ArticleName/Somberevooruitzichtenvoorlijnvaart/Default.aspx

[37] Source: Nieuwsblad Transport; http://www.nieuwsbladtransport.nl/Modaliteiten/Article/tabid/85/ArticleID/17741/ArticleName/CKYHGreenAlliancestaaktVerreOostendienst/Default.aspx

7.3 Conclusion

Bunker prices are the most important determinant for slow steaming to exist. For shipping companies, a bunker price above the $250 per ton should be enough to implement slow steaming. When the interests of shipper are also considered however, this point lies at $600 per ton. From an economic point of view, slow steaming is only sustainable with bunker prices above $600. The high bunker prices together with the bad predictions for liner shipping companies, their power in the industry and the stricter environmental standards, it can be expected that slow steaming will be certainly present in the industry for the coming years. Only declining bunker prices and pressure from shippers can cause shipping companies to increase speeds again, on the long term.

8. Conclusion

Slow steaming is one of the most important developments in the liner shipping industry of recent years. Shipping companies are unanimously convinced of the cost savings that this method realises. However, shippers are complaining more and more because they are not compensated by these costs savings, they only face higher costs due to slow steaming. This thesis analysed the economic consequences of slow steaming. In addition to other academic papers, consequences for shipping companies, shippers, and the environment were taken into account. Four sub-sections contributed to answering the following research question;

'To what extent is slow steaming in the liner shipping industry economically justified?'

The first section dealt with the efficiency of slow steaming. The NE3 Far-East service of Cosco Container Lines was analysed to calculate the costs and savings from slow steaming for the shipping company and the shippers. Calculations revealed that the shipping company faces an amount of $42,341 for capital and operational costs per vessel per day. With the increasing time at sea and additional vessels that are needed, slow steaming can contribute to extra costs ranging from $1 million to $16 million for the shipping company for operating the whole loop once. Furthermore, shippers face extra inventory costs due to slow steaming. Every additional day at sea costs shippers $809,852.

Considerable savings are made on bunker costs due to slow steaming. These savings ranged from $3,7 million to $12,6 million for liner companies, dependent of the speed reduction. Because fuel consumption decreases with lower sailing speeds, CO_2 emissions will also be reduced. Although emissions could be reduced with 50%, these savings were not of that quantifiable size as the previously mentioned costs and benefits.

When all costs and benefits of slow steaming were taken together, a speed of 17 knots resulted to be the most efficient speed for this service. In reality, 17 knots is also implemented on the NE3 service. This speed saves almost 9% of the total costs of a commercial speed of 25 knots. However, speeds of under the 17 knots were considerably more costly than a high speed of 25 knots. Inventory costs for shippers and vessel costs became too high for these low speeds. There is thus a limitation in the efficiency of operating lower speeds in the liner shipping industry, especially when long terms consequences were also considered.

The second section indicated that equity-effects are present when slow steaming is implemented. With every speed reduction, shippers face additional costs. In contrast, shipping companies save in total already $12 million from only slowing down from 25 to 23 knots. An interview with Mr. Wiesehahn of EVO made clear how these unfair situations can exist. The shipping market is still not a free and transparent market in which costs savings are translated in lower prices. The remains of the old-conference system has still too much impact on the industry.

Despite these equity-effects, slow steaming can be seen as the most effective method to reduce bunker costs in the short term, as the third section showed in this thesis. Savings from shifts in fuel grades do not come close to the savings of slow steaming. Innovations in ship design could be more beneficial in absolute terms than slow steaming is. However, these are investments of shipping companies and shipyards on the long term, which should be aspired at any time and not only to reduce costs in a period of high bunker prices.

The final part of the thesis considered the sustainability of slow steaming in the future. Where it would be economically only efficient to sail at lower speeds with bunker prices of $600 per ton and higher, shipping companies should already have an incentive to operate at lower speeds at prices of $250 per ton. Pressure from shippers is thus expected when slow steaming is maintained with bunker prices of under the $600 per ton. However, with the actual power of shipping companies, high bunker prices, bad forecasts on incomes for the liner shipping industry and tighter legislation on emissions, slow steaming is expected to be maintained in the coming years.

With efficiency, equity, effectiveness and sustainability as key criteria for the economic justifiability of slow steaming, the following can be concluded;

With bunker prices above the $600 per ton, slow steaming is economically and socially justified as an effective method to reduce fuel costs. Although shippers might face some extra costs, from total economic perspective and including shippers' and environmental interests, a speed of 17 knots is in that case more efficient than speeds of 23 or 25 knots would be. However, improvements in the transparency and market functioning of the shipping industry could contribute to more fair situations for shippers and shipping companies. Especially when bunker prices are in between the $250 and $600 per ton, pressure from shippers to realize price compensation or faster speeds is expected because slow steaming is then not economically justified.

These results strengthens the motive for policy interventions to reduce GHG emissions of shipping. Bunker tax levies and emission trade schemes creates more incentives for shipping companies to reduce their speeds, what effectively reduces CO_2 emissions.

Finally, this thesis has limited its focus on the Far-East trade. Therefore, the results should not be generalised to other trades, as these trades requires other capacities and distances. On a trade were distances are much shorter, there would be less time at sea to save fuel consumption. This would result in other efficiencies of slow steaming. Thus, a similar analysis on other trades would make clear how important slow steaming is on a more global scale.

Another recommendation towards further research lies in the slow steaming effects for different vessel capacities. As this thesis only considers the same capacity of a ship (8500 TEU), there might be even more slow steaming savings possible when the ships become bigger. It would be interesting to investigate the behaviour of the several slow steaming costs and benefits with varying vessel capacities.

Furthermore, as bigger ships can save a lot of bunker costs, smaller and faster vessels should be much cheaper in its bunker consumption. Therefore, with the shippers preference for fast services, a shipping line with faster, smaller and possibly cheaper ships should be quite profitable in the end. Again, this would be an interesting field of future research.

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Appendix, Part A, Additional Tables

Table A1, Bunker prices at several ports during the years. (source: Notteboom and Vernimmen, 2009)

Year	Rotterdam	Genoa	Fujairah	Singapore	Tokyo	Durban	Houston	Long Beach
Indicative bunker market prices for 380 CST (USD per ton)								
2001	116	130	128	131	159	135	114	127
2002	133	145	145	148	169	151	134	143
2003	152	165	167	172	193	173	163	163
2004	155	170	177	181	208	180	168	189
2005	234	251	259	264	296	263	250	267
2006	292	312	311	314	345	320	302	319
2007 H1	288	311	321	321	363	322	299	329
2007 Q4	505	516	513	517	565	-	502	505
2007 Q4 vs. 2001	335%	297%	301%	295%	255%	-	340%	298%
2007 Q4 vs. 2004	226%	204%	190%	186%	172%	-	199%	167%

Table A2, Bulk carrier and containership comparison on speed, fuel consumption and CO2 emissions per size. (source: Buhaug et al. 2009)

Type	Size (dwt and TEU)[1]	Average speed (knots)	Fuel consumption (thousand tons)	Grams of CO2/ tonne-km
Bulk carrier	200,000 +	14.4	1,951.8	2.5
Bulk carrier	100,000 -199,999	14.4	9,694.9	3.0
Bulk carrier	60,000 - 99,999	14.4	14,551.4	4.1
Bulk carrier	35,000 – 59,999	14.4	14,519.8	5.7
Bulk carrier	10,000 - 34,999	14.3	12,833.2	7.9
Bulk carrier	0 - 9,999	11.0	1,338.0	29.2
Container	8,000 +	25.1	6,145.2	12.5
Container	5,000 – 7,999	25.3	17,575.2	16.6
Container	3,000-4,999	23.3	19,911.4	16.6
Container	2,000-2,999	20.9	11,823.2	20.0
Container	1,000-1,999	19.0	12,425.1	32.1
Container	0-999	17.0	4,348.3	36.3
RoPax Ferry	(no cargo)	25.0	16,312.7	-

[1]. Dwt for Bulk Carrier and TEU for container ship

Table A3, Trade Route Deployment (source: Containerisation International online on 1 june 2011)

Trade Route	Number of vessels deployed	TEU deployed
East Asia – North Asia	382	688,162
Europe – Far East	349	2,774,807
Far East – North America West Coast	291	1,622,901
East Asia – South East Asia	280	543,565
Far East – Mid East	224	1,309,400
Far East – Indian subcontinent	220	911,115
North East Asia – South East Asia	190	354,314
Far East - Mediterranean	187	1,163,146
Far East- North America East Coast	183	885,238

Table A4, Vessels deployed on the COSCO NE3 service (source: Containerisation International Online)

Vessel name	Capacity (TEU)
COSCO Beijing	9,469
COSCO China	8,204
COSCO Germany	8,204
COSCO Japan	8,495
COSCO Kaohsiung	10,020
COSCO Korea	8,495
COSCO Napoli	8,204
COSCO Oceania	10,020
COSCO Philippines	8,495
COSCO Taicang	10,020
Average Capacity	**8,962**

Table A5, GHG emissions from shipping in 2007.

	International shipping (million tonnes)	Total shipping (million tonnes)
CO_2	870	1050
CH_4	Not determined*	0.24
N_2O	0.02	0.03
HFC	Not determined*	0.0004

* A split into domestic and international emissions not possible

Appendix, Part B

Interview Marco Wiesehahn, policy advisor and secretary of the Council for Shippers at EVO.

11 am, 20 June 2011

EVO office in Zoetermeer

What are the positive consequences of slow steaming?

It appears to be that slow steaming contributes to a decrease in fuel consumption. A logic consequence of less fuel consumption will be a positive effect on the environment. This is also for shippers not unimportant, certainly with increasing pressure on shippers to build a CO2-profile. Also in the use of transport modalities, certainly for maritime transport, an internalization of external costs will be introduced in the nearby future. It is therefore important to develop some methods and techniques to reduce the emission of GHG's as much as possible. This is in the shippers' interest because its image can be 'cleaned' in this way. This is simply worth money.

Another positive point are the lower costs for the shipping company itself. Again, this appears to be the case. Of course when you implement slow steaming, the costs of that single trip will be lower in the end, but the long term has to be considered. Extra's will be given for the total supply of transportation for containers or other goods across the world and it will be the question whether this will really be cheaper in the end, I don't know this exactly but the presumption is that for the shipping company this will reduce the costs a bit, and that should have its effects on the price for shippers.

But this decrease in price has not been shown yet,

No, the picture is that the additional surcharges for bunker prices are passed through enthusiastically on the shipper, but when prices decrease or methods and techniques are developed to reduce the price of the product, then the shipper does not see anything of this back. However, that is simply the market. But these would be the two most important positive consequence of slow steaming indeed.

Okay, this is a clear picture. And the question is indeed whether all the presumed cost savings are as high as told by the liner shipping company..

True, and what many people neglect in this case is also that much is dependent from the design of the ship. A lot is done by shipbuilders to deliver the maximum performance by a certain speed. And this speed is for the actual shift of vessels nearby the 23 and 25 knots. When slow steaming is implemented, this extra efficiency of the design is taken away. This is of course not taken into account by the profit and loss account of slow steaming, but it is an interesting issue. And sure, shipbuilders will again try to get a maximum out of the design for vessels that will sail at speeds of 20 knots or something. But with the actual ships that are operated, I question whether much is lost in design efficiency. It definitely is an issue which is hard to calculate and on first sight, many positive points seems to be present. For the shipper, there will be some negative points and whether it truly is that positive as pointed out by some people, that is the question.

So negative effects are indeed also present..

Yes it is simply an accumulation of inventories. That is where it is all about. You'll have to imagine that a shipper tries to keep its velocity as high as possible and the longer a vessel will need time to arrive at a port, the longer the shipper gives its invested capital away. Capital that does not pays off at that moment. This costs money. This is the most important issue of slow steaming for shippers. The supply chain needs to have as less as obstacles as possible, obstacles are time and time is money. The shipper has of course a reluctant attitude towards this situation. But still, there is a certain break-even point. When fuel consumption costs are that high that the freight rate will rise, and that slow steaming will contribute to less fuel consumption and a lower product price, there will be some point that this offsets the extra costs in the invested capital of shippers. But what speeds represents this break-even point, that is still unclear. I think that the present optimal for shippers is around the 24 – 25 knots but I can imagine that the fuel consumption will cost the shipping company, surely with the actual bunker prices, more than 50% of its total costs. This is a heavy situation for them. When these costs are passed through on the shippers, then slow steaming would be also more interesting for them.

But again, shippers does not seem to see anything back of the costs-savings of slow steaming.

No, and that is what I mentioned before, the problem of the market. When shipping companies make their processes more efficiently, or at least cheaper, then this will not say automatically that shippers are also benefitted.

From my point of view, this seems to be unfair. The shipping company gets already its partially compensation for the higher bunker prices in terms of the BAF-surcharge. As a result of slow steaming, they have also extra cost savings. The shippers however, face longer transit times and higher freight rates due to the surcharges. How is this possible?

I hope that you have thought about this question already because the problem lies in the old conference-system in the international maritime transportation. This system is still present in United States, South –America and Asia, where shipping companies make agreements about the implemented capacity, trying to have some control over the prices in this way. This has been banned in Europe since 2008. That is then the explicit cartel idea of making price-agreements, officially. But this will not say that this does not happen. There are enough signals that the game is still not played within the rules.

The fact that the EU has recently done some investigations in particular shipping company offices says enough. It is not a transparent and free operating market. Shipping companies are not forced by the market to pass efficiency benefits through on the price to make competition advantages. They can easily keep those benefits for themselves actually. Huge amount of money are made by those companies each year.

And there is nothing that institutions like the European Commission or certain defenders of interests can do about this?

Well, we at EVO try to do it. When the European Commission ask about more information about the case, then you'll have to deliver evident proof and examples which make clear that cartel activities still take place. And when we talk about market functioning, we try to get more transparency in the way surcharges are implemented by shipping companies. When a couple of hundreds of euro's are passed through on the freight rate because of surcharges, and the reasoning behind these surcharges are very unclear, then shippers will ask why this is the case. At this moment, shipping companies don't care about these questions, as a shipper you just have to pay the price. And when you don't do this, a lawyer of them will contact you very soon. This way of business is where EVO tries to do something about it to make a ranking how they are operating with their customer service.

Which are apparently only small steps..

Yes but only with negative or positive publicity, these methods of business can be influenced. The bigger shippers can put some pressure on the shipping companies and make some price-agreements, but those are only present in very small numbers. For Heineken or Phillips, this won't be that big issue but smaller companies face harder relations with the shipping companies.

For these shippers, what are really the consequences of sailing at lower speeds? Is it only the extra costs of inventories?

Yes, and the whole process of these companies is designed on specific lead times. And when shipping companies simply decide that your process can only start 6 weeks later, the impact on the company and the chain behind the company, and the chains of those companies, will be enormous. These are consequences that are hard to be made quantifiable, but by simply telling your customers that ships will sail 2 more weeks for the same route has a lot of consequences.

How can this 'unfair' situation be solved? With a compensation for the shippers?

No, the solution has to be found in an open and free market. At that moment, the benefits from more efficiency in shipping companies will merit that parties that have the right to benefit.

And then it will also become a need for the shipping company to surpass the benefits also to the shippers in terms of lower prices?

Yes, then they will try honestly to get a good average and I think that they will also create a better story towards slow steaming in that case. A fair analysis of the costs and benefits of slow steaming will be offered to be more competitive than their competition. Nowadays there is too much unclear and slow steaming has been implemented too radically.

Okay. Slow steaming has been implemented to reduce fuel consumption costs, are there possibly other ways or methods to reduce these bunker costs for shipping companies?

Design plays also a considerable role in the efficiency of ships. We talk about the design of the hull of the ship and the design of the engine of course. Further, the type of fuel is also important for fuel consumption costs. But when cheaper, and thus more polluting, types of fuel are used, then this is also not a favourite option for the shippers. These are two important points where shipping companies can take care of themselves to operate more efficiently. I assume they already take care of these points of course. But I have not a magic box where I can get some other solutions I guess.

Shipping companies tell us that slow steaming is a very positive trend, but when it is so positive, why has this not happened earlier?

Good question.. I think that the external pressure on shipping companies from the corner of environmentalists rises to be more efficient with fuel. This is an important incentive for them to come, at least, with a story. That is how I see this, as a story in which they claim to be more efficient but the truth is still unclear I think.

What is probably also a nice example are the vessels with those major canvas wings. I don’t know in which way this has a positive contribution to the fuel consumption but it should matter and do something. Maybe it is the ultimate solution!

I doubt whether it is the ultimate solution, but it should contribute!

Do you think that slow steaming is sustainable in the future? When bunker prices declines, does this also mean the end for slow steaming? Or are environmental norms again too important?

I think it is sustainable, but not as only option. The market asks also for faster services. Shippers will not agree that China or the Far East is accessible only with slow steaming services. There are many shippers whose have huge interests in fast transit times. When this alternative is not present, then they will put pressure on the shipping companies to get the faster lines back. So they will continue with slow steaming but not at all routes and services.

And when the bunker prices will decline again, won't there be a motive for shipping companies to rise their speeds again? Because then costs savings won't be present possibly?

Well, costs savings can then still be possible when emission trading schemes are developed and bunker taxes are being implemented. Those are methods in which the government tries to put pressure on the emissions of ships. I can imagine that in the end, although the bunker prices decreases, that those levies are of that size that it is still interesting to sail at lower speeds. When those levies will not be implemented, what actually is a fiction because they will, then there will be again a certain break-even point of that speed that is the most efficient.

One point that was mentioned in one article I have read was about time buffers and schedule integrity. It assumed that when a service is deployed with lower speeds, that this contributes to wider time buffers and more schedule integrity. What can be true about this hypothesis?

Time buffers are basically made by the shipping companies themselves. You can make wider buffers in your schedule while you sail at high or low speed, that does not matter. Then I would advice to build the schedules with a wider margin, that would be wise to do. This is certainly wise because most shippers are annoyed by the fact that more than 50% of the agreements are not accomplished. Time is always a dominant factor here, and most of the times, ships are too late on destination. It would then be reasonable I think to build more margin in your schedules and to keep yourself to your agreements.

And also in this case, the market is too weak to put naturally pressure on these issues?

The problematic is that you don't have many options in this market. Probably there are two or three companies that offers a service on your lane, which is scarce. That makes it difficult.

Well, I have no more questions left actually. I don't know whether you want to pick up something that has not been discussed yet?

Well I have also received a thesis from one of your fellow students about slow steaming and the radical implementation of it by the liner shipping companies. He did a survey among several shippers. A nice thing of this thesis was about customer service. When the companies just inform you that, unless the contract, the freight will be delivered a couple of days or weeks later. What shippers then did was contacting the customer service of the shipping companies. But those people of the customer service were not even aware of this implementation and that they were also not equipped to realise what consequences this would have on the clients supply chain. Further they could also not say when those products would then arrive at the agreed place. So the whole service among the implementation of these standards is totally wretched. In each market or industry, there could be cost increasing measures, but the way in which shipping companies take care of these measures is not market-proof. And they also begin to realise this.

Like the CEO of Maersk Line, who recently asks for a radical change in the shipping industry?

Exactly. When we are able to put some pressure on them with an aggregated shipper sound, they will eventually realise that things does not work like that. And that is a task that we want to fulfil here at EVO.