Erasmus University Rotterdam

MSc in Maritime Economics and Logistics

2011/2012

Northern Sea Route: a feasibility study for bulk shipping. Analysis of future potentials and impacts of the introduction of the NSR

By

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2011/2012

MSc Maritime Economics and Logistics

Master thesis

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Acknowledgements

I would like to express my gratitude to my supervisor Ms.Larissa van der Lugt (Senior Researcher Ports and Transport Economics, Erasmus University Rotterdam), who has been more than helpful with her guidance through the research process. Her collaboration support and constructive suggestions assisted me in overcoming all obstacles while producing this academic research. Moreover I would like to thank all the staff of the Center for Maritime Economics and Logistics (MEL) for their collaboration and kind encouragement throughout my time spent at MEL and especially during the research and data gathering period.

Preface

This research topic gained my attention right from the beginning. The fact that the Northern Sea Route has not yet been fully examined combined with the high interest of the shipping sector for the introduction of these routes to their voyage schedules made this topic extremely interesting in my opinion. Moreover the fact that this route is one of the most challenging alongside with the fact that it could alter in depth trade between Europe and Asia made me consider it as a topic of major interest. The possibility of conducting an academic research that could also be useful in my future career due to the fact that I could gain in depth knowledge regarding the NSR made me choose this very topic.

Looking back in the history behind the North East Passage, in the 16^{th} century it was the English and the Dutch who first tried to establish the Northeast Passage in an attempt to find a route to Asia other than the much longer through the Cape of Good Hope which was controlled by Portugal (Kon, 2000). Due to the special characteristics of the Northeast Passage and the fact that the vessels of those days were incapable of navigating in waters covered by thick ice the attempts failed. In 1869, with the opening of the Suez Canal there seemed to be less economic reasons to explore the NEP[1] since the distance to Asia had already been significantly decreased. In following years however the increase in world trade gave the trigger to Russia to re-examine the potentials of the NEP and in 1878 the Swedish scientist A.E Nordenskiold financed by Russia attempted to cross the NEP. At first he was held up due to the winter near Bering Strait but eventually in 1879 he was sailing back to Europe by the Cape route, being this way the first to ever circumnavigate Europe Asia and Africa. It was an achievement of historical significance that actually gave birth to navigation through the NSR.

[1] NSR: Northern Sea route: widely used term for this specific route

Summary

The purpose of this paper is to assess the economic feasibility of the Northern Sea Route as an alternative to the Suez Canal Route subject to bunker fuel oil prices and ice breaking fees and to examine potential effects that could arise from the introduction of the NSR. A cost comparison of these two routes showed that even when no dedicated vessels are required for the NSR, the Suez Canal Route remains the preferable route of choice mainly due to the increased ice breaking fees. Through sensitivity analysis it was demonstrated how decrease in ice-breaking fees of more than 50% is required in order for the NSR to become economically feasible. Furthermore due to the decreased distance between North Europe and East Asia the NSR is the preferable route of choice when bunker fuel oil prices are increased by more than 150% in compare with present values .Finally in this paper the most important effects of the introduction of the NSR were examined and presented. The introduction of ultra slow steaming, the periodical use of the NSR for time sensitive products, the possible trigger of slow steaming regulation and the use of idle fleet of smaller vessels of up to 70.000 dwt , which are able to navigate through the Inner NSR, where found to be the most plausible and important effects of the introduction of the NSR.

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Glossary of terms

NSR:Northern Sea Route

NEP:Northeast Passage

NWP:Northwest Passage

INSROP:International Northern Sea Route Program

TEU:Twenty foot equivalent

USD:United States Dollar

Ultra slow steaming: Sailing with speeds below 10knots

DWT:Deadweight tonnage

GHG:Green house gas emissions

1.1Introduction

Fuel prices and delivery times play a crucial role in shipping (Carrère, 2005). Shipping companies often adjust their preferred routes according to canal fees, reliability and other parameters such as piracy and insurance premiums that could change the economic performance of a specific route (Stopford, 2009). This is why the introduction of the Northern Sea Route (NSR), which is the widely used term for what outside Russia, in the past, was mostly known as the Northeast Passage (NEP)[2], could alter dramatically many parameters in terms of fuel costs, distance covered (See figure1.1)for trade between Europe and Asia as well as strategies followed by the shipping sector, which we will cover in detail later on, in this paper. In Russia the NSR expresses a vision for a major seaway line that could connect the Europe with North Russia and Asia. Major investments have been made over the past decades in shipping infrastructure, powerful nuclear ice-breakers- and claims jurisdiction over the NSR (Corbett, Lack, Winebrake, Harder, Silberman, & Gold, 2010).

Figure1.1: Northern Sea Route and Suez Canal Route

Source: INSROP

[2] NEP: Northeast Passage the commonly used term for the route up until the 20th century

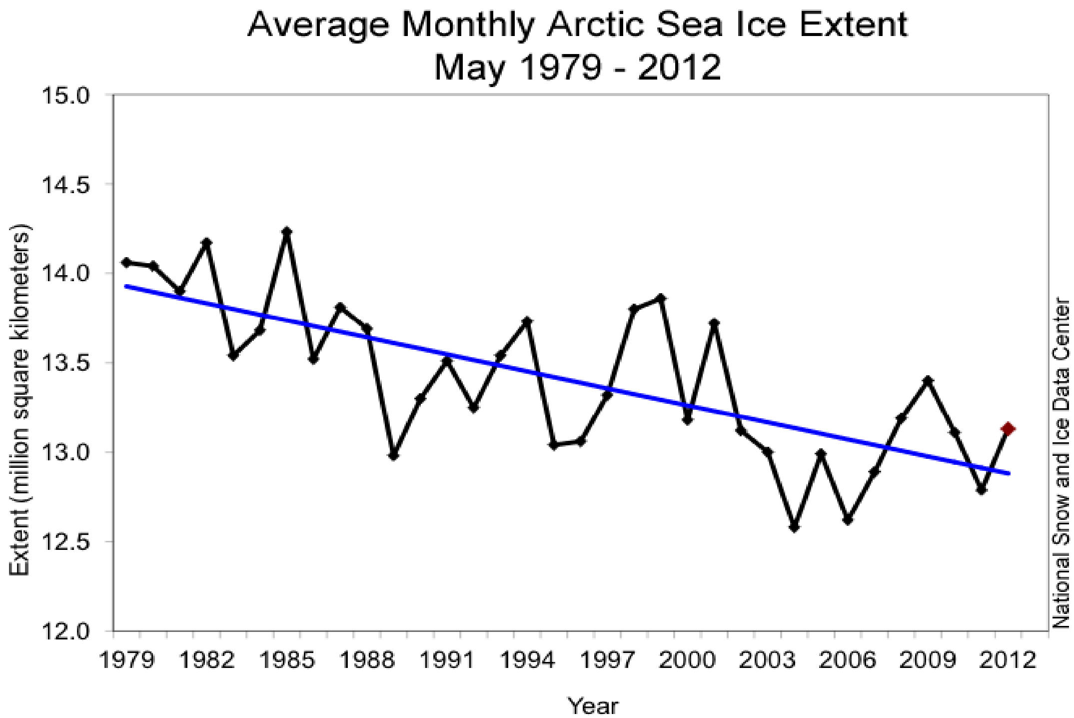
The NSR should be seen not as a clearly defined linear route but rather as the whole sea area north of Russia. Due to the very challenging and highly unpredictable weather conditions over this area the optimal route choice for ships navigating in the NSR will vary significantly (Parsons, Dinwoodie, & Roe, 2010). One, by taking a look at the globe, can easily realize how the NSR can offer great savings in distance, time and thus expenses especially for transport between North Europe and East Asia. The distance savings can be as high as 50% compared to the currently used shipping routes through the Suez or Panama Canal (Ragner, 2008). This very fact has always triggered the shipping community since the first discoverers went out in search of this Arctic short-cut five centuries ago.

The fact is however that the NSR never became widely used .Sea-ice has always been a major obstacle to commercial transit traffic, but in recent years this fact seems to alters significantly (Arctic Sea Ice News&Analysis, 2012).

The area of the NSR and the Arctic region in general is covered by layers of sea ice most of the year. During winter these layers of ice grow incredibly and reach their maximum usually in March and their minimum in September. Over the last years this seems to be altering very fast due to environmental issues connected with GHG[3] emissions that have increased the global temperature and have lead to the melting of ice in the arctic region. The amount of ice covering the NSR have significantly declined over the last 33 years. The decrease of the average amount of ice has been steady over the years (see chart 1.1)

[3] GHG: Green House Gas emissions

Chart1.1 Average Monthly Arctic Sea Ice Extent (1979-2012)



Source: National Snow and Ice Data Center

There has been recorded an average decline of ice of 2,3% per decade which is expected to keep in the same pace or even increase over the next decades (Brigham, 2010). In September 2002 the ice extent reached its minimum since 1979.That is a 23 years minimum. It is clear that the Arctic region is changing and eventually the NSR will become navigable for more months during the year providing greater reliability than now and decreased distances in compare with the alternative of the Suez Canal or the Cape of Good Hope. The Arctic ice cover is decreasing, and if this trend doesn't change over the coming years the NSR will probably become one of the major shipping routes for trade between Europe and Asia in the near future. This very reason has created a great interest over the maritime community regarding the potential use of the NSR. In this paper we will concentrate in the presentation of as many issues as possible regarding the use of the NSR in compare with the use of the Suez Canal. Moreover we will try to assess the potential impacts of the introduction of the NSR to the various strategies followed by shipping companies in order to face excess capacity and increased fuel costs. A more analytical explanation of the research questions and the methodology to be followed in this paper is provided in Chapter 7.

1.2Description of scope

There is a rather limited work regarding bulk shipping via the NSR and an even more limited research regarding the potential impact the NSR might have in strategies used in the shipping sector. Regarding the work already done on the NSR, the most extensive was focused in technical aspects for the use of the NSR conducted by the International Northern Sea Route Program (INSROP).INSROP was a six year (June 1993-March 1999) international research program which published more than 167 technical reports covering several aspects of the NSR.More details on INSROP will be presented later on in this paper. Moreover the potential reliability of the supply chain when sailing via the NSR has also been examined by several studies focused in the potential use of the NSR for liner shipping. The lack of extensive research for bulk shipping alongside with the main foundlings of INSROP which state that the NSR will be firstly used for bulk shipping has lead me to choose bulk shipping in this research. We identify as a gap the importance of bunker fuel oil prices alongside with the ice-breaking fees for using the NSR and how these parameters will affect the preferable route of choice. Moreover, the implications of the introduction of the NSR , has not yet been fully examined. We will identify them and present them based on recent articles and reports.This way we will focus both on the economic feasibility of the NSR according to bunker fuel oil prices and ice-breaking fees and in the potential implications of the introduction of the NSR. Initially, we will provide a quantitative approach to the introduction of the NSR with the use of a cost comparison model. Moreover we will try to assess the impact of changes in bunker fuel oil prices and ice-breaking fees in the economic feasibility of the NSR with the use of sensitivity analysis, so as to have a clear picture regarding the frame in which the NSR is an economic viable route. Finally we will try to get an insight into the implications the introduction of the NSR might have in the strategies widely used in the shipping sector. This way we are trying to provide a holistic approach in the NSR and its parameters.

1.3Research Question-Sub questions

The research question that we will examine in this paper is: “Will the NSR be economically feasible in the near future in case no dedicated vessels are required?”

The economic feasibility of the NSR when ice-class vessels dedicated to this specific route are required has been examined by INSROP and it was concluded that when investments are needed for ice-class vessels the NSR cannot be economically feasible in compare with the Suez Canal alternative. For this reason we will examine the future scenario when sea ice extent has been reduced enough so as to alow low ice-class vessels, with the help of icebreakers to navigate in the NSR. We will assess the total costs when sailing via the NSR and via the Suez Canal so as to determine which route is preferable in terms of total cost.

Moreover we will examine how the bunker fuel oil prices and ice-breaking fees will affect the preferable route of choice for shipping. A cost calculation model will be created in excel and with the use of different price scenarios for these two parameters we will determine which route is preferable for different prices.

Finally we will try to assess the future implications of the introduction of the NSR in strategies used in the shipping sector such as slow steaming. Through literature review and research over the internet we will conduct qualitative analysis so as to determine the most possible effects the introduction of the NSR might have.

1.4Existing research on the subject

Regarding the economic feasibility of the NSR there are some papers mainly focused on liner shipping.Moreover emphasis was given in the potential reliability of the NSR supply chain. The most important papers regarding the NSR are the following:

- The INSROP Simulation Study (INSROP,1999)
- Prospects for maritime export of Russian oil,gas and other cargoes,via the Northern Sea Route and the Northern Maritime Corridor (Y.Logvinovich,2008)
- The potential economic viability of using the Northern Sea Route as an alternative route between Asia and Europe (Miaojia Liu, Jacob Kronbak,2009)
- The Northern Sea route by Claes Lykke Ragner , 2008
- Northern Sea Route Cargo flows and Infrastructure-Present statue and future potential (Claes Lykke Ragner,2000)
- All papers published by INSROP (1993-1999)
- Economic Feasibility of the Northern Sea Route Container Shipping development (Svetlana Chervona,Anton Volkov,2010).

INSROP Simulation Study

The most important study regarding the NSR was with no doubt the *INSROP Simulation study (1999),* which was the final work of INSROP. This study combined founding of many previous studies conducted by INSROP. It was an effort to to compare NSR vs Suez Canal for sailing from Hamburg to Yokohama.The main components of this study were:

- Creation of technical drawings of new hypothetical vessels (both bulkers & containerships) adapted for navigating via the NSR all year long. Additionally conventional vessel of same size was used for sailing via the NSR.
- Inner and Outer NSR routes were examined regarding their sea ice extent with respect to historical ice data., which were collected from 1957-1990. These

data are out-of-date in compare with present values and could not contribute in this study.

- Total costs for the various vessels used in the study were calculated on an annual and voyage basis. In our study we will use the voyage basis approach.

A more detailed reference on existing work on the NSR is provided in the literature review.

1.4.1Outcomes of previous studies-Contribution of this paper

The comparison of the NSR vs Suez Canal was first examined by INSROP. The models used by INSROP had significant weaknesses but some main conclusions were drawn by the conducted studies. The outcomes of the INSROP simulation study and other important papers of INSROP were:

- When building and Capital costs are included, the NSR is not profitable in compare with the Suez Canal under no circumstances. In the same spirit we focused our research in the future scenario when regular bulk carriers can operate in the NSR.
- When building and Capital costs are excluded the NSR might be profitable under current market conditions (market conditions for the year 1999)
- For 1999 market conditions and data the NSR in order to become feasible specific expenses needed to be reduced. NSR fees needed to be reduced by 26% alongside with reductions in sea-ice insurance premiums.
- In 1999 the majority of vessels navigating via the NSR were bulkers of up to 19,900 DWT while via the Suez Canal much larger bulkers were able to sail from Europe to Asia. Due to this the NSR had another disadvantage not being able to provide economies of scale to carriers choosing the NSR.This fact has changed over the years due to reduction in sea ice and technical developments and thus will be included in our study.
- In order to maximize NSR's potentials at least Handymax vessels, close to 50,000DWT.should be able to navigate via the NSR according to INSROP.

With respect to all the above mentioned we will try to fill the gaps of previous studies:

- INSROP concluded that when capital and building costs were included the NSR was not profitable. In contrary to 1993 today it is quite a realistic scenario to examine the future potential of a significantly sea-ice reduced NSR. Thus based on NASA's founding regarding the decrease in Sea Ice and INSROP's founding's we will examine the NSR feasibility for regular bulk carriers
- In 1993 vessels of up to 19,900 DWT were examined by INSROP due to the fact that bigger vessels did not navigate in that region. Today that is not the case. In

2011 the 75,600 DWT bulk carrier “Sanko Odyssey” loaded with iron ore was the biggest dry bulk carrier sailing via the Inner NSR, while in 2010 the 162,000 DWT Suezmax,”Vladimir Tikhonov” loaded with 120,000 mt gas was the biggest vessel that ever sailed via the NSR[4]. Taking into consideration these recent achievements we used a Panamax bulk carrier of 70,000 DWT for our research, filling the gap of the 19,900DWT vessel used in 1993.

- Previous studies used data collected from 1950 to 1990. Data such as ice-breaking fees, operating costs, Canal dues and bunker fuel prices have significantly changed since then. In this paper up-to-date data will be used so as to provide a realistic outcome in our research.
- The importance of bunker fuel oil prices in combination with ice-breaking fees was never examined, this paper will address this issue in the comparison of the NSR vs Suez Canal.
- Finally possible effects the introduction of the NSR might have in the shipping sector will be presented, in a clear and holistic manner.

1.5Brief description of research methodology

First cornerstones of the use of the NSR will be coverd.By presenting the Arcitc Routes and their basic characteristics, the current conditions over the NSR, the management and current status of the NSR, the fees related with the use of the NSR and the International Northern Sea Route Program a clear picture regarding most of the parameters related to the NSR will be presented to the reader. Then we will proceed to the research itself and explain in detail the steps that we will follow. Regarding the economic feasibility of the NSR we will present all the formulas that are necessary for our cost comparison. All costs are going to be presented and a spreadsheet with the formulas that will be used is going to be created. In cost comparison two panamax bulk carriers will be used. The formulas which will be used are those presented in Maritime Economics 3rd edition by Martin Stopford. Martin Stopford is an Economist with more than 35 years of experience in the shipping sector. His book Maritime Economics is one of the most commonly used in Maritime Economics worldwide. In our sensitivity analysis a model with the use of office excel will be created. Bunker fuel oil prices and ice-breaking fees will be the inputs in our model while total cost for using these routes will be the outcome.As a base price for bunker fuel oil prices we will use a base price of 550 USD,which is below the average price of the last 24 months so as to cover the possibility of a major reduction in bunker fuel oil prices in the future.Bunker fuel oil price will be subject to increases in order to examine under which circumstances the increase in bunker fuel oil makes the NSR profitable in compare with the Suez Canal .For the

[4] Source: Arctic Bulk : http://www.arcticbulk.com/page/241/NSR-Transits-2011 (accessed 20/07/2012)

ice-breaking fees the latest available release by the Ministry of Sea and River transport will be used. Altering these two variables will provide different outcomes regarding the preferable route of choice in terms of total cost. Finally for the assessment of the future implications of the introduction of the NSR extensive literature review of recent works and articles will provide the framework for our analysis. Papers, articles and interviews of executive maritime professionals (retrieved mainly through the internet) will be the basis of our assessment.

Figure1.2: Extreme sailing conditions in the NSR

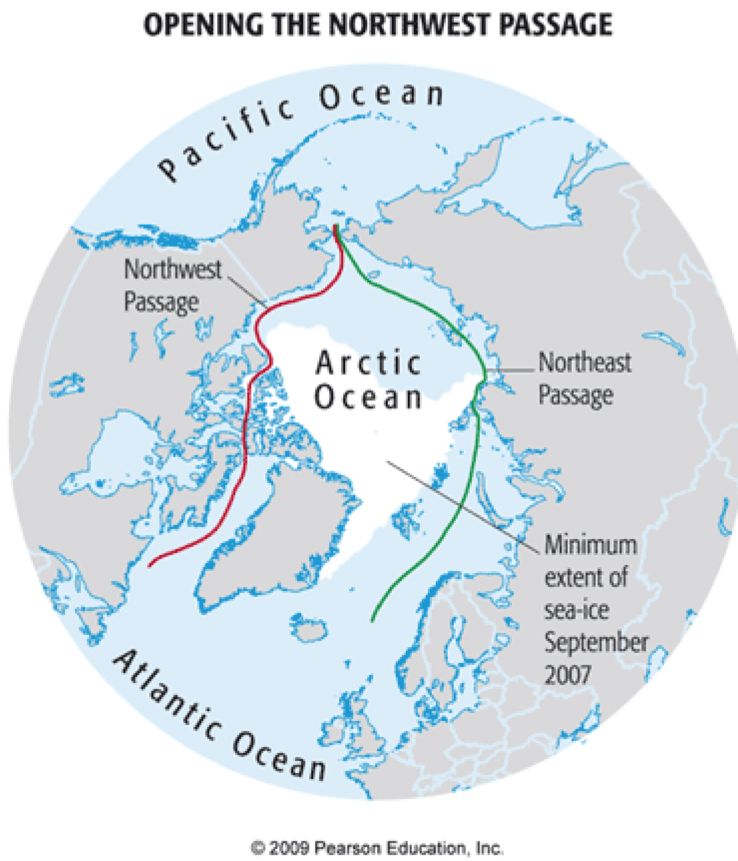
Source: Barents Observer[5]

[5] http://barentsobserver.com/en/business/shipping-double-northern-sea-route accessed 19/07/2012

1.6Limitations

There are a number of limitations regarding this study that need to be mentioned. First of all the number of studies, regarding the NSR, are rather limited in compare with other maritime related topics. Moreover obtaining efficient data for the cost comparison can be quite challenging. Data such as the insurance premiums for K&R (Kidnap and Ransom) , extreme weather and sea ice for the NSR, fees related to piracy, such as armed escort, which affect the total voyage costs for each route, are rather difficult to find and thus can affect the final outcome of the cost of each route. Moreover there are only a small number of companies operating in the NSR which makes it even harder to get an insight from professionals who could provide a clear image regarding the operational procedures and challenges of the NSR. Initially obtaining some information for the operational performance of the NSR was intended. Unfortunately due to time limitations and the limited number of companies active in the NSR this was not possible. Wherever data are not available assumptions based on literature review will be made, and this very fact will be clearly stated. Finally we must mention the including accurate insurance premiums for K&R (Suez Canal) and Sea ice (NSR) as well as fees for armed escort services was not possible due to lack of sufficient data.

Figure 1.3: Opening of the NSR and NWP



Source:Peasrson Education Inc

2. Literature Review

NSR and Environmental aspects

Arctic Sea Ice is melting fast. This is a fact that has been recorded over the last decades. Arctic sea ice extent in February 2012 averaged 14,56 Million square kilometres . This is the 5th lowest February ice extent of the last 33 years (Arctic Sea Ice News&Analysis, 2012). In general over the last years there has been a reduction in the amount of sea ice in the Arctic region in historically high levels. To be more precise NASA scientists mentioned that in 2009 the yearly average amount of ice recorded in the Arctic sea was the lowest since satellite measurements began in 1979. (NASA, 2009) The past three decades the sea ice in the Arctic region has totally been reduced by 33% (Brigham, 2010).

This environmental change generates opportunities for the introduction of new shipping routes. The Northern Sea Route connects Europe to Asia providing an alternative route of that through the Suez Canal. Moreover the North-West Passage connects America with Asia providing an alternative route of that through the Panama Canal. These shortcuts create a significant decrease in the voyage length. Although the Arctic region is changing dramatically and the ice is thinning year by year, still the waters are navigable only 3 to 4 months per year (Huebert, 2008). The potential value and importance of these routes are clear. The shipping shortcuts of the Northern Sea route (over Eurasia) and Northwest route (over N. America) create a decrease in the oceanic voyages of several days saving shipping companies thousands travel miles. The Northern Sea Route reduces the sailing distance between Rotterdam and Yokohama from 11,200 nautical miles through the current route via the Suez Canal to only 6,500 nautical miles. That is a more than 40% saving in voyage distance (Borgerson, 2008). In the same way the North West Passage reduces the voyage distance from Seattle to Rotterdam from 8,860 nautical miles, through the Panama Canal, to only 6,860 nautical miles via the North-West passage (Borgerson, 2008). The distance is one of the most important determinants of seaborne costs (Carrère, 2005) and this is why the NSR has been considered as an issue of major importance for the Shipping sector.

Economics of the NSR

When it comes to the use of the Arctic shipping routes the avoidance of Canal fees,fuel costs and other related costs have to be taken under consideration (Corbett, Lack, Winebrake, Harder, Silberman, & Gold, 2010).Moreover insurance costs related to piracy which today are a considerable proportion of the total operating costs (King, 2008) could decline significantly with the use of the Arctic shipping routes and the NSR. Although the introduction of the Arctic shipping routes is still in an experimental stage, used only by a small number of companies the majority of the maritime world is following the news closely due to the various benefits of this routes (Lloyd's List, 2010).Shipping companies have used various methods so as to improve ship scheduling and cost analysis by identifying cost items relevant to the planning of a shipping route (Chan Ting & Hshiung Tzeng, 2003). In the recent past an effort was made by Saran Somanathan,Peter Flynn and Jozef Szymanski to examine whether the distance saved using the North West passage over North America justifies the investments nescessary to use this route for liner shipping. In their work an economy transit model created in a previous research, in order to analyze the transit speed of slow and fast ships using the North West passage was created in order to to analyze the economic efficiency of the North West route in compare with the route through the Suez Canal (Somanathan, Flynn, & Szymanski, The Northwest Passage A simulation, 2006). The outputs of those reasearches (Somanathan,Flynn & Szymanski 2006 & 2007) were the first examining the feasibility and the economic efficiency of the North West Passage for liner shipping. Furhermore the efficiency of the North-west passage was examined for several ports worldwide in compare witht the route through the Suez Canal.The most intense work regarding the NSR has been done by INSROP which operated from 1993 up to 1999. Their work contains many papers and reports which are mainly focused in the technical aspectes,potentials and juresdiction of the NSR.There can be found more than 160 technical reports created by INSROP.

Feasibility of the NSR

It has been proved by the work done by INSROP that when investments for dedicated high ice class vessels are needed the NSR can not be economically feasible (INSROP:A simulation study,1999).For this very reason we will focus in the future scenario when regular bulk carriers can navigate througt the NSR with the assistance of ice breaking vessels.The efficiency of the ice-breaking fleet has been covered in terms of nescessary investments. (Corbett, Lack, Winebrake, Harder, Silberman, & Gold, 2010).Moreover the economic viability of the NSR for liner shipping services and the pontied impacts in reliability of the supply chain has been examined(Miaojlia Liu, Jacob Kronbak,2009)This paper was clearly focused on liner shipping giving great emphasis in reliability and impacts of the NSR in the container supply chain. For bulk shipping only the effect on supply chain efficiency has been examined so far (Halvor Schøyen,Svein Bråthen 2010).Additionaly Claes Lykke Ragner (former head of secretary of INSROP) in his paper "The Northern Sea Route" (2008) identified the need for further research on the NSR since there are evidence of increased interest for this specific route.Claes Lykke Ragner moreover highlighted the need for a legislative framework and measures for avoidance of bureaucracy in order to have a more viable route.In the same way Herbert,R.Y highlighted the need for a regional agreement on the management and conservation of the arctic marine environmet in relation with shipping arctic shipping.Selin V, in his paper, *The Economics of the Northern Sea Route:historical trends,current state and perspectives,* has spotted the future trends regarding NSR to most probably focus on bulk shipping and time-sensitive products. Several studies have been published by the Arcitc Council regarding the development of the Arctic marine region through the years and the challenges for shipping via the Arctic.Finally the Central Marine Research & Design Institute, has examined the prospects for Russian Maritime exports of oil gas and other cargoes via the NSR.

In this paper we will try to assess the possibility that the NSR might provide,due to its decreased distanse, an efficient alternative to the route through the Suez Canal taking into consideration the effect that changes in bunker fuel oil prices and ice-breaking fees might have in the preferable route of choice.The connection of several variables with the cost function is clearly described by L. Breierova in his paper: *An introduction to sensitivity analysis* (Breierova & Choudhari, 1996).We will take into account operating costs,as described in the operating costs report of Moore and Stephens for panamax bulk carriers, which cover 12 main operational sub- costs for panamax bulk carriers (Stephens, 2009).Furthermore in our cost comparison voyage costs for each route will be calculated based on the formulas provided by Martin Stopford (Stopford, 2009) in Maritime Economics 3rd edition.For every cost participant that will be excluded in our cost comparison there will be a clear statement regarding the the reason it was excluded.Moreover we will try to examine how changes in bunker fuel oil prices and ice breaking fees might affect the choice of optimum route for bulk shipping and identify for which future values of bunker fuel oil and ice-breaking fees the NSR will be profitable, with the creation of a cost model in excel which will have as inputs bunker fuel oil prices and ice-breaking fees and as an output the total cost for each route.This variables will form the basis of our sensitivity analysis (Breierova & Choudhari, 1996).Finally through qualitative analysis the potential impacts of the introduction of the NSR will be presented. Articles with interviews of executive maritime professionals , research over the internet,(look at internet sources) and literature review will be the cornerstone of this effort (Ospina, 2004). Regarding the possibility of regulating slow steaming due to the introduction of the NSR the various impacts,advantages and disadvantages of regulating slow steaming have been covered by J Faber and M. Tsimblis in their paper : *Regulated slow steaming in maritime transport, An assesment of Options Costs and Benefits.*

3. Arctic Routes and basic characteristics

3.1Nortern Sea Route

The Northern Sea Route or what was known as the Northeast Passage up until the beginning of the 20th century connects the North Atlantic with the Pacific Ocean. As we have mentioned earlier the NSR is not a specific route but a whole sea area north of Russia. When navigating through the NSR the optimum route choice is subject to weather conditions and can vary significantly (Chernova & Volkov, 2010). The decision over which route is the optimum one is based in a great extent in satellite weather reports provided mainly by the NSR authority. The NSR can be divided in two main sub-routes which are the Inner and Outer Northeast routes.The first, the Inner Northeast Route, is a coastal one and is used today mainly for transportation and especially for exports from North-west Russia. The Outer Northeast route, is characterized by much deeper waters and lies near the islands of Severnaya Zemlya and New-Siberia (Utanríkisráðuneytið, 2005)

The distance of the NSR is considered to be from 2100 to 2900 nautical miles (M.Liu,J Kronbak,2009). The NSR is the shortest sea route connecting Northern Europe and East Asia (Y.Logvinovich, 2008)

In the Regulations for Navigation over the Northern Sea Route the Russians provide a specific definition regarding the NSR. According to this paper the NSR as a passage is connecting Novaya Zemlya to the Bering Strait. Bering Strait includes from west to east, the Kara Sea, Laptev Sea, East Siberian Sea and Chukchi Sea. In some cases the Barents Sea is also considered to be included (Kon, 2000)

The first voyage through the NSR took place in 1932 by a soviet expedition led by Professor Otto Yulievich Schmidt which sailed from Arkhangelsk to the Bering Strait. In 1932, the administration of the NSR, a dedicated governmental body, was created, and in 1991 the “Regulations for Navigation on the Seaways of the Northern Sea Route” were approved by the Russian government (M.Liu,J. Kronbak,2009). Through this document shipping through the NSR was regulated for all vessels of any nation for commercial purposes

3.2Northwest Passage

Like the NSR the Northwest Passage (NWP) is a sea passage providing a route from the Atlantic Ocean to the Pacific Ocean through the Arctic (See figure X). The route is located 800km north of the Arctic Circle and less that 1900 km from the North Pole. A series of deep channels through Canada's Arctic islands create the Northwest Passage. Five to seven seaways in the Canadian Arctic Archipelago are the main seaways of the Northwest Passage. The MacClure strait, the Davis Strait, the Prince of Wales Strait and the Baffin Strait .Large ships can sail only via the Baffin bay and the Davis Strait.

Similar to the NSR, for centuries efforts have been made to navigate through this hostile area due to the decreased sailing distances it provides. Reaching the Northwest Passage as well as the exit to the Pacific is quite challenging due to polar ice caps and unpredictable weather conditions. Sir Martin Frobisher made the first attempt to cross the Passage in the 16^{th} century. The goal of using the passage for commercial use remained was always considered of prime importance. In 1969 the oil tanker SS Manhattan crossed the NWP with the escort of a Canadian icebreaker. The Manhattan began from the east coast of North America and travelled through the NWP to the west coast through the Baffin Sea. SS Manhattan was the first commercial vessel that sailed through the NWP (Kitagawa, 2008)

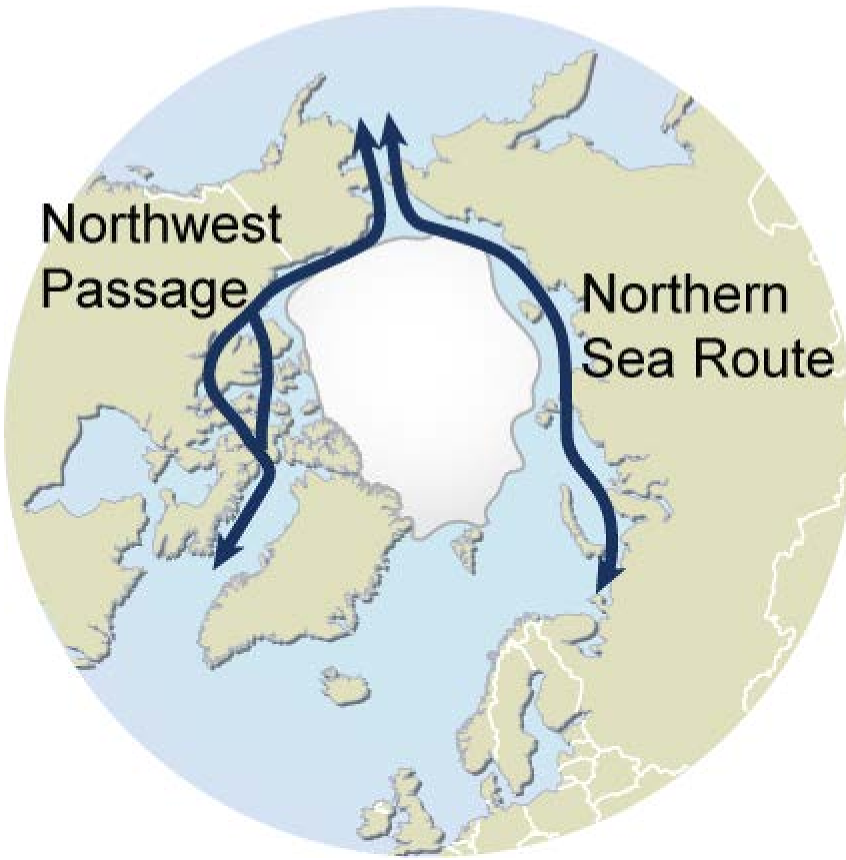
Although her journey was a great success it was concluded that the Trans-Alaska Pipeline was the more efficient and economic way for transporting oil from the North Slope to a tanker terminal located on the west coast (Kitagawa, 2008)

Manhattan managed to provoke a lot of discussion regarding Canada's claims future jurisdiction over the area. As global warming has lead to the melting of several sea routes of the NWP the issue is being under discussion once again. In 2007 the Northwest Passage became accessible during August without the escort of icebreakers. Three ships completed their journey through the NWP in 2007.

Climate change and the seasonable use of the NWP has created hopes for the opening of the Northwest Passage to commercial traffic for longer periods. However the development of such as sea lane would require important investments in ice breaking vessels , navigation technology systems and ports so as to meet current IMO requirements (Somanathan, Flynn, & Szymanski, The Northwest Passage A simulation, 2006)

Global warming, and the intention for investmets from Canadian authorities will determine the future of the NWP in the coming years.

Figure 3.1: The NWP and the NSR



Source: American Geological Institute

4. Current conditions over the Northern Sea Route

4.1Weather conditions in the NSR

Navigating through the NSR and the Arctic in general is very challenging. The ice conditions play a vital role both in route planning and the reliability of the NSR.The ice extent determines the length of the navigational season, the optimum route, the speed of sail and the necessity for ice breaking escort (jakobson, 2010)

Several researches over the last decades have shown that the sea ice over the Arctic has been shrinking. (Lloyds List, 2010)Although there is uncertainty regarding the speed in which the ice is melting the scientific community is rather agreeing in the fact that sea ice over the Arctic region has decreased dramatically over the last decades Moreover the 12 month mean sea ice extent over the Arctic has decreased significantly from 1953 to 2010 .This very fact has lead to the widely accepted opinion that the NSR will be open for regular cargo transit in the future for an increased period of time in compare with present day. According to the Arctic Climate Impact Assessment (ACIA) the NSR sailing season will be increased in the coming years up to 120 days per year, for ordinary cargo vessels. As for new ice-strengthened cargo vessels the sailing season might be even longer than that (Ragner,2008). Today there are several areas covered by thick layers of ice that make the use of high ice-class vessels or icebreaker assistance mandatory(Lloyd's list,2010).

Variability in weather conditions and ice conditions make the NSR a rather unpredictable route which is the main problem when shipping along it (Wergeland, 1992). While sailing in the NSR weather conditions can vary significantly even from the eastern to the western sect (M.Liu,J.Kronbank,2009).Furthermore sea ice extent can vary significantly according to the season. The seasonality of the Arctic, and the annual sea ice patterns play a critical role when planning sea transport through the Arctic and the NSR (Arctic Council, 2012)

It is important to mention that although the ice over the Arctic has decreased significantly, making feasible, for some months during the year, marine transportation through the NSR and the NWP, there has not been any official research indicating that the sea ice over the Arctic Ocean will definitely disappear during this century. Several studies claim that it is highly possible however no scientific proofs exist so far (Somanathan, Flynn, & Szymanski, Feasibility of a Sea Route through the Canadian Arctic, 2007).In this study we will not focus in the arctic conditions but rather in the feasibility of the NSR for given ice-conditions that allow regular bulker to navigate via the NSR.

4.2Traffic volumes via the NSR

Table 4.1 provides a clear picture regarding NSR cargo shipment from 1945 to1999. The maximum amount of cargo shipped via the NSR was achieved in 1987. During this year 6.57 million tons were shipped through the NSR. From 1987 to 1999 the cargo shipment through the NSR declined by 76 %(See table 4.2)

Moreover cargo shipment from Europe decreased due to a decline in investments and geological prospects in the region (A.G Granberg, 1998).

Table 4.1 Total volumes of cargo transported via the NSR (1945-1999)

Year:	1945	1960	1970	1980	1987	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Volume:	0,44	0,96	2,98	4,95	6,58	5,51	4,80	3,91	2,97	2,30	2,36	1,64	1,95	1,46	1,58

Source: Claes Lykke Ragner,2000

NSR cargo seemed to stabilize during the mid 90s (Ragner, 2008)with average annual volumes from 1,4 million tons to 2,0 million tons. In general present cargo flows consist of approximately 850.000 tons of non-ferrous metals and ores, 400,000 tons of dry bulk cargo, 250,000 tons of fuel and 50,000 tons of gas (Chernova & Volkov, 2010). Since 1999 there haven't been any major developments regarding either the NSR infrastructure or the ice-breaking fleet (Selin V, 2003). The MSC[6] have reported in late 2000 that the transportation of goods via the NSR during summer time has been running smoothly and efficiently during the last years due to the reduction of sea ice.As a result transit volumes via the NSR have been steadily increasing since 1999 (See chart 4.1).

[6]MSC: Mumarsk Shipping Company

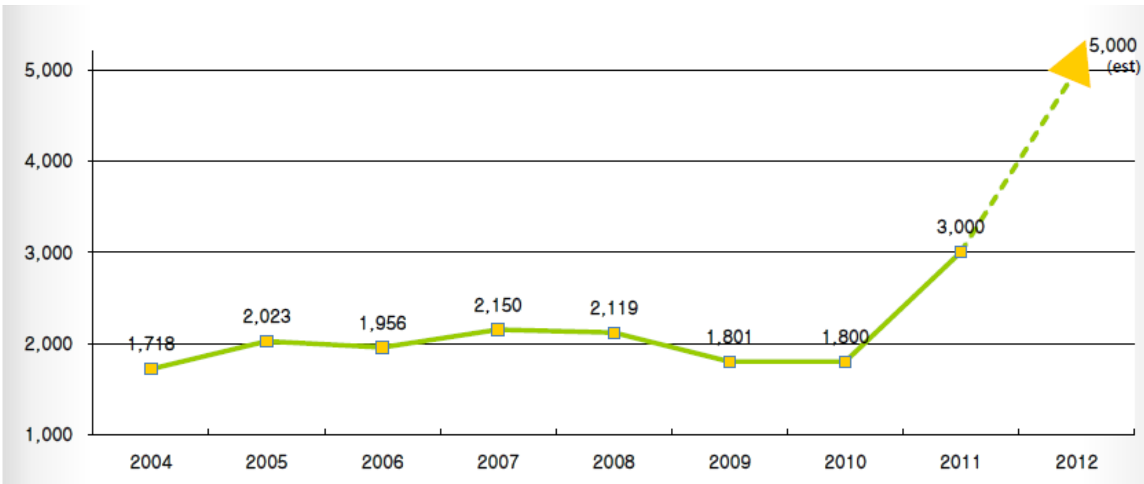
Table 4.2 Dynamics of NSR Cargo Shipment

	1987	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Change 1987-99
Cabotage import to NSR ports, *of which*	2943.6	2490.4	2261.6	1806.9	1413.6	795.3	829.3	635.5	703.1	455.5	645.4	-78.1 %
- from west Russian ports	1808.1	1355.1	1193.8	974.4	768.9	573.5	576.8	462.0	558.4	452.6	616.8	-65.9 %
- from east Russian ports	1135.5	1135.3	1067.8	834.5	644.7	221.8	252.5	173.5	144.7	2.9	28.6	-97.5 %
Cabotage export from NSR ports	1684.7	1556.0	1450.7	1272.2	728.5	710.3	766.0	595.2	645.4	421.7	311.3	-81.5 %
Intra-Arctic cabotage	358.6	136.2	170.0	169.7	95.3	18.3	10.8	10.0	36.2	50.5	61.3	-82.9 %
Foreign trade, *of which*:	1590.7	1212.8	745.5	456.1	520.3	636.0	655.5	383.2	560.6	530.7	562.2	-64.7 %
- import	509.8	11.8	1.9	5.3	3.0	57.1	49.5	15.6	35.6	6.6	13.0	-97.5 %
- export	1080.9	1201.0	743.6	450.8	517.3	578.9	606.0	367.6	525.0	524.1	549.2	-49.2 %
Transit	1.0	115.1	176.2	202.3	208.6	140.2	100.2	18.1	0.0	0.0	0.0	-100.0 %
Total volume of shipments	6578.6	5510.5	4804.0	3909.2	2966.3	2300.1	2361.8	1642.0	1945.2	1458.4	1580.2	-76.0 %

Source:Claes Lykke Ragner,2000

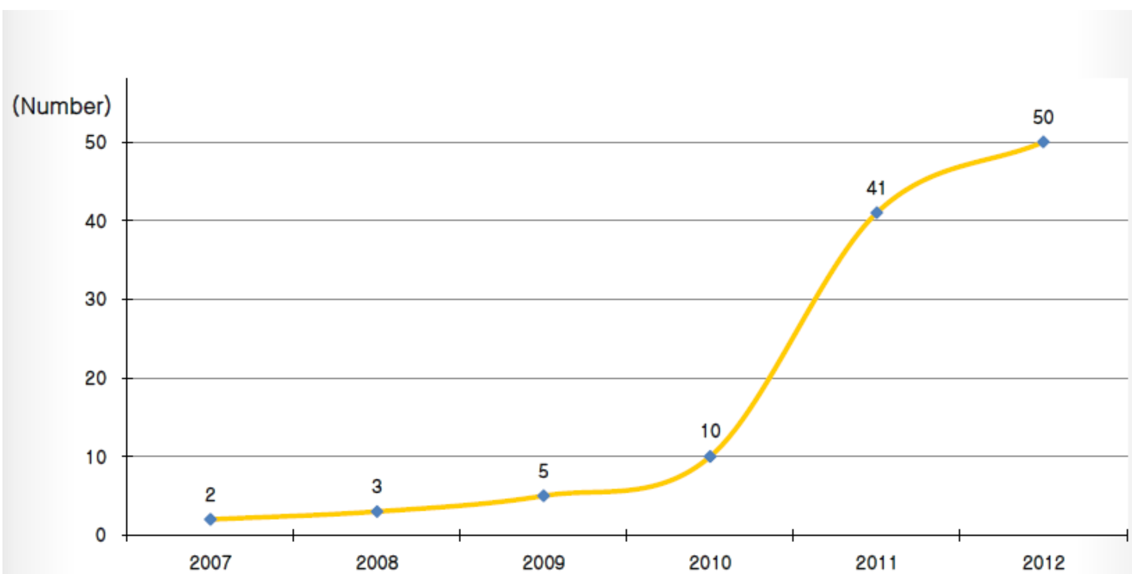
Today the cargo shipped via the NSR is negligible in compare with the traffic volumes shipped through the Suez Canal.The Russian government during the 90's reduced in a great extend the previously high level of subsidies to the NSR transport system. This fact lead to a major decline in transportation via the NSR. From the early 90's up until the present day traffic volumes via the NSR have been rather low. However the interest of the maritime sector is high and transit cargo potentials have been examined in several studies. Claes Lykke Ragner mentions that the two most promising cargoes for the NSR are chemical/mineral fertilizers and ferrous metals. Everyone seems to agree that the NSR will first be used for bulk shipping due to the fact that bulk cargo is less sensitive to potential delays and unreliability to schedule, which is quite common when using the NSR. The future traffic volumes via the NSR are subject to a number of parameters with global climate being one of the most important (Emmerson, 2012)

Chart 4.1Cargo Traffic via the NSR 2004-2012 (2011-2012 estimated)



Source: International Transit Transportation on the NSR: Reality and Opportunity

Chart 4.2 Transit Transportation through the NSR



Source: International Transit Transportation on the NSR: Reality and Opportunity

4.3Fees for the use of the NSR

The use of the NSR is not free. Ice-breaking fees charged by the Russians consist one of the major participants in total cost when shipping through the NSR (Ragner,2000).There are a number of factors that determine the exact fee for ice-breaking services. Ship size, specific route, ice class of the vessel and level of support required determine the exact fee for ice-breaking services when sailing through the NSR (M.Liu,J.Kronbank,2009). Moreover the aforementioned fee also includes other services such as aircraft guidance, meteorological services and the use of communication systems. One basic rule for determining the basis of the fee is that “The larger the ship the low per ton tariff” (M.Liu,J.Kronbank,2009). As was mentioned earlier in this paper the NSR is not a specific route but a whole sea area. For this reason the NSR is divided in three sectors each with different tariff (Mulherin,1994).

The three different tariff regions of the NSR are:

Table 4.3 Tariff rates according to NSR region

	From	To	Tariff rate
Tariff Region A	Novyaya Zemlya	Severnaya Zemlya	70% of C
Tariff Region B	Severnaya Zemlya	Bering Strait	80% of C
Tariff Region C	All areas north of the 78 N parallel		C

Source: INSROP

Note that tariff for region C is the base tariff which determines tariffs for region B and region C. (M.Liu, 2009).

In early 1990s the volume shipped via the NSR was about 4million tons per year with an icebreaking fee of about 2-4 USD[7] per ton of cargo (M.Liu, 2009). Later the same decade when shipment through the NSR decreased to about 2,5 million tons per year tariffs were increased to 7,5 USD per ton of cargo due to the fact that operating ice-breaking services in the area became unprofitable. The Russian government during that period provided subsidies so as to ensure the existence of ice-breaking services in the NSR. In 2003 subsidies stopped being granted by the government which led to an additional increase to an average of 23USD per ton of cargo in an effort to maintain the existing ice-breaking vessels and modernize the fleet (M.Liu, 2009).

We managed to found the most recent ice-breaking fee document issued by the Federal Rates Service and registered by the Ministry of Justice of the Russian Federation on the 21th of June 2011.The document is entitled: “Order on setting of rates for services of the ice-breaker fleet on the Northern Sea Route”

[7] USD: United States Dollar

Table4.4: Maximum rates for services of the icebreaker fleet on the Northern Sea Route to ensure the transportation of cargo

№	Nomenclature of cargo			
1	General cargo	Unity	Rate Rubles/ton	Rate USD/ton
1.1	Cargo, transported in standard containers	Rubles per ton of nominal gross mass of container	1048	32,4
1.2	Non-ferrous metal	Rubles per ton	2050	63,5
1.3	Converter matte	Rubles per ton	1905	59
1.4	Products of mechanical engineering and instrument-making including equipment and parts thereof	Rubles per ton	2464	76,4
1.5	Vehicles, cars and their parts	Rubles per ton	2576	79,8
1.6	Articles out of metals of industrial purpose	Rubles per ton	1747	54,1
1.7	Others	Rubles per ton	1048	32,4
2	Bulk cargo	Rubles per ton	707	21,9
3	Bulk liquid cargo	Rubles per ton	530	16,4
4	Timber cargo:	Rubles per ton	404	12,5
4.1	Round lumber	Rubles per ton	118	3,65
4.2	Saw-timber and other products of timber, woodworking, pulp and paper industry	Rubles per ton	148	4,5

Source: Federal Agency of Sea and river transport[8]

As we can see from table3 the maximum rate for ice-breaking fee to vessels transporting bulk cargo is set to 707 Ruble per ton (21,7 USD)[9].For liquid bulk the ice-

[8] *http://www.morflot.ru/index.php?cid=21* , accessed 10/07/2012)

[9] 1 Ruble=0,031 USD on 14/07/2012 source: www.exchangerates.org.uk

breaking escort fee is set to 530 Ruble per tone (16,3 USD). The most expensive product for ice-breaking escort is vehicles cars and their parts with an escort fee of 2576 ruble per ton (79,08 USD). Container transport escort services have a fixed fee of 1048 rubles per ton (40,8 USD). Here we must mention that ice breaking fees for vessels not carrying any cargo differentiate significantly (See table 4)

Maximum rates for services of the icebreaker fleet along the Northern Sea Route collected from transport ships sailing in ballast, towing, technical, auxiliary (including research*) and other floating craft not intended for cargo transportation**.**

Table 4.5:Ice-breaking fees according to the area of escorting

№	Area of escorting	Unity	Rate
1	Transit along the waterways of the Northern Sea Route	USD per ton of full displacement	31
2	To ports of the Laptev Sea from west or from east, to ports of the East Siberian Sea from west or from east	USD per ton of full displacement	21,4
3	To ports of the Kara Sea and to ports situated on Ob and Yenisei rivers from west	USD per ton of full displacement	6,2

Source: Federal Agency of Sea and river transport[10]

Tables 4.3 and.4 4 present the maximum rates per ton of cargo for ice-breaking escort. That is for vessels of the lowest ice-class allowed to sail through the NSR, which is 1B class. More details on ice-class of vessels will be discussed later on, in chapter 7.

[10] *http://www.morflot.ru/index.php?cid=21* , accessed 10/07/2012

5.The International Northern Sea Route Program (INSROP)

The International Northern Sea Route Program (INSROP) was a research program which was active for six years (from June 1993 to March 1999). INSROP was created in order to gather information and create data bases regarding the ice covered shipping lanes in the North Russian coast focused to the shipping lane from Novaya Zemlya to the Bering Strait which is also know as the Northern Shipping Route (NSR).

In the official web-site of the INSROP there are several information regarding the actions and responsibilities of this 6 years scientific program. According to the information found in the official INSROP website (Insert footnote with the website), INSROP was initially created in an effort to gather sufficient information on the NSR. The Russian government opened the NSR for foreign vessels in 1991 which made the creation of a program like INSROP of prime importance. INSROP had recognized the sea ice and political instability in Russia as two of the major drawbacks in the development of the NSR, while Suez and Panama Canals draft limitations , political instability in the Middle East and piracy over the S.E Asia were all factors that can lead to the commercial establishment of the NSR over the Suez and Panama Canal.

From 1993 to 1999 INSROP published 167 technical reports covering all technical aspects regarding ice breaking services, technologies required for navigation over the NSR, ice-classes and many other end products. All INSROP reports have been available to the public. INSROP completed its course with the Northern Sea Route User Conference which was organized by the INSROP partners in Oslo, Norway, November 1999. The conference's main objective was to make broadly known the INSROP's results and to inform the shipping community about the potentials of the NSR.

According to INSROP the main challenge for establishing NSR as a commercial shipping route is the extreme weather conditions over that area. Despite the fact that in 1999 ice breaking vessels which could overcome the extreme weather conditions were widely available the investments needed to build a fleet of highly ice-classified vessels was rather unprofitable. As an equally important issue the INSROP had recognized the need for an efficient administration of the infrastructure and the ice-breaking fleet needed for the NSR

INSROP came to some important conclusions regarding the future potentials of the NSR. According to INSROP an enormous increase in commercial shipping through the NSR is realistic and quite feasible. The most significant potential for shipping through the NSR is for bulk shipping and more specifically for the huge oil and gas reserves which can be found in the Arctic region, onshore and offshore. The potential of shipping oil and gas to the European markets from the Russian Arctic is considered to be as the ideal scenario for the establishment of the NSR as a major shipping route. Regarding transit traffic once again bulk shipping seems to be the main cargo participant in the future for trade between Northwest Europe and Northeast Asia, and Northwest Europe and North American West Coast.INSROP concluded that NSR cannot be a viable alternative to the Suez Canal when new ice-class vessels are required especially for NSR transits. Moreover reasonable tariff policy is of prime importance in order for the NSR to be most profitable in compare with the Suez Canal. INSROP came to the conclusion that under no realistic scenario building vessels specifically for the NSR can be profitable in compare with building ordinary vessels able to navigate through the Suez Canal. For this very reason we will focus mainly in the future potential were ice-class vessels are not required for navigating through the NSR and the ice-breaking escort is sufficient for transit through this route with ordinary, slightly modified vessels.

Another issue regarding the NSR according to INSROP is the ecological vulnerable areas the NSR is covering and the challenges arising when shipping through this route. An accident over this specific region could lead to an ecological disaster and thus increased safety measures are of major importance.

Finally INSROP recognizes as the most important parameter for a successful utilization of the NSR the political issues regarding the management , administration and jurisdiction over the route. Several issues on a political level will need to be solved before the NSR can become an important opponent of the Suez Canal. The ice-breaking fleet of the NSR is rather slow, but reliable for the moment. In case volumes increase significantly huge investment in new technologically advanced ice-breaking vessels will be necessary. In order this investments to take place specific political actions will need to take place. The economic and political issues that haven’t allowed Russia to establish the NSR as a more competitive alternative to the Suez Canal will need to be solved in the near future in an effort to attract more volumes and increase the reliability and competitiveness of the NSR.

6. Management and present status of the NSR

6.1 Present status of NSR administration

Today the Federal agency of marine and river transport of RF transport Ministry is responsible for the Administration and management of the NSR. The Russian government considers the development of the NSR and the Arctic Marine transport network in general as of essential importance for the economic development of the Russian North. The NSR is treated as an essential part of the infrastructure development of the Russian North as well. The administration of the NSR was first established in 1971 in Moscow (M.Liu,2009). The operations taking part over the NSR are being controlled by two shipping companies which act as Marine Operations Headquarters (MOHQs). They are responsible for tasks such as scheduling , route planning, navigational assistance etc(See figure X). The fact that the NSR administration has authorized private shipping companies to perform the operational management of the NSR creates many questions due to potential conflict among various stakeholders. According to M.Liu and J.Krobank by authorizing private shipping companies to perform the operational management of the NSR one can expect that emphasis will be given on cost and revenue which are mandatory for private companies rather that the socioeconomic effects of an increased utilization of the NSR .Vessels operating in the west side of the NSR are under the authority of the MOHQ at Dikson region on the Kara Sea Coast. Mumarsk Shipping Company (MSC) is responsible for the administration of the Dikson MOHQ while vessels navigating at the east side of the NSR are under the authority of the Far Eastern Shipping Company (FESCO) which has its headquarters in Vladivostok and the MOHQ in the East Siberian Sea Port of Pevek.

According to “The concept of NSR development, 2009” the NSR administration today provides shipping companies navigating though the NSR with the following services:

- Rescue fleet
- Nature conservation fleet
- Linear, auxiliary and port ice-breakers
- Marine ports
- Buoy and hydrographic boats
- Coastline sector objectives
- Radio-connection services
- Survival services
- Navigate-hydrographic, hydro-meteorological, aircraft-provision
- Technical service of the fleet
- Administrative agencies
- NSR operating services

Figure 6.1: Nuclear Icebreaker vessel sailing in the NSR

Source: http://www.world-nuclear-news.org

6.2Requirements for using the NSR

There are several steps that need to be followed in order to navigate through the NSR. The first step is to obtain permission by the Administration of the NSR (ANSR) (S.Chernova,2010). The request for permission should be addressed either to MSC or FESCO according to the entering area as discussed in paragraph 5.1. The following information should be included in the request for sailing through the NSR (M.Liu,2009)

- Name of vessel,flag of vessel, port of registry, contact details of the ship-owner
- Gross and net tonnage of the vessel
- Dimensions of the vessel (length/breadth/draft)
- Engine of the vessel, speed when navigating through the NSR, propeller material and design
- Type of bow
- Ice class of the vessel including classification society and date of last inspection
- Expected date of entry to the NSR
- Certificate of insurance or other security for civil and environmental liability
- Purpose of the voyage

- Place of inspection according to the ship-owners preference by the inspectors of the NSR Authority

When approval is obtained the vessel is to be inspected for ice-worthiness by inspectors of either MSC or FESCO. Permission for navigating through the NSR is obtained after the inspection is successfully completed. The exact date and route to be followed is determined by the NSR authority with respect to weather conditions and ice-breaking vessels available at the moment.

6.3Fees for the use of the NSR

The use of the NSR is not free. Ice-breaking fees charged by the Russians consist one of the major participants in total cost when shipping through the NSR (Ragner,2000).There are a number of factors that determine the exact fee for ice-breaking services. Ship size, specific route, ice class of the vessel and level of support required determine the exact fee for ice-breaking services when sailing through the NSR (M.Liu,J.Kronbank,2009). Moreover the aforementioned fee also includes other services such as aircraft guidance, meteorological services and the use of communication systems. One basic rule for determining the basis of the fee is that “The larger the ship the low per ton tariff” (M.Liu,J.Kronbank,2009). As was mentioned earlier in this paper the NSR is not a specific route but a whole sea area. For this reason the NSR is divided in three sectors each with different tariff (Mulherin,1994).

The three different tariff regions of the NSR are:

Table 6.1 Tariff rates according to NSR region

	From	To	Tariff rate
Tariff Region A	Novyaya Zemlya	Severnaya Zemlya	70% of C
Tariff Region B	Severnaya Zemlya	Bering Strait	80% of C
Tariff Region C	All areas north of the 78 N parallel		C

Source: INSROP

Note that tariff for region C is the base tariff which determines tariffs for region B and region C. (M.Liu, 2009).

In early 1990s the volume shipped via the NSR was about 4million tons per year with an icebreaking fee of about 2-4 USD[11] per ton of cargo (M.Liu, 2009). Later the same decade when shipment through the NSR decreased to about 2,5 million tons per year tariffs were increased to 7,5 USD per ton of cargo due to the fact that operating ice-breaking services in the area became unprofitable. The Russian government during that

[11] USD: United States Dollar

period provided subsidies so as to ensure the existence of ice-breaking services in the NSR. In 2003 subsidies stopped being granted by the government which led to an additional increase to an average of 23USD per ton of cargo in an effort to maintain the existing ice-breaking vessels and modernize the fleet (M.Liu, 2009).

We managed to found the most recent ice-breaking fee document issued by the Federal Rates Service and registered by the Ministry of Justice of the Russian Federation on the 21th of June 2011.The document is entitled: “Order on setting of rates for services of the ice-breaker fleet on the Northern Sea Route”

Table6.2: Maximum rates for services of the icebreaker fleet on the Northern Sea Route to ensure the transportation of cargo

Table 6.2

№	Nomenclature of cargo			
1	General cargo	Unity	Rate Rubles/ton	Rate USD/ton
1.1	Cargo, transported in standard containers	Rubles per ton of nominal gross mass of container	1048	32,4
1.2	Non-ferrous metal	Rubles per ton	2050	63,5
1.3	Converter matte	Rubles per ton	1905	59
1.4	Products of mechanical engineering and instrument-making including equipment and parts thereof	Rubles per ton	2464	76,4
1.5	Vehicles, cars and their parts	Rubles per ton	2576	79,8
1.6	Articles out of metals of industrial purpose	Rubles per ton	1747	54,1
1.7	Others	Rubles per ton	1048	32,4
2	Bulk cargo	Rubles per ton	707	21,9
3	Bulk liquid cargo	Rubles per ton	530	16,4
4	Timber cargo:	Rubles per ton	404	12,5
4.1	Round lumber	Rubles per ton	118	3,65
4.2	Saw-timber and other products of timber, woodworking, pulp and paper industry	Rubles per ton	148	4,5

Source: Federal Agency of Sea and river transport[12]

[12] *http://www.morflot.ru/index.php?cid=21* , accessed 10/07/2012)

As we can see from table3 the maximum rate for ice-breaking fee to vessels transporting bulk cargo is set to 707 Ruble per ton (21,7 USD)[13].For liquid bulk the ice-breaking escort fee is set to 530 Ruble per ton (16,3 USD). The most expensive product for ice-breaking escort is vehicles cars and their parts with an escort fee of 2576 ruble per ton (79,08 USD). Container transport escort services have a fixed fee of 1048 rubles per ton (40,8 USD). Here we must mention that ice breaking fees for vessels not carrying any cargo differentiate significantly (See table6. 2)

Maximum rates for services of the icebreaker fleet along the Northern Sea Route collected from transport ships sailing in ballast, towing, technical, auxiliary (including research*) and other floating craft not intended for cargo transportation**.**

Table 6.3:Ice-breaking fees according to the area of escorting

№	Area of escorting	Unity	Rate
1	Transit along the waterways of the Northern Sea Route	USD per ton of full displacement	31
2	To ports of the Laptev Sea from west or from east, to ports of the East Siberian Sea from west or from east	USD per ton of full displacement	21,4
3	To ports of the Kara Sea and to ports situated on Ob and Yenisei rivers from west	USD per ton of full displacement	6,2

Source: Federal Agency of Sea and river transport[14]

[13] 1 Ruble=0,031 USD on 14/07/2012 source: www.exchangerates.org.uk
[14] *http://www.morflot.ru/index.php?cid=21* , accessed 10/07/2012

Tables 6.3 and.6 4 present the maximum rates per ton of cargo for ice-breaking escort. That is for vessels of the lowest ice-class allowed to sail through the NSR, which is 1B class. More details on ice-class of vessels will be discussed later on, in paragraph 6.4

6.4 Ice classes and ice worthiness

According to the American bureau of shipping report for vessels operating in low temperature environment vessels build to an ice-class need to have a much thicker hull and increased structural support so as to face the challenges when navigating through ice waters (Shipping, 2010). According to the ice class sea chest of the vessel might be constructed and arranged differently in compare with a regular vessel. A number of other measurements need to be taken when constructing an ice-class vessel, extra propeller protection, more watertight bulkheads and heating equipment for fuel and ballast tanks are some of the actions taken according to the vessels ice class (American Bureau of Shipping,2010)

Over the past years the ice class classification was rather confusing due to the fact that there were a number of societies active in ice class classification and each one of them was using different standards and rules. Today the rules for ice class classification have been unified making it easier to keep some international standards when building ice-class vessels. Table 4 provides summarized the main classification societies and the types of ice classes used. Vessels in 1A and 1B ice class are able to navigate through hard ice conditions while vessels in 1C class can navigate only through easy ice conditions (Administration, 2010). MOHQs mentions that only vessels of 1B and Higher ice-class are allowed to sail through the NSR (M.Liu,2009). Despite the fact that several systems of ice class classification are used today the unification of recent years makes in quite easy to convert ice-class of different classification societies.(see table 5.1)

Table 6.4

Equivalence of ice classes for different classification societies

American bureau of shipping	I AA	IA	IB	IC
Bureau Veritas	IA SUPER	IA	IB	IC
Det Norske Veritas	ICE-1A*	ICE-IA	ICE-IB	ICE-IC
Germanisher Lloyd	E4	E3	E2	E1
Lloyd's Register Shipping	1 AS	1A	1B	1C
Russian Register of Shipping	UL	L1	L2	L3
Registro Italiano Navale	IAS	IA	IB	IC

Source: Finish Maritime Administration, The equivalence of the finish ice classes and the ice classes of classification societies (Finish Maritime Administration, 2010).

7. Research Questions and objectives of this thesis

7.1 Research questions

In this paper we will examine the economic feasibility of the NSR in compare with the Suez Canal for bulk shipping in relation with changes in bunker fuel oil prices and ice-breaking fees.We will conduct cost comparison for different scenarios. We will consider 2 shipping companies operating one in the NSR and one through the Suez Canal.. Moreover we will compare same vessels for the outer NSR vs the Suez Canal.Finally we will assess the potential impacts of the NSR in slow and super slow steaming. The research questions that are going to be examined are the following:

- Will the NSR be feasible for bulk shipping when no dedicated vessels are required?
- For which prices of bunker fuel oil and ice-breaking fees can the NSR become a viable alternative to the Suez Canal?
- Which might be the potential impact of the introduction of the the NSR in strategies used in the Shipping sector?

7.2 Objectives of this paper

In this paper we will try to assess the costs related to the use of the NSR and the Suez Canal and to determine under which prices of bunker fuel oil prices and ice-breaking fees the NSR consists a viable choice. Finally we will assess the effects the introduction of the NSR might have in strategies used in the maritime sector. We will conduct a cost comparison in order to compare the economic performance of these two routes when no dedicated vessels are required. We will create a spreadsheet (with all the cost formulas based on Stopford) for calculating all costs (operating,voyage) and conduct sensitivity analysis in order to examine under which hypothesis, the NSR can become economically feasible in compare with the Suez Canal. In the sensitivity analysis the bunker fuel cost and the ice-breaking fees will be the independent variables. Loading and unloading costs are subject to ports of call, cargo handled and a number of other parameters and thus will be not taken into account.Our goal is to assess under which hypothesis-prices of the aforementioned parameters the NSR might be a feasible alternative to the Suez Canal for bulk shipping

The Hypothesis will include different pricing regarding

- Ice breaking fees
- Bunker fuel costs

Figure 7.1 Major dry bulk ports

Major bulk ports: Source Clarksons Dry Bulk Trade Outlook 2012

8. Costs and Revenues in the Maritime Sector

In this chapter we will briefly mention all costs and revenues related with the maritime sector. For our comparison of costs when sailing via the NSR and via the Suez Canal we will include only Operational and Voyage costs, which will be analyzed further in paragraphs 8.2 and 8.3 respectively.

According to Martin Stopford the 3 main variables that lead to survival or not in shipping are:

- Revenues from chartering/Operating the Ship
- Costs of running the ship
- The method of financing the vessel

In figure 8.1 the relationship of these cash flow items is demonstrated diagrammatically.

Revenue (box on the left) is generated by trading the vessel. Running costs and capital payments need to be deducted from the revenue.

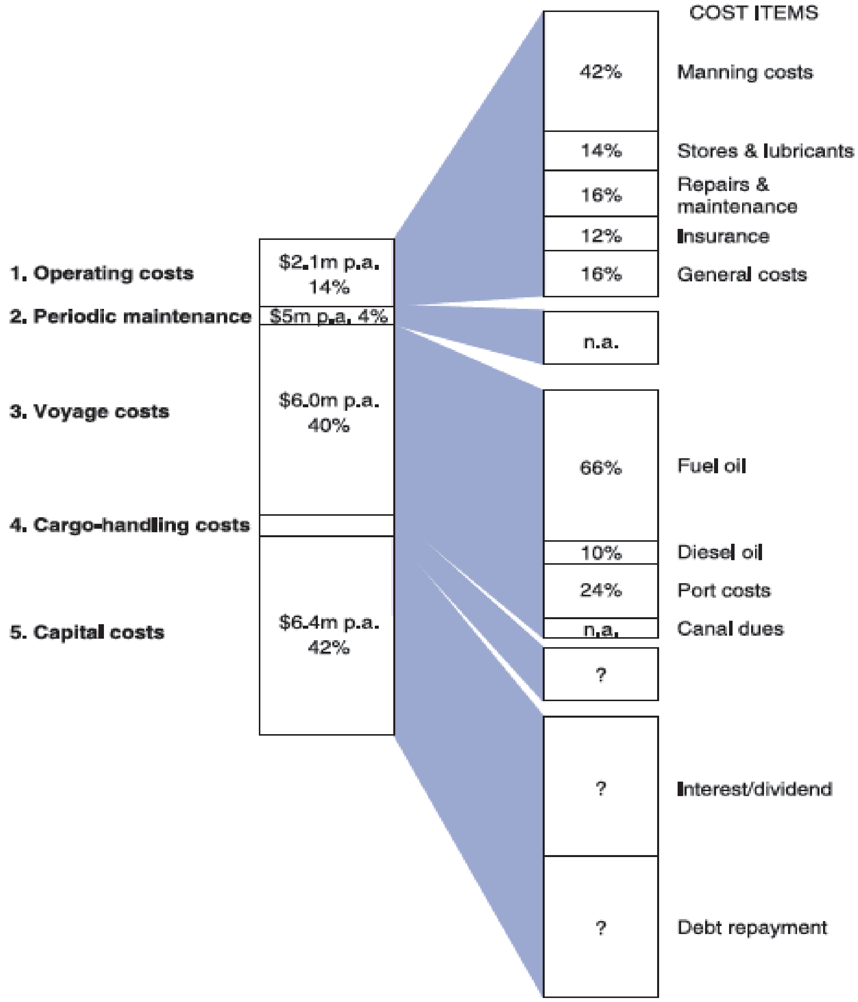
The main costs are:

- Operating costs
- Voyage costs
- Cargo handling costs

Capital repayments cover interest and maintenance of the vessel (Martin Stopford,2009). After these charges the amount left may be subject to taxation and after that either dividends are paid or the amount is invested within the business.

The shipping sector has no internationally accepted cost classification. In this paper we will use cost classification as seen in Martin Stoprford's book Maritime Economics. Wherever it is necessary adjustments will be made for the NSR voyage costs and the Suez Canal voyage costs. The approach that is going to be used classifies costs in five main categories:

Figure 8.1 Cost Components



Source:Martin Stopford,2009

- Operating Costs: These costs cover the expenses related with the daily operation of the vessel. They include costs such as, crew, maintenance and stores which will occure no matter in which route the vessel in navigating or in which trade it is engaged. Some changes in crew wages will occur according to the preferred route.
- Periodic maintenance costs refer to costs that occur when the vessel is dry-docked for repairs. In general periodic maintenance costs are considered as independent from the operating costs. These costs are not affected by the route of each vessel.

- Voyage costs are extremely variable from vessel to vessel and from route to route. They usually include sub-costs such as fuel costs, port charges, canal dues and in the case of sailing through the NSR ice-breaking fees. Voyage costs and their sub-costs will be the determinants of the economic feasibility of the NSR vs the Suez Canal.
- Capital costs vary according to the way the vessel has been financed. The form of dividends to equity or interest and capital payments to dept finance are the two main forms of capital costs.
- Cargo handling costs: They include the costs of loading, stowing and discharging the cargo. They are not affected by the route choosen and thus will not take place in the cost comparison.

8.1Unit Costs

The relationship between cost and ship size/amount of cargo is of major importance. When calculating the cost of moving cargo from the NSR and via the Suez Canal we will focus on the total cost occurring for the voyage. the unit cost or cost per ton occurring when shipping via one of the two routes is adding to value since identical vessels are being used in the cost comparison. At this point we need to define the annual cost per deadweight tonne of a ship. The annual cost per deadweight tone is the sum of the operating costs, voyage costs, cargo handling costs and capital costs which incur during a year divided by the deadweight of the ship. As we mentioned only voyage and operation costs will be examined in the comparison of the NSR and the Suez Canal.

$$C_{tm} = \frac{OC_{tm} + PM_{tm} + VC_{tm} + CHC_{tm} + K_{tm}}{DWT_{tm}} \quad (8.1)$$

Where:

C: Cost per dwt per annum (or per M3 or any other capacity measurement)

OC:Operating cost per annum

PM:Periodic maintenance per annum

VC:Voyage costs per annum

CHC:Cargo handling costs per annum

K:Kapital costs per annum

DWT:Vessels deadweight

t: The year

m:The mth vessel

This relationship demonstrates the fact that operating, voyage and capital costs do not increase proportionally with the deadweight of the vessel. Therefore by using a bigger vessel the unit freight cost is reduced, which is the basic principle of economies of scale. For this very reason the outer NSR will be examined in our cost comparison due to the fact that there is no draft limit, whereas in the inner NSR there is a draft limit for navigating vessels.

8.2Operating Costs and their components

Operating costs are the costs related with the daily operation/functions of the vessel. Fuel is excluded since it is included in voyage costs. Day to day repairs and maintenance are considered part of the operating costs but dry docking is not since it is treated as a separate cost. Operating costs account for approximately 14% of total costs (Stopford,2009). A more detailed view on operating costs and the impact of the vessel’s age can be seen on table 8.1

The main components of operating costs are:

$OC_{tm} = M_{tm} + ST_{tm} + MN_{tm} + I_{tm} + AD_{tm}$ (8.2)

Where:

M:Manning costs

ST:Stores

MN:Routine repairs and maintenance (excluding dry docking)

I: Insurance costs

AD:Administration costs

In general the operating costs structure depends in a great extend on the size and nationality of the vessel’s crew, maintenance policy, age of the vessel, insurance of the vessel, and the efficiency with which the ship is being managed by her owner (Stopford,2009)

Crew Costs

Crewing the vessel includes many direct and indirect expenses for the shipowner. Basic salaries, wages, insurance of the crew, pension payments are some of the expenses included in crew costs.Two factors determine crew costs of a vessel. The size of the crew and the employment policy followed by the owner and the vessel's flag state (Stopford,2009). Manning costs can account up to 50% of operating costs subject to the vessel's size and age. Flag state of the vessel sets the minimum allowable crew on board. Moreover other factors such as the automation of the engine room, cargo handling, catering and skills of the crew play a vital role in the number of crew necessary for operating the vessel. Recent developments in technology and innovative solutions have lead to a significantly recuded crew even for very large vessels. For example the new triple E of Maerks with 400 meter length 59 meters wide and 73 meters tall will need only 17 crew members onboard so as to be fully operational[15]. In our cost comparison two identical vessels are going to be used and thus no differences in crew costs will be taken into account. When navigating through the NSR crew wages might differ due to the extreme weather conditions, but in compare with the total cost this difference is considered to be negligible.

[15] Source: www.maersk.com accessed 20/07/2012

Table 8.1 Operating costs of 3 Capesize bulk carriers by age (in $000 per annum)

Age of ship	5 Years	10 Years	20 Years	% Total Average
Crew cost				
Crew wages	544	639	688	30%
Travel, insurance etc	73	82	85	4%
Victualling	46	54	64	3%
Total	743	871	956	41%
%	32%	31%	26%	
Stores & Consumables				
General stores	129	144	129	6%
Lubricants	148	148	219	8%
Total	277	292	348	15%
%	12%	11%	9%	
Maintenance & Repairs				
Maintenance	90	169	10	4%
Spares	74	169	181	7%
Total	164	338	393	14%
%	9%	15%	13%	
Insurance				
Hull & machinery & war risks	133	148	303	9%
P&I	63	94	120	4%
Total	196	243	423	14%
%	32%	32%	44%	
General Costs				
Registration Costs	17	17	17	1%
Management Fees	255	223	255	12%
Sundries	57	57	57	3%
Total	330	298	330	15%
%	14%	11%	9%	
Total per annum	1,710	2,041	2,450	100%
Daily Costs (365 days)	4,685	5,591	6,712	100%

Source: Martin Stopford, Maritime Economics 2009

For our cost comparison when sailing via the NSR and via the Suez Canal the Operating costs of the vessels are going to be retrieved by Moore Stephens Operating Costs 2009.[16]

[16] MOORE STEPHENS Chartered accountants OpCost 2009 Benchmarking running costs

Stores and Consumables

Stores and consumables (such as expenditures for consumable supplies) accounts for approximately 15% of total operating costs (Stopford,2009). There are two major classifications for these types of costs: General stores which include cabin stores and all the main items that are used on board of the vessel, and lubricating oil which is a significant cost, since vessels can consume hundreds of liters of lubricant oil while sailing.

Maintenance-Repairs and Periodic Maintenance

According to Martin Stopford routine maintenance (excluding major dry-docking) accounts for approximately 14% of total operating costs and cover the day to day repairs necessary in order to keep the vessel to the standard required condition in which it can comply with the shipping company's policy, its classification society and charterers standards. Breakdowns and spares and considered the two main participants in maintenance and repairs costs.

- Routine maintenance: Actions necessary for the main engine and auxiliary equipment. Actions related with the superstructure, tanks (actions such as painting, steel renewal etc)
- Breakdowns:Any failure which might occur (mainly mechanical) and which is outside the programmed maintenance of the vessel.
- Spares: Any parts that need to be replaced so as to secure efficient operation of the vessel.
- Periodic maintenance, involving dry docking and scheduled surveys of the vessel, is one of the major cost participants. According to Stopford it accounts for 4% of total operating costs depending on age and condition of the vessel. Regular surveys need to be conducted on the vessel so as to maintain it in a particular class mainly for insurance purposes. Usually these surveys need to take place every two years and every four years an inspection to determine the seaworthiness of the vessel takes place. (Stopford,2009). For the inspection of four years period the vessel must be dry-docked and all machinery and equipment of the ship is checked thoroughly. As the vessel's age increase these inspections become more extensive and costly. For example in an older vessel there might be need for replacement of steelwork due to decreased thickness or even increased repairs to the vessels hull. These kind of expenses might be increased when sailing through the NSR due to the increased safety standards and the increased damage that might occur to the vessel when navigating through sea ice. For simplicity reasons in calculations we will not include in our comparison the periodic maintenance costs.

Insurance Costs

Insurance payments vary significantly from vessel to vessel. According to Martin Stopford insurance represents approximately 14% of operating costs. Insuring the hull and machinery represents two thirds of insurance costs and third party insurance represents the other one third. When sailing through the NSR additional insurance premiums need to be paid due to extreme weather conditions and sea ice which might damage the vessel (Lloyd's List,2012). Likewise when sailing in areas of increased risk insurance premiums related to war risk and piracy need to be paid (Arctic Sea Ice News&Analysis, 2012). It is quite hard to determine the exact amount of insurance premium that needs to be paid either for sea ice or for piracy since this kind of information are hardly ever published and the exact amount depends on a number of factors. For instance for insurance premiums related to piracy underwriters consider the vessel's speed, the height of its freeboard and the distance between upper deck and sea level. Furthermore discount might be applied for measures taken by the shipping company such as robust citadel (enforced hiding cabin for the vessel's crew) or the existence of an armed team on board of the vessel when sailing in extremely dangerous areas[17]. Insurance premiums have altered significantly over the last years. In 2008 a typical premium was 25.000$ for a single voyage while nowadays with the mitigation measurements we mentioned this amount can be quite lower (Lloyd's List, 2011). This reduction has occurred mainly due to the existence of experienced armed teams onboard which is also quite expensive for the shipowner. In both cases either when sailing via the Suez Canal and through areas such as Somalia which are considered of high risk or via the NSR insurance premiums due to piracy or Sea Ice are rather common and contribute in the increased Insurance costs. We will treat the insurance premium for piracy and the cost of potential armed escort as equal since there are no data available for these kinds of expenses.

General Costs

According to the flag of the vessel a fee for registering the vessel is paid to the flag nation. This fee can vary significantly according to the vessel's state flag. This cost is included to the annual total operating costs of the vessel. In our cost comparison the two vessels that are going to be used will have the same flag, so the costs occurring

[17] http://www.businessinsurance.com/article/20120226/NEWS07/302269991#2 accessed 20/07/2012

due to the registration fee will be excluded from the cost comparison. Other general charges such as shore-based administration fees, and general management fees belonging to general costs as described by Stopford are also going to be assumed equal for the two identical vessels used in the cost comparison and thus excluded from the calculations.

8.2Voyage Costs

Voyage costs will be the most important factor in our cost comparison when sailing via the NSR and through the Suez Canal. They are of prime importance since they account for approximately 40% of total costs (Moore Stephens 2009). Voyage costs differ according to the voyage taken by the vessel. The items related to voyage costs according to Stopford (adjusted) are:

- Fuel Costs (subject to speed, consumption)
- Canal fees (when sailing via the Suez Canal)
- Ice-breaking fees and pilotage (when sailing via the NSR)
- Port dues and tugs

Port dues and tugs will be excluded from our cost comparison since the vessels served by the Port of Rotterdam and the Port of Yokohama are of the same size and carry the same amount of cargo. The formula that provides voyage costs is: (adjusted from Martin Stopford, 2009)

$$VC = FC_S + PD + TP + CD + ICF \quad (8.3)$$

Where:

VC: Voyage Costs

FC_S:Fuel Costs for main engines and auxiliaries at speed S.

PD:Port dues and light dues

TP:Tugs and pilotage

CD:Canal dues

ICF:Ice breaking fees

As we mentioned earlier Port dues and tugs will be excluded from the voyage costs comparison.

So for comparing voyage costs equation 8.3 will take the form:

$$VC_i = FC_S + CD + ICF \quad (8.4)$$

Where i= either Suez Canal or Northern Shipping Route (NSR).

Fuel Costs

Fuel Cost is by far the most important cost participant is voyage costs, accounting for approximately 47% of the voyage costs (Stopford,2009). Fuel savings is therefore the most important advantage alongside side less voyage days when sailing through the NSR. The fuel consumption will be also affected by the vessel speed which will be lower when sailing via the NSR due to the speed limits of the icebreaking vessels .Fuel prices have increased during the period 1970-1985 by 950% (Stoprford,2009) a fact that has lead to the design of fuel efficient vessels. Moreover during the last year strategies such as slow steaming have become widely used in the shipping sector due to the increased fuel savings when sailing in lower speeds but also for the environmental benefits (Brigham, 2010)

8.3Canal dues

In our cost comparison the Canal dues of the Suez Canal authority will play an important role. The toll cost of the Suez Canal is based on the Suez Canal net ton and in special Drawing Rights. For the calculation of the canal fee of our vessel we will use the Suez Canal Net Tonnage System. The Suez Canal Net Tonnage is actually a way of calculating the revenue-earning capacity of the ship (Stopford,2009). It mainly referrers to the space under deck where cargo can be stored and it differs from the widely used term of net tonnage. The Suez Canal Net Tonnage can be measured by adding the gross and net tonnage of the vessel dividing it by two and adding 10% (see formula 8.5) when the vessel does not have a certificate.(See also table 9.3 Suez Canal net tonnage fee according to vessel)

The official Suez Canal Net Tonnage is usually calculated by a classification society or by a official organization able to issue the Suez Canal Net Tonnage Certificate (Stopford,2009). For our vessel's Suez Canal Dues equation 8.5 is going to be used.

$$Suez\ Canal_{NET\ TONNAGE} = (GT_{Vessel} + NT_{Vessel}) * \frac{1}{2} + 0{,}1 * (GT_{Vessel} + NT_{Vessel}) \quad (8.5)$$

Where:

GT:Gross Tonnage and NT: Net Tonnage of the vessel.

Ice-breaking fees

Ice breaking fees will also play a vital role in our cost comparison. Ice breaking fees for vessels navigating via the NSR have been discussed with details in Chapter 6 .In our cost comparison four different scenarios will be examined. Current ice-breaking fees and reductions of 20%,50% and 100% (Free transit via the NSR) so as to have a broad estimation of each total contribute in costs when navigating via the NSR.

We will now briefly describe some details regarding Port charges and Cargo handling Costs although they will not be part of our cost comparison model:

Port Charges

Port charges play a significant role in total voyage costs. Port dues and services charges are the two main components of port charges. Port dues are generated due to the use of the port facilities by the vessel (docking, wharfage charges) . Service charges occur due to services used by the vessel on the port such as pilotage, towage and cargo handling. Usually the port costs vary significantly depending on the pricing policy of the port authority (Stopford, 2009)In our cost comparison port visits will not be taken into consideration. Port charges in the Port of Rotterdam and the Port of Yokohama are equal since identical vessels are being examined and thus those costs will be excluded from the comparison. We examine direct shipment from Rotterdam to Yokohama via the NSR and via the Suez Canal with no other port calls in between.

Cargo Handling Costs

Finally another participant of total costs are cargo handling costs. Loading and discharging the cargo can create a major cost for shipowners especially in liner shipping. Cargo handling costs are the sum of loading costs, discharging costs and allowance for the potential costs of claims that may arise (Stopford,2009). So Cargo handling Costs are given by the equation:

$$CHC_{tm} = L_{tm} + DIS_{tm} + CL_{tm} \ (8.6)$$

Where:

CHC:Total Cargo Handling Costs

L:Charges for Loading the Cargo

DIS:Charges for Disloading the Cargo

CL:Costs for potential cargo claims

9. Research Methodology

9.1Comparison of Costs

In chapter 8 we mentioned all types of costs in shipping and made clear which of those costs are going to be included in our comparison of costs for sailing via the NSR and via the Suez Canal. It is now time to define the modified equations that will provide us the costs for both shipping routes.

Sailing via the NSR from equations 8.2 and 8.3 we have :

$$TC_{NSR} = OPC_{NSR} + VC_{NSR} = M_{tm} + ST_{tm} + MN_{tm} + I_{tm} + AD_{tm} + FC_S + CD + ICF \quad (9.1)$$

When sailing via the NSR Canal Dues=0. Operating Costs for a Panamax bulk carrier are retrieved by Moore Stephens 2009.Based on the assumptions of costs made in chapter 8 the above equation will take the form:

$$TC_{NSR} = OPC_{NSR\ Panamax\ vessel} + FC_{@speed} + ICF_{NSR\ Panamax\ vessel} \quad (9.2)$$

Where: TC_{NSR} : Total cost for the voyage via the NSR

OPC_{NSR} Operating costs for a Panamax vessel retrieved by Moore Stephens 2009 Operating costs report (See table 9.1)

Table 9.1: Operating Costs of a Panamax bulker 2009

Panamax Bulk Carrier		
Item	US$/Year	US$/Day
Crew wages	862,103	2,362
Provisions	67,372	185
Crew other	110,997	204
Crew total cost	1,040,472	2,851
Lubricants	175,883	482
Stores other	151,001	414
Stores total	326,884	896
Spares	172,858	473
Repairs&Maintenance	151,338	415
Repairs&Maintenance total	324,196	888
P&I Insurance	108,796	298
Insurance	141,241	387
Insurance total	250,037	685
Registration costs	15,885	43
Management fees	281,265	770
Sundries	68,551	188
Administration total	365,701	1,001
Total Operating Costs	2,307,290	6,321

Source: Moore Stephens Chartered Accountants Op.Cost Report 2009.

$ICF_{NSR\ Panamax\ vessel}$: Ice breaking fee for a Panamax vessel navigating through the NSR calculated by the data available by INSROP (See table 3). The vessel is going to be assumed to have a net tonnage of 60.000 Tones out of the 70.000 DWT.

$FC_{@speed:}$:The fuel costs of the Panamax vessel which will be subject to speed and fuel prices. According to Martin Stopford we have the Fuel consumption for a Panamax vessel for several speeds.

Table 9.2 Panamax Vessel Fuel consumption according to speed.

Speed (Knots)	Fuel Consumption (tons/day)
16	44
15	36
14	30
13	24
12	19
11	14

Source: Martin Stopford 2009

Sailing via the Suez Canal

When sailing via the Suez Canal Icebreaking fees are equal to zero. Canal dues are calculated for the Panamax bulk carrier according the Suez Canal Net Tonnage as described in Chapter 8 (See equation 8.5). After calculating the Suez Canal Net Tonnage of our Panamax bulk carrier, we are in a position to calculate the exact Canal due (See table 9.3)

Table 9.3: Suez Canal Net Tonnage Fees according to vessel type

		Suez Canal Suez Canal net tonnage net tonnage						
Vessel type	Condition	First 5000	Next 5000	Next 10000	Next 20000	Next 30000	Next 50000	Rest
Tankers of Crude Oil	Laden	7,65	4,80	3,90	1,70	1,50	1,40	1,30
	Ballast	6,50	4,08	3,32	1,45	1,28	1,19	1,11
Tankers of Petroleum Products	Laden	7,65	4,80	3,90	2,35	2,30	2,20	2,10
	Ballast	6,50	4,08	3,32	1,45	1,28	1,19	1,11
Dry Bulk Carriers	Laden	7,65	5,20	4,40	1,40	1,30	1,25	1,20
	Ballast	6,50	4,42	3,74	1,19	1,11	1,06	1,02
LPG Carriers	Laden	7,65	4,90	3,90	2,80	2,60	2,50	2,50
	Ballast	6,50	4,17	3,32	2,38	2,21	2,13	2,13
LNG Carriers	Laden	7,65	5,30	4,90	3,40	3,30	3,20	3,10
	Ballast	6,50	4,51	4,17	2,89	2,81	2,72	2,64
Chemical and Other Liquid Bulk	Laden	8,00	5,50	4,70	3,00	2,90	2,80	2,80
	Ballast	6,80	4,68	4,00	2,55	2,47	2,38	2,38
Container Ships	Laden	7,65	5,00	4,00	2,80	2,60	2,05	1,95
	Ballast	6,50	4,25	3,40	2,38	2,21	1,74	1,66
General Cargo Ships	Laden	7,65	5,50	4,00	3,00	2,90	2,85	2,80
	Ballast	6,50	4,68	3,40	2,55	2,47	2,42	2,38
RO - RO Ships	Laden	7,65	5,30	4,30	3,10	2,90	2,80	2,70
	Ballast	6,50	4,51	3,66	2,64	2,47	2,38	2,30
Vehicle Carriers	Laden	7,65	5,00	3,85	2,75	2,60	2,05	1,95
	Ballast	6,50	4,25	3,27	2,34	2,21	1,74	1,66
Passenger Ships	Laden	7,65	5,00	4,30	3,05	3,00	2,90	2,80
	Ballast	6,50	4,25	3,66	2,59	2,55	2,47	2,38
Special Floating Units	Laden	8,30	5,10	4,80	3,40	3,20	2,90	2,80
	Ballast	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Other Vessels	Laden	8,00	5,00	4,40	3,20	3,10	2,90	2,80
	Ballast	6,80	4,25	3,74	2,72	2,64	2,47	2,38

Source: Suez Canal Authority[18]

Based on equations 8.2 and 8.3 the total cost for sailing via the Suez Canal will be:

$$TC_{Suez\ Canal} = OPC_{\ Panamax\ vessel} + FC_{@speed} + CD_{\ Panamax\ vessel}$$

$TC_{Suez\ Canal}$: Total Cost for sailing via the Suez Canal

[18] http://www.suezcanal.gov.eg/ accessed 28/07/2012

$OPC_{Panamax\ Vessel}$: Operating costs for the Panamax Vessel

$CD_{Panamax\ Vessel}$: Canal dues for the Suez Canal of the Panamax Vessel

The vessel sailing via the Suez Canal is going to be assumed to sail at an average speed of 16 knots for calculation reasons. Different scenarios are going to be examined in our calculations. The scenarios will cover reductions in ice-breaking fees of20% 50%,60% and 100% (Free transit via the NSR). Changes in bunker fuel oil prices: Increases of 20%,50%,80%100%,150%,190%.The base-line price will be set at 550 USD/ton.

9.2Sensitivity Analysis

We will create a spread sheet covering the bellow cost participants when sailing via the NSR and the Suez Canal:

- Bunker fuel oil prices
- Sailing speed of the vessels/Fuel consumption
- Ice breaking fees

We will try to determine under which changes in the aforementioned cost participants the NSR could become a feasible alternative of the Suez Canal route. At this point we must mention that environmental and political changes will not be taken into account. We will try to provide a clear picture regarding which range of these parameters could make the NSR as attractive as possible. Finally the Suez Canal possible price adjustment will not be taken into account. Suez Canal Authority most probably would alter its pricing policy in case the NSR increased volumes and market share (Lloyd’s List, 2010)

9.3Impact of the NSR in strategies used for facing excess capacity

At this point we will conduct qualitiative analysis regarding the potential impact and possibilities the introduction of the NSR might provide. Slow steaming utilization of specific vessel size idle fleet and regulation of slow steaming will be examined. We will try to assess which implication the future introduction of the NSR might have in these areas. Our research will be based in literature review and extensive research over the Internet. Papers, articles and interviews will be used in this effort.

10. Analysis

10.1Analysis of 1st research question

Is bulk shipping via the NSR a viable alternative to shipping via the Suez Canal when no investments in dedicated vessels are nescessary?

In our cost comparison when sailing via the NSR vs the Suez Canal we assumed that in the future low ice-class modified bulk carriers will be allowed to sail via the NSR. This assumption was made due to the fact that in several studies, mainly for liner shipping, it has been proven that when new investments in high ice-class vessels (1A ice class) are necessary the NSR is unfeasible in compare with the Suez Canal route.. A number of hypothesis took place in order to calculate all the costs when sailing via the NSR and via the Suez Canal. In brief the hypothesis in our cost comparison are the following:

- The bulk carriers are Panamax vessels of 70.000 DWT
- Capital costs do not take place in our comparison
- Insurance premiums for sea- ice and piracy were assumed to be both 25.000$
- The vessel navigating via the NSR is assumed to have an average speed of 14knots
- The vessel navigating via the Suez Canal is assumed to have an average speed of 16knots
- Suez Canal fees were calculated by the Suez Canal Net Tonnage System
- Ice-breaking fees were calculated by the most recent available data by INSROP.
- Bunker fuel oil prices were taken at the average price of 550 USD[19]
- Both Panamax vessels have a net tonnage of 60.000 tons
- Operating costs were taken for Panamax Bulk Carriers by Moore Stephens ,2009 report on operating costs (See table 10.4)

The first step in order to make to cost comparison for the two routes is to calculate the days at sea for each vessel for both routes, and the total consumption for each vessel according to speed and days at sea (See table 10.2)

Table 10.1 Distances Rotterdam-Yokohama

	Distance Nautical Miles			
	NSR(n.miles)	Suez Canal	Distance Savings (%)	
Rotterdam-Yokohama	8452	12894	34,42	

[19] http://www.bunkerworld.com/prices/port/nl/rtm/ accessed 29/07/2012

From the data in table 10.1 we calculated the days at sea for each vessel for both routes. Fuel consumption for several speeds for the two Panamax vessels were retrieved by Martin Stopford,2009.

Table 10.2 Days at Sea Speed and Consumption

	Days at sea				
Speed (knots)	NSR	Suez Canal	Consumptions (Tons/day)		
16	22,01	33,57	44		
15	23,48	35,81	36		
14	25,15	38,37	30		
13	27,09	41,32	24		
12	29,34	44,77	19		
11	32,01	48,84	14		

Sourse:Disntances by INSROP, fuel consumption for Panamax bulk carrier by Martin Stopford,2009

The next step was to calculate total fuel consumption for both vessels according to fuel consumption per day (subject to speed) and total days at sea. Based on the formula of Suez Canal Net Tonnage System, the Suez Canal Net tonnage of the vessel was calculated and the exact Canal fee for the Panamax bulk carrier was calculated as well (See table 10.3)

Table 10.3 Vessel's GT/NT/Suez NT/Fee

Suez Canal	
GT (tons)	70000
NT (tons)	60000
Suez NT (tons)	78000
Fee $	123310

The Suez Canal NT was calculated as described by Martin Stopford (see equation 8.5) and by the Suez Canal Authority official web site. Similarly based on the information provided by INSROP reports we calculated the Maximum ice-breaking fee for our bulk carrier, as described in Chapter 4 paragraph 3 .Our vessel was assumed to sail in the Outer NSR where no draft limits exist. Moreover in the Outer NSR the tariff fee is the maximum, set at 707 rubles per ton (22,058 USD/Ton). This price was taken by the document No 322 by the Russian Ministry of Transportation, Federal Agency on

Maritime and River Transport (published 26/07/2005) which is the latest official document available.

Based on these facts we calculated all the main cost participants and came up with the total cost on navigating via the NSR and via the Suez Canal for two Panamax bulk carriers transferring 60.000 tons of cargo. Table 10.4 presents the summarized founding

Table 10.4 Sensitivity Analysis Findings

Costs of sailing via the NSR and via the Suez Canal		
Cost Participants		
ITEM	NSR	Suez Canal
Bunker fuel price (USD)	550	550
Speed of vessel knots	14	16
Consumption tonns/day	30	44
Consumption total(tons)	754,5	1477,08
Total cost of fuel (usd)	414975	812394
Duration of voyage (days)	25,15	33,57
Insuranse premium ($)	25000	25000
Suez Canal dues	0	123310
Ice breaking fees $ (100%)	1323480	0
Vessel DWT	70000	70000
Vessel NT	60000	60000
Suez Canal NT	78000	78000
Operating cost/day ($/day)	6321	6321
Operating cost voyage ($)	158973,2	212195,97
Total Cost ($)	1922428	1172899,97

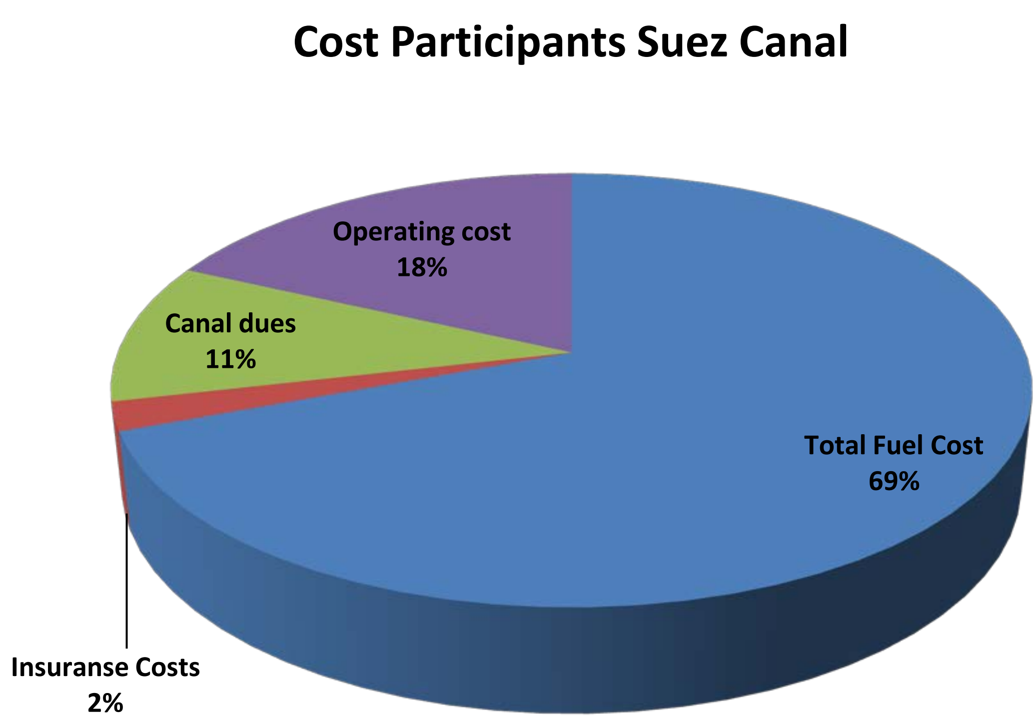
As it can be seen from table 10.4 the Total cost sailing via the NSR with a Panamax bulk carrier was found to be at 1.922.428 USD while via the Suez Canal was found to be 1.172.899 USD. In other words with the current conditions a single voyage from Rotterdam to Yokohama is more expensive by almost 750.000 USD when sailing via the NSR in compare with the Suez Canal.

This is mainly due to the fact the pricing policy followed by the Ministry of Transportation of Russia regarding ice-breaking fees is extremely uneconomical. It is quite clear that with the present pricing policies sailing via the NSR is not a viable alternative to that of Suez Canal even with no additional investments in high ice class vessels.

As we can see from graphs 10.1 and 10.2, when sailing via the Suez Canal, Canal dues represent approximately 11% of Operating,Voyage and Insurance Costs (See graph 10.1)(Capital, cargo handling, port charges and other costs are excluded).

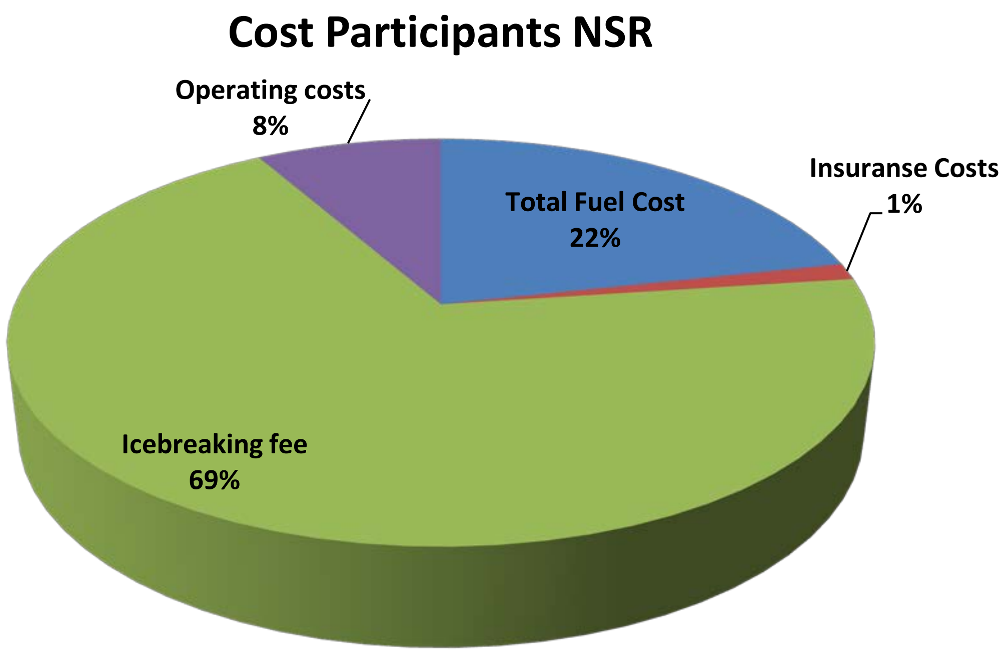
On the other hand when sailing via the NSR, ice breaking fees represent approximately 59% of Operating , Voyage and insurance costs. This very fact is a major drawback when it comes to the establishment of the NSR as the main competitor of the Suez Canal route

Chart 10.1



Created by the author

Chart 10.2



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10.2Analysiis of 2nd research question

As we saw sailing via the NSR even with no investments involved is not a viable alternative to the Suez Canal route. In this paragraph we will assess the changes that need to take place in ice-breaking fees and bunker fuel oil prices so as to make the NSR a viable and profitable route in compare with the Suez Canal. Several scenarios regarding the ice-breaking fees and the bunker fuel oil prices will be assessed.

The NSR is greatly affected by icebreaking fees while the route via the Suez Canal is mainly affected by bunker fuel oil prices. For this reason in our sensitivity analysis we will alter these two main cost participants in order to make clear the margins at which the NSR becomes economically feasible in compare with the route via the Suez Canal.

Regarding the Icebreaking fees we will examine the following future scenarios:

- Current icebreaking fees
- Reduction of 20%
- Reduction of 50%
- Reduction of 60%
- Reduction of 100% (Free transit via the NSR)

Regarding the bunker fuel oil prices the we will examine the following future scenarios

- Current bunker fuel oil prices
- Increase of 20%
- Increase of 50%
- Increase of 80%
- Increase of 150%
- Increase of 190%

We have created a cost comparison model used in the 1st research question. In this model we will alter the prices of cost participants, in order to assess under which pricing scenarios the NSR could become economically feasible in compare with the Suez Canal Route.

Keeping bunker prices constant at current levels of 550 USD/ton and altering icebreaking fees we noticed that the NSR reached the same total cost as the Suez Canal when icebreaking fees were reduced by almost 60%. In other words for a reduction of 60% in icebreaking fees (other parameters being equal) the NSR was slightly economically preferable in compare with the Suez Canal. For all values of icebreaking fees reduced by more than 60% in compare with the present ice breaking fee policy the NSR was the preferable route.

Keeping icebreaking fees constant at present levels and increasing bunker fuel oil prices we noticed that the NSR becomes the preferable route of choice when bunker fuel oil prices are increased by 190% in compare with the current 550USD/Ton price. Specifically for an increase of 190% in bunker fuel oil prices (other parameters being equal) the total cost for sailing via the NSR with a Panamax bulk carrier is 2.714.653$ while via the Suez Canal is 2.723.833$. For all bunker prices of more than 1600 $/ton the NSR was the preferable route of choice in terms of costs.

All the in-between stages, and the preferable route of choice based on total costs are demonstrated in table 10.5.The inner cells show the preferable route of choice for combinations of cost reductions in bunker fuel oil and ice-breaking fees. In rows there are mentioned the change in bunker fuel oil prices and in columns the change in ice breaking fees. In the inner cells the preferable route is mentioned. The green color declares that the NSR is cost efficient in compare with the route via the Suez Canal , while the red color demonstrates the Suez Canal suitability.

Table 10.5 Preferable route for different bunker and ice breaking fee prices

Ice breaking fee / Bunker Fuel oil Prices USD/ton	Current fee	20% Reduction	50% Reduction	60% Reduction	100% Reduction
Avg Price (550 USD/tonn)	Suez	Suez	Suez	NSR	NSR
20% Increase	Suez	Suez	NSR	NSR	NSR
50% Increase	Suez	Suez	NSR	NSR	NSR
80% Increase	Suez	NSR	NSR	NSR	NSR
100% Increase	Suez	NSR	NSR	NSR	NSR
150% Increase	Suez	NSR	NSR	NSR	NSR
190% Increase	NSR	NSR	NSR	NSR	NSR

Created by the author

10.3Analysis of 3rd research question

Potential implications of the introduction of the NSR in slow steaming

In this part we will assess the potential implications of the introduction of the NSR in slow steaming and operational strategies presently used. Our research will be based on literature review and extensive research over the internet for relevant interviews and articles of leading maritime professionals regarding the future of slow steaming and other strategies used in the maritime sector.

We have identified 4 main implications that might be triggered by the introduction of the NSR:

- Introduction of ultra slow steaming
- NSR as a mitigation route for market fluctuations
- Slow Steaming regulation triggered by the introduction of the NSR
- Using excess capacity of idle fleet of Handysize and Capesize vessels for shipping via the NSR as an alternative to slow steaming in order to absorb excess capacity

10.3.1 NSR and the introduction of ultra slow steaming

Slow steaming is being used in the Maritime sector for several reasons. According to MAN Prime Survey 2011 which was conducted among representatives of the global container, bulk and tanker shipping industry the main advantages of slow steaming have been recognized to be the following: (See figure 10.3).

- Fuel Cost Savings
- Utilization of existing capacity
- Avoidance of Idling costs
- Schedule reliability
- Service and maintenance costs
- Lower emissions

Figure 10.3 Main advantages of slow steaming according to Man Survey 2011

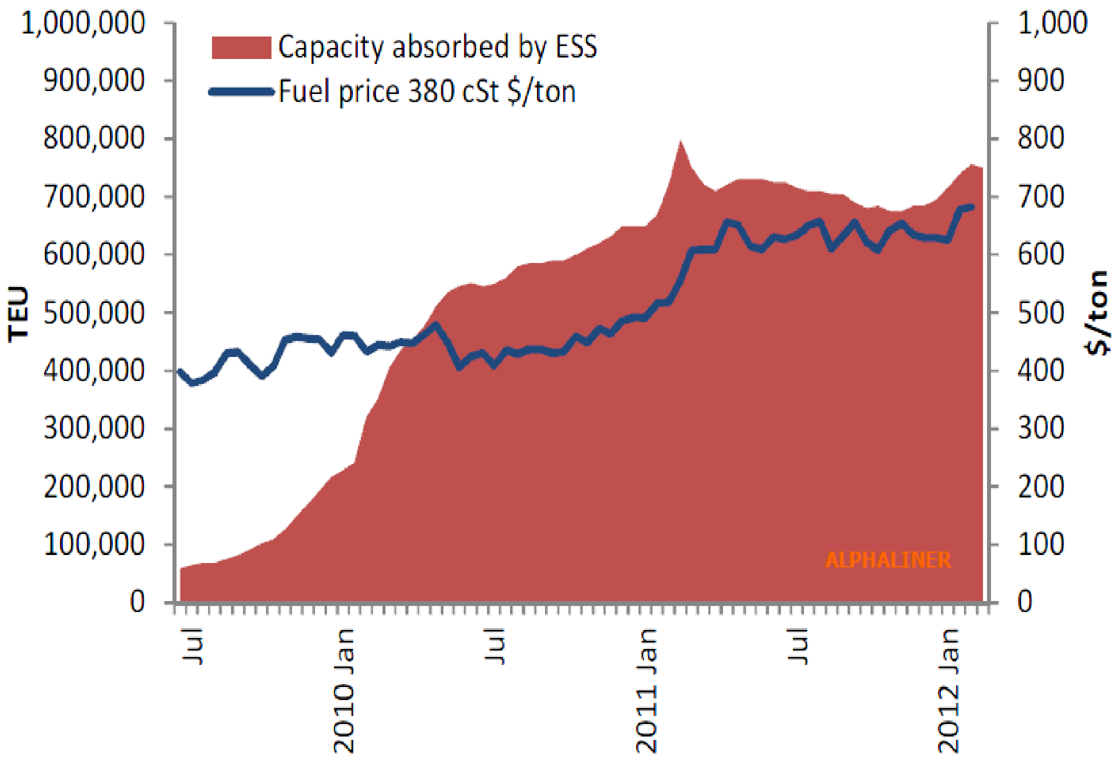
Main advantages of slow steaming	Considerers	Implementers
Fuel cost savings	93.7	94.7
Greater utilisation of existing capacity	22.5	34.2
Avoidance of idling costs	29.7	28.9
Schedule reliability	10.0	15.8
Service and maintenance savings (e.g. longer TBO)	17.1	18.4
Lower emissions	36.0	42.1

Source: Man Survey on Slow Steaming, 2011

In order to face market fluctuations carriers use slow steaming and often longer hauls to achieve a better utilization of their fleet (Chan Ting & Hshiung Tzeng, 2003). According to BIMCO president Yudhishthir Khatau[20] market recoveries require a number of mitigation measures like the use of slow steaming for absorbing excess capacity, postponement of new deliveries, restraints regarding new tonnage, and avoidance of speculative ordering. Slow steaming and Extra Slow Steaming (ESS) have helped carriers to absorb excess capacity in a great extent (See chart 10.3).

[20] http://www.tradewindsnews.com/weekly/w2012-03-02/article272639.ece5 accessed 29/07/2012

Chart 10.3 Containership Capacity absorbed by Extra Slow Steaming 2009-2012



Source: AlphaLiner volume 2012, issue 05

According to AlphaLiner Report 2012, Extra Slow steaming in 2011 helped to absorb between 650.000 and 730.000 TEU. Moreover according to AlphaLiner extra slow steaming is at the moment absorbing 4.9% of the total container fleet , or 750.000 TEU. Long hauls also help in absorbing excess capacity since vessels are being deployed for a longer period of time. According to AlphaLiner, carriers have stretched 25 long hauls by a week a fact that has lead to an additional absorb of 150.000 TEU of excess capacity. This very fact has lead most shipping companies treat slow and super slow steaming as a strategy that is here to stay. Henrik Ramsov, Maersk Tankers Chief

Operating Officer mentioned[21] that based on the fact that a one knot reduction in the speed of VLCCs leads to a reduction of around 8% in capacity anyone can realize that slow steaming is here to stay. Maersk Line chief commercial officer Lucas Vos mentioned that despite the oversupply of new tonnage the market is able to absorb excess capacity via Slow Steaming and scrapping.

The fact is that long hauls alongside with the use of slow and super slow steaming have helped the market to face excess capacity in a great extend. With the establishment of the NSR as a main route for trade between Europe and Asia sailing distances will be greatly reduced. On the one hand we have showed that fuel saving can be enormous due to decreased distances. On the other hand this reduction could lead to a much worst fleet utilization. Table 10.6 presents the required speeds for vessels sailing from Rotterdam to Yokohama both via the NSR and via the Suez Canal so as to have the same voyage duration. For a 35 days voyage the average speed when sailing via the Suez Canal must be approximately 15 knots while via the NSR the average speed needs to be approximately 10 knots (See table 10.6). Balancing the optimum vessel speed is subject to bunker fuel oil prices and extra charter cost of a longer voyage (Clarksons Research service).For instance if slow steaming saves 30.0000$ in bunker fuel oil and the voyage last a day longer due to slow steaming with the vessel's charter rate being 20.000$ per day it is preferable to operate the vessel under slow steaming since bunker fuel price is greater than charter rates. In the case of the NSR things are a little more complicated. Technical reasons don't allow vessels to move at such low speeds so as to achieve the same fleet utilization as if sailing via the Suez Canal at current slow steaming levels. In order to achieve speeds of 8 or 10 knots engine load should be below the acceptable limit. It is clear that in the case of the introduction of the NSR if Ultra Slow steaming[22] is the preferable option, investments in research and development of new engine types will need to take place so as to allow vessels dedicated in the NSR route to sail at speeds below current super slow steaming. New engines which would be able to function at a design speed of 10knots would make vessels active in the NSR route provide the same utilization and excess capacity absorb as vessels today active in the Suez Canal at super slow steaming (15

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[21] http://www.tradewindsnews.com/weekly/w2012-04-13/article274621.ece5 Accessed 28/07/2012

[22] Ultra slow steaming will be referred to speeds close to 10 knots or below

[22] http://www.tradewindsnews.com/weekly/w2012-04-13/article274621.ece5 Accessed 28/07/2012

knots).The fact is that vessels are designed for specific speeds, and many vessels at the moment are operated at as low engine load as possible due to the increased focus in fuel savings and reduced emissions. When sailing via the NSR if vessel utilization is to be the same as today vessels would have to operate at much lower speeds than those that can be achieved at the moment. Numerous factors such as the World economy, supply and demand of sea transport, fuel prices and regulations will play a crusial role. It is quite clear that if slow steaming keeps playing such a vital role in the effort to absorb excess capacity , major research and development of new types of engines will need to take place is ultra slow steaming is decided to be the answer to decreased hauls.

There is a balance between fuel costs savings and absorbing excess capacity. Even if NSR in the future is free of ice-breaking fees and can offer reliable schedules during all year, there still should be an adjustment of the world fleet to the decreased haul well in advance. New technologies that will allow vessels sail at speeds below current minimum levels would help in the introduction of ultra slow steaming which could be the answer to decreased distances and excess capacity generated by them.

Table 10.6 Required vessel speeds for given Days at Sea.

Rotterdam-Yokohama	Required average speed (knots)		
Days at Sea	**Suez Canal**	**NSR**	
25	21,5	14,08	
30	17,9	11,7	
35	15,35	10,06	
40	13,4	8,8	
45	11,9	7,8	

Source: This paper

10.3.2.NSR as a mitigate factor for reliability and market fluctuations

With the introduction of the NSR carriers will have an additional route of choice for trade between North Europe and East Asia. The reduced distance provides huge cuts in fuel costs but at the same time shorter vessel deployment. The choice between the NSR and the route via the Suez Canal will be affected by a number of parameters. Market conditions, bunker fuel oil prices, extra charges for the use of the NSR and costs of deploying an extra vessel either for the longer route or for lower sailing speeds will be the major participants that will affect the final route choice. Several carriers like Overseas Container Lines are looking the possibilities to have a mix of normal speeds and super slow steaming to provide fast delivery times for time sensitive products (B.Mongelluzo,2011). It is a realistic assumption that the NSR might be used as an additional route to Asia for time sensitive products and in order to meet specific shipper's needs. Bulk shipping products are less time sensitive in compare with technology gadgets for example, so for the latest it would be a realistic assumption that there would be space in the market for faster shipments with a cost premium for the faster service. The willingness of the customers to pay any additional charges in order to benefit from shorter shipping times and potentially greater supply chain reliability would affect in a great extent the adoption of such a strategy.

The reduction of vessels speed may have helped carriers to reduce fuel costs and absorb excess capacity but it has also made many shippers to hardly applaud the effort (Journal of Commerce Magazine,02/2011).

Time sensitive shippers have actually 2 main options either maritime shipments or air shipments which are far more costly than maritime transport. In this point we consider 2 future scenarios

- NSR fully operational and competitive to the Southern alternative
- NSR, reasonably, more expensive in compare with the Southern Alternative

In the first case it is quite reasonable to assume that the NSR will be the preferable route of choice for trade between North Europe and East Asia. In that case according to fuel oil prices and the cost to deploy an extra vessel the decision of the optimum speed will be made. The NSR will be the preferable route of choice due to the 30% decrease in sailing distances and factors such as market conditions (excess capacity) charter rates, and fuel costs will determine the optimum speed for operating via the NSR.

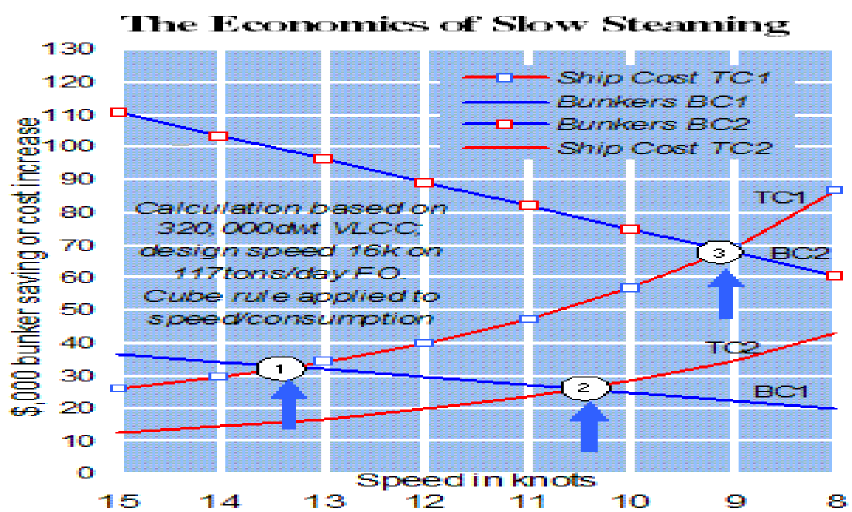
In the second case where the NSR is preferable under specific conditions due to a number of factor (insurance premiums for sea ice, ice breaking fees, capital costs for ice-breaking vessels). Shippers would eventually determine according to their willingness to pay extra for faster delivery times. Carriers would have to cover those extra expenses by charging additional costs for the faster service and the increased reliability in service times.

Sail via the Suez Canal route when the market is down and there is an extensive need to absorb excess capacity via longer sailing distances (subject to fuel prices). Sailing via the NSR for time sensitive products and market booms when slowing down the supply chain is not an option. Bunker fuel oil prices and total costs for adding an extra vessel always will be a major participant in the equation.

According to the market conditions and the NSR competiveness and reliability the bellow scenarios seem quite realistic:

- NSR as an alternative, more expensive for shippers, route, serving mainly time sensitive products
- NSR main route for trade between N. Europe-E.Asia
- Use of the NSR when the market is booming and charter rates exceed fuel costs in order to achieve faster voyages
- Use of the Suez Canal when market is down and excess capacity needs to be absorbed by longer hauls.

Figure 10.5 The economics of slow steaming



Source:Clarksons Reasearch Services[23]

10.3.3.*NSR as a trigger to regulate slow steaming*

There has been a lot of discussion for the need to regulate slow steaming in an effort to reduce green house gas (GHG) emissions . One of the main triggers of this discussion has been the protection of the Arctic region from GHG emissions and potential oil spills generated by accidents (Faber, Nelissen, Hon, Wang, & Tsimplis, 2012). The introduction of the NSR most probably will generate more extensive discussions regarding the need for the regulation of slow steaming in Arctic regions and maybe

[23] http://www.clarksons.net/sin2010/markets/Feature.aspx?news_id=31165 Accessed 28/07/2012

globally. In February 2012, CE Delft, ICCT and Professor Mikis Tsimplis , contracted by Transport and Environment and Seas at Risk, wrote a report focused on the need to regulate slow steaming. The discussion of regulating slow steaming is focused on the fact that by reducing a vessels speed by 10% the energy required for the voyage , and thus the generated emissions, are reduced by 19% (Seas at Risk, 2009). While the environmental benefits of regulating slow steaming are clear and unquestionable issues such as the legal feasibility, the impact on the market and the feasibility of introducing regulated slow steaming still need a lot of research and arise different reactions (Faber, Nelissen, Hon, Wang, & Tsimplis, 2012). According to CE Delft Report one of the major triggers in the discussion of regulating slow steaming is the protection of the sensitive arctic environment. Arctic shipping is still in a premature phase but when NSR begin becoming feasible as a route and carriers start to increase their shipments via the NSR the whole discussion on the need to regulate slow steaming will most probably be triggered quite more intensively. According to CE Delft regulating slow steaming has a number of advantages and disadvantages.

Advantages of regulating slow steaming

A regulative framework for the reduced speed is by far the most efficient and reliable way to reduce vessels emissions, If implemented in an efficient way it would be cost free for the shipping sector and it would not add any additional costs to shippers and consumers. Regulated slow steaming would provide reduced GHG emissions generated by ships no matter what is the market condition or the fuel oil prices. Without regulating slow steaming ships speed would adjust to market conditions and demand for sea transport . This way reduced emissions would only incure when the market is down and fuel costs are increased. The authors conclude that regulated slow steaming is quite easy to enforce and monitor.

Disadvantages of regulating slow steaming

Market flexibility would be greatly affected by a speed restriction. Both shipping companies and shippers seem to be against the possibility to enforce regulated slow steaming. Moreover it based on a case study conducted by the authors it is quite clear that slow steaming is not cost effective for all ship types on all routes which means that several carriers would by greatly affected. Moreover by regulating slow steaming other types of fuel efficiency might be treated as less cost efficient leading this way in less innovation. Finally authors conclude that while regulating slow steaming does not require any additional costs, if implemented correctly, it also does not generate any additional revenues both for the shipping sector and for the effort to fight climate change.

Regulating slow steaming is legally feasibly and can be implemented easily

Authors suggest that compulsory slow steaming should be enforced by states according to vessels flag, on all vessels sailing in territorial waters, but it could not be enforced when the ship is on transit or innocent passage. Territorial issues for vessels outside EU most probably would need extra attention and research. Moreover regarding the implementation of enforced slow steaming it is proposed that ships speed should be monitored by operators and by regulators with the first reporting at all time to the regulators. Technologies of this type already exist and significant investments would not be required. Finally it is stated that although global regulation of slow steaming could take decades to be enforced, regulation over the Arctic should be examined more closely and due to the environmental sensitivity of the region it could be a matter of only a few years before reaching an agreement.

10.3.4*. Using excess capacity of idle fleet of Handysize and Capesize vessels for shipping via the NSR as an alternative to slow steaming in order to absorb excess capacity.*

As we have mentioned earlier the Outer NSR has no draft limit while the Inner NSR has a draft limit of approximately 12m. This means that in the Inner NSR only vessels of up to 12m draft can navigate. In case the Outer NSR remains unreliable and the Inner NSR is the first arctic route open for long periods and able to provide reliable schedules, a strong opponent to slow steaming will appear in terms of absorbing excess capacity. There are many voices in the Shipping sector that state the fact that Slow and Super Slow Steaming can no longer absorb excess capacity efficiently due to the Operating Voyage and Capital costs of the additional vessels that are being added up due to decreased speeds.According to AlphaLiner the total capacity absorberd through super slow steaming and slow steaming has been reduced due to the closure or suspension of many long haul loops that were under super slow steaming (AlphaLiner report,2012[24]). Alpha Liner report continues by mentioning that due to the cost of employing extra vessels and additional equipment which tends to overcome the savings in fuel oil, and the increase in transit time that commercially is hard to justify to shippers there seems to be significantly less potential to absorb any more excess capacity via Slow Steaming. In the same philosophy Craig Marston, managing director

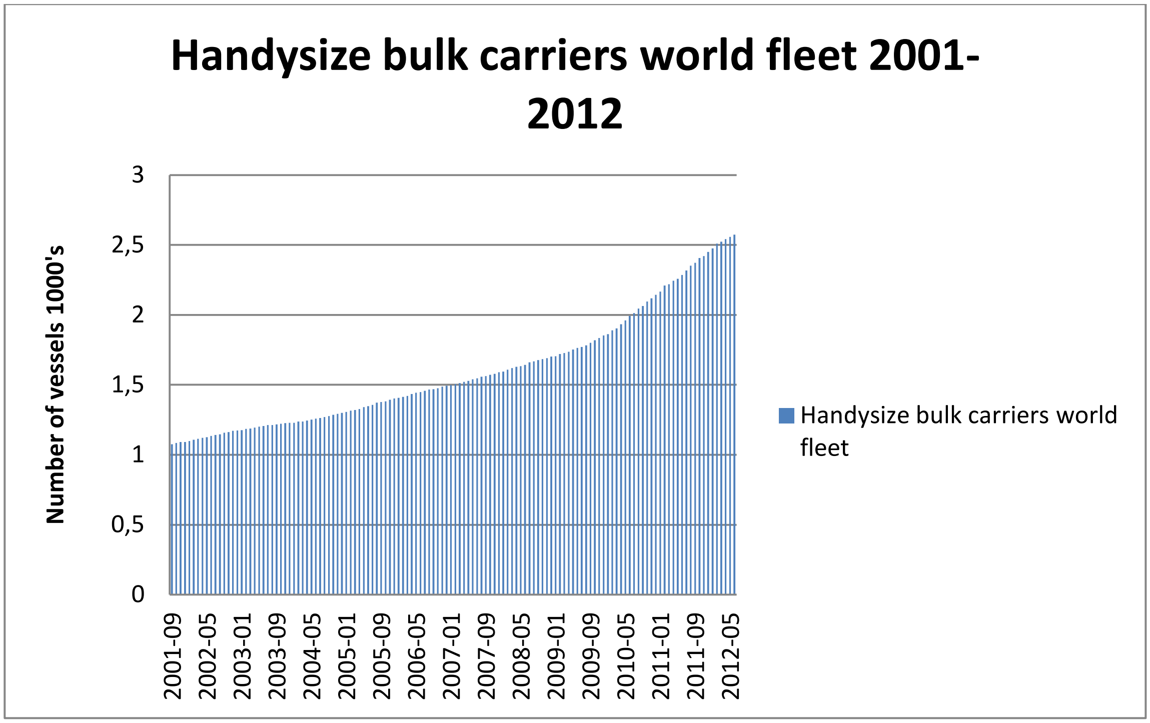
[24] http://scanwellnetwork.com/node/1074 accessed 28/07/2012

of CEM Marine, mentions that slow steaming that initially helped to absorb excess capacity has now reached a point where carriers add capacity so as to save fuel via slow steaming "leading this way to a zero-sum game"[25]

The draft limitation in the Inner NSR dictates that Carriers would be able to use only vessels of approximately up to 70.000 dwt. It is quite clear that carriers would face the dilemma of sailing via the Suez Canal with longer hauls, bigger vessels and slow steaming as their weapons to absorb excess capacity, or sail via the Inner NSR with smaller vessels which would alter vessel utilization and demand for ships of up to 70.000 DWT. Factors such as the world fleet of vessels with draft that allows them to navigate in the Inner NSR (See chart 10.4), prices of new-building vessels and second hand vessels market condition, charter rates of these kind of vessels potential tonnage surplus of these vessels and the attractiveness of the Inner NSR would all play a vital role in the final selection. Extensive analysis of different scenarios regarding future values of the aforementioned factors and how they would alter the choice between the NSR and the Route via the Suez Canal needs to be conducted so as to provide a clear picture regarding the implications the introduction of the Inner NSR would have in demand for vessels of up to 70.000 DWT, in charter rates of these vessels new building and secondhand prices. In any case carriers might have an alternative option, other than slow steaming, in an effort to absorb excess capacity with the deployment of smaller vessels active in the Inner NSR.

[25] Slower steaming trend sparks: https://www.hightable.com/maritime-and-shipping/insight/slow-steaming-wont-be-the-answer-going-forward-24968 accessed 29/07/2012

Chart 10.4 Handysize bulk carriers world fleet 2001-2012



Source: Clarksons data base, created by the author

11. Conclusions

As we showed in the 1st research question the total cost for sailing via the NSR with a Panamax bulk carrier was found to be at 1.922.428 USD while via the Suez Canal was found to be 1.172.899 USD. In other words even when no investments in high ice-class vessels is necessary, a single voyage from Rotterdam to Yokohama is more expensive by almost 750.000 USD when sailing via the NSR in compare with the Suez Canal route.

This is mainly due to the fact that the pricing policy followed by the Ministry of Transportation of Russia regarding ice-breaking fees is extremely unprofitable for ship-owners in compare with the pricing policy followed by the Suez Canal Authority. As we saw while for the route via the Suez Canal, Canal Dues, represent approximately 11% of total costs (capital and handling costs excluded) for the NSR the ice-breaking fees represent 69% of total cost. This very fact demonstrates clearly the main reason of the NSR's unprofitability even with reduced sea-ice.

Furthermore in our sensitivity analysis we demonstrated that a single reduction in ice-breaking fees of approximately 55% would make the NSR a feasible alternative to the Suez Canal. In the same way for increases in bunker fuel prices of almost 190% the NSR was preferable in terms of total cost due to the decreased distance it provides. Several scenarios combining bunker fuel oil prices and ice-breaking fees differentiations were examined and the preferable route of choice for each one of them was presented.

Finally through literature review and extensive research over the internet we came to the conclusion that the 4 most possible and important effects the introduction of the NSR might have are the following:

- Introduction of ultra slow steaming. Slow steaming and super slow steaming have helped carriers absorb excess capacity in a great extend. With the introduction of the NSR vessels sailing via this route will have to further reduce their speed to near 10knots (ultra slow steaming) in order to balance the reduced distance and achieve the same vessel utilization. Such low speeds require technical implementations that would allow engine loads that correspond to these speeds.
- NSR as a mitigation route for market fluctuations. The use of the NSR for time sensitive products and in periods when the market is booming and charter rates exceed fuel costs was found to be one of the plausible effects of the introduction of the NSR. The increased costs for sailing via the NSR might be balanced by the willingness of shipper to pay an additional time-related-premium for fastest shipments.

- Slow Steaming regulation triggered by the introduction of the NSR. The discussion regarding the need for regulating slow steaming started mainly due to the need for protecting the Arctic marine environment. Increased use of the NSR would most probably trigger intensive discussions and maybe even the realization a legislative framework for the slow steaming regulation. The most important aspects of regulating slow steaming, advantages and disadvantages were presented in this paper.
- The utilization of smaller vessels able to navigate in the Inner NSR. Use of the idle fleet of vessels up to 70.000 dwt and utilization of their tonnage surplus. Since the Inner NSR is the most plausible arctic route to experience an important increase in cargo shipments the following years, its limitations in draft might play a vital role in the demand for vessels of up to 70.000dwt.

Further research on this topic:

- Sufficient ice-data collection and evaluation of the time-frame for an almost ice-free NSR.
- Research regarding the willingness of shippers to pay for shorter shipping times. Exploration of the Gap between maritime transport costs and air transport costs to determine the plausible margins within this time related premium could be set.
- Further analysis of the existing panamax vessel fleet. Forecasting of future idle fleet of vessels and tonnage surplus that could be used in the NSR.
- Implications of future Arctic resource projects in the development of the NSR

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13. Appendices

Table13.1 Tonnage surplus according to vessel type

Vessel type	Idle fleet (million dwt or m^3)
Tanker	10.48
Dry bulk	2.86
Conventional general cargo	0.78
LNG carrier	1.53
LPG carrier	0.13

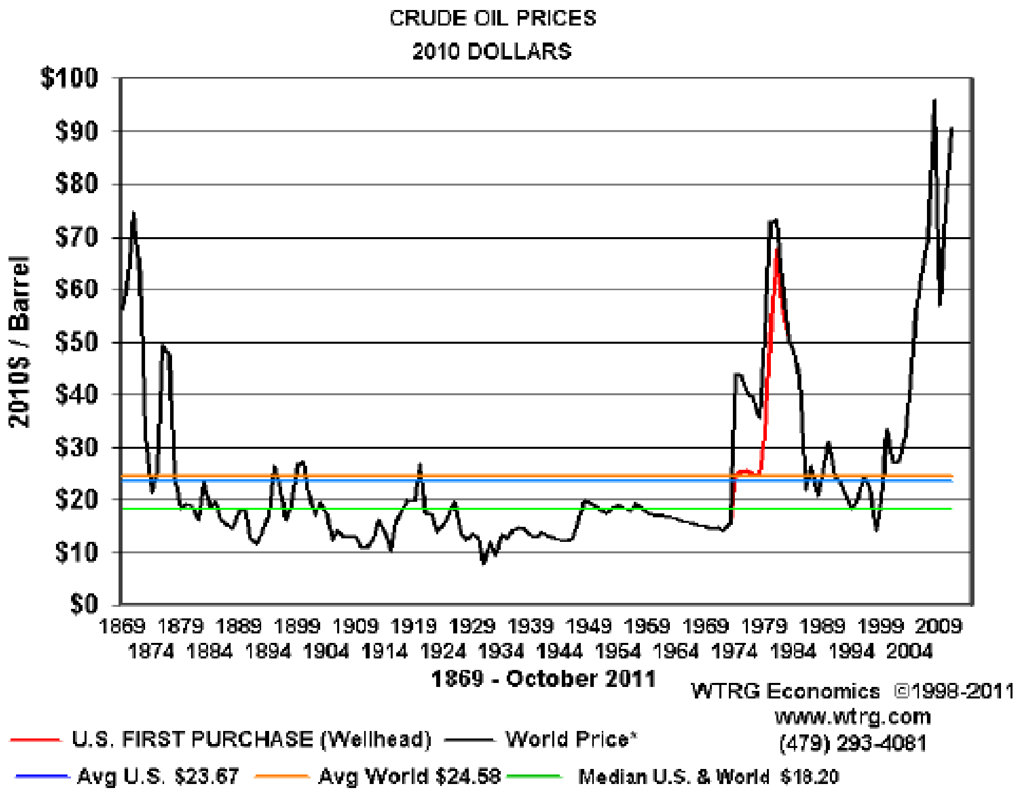
Source: UNCTAD 2011

Table13.2 Fuel oil prices forecasting

Oil Price Scenario	2005	2010	2020	2030	2040	2050
Global baseline	55	70	78	96	115	138
Global action	55	70	74	77	76	69
Fragmented action	55	70	75	88	102	117

Source: EC (2011) 288 Final

Chart13.1 Violation of oil prices



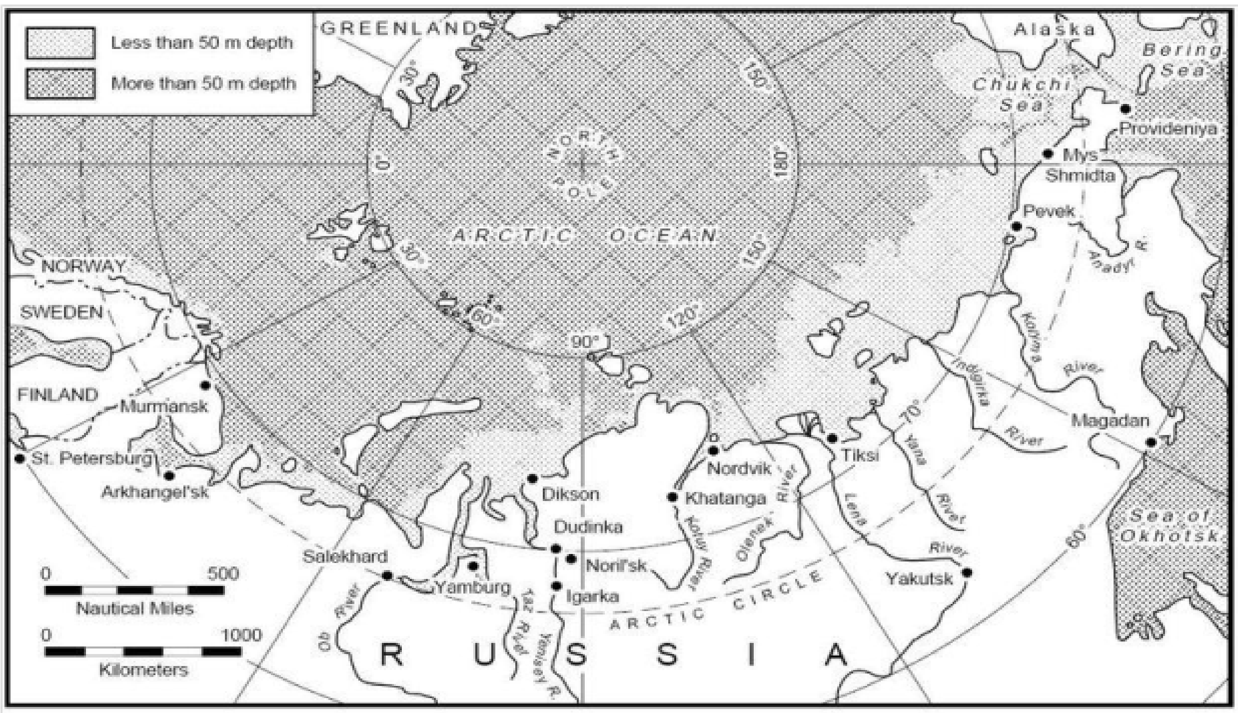
Source:WTRG

Table13.3 Maritime fuel price scenarios

		2020	2030	2040	2050
Base	Global baseline, shift in 2018, 30% price increase for low sulphur fuel	507	624	748	879
Low	Global action, shift in 2024, 10% price increase for low sulphur fuel	370	424	418	380
High	Global baseline, shift in 2018, 50% price increase for low sulphur fuel	585	720	863	1,035

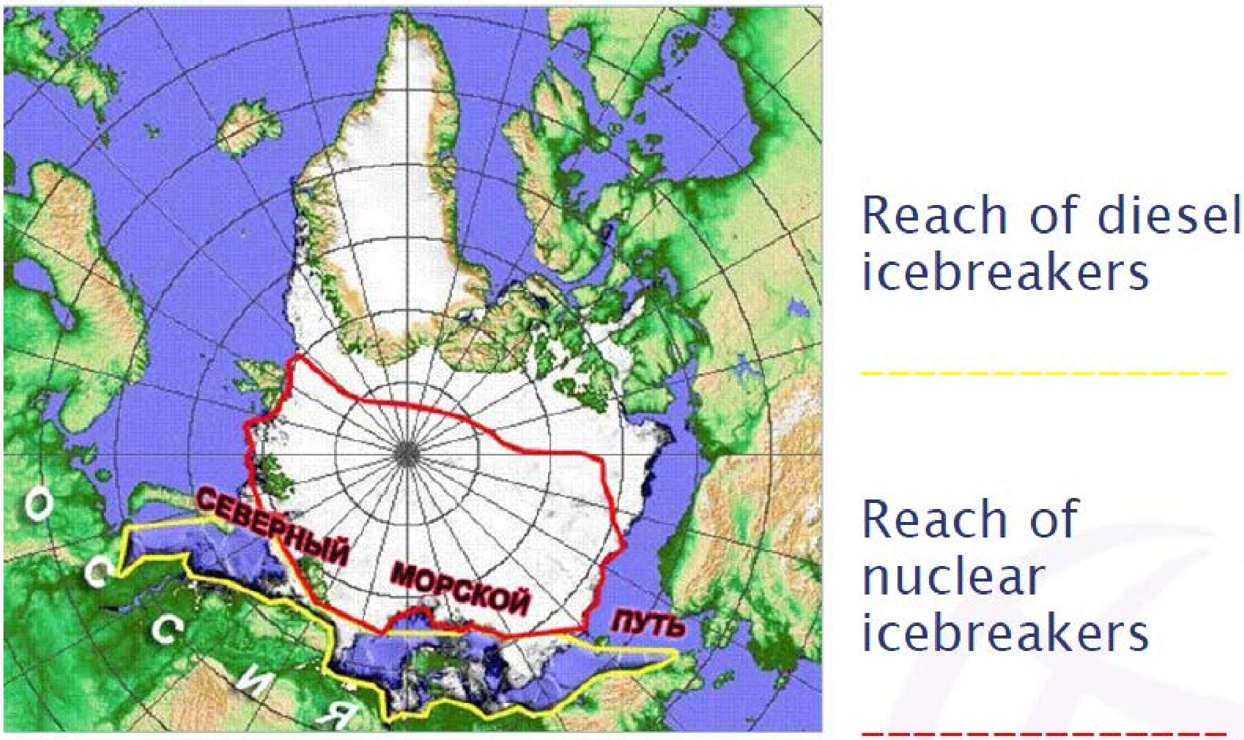
Source: CE Delft report regulating slow steaming

Figure 13.1Map of depths in the NSR



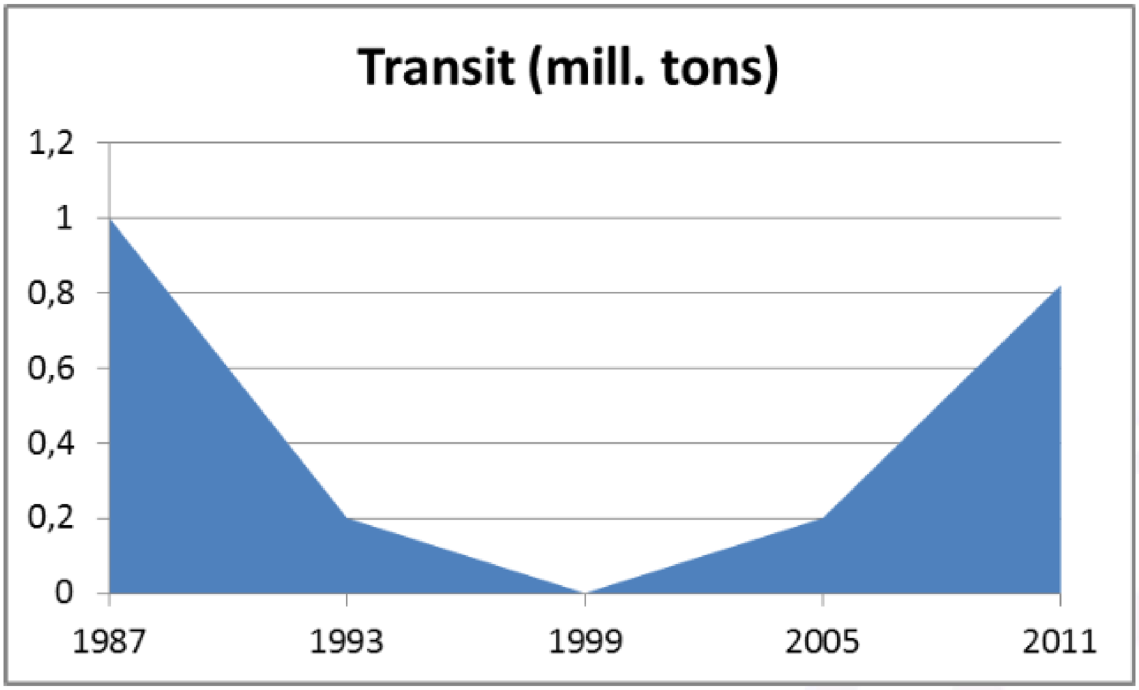
Source: http://benmuse.typepad.com/.a/6a00d8341d9cb353ef010535b9c90a970c-800wi assessed 14/07/2012

Figure 13.2Areas reached by nuclear and diesel ice breakers



Source: Rosatomflot

Chart 13.2 Transit volumes via NSR 1987-2011



Document 13.1: Letter from the head of administration of the NSR "To the Owner or Master of the vessel"

To the Owner or Master of the Vessel

Dear sir,

We would like to draw your attention to the fact that "Regulations for Navigation on the Seaways of the Northern Sea Route" (NSR) officially are published 13.07.91 in the Notices to Mariners N 29.

Due to this "Regulations" the vessel intending to navigate through the NSR shall satisfy special requirements.

For taking decision concerning the possibility of leading your ship through NSR you should submit to Northern Sea Route Administration (NSRA) a notification, where you must indicate the following:

1. Name of ship, flag, port of registry, shipowner (full name and full address)
2. Gross/net tonnage Reg. T

2.1. Full displacement of the ship

3. Main dimensions (length, breadth, draft), output of main engines, propeller (construction, material), speed, year of build
4. Ice class and classification society, date of last examination

4.1. Construction of bow (ice knife or bulb-bow)

5. Expected time of sailing through the NSR
6. Presence of certificate of insurance or other financial security in respect of civil liability for environmental pollution damage
7. Aim of sailing (commercial voyage, tourism, scientific research, etc.)

The permission to pass through NSR, dates, region of navigation and conditions of ice-pilotage you would be given by our experts after survey of your ship on her compliance to the Requirements for the Design, Equipment and Supply of Vessels Navigating the NSR.

Such survey could be done at any suitable for you port (all expenses on your account). After that all details of the leading of vessel via seaways of NSR must be clarified in your agreement with Murmansk Shipping Co. or Vladivostok Far-Eastern Shipping Co. which is responsible for arrangement of the above escort.

Please take notice that this permission for navigation on the seaways of the Northern Sea Route would not give you right to conduct any scientific research in Russian Arctic, and tourism or fishing as well. For these purposes you must send a special request to the Ministry for Foreign Affairs of Russian Federation.

Now only tranzit escort of the foreign vessels via NSR (or sailing to port of Igarka) is possible, becouse Russian Arctic ports (except Igarka) are not open for entering of foreign vessels.

On this subject you may contact to
Northern Sea Route Administration
Address: 1/4, Rozhdestvenka, Moscow
103759, Russian Federation
Telex: 411197 MMF SU
Tel: (095) 926 16 96

Best Regards
Capt. V. Mikhailichenko
Head of NSRA

Source: INSROP database