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Evaluation of the Proposed Arctic Rail Link and Northern Sea Route: A Study of the Economic Prospects of Finland's Arctic Region

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Figure 1: The route chosen by the Finnish government in 2018 for the planned extension of Finland's rail network from Rovaniemi to Kirkkoniemi (Kirkenes) in Norway. Source: Autio (2018).

Abstract

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As the concluding work of the International Business & Logistics degree, this dissertation sets out to evaluate the feasibility of the Arctic Sea rail track as a new logistics channel in Northern Finland and the prospects of the Northern Sea Route.

At present, the Arctic Sea track remains at a conceptual level and the NSR is widely underdeveloped. The hypothesis is that both of these logistics channels will develop over time correlating with one another, the Arctic Sea track being more dependent on the development of the NSR than vice versa.

The future development of these is dependent on several factors and stakeholders. Therefore, the method of research is a comparative literature review, combining and analyzing relevant studies and other resources. The first portion of the thesis reviews the potential shipping demand for the Arctic Sea track from the NSR and the regional industries. The next point of examination is the nature of container shipping and the NSR's competitiveness as a sea route between Europe and Asia compared to the more prevalent Suez Canal route. As a relevant stakeholder to this topic, the stance of the shipping industry has been taken into consideration. Reviewing these factors is intended to facilitate evaluation of the potential container traffic through the NSR.

The dissertation also evaluates the obstacles and the resources present in the Arctic region, to better understand what fixed regional incentives promote economic development, and what are the necessary development requirements.

The region is rich in resources, but requires large investments to develop. The geopolitics and international political forums for Arctic are examined, along with the Arctic interests of different states to investigate the basis of intergovernmental cooperation and coordination in the area.

The research concludes that the NSR and the Arctic region's infrastructure will likely develop and witness greater use than thus far. The driving factors are climate change and investments in resource extraction. The improved accessibility brought by this development should pave the way for the shipping industry in due course. Despite these changes, the Arctic Sea track does not appear to be as financially feasible as hypothesized at the beginning of the research.

1 Introduction

This thesis begins by focusing on an infrastructure project, called the Arctic sea track (Jäämeren rata) and its economic prospects of it. The project is a railway extension connecting the already existing Finnish rail network to the Arctic Sea and the Northern Sea route (NSR), so the NSR and the Arctic region will be thoroughly examined as well and the latter part shifts focus towards them.

The Northern sea route has a lot of potential because it is significantly shorter and therefore faster than the more prevalent southern sea route via Suez Canal. The reduction in fuel costs and carbon emissions and the possibility to avoid piracy and politically unstable regions are the main reasons why the NSR is increasingly attractive to the shipping liners. The route has been tested and used to transport mainly minerals, oil and other bulk materials, but the traffic has been very meager, because the passage is only open for a short season when it is not frozen to impassable. However due to climate change the navigable period will be longer in the future.

The Arctic Sea track would open a completely new channel for Finnish imports and exports between the booming Asian markets and Finland and decrease the logistics costs and lead-times, improving the geopolitical status of Finland and the Nordic region as a whole.

It would also benefit the following industries: mining, forestry, tourism, and several other industries, supporting economic growth both in the proximity of the new infrastructure and on a domestic level by further integrating the northern regions of Finland to the rest of the country.

Access to the Arctic Sea would also mean access to the rich oil and natural gas reserves in the Arctic area and provide business for the track as an intermediate for hydrocarbon shipments between the extraction sites and the consumer.

2 Research objective

The research objective is to evaluate the economic prospects of this infrastructure development, focusing mainly on the Northern region of Finland in the direct proximity of the new logistics channels, but also on a larger scale on the Arctic region along the NSR.

Since the research object is still at a conceptual stage, there is a limited amount of literature written of the Arctic rail track and its economic impacts. Northern Lapland Regional Cooperation Authority (NLRCA) has published a comprehensive report about the financial feasibility of the track, its benefits to regional industries and the estimated amount of cargo; however the main focus of this research is lacking in depth analysis of what lies beyond Kirkenes, on the Norwegian coast: namely, what are the defining factors for the future of the NSR and how the Arctic region is reshaped as climate change has made the region more accessible than ever before and its geopolitical importance has grown as a result. The NLRCA report will function as one of the core resources for the anticipated traffic on the Arctic track, along with a more recent report by Liikennevirasto (now Väylävirasto, the Finnish Transport Infrastructure Agency).

Research on the prospects of the NSR and the Arctic region requires a more comprehensive set of literature, as both research objects are complex entities defined by a variety of factors, and so far there does not appear to have been an all-inclusive study of either. This literature review will examine relevant research made on the most important contributing factors.

3 Introduction to the Northern sea route (NSR)

The Northeast sea route is a possible alternative for the Suez Canal as the shipping route between East Asia and Europe. The travel distance between Yokohama, Japan and Rotterdam, Netherlands can be decreased by 40% compared to the Suez Canal (Liu, 2010) and even more so between Kirkenes and East Asian ports due to closer proximity to the NSR. The reduced travel distance however does not convert to an equal shipment time reduction. The vessels can travel faster via blue water than ice water. However, according to another study (Zhang, 2016) the travel time could be decreased by approximately 10 days with the northern alternative for both container and tanker vessels.

The carriers needed to operate through the NSR have to have reinforced hulls to sail through the icy water, which increases the initial investment by 30% for ice reinforced vessels and 120% for “double acting” vessels compared to an ordinary ship. The operating expenses of both types of vessels are 50% higher. It is possible to sail through the ice, but the travelling speed decreases linearly from 19 knots to 0 until 2,5m of ice for the double acting vessels, which are able to operate independently without ice breaker assistance for the whole year. For class 4 pc ice-reinforced vessels the declining of speed goes from 24 knots to 0 in up to 1,5m of ice (NLRCA, 2012).

The lack of busy ports and transshipment opportunities on the northern sea board of Russia causes a significant loss of profit for container vessels compared to the traditional southern routes, in case the route is not able to cater enough demand for a ship and may be attractive for shipping companies only if demand in Europe or Asia is able to cater a whole ship. Another problem for the container vessels is that even during the summer period there are floating icebergs which increase the risk of compromising the carefully stacked containers in the case of a collision, which even further discourages the container shipments on the NSR. In addition, some goods shipped in a container, such as electronics, require special measures to protect them from the cold climate. The Northeast Passage is likely to be a viable option only as a supplement route for Suez Canal for container traffic. As for oil tankers, the study shows possible savings relative to the Suez Canal. If same-sized vessels are compared, oil tankers do not operate by a fixed schedule and can utilize the NSR more flexibly when it is preferable (Zhang, 2016).

According to a NLRCA estimate, the amount of annual container cargo between Asia and Baltic Sea countries through the arctic sea track could rise up to 5-8 million tons by 2030 and to 10-15 million tons by the 2050. With additional infrastructure projects, such as an undersea tunnel between Helsinki and Tallinn and development of Rail Baltica, larger area could be reached, up to Poland and Czech Republic (NLRCA, 2012).

Due to the global climate change the Arctic ice coverage is decreasing each year, which presents an opportunity to further utilize the Northern Sea route between Europe and East Asia. Approximately 90% of world trade is carried by the maritime shipping industry (ICS). The NSR sees a significantly lower amount of ships passing through it compared to the Suez Canal; less than one percent. However, if only 10% of the Chinese exports were to be transported through the NSR in the future, the estimated value of the goods would be approximately $700 billion USD (GRI, 2014). The NSR would also serve as a route to Europe for many other East Asian countries' exports and even for the cities on the northwestern coast of the American continent, if to a lesser extent.

One of the important factors that affect the profitability of the NSR is the ice-breaking fee that Russia charges to keep the route operational. The fees have had great volatility in the past. In the 1980's the NSR had its historical peak in cargo and the fee was at its lowest at $3 USD/ton. The amount of cargo dropped between 1990-2005 and the fees raised to $23 USD/ton by 2005. After that the NSR has had slow but steady growth in activity and the fees had decreased to $5 USD/ton by 2010 (NLRCA, 2012).

Environmentally the NSR offers lower global CO_2 emissions due to the shorter travel distance, but on the other hand increases local emissions in the fragile Arctic ecosystem. Risks of oil spills will increase since the passing vessels will initially consist of tankers primarily. The NSR in conjunction with the Arctic track has the economic incentive to bypass the Baltic Sea and avoid the EU sulfur fuels directive and the fees related to that.

3.1 Review on mining and forestry sector

Some of the biggest beneficiaries of the Arctic Sea track would be the Finnish mining and forestry industries, due to the low price-weight ratio of bulk goods. Research by ETLA discovered that most of the new mining operations opened in Finland are located in the Northern region where the track would be located as well. The research also indicates the importance of the infrastructure particularly for the mining sector and that

the initial investments can rise high to establish a sufficient transport channel between a new mine and the national rail network in the inconveniently underdeveloped areas. The same study also notifies that the mining industry by itself is not enough to provide enough traffic to make the investment of the Arctic Sea track financially feasible and other factors should be taken into consideration to justify the railway extension, although the mining products do provide a good core demand for the infrastructure development (ETLA, 2011).

The forestry industry is needed to supplement the mining products in order to have sufficient amounts of cargo on the railway. In the future the northern region of Finland will increase its national share as a wood supplier due to warming climate and its untapped potential. The already existing and planned bio refineries, especially in proximity to the network, such as Kemi, will increase the demand of energy wood as a biofuel ingredient. Wood as a renewable resource will become an increasingly prevalent source of energy for several manufacturing industries, energy production more generally, and is already widely used in the construction of housing. The forest industry does not consider that there is a bottle neck for the production because of lack of railways in the region, but would most likely utilize the opportunity if it were constructed. It is estimated that the mining and forestry industries will contribute up to 1,8 million tons of annual cargo on the proposed Rovaniemi – Kirkkoniemi (the Finnish name of Kirkenes) interval of the railway (NLRCA, 2012).

3.2 Review on energy sector

The Barents Sea region contains substantial amounts of natural gas and oil. It is estimated that the Arctic holds 90 billion barrels of undiscovered oil and 47 trillion cubic meters of undiscovered natural gas. The development of more advanced extraction technologies and the globally depleting fossil resources have made the Arctic reserves more appealing and financially viable. Norway and the Russian Federation have already invested heavily in the development of Arctic hydrocarbons in the offshore. The oil tanker and LNG shipments from the Arctic to the world markets are expected to increase in the coming years. Russia is making progress in the development of hydrocarbon extraction in the Shtokman gas field which would significantly increase the maritime traffic in the Arctic. According to an estimate, with the development of vessel and transportation technology, the tanker shipments will become a more affordable alterna-

tive for the pipelines in the Northeast Passage, which would reflect as increased traffic in the port of Kirkenes if it were to be connected to the railway infrastructure (Arctic council, 2009).

The transportation volume of oil and natural gas at the Barents Sea is estimated to increase to 40 million tons by 2020. The Norwegian coastal administration has recommended making Kirkenes harbor as a support port for the oil and natural gas extraction industry, which would require building facilities able to receive and handle oil and natural gas and to be able to convert the natural gas to LNG. The port would be required to be able to receive large tanker ships which would give a capacity to receive other sizeable vessels as well. The oil and LNG shipments are estimated to supplement a significant amount of demand for the Arctic Sea track once operational (NLRCA, 2012).

3.3 Other involved industries

Tourism and passenger traffic would also benefit and provide supplemental traffic for the Rovaniemi – Kirkenes part of the railway. Lapland receives a high portion of tourists visiting Finland and along the new track there are several tourist resorts. The tourism industry also has many seasonal employees who do not live in the local surrounding area and need to travel there according to the tourist season. The local population would also benefit from the railway in Lapland where the distances are relatively long. Russia's massive investments to develop the extraction in the Shtokman gas field require a lot of labor and are likely to increase the demand for passenger infrastructure in the area. There is a dilemma of having faster passenger train and slower mineral shipments on a single track railway. This would decrease the availability of the track or require higher investments to build several bypass points along the track.

The Norwegian fishing industry is estimated to steadily increase its output and 0,4 million tons of fish are estimated to go through the Arctic Sea track to Finland, Russia and other eastern European countries (NLRCA, 2012).

4 Container shipping and the NSR

Maritime shipping dominates global trade when it comes to modes of transport and the volume of cargo transported, mainly because it is the most cost-efficient mode of transport to deliver large amounts of goods over long distances. Purchasing, maintaining and operating a cargo ship are not cheap per se, but when the costs are divided among tons of cargo and numerous customers, it becomes the most affordable option. Being the most common mode of transport across the world means that there are many companies in this line of business and the competition is ever present. Healthy competition tends to lower the prices in any field of business and when the competitive advantage of maritime shipping is the price, this magnifies this fact even further.

Slight margins and stiff competition means that transit shipping companies aim to utilize as much of the cargo space as possible throughout the route. Container ships have steadily grown in size since their invention and the trend is likely to continue as more containers on board help to lower the unit cost and provide competitive advantage.

In order to keep the ever growing vessels at peak capacity or as close to it as possible, the shipping liners select routes among major ports, cities and industrial centers. The modern container ships have reached such magnitude that it is not practical to use them between point A and point B, since there likely is not enough traffic or transportation needs between two individual destinations.

Massive container ships mainly visit major ports, which act as regional hubs. Smaller feeder vessels link the smaller ports to these hubs and further distribute smaller quantities of goods to their final destination or closer to it. Major ports are bustling with traffic, so the transit shipping is highly scheduled.

One of the main issues for the maritime shipping companies is the difficulty to establish a transit shipping routes along the NSR due to the lack of major population centers on the Northern coast of Russia. Container ships rarely deliver a full shipload to a single destination. The principle of liner shipping is to load and/or unload goods in several, if not all, of the ports along the route. Purpose of this is to optimize the utilization of ships' capacity. The lack of inhabitation along the NSR is a disadvantage that cannot be practically fixed.
That is one of the main advantages of Suez Canal Route (SCR) in comparison to the NSR. From East Asia to Europe, through SCR, there are several countries and multiple population centers along the way. Therefore, the liner ships are able to distribute cargo

to a greater variety of destinations and receive regular maintenance as the density of ports is higher.

It is highly unlikely that the NSR would replace SCR or even rival the amount of traffic. The SCR is by far the cheaper alternative of the two, amounting cost of 1400 – 1800 USD/TEU and 2500 – 2800 USD/TEU for SCR and NSR respectively. (Verny & Grigentin, 2009).

Although, this does not mean that the NSR would not see any container traffic at all. NSR's advantage compared to Suez Canal Route is the approximately 40% shorter sailing distance and 6.5 – 14 days quicker voyage between East Asia and Northwestern Europe (Faury & Cariou 2016).

The amount of containerized cargo has been steadily increasing since the end of the Second World War and this trend is likely to continue due to globalization. The SCR has its limits and the NSR could be utilized as an alternative seasonal route to ease the congestion along the SCR during seasonal peaks. The Suez Canal is being developed to prepare for the ever increasing demand; it is planned to be renovated to increase the maximum ship size to 14,000 – 16,000 TEU. While this is intended to ease the congestion, granting access to larger vessels will reduce the number of ships in each convoy and as a result the canal will be able to offer its services less frequently and the waiting time will increase (Verny & Grigentin, 2009).

The container ships with a high end TEU capacity would not be able to sail through the NSR due to bathymetric reasons. Their draught could not get through the shallow points along the NSR. As the SCR is developed to cater for larger vessels and if this is to increase the waiting time and congestion on the canal, this could lead to a division of larger vessels utilizing the SCR and smaller ones opting for the NSR in the future. Larger vessels are also more dependent on the higher density of inhabitation, as discussed before.

As the global economy grows and becomes more and more interconnected, alternative routes are examined to diversify the options and meet the growing demand. One factor that could raise the demand for container shipping along the NSR could be the liberalization of the Russian economy and the following growth in the demand of imported manufactured goods (Verny & Grigentin, 2009).

Maritime transport is also relatively slow and intercontinental voyages may take several months, so the delivery orders are placed in anticipation of the upcoming need of the goods and commodities months before the arrival. Delay penalties are a substantial risk for a carrier, not only because of the concrete financial losses due to the fine, but also because of the harm done to the carrier's reputation. If deliveries arrive late, in the worst case scenario, it can even halt the production of the client and with plenty of competing carriers to choose from, customer would be likely to select another, more reliable carrier. The shorter and faster voyage along the NSR could be seen as way to avoid delay penalties, but the lack of traffic in the region makes it difficult to provide a replacement vessel in a case when a ship needs urgent maintenance or is forced to stay docked for some other reason (Verny & Grigentin, 2009). Increased traffic along the NSR would improve the availability of replacement vessels and counter the problem.

5 East Asian shipping companies

When assessing the future of a new logistics channel, the Northern Sea Route in this case, it is relevant to take into consideration the wants and needs of shipping companies. These companies are, after all, major actors and end users on the route and they possess valuable insight, gained from years of operating in the field of global maritime transport.

Beveridge et al. (2016), conducted a survey of several East Asian shipping companies, regarding the opportunities and challenges of the NSR from the perspective of maritime industry. Although the actors in maritime industry are not limited to the Asian companies, with a fair assumption that the international maritime industry operates to a great extent in a similar manner all over the world, this survey by Beveridge and colleagues is utilized as directive information on the mindset of the maritime industry regarding the Arctic market in this research.

To better illustrate the survey and its results, Figures 2-5 have been added as visual aids. The percentages refer to the portion of the survey participants. The complete survey is not included in this paper, but merely some of the key points.

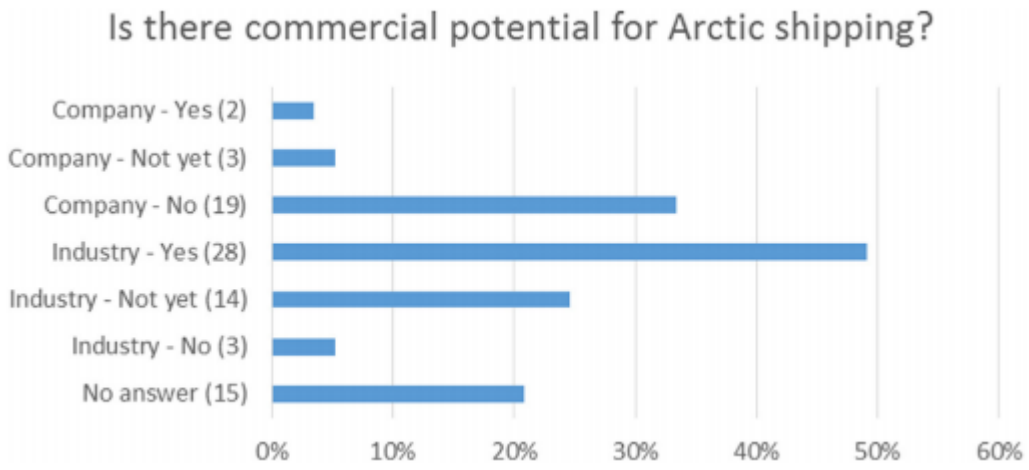


Figure 2. Survey results, Arctic potential (Beveridge et al 2016).

What we can tell from the answers of Figure 2 is that the general stance of the survey participants is that they are not very anxious to enter the Arctic market themselves. However, it is worth pointing out that a great portion of these companies have faith in this market for their industry in general, either now or in the future.

It appears that the clear majority of these individual companies have no interest to pioneer the expansion into the Arctic region, as being among the first adds to the uncertainty. Nevertheless, the perceived potential for the industry as a whole might indicate that as the infrastructure along the NSR develops, the threshold to follow lowers.

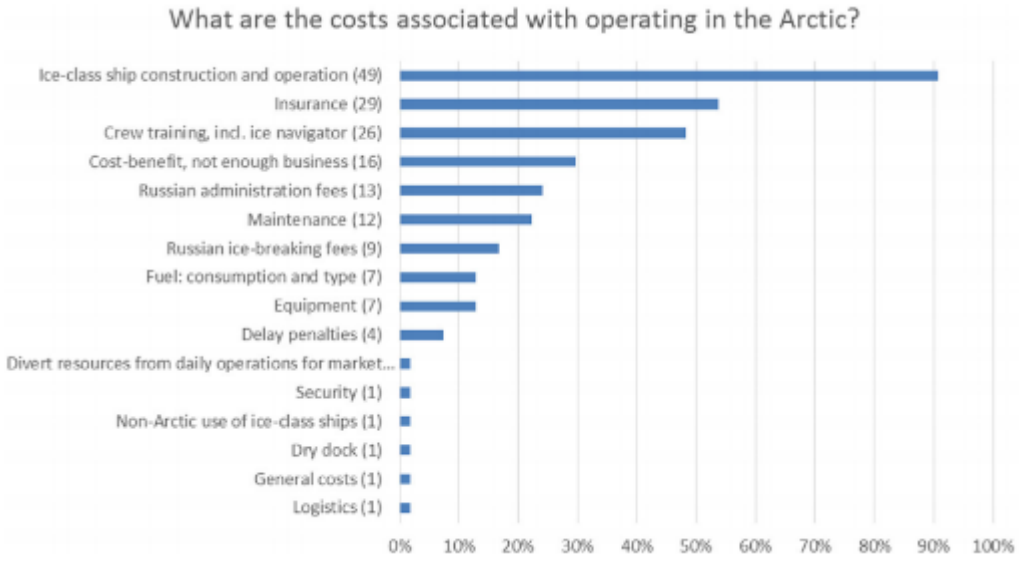


Figure 3. Survey results, costs (Beveridge et al 2016).

To better understand the threshold for the shipping industry to enter the Arctic market, we can observe the additional costs related to the Arctic market from the Figure 3.

Over 90% of the survey participants pointed out that the initial investment of constructing an ice-class vessel and operating it is a significant expense. This concern is supported by a comparative review of relevant research by Theocharis et al. (2018). The consensus is that building and operating ice-class vessels is indeed more expensive than conventional vessels, although there is a lot of deviation among the studies.

The estimated capital premium for ice-class vessels, according to the studies included in the review, ranges between 5% and 35%. The fuel consumption is also higher due to the weight of a sturdier hull and ice resistance. For a container ship the premium ranges between 8% - 15% by the lower estimates and 50% - 58% by the higher estimates. For bulk carriers and oil tankers the estimates go between 5% and 30% (Theocharis et al 2018). There are different levels of ice classification: higher level ice class vessels are more durable and are able to sail through thicker ice sheets, consequently higher ice classification is also more expensive than a lower one. This could be a contributing

factor to the variation in these estimates, since different literature could have been referring to a different ice-class than another.

Also, the vessels sailing through the Arctic, or any frigid region, have to be modified with enhanced capacity to produce heat in order to keep important machinery, equipment, doorways, etc. from freezing for safety reasons and operability of the vessel. Producing this extra heat will also increase fuel consumption. (Farré et al 2014).

The insurance premiums were deemed a major cost by more than half of the shipping companies. The most prevalent types of insurances concerning the Arctic shipping literature are Hull and Machinery (H&M) and Protection and Indemnity (P&I).

The literature seems to lack a clear consensus on the insurance premiums, as the lowest estimate for both H&M and P&I is 5% and highest estimates are 200% premium for the H&M and 100% for the P&I. Several estimates lay in between these extremes and the H&M premium is generally considered to be higher than the P&I. (Theocharis et al 2018).

The insurance premiums have their roots in the risks associated with the Arctic route, which are reviewed more in depth below.

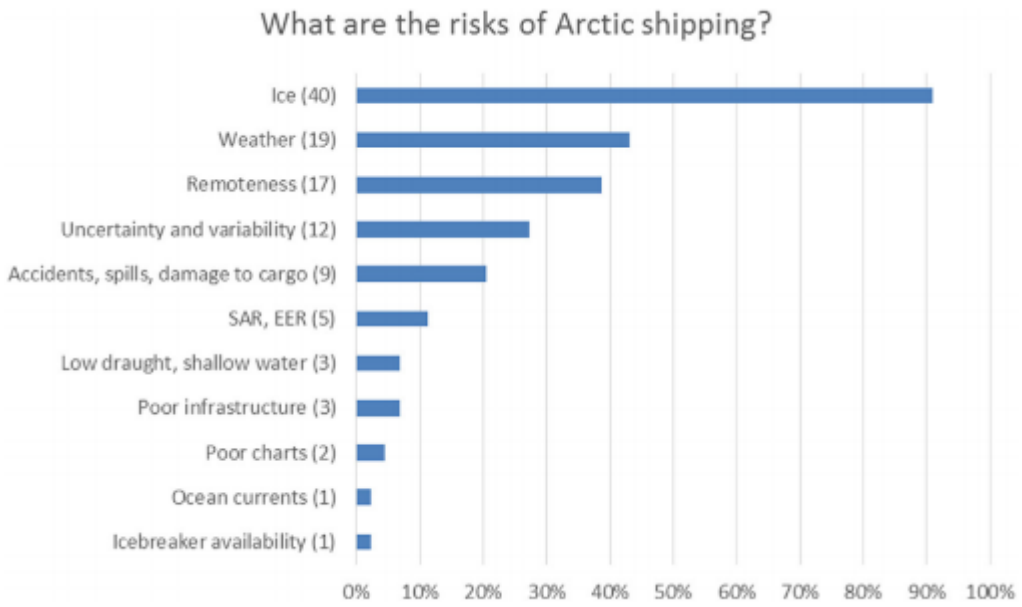


Figure 4. Survey results, insurable risks (Beveridge et al 2016).

The risk assessment by the survey participants is very coherent with the associated costs. It is worth mentioning that respondents had the liberty to answer whatever they wished to the open questions, so there might be some overlapping among the answer categories. For example, remoteness is a risk mainly due to the lack of infrastructure and search and rescue (SAR) coverage in the region. If the density of maintenance ports and SAR facilities would be higher, the remoteness itself would not carry an inherent risk.

Arctic shipping is largely defined by the ice and the frigid weather conditions of the region, occupying the two top spots concerning the associated risks of the survey. The ice is a recurring topic in almost all the literature about the Arctic and will be addressed in more detail in a separate segment dedicated to it in this thesis.

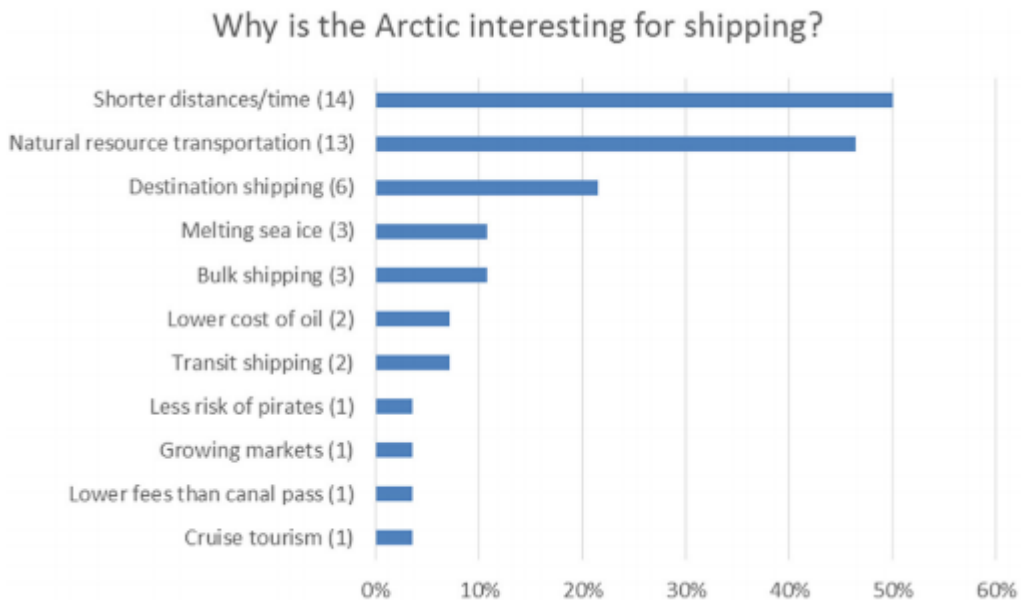


Figure 5. Survey results, appeal/opportunities (Beveridge et al 2016).

Despite the several challenges regarding the Arctic market, it is not completely without appeal. The shipping industry considers that the shorter distance and the time saved in the process are the main benefits of the NSR for the transit shipping between Asia and Europe.

The natural resource transportation and bulk shipping have to do with the resource extraction originating from the Arctic region, while destination shipping is a broader concept that covers them both, but also has to do with delivering machinery, equipment and other materials to offshore oil rigs and other resource extraction sites.

6 Ice

The greatest obstacle to the greater use of the NSR is the harsh, unpredictable climate and the sea ice. The ice coverage expands on the route completely for most of the year, which is why major traffic through the area has been absent.

Nevertheless, climate warming melting the polar ice has extended the open period and will likely continue to do so in the future, especially when the global warming increases the polar temperatures more than the global average.

The sailing period can also be increased to a certain extent with icebreaker escorts or by investing in ice-class vessels. Even during the open period, when the route is not completely impassable due to thick sea ice, there are still floating icebergs of varying sizes. They are an unpredictable variable and they possess the risk of damaging the ships. This creates the necessity to address the issue somehow. Deploying reinforced ice-class vessels and/or hiring icebreaker escorts might be able to evade the damage, but it is best to avoid collision with proper navigation and real time data on the ice forecasts.

The current availability of icebreaker vessels is not sufficient to cater for a substantial amount of traffic. This is another challenge that may create a bottleneck along the NSR and limit its potential flow and should be addressed if the NSR is to become a major logistics channel.

The lack of icebreaker vessels is quite reasonable though. The NSR has not had major traffic and ergo, demand for an extensive fleet of icebreaker vessels standing by. As the demand for icebreaker services increases, it is to be expected that more vessels will be constructed and deployed. For example, South Korea hosts a significant ship-building industry and has great interest towards the Arctic. Polar specific orders for its shipping industry are part of their economic expectations concerning the Arctic. (Kim, 2015).

Icebreaker fees could be avoided all together with exceptional navigation (Lin & Chang, 2018). Qualified ice navigators charge a premium for their skills though (Verny & Grigentin, 2009).

The extent of the polar ice sheet coverage changes immensely between the winter maximum in March and the summer minimum in September. The average winter extent from 1981 to 2010 was 15.51 million km^2, while the average summer minimum between 1979 and 2000 was 6.71 million km^2 (Farré et al 2015).

An important contributing factor to the thickness and hardness of the ice sheet is its age. A multiyear ice sheet that has survived the summer season is generally thicker and stronger than first year ice. The Arctic ice coverage diminished to a record low extent of 3.41 million km^2 in September 2012 and this record was nearly broken again in September 2020, when the extent was recorded at 3.44 million km^2 (NSIDC, 2020). This development of shrinking summer minimums means that the following winter maximums consists increasingly of first year ice, instead of multiyear ice.

The NSR is free of ice during the summer period, which enables the utilization of the route in the first place. This also means that when the NSR is frozen during the winter, the ice sheet that blockades the itinerary is made of first year ice in its entirety, as illustrated in Map 1.

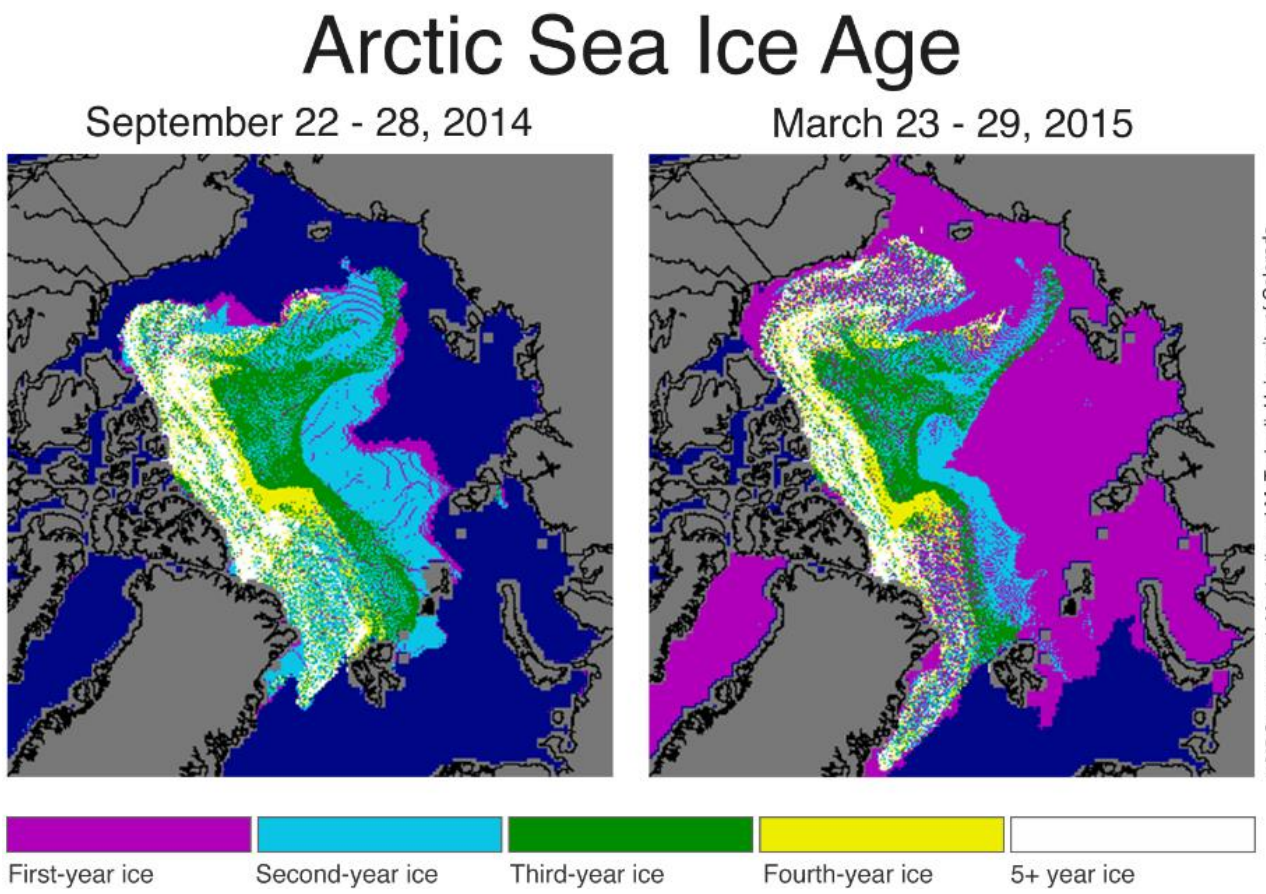
Towards the winter months, as the Arctic Sea freezes, the thickness of the first year ice along the NSR is approximately 2 meters on average in March when it should be at its annual peak (see Map 2). The thickness of the ice accumulates gradually, meaning that between September and March, even when the route starts to freeze, there is a period of time when the thickness is somewhere between 0 and 1 meter, before surpassing it on its way to the March maximum.

High level ice class vessels, such as 1A Super, are able to sail through ice sheets of 1 meter in thickness. This would mean that the sailing period for such vessels would be extended at both ends of the season. In the spring when the ice would start to melt, the sailing season could be started at the point when the thickness comes down to 1 meter and in the autumn it could be continued until the 1 meter of ice accumulates. The same principle applies to lower tier ice class vessels: for 1A class the critical point would 0.8 meters, for the 1B class 0.6 meters, and so on.

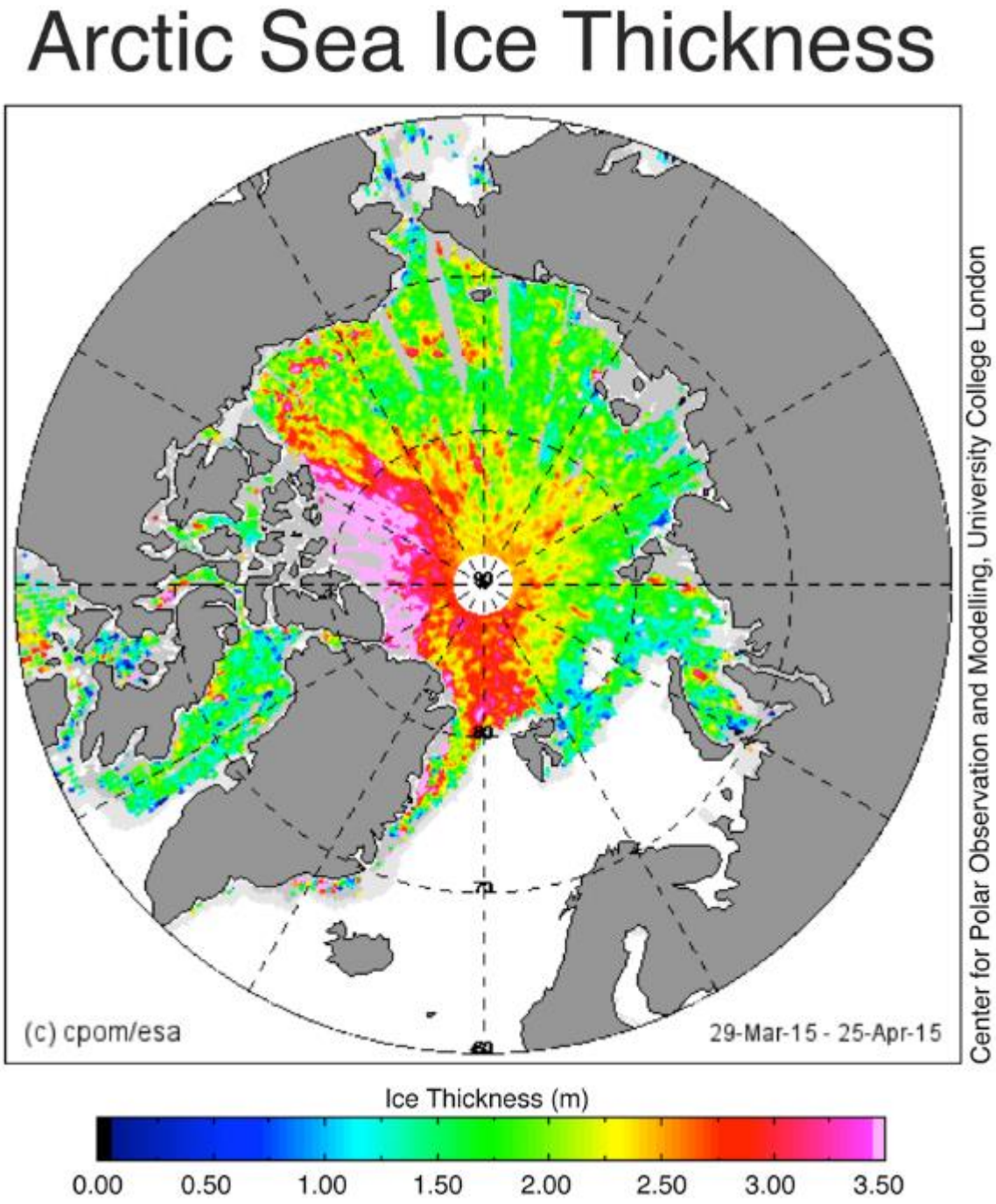
The sailing period can be further extended with the icebreaker escorts, but the ability to sail independently means that the NSR would be slightly more competitive as the ice-breaker fees can be deducted from the cost structure.

As the temperatures rise, it is theoretically possible that at a certain point in the future, the Arctic Sea ice would not surpass 1 meter in thickness along the NSR, even during the March maximum. In this hypothetical scenario, the level 1A Super ice class vessels could operate along the NSR all year round. Some projections predict that the Arctic Ocean could have ice-free conditions by 2050 (Palma et al, 2019) in which case the above mentioned scenario would occur sometime before then.

Such evolution of the ice conditions would redefine several disincentives of the NSR. Some of the reluctance of the maritime industry to invest in ice class vessels can be explained by the dilemma of where to assign the ice class vessels when they cannot operate along the NSR. When the NSR is unavailable, even to the ice class ships, they would have to be assigned somewhere else, most likely to open water routes where conventional ships operate regularly. Due to higher operating expenses, the ice class vessels are at a disadvantage on the open waters against the conventional vessels. Therefore, if we consider that the period when the NSR is navigable is the time when the shipping industry can reap the benefits of the NSR and the period when ice class vessels have to be located elsewhere is the negative counter weight, the cost-benefit ratio shifts according to the ice thickness. It might not be even necessary that the NSR should be navigable all year round. For example, it might be sufficient that the NSR is navigable for 11 months of the year and the one month operating elsewhere would not undo the benefits of the NSR sailing period. This tipping point can be some other duration as well, but when it is reached, the economic feasibility of the NSR would increase dramatically.



Map 1. Arctic Sea Ice Age (NSIDC, 2020).



Map 2. Arctic Sea Ice Thickness (NSIDC, 2020)

The ice in the ocean is not the only threat. The sea spray, snowing, raining, fog and all sources of moisture accumulate ice on the ships structure and equipment above the waterline. This icing creates many hazards as vital equipment and machinery might cease to function. The doorways and exits for the crew could be sealed close by the ice, a matter of life and death in case of an emergency and a great obstacle for the functionality of the ship even in less dire circumstances.

The icing on the structures of the ship contains the risk of accumulating to a critical point in weight, making the ship top-heavy, when it can compromise the balance and stability of the vessel. Combined with a strong heave of the sea during a storm, this could lead to perilous results and even tip the ship over.

Therefore, other winterization preparations are needed as well. Winterization is the process of altering the ship to withstand the challenges presented by the frigid climate conditions. Some of the solutions include building the vulnerable parts of the ship and crucial equipment from materials resistant to the cold, in order to prevent or postpone the freezing all together or at least ensure the functionality in case of freezing. For example, refraining from the use of plastic as the material for the pipes and hoses helps to avert breakage. (Farré et al. 2014).

7 NSR for resource extraction and transport

The adoption of the NSR as a choice itinerary comes much more naturally for tanker and bulk shipping, in contrast to container shipping. Tankers and bulk carriers tend to be fully loaded in their place of embarkation and deliver the cargo to a particular destination. Therefore, they do not struggle with the same problem as the container shipping with the lack of inhabitants along the NSR and the capacity maximization issue that comes with it, as discussed above. Also, commodity shipping does not operate under an equally tight schedule as the container shipping, giving it more resistance to possible delays.

The NSR is also in the immediate proximity of the vast natural resource reserves of the Arctic. The NSR is a notably shorter route than the SCR between Northeast Asia and Northwest Europe. For an oil tanker departing from the Barents Sea to Shanghai, the difference in length would be even more significant since the origin itself is located along the NSR and is simultaneously further away from the Suez Canal than most other reaches of Europe.

A study of the competiveness of oil tankers along the NSR confirmed that the NSR is a commercially viable alternative for tankers from July to November in its current state (Faury & Cariou, 2016).

Resource extraction will likely pioneer economic development in the Arctic. For container traffic, selecting the NSR is completely optional and in its current state, relatively unappealing. The natural resources on the other hand are located there and anyone who wishes to utilize them has to set up operations in the region. Evidently the resource reserves have provided sufficient economic incentive to enter the region as billions of euros worth of investments are directed toward the development of resource extraction and the accommodating infrastructure.

In 2017, a major harbor was constructed in Sabetta, Russia, as part of the Yamal LNG joint venture between Russia and China. The port is expected to boost Arctic shipping and is a valuable addition to the infrastructure along the NSR (Farré et al, 2014). This is just one example of how resource extraction contributes to the route facilities.

The tankers require services, such as maintenance ports, communications and search & rescue coverage, the same as any other maritime transport. The influx of funding paves way for other industries that are able to benefit from the same services, facilities and technical solutions, generating multiplier effects.

8 NSR development needs

In order to support large scale maritime traffic, the NSR requires better developed infrastructure, depots for maintenance and refueling, icebreaker service, reliable communications and search & rescue facilities to counter the risks. Absence of a support infrastructure means that there are either additional risks or expenses for the carrier, which has a direct impact on the appeal of the route.

A critical part of the NSR infrastructure is the search and rescue (SAR) network. The Arctic Ocean is a hazardous environment and contains severe risks for the ships and their crews. Russian authorities are anticipating growth in traffic along the NSR and have invested 30.1 million dollars to construct 10 SAR centers along the route (Farré et al. 2014).

The SAR operations along the NSR are to be governed by Russia, according to the Arctic Council agreement of 2011 regarding the topic. However, this agreement is non-binding and any physical implementation is not stipulated (Farré et al. 2014). The SAR agreement should be fully implemented to ensure the safety of the route (Lipponen, 2015).

Some of the SAR responses could be conducted by icebreakers in the vicinity, especially in the more remote reaches of the NSR. Russia has the largest icebreaker fleet in the world and currently 5 icebreakers are operational. Still, the current availability of icebreakers might reach its limit if the traffic on the NSR increases, as some of the existing icebreakers are already assigned to the Yamal LNG project (Farré et al. 2014). As part of the maritime responses, along with the SAR, the capabilities of response to oil spill accidents must be improved as well, since the Arctic eco-system is particularly vulnerable and a lot of oil is transited through the region.

8.1 Communications

Proper communications have an essential role in establishing a secure transport route through the Arctic. Even if the land based support network for the Northern route would be up to world standards, it would all be futile if the communications should fail or if the locating of vessels in a maritime emergency could not be done. The weather conditions are unpredictable and harsh, which introduces several risks for the traffic in the region.

In case something were to happen, it is crucial that distress signals reach the land based search and rescue facilities or other vessels in relative proximity if need be. Proper communications combined with a sufficient SAR coverage would also help to reduce the insurance premiums, which would increase the appeal of the route for the shipping industry. As indicated by the survey for shipping companies, the insurance premiums (Figure 4) for the NSR were considered the second most relevant additional cost for the NSR in comparison to SCR (Beveridge et al 2016).

The current means of communications available in the region are Iridium satellites, providing telephone and low-speed Internet connection. Radio transmission is also available in Very High Frequency (VHF), High Frequency (HF) and Medium Frequency (MF) (Farré et al. 2014). While these options can support sufficient voice communication, they lack the ability to transfer larger quantities of data required to receive modern weather and ice forecasts and augmented GPS (Global Positioning System) signals.

While the ships are loading, unloading, receiving maintenance or visiting a harbor for other reasons, they navigate in very close quarters to the facilities. This is where the GPS signals have to be augmented to tell the ships position up to a decimeter of accuracy. The standard GPS signal without the augmentation has the accuracy of approximately 3-5 meters.

Another unique challenge regarding the Arctic is that the geostationary satellites cannot be used above 70-75 degrees of Northern latitude.

9 Politics

As climate change and the melting of polar ice has made the Arctic region more accessible, its geopolitical importance has grown correspondingly. The Arctic region contains a quarter of the known oil and natural gas reserves of the world and 17% of its minerals (Lipponen, 2015) which partly explains the high appraisal.

The development of the NSR requires political stability and international standards governing how to operate in the region in order to balance the interests of Arctic countries and other participants interested to do business in the region. Private enterprises and investors look for predictability and stability when making decisions. The Arctic eco-system is particularly vulnerable and in order to ensure the future of the unique flora and fauna of the region, international standards and regulations must be in place and enforced.

9.1 Arctic Council

The Arctic Council (AC) is the main international forum for issues regarding the Arctic. The AC has performed well in its role as a separate platform for dialogue dedicated to the Arctic region. The Crimean crisis and the war in Ukraine have caused tensions between EU and Russia, but despite this, the cooperation within the AC between Russia and other members, many of which are members of EU as well, has been able to continue (Lipponen, 2015).

The AC members share the common interest of developing the Arctic region in a sustainable manner. The Arctic is a challenging frontier which calls for technological solutions on many different fields, a task too ambitious for a single entity, but feasible for a collective. Climate change is a challenge that encourages cooperation in preference to petty squabbles and this is highlighted in the AC as the Arctic is unavoidably relevant in this respect.

A great many countries and business entities have a keen interest to exploit the resource rich Arctic, which provides external pressure for the Arctic countries to work together, in order to gain a stronger position against outside influence and to ensure the national interests concerning the extraction of resources. This could be seen as

somewhat comparable to OPEC, in a way that the Arctic countries share something in common on the geopolitical board and act together to better utilize their assets.

Even though the Arctic countries flock together to wield greater influence in the region, this does not mean that they would exclude cooperation with others: present arrangements allow for negotiating on better terms. In fact, the AC has more non-Arctic observing members than actual Arctic countries, although the status of an observing member does not grant the right to vote on regulation or other issues decided in the Council.

In principle, Arctic Council consists of countries with a geographical standing within the Arctic Circle, with additional observing members with varying interests in the region. These observer members include South-Korea, Japan and China, along with several other non-Arctic states and organizations (Arctic Council, 2020). The NSR mainly shortens the voyage from the ports of South-Korea, Japan and China to the ports Northwestern Europe (Verny & Grigentin, 2009), which is why they are particularly relevant in this context.

9.2 East Asian Governments

The common interest of East Asian governments, regarding the Arctic, is mainly economic. The vast untapped energy reserves in the region are one of the main reasons why these countries have issued their strategies and political agendas for the Arctic. As global manufacturing has shifted to Asia, energy consumption has increased accordingly, and a substantial portion of the energy supply in each of these countries is being imported, thus the search for alternative suppliers has an extreme strategic importance. This energy demand will keep growing and it has been projected that the energy consumption in China will double by the year 2040 (Farré et al, 2014).

Another common economic factor for these countries is that their economies rely on exports around the global market; therefore prospecting for new logistics channels is equally important to sustain and grow their economies.

South-Korea's master plan for Arctic policy is a good example of political and economic interest towards the Arctic by Asian governments. For a country that is not in the Arctic, to dedicate time and effort to create a comprehensive set of policies for polar activities

and planning implement coherent regulation and legislation, signals a great commitment and willingness to operate extensively within the Arctic in the future (Kim, 2015). Although South-Korea is not an Arctic coastal state, it considers itself as user-state. Korea has stakes in fishing, ship building and maritime trade. and imports fossil fuels for its energy needs.

The master plan consists of four main strategies: the first focuses on international co-operation, the second on scientific development, the third on economic aspects and the fourth on legislation. The strategies are in order of implementation, which indicates that Korea is well aware that in order to do anything in the Arctic region, first of all it needs the consent of the countries to which the jurisdiction of the area belongs.

Secondly, Korea is involved in the development of scientific solutions regarding the Arctic. This includes environmental research to preserve the Arctic ecosystem, combat climate change and finding sustainable ways to perform the economic activities in the region. Finding technical solutions to the many challenges reviewed in this thesis are also on the scientific agenda (Kim, 2015).

The economic strategy comes as third, which demonstrates that there is a common understanding among the stakeholders that in order to partake of the economic activities and receive such benefits, it is necessary to contribute to the work that enables these. The fact that there is a functional platform for international cooperation for the Arctic issues, such as the AC, and that it is able and willing to demand contributions to Arctic development and preservation, is a great victory for the environment and a substantial boost for solving the numerous technical challenges as more and more actors are involved, along with their intellectual capital.

China, another non-Arctic country, has been acquiring its own icebreaker research vessels for the Arctic use and conducted seven complete through transits on the NSR in the 2018, more than it has any previous year. While this might not sound like a lot, the total amount of through transits on the NSR in 2018 was 27 (CHNL, 2020).

China has also signed several contracts with Russia for petroleum development projects in the Arctic. Examples of these include Gazprom's 30-year $400 bn agreement with China to supply Siberian natural gas mainly through a pipeline in May 2014, and

the signing in July 2014 of an agreement of a smaller LNG project for maritime transport from the Yamal peninsula (Farré et al, 2014).

9.3 EU

The European Union might serve as a source of funding for the projects within the union and in line with its interests. The EU has a particular interest in developing the Union towards a federal state and for projects that promote the integration among the different regions and the member states. The Arctic track should be examined as a part of larger European transport network, connecting the Arctic Sea through Finnish railway network to Rail Baltica via Helsinki-Tallinn tunnel.

The most prominent alignment option for the Arctic, from Rovaniemi to Kirkenes, would require an investment of approximately 2 billion euros on the Finnish side of the border, which is quite a significant investment in the frame of the state budget of Finland and calls for broader base of investors (Liikennevirasto, 2018). On the scale of the EU budget, such investment is relatively much smaller.

The Rovaniemi – Kirkenes line would also require an investment of 0.85 billion euros from Norway, but as Norway is not part of the EU, it would not receive funding from the EU. This should not prove to be an obstacle though, as Norway is going to invest 56 billion euros in infrastructure projects in the North by 2023 (Lipponen, 2015).

The EU is not going to finance the whole project, but will most likely participate in it to some extent, as EU has funded several infrastructure projects in the past. The more potential the EU sees in this project and in the Arctic region in general, the easier it will be to receive funding. If the EU considers the project to be of utmost importance for its geopolitical strength in the North, the contribution to the project could be substantial.

The Arctic region contains 17% of the known mineral reserves of the world. The European Union consumes 20% of the global ore and mineral output, but produces only 3-4%. This imbalance provides an incentive for the EU to fund and develop logistics and mining operations in the Arctic (Lipponen, 2015).

The emergence of the NSR as a logistics channel would increase the geopolitical importance of the European Northern coast. The coast belongs in its entirety to Russia

and Norway, neither of which are EU members. If the EU is to strengthen its position in the region, it would be logical to locate investments in Finland, as it is a member state in the closest proximity of this scene.

As mentioned earlier, there is a growing interest towards the Arctic among Asian governments. These countries are further dislocated from the region than the EU and in this light, it would be highly unexpected if the EU would choose to be left out from this arena.

9.4 Russia

The Northern Sea Route falls under the jurisdiction of the Russian Federation; more specifically it is governed by the Northern Sea Route Administration (NSRA). Therefore, the influence of Russia regarding the NSR cannot be overstated.

Russian administration fees and the cost of ice-breaker services are important factors for shipping liners when weighing the cost-benefit ratio of the Northern Sea route, as pointed out in Figure 3 above. The fees and taxes to the NSRA for the passage through the NSR range between 4.36 and 23.82 USD/ton depending on the type of hull and time of the year. Ice-breaker hulls during the summer are the cheapest. For equivalent ships, the NSR fees are twice as high in comparison to the Suez Canal. (Verny & Grigentin, 2009).

Russia is in a position where it can lower these expenses and make the itinerary more appealing; if there will be enough political willpower to do so. Russia might want to follow the example of Egypt, as the passage fees from the Suez Canal provide a significant income.

10 Environment

The Arctic is a particularly sensitive area to global warming as the temperatures rise there more than the global average. This phenomenon is called Arctic Amplification (AA), or polar amplification in a broader concept. The AA is greatly driven by the deterioration of the Albedo effect in the Arctic. The Albedo effect is the surface's ability to reflect photons. This is a vicious circle as the ice coverage is melting and losing its ability to reflect the sunlight; this further amplifies the raise in temperature which causes even more melting. (Palma et al 2019).

Black carbon particle fallout on ice and snow is particularly harmful, since this not only weakens the Albedo effect, but on the contrary, absorbs more heat. The layer of black carbon remains on the surface even when the ice and snow melts beneath. This calls for a regulatory framework on the emissions and the level of purity of the fuel used by the ships sailing through the region (Lipponen, 2015).

Another contributing factor is changes in the sea currents and the impact it has on the poleward transition of heat and moisture (Palma et al 2019). The marginal ice zone (MIZ) is a transition segment where the open ocean meets with the packed ice. One definition for the MIZ is that it is an area where the sea ice concentration is between 15% and 80% (Palma et al 2019). The MIZ is ever present borderline all around the polar ice coverage, but the spread of the MIZ varies in width, approximately between 50km and 300km. The MIZ is very dynamic in nature and the position of this borderline area shifts depending on the time of the year, temperature and weather conditions.

The MIZ is particularly productive and high in bio-diversity in comparison to the rest of the Arctic Ocean. This is due to the unique oceanographic features occurring in the MIZ, behavior of the water movement that maintains the phytoplankton in the photic zone, while also bringing it nutrients. This creates an environment in which phytoplankton and algae can thrive, building a foundation for higher trophic levels (Palma et al, 2019).

Among the more complex species that thrive in the MIZ, are the several species of seals. Like all higher trophic levels, the seals benefit from the bio productivity of the lower trophic levels as a food source. Another factor that attracts seals to the MIZ is that they need the ice for breeding and the access to water for hunting. The patchy ice

of the MIZ also helps them to evade predators. As for the predators, the iconic polar bear is the only apex predator in the Arctic and its main source of food are the seals and therefore the MIZ acts as vital hunting ground for them.

Oil spills are environmental disasters wherever they happen, but the Arctic region is more vulnerable in this case as well. The remoteness and the difficulty to navigate in the icy waters of the Arctic Ocean make the clean-up operations harder to conduct than in open waters. On top of this, the low air and water temperature hinders the natural cleaning process of dissolving, decomposition and evaporation of substances (Palma et al, 2019).

If an oil spill were to happen and it would disrupt the bloom of the algae and phyto-plankton, in the worst case scenario, it could collapse the entire eco-system that depends on them, as discussed above. Combined with the fact that the oil extraction and transportation are some of the most prominent economic drivers in the development of the Arctic region, it is crucial that every single precaution is taken in order to prevent such accidents from happening.

A less known fact about the victims of environmental damage is that the cod populations are among the most endangered species in the Arctic region due to climate change (Palma et al, 2019). While this has little impact on most Arctic industries, such as resource extraction, maritime transport or even tourism destined to see Arctic fauna, it is a real concern for the fishing industry. Norway and Russia administer together one of the richest fishing areas for cod in the world in the Barents Sea and Norwegian fish production fulfils 50% of the fish consumption in the EU (Lipponen, 2015). Even without any economic incentives, the preservation of any endangered species should be prioritized for ethical reasons.

11 Cruise ships

Tourism has recently brought a relatively significant human presence into to the Arctic. Cruise ships have been the fastest growing segment of visiting the area. As the polar ice is melting, the region has become more easily accessible than before. While this makes it easier for cruise ships to tour these icy waters, the melting of the ice and the changes it causes to the eco-system, threaten the future of the several unique species that live in this habitat.

Therefore the climate change and the global warming acts as a double-edged sword for the Arctic cruise liners, as it makes the region more accessible, but at the same time it endangers the existence and survival of the Arctic wildlife, which are the main attractions and the purpose of these cruises.

As the environmental awareness of global warming and the irrevocable changes it causes to certain eco-systems has spread among people all over the world, this has created a demand for a specific segment of tourism. The “last chance tourism”, as the name suggests, offers people the chance to visit and see some of the eco-systems that are under pressure of changing forever, along with the unique flora and fauna habiting these regions. The Arctic zone is great example of such an environment, since climate change has a magnified impact around the polar caps. The Arctic is also home of several species that cannot be found anywhere else, the most iconic being the polar bear.

The MIZ is where a substantial portion of the Arctic wildlife is present. The deeper into the MIZ the tourist cruisers sail, the higher the changes are to witness the rare animals. The search for the wildlife has to be balanced with the risk, as the risks become correspondingly higher the deeper the vessels sail into the MIZ as the density of the free floating ice increases until reaching the impassable solid ice coverage. Since the cruise ships are the most prominent form of sightseeing for the Arctic wildlife, the navigation within the MIZ is one of the key factors for the development of tourism in the Arctic. This integral factor of risk also stipulates that the SAR facilities are ready and available in case of an emergency.

Differing from other types of maritime traffic in the Arctic, the tourist vessels intentionally sail into and within the MIZ, while industries, such as fishing, tankers, bulk and container vessels, try to avoid the ice as much as possible.

Some other exceptions that intentionally sail in the MIZ are the research expedition vessels with a particular interest to examine the zone and the naval operations that might benefit from this positioning. For example, the MIZ has the strategic advantage from a military perspective that the vivid interactions of the loose ice and the noise it causes, can help to disguise the sound of a submarine underneath it. Also, the submarines are not jeopardized by the ice on the surface.

However, the tourism industry is the only actor that has the active ongoing economic driver to sail within the MIZ. The MIZ follows the receding pack ice which prolongs the open sailing period. This means that the tourism season can start earlier in the spring and continued longer into the autumn. During the summer when the ice coverage is minimal, cruises can be planned to even further remote locations.

This opportunity to go further also poses a challenge for the cruise liners, as it is not only an opportunity, but also a commercial necessity. Going further into the Arctic means that the support infrastructure is left far behind and SAR operations are more difficult to conduct.

12 Conclusions and suggestions for further research

Maritime shipping is a margins game and as long as the SCR is the cheaper alternative than the NSR, the shipping industry will stick to it. This economic emphasis in the decision making process suggests that if or when the NSR becomes a more cost efficient alternative, the shift in the center of gravity in the maritime transport between Asia and Europe could be quite rapid and grow at an exponential rate, after the critical point in the cost structure has been reached.

The Arctic region has become geopolitically important and this trend will most likely accelerate as the area develops. This uplifted interest predicts a boost for technologies that preserve the environment and combat climate change as well as providing solutions to the challenges operating in the region, such as navigation systems, weather and ice forecasts etc. There is an active platform for international cooperation which enables the combined efforts of numerous countries and organizations.

The existing literature seems to stack up some of the prevalent downsides relevant on the NSR and thus certain overlapping occurs. There is a lack of consideration that investing in one thing might levy the expenses on something else. For example, investing in ice-class vessel levies the costs of icebreaker fees, as long as the ice sheet thickness does not surpass the durability of the ice class vessel. As another example, the lack of SAR coverage is considered deterrence for activities on the NSR, as are the insurance premiums. However, developing the SAR coverage and improving the safety of the itinerary should also lower the insurance premiums. The existing research is not wrong; none of those issues can be overlooked, but what the current research is lacking is a comprehensive study of how these obstacles on the NSR interact among each other.

The prediction of this paper is that the pressure to increase resource extraction will pioneer the development; this phase is in fact already in process. The supporting infrastructure built as part of this process will make the region more accessible and secure. At this point the NSR will experience growth in traffic from destination shipping, oil tankers, bulk shipping, fishing and cruise ships. This will boost the development even further and lower the administrative fees as the NSR develops a larger customer base. Simultaneously the evolution of receding polar ice will continue its ongoing trend and will reach a point when the sailing period for ice class vessels is long enough that the

NSR is commercially viable alternative to SCR. As the costs and other obstacles gradually diminish, regular container shipping routes will be established along the NSR, although the scale will be much smaller than along the SCR. Container ships with higher TEU capacity cannot utilize the NSR for bathymetric reasons, nor would it be viable due to the lack of inhabitants along the NSR.

This is just a speculation of how the Arctic region and NSR might develop, but this is definitely an area for more comprehensive further research. How the stakeholders should approach the presented obstacles, which of them are by products of another problem, what is the optimal order to start solving them and how does the feasibility of the NSR gradually increase as these challenges are met are all questions requiring further investigation.

As for the prospects of the Arctic Sea rail track, we can safely assume that the track would not serve as an alternative channel for container traffic, as we have covered in this paper; regular container shipping along the NSR will not be among the first industries to emerge in the Arctic. On top of this, the report by Liikennevirasto (2018) estimated that if the track did exist, containers from the Barents Sea to Tampere would still be cheaper if brought by ship from the South. The same report indicated that any LNG or oil imports from the Arctic would also be preferably transported by ships, as refineries are usually located on coastal areas for this reason.

The Finnish Arctic holds substantial mineral wealth and forests. The Arctic track could promote further investments to these segments and the bulk shipping through NSR shows more promise than the container shipping. There is also endless demand for such resources on the Asian markets.

As the geopolitical importance of the Arctic grows and several countries from across the world want to have stake in the region, the EU will likely want to strengthen its presence in the region as well. Funding from the Union would make the project financially much more feasible.

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