International Transport Forum

# Commercial Navigation Along the Northern Sea Route

## Prospects and Impacts

178 Roundtable


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Discussion Paper

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Cite this work as: van Hussen, K. et al. (2020), "Commercial Navigation Along the Northern Sea Route: Prospects and Impacts", *International Transport Forum Discussion Papers*, No. 2020/19, OECD Publishing, Paris.

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# Introduction

With global warming and sea ice decline, new shipping routes along the Arctic could become available. An increasing body of literature discusses opportunities for commercial shipping along the Northern Sea Route (NSR), a shipping route along the Arctic that significantly reduces travel distance between Northwest Europe and East Asia. This paper discusses both the prospects and potential impacts of commercial navigation along these routes.

This paper starts with a description of the context for the use of the NSR, briefly describing sea-ice decline, global trade flows and the geopolitical and regulatory context. It subsequently provides a detailed description of the use case of the NSR, outlining physical characteristics, including sea ice and bathymetries, the challenges for commercial utilisation and finally, existing approaches and results of quantitative *ex-ante* research into commercial NSR use.

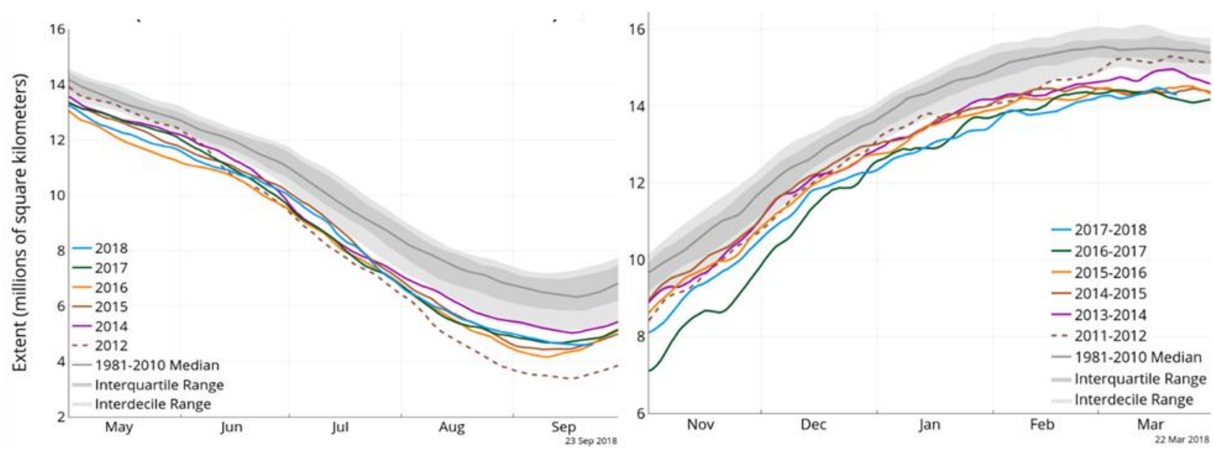
As a reflection on these findings (that apply a rough differentiation of types of ships), this paper further elaborates potentially relevant markets and commodities for which the NSR could be an alternative. It identifies potential impacts of NSR utilisation on global trade flows, the Arctic environment and climate change and regional economic development. Finally, it presents conclusions on the role that the NSR could play in the future.

# Context for Northern Sea Route utilisation

Global warming has different effects on different components of the earth's system. Important long-term changes for the maritime sector are occurring in the Arctic. The upcoming IPCC report on "climate change and oceans and the cryosphere" identifies a number of drastic changes in the Polar Regions due to global warming. Of these transformations, changing sea ice is the most relevant for maritime transport as it could reshape accessibility to the Arctic routes (IPCC, forthcoming).[1] Although the earth as a whole is slowly warming, the air temperatures in the Arctic continue to warm at almost twice the rate in comparison to the world average (Osborne, Richter-Menge and Jeffries, 2018). The effects of these temperature increases on the polar ice caps are already noticeable on Arctic sea ice conditions.

The Arctic Ocean and its sea ice are a dynamic system when it comes to sea ice extent and sea ice distribution. Arctic sea ice extends in winter and contracts in summer. The extent of the sea ice has decreased significantly in the past decades. For example, the extent of the sea ice remaining in the Arctic Ocean at the end of summer (in September) has been shrinking for the past 30 years (see the figure below). Furthermore, Arctic sea ice decline has been faster in the past ten years than in the previous 20 years (AMAP, 2012). The *lowest minimum extent* of the Arctic sea ice was on 17 September 2012, with an average of 3.39 million square kilometres (NSIDC, 2018a). The lowest *maximum extent* of the Arctic sea ice was on 7 March 2018, where the sea ice averaged 14.40 million square kilometres (NSIDC, 2018b).

Figure 1. Changes in Arctic sea ice extent in summer (left) and winter (right)




Source: NSIDC.org (2019).

Across the entire Arctic, the length of the sea ice melt season has increased by around 20 days since the 1980s and the Arctic Ocean is projected to become nearly ice-free in summer within this century, likely within the next thirty to forty years (AMAP, 2012).

Shipping is the biggest method (in tons and value) of transporting goods over the world. Globally, 90% of world trade in volume and 80% in value – and the overwhelming majority of trade between non-neighbouring countries – is carried by ship (Bekkers, Francois and Rojas-Romagosa, 2016). In 1869, the Suez Canal opened, allowing for direct passage from the Atlantic to the Indian Ocean. This new route, hereafter called the Southern Sea Route (SSR) and illustrated in Figure 2, reduced shipping distances by 23% compared to the Cape route via South Africa (Buixadé Farré et al., 2014).

Figure 2. Overview of the Northern Sea Route and the Southern Sea Route


Source: Bekkers, Francois and Rojas-Romagosa (2016).

With declining sea ice, the NSR will further reduce the distance for ships travelling between Europe and the Pacific by 40% compared to the SSR (AMAP, 2012). This potentially results in significant time savings of around 14 days compared to the Suez Canal (see Table 1).

Table 1. Time savings when transporting on the Northern Sea Route

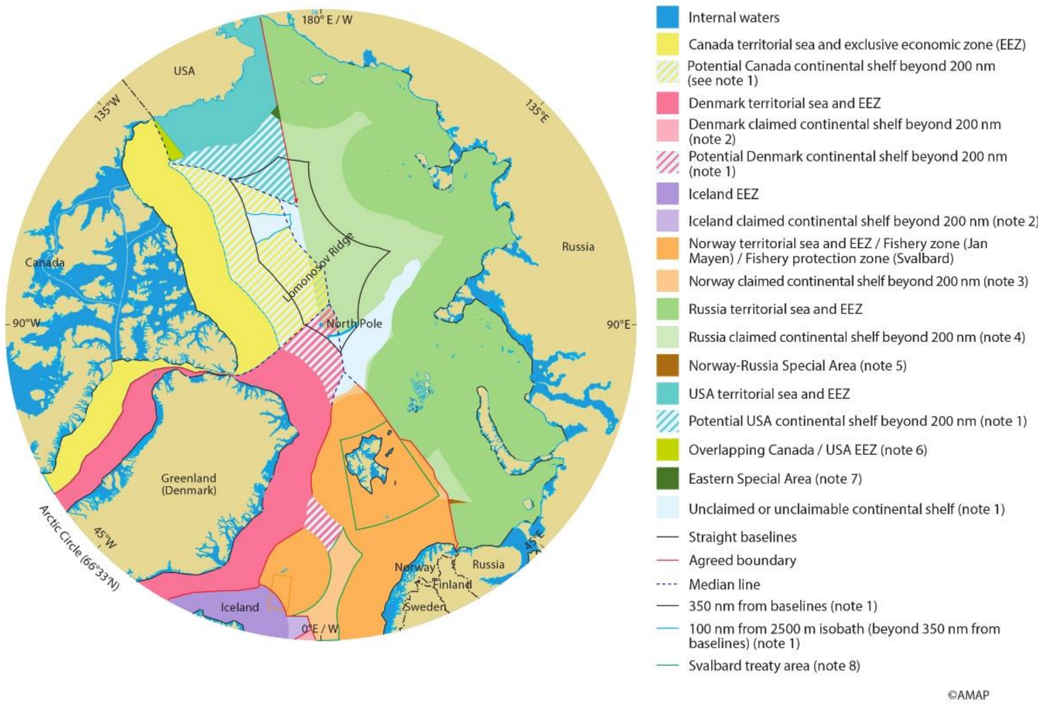
| Route | Trip from Hamburg to Yokohoma | | |
|---|---|---|---|
| | Distance (Nm.) | Speed (knots) | Travel time (days) |
| Suez Canal | 11.585 | 15 | 32 |
| Norhter Sea Route | 7.356 | 14 | 18 |

Note: Speed may depend on weather conditions.

Source: Rahman, Saharuddin and Rasdi (2014).

The opening of the Arctic provides economic opportunities, for example, in the field of resource extraction and shipping. These opportunities lead to a need to define who has the right to extract resources. By international law, nations can claim up to 370 km off its coast, known as the exclusive economic zone (EEZ).[2] Nations have the right to explore the waters and seabed within their EEZs, but not the surface, which is considered as international water. (Roston and Migliozzi, 2017) However, as the region is slowly melting, disputes arise as countries claim overlapping grounds (see Figure 3). Notable presences in the area are Russian and Chinese. Russia as an Arctic nation has been active in the region for decades, while China is preparing to heighten their stakes in the Arctic as it broadens its Belt and Road initiative for trade to include the Arctic.[3] Overall, the Arctic is submitted to a diverse range of stakeholders, each with different interests and strategies to their ambitions in the Arctic region.

Figure 3. Territorial boundaries and claims in the Arctic




Source: AMAP (2012).

## Regulatory context

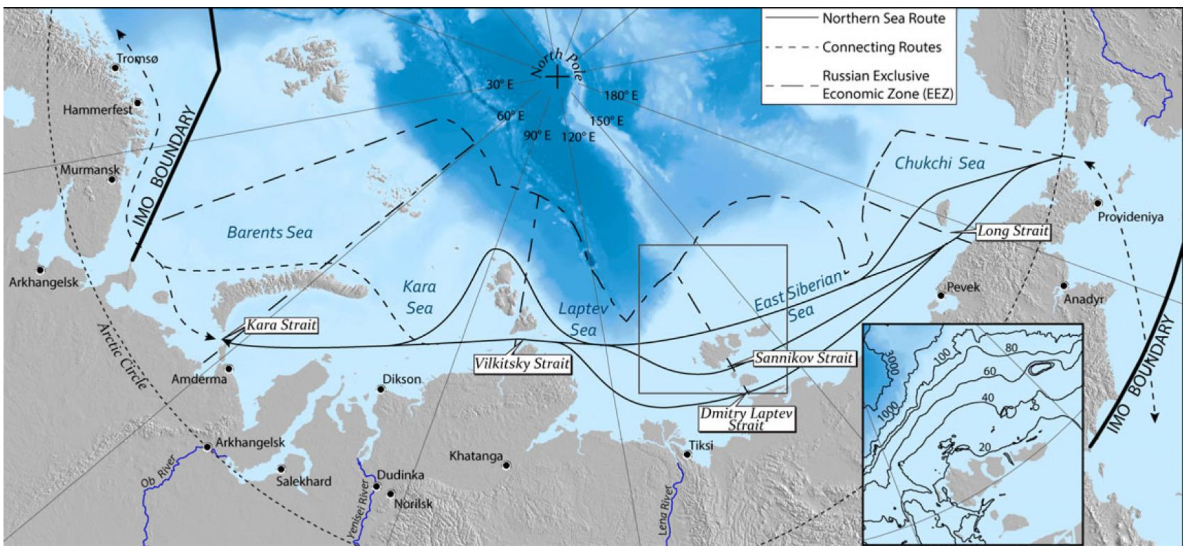
The United Nations Convention on the Law of the Sea gives coastal States "the right to adopt and enforce non-discriminatory laws and regulations for the prevention, reduction and control of marine pollution from vessels in ice-covered areas within the limits of the exclusive economic zone, where particularly severe climatic conditions and the presence of ice covering such areas for most of the year create obstructions or exceptional hazards to navigation, and pollution of the marine environment could cause major harm to or irreversible disturbance of the ecological balance. Such laws and regulations shall have due regard to navigation and the protection and preservation of the marine environment based on the best available scientific evidence" (UN, 1982).

Moreover, since January 2017, the Polar Code has been in place According to the Polar Code, nearly all ships with a gross tonnage over 500 tonnes that sail in the Arctic region should have at least a Polar Ship Certificate and a Polar Water Operational Manual. These documents include guidelines for lifeboats, vessel construction requirements, clothing, tools, survival packages, navigation devices, provisions, etc. The Code also addresses the anti-pollution rules. Any form of dumping chemicals is prohibited. In addition, the Code forbids dumping of sewage water, chemicals, plastic material and food remains.

# The case for the Northern Sea Route

The NSR is a series of sea routes connecting Northeast Asia with Northwest Europe through the Arctic Ocean. The total length of the NSR, measured, for example, from Rotterdam to Yokohama, is approximately 13 700 km. There are significant physical and infrastructural challenges to transport freight over the NSR (Buixadé Farré et al., 2014). The part of the route that predominantly constrains business is from the Kara Strait, along the Russian Arctic coast to the Chuckchi Sea (approximately 4 800 km in length).

Figure 4. Summary of the Russian maritime Arctic



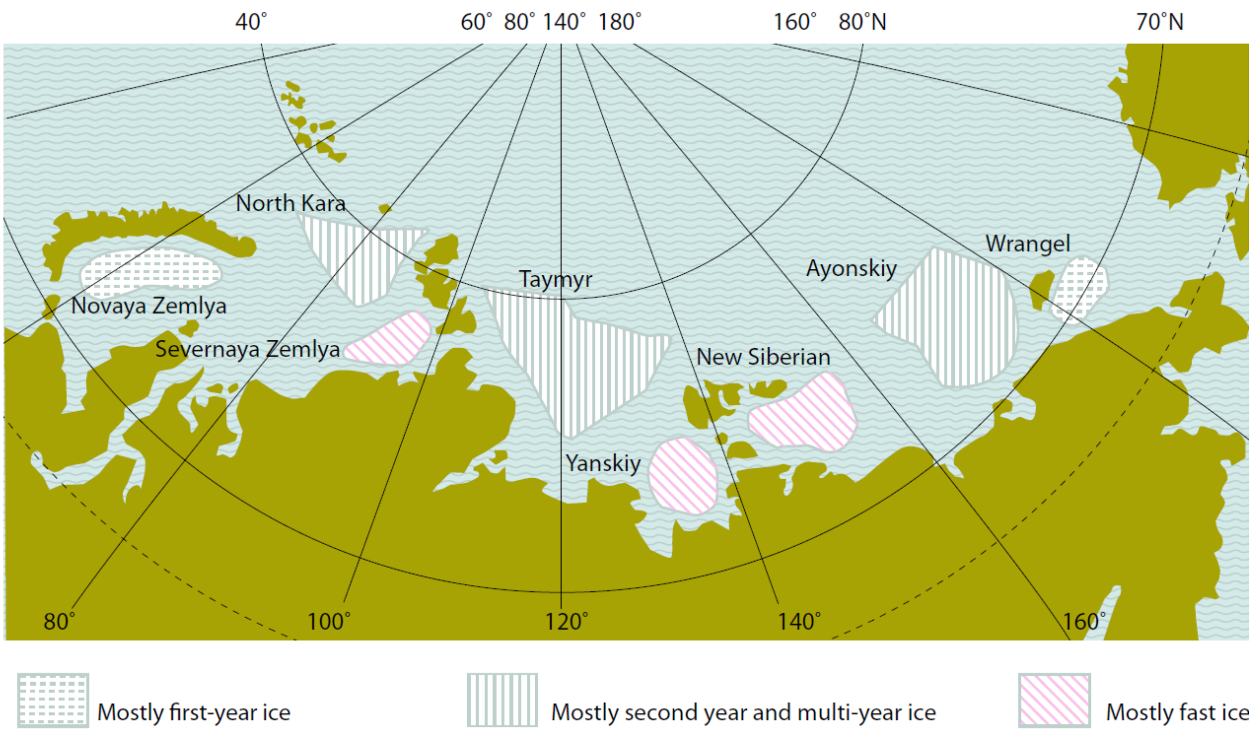

Source: adapted from Stephenson et al. (2014).

The sea ice levels in the Arctic Ocean are the main barrier to the commercial use of the NSR today. Yearly variations of sea ice are relatively unpredictable and need constant monitoring for navigation through the NSR in the limited navigation season. Furthermore, in the summer, the Arctic Ocean contains ice massifs, which are variable accumulations of pack ice that cover hundreds of kilometres. Ships encounter them regularly. These ice blocks are something to take into account as they block the route and present safety issues, especially when combined with the high probability of inclement weather conditions such as fog and extremely low temperatures that are typical for the Arctic Sea (OCIMF, 2017; Bekkers, Francois and Rojas-Romagosa, 2016). Therefore, even though an official route through the NSR exists, ships might not always follow the same route each time or are dependent on icebreaker convoys. The actual route, therefore, depends in part on the presence and thickness of sea ice.

While sea ice conditions generally get more favourable with southward distance from the North Pole, bathymetry restrictions tend to be more severe at lower latitudes. These bathymetry restrictions pose a constraint on shipping through the NSR for various ship sizes.

The continental shelves of the Russian Arctic are broad and shallow, creating limitations that restrict NSR route choice depending on ship type and load. Using Figure 4 for illustration, the bathymetry in large straits such as the Vilkitsky Strait (100-200 m) and the Long Strait (33 m) is not a problem for most vessels. The Dmitry Laptev and Sannikov Straits, south of the New Siberian Islands, are especially shallow at 6.7 m and 13 m respectively (Stephenson et al., 2014. The latter two are the most difficult straits to navigate for container and bulk ships. Ports along the coastal routes in this region have drafts up to nine metres (with 20 000 DWT cargo capacity, assuming a 30 m beam) whereas for bigger ships using the route to the north of the New Siberian Island may have up to a 12.5 m draft and carry approximately 50 000 DWT cargo. The northern route, however, brings ships closer to thicker sea ice.

Figure 5. Ice massifs along the Northern Sea Route




Source: OCIMF (2017).

All in all, there is a clear trade-off between vessel size and the navigation potential in the region. Ships carrying cargoes of more than 50 000 DWT will be more constrained than smaller vessels, with the larger ships operating fewer days as more northern routes become more ice-prone and farther from coastal support bases.

Added to this trade-off, the bathymetry and ice conditions together make the NSR east of the Kara Sea a complicated and extreme system with low predictability. A survey by Lasserre and Pelletier (2011) shows that the market is aware of these uncertainties.

The benefit of the NSR for commercial shipping is the travel distance and travel time from Europe to East Asia and vice versa. The NSR (at least under ice-free conditions) can potentially decrease costs and/or increase sales, as more trips can be made per year compared to the SSR. However, there are a number of challenges and investments for navigating the NSR. Principal among those are the bathymetry restrictions imposed by the NSR, as explained above. The lion’s share of the volume currently transported over the Suez is transported by ships that are too large (in terms of draft) to pass the Laptev or even Sannikov straits.

Given a specific ship size and bathymetry, the key driver for the attractiveness of the NSR is the cost-effectiveness for year-round operations. The main factors that affect the cost-competitiveness and/or profitability of the Arctic routes are below, building on literature reviews on the topic, notably Lasserre (2014) and Yumashev et al. (2017).

Firstly, before transiting the NSR, companies should evaluate the ship's capabilities to operate in the Arctic. Ships should be prepared to operate safely in extreme cold weather conditions. One of the biggest investments is in ice-capable ship classes with reinforced hulls. Ships with reinforcements are divided into different ship classes.[4] For example, Polar Class (PC) ships are better able to navigate ice-filled water than other classes and, therefore, have longer navigation seasons. The implication of this reinforcement is that initial capital investment and depreciation costs of vessels are relatively high. Literature reviews by Lasserre (2014) and Theocharis et al. (2018) show that most scholars reason that the capital cost premium for winterisation and ice class vessels are in the order of 20-30% higher compared to a benchmark vessel.

Profits from the use of the NSR need to recover both investments in ice-strengthening and lower fuel efficiency while sailing on the SSR outside of the NSR navigability window. The length of the navigability window is, therefore, the main factor and also the trend underlying the business case in ice-strengthening ships for NSR utilisation.

Fuel costs are an important cost factor when taking the NSR. Lasserre (2014) reviewed 26 studies that analysed the profitability of commercial Arctic shipping where he found fuel costs to be the largest single cost factor in every single model simulation. In addition to shorter travel distances, fuel cost depends on two important parameters: fuel type and fuel consumption rate.

Normal container and bulk ships use fuel type IFO 380. However, these fuels may not be suited for very cold temperatures. Specialised fuels may, therefore, be necessary but will likely be more expensive.

Various factors affect the fuel consumption rate. Firstly, shipping in the Arctic is slower because of the prevalence of thick ice in the winter, drifting ice and fog during the summer. A lower speed reduces fuel consumption rates drastically. In fact, ships will sometimes adopt slower speeds on regular waters for economic reasons, in which case it is referred to as "slow steaming". NSR shipping may not apply slow steaming for economic reasons, but will nonetheless achieve higher fuel efficiencies because of it. Literature reviews by Lasserre (2014) indicate that most studies suggest speeds that are in line with slow steaming (less than 18 knots). Conversely, an ice-strengthened ship is heavier and, therefore, less fuel-efficient, increasing fuel cost when sailing on the SSR outside of the NSR navigability window. In addition, unexpected sea ice conditions on the NSR may lead to localised rerouting and higher fuel expenditure.

Crewmembers navigating the Arctic, whether on a PC-class ship or a normal ship, require specialised training. When navigating near ice, it is recommended to have additional lookouts, helmsman for manual steering, manning the engine room and having a translator for communication with the Russian icebreakers (OCIMF, 2017). Cost increases in the range of 10% to 28% compared to normal container shipping over the traditional route are well accepted (Theocharis et al., 2018).

Navigation through one-year sea ice in the NSR requires escorts with icebreakers during certain parts of the year. It is likely that, with the ongoing trend of sea ice decline, ice-breaker escorts will only be needed at the start and end of the NSR season when ice concentrations are significant. Maintaining and operating an ice-breaker fleet incurs a cost, leading to an ice-breaking fee to shippers. Due to geostrategic and commercial reasons, Russia could also choose to vary ice-breaking fee levels in order to change the attractiveness of the Arctic routes.

The certain natural risks of the NSR discussed previously can heighten the risk premium. Among the factors considered for the risk assessment and thus the rate, are: the experience of the crew in Arctic shipping; the availability of rescue units; the distance to a port in case of damage; the ice class of the ship; and the prevalence of fog and ice along the route considered (Lasserre, 2014). For non-PC vessels, rates are likely to be costly, ranging from 50-200% higher than usual. Many other additional investments and costs are also needed, according to literature. These are, among others, patchy search and rescue capabilities, scarcity of relief ports along the route, ice radar and infrared cameras for ice detection (OCIMF, 2017; Bekkers, Francois and Roja-Romagosa, 2015).

The trend of sea-ice decline enables the NSR to facilitate higher volumes of commercial traffic. Several studies have looked at possible economic (and environmental) impacts of Arctic shipping. It is estimated that in the hypothetical situation without any navigability constraints in the Arctic, 4.7% of the world's future trade will reroute to the NSR (Riahi et al. (2017); O'Neill et al. (2017); Bekkers, Francois and Rojas-Romagosa (2016)). This includes traffic to and from a variety of origins and destinations, with varying time savings depending on the proximity of the NSR. The rerouted traffic equals two-thirds of the expected traffic otherwise taking the Southern Sea Route through the Suez Canal.

A paper written by Yumashev et al. (2017) is one of the more recent comprehensive assessments of economic and environmental benefits and costs of arctic shipping in scientific literature, with a realistic shift towards the NSR within their modelling approach. It illustrates most of the physical and financial challenges discussed in the present paper. Hansen et al. (2016) had already estimated ship owner's business case of investing in ice resilience to seasonally reroute to the NSR, taking into account the multiple restrictions, while Bekkers, Francois and Rojas-Romagosa (2016) assess what the traffic volume would be without any navigability constraints. Yumashev et al. (2017) combine these results, superimposing business restrictions on the work done by Bekkers, Francois and Rojas-Romagosa (2016), to model the traffic on the NSR over the next two centuries.

## Modelling approach and assumptions

The approach applied by Yumashev et al. (2017) for determining the shift towards the NSR is based on comparing the cost-effectiveness of year-round operations using ordinary vessels on the SSR versus ice-strengthened vessels operating on the NSR whenever possible and on the SSR otherwise (where the ice-strengthened vessels sail at a disadvantage). Furthermore, Yumashev et al. (2017) account for a variety of barriers, such as few ports and markets on the NSR compared with the SSR, limited navigability windows, year-on-year variations in season length, volatility of navigability within seasons, limited economies of scale, and more. Yumashev et al. (2017) also developed a simplified semi-empirical deterministic model overtime to translate representative concentration pathway (RCP) climate scenarios into navigability conditions.

Additionally, Yumashev et al. (2017) make important restrictions on fleet capabilities of passing through the Sannikov and Dmitry Laptev straits. Larger ships will use the more northern routes with no bathymetry restrictions but less favourable sea-ice conditions. Container ships are assumed to only sail in the so-called inner navigability window when uncertainty due to sea ice is reduced.

Table 2. Modelled bathymetry constraints based on shipping size and shipping type

| Ship size | Container | Non-container (tankers and bulkers) | Routes |
|---|---|---|---|
| Low cargo and size | < 2 500 TEU | < 50 000 DWT | Sannikov and Dmitry Laptev straits |
| High cargo and size | > 2 500 TEU | > 50 000 DWT | North of the islands |

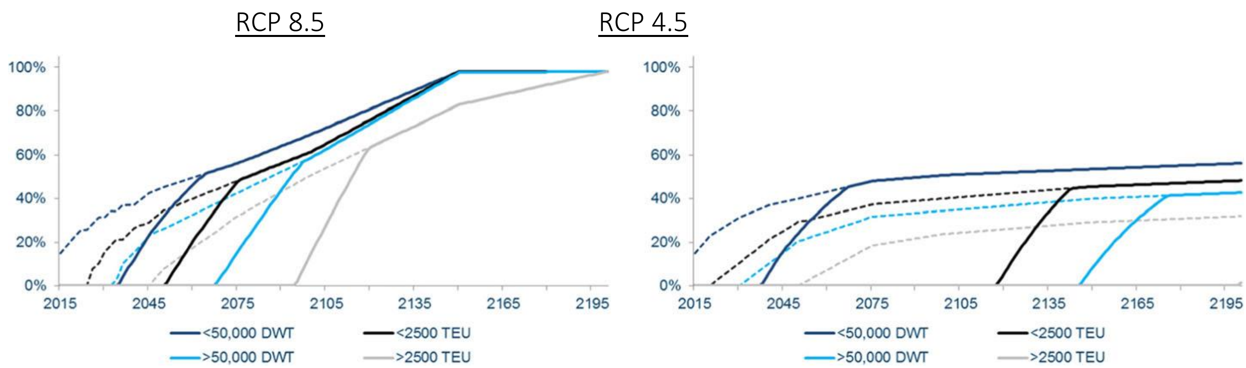
Source: adapted from Yumashev et al. (2017).

## Modelling results

Figure 6 describes and interprets the modelling results. The maximum traffic for the ships follow a nonlinear pattern as determined by the seasonal behaviour of declining sea ice. This decline is modelled as a function of time under RCP 8.5 and RCP 4.5 climate scenarios, differentiated by four types of ships.[5] The y-axes refer to the percentage of ships that have invested in ice-strengthening and take the NSR over the SSR, compared to the total number of ships that would take the NSR under the hypothetical case of year-round ice-free conditions (the "Full Navigability Assumption").

Figure 6. Norther Sea Route re-routing of four ship categories under RCP 8.5 and RCP 4.5




Source: Yumashev et al. (2017).

The following elements are important for the interpretation of this figure:

- Despite the increasing navigability due to sea ice decline, shipping companies are not going to invest in large-scale operations until profitability conditions are met. This is represented by the dotted lines versus the continuous lines, where the dotted lines represent the navigability window, and the continuous lines represent the actual utilisation based on business-case restrictions.
- The intersection of the continuous line with the X-axis is the so-called trigger point at which operations become profitable. This is the year where investments in ice-strengthening will take off, taking some 30 years before the fleet has been renewed.
- The light blue versus the dark blue and the light grey versus the black lines represent larger ship classes that cannot pass through the shallow straits. These lines represent the navigability window for taking a more northern part of the route by-passing narrow straits.
- The year at which the lines reach 100% shows when year-round navigability is expected for that ship class.
- The analysis applies stylised cases for potential rerouting where, in practice, more differentiation is introduced by the proximity of the NSR and related distance reduction versus the SSR.

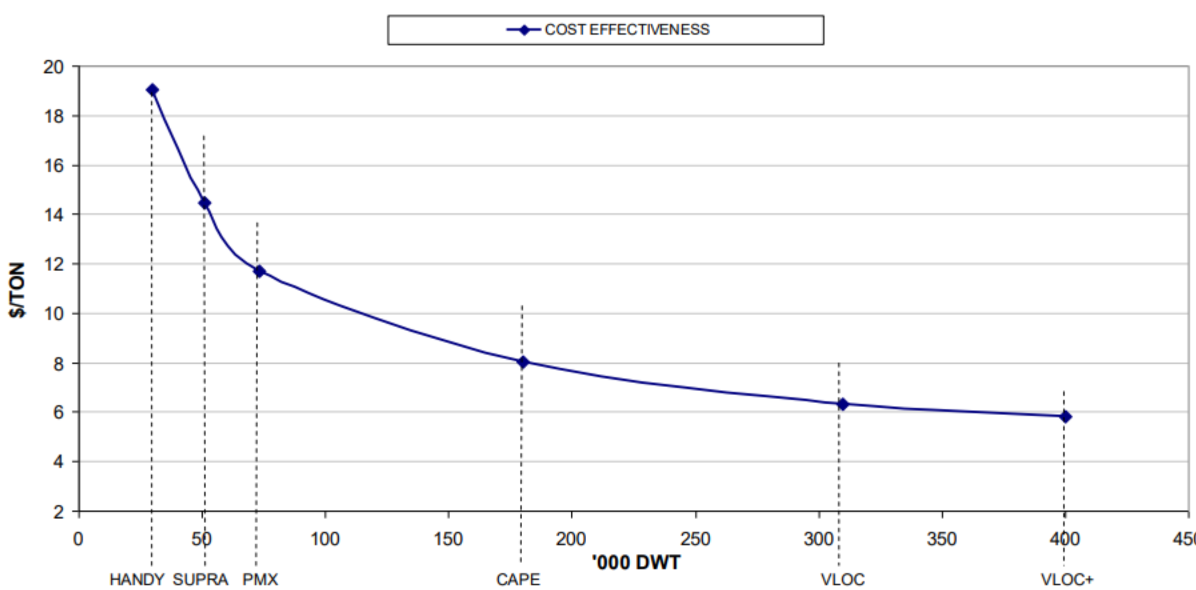
The RCP 8.5 scenario results show that the first route through the straights, where only "small" ships of 50 000 DWT/2500 TEU can operate, becomes profitable around 2035 for non-container ships and 2051 for container ships. This difference is driven by the tight time schedules in the business model of container ships, which are modelled to only take the NSR when limited assistance is required and navigability conditions are less uncertain. The second route, which bypasses the New Siberian Islands without tonnage restrictions, becomes profitable around 2068 for non-containers and closer to 2095 for containers.

The RCP 4.5 results show that, with less extreme climate change, the NSR will be utilised much later in the future, never with year-round operations and that the business case for rerouting will not become positive for > 2500 TEU container ships.

## Reflection on the business case for Arctic shipping

Investments in ice-strengthening introduce uncertainty and volatility in business results (depending on the navigability window) and dependency on the NSR's availability. Such investments can be classified as sunk costs, which a company needs in order to make the transit possible (e.g. ice class ship investment, higher fuel costs, crew training). In addition, fuel efficiency is lower than in vessels that are not ice-strengthened. This negatively affects the market power of NSR operators, making them prone to tariff regimes imposed on vessels sailing in NSR waters.

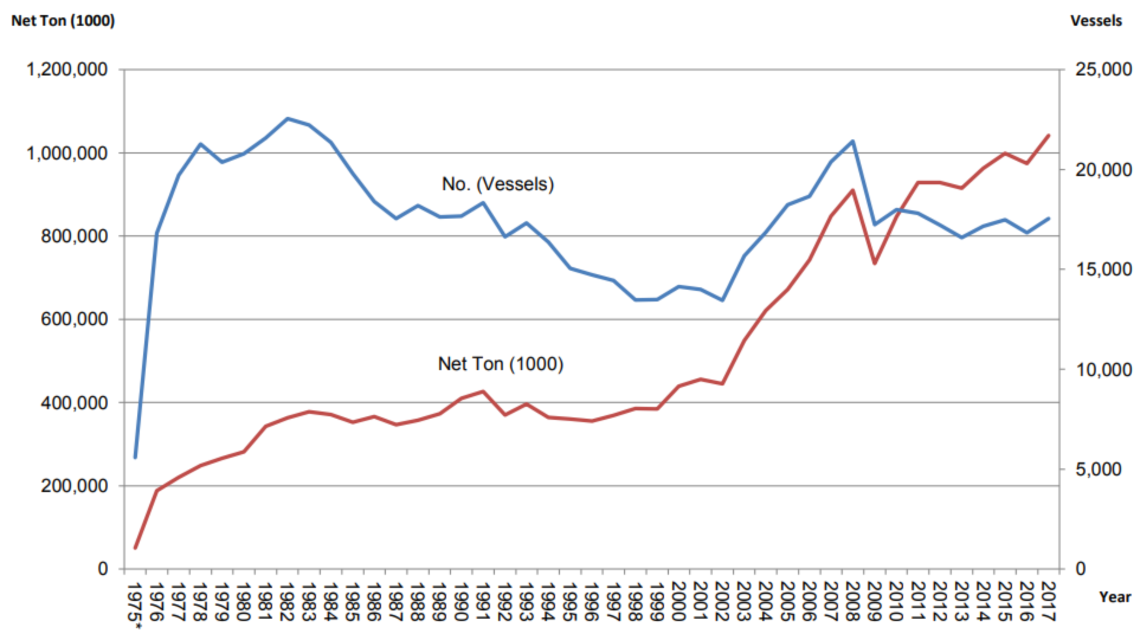
Figure 7. Cost-effectiveness of different size bulk carriers carrying ore from Australia to China




Source: Gratsos (2011).

Moreover, in a sector where economies of scale and just-in-time deliveries are vital for profitability, the limited ship trade volumes due to physical conditions are among the biggest constraints for making Arctic shipping possible on a large commercial scale. Shipping can be divided into two broad categories: non-containers (tankers and bulkers) and container shipping. The cost-effectiveness (EUR/TEU or EUR/DWT) for both types of shipping varies by the size of the ship. Bulk carriers have to compete with the larger Suezmax ships, which cannot be deployed on the NSR, but offer a substantially lower cost per tonne-kilometre (tkm). Figure 7 depicts diminishing costs/tkm related to the size of a bulk ship. For example, a draft limit of 13 meters at the Sannikov Strait for a bulk ship coincides with approximately the Supramax size (i.e. 50 000 DWT), which has almost a double cost/tkm compared to the Suezmax (up to 200 000 DWT). These differences in economies of scale will further increase, as can be observed in Figure 8, showing that the number of vessels passing the Suez Canal in the last four decades remains rather constant (around 17 500), while the net tonnages passing the canal have sharply increased (roughly five times, from 200 000 net tonnes to more than one million net tonnes). This suggests that the smaller ship classes that can sail the shallow parts of the NSR will not be able to compete economically on price with Suezmax-sized traffic, despite shorter travel times.

Figure 8. Annual net tonnages and number of vessels passing the Suez Canal




Source: Suez Canal Information Center (2017).

The same holds for container ship economics, as is demonstrated in the table below. Costs per TEU decrease significantly with the ship's capacity. Larger ship capacities require deeper drafts since capacity is a function of weight and that weight influences buoyancy. Therefore, bathymetry is a constraining factor in the maximum amount of a ship's capacity. For instance, Yumashev et al. (2017) restrict ship size in the Sannikov Strait to a maximum of 2 500 TEU in their business model. This means that taking the NSR can potentially have higher costs per TEU per day compared to the SSR. In addition, strong uncertainties regarding the ice-free window can be difficult for container ships, which usually have time-sensitive cargo.

Table 3. Costs per TEU per day at sea for container ships, according to capacity

| Total shipping capacity (TEU) | Price per TEU (USD) |
|---|---|
| 12 500 | 12.43 |
| 18 000 | 10.99 |
| 22 000 | 10.04 |
| 24 000 | 9.57 |

Source: ABB.com (2019).

## Historical traffic on the Northern Sea Route

In 2011, traffic volumes on the NSR equalled 111 000 tonnes. At the time, the main transported commodities were hydrocarbon liquids[6], oil, fish and some general cargo (Gunnarsson, 2013). In the last eight years, traffic volumes have increased from 111 000 to around 10.2 million tonnes in 2018. While the traffic growth has been substantial, the traffic volume transiting through the NSR is still a small fraction of domestic destinational shipping in the same area. For instance, in 2018 transit traffic counted for about 500 000 tonnes (the highest number since 2013) of the total 9.7 million tonnes transported on the NSR (Humpert, 2018a), which translates into only 5%. This shows that the NSR is still a trading route for local niche markets.

Historically, there has been a clear distinctive pattern between east- and westbound services on the NSR. The majority of vessels sail from east to west and deliver their cargo in the European ports. Only a few are also travelling back on the NSR, which causes a high rate of ballast journeys (Humpert, 2014). Therefore, in contrast to routes through the Suez and Panama Canal, the NSR has been more of a one-way route.

## Main commodities transported over the Northern Sea Route

The majority of currently transported commodities on the Arctic are oil products, liquefied natural gas (LNG) and general cargo (i.e. containers and project cargo). The main types of vessels active on the NSR are tankers, bulkers, trawlers or fishing vessels and general cargo vessels. The following commodities are briefly described and practical examples are given:

- general and project cargo
- oil products and gases
- passenger transport.

General cargo (also called break bulk cargo) is transported by a multi- or single-purpose vessel, which is capable of carrying containers, crates, boxes or barrels. To ship goods on the NSR, these vessels need a substantial initial investment of around 20% to 30% higher compared to a benchmark vessel (Yumashev et al. 2017), and will also incur higher operational costs.

Next to COSCO, Maersk, MOL and Teekay are looking into new ways of travelling from east to west. Maersk is even the first carrier that has sent a container vessel along the route, the Venta Maersk.

### Case: Container transport - The Venta Maersk has completed a trial passage on the Northern Sea Route

One of the world's leading container carriers is testing transport on the Northern Sea Route. The Venta Maersk completed a full transit on the Northern Sea Route on 28 September 2018. The Venta Maersk is one of the new Baltic feeders in a fleet of seven. They are designed to operate in water temperatures as low as -25 °C, are capable of carrying around 3 600 TEU and have a capacity of 600 reefer plugs.

On 22 August 2018, the Venta Maersk set sail in Vladivostok. Before heading through the Bering Strait, the route stopped in Busan and Vostochny Stevedoring Company. The voyage took 37 days to complete. Maersk used this trial passage to test systems, crew capabilities, and the support setup and to gain operational experience in the conditions on the NSR.

According to Palle Laursen, Maersk's Chief Technical Officer, Maersk does not see the NSR as a competing alternative to other east-west routes. Currently, the passage is only accessible for around three months a year. However, this could change in time (Chambers, 2018).

### Case: Project cargo - Heavy lift shipping on the Northern Sea Route

In the last couple of years, multiple project cargo shipments have been transported via the Northern Sea Route. Project cargo shipment is transportation of large, heavy, often high-value equipment, critical to the projects they are intended for. In 2017, Hansa Heavy Lift transported the first ship-to-shore cranes through the NSR, via the port of St. Petersburg to the port of Vostochny (JOC, 2017). In another example, BigLift arranged transportation of parts for the Pioneering Spirit (the world's largest construction vessel) from China to Rotterdam. The vessel using this route, the BigLift Barentz, was specifically designed for these polar conditions. (Port of Rotterdam, 2018) Lead-time and on-time delivery are very important determinants for project cargo. Saving days (up to 40% compared to the Southern Sea Route) could provide substantial cost benefits. However, sailing through the Arctic also means that travel times are not always known in advance.

### Case: Oil products or gases, Yamal LNG Project

Tankers spend on average 14.7 days on the NSR and carry around 30 000 tonnes of chemicals. The Port of Sabetta handled 17 million tonnes of cargo in 2018 (Staalesen, 2019). In 2030, the export volume is expected to reach 50 million tonnes. A major part of the Port of Sabetta is the Yamal LNG project (Ship Technology, 2012).

LNG – to a large extent, the Yamal LNG Project – is an important export commodity (Humpert, 2014). The Yamal LNG project involves the development of the South-Tambeyskoye field (with a gas reserve of 1.3 million $m^3$) and the construction of a gas liquefaction plant. This project is a joint venture between Novatek (80%) and Total (20%). Europe is LNG's main export market. A majority of the voyages goes primarily to Western Europe (Montoir, France and Rotterdam, Netherlands). A voyage to Western Europe (including loading and unloading) takes around 24 days.

### Case: Passenger traffic - Cruises on the Northern Sea Route

A new sea cruise business has emerged on the NSR. In 2018, the MS Bremen sailed westwards from Nome, Alaska in the United States to Bergen, Norway. In the summer of 2019, The Silver Explorer sailed the entire Northern Sea Route passage (Portnews, 2019).

Previously, Russian icebreakers and research vessels dominated passenger traffic on the Northern Sea Route. However, the future of the Arctic seems promising. Over the next four years, around 28 new cruise ships will be released on the market. This new fleet has a higher ice-class and is capable of offering voyages deeper into Arctic destinations.

The expected rise in passenger traffic also affects the Arctic regional ports. Ports and countries like Longyearbyen, Norway; the Russian archipelago of Franz Josef Land, Iceland, Greenland, Canada and Alaska might get a bit more crowded during the summer period. (Nilsen, 2018) Cruising on the Arctic appears to have become a growth market, though volumes are very modest compared to the traditional cruise markets.

# Impacts of using the Northern Sea Route

The NSR is expected to compete with alternative routes. Below is a brief description of competing routes and a discussion of how the NSR might fare with these routes.

## Suez Canal

The main shipping route between Asia and Europe is the Suez Canal route, also known as the Royal Route. In 2017, 17 550 vessels passed through the Suez Canal (a daily average of 48 vessels). They transported a total of 1 billion net tonnes. The average travel time of sailing from Asia to Europe is roughly equal to 38 days.

## Taking the train: Belt and Road Initiative

Two main train routes head from East to West: the northern route (via China and Russia to Europe) and the southern route (through China, Kazakhstan and Russia to Europe). Both routes travel through approximately six different countries. Despite such difficulties as extreme temperatures, security along the route and different widths of tracks, there are clear advantages to transport by train, like lower $CO_2$ emissions and a lead-time of around 20 days. The reduced lead-time also lowers inventory costs. Since the beginning of the Belt and Road Initiative (BRI) – formerly known as One Belt One Road – the number of annual trains has risen to around 6 000 in 2018 from practically zero (EP, 2019).

## Comparing the Northern Sea Route with alternative routes

For every network, the cost (related to the distance), travel time, speed, and capacity have to be determined. When comparing these networks, both the Northern Sea Route and the Trans-Siberian Railway, for example, provide time savings of 14 and 12 days respectively over the Southern Sea Route (SSR). The choice of network will depend primarily on the following factors.

First, the profitability and attractiveness of the NSR depend largely on the fuel price and consumption. Depending on the fuel consumption, carriers may opt for "(super) slow steaming" to reduce fuel costs. The slower speeds would make a shorter route all the more attractive, thus increasing the profitability of the NSR.

Second, the majority of intercontinental voyages and shipments are liner services. They follow a fixed route. These services are scheduled well in advance and strive for a just-in-time delivery. Travelling the NSR might be complicated, as the ice-free conditions are not stable. As such, the uncertain accessibility and thereby unreliability of the NSR due to unstable weather (i.e. wind, visibility constraints, fog, drifting ice) is an important determinant for carrier route choices.

Shippers prefer to establish liner schedules in advance. In addition, they use multiple ports along that set route. These ports are well connected to the hinterland by inland transport (e.g. rail and road). Compared to the Arctic region, these markets are more developed.

Finally, using the SSR offers logistical advantages the NSR cannot, as there is a whole network of terminal, hinterland transport and logistics services along this sea route that does not exist and can likely not be replicated along the Northern Sea Route. This applies to containers, not bulk cargoes, which have more direct connections between origin and destination. Some of the regional development consequences of this are further explained below.

While the Northern Sea Route and the Trans-Siberian Railway are alternatives offering long-term potential, they currently do not threaten the Southern Sea Route significantly in the foreseeable future. That said, depending on the flux of fuel prices in the future, reliability of the NSR and development of the regional market, the Arctic route could become a real alternative for certain niche markets.

## Environmental and climatic impacts

There are numerous hidden climatic and environmental costs that result from increased emissions in the Arctic region (Yumashev et al., 2017), despite the potential net economic benefits of Arctic shipping. Gross gains from using the NSR in the RCP 8.5 scenario are USD 6.5 trillion in net present value (NPV). These gains are offset by climate losses (from $CO_2$ emissions and short-lived pollutants) that account for USD 2.15 trillion (Yumashev et al., 2017).

Increased radiative forcing from short-lived climate forcers (SLCF) such as black carbon is a key driver for the estimated climate losses.[7] The shipping industry has traditionally relied on heavy fuel oils (HFOs) that belong to some of the most polluting fossil fuels and generate a broad spectrum of emissions. The net effect is an increase in radiative forcing and thus global warming. Although there is a decreased fuel consumption, GHG-equivalent savings are offset by a higher environmental impact per unit of emissions in the Arctic context. Yumashev et al.'s (2017) model run highlights the importance of SLCFs. It shows that 98.3% of the climate losses (USD 2.15 trillion) is due to SLCF shipping emissions. This underlines the importance of the impact of short-lived pollutants like black carbon and sulphate aerosols into climatically sensitive areas such as the Arctic.

These numbers will vary depending on the extent of regulation imposed on the sector. While the analysis includes long-term fuel efficiency trends, emissions per unit of fuel consumption have been assumed to be constant. For example, climate forcing could change if the IMO2020 regulation and possible further steps thereafter on cleaner emissions were fully implemented. This is notably the case in RCP 2.6 and RCP 4.5, where climatic impacts caused by Arctic shipping would be lower.

Gains and losses are distributed unevenly over different regions. Regions that experience economic gains are not necessarily those that suffer environmental losses. For example, while net economic benefits are expected for global shipping, the local Arctic environment can be drastically negatively impacted. The remoteness of the NSR and its delicate ecology mean that the environment might be impacted disproportionally compared to other ecosystems. Due to its remoteness and infrastructure, environmental risks like oil spills are difficult to stop and can, therefore, have a significant impact on local ecosystems. Future shipping operations should consider these risks and should, where possible, mitigate them. For example, some of the main risks can be substantially reduced by the choice of fuel and the location of bunker tanks in the ship (OCIMF, 2017).

## Regional development consequences

Another impact of the Northern Sea Route is felt by regional ports and the Arctic market. Aside from being a new gateway from East to West, multiple analysts and researchers look to the Arctic regions (and neighbouring regions) as potential players in emerging markets.

The Russian ports in the Arctic handled 92.7 million tonnes of cargo in 2018. Around 70% of that cargo is oil products and LNG (Staalesen, 2019). Active seaports in the region are Port Novy, Arkhangelsk and Sabetta. The largest port in the region is Murmansk, handling more than 60% of the total volume.

The Port of Murmansk is located in an inlet of the Barents Sea. It lies around 100 km from the border between Russia and Norway. The port remains accessible throughout the year and is well connected to the Russian hinterland (especially St. Petersburg) by rail, road and air. From 2004 onwards, the port invested in a new oil, coal and container terminal. These new facilities should enhance annual throughput, rising from 28.5 million tonnes in 2010 to an estimated 65 million tonnes by 2035 (Portnews, 2020).

According to Murmansk Governor Grigory Straty, Murmansk should soon be the main Arctic container port, as it has the best geographical location (Staalesen, 2016). Neighbouring port Arkhangelsk also aims at being a container port. All in all, transit shipping might very well strengthen the position of these ports along the Arctic passage.

Scandinavian countries are also seeking business opportunities in the “Polar Silk Route”. Norway and Finland have played with the idea of an Arctic railway between Kirkenes, Norway and Rovaniemi, Finland. A new Arctic railway could create a network of connected ports along the sailing route in an important determinant in a potentially expanding market (Mehta, 2018).

China also sees opportunities in developing the NSR and the role Scandinavian countries might play in it. In 2017, President Xi Jinping visited Finland and strengthened the collaboration between Finland and China. Since, Chinese and Finnish actors have been looking for concrete investments and co-operation. However, at the moment, there are only a couple of co-operated investments.

# Conclusions

Shipping is the one biggest method (in tonnes and value) of transporting goods over the world. Globally, 90% of world trade in volume and 80% in value – and the overwhelming majority of trade between non-neighbouring countries – is carried by ship. In 1869, the Suez Canal opened, allowing for direct passage from the Atlantic to the Indian Ocean, thus reducing shipping distances by 23% compared to passing the Cape of South Africa. However, due to the changing temperatures in the pole area, the Northern Sea Route (NSR) becomes more and more accessible.

The expected economic gains that can be made in the Arctic creates pressure and a need to define who has the right to extract resources. International law allows for nations to claim ownership of up to 370 km of seabed off their coasts (known as the EEZ). Nations have the right to explore the waters and seabed within their EEZs—but not the surface, which is considered international water.

Russia and China are the most notable presences in the NSR area. Russia as an Arctic nation has been active in the region for economic and political reasons for decades. In addition, China is preparing to heighten its stakes in the Arctic as it broadens its Belt and Road Initiative for trade to include the Arctic.

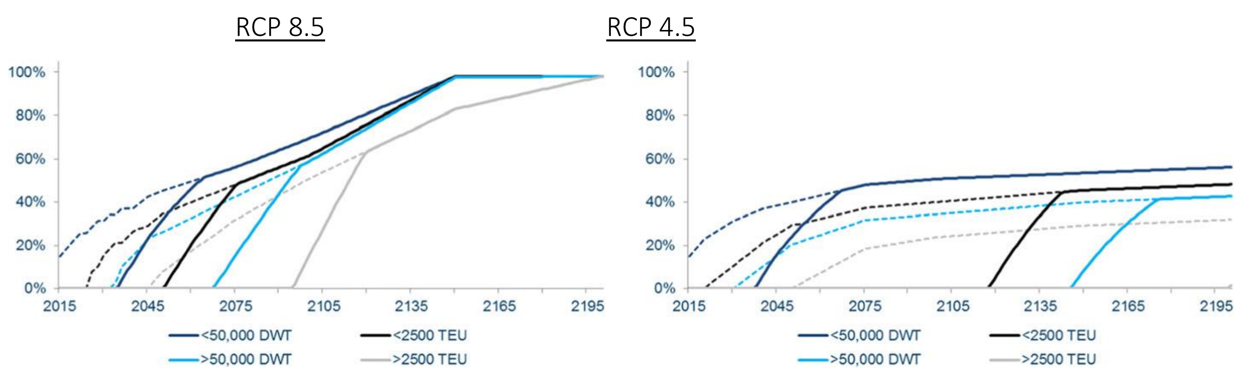
Overall, the Arctic is submitted to a diverse range of stakeholders, each with different interests and strategies to their ambitions in the region. The UN Polar Code imposes strict regulation for users of the NSR, requiring that they apply proper safety and environmental precautions to the vessels that will be deployed on the route.

Currently, the NSR is only safely navigable for polar-class vessels during some summer months when the route is more or less ice-free. However, there is broad agreement that sea ice will continue to break apart and melt throughout this century. This trend implies that the extension of the ice caps will be reduced considerably in the near future. This reduction will offer a wider window of usage of the Arctic Ocean, thereby making it possible for the NSR to accommodate higher volumes of commercial traffic.

The transpolar sea route across the Arctic Ocean will reduce the distance for ships travelling between Europe and the Pacific by 40% compared to the Southern Sea Route (using the Suez canal). The NSR (at least under ice-free conditions) can potentially save ships significant fuel and crew costs, resulting in overall cost savings compared to deploying the same ship on the SSR. And, assuming similar speeds, this might, besides these cost savings, also result in significant time savings of around 14 days compared to the SSR using the Suez Canal.

It has been estimated that in the long run, *without any navigability constraints*, up to 4.7% of the world's future trade, which is two-thirds of the expected traffic otherwise going through the SSR, might be rerouted through the Arctic.

Figure 10. NSR rerouting of four ship categories under RCP 8.5 and RCP 4.5




Source: Yumashev et al. (2017).

However, maritime route choice does not depend on the nautical distance alone. There are many criteria used by shipping lines when deciding what type of vessel to deploy and on what route. Generally speaking, the following main criteria come into play: 1) nautical distance; 2) the ship's construction type (investment in USD/tonnes DWT depends on the nautical environment in which the vessel has to operate); 3) vessel size that can be used on a specific nautical route; 4) safety conditions on the route; 5) availability of the route throughout the year (predictability, reliability); and 6) other costs added to the trip (toll, ice breakers, etc.). The final route choice is made after assessing all the criteria in conjunction.

The first NSR trajectories that will open in the near future also offer the most limited drafts. For the next four decades, only much smaller (therefore, more expensive in USD/tkm) vessels can use the NSR compared to the SSR. This will greatly reduce the attractiveness for large volumes, both for container and bulk trades. It is only when more polar trajectories become available that the NSR comparison with the SSR becomes more favourable. However, this might take another 50 to 130 years. In addition, the physical safety conditions (for vessels and crews) and reliability are less favourable for the NSR.[8]

The tariff setting of canals shows that pricing strategies are clearly linked to the alternatives (for SSR, the alternative would be rounding the Cape, actually done by, for example, VLCCs). One can expect, then, that the Suez Canal tariff on the one side and the tariffs charged by Russian icebreakers and other services on the other side to be closely balanced, each at optimising their respective market shares, while maintaining an overall price level lower than the third alternative, i.e. the Cape route.

Based on the above, the NSR is expected to remain a much studied, but much less used, nautical sea route in the next four decades. This said, there will likely be an increasing number of transits and local sea trips in the NSR area, with relatively small vessels, and aimed at niche markets (local project cargoes). This may gradually transform into transit shipping, where already ice-strengthened ships provide ad hoc high-value short delivery time services. This can pave the way for small size bulk shipping, which will likely materialise sooner than container shipping. Under the most extreme RCP 8.5 climate scenario (quickest warming scenario), NSR transit operations of < 50 000 DWT ships could start to become profitable after 2035. However, for several decades these volumes will only marginally eat away some of the much more voluminous vessels using the SSR. Substantial bulk volumes might only take off around 2070 (in RCP 8.5), and may even take more than a century in the RCP 4.5 scenario (this scenario is compatible with Paris 2050 objectives). For voluminous container traffic, the commercial chances are even smaller and only achievable much later.

The earlier mentioned 4.7% of world trade using the NSR (in the long run, assuming full year-round navigability of the NSR) will remain hypothetical within this century, and might only be reached by the year 2200 under the most extreme climate scenario.

The environmental impacts of the increased use of the NSR are not one dimensional:

- GHG-equivalent savings are offset by a higher environmental impact per unit of emissions in the Arctic context, despite a decrease in fuel consumption
- the reduced trade distances increase industrial productivity, leading to an increase in absolute GHG emissions
- gains and losses are distributed unevenly over different regions. Regions that experience economic gains are not necessarily those that suffer from environmental losses.

If expectations on the modest amount of vessels that will use the NSR are going to be realised (due to current usability restrictions and inferior business conditions compared to the SSR alternative), the actual emission damages in the next few decades might be fairly modest.

# Notes

1 https://www.ipcc.ch/site/assets/uploads/2018/04/Decision_Outline_SR_Oceans.pdf.

2 Source: https://stats.oecd.org/glossary/detail.asp?ID=884.

3 The BRI was launched by President Xi jinping in 2013 and comprises China's effort to improve connectivity on a trans-continental scale. Source: https://www.beltroad-initiative.com/arctic-policy/.

4 Lloyds Register is among the classification societies who assess ships specially built for polar operations. For example, see www.lr.org/en/polar-code/.

5 The Representative Concentration Pathway (RCP) scenarios reflect a range in potential warming in the year 2100, expressed as radiative forcing values (in $W/m^2$) in the year 2100. Four RCP scenarios have been developed: RCP2.5, RCP4.5, RCP6.0 and RCP8.5. RCP4.5 was applied included in the analysis by Yumashev et al. (2017) as it was at the time considered to be more or less correspondent to the Paris Agreement (Salawitch et al., 2017). RCP8.5 was applied as it reflects emissions that will keep on rising based on historical trends.

6 Hydrocarbon liquids is a gas condensate.

7 Radiative forcing is the difference between sunlight absorbed by the earth and energy radiated back to space. Positive radiative forcing means that the Earth receives more incoming energy from sunlight than it radiates to space; this net gain of energy will cause warming.

8 Although the piracy risks might be lower.

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International Transport Forum

# Commercial Navigation Along the Northern Sea Route

This report assesses the business case for commercial navigation through Arctic waters along the Northern Sea Route and offers insights in the possible impacts on global trade flows.

All resources from the Roundtable on Future Maritime Trade Flows are available at: www.itf-oecd.org/future-maritime-trade-flows-roundtable.

Published: 11/2020 | Photo credit: Aun Photographer/Shutterstock

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