The Northeast and Northwest Passages in global trade

Opportunities, risks and geopolitical dynamics of a melting world region

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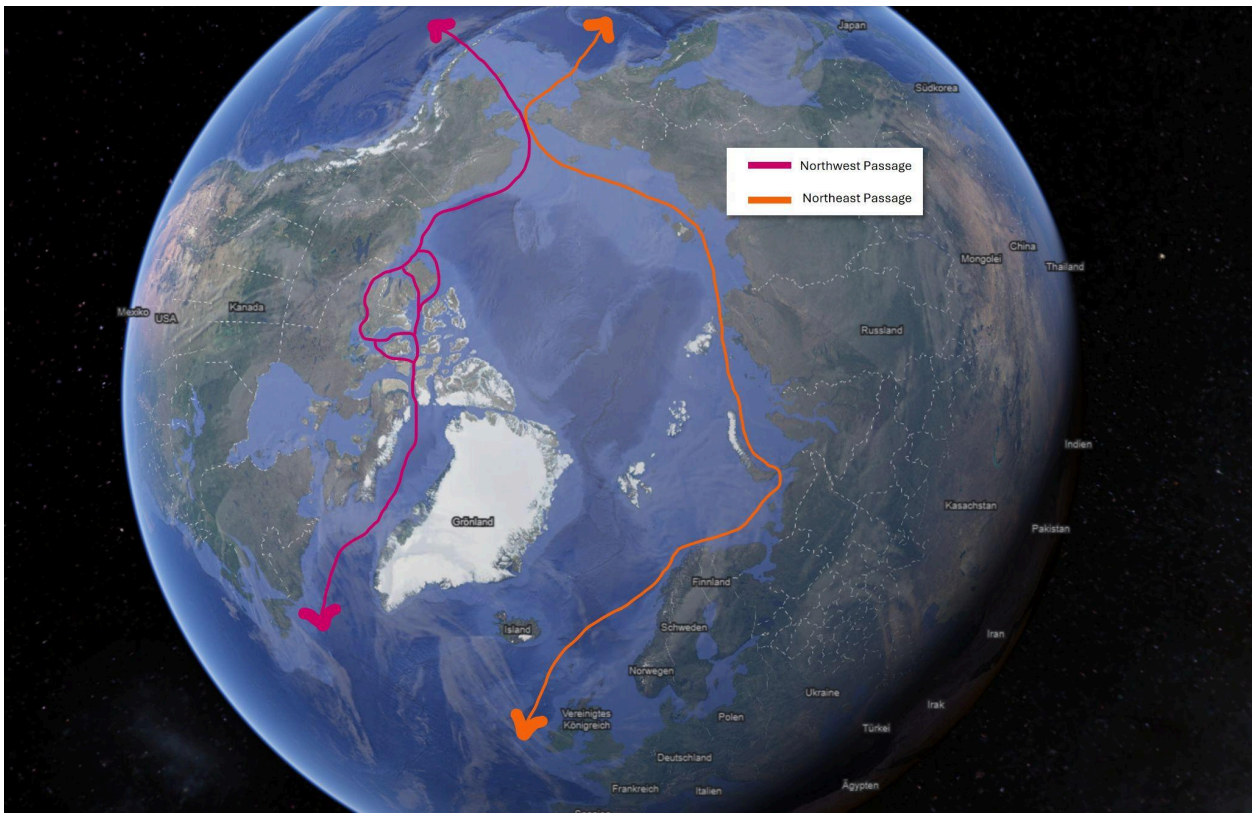

Map of the Arctic with the most important polar passages: ***Northwest Passage*** *(purple) through the archipelagos of Canada and* ***Northeast Passage*** *(orange) along Russia. The routes shown illustrate the potential shortcut between Europe and Asia through Arctic waters.*

Executive Summary

The Northeast and Northwest Passage in global trade: Opportunities, risks and geopolitical dynamics of a melting world region

The Arctic is at the tipping point of global infrastructure development. As the ice melts continue, the Northeast Passage (NSR) along the Russian coast and, in the future, the Northwest Passage (NWP) through the Canadian archipelago are gaining massive geopolitical and economic importance. The NSR in particular will develop into a reliably seasonally usable route between Europe and Asia as early as the 2030s - with potential savings of up to one million US dollars per transit. At the same time, a new strategic coordinate system is emerging: Russia is consolidating its influence on Svalbard, the USA is establishing Greenland as a hub for military and digital infrastructure. The Arctic is thus becoming an operational extension of existing great power conflicts - not abstractly, but concretely visible in ports, fishing fleets and fiber optic cables.

The economic usability of the Arctic sea routes remains highly differentiated. While the NSR is becoming increasingly attractive for project-based bulk freight transport, the NWP remains a strategic future project for the time being due to climatic, legal and logistical hurdles. At the same time, infrastructural reinforcement areas are being created along the new trade axes - such as Kirkenes, Finnafjörður or Barentsburg - whose control will in future extend far beyond logistical relevance. The legal order, however, remains incomplete: important passages are subject to competing sovereignty claims. Without international agreement, there is a risk of an increase in legal gray areas - with subsequent economic, ecological and security policy costs.

The ecological price remains high. The development of the Arctic is both a symptom and a driver of climate change. Without robust governance, binding emissions standards and regionally anchored protection regimes, fragile ecosystems could be irreversibly damaged - with global feedback effects.

Core recommendation:
The international community must act now. A coordinated Arctic strategy that combines technological modernization, economic resilience and geopolitical de-escalation is required. Without this regulatory framework, the Arctic will not become the new trade hub - but rather the next strategic conflict zone in the multipolar world order.

Current use of Arctic routes

Traffic volume: Trade via the Arctic sea routes is currently still comparatively low. Although freight volumes on the Northeast Passage have increased significantly in recent years, they remain modest compared to world trade. In 2023, around 36.2 million tons of goods were transported there - a historic high. For comparison: the global seaborne trade volume was around 12.3 billion tons in 2023, meaning that the NSR contributed less than 0.3% to global sea transport. A large part of the NSR supply consists of oil, gas and minerals from Arctic production sites; Over half of the 36 million tons in 2023 were liquefied natural gas (LNG) alone. In contrast, the Northwest Passage has so far played little role in freight traffic. Only a few dozen transits take place there each year, often expedition yachts, cruise ships or supply trips for communities. In 2023, a total of 41 complete transits of the Northwest Passage were recorded, including 13 by commercial cargo ships. For comparison: The Suez Canal was crossed by over 20,000 ships in 2023. It turns out that the Arctic routes are currently *Niche corridors* which are primarily used by the raw materials industry and special applications.

Type of goods: The types of goods on the Northeast Passage differ from the usual container trade. Raw materials are mainly transported there. Regular LNG exports from the Yamal gas project in Siberia take place both to Europe and seasonally to Asia. In addition, Russian petroleum, ore concentrates, coal and wood are shipped via the NSR. Transit trips - i.e. through traffic between Europe and East Asia - only make up a small part (around 2.1 million tons in 75 transit trips in 2023).

These transit freights recently consisted primarily of Russian oil for China as well as occasional project cargoes (e.g. heavy plant components).
The Northwest Passage is currently used almost exclusively for local purposes: supplying remote communities in Canada and Alaska (such as fuel deliveries), small volumes of raw material transport from mines, as well as adventure travel and cruises. In 2022, for example, For example, only 8 cargo ships pass through the Northwest Passage, some with general cargo such as wood pulp or components for projects. There is currently no significant regular container traffic on either the Northeast or Northwest Passage.

Seasonal use: Both routes are currently only accessible during a limited time window in summer and early autumn. Thanks to the use of Russian icebreakers, the Northeast Passage tends to be open longer, but here too, through traffic is concentrated in the months of July to October. The peak of shipping activity in the Arctic is regularly September, when sea ice reaches its seasonal minimum. In September 2023, a total of 1,122 ships were sailing in Arctic waters, compared to less than half of them in June. The maximum ice-free period of the NSR expanded as a result of warming: in 2020, the route was open for 88 days (beginning of August to the end of October) - significantly longer than previous records (69 days in 2012). The Northwest Passage is generally navigable for even less time. For many years it remained completely impassable; Since 2007, however, in mild summers, all of its canals have been ice-free for a few weeks. Nevertheless, the situation there is unpredictable due to changing winds and ice drift - sailing through without icebreaker assistance is usually only possible within a short time window

from around August to September. Accordingly, the few NWP transits are planned opportunistically: in 2018 and 2019, individual cruise ships (e.g. *Crystal Serenity*) the passage in late summer, accompanied by icebreakers and supply ships. Overall, the use of both routes remains highly seasonal, which limits scheduled scheduled services.

Table 1: Freight traffic via the Arctic routes (Northeast and Northwest Passage) in comparison

Key figure	**Northeast Passage (Russia)**	**Northwest Passage (Canada)**
Annual freight volume (2023)	approx. 36.2 million tonnes (record value, mainly raw materials).	No significant bulk freight traffic; only a few thousand tons (local supply freight)
Number of passes (2023, full transits)	75 transit trips (through Europe – Asia). plus numerous regional transports (a total of ~1800 ship trips in Arctic Russian waters).	41 transits in total (including 13 cargo ships, 11 cruises, 17 yachts) - many of which are leisure vessels rather than commercial traffic
Seasonal navigability	Summer/autumn, open around July–October; Peak traffic in September. Winter only with icebreaker escort on parts of the route.	Late summer, usually only a few weeks in August/ September largely ice-free. In severe ice years, no way through at all.
Predominant goods	*Raw materials:* LNG, crude oil, iron ore, coal, wood products; plus project loads. Hardly any containers...	*Local goods:* supplies (fuel, supplies) for Arctic communities; minor mining products. Tourism (cruises).

Potential economic benefits

The attractiveness of the Arctic routes lies primarily in the shortening of the distances between the major economic areas. A ship passage from Northern Europe to East Asia via the polar seas can be significantly shorter than the traditional route through the Suez Canal (or the Panama Canal for North America-Asia). This promises time and fuel savings as well as lower costs per trip. Depending on the starting and destination ports, the Northeast Passage can save up to around 30-40% of the route. An often-mentioned example is the route Rotterdam – Yokohama (Japan): around 11,200 nautical miles (approx. 20,700 km) have to be covered via Suez, and only around 6,500 nm (~ 12,000 km) via the Northeast Passage - the journey is shortened by over 40%. In practical terms, instead of around 30 days transiting through the Indic and Suez, this may mean only ~20 days through the Arctic, conditions permitting. The distance saving between Shanghai and Europe is also around 24%. The Northwest Passage offers comparable advantages on routes between the Pacific and the Atlantic: from the US west coast (Seattle) to Europe, for example, the route via Panama is ~8000nm, through the Canadian Arctic around 6000nm – 25% shorter. These reductions have a direct impact on transport time.

Fewer days at sea not only mean faster deliveries, but also lower operating costs (fuel, personnel) per trip.

From an economic perspective, the potential advantage of Arctic routes arises primarily from the significant shortening of distances between important trading centers. This not only directly reduces transit time, but also proportionally reduces operating costs per travel unit. Fuel is the largest single item in the cost structure of modern container ships. According to the International Chamber of Shipping (ICS), the average daily operating cost of a 20,000 TEU container ship is around $40,000-50,000, of which around 60-70% is fuel. Depending on the route, the Northeast Passage can shorten the journey by up to 5,000 nautical miles. This corresponds to around 10-12 days less transit time at moderate travel speeds, which represents a calculated saving of around USD 500,000 to 600,000 through reduced operations and fuel consumption alone (cf. UNCTAD Maritime Transport Review 2023).

In addition, there are no Suez Canal transit fees on the Arctic routes, which currently amount to up to USD 500,000 per transit for large container ships. The economic savings from using the NSR can therefore – under favorable conditions – amount to around USD 1 million per trip. This is a relevant margin in an industry with tight profit margins. Studies (cf. Lasserre, 2015; Liu & Kronbak, 2010) show that the NSR is economically competitive with the Suez route under seasonally optimal conditions (light ice, no icebreaker required) - especially for bulk cargo, project cargo or energy-intensive cargo such as LNG. The Arctic has so far been less attractive for liner shipping due to its limited season, lack of infrastructure and high planning uncertainty.

There are also potential ecological advantages: Shorter routes mean lower CO_2 emissions per tonne transported. According to a study by Furuichi & Otsuka (2014), CO_2 emissions on the Europe-Asia route via NSR can be reduced by up to 30% compared to the Suez route. This could create additional monetary incentives in a future with carbon pricing or emissions trading systems.

However, this is counteracted by increased requirements: the construction and operation of ice-strengthened ships (ice class PC5 or higher) causes additional costs of 10–30% compared to standard tonnage. In addition, insurance premiums for Arctic use are higher - especially for the Northwest Passage, which is considered more difficult to estimate. There is also a risk that unexpected weather changes or sudden ice drift could lead to delays. These operational uncertainties can currently hardly be fully calculated, but they have a dampening effect on commercial use.

In summary, the economic benefits of Arctic shipping routes can be seen in several dimensions: firstly, through significant savings in fuel and transit costs through significantly shortened routes (up to 40% reduction); secondly, by bypassing geopolitical bottlenecks such as the Suez Canal. Thirdly, environmental factors are becoming increasingly important, especially in light of global CO_2 pricing. However, there are substantial risks: increased investments in ice-class ships, infrastructural deficits along the routes, seasonal usability and complex insurance and liability issues. The economic success of Arctic routes depends crucially on whether technical, political

and climatic conditions enable advances in the coming decades that allow year-round or at least reliably seasonal use.

Another example illustrates the economic contrast on the route between Seattle (USA) and Rotterdam (Netherlands), a typical connection via the North Pacific and the Canadian Arctic:

Parameter	**Via Panamakanal**	**Via Northwest Passage (NWP)**	**difference**
Nautical miles (Seattle–Rotterdam)	~8.000 nm	~6.000 nm	–2.000 nm (~25 %)
Travel time (Tage, Ø 18 kn)	~22 days	~16 Takes	– 6 Takes
Fuel consumption (t MGO)	~2.400 t	~1.800 t	–600 t (~25 %)
Fuel costs (at 750USD/t)	$1.8 million	$1.35 million	-$0.45 million
Canal fees	~350.000 USD	no	-$0.35 million
Insurance / ice class / surcharges	low	~500.000 USD	+$0.5 million
Total cost of ownership (estimated)	~$2.95M	~$2.35M	-0.6 million USD

Here, too, there is considerable potential for economic savings, which, however, can only be realized if the passage is continuously usable and has an infrastructural security. Currently, ships transiting the Northwest Passage rely on extensive advance planning, satellite observation and frequent rerouting. The Canadian government also charges for navigation services and requires special environmental regulations, which limits the route's attractiveness. Nevertheless, players in the energy sector – for example for LNG transports from Alaska or Canada – also see strategic options here in the medium term.

Sample tabular calculation: Comparison of NSR and Suez route for container ship (20,000 TEU)

Parameter	Via Suez Canal	Via Northeast Passage (NSR)	difference
Nautical miles (Rotterdam–Yokohama)	~11.200 nm	~6.500 nm	–4.700 nm (~42 %)

Travel time (Tage, Ø 18 kn)	~30 days	~20 Takes	–10 Takes
Fuel consumption (t MGO)	~3.200 t	~2.000 t	–1.200 t (~37 %)
Fuel costs (at 750USD/t)	$2.4 million	$1.5 million	–$0.9 million
Canal fees	~500.000 USD	no	-0.5 million USD
Insurance / ice class / surcharges	low	~700.000 USD	+$0.7 million
Total cost of ownership (estimated)	~$3.5M	~$2.9M	-0.6 million USD

This model calculation is based on figures from UNCTAD (2023), Furuichi & Otsuka (2014) and Liu & Kronbak (2010). It takes into account common parameters such as average speeds, current fuel costs (Marine Gas Oil), and realistic fees. The difference is largely due to the elimination of Suez fees and lower fuel consumption, but is partially offset by additional costs for polar conditions.

According to Lasserre (2015), the Northeast Passage only remains economically competitive under optimal conditions: d. h. seasonally open, low ice cover, and adequate logistical support. There are already clear advantages for bulk cargo (e.g. LNG), whereas container lines usually remain dependent on predictable routes such as Suez for reasons of efficiency and frequency.

Individual studies such as those by Furuichi & Otsuka (2014) also point out the potential emissions advantages: a route via NSR could cause up to 30% fewer CO_2 emissions compared to the Suez route, which also becomes fiscally relevant given increasing CO_2 pricing (EU ETS, IMO requirements).

However, these quantitative advantages must always be weighed against uncertainties and ecological and insurance premiums - a circumstance that, according to Liu & Kronbak (2010), is still preventing large liner shipping companies in particular from systematically integrating NSR into their schedules. and any waiting times due to ice conditions.

When the Arctic routes will be economically viable depends on a variety of economic, technological and political factors. In this context, “economically sensible” means that the expected economic benefits – for example through shorter transport routes, reduced fuel costs and elimination of transit fees – exceed the additional costs and risks of transit through the Arctic. These include increased operating costs due to ice reinforcement, insurance premiums, the risk of unpredictable ice conditions and previously inadequate infrastructure.

When can the rods be used sensibly?

The question of when the Arctic routes will be economically viable and open year-round or seasonally depends largely on the development of sea ice cover. The Northeast Passage (NSR) and Northwest Passage (NWP) differ significantly in their climatic conditions and infrastructural challenges. Scientific scenarios can be divided into two plausible development paths, which we refer to here as dynamic scenario (early navigability) and conservative scenario (delayed navigability).

These scenarios are based on the so-called “Shared Socioeconomic Pathways” (SSPs), a standardized climate forecasting framework as used in the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC, 2021). The SSPs combine assumptions about economic, social and technological developments with their impact on greenhouse gas emissions. The numbers linked to this (e.g. SSP2-4.5 or SSP5-8.5) indicate the expected radiative forcing in watts per square meter (W/m²) up to the year 2100 - a measure of the additional warming caused by greenhouse gases.

- SSP2-4.5 represents a medium development path with moderate climate protection measures and leads to warming of around 2.0–2.5°C by 2100.
- SSP5-8.5 describes a scenario of continued fossil fuel growth and minimal policy control, which can lead to warming of over 4°C.

These two scenarios therefore represent a plausible spectrum for the future of Arctic sea ice conditions - from ambitious climate policy to a largely unregulated course of global emissions.

Northeast Passage (NSR): The NSR along the Russian coast is considered climatologically favored because it largely lies within the seasonally thawing seas. According to data from the NSIDC (2023) and model simulations from the IPCC (AR6, 2021), there has been a decline in the area of sea ice in September by around 13% per decade since the 1980s. The average ice area has fallen from 7.5 million km² (1980) to around 3.6 million km² (2020).

- In the dynamic scenario, with persistent high emissions (SSP5-8.5), an almost ice-free Arctic in September (i.e. <1 million km² ice area) is regularly expected between 2035 and 2045. For the NSR, this means a seasonally, reliably navigable route for around 4-5 months per year. Commercial navigability with reduced icebreaker support could become the norm from the late 2030s (cf. Notz & Stroeve, 2018; Smith & Stephenson, 2013).
- In the conservative scenario, under moderate emissions development (SSP2-4.5), the threshold for plannable use of the NSR shifts to the period 2045 to 2060. The season is still limited to 2–3 months with restrictions in peripheral sea areas (see IPCC AR6).

Northwest Passage (NWP): The NWP runs through the complex island archipelago of northern Canada. Due to narrow fairways, drifting sea ice and hydrological imponderables, there are considerably greater uncertainties. Although there is also a long-term decline in the ice surface, the melting pattern is more diffuse.

- In the dynamic scenario, model analyzes (e.g. Laliberté et al., 2016) predict a first regularly open navigation season between 2045 and 2055 - initially for special ice-class ships over limited periods of time. The prerequisite would be a massive reduction in multi-year ice and international cooperation in terms of infrastructure and search and rescue capacities.
- In the conservative scenario, a reliably seasonal NWP is unlikely to emerge until after 2065 at the earliest - and even then only for defined corridors such as the M'Clure or Amundsen route. Political factors (e.g. sovereignty issues) and a lack of supply infrastructure make early integration into world trade more difficult.

In summary, it can be said that the Northeast Passage will most likely be economically viable for seasonal purposes between 2035 and 2050 – sooner or later depending on the emissions path. The Northwest Passage, on the other hand, remains a long-term project whose economic potential could only be realized after 2050 (optimistic) or even after 2070 (conservative). Both routes require parallel development in maritime infrastructure, insurance technology, and geopolitical stability.

The international shipping industry is facing a strategic turning point. The Northeast Passage (NSR) along the Russian Arctic coast offers a realistic prospect of seasonal usability as early as the 2030s as ice melt progresses. This creates a double challenge for large logistics companies and shipping companies: firstly, choosing the right time to invest in fleet adaptation, route scouting and infrastructure coordination; secondly, to avoid the risks of starting too late – for example due to infrastructural dependencies, high transit fees or regulatory exclusivity.

Nevertheless, many large liner shipping companies are reluctant to take concrete steps to integrate NSR into their strategic route planning. Reasons include: regulatory uncertainty, lack of Western infrastructure, and strong Russian control over pilotage services, transit corridors and emergency management. This is precisely where the risk lies: Anyone who ignores the Northeast Passage leaves it entirely to those actors who are prepared to strategically use geopolitical risk and operational uncertainty - above all Russia and increasingly China.

Therefore, the clear recommendation here is that leading shipping companies and maritime logistics associations must prepare pilot projects, seasonal route tests and infrastructure cooperation with Arctic-affine states (e.g. Norway, Finland) by 2025 at the latest. This includes expanding ice reporting, partnerships with weather data platforms, investments in dual-class ships and monitoring Russian fee and navigation policies. Anyone who arrives late risks missing out on the most strategically important new trade route of the 21st century.

Geopolitical interests and conflicts

The opening of the Arctic has many challenges geopolitical actors and interests come into play. Control over new sea routes, access to resources and more strategic Influence in the region is already leading to tensions. Below is an overview of the most important players:

- Russia: No country is as directly affected by the Northeast Passage as Russia, because the route largely runs along the Russian coast. Moscow considers the NSR as *national development axis* and strategic leverage. President Putin regularly emphasizes the importance of this “national transport route” and has formulated ambitious goals (e.g. 80 million tons of freight by 2024, with a perspective of 150-200 million tons).[1] To achieve this, Russia is investing heavily in Arctic infrastructure: a nuclear icebreaker fleet, expansion of ports (such as Sabetta on the Yamal Peninsula), emergency port sites and new railway and pipeline routes to Arctic ports. The newest nuclear icebreaker took off in 2022 *Ural* [2] Service on, part of a modern fleet that is intended to enable shipping all year round. Geopolitically, Russia also sees the NSR as an alternative lifeline for trade with Asia, especially since Western sanctions in the wake of the Ukraine war made other routes (Suez, Baltic Sea) less safe. Militarily, Moscow has reactivated old Arctic base stations along the route and built new radar and rescue centers to show its presence. This militarization worries the NATO countries. At the same time, Russia is trying to attract foreign partners (especially China) to use and finance the NSR in order to generate income through transit fees and joint projects.

- China: The People's Republic of China, although not geographically a neighboring country, has a great interest in the polar routes and describes itself as "*Near-Arctic State*(almost Arctic state). The “Polar Silk Road” has been anchored in China’s strategy since 2018 as part of the Belt and Road Initiative[3]. Beijing sees this as a long-term opportunity to diversify trade routes to Europe and reduce dependencies on routes characterized by US influence (Malacca Strait, Suez). In practice, China has invested in Arctic infrastructure in recent years (e.g. financing the Yamal LNG terminal) and advanced its own icebreaking programs (the Chinese icebreaker *Xue Long* regularly travels at high latitudes). The state-owned shipping company COSCO has already made 42 trips on the Northeast Passage between 2013 and 2021, with a peak of 14 transits in 2021. These exploratory trips served to gain experience. However, in 2022, Chinese ships paused their Arctic voyages - probably out of concern about political implications after the Ukraine war. In 2023, more Russian oil was again delivered to China via NSR[4]. So China's interest is real, but it is being pursued cautiously. Beijing is officially cooperating with Russia, but it is unclear whether The Arctic is primarily important for China economically (resources, route) or as a lever in great power politics. Other Asian countries such ase Japan and South Korea are also monitoring the development, not least because their ports would benefit most from the reduction in distance. They participate through scientific programs and the expansion of ice-going merchant ships (for example, South Korean shipyards are building LNG tankers for Arctic service).

[1] All eyes on Russia’s Northern Sea Route - Stefan Hedlund
[2] Belfer Center for Science and International Affairs, Harvard Kennedy School
[3] China's Polar Silk Road: Long Game or Failed Strategy? - By Erdem Lamazhapov, Iselin Stensdal and Gørild Heggelund
[4] China Pushes Northern Sea Route Transit Cargo to New Record - Malte Humpert

- Canada and USA: In North America, interests in the Northwest Passage clash, particularly between Canada and the USA. Canada considers the waters of the Arctic archipelago as *domestic waters* and therefore fully subject to its sovereignty. Since 1985, Canada has drawn straight baselines around the islands and claims the passage as a historic Canadian fairway. The USA (and EU), on the other hand, insist that it is *international strait* acts through which foreign ships have rights of passage[5]. These legal views have been in conflict for decades (see Section 4). In practice, Ottawa and Washington agreed in a cooperation agreement in 1988 to put the dispute to rest for the time being: the USA informs Canada before military ships pass through, but without recognizing its legal claim. More recently, tensions have flared up again as the US Navy openly announced in 2018 *Freedom of Navigation* spoke in the Arctic. Canada is sensitive to any unauthorized use of the passage, citing safety and environmental reasons. Overall, Canada is interested in maintaining sovereignty and environmental protection in its Arctic zone, but shows less ambition than Russia to derive economic benefit from the passage. The large domestic trade projects like those in Siberia are also missing there. The USA, in turn, has little commercial interest in the NWP (the ports on the US Westcoast are well connected via Panama), but have a strategic interest in free sea routes and in containing Russian influence in the Arctic. As an Arctic coastal state (Alaska), the USA has recently become more involved diplomatically - in 2020 its own Arctic representative was appointed for the first time. The USA is also cooperating militarily with Canada and Scandinavian countries in order to be more present in the far north (joint maneuvers, establishment of the *Arctic Coast Guard Forum* for rescue cooperation).

- Europe and NATO: Several NATO states (Norway, Denmark via Greenland, Canada, USA) border the Arctic, and the EU also has Arctic actors in Finland/Sweden. On the one hand, European states emphasize environmental and climate protection in the Arctic, but also recognize the economic opportunities. Norway has long used the Arctic Ocean route along its coast to Murmansk and sees the NSR as an extension of it. However, European shipping companies are so far *reserved*: Large lines such as Maersk, CMA CGM and MSC have publicly declared - partly for climate protection reasons - that they do not want to start scheduled services through the Arctic for the time being in order to protect the sensitive region[6]. At the same time, European companies are working on ice class technologies and researching route options. Geopolitically, NATO is increasingly turning its attention to the north: Russia's armament in the Arctic (new military bases from Franz Josef Land to Chukotka) and China's presence (research stations, ice crossings) are seen as challenges. NATO maneuvers like *Trident Juncture* or increased patrols in the Arctic Ocean recently signaled that the alliance wants to show its presence in the “Far North”. The coexistence of civil-commercial interests and military security is a balancing act. Arctic countries such as Norway and Iceland are trying to play their role as *turntable* for possible Arctic routes (e.g. Kirkenes port in northern Norway as an NSR end point), while supporting deterrence against Russia in the

[5] 30 Year-Old Compromise Divides USA and Canada - Siri Gulliksen Tømmerbakke
[6] The Controversy Over Arctic Shipping - Jared Vineyard

defense alliance.

- Indigenous peoples and riparian communities: The Arctic sea routes pass through or near the homelands of indigenous communities, particularly the Inuit in Canada/Greenland and the Siberian peoples in Russia (e.g. Chukchi). These communities have distinct interests, often shaped by cultural and environmental protection. Many indigenous organizations (such as the Inuit Circumpolar Council) are demanding a say in Arctic shipping projects. Their main concerns are protecting the marine environment - as their way of life depends on fishing for fish and marine mammals - and maintaining sovereign rights over traditional waters. In some cases, there are also economic opportunities: ports or emergency berths could create local jobs, and fees or participation in route development would benefit the communities. Canada and Greenland are therefore involving Inuit representatives in consultations. Nevertheless, there are fears of being ignored by the major powers. For example, an oil spill in the Northwest Passage could ruin the hunting grounds of the Nunavut Inuit without them sharing in the profits of the tankers passing through. This tension between global trade and local self-determination is a key geopolitical factor. The *Arctic Council* – the central forum of the 8 Arctic states – includes indigenous organizations as permanent participants in order to make such concerns heard. However, the Arctic Council has been politically paralyzed since 2022 by the Ukraine war (Western states are boycotting official meetings under the Russian chairmanship), which weakens the platform for consensus and indigenous participation.

In summary, solid geopolitical interests clash on the issue of Arctic shipping routes: Russia and Canada insist on sovereign control, while the USA, EU and others focus on free shipping. China and other rising powers see strategic and economic opportunities but do not want to risk environmental degradation or conflict. This situation has the potential for diplomatic tensions – even an “Arctic race”. On the other hand, the extreme environment is forcing *cooperation* (e.g. in emergency services, weather and ice observation). In this respect, the polar sea routes are not only a trade issue, but also a touchstone for international cooperation in the face of climate change.

Greenland and Svalbard in focus

Greenland and Svalbard in Focus Greenland and Spitsbergen (Svalbard) are two of the key geopolitical key points in the Arctic - not only because of their geographical proximity to potentially dominant shipping routes such as the Northwest Passage and the Northeast Passage, but above all because of their infrastructural, military and legal role in the changing maritime order system of the 21st century. While both regions are often treated in studies as logistical hubs and sources of raw materials, what has so far gone largely unnoticed is that their strategic importance is not just passive: they could actively become control centers of a new Arctic order - through control, data infrastructure, search and rescue logistics and the setting of normative standards.

Greenland occupies a special position in this perspective. The island forms the northernmost bridgehead between North America and Europe, is in the approach path of potential trans-Arctic routes and is increasingly viewed as an operational base for military, commercial and scientific activities. The Thule Air Base - operated as part of NORAD - not only fulfills early warning functions, but also serves as the USA's northern flank base in an area that is increasingly being challenged by the Russian Northern Fleet and Chinese polar ambitions. In addition, the USA is increasingly recognizing that Greenland has the potential, not only militarily but also in terms of infrastructure, to act as a gateway hub for shipping, data communications and raw materials processing. A possible future transit connection between West Greenland and Canadian or Icelandic ports along the seasonally open NWP would have immense strategic impact - also for emergency logistics, sea rescue and remote monitoring. Against this background, the US's efforts to expand political influence in Greenland are less an expression of geopolitical symbolism than a sober pursuit of security-strategic ability to act in a region that could become a global infrastructure axis in the future.

Svalbard, on the other hand, marks – despite its comparatively small area – a vector access point to the entire Barents region. The archipelago lies less than 1,000 kilometers from the Kola Peninsula, where Russia's strategic submarine forces and naval infrastructure are concentrated. At the same time, thanks to its proximity to the Northeast Passage, Svalbard offers an ideal position for establishing dual-use infrastructure: scientific stations, automated weather and ice services, but also covertly usable surveillance and communication hubs. The Svalbard Treaty of 1920 creates a legally unique environment: economic use by third countries is permitted, military stationing by Norway is excluded - a status that is increasingly breaking between the lines of geopolitical rhetoric. Norway can only enforce its sovereignty through civil law, which Russia systematically exploits - for example with its permanent presence in Barentsburg.

Russia's activities in Svalbard clearly demonstrate a long-term strategy of economic and symbolic presence. Despite its economic unprofitability, the mining town of Barentsburg is continually being artificially kept alive by Russian investments - not least through the state-owned company Arktikugol. In addition to mining, Russia has a consulate, a Russian-language school, a church and various civil society institutions there, which can be read as an expression of permanent territorial claims. Security services report covert activities that go beyond traditional economic activity - including signal acquisition, electronic infrastructure surveys and potential satellite interference.

Economic proxy politics is also becoming increasingly visible: the attempt by Russian or Russian-affiliated actors to acquire land or infrastructure facilities on Svalbard through companies or foundations is part of a strategy of “civil normalization” that could amount to de facto control in the long term. Norway is faced with the dilemma of, on the one hand, implementing the Svalbard Treaty - which expressly allows economic use by third countries - and, on the other hand, maintaining its territorial integrity and security policy responsibility towards NATO. The Norwegian army has recently increased its presence, but the legal scope for military intervention is limited.

A realistic scenario would be that Russia gains de facto control over parts of Svalbard through a mixture of permanent economic presence, symbolic infrastructure (consulate, science station, church) and the use of dual-use technology (e.g. “civilian” research facilities with additional secret service functions) - without open confrontation, but with serious consequences for the Arctic security architecture. If Norway comes under domestic political or international pressure in the coming years, Moscow could specifically try to reinterpret rights from the Svalbard Treaty or assert more influence on administration and usage rights through international bodies. In this context, even a Russian attempt to establish new stations within the framework of humanitarian, scientific or climate-related “responsibility to protect” would be conceivable – for example under the banner of Arctic research or environmental protection cooperation.

The fact that Svalbard has not yet been systematically included in China's Arctic strategy could prove to be an illusion: the attempted property acquisition by Chinese actors in 2024 points to a long-term expansion of strategic presence through economic proxy politics.

An aspect that has received little attention so far is the question of digital and maritime infrastructure. Both regions – Greenland and Svalbard – could become indispensable hubs in an Arctic era of digital navigation, real-time monitoring and climate-adaptive shipping. The increasing need for satellite-based communication, the relocation of global data lines to polar zones (e.g. through new subsea cables), as well as the emergence of automated navigation systems (AIS, eNavigation) are turning these landmasses into infrastructural domino positions. Those who establish communication points, ground stations and emergency supply depots there at an early stage control not only the physical but also the informational infrastructure of the Arctic.

In this light, the growing geopolitical competition appears not as a result of increasing military presence, but as a race for infrastructural dominance in a space that has not yet been standardized. Greenland could form the backbone of trans-Arctic transport and communications networks in the coming decades, while Svalbard emerges as the security policy interface between NATO and Russia - not through open confrontation, but through ongoing presence, functional integration and control of critical infrastructure in advance of future route developments.

Other potentially relevant landmasses – such as the Faroe Islands, Jan Mayen or Franz Josef Land – could act as secondary amplifiers in this system: logistical support, technical intermediate points or diplomatic proxy spaces. But Greenland and Svalbard remain the strategic tandem that will help decide the conditions for maritime power projection and economic viability in the Arctic. An Arctic geopolitical order will not emerge on the high seas – it will be formed at the edges.

These geopolitical developments are taking place against the background of dynamic ice melting, the course of which can no longer be observed linearly, but rather at an accelerated rate and with regional differentiation. As shown in our analysis of the seasonal opening of the Northeast and Northwest Passages, the maritime traffic windows – depending on the chosen emissions path – could increase significantly as early as the 2030s (see IPCC AR6, Notz &

Stroeve 2018). As a first-use route, the Northeast Passage is more likely to be economically viable sooner, while the Northwest Passage will follow with a delay. However, both routes become more plausible as Greenland and Svalbard become more established as controlling hubs.

In the context of these changing climatic and security policy conditions, the transatlantic regulatory framework itself no longer appears to be stable. In our joint research paper on the so-called Borrela Accord, we argued that NATO's disintegration is conceivable in the next two decades - not necessarily through an open break, but through erosion of common interests and divergent regional agendas. In such a scenario, the US could establish a new strategic-economic alliance around the Arctic Circle that is more focused on maritime dominance, resource access and technological infrastructure. This new alliance – Arctic-based, digitally connected, economically focused – would define the Arctic not just as a transit region, but as an integral part of a new global order.

In this case, Greenland and Svalbard would not just be logistical or military outposts, but rather the cornerstone of a multilateral infrastructure policy - a network of data, depots, contracts and access that creates geostrategic reality beneath the surface of a seemingly open polar sea.

Russia is increasing its presence and control in Spitsbergen (Svalbard) through targeted economic activities and infrastructural measures. A central element of this strategy is the dominance of Russian fishing fleets in the waters around Svalbard. Reports show that Russian trawlers account for a significant share of fishing activity in the Barents Sea, particularly through the intensive use of demersal and pelagic trawls. This intensive use not only leads to economic dominance, but also to an increased presence of Russian citizens in the region.[7]

The settlement of Barentsburg, the largest Russian outpost on Svalbard, had around 455 residents in 2020, most of whom work in coal mining and increasingly in the tourism sector. Although the population has been declining in recent years, the proportion of Russian and Ukrainian residents remains significant. This demographic composition highlights the continued Russian presence and influence in the archipelago.

In addition to fishing activities and demographic presence, Russia is pursuing infrastructural projects designed to further consolidate its position on Svalbard. An example of this is the planned revival of the abandoned settlement of Pyramids through the construction of a joint Russian-Chinese research center and the promotion of tourism. Such initiatives not only serve scientific and economic purposes, but also strengthen Russia's geopolitical position in the Arctic. These developments illustrate that Russia is gradually expanding and consolidating its control over Svalbard through a combination of economic activity, demographic presence and infrastructural investments.

[7] Reconstructed Russian Fisheries Catches in the Barents Sea: 1950-2014 - Sarah Popov, Dirk Zeller

Legal status and sovereignty issues

DThe legal classification of the Northeast and Northwest Passages is complex and controversial. In principle, the United Nations Convention on the Law of the Sea (UNCLOS) regulates the use of the seas, but with regard to Arctic transits it leaves room for interpretation.

Northwest Passage (NWP): Canada has claimed all waterways within its Arctic archipelago as internal waters since 1985. That means they would be legally treated as land territory, with full Canadian sovereignty and no automatic right of passage for foreign states. To support this, Canada drew straight baselines around the outer islands, citing historical Inuit use (customary law) in part. The United States and most maritime nations disagree with this view. They see the Northwest Passage as an international strait because it connects two high seas (Atlantic and Pacific) and is suitable for international shipping. According to UNCLOS, such a strait would have a right to *Transit passage* apply, under which foreign ships (including warships) have extensive rights of passage, without authorization from coastal states. This position is represented by a. the USA since the 1960s, which repeatedly led to diplomatic tensions with Canada. A famous incident was this *SS Manhattan*-Transit in 1969 (a US tanker with icebreaker escort), which led Canada to create clear rules. To this day, the “agree to disagree” between Canada and the USA still applies: people disagree, but deal with it pragmatically – for example, the US Coast Guard gets Canadian supplies on scientific trips through the NWP *“concurrence”* without giving up one's own legal position. Other states such as Russia support Canada's claim to sovereignty (because they have parallel interests in its passage), while EU states tend to follow the US view. Recently, the debate has flared up as to whether, as the passage becomes more usable, the issue should be brought before an international court. So far, however, all sides are shying away from escalation because the passage is not yet of great commercial importance and they do not want to endanger the good cooperation in the Arctic. In effect, Canada exercises control (its coast guard monitors the area and ships usually sign up voluntarily). Legally, however, the status question remains *unclear* and could become more explosive in the future.

Northeast Passage (NSR): The route along Russia's coast is also legally complex. It runs through various water zones - partly the high seas, partly through the Russian 200-mile exclusive economic zone (EEZ), partly through straits declared by Russia as inland waters (e.g. the Strait of Vilkizki north of Siberia). Russia has created its own legal regime for the “Northern Sea Route”: according to Russian law, the NSR is one *historically grown national transport route*, which is under Russian jurisdiction. Foreign ships must obtain permits, request pilots and icebreakers, and adhere to Russian regulations. Moscow is relying on Article 234 UNCLOS, which gives coastal states in ice-covered maritime zones special rights to issue regulations on environmental protection and ship safety. Russia interprets this article very extensively in order to exert extensive control over the NSR. Western countries – especially the USA – do not agree with this. The USA argues, similar to the NWP, that international transit rights must apply and that Russia's regulations should not cover all parts of the route. A sticking point are the narrows in the Russian Arctic (e.g. Dmitri Laptev Strait), which Russia claims as internal waters. Western international law experts, on the other hand, see them as international straits because they

connect the Siberian Sea and the Chukchi Sea. So far there has not been an open conflict because most Western ships request Russia's permission on their own initiative - for practical reasons (icebreaker service). However, the situation is tense: As part of the 2022 sanctions, Russia threatened to shield the NSR from a security perspective, and Western military officials may be planning Freedom of Navigation trips (without authorization) in order to set a precedent. An example: In 1965, a US Coast Guard icebreaker (*Northwind*) once into the East Siberian Sea, which sparked protests. Now that the route is becoming more strategic, such cases could increase. In any case, it is internationally recognized that Russia's sovereignty extends over its territorial waters (12 nautical miles from the coast) and *special rights* in the EEZ for environmental requirements (Article 234). The high seas beyond remain clear. Where exactly the boundaries are - especially what *Binnengewässer* vs. *thoroughfare* counts – remains controversial. In practice, however, Russia has one with its icebreaker fleet *Effective monopoly* to the safe accompaniment of the NSR, which means de facto control.

International legal framework: Beyond national claims, there are efforts to regulate shipping in the Arctic through multilateral agreements. The Arctic Council established a 2011 *Search and Rescue Agreement* completed, which divides responsibility for emergencies regionally - this improves the safety of the transit routes. An agreement on emergency response to oil spills followed in 2013. These agreements show that the neighboring countries can cooperate without resolving sovereignty issues. However, none of these treaties clarify the legal status of the passages themselves. UNCLOS would have mechanisms (e.g. arbitration), but so far these have been avoided.

Sovereign rights vs. global interest: The central question is: *Are the Arctic routes international sea routes (such as the Strait of Malacca) or internal/territorial waters of the neighboring countries?* Canada and Russia take the latter view and insist on full sovereignty, while the United States and most maritime nations insist on the former. So far this dispute has been primarily theoretical in nature; however, it could become more severe as traffic volume increases. An unregulated state poses risks for investors and shipping companies - no one wants to plan a passage that is suddenly blocked by geopolitical tensions. Therefore, there may be one in the future *Compromise solution* must be sought, such as special transit corridors with certain requirements. The unique sensitivity of the Arctic could also pave the way for a special regime (similar to the Antarctic Treaty, but the starting point is legally different since the Arctic is not an unclaimed continent).

Overall, the legal questions surrounding the Northeast and Northwest Passages are still unresolved. What is clear is that environmental regulations in the Arctic are absolutely necessary and, according to UNCLOS Article 234, legitimate. Coastal states are allowed to impose regulations to protect ice-covered sea areas - which both Canada and Russia have done (e.g. mandatory ice class, pilotage requirements, speed limits). What remains controversial, however, is who has the final say on the passage of foreign ships. This struggle for legal interpretative sovereignty is part of the larger geopolitical game surrounding the Arctic (see Section 3). Until there is clear clarification - whether through agreements or common law - any commercial use of the routes will have to live with this legal uncertainty.

Environmental and climate impacts of Arctic shipping

The Arctic is ecologically one of the most sensitive regions on earth. The very fact that the passages become navigable at all is a consequence of this climate change: The average extent and thickness of sea ice has been decreasing dramatically for decades. This has worrying global consequences, but it is the prerequisite for the new routes. At the same time brings *more ship traffic* in the Arctic again new environmental pressures with it, some of which can have global feedback.

Climate change as an enabler and risk: Over the last 40 years, the Arctic has lost around 75% of its summer sea ice (by volume). Climate models predict that by... Mid-21st century A practically ice-free Arctic Ocean is possible at times in late summer[8]. This extends the navigation period (see Section 1) and once impassable routes become navigable. However, this "positive effect" from a shipping perspective is part of the same development that poses enormous challenges for the planet. In addition, disappearing ice and higher temperatures in the Arctic are not a linear process: Extreme weather and unpredictable ice drift may increase, posing new dangers to shipping (sudden ice blockages, storms). A growing number of ships could in turn cause climate change continue to heat up. Are particularly problematic Rußpartikel (Black Carbon) from ship exhaust gases: These dark particles can deposit on ice and snow and absorb more solar radiation, which accelerates melting[9]. Studies warn that increased shipping traffic in the Arctic could further increase regional warming. It has been calculated that if Arctic shipping continues to grow unabated, up to 5% of global traffic will take place there by 2050 and one *measurable increase in warming* would effect. In this respect, the development of routes is a double-edged sword from a climate perspective: it results from climate change and potentially contributes to its acceleration.

Danger of oil spills: One of the biggest environmental threats is a Tanker accident or accident in the Arctic. An oil slick in a polar environment would be devastating: in cold water and half-darkness in winter, petroleum would break down extremely slowly. Wildlife – from plankton to fish to seabirds and marine mammals – would be at massive risk. The Elimination An oil spill in the Arctic is considered almost impossible, especially when ice is floating. The experiences with the Exxon Valdez tanker accident in Alaska (1989) or smaller leaks show that even more accessible subarctic regions could only be incompletely cleaned. In remote passages like the NWP, where there is little infrastructure, weeks could pass before adequate equipment is on site. Accordingly, preventive measures were discussed internationally: The International Maritime Organization (IMO) has a ban on 2021 heavy fuel oil decided in Arctic waters (with transition periods until 2029) - this viscous oil would clump in the event of accidents and is particularly harmful to the environment. Many shipping companies are therefore switching to distilled fuels or LNG when sailing at high latitudes. In addition, strict regulations apply to the disposal of garbage, wastewater and ballast water pollution to keep it low. Nevertheless, the risk remains: a single accident could cause damage that lasts for decades. Indigenous communities

[8] As Arctic ice thaws, questions around Arctic shipping heat up - Stella Bartolini Cavicchi, OceanMind
[9] Increased Arctic Shipping Believed to Accelerate Climate Change - William Dube

warn that a major oil spill would pose an existential threat to their traditional way of life (hunting/fishing).

Impact on wildlife: The Arctic seas are home to unique ecosystems. Marine mammals such as walruses, seals, beluga whales, narwhals and whales rely on intact habitats and undisturbed migration routes. Ship traffic can affect these animals in a number of ways: Through Underwater noise For example - the noise from ship engines and icebreakers can carry over long distances under water and significantly disrupts the orientation and communication of many marine mammals[10]. Arctic whales that use echolocation to navigate could be displaced or become stressed. Still exists Risk of collision: Collisions between whales and ships are already occurring in temperate latitudes; This could increase in the Arctic, especially if new routes lead through previously quiet areas. *Ship propellers* can also break pieces of ice and thus influence ice households, which can occur e.g. B. is problematic for resting walruses or seal pups on ice floes. Fisheries and food chains could also be influenced indirectly: deposits of exhaust gases and small chronic leaks add up - for example, in previously unpolluted fjords, pollutants could enter the marine food chain (from algae to fish to polar bears/people). There is also the risk of Bio Invasion: Ships could bring foreign species (e.g. mussels, crabs) into the Arctic via ballast water, which would displace native species there. These ecological risks are not hypothetical – there are numerous examples from other marine regions. In the Arctic, however, the effects would be particularly tragic because many organisms are very specialized and vulnerable.

Ice melting and feedback: The increase in shipping traffic is *Consequence and cause* progressive ice melting. Each additional year that routes remain open longer can, in turn, attract even more traffic. It should be borne in mind that the Transport routes themselves are sensitive to climate changes: This led to e.g. For example, in 2018, an unusually late cold snap resulted in a commercial freighter (with an icebreaker) getting stuck in the Laptev Sea in October because new ice was growing faster than expected. Climate change not only means less ice, but also more instability. This can seem paradoxical: a warmer world, but suddenly difficult conditions locally. For the ecosystem, this means that protection concepts must be flexible. Possibly will be in the future *dynamic protection zones* established that, depending on the season and animal migration, certain areas are closed to ships (analogous to “traffic separation areas” for whales). There are initial steps in this direction: Canada, for example, is considering temporary route changes if herds of whales are spotted.

Regulatory responses: In view of these challenges, several sets of regulations have been created. The most important is the one already mentioned Polar Code the IMO (in force since 2017). This mandatory one Polarkodex prescribes stricter safety and environmental protection measures for ships in the Arctic/Antarctic: special ice class construction, equipment for emergencies (e.g. ice search headlights, cold protection for crew), requirements for route planning according to ice conditions, as well as limits for emissions and waste disposal. The Polar Code goes beyond the general MARPOL/SOLAS regulations and is specifically tailored to the polar region. This is to ensure that only suitable ships dare the passage and that Risk of

[10] AS3: Reducing the effects of shipping on biodiversity - William Halliday, Wildlife Conservation Society, Canada

accidents minimized becomes. Nevertheless, environmentalists criticize gaps: The code does not apply to smaller ships (<500 GT), which e.g. B. excludes many fishing vessels and yachts. Also questions of enforcement (who controls in remote areas?) and the *Incident liability* have not been conclusively clarified. Organizations like the WWF are therefore calling for the Polar Code to be expanded and tightened. Furthermore, will Protected areas discussed: Parts of the Arctic could remain taboo for all shipping, e.g. B. To secure whale refuges.

Overall it depends Environmental balance Arctic shipping routes depend on how strictly the requirements are followed and how well accidents can be prevented. One thing is clear: every increase in traffic brings benefits *additional burdens* for an ecosystem already stressed by climate change. Even small disruptions can have major effects in the Arctic. Scientists and indigenous speakers therefore urge a cautious approach: the development of the Northeast and Northwest Passages should not come at the expense of the “last untouched seas”. Ideally could *shorter routes* and modern, clean ships even have one Net climate benefit bring (less overall CO_2 emissions for world trade). But this potential will only be exploited if strict environmental standards are adhered to Worst case scenarios (Major accidents) can be prevented. The international community has a responsibility to create binding regulations in a timely manner before traffic increases significantly.

Climate change as a geopolitical-economic lever? An assessment of potential net benefits for the United States, Russia and China

The question of whether certain nation states – namely the United States of America, the Russian Federation and the People's Republic of China – could derive a net economic benefit from accelerated ice melt in the Arctic Ocean touches on an aspect of global climate policy that has so far only been marginally discussed. Climate change is generally viewed as a global threat that negatively affects all economies, regardless of national borders. Nevertheless, within the framework of geopolitical-economic analyses, it is legitimate to examine whether there could be state-strategic incentives in individual cases not to pursue climate protection measures with maximum intensity, provided that this results in sectoral or regional competitive advantages. However, such an assessment requires a precise distinction: between short-term sectoral benefits and long-term overall economic damage.

From the perspective of the Russian Federation, the melting of ice in the Arctic Ocean is already a de facto condition for development. Russian Arctic policy is strongly oriented towards the gradual development of the Northeast Passage (NSR) as a maritime corridor between Europe and East Asia. This route, which runs along the Siberian coast, has gained massive logistical performance in recent years thanks to government investments in icebreakers (currently: 9 nuclear-powered ships), new seaports (e.g. Sabetta, Murmansk, Pewek) and surveillance facilities. The Russian energy sector - particularly in the area of liquefied natural gas (LNG) - benefits from easier seasonal logistics. Between 2017 and 2023, annual cargo volumes on the NSR increased from 7.5 million to over 34 million tons, with a target of 80 million tons by 2035 (Rosatom, 2023). According to the IEA, the increasing freedom from ice reduces transport costs per ton by up to 30% compared to classic southern sea routes. In addition, Russia expects to have over 40% of the known Arctic oil and gas reserves (US Geological Survey, 2008). Estimates put the resources at over 100 billion barrels of oil equivalent. At the same time, Russia is less affected by the effects of sea level rise because large parts of the population live away from vulnerable coasts. In this respect, there is an economic and strategic advantage from the acceleration of ice melting - at least in the short term in terms of raw material exports, transit tariffs and geopolitical influence.

For the People's Republic of China, the starting position is structurally different. China has no Arctic coastal access, but is pursuing an ambitious Arctic policy as part of the “Polar Silk Road”. According to China's Arctic White Paper (2018), Beijing considers itself a "near-Arctic state" and has invested over $1.5 billion in research icebreakers, satellite monitoring, and dual-use port technology since 2010. The economic arguments for accelerated ice melting arise, among other things, by reducing the transport distance from Shanghai to Rotterdam by around 6,500 nautical miles (approx. 40% route saving), which corresponds to 10-14 days transit time. The resulting savings in fuel consumption and transit fees (Suez Canal: approx. USD 500,000 per large container ship) can amount to up to USD 1 million per trip. McKinsey estimates the total possible savings for China's exporters by 2050 at $150-200 billion. At the same time, China is

massively affected by climate impacts: according to the World Resources Institute, over 200 million people in the country could regularly suffer from water shortages by 2050; In coastal regions such as the Pearl River Delta, more than $1 trillion in damage is expected by 2100. USD possible due to flooding. This puts the possible net advantage into perspective considerably.

The United States, including Alaska, has over 12,000 km of Arctic coastline and controls parts of the Beaufort and Chukchi Seas. The USGS estimates the Arctic raw material reserves there to be around 30 billion barrels of oil equivalent. There are also geostrategic advantages: The Northwest Passage (NWP) shortens the route between New York and Tokyo by around 3,000 nautical miles compared to the Panama route. The USA could make greater use of this passage in the future by expanding Arctic infrastructure (e.g. Dutch Harbor, investments in Arctic-capable Coast Guard ships, satellite communication via Starlink). However, studies by RAND and GAO predict that as early as 2040, climate-related extreme weather events, crop losses and health care costs could result in damages of up to 2% of US GDP annually. This represents an economic risk of more than $400-500 billion annually. In addition, rising insurance premiums, infrastructure losses and political instability could neutralize the competitiveness of Arctic routes in the long term.

Overall, the overall picture is ambivalent. There are sectoral incentives for all three states under consideration to use current climatic developments to promote Arctic logistics, resource utilization and the expansion of geopolitical power. But the overall economic balance – taking into account economic damage, social costs and reputational risks – speaks against a real net economic benefit from forced or tolerated ice melting.

However, there is a pronounced inertia advantage: the short-term gains of Arctic economic sectors (particularly energy, logistics, shipbuilding, geospatial data, security technology) are very likely to occur within the next two decades, while the full climate damage often only takes effect after 2050. This temporal asymmetry makes political mobilization for immediate climate action difficult. The strategic challenge is therefore less about preventing deliberate sabotage of global climate goals and more about identifying and neutralizing systemic disincentives.

International climate policy - particularly within the framework of the Paris Agreement and through initiatives such as the Arctic Council or the IMO Polar Code - is required to address structural market distortions in addition to emission reductions. Only through global mechanisms for internalizing external costs, such as CO_2 pricing for maritime transport, transparency requirements for Arctic investments and sanction mechanisms in the event of ecological threats, can the opening of the Arctic result in an economically motivated erosion of responsibility for climate policy.

Infrastructure, technological requirements and risks

The Arctic places extreme demands on people and materials. Year-round, safe use of the Northern Sea routes requires enormous investments in Infrastructure and Technology. Currently, the requirements for routine navigation are still limited, which poses risks from a commercial perspective. This section highlights the status and requirements in terms of ship technology, port infrastructure, navigation and emergency management.

Special ship technology: Not every ship can simply turn north - ice-going ships are essential. Most commercial freighters (especially large container ships) do not have an ice class and would be at considerable risk if the ice was even thin. Either specially built or retrofitted ships are used for Arctic trips. These include ice-reinforced hulls (special steel, reinforced bow section), a shape that can break or displace ice, and protection of the rudder and propeller against pieces of ice. Classification societies assign different ice classes (e.g. PC 1-7 according to the Polar Code or Baltic ice classes), with only the highest levels allowing real use in multi-year ice. Modern icebreaking ships and icebreaking cargo ships (so-called *Arctic max*-Tankers) often have diesel-electric propulsion with several azimuthal propellers in order to be able to maneuver in the ice. Are an innovation *Double active*-Ships that can travel both forward in the water and stern in heavy ice. Russia currently has the largest fleet of Arctic-capable merchant ships, including dozens of icebreakers and Arctic-capable LNG tankers that can withstand temperatures of -50°C. Countries like South Korea, Finland and China also make ice ships. Nevertheless, the absolute number of such ships is small in relation to the world merchant fleet. A significant increase in traffic would require a fleet renewal, which takes years or decades and is expensive. Many shipping companies are hesitant to invest in expensive ice ships as long as it is unclear whether the Arctic routes are really worth it. Insurance also plays a role here: insurers charge high premiums for Arctic trips or refuse coverage without an ice class and an experienced crew. Although they are technological *autonomous or remotely controlled ships* on the horizon (such as unmanned icebreaker drones), but it will probably still be a while before they are used in open traffic.

Icebreakers and Support Vessels: Icebreaker fleets are the backbone of the Arctic shipping infrastructure. Russia maintains by far the largest icebreaking fleet in the world, including several nuclear-powered heavy icebreakers (Arktika class) that can break ice up to 3 meters thick. These ships (e.g. *Arctic*, *Siberia*, *Ural*) accompany convoys through the Northeast Passage and keep the shipping channels open. Other neighbors have smaller fleets: Canada has some medium-sized diesel icebreakers for the NWP and Coast Guard, the USA has two old heavy icebreakers (primarily for Antarctic supplies), Finland/Sweden use icebreakers mainly. a. in the Baltic Sea. China has with us *Xue Long 2* also a modern icebreaker and may be planning its own nuclear icebreakers. However, there is a lack of large icebreaking capacities for the Northwest Passage - Canada is more likely to rely on this *Avoidance* (Ships should wait for ice-free periods). In addition to icebreakers, rescue and recovery ships as well as supply ships (for fuel, evacuation, etc.) are needed, which are available in remote areas. Currently, in the event of an accident, for example: For example, in the central Arctic Ocean, a Russian icebreaker would probably be the quickest to arrive, as western capabilities are rarely stationed

this far north. This entails geopolitical dependencies (Western ships would be dependent on Russian help in an emergency). In response, the Arctic states have agreed to coordinate their sea rescue operations: The Arctic SAR agreement allocates search and rescue sectors - e.g. E.g. Canada is responsible for the Canadian Arctic, Russia for the Siberian Arctic, etc. In practice, however, huge areas remain *far from the nearest base*. The rescue times in an emergency would be long; There are hardly any helicopter bases or medical stations near the poles.

Port and communication infrastructure: Another bottleneck are ports and logistics centers along the routes. There are only a few suitable deep-water ports on the Northeast Passage: Murmansk and Arkhangelsk at the European end, Petropavlovsk-Kamchatsky at the Pacific end, with only smaller facilities in between at Arctic settlements (Dudinka, Tiksi, Pevek) and the new LNG port Sabetta. Russia is planning additional refuges and hub ports such as the Northern Sea Region (e.g. in the Murmansk region). In the Canadian Arctic, however, there is no fully developed port on the Northwest Passage. The former only cargo port, Churchill on Hudson Bay, is located away from the actual passage. Canada is currently only expanding a naval base (tank farm) near Nanisivik (Nunavut), which could possibly be used for civilian purposes. The lack of ports means there are hardly any options for bunkering (fuel absorption), repairs or shelter in storms. A ship has to complete the entire Arctic passage virtually self-sufficiently. In the long term, intermediate stations would be necessary, for example on Novaya Zemlya, the Chukchi Peninsula or in Canada's Cambridge Bay, to support traffic. Digital infrastructure is also important: At high latitudes, satellite coverage (for communication and GPS) is patchy - geostationary satellites “see” the polar region poorly. New technologies such as Starlink (satellite internet) could help here. You also need reliable ice maps and weather data in real time. Russia maintains several ice reconnaissance satellites and transmits current images to convoys. The USA and EU (via EUMETSAT) also provide Earth observation data. However, these must be integrated into ship bridges and manageable for captains. Currently, a lot of the work is done through direct coordination with icebreaker guides who bring in their local knowledge. A vision is that *digitale Arctic-Sea-Route-Manager*, which routes ships dynamically depending on ice conditions - research projects are underway here.

Technical risks and challenges: Despite preparation, the Arctic remains a high-risk area for shipping. *Extreme cold* can clog machines (diesel fuel becomes viscous, hydraulics freeze, metal becomes brittle). *Polar night* and fog make navigation difficult over long periods. *Magnetic anomalies* Compasses sometimes get in the way near the poles. Even the most modern ships can get into trouble due to unexpectedly thick ice or ice compression (when wind pushes ice floes on top of each other). In 2018, a Russian icebreaker that got stuck in the ice had to be abandoned. Another risk is the lack of alternative routes: in densely trafficked waters there are often alternative routes in the event of closures - in the Arctic there is usually only a narrow corridor. In the event of blockages (e.g. due to a stuck ship or military tensions) you would have to drive the entire long distance back. The crew's working conditions are also tough: monotonous ice landscape, isolation, increased attention around the clock - this places high demands on training and psyche. The Polar Code therefore requires special training for captains and officers to be prepared for Arctic conditions.

Economic risks: In addition to the physical risks, there are economic uncertainties. The Arctic routes are not reliable all year round, which makes planning and contracting difficult. Shipowners who e.g. B. Those who operate container lines rely on timetables with tight cycle times - a route that is only open in summer does not fit well into this concept. Additionally, unexpected delays (due to weather/ice) may result in penalties if delivery dates are missed. As a result, hardly any liner shipping companies have so far agreed to plan the detour via the Arctic. These are usually single trips or charter ships that are arranged flexibly. Another factor is transit fees: Russia charges service fees (icebreakers, administration) for the NSR, which eat up part of the cost savings. Although the Suez Passage is not free, Russia could increase the fees if traffic increases, especially since it acts as a quasi-monopolist. The uncertain legal situation (Section 4) also acts as a business risk - no one wants to get into a legal dispute or even a military conflict over transit rights. Finally, insurance companies charge high surcharges for polar travel or limit the sum insured in order to cover risks that are difficult to calculate. All of this makes the economic calculation complex: it is not enough that a route is shorter; it must also be reliable, safe and plannable in order to compete with established routes.

Future outlook – infrastructure under development: Despite all the hurdles, efforts are underway to make the infrastructure fit for more traffic. Russia is pushing forward with its NSR development program adopted in 2022 (equivalent to ~US$29 billion by 2035). These include new icebreakers (including smaller nuclear cargo ships for the estuaries), the establishment of 16 emergency bases along the route, navigation satellites in polar orbit (project “Arktika”), and possibly the establishment of a specialized Arctic shipping company under the Rosatom fleet. Canada and the USA invest primarily in surveillance and protection (radar, coast guard); A large commercial port in the Canadian Arctic is not yet planned. However, Alaska is discussing the expansion of Nome into the first deep-water port on the Bering Strait, which could also serve Arctic transit traffic. The Nordic countries (Norway, Finland, Iceland) are exploring opportunities for themselves as logistics hubs: A rail freight connection from Finland to the Barents Sea coastal town of Kirkenes was considered to enable Asian freight to land there. Iceland is applying with the project of an international port at Finnafjörður if a transpolar sea route (across the geographical Arctic Ocean) becomes a reality. This vision of a direct transpolar sea route - which no longer runs along coasts, but through the middle of the Arctic Ocean - could emerge in a few decades if the summer ice cover almost completely disappears. A completely new corridor would then be freed up that would be independent of national coasts. However, this would still require far-reaching technological and legal solutions (e.g. ice navigation without coastal protection, international governance for the high seas in the Central Arctic).

In summary, the technological and infrastructural requirements for regular scheduled traffic via the Arctic are still being developed. Currently, high demands on ships, a lack of ports and insufficient rescue capacities prevent safe and profitable operations on a large scale. The coming years will show whether appropriate investments will be made as the ice melt progresses. Shipping companies will closely monitor infrastructure developments before changing their route planning. Security – in both technical and political terms – is a key factor. Without them, the Northeast and Northwest Passages will initially remain special routes for specialized operations, despite their great future potential.

Recommendations for action for a regulated opening of the Arctic sea routes

Empirically based measures for states, companies and international institutions

The geopolitical order of the Arctic is shifting rapidly – not through conferences, but through infrastructure, presence and control. The Northeast Passage will become the main maritime artery between Europe and Asia, while Svalbard and Greenland will become the new geopolitical frontiers of the 21st century. Russia is de facto consolidating its grip on Svalbard through fishing policy, permanent economic presence and symbolic infrastructure. The USA is systematically integrating Greenland into a new security and data ecosystem.

Against this background, it is not enough to treat the Arctic as an abstract space of future possibilities. Concrete, resilient and empirically based measures are needed – now. The following recommendations for action combine technological, security policy and economic perspectives and are aimed at governments, companies and multilateral institutions alike. Anyone who thinks strategically has to make decisions today.

1. The logistics industry must now strategically anticipate the Northeast Passage

Given the melting ice cover, government investments (e.g. USD 29 billion by Russia by 2035) and growing use by players such as COSCO and Novatek, the Northeast Passage will be navigable on a seasonally predictable basis in the 2030s. Ignoring is not an option: If you don't prepare now, you risk operational dependencies and market exclusion.

Recommendation:
Maritime companies must now:

- route planning simulations,
- seasonal test traffic,
- PC5+ Ice Class Fleets
- and invest in partnerships with Norway, Finland and Iceland.

Goal: Building a European Arctic supply chain as a counterpoint to Russian dominance.

2. Political actors must recognize that the Arctic is being re-divided

Russia actually already controls large parts of Svalbard through fishing, infrastructure projects and a symbolic permanent presence (e.g. Barentsburg). At the same time, the USA is

expanding its technological, military and diplomatic control over Greenland. The Northeast Passage is the infrastructural driver of this realignment - it shifts the center of maritime power projection to the north.

Recommendation:

- Formulation of an Arctic Strategy 2030+ that explicitly addresses Svalbard and Greenland as future demarcation lines.
- Establishment of a monitoring system for economic, legal and demographic influence on Svalbard.
- Integration of the Arctic into the security policy early warning architecture of the EU and NATO.

3. Upgrade infrastructure policy in a targeted manner – benchmarked like in defense

The average response time to maritime emergencies in the Arctic is 12-72 hours – well above international standards. Russia is planning 16 SAR bases by 2030; comparable capacities are lacking in the West.

Recommendation:
States with Arctic connections should at least **1-1.5% of forecast Arctic cargo value** invest in emergency ports, SAR centers and supply corridors – analogous to NATO's 2% defense quota.

4. Make multilateral Arctic regimes assertive

UNCLOS Article234 is used strategically by Russia to control territory. At the same time, 36% of all ships in the Arctic (e.g. trawlers, yachts) are exempt from the Polar Code. Without enforcement authority, international institutions effectively lose their regulatory power.

Recommendation:

- Extension of the Polar Code to ships >300 GT
- Introduction of an Arctic Transit Tracker
- Establishment of a permanent Arctic monitoring system modeled on Copernicus

5. Strategically limit and prioritize economic use

The NSR can accommodate up to 4% of Asia-Europe trade – primarily LNG, project cargo, bulk. Scheduled transport (e.g. container services) remains uneconomical due to seasonal uncertainties.

Recommendation:

- Focus on project-based seasonal trips with predictable risk
- Establishment of standardized insurance frameworks for polar transits (public-private)

6. Technology and digital infrastructure are the key to sovereignty

Only 60% of the navigation zones north of 75° are covered by real-time data. At the same time, global data communication is increasingly shifting to polar positions. Russia and China are investing heavily in dual-use infrastructure (e.g. fiber optics, satellites).

Recommendation:

- Establishing an Arctic Innovation Fund to promote AI navigation, multispectral ice mapping and autonomous icebreaking drones
- Development of a European LEO communication architecture for high latitudes (e.g. Arctic Starlink Counterpart)

7. Enshrine the rights and participation of indigenous communities in a binding manner

85% of traditional hunting routes are affected by Arctic shipping corridors. Without binding participation, there is a risk of social conflicts and crises of legitimacy.

Recommendation:

- Introduction of national participation formats with veto rights (e.g. Sameting model)
- Involvement of indigenous committees in environmental oversight, infrastructure levies and navigation planning

Conclusion

The opening of the Arctic is not a future scenario – it has already begun. Over the course of the 2030s, the Northeast Passage will become a seasonally reliable trade route, with potential savings of up to one million US dollars per transit and significant strategic advantages over the established sea routes. But while parts of the maritime economy are hesitantly observing this change, other actors have long since established facts: Russia is securing de facto control over Svalbard through permanent presence, infrastructure measures and economic proxy politics. The US is consolidating its position in Greenland through military installations, digital infrastructure and diplomatic alliances.

What is emerging is not a uniform international opening, but rather the emergence of new zones of influence along the Arctic route axes. The Northeast Passage acts as a geopolitical catalyst: it shifts power projection, investment flows and attention northward. Anyone who ignores them runs the risk of running out of space in the future Arctic infrastructure area.

Economically, the passage remains a niche route for the time being – ecologically it is highly sensitive terrain. But strategically it is already a test of cross-sector foresight. Whether shipping companies, governments or multilateral institutions: it is important to make decisions today that will ensure the ability to act in the coming decades. Infrastructure, technology and governance must look ahead to a world in which Greenland is American, Svalbard is Russian – and the Arctic is no longer neutral territory.

The Arctic is becoming a seismograph of the global order in climate change. Their development not only determines trade flows, but also questions of sovereignty, resilience and strategic access.

Attachment

Policy Matrix: Regulation and Development of Arctic Sea Routes

Actor	Priority 2025-2035	Strategic measure	Goal/effect
Shipping companies & logisticians	Build route flexibility in high latitudes	Investment in PC5+ ice class tonnage, seasonal test traffic, partnerships in Kirkenes/Iceland	Early market access to NSR; Cost reduction & first mover advantages
Ports & Terminal Operators	Develop Arctic hubs	Development of hub logistics centers in Finnafjörður, Kirkenes, Nome; Infrastructure for LNG, project cargoes	Diversification of global supply chains, regional growth, location advantages in a new trading zone
Insurer/Underwriter	Revise risk models for Arctic transits	Development of standardized insurance frameworks for seasonal NSR use; Integration of ice & satellite data	Reduction of economic entry barriers for actors with ESG-oriented risk positions
EU & NATO countries	Secure strategic control over Svalbard	Establishment of a civil-military situation center in Tromsø; EU/NATO governance to enforce international law norms	Limiting Russian expansion in Svalbard; Protecting critical infrastructure & communication routes
USA (Strategic Partners)	Consolidate influence in Greenland	Expansion of Thule into a digital & maritime infrastructure platform; Investments in dual-use logistics	control over western access to the Arctic; Supporting transatlantic security architecture
Arctic coastal states	Build infrastructure parity with Russia	Establishment of emergency ports, SAR zones, communication networks along the NSR/NWP	reduction of Russian monopoly position; Securing sovereignty through functional presence

Multilaterale Organisationen (IMO, Arctic Council, EU)	Close governance deficits in transit & environmental protection	Extension of the Polar Code (<500 GT), satellite-based transit registration, binding emission limits	Law enforcement in gray areas, ecological resilience, protection against systemic risks
Indigenous organizations	Ensuring voice and participation	Participation in infrastructure planning, environmental supervision, revenue from transit taxes (sameting model)	Avoiding social conflicts, protecting cultural and ecological rights
Research & Innovation	Drive digital navigation and risk reduction	AI-based route control, autonomous icebreaking drones, multispectral ice mapping (SAR, LEO satellites)	Increasing planning ability, reducing transit risks, technological sovereignty