The potential of container vessel operation on the Northern Sea Route: Nautical, regulatory, and operative issues[1]

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Extant literature dealing with operative and economic aspects of container shipping in the Northern Sea Route (NSR) has concentrated on the analysis of a particular vessel *type*. Table 1 demonstrates that this type corresponds to a small, ice-classed container ship such as the *COSCO Yong Sheng*, whose voyage from Dalian to Rotterdam in August, 2013, constituted one of the first known container shipping operations by way of the NSR.

Unfortunately, this type of vessel is rather the exception in global container shipping, especially when it concerns routes between Northern Europe and Asia. Almost none of the container vessels operating on the high seas today, including any of those 90 vessels worldwide whose completion is expected by 2017, is ice-classed. Further, the average capacity of vessels on routes between Europe and Asia has exponentially grown, from 4,500 TEU in 1998 to 8,000 TEU in 2011 and 11,000 TEU in 2014 (Ferrari et al., 2012; Mietzner, 2015–this book). The largest container cargo vessels existing today have a capacity of over 19,000 TEU. As a result of this development, the draft and beam of such ships have greatly increased. Critical authors believe that these effects likely relativize the potential of the NSR as an alternative route for global container shipping (Ho, 2011).

In an attempt to contribute to this debate, we use one of the largest existing container vessels, the M/V *Mærsk Mc-Kinney Møller*, as our unit of analysis, letting her complete a hypothetical voyage through the NSR and elaborating in detail both the nautical, operative, and regulatory issues she would face during her journey. Her technical specifications are presented in Table 2. Thus, we attempt to discuss not only the contemporary but also the future situation of container shipping by considering the current size developments in container shipping.

Nautical issues

The waters of the NSR are part of a large and shallow shelf sea that stretches far to the north from the coast of the Russian mainland (cf. exhibit 1). As a result, many key passages and straits, both within the NSR and in the adjacent seas, are characterized by waters less than 30 meters deep, and some of these are exceptionally shallow (cf. Table 3 and Exhibit 2 in this chapter). Vessels as large as the *Mærsk Mc-Kinney Møller* with a draft of 14.5 me-

1 This chapter partially draws on material and texts first published in the second author's Master's thesis at the University of St. Gallen (Switzerland).

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ters are not able to pass these bottlenecks without causing major damage to the hull or even running aground. The only option that remains is to sail around, rather than through these problematic waters. The reader should note that the problem of shallow waters exists irrespective of the extent to which they are ice-covered.

Authors	Vessel capacity (TEU)	Ice-classed?	Window of operation	Trip
Niini, Arpiainen, and Killi (2006)	750 / 5,000	Yes	Year round	Europe–Aleutian Islands
Verny and Grigentin (2009)	4,000	Yes	Year round	Shanghai–Hamburg
Liu and Kronbak (2010)	4,300	Yes	Seasonal (90–270 days)	Yokohama–Rotterdam
Furuichi and Otsuka (2014)	4,000	Yes	Seasonal (105–225 days)	Yokohama–Hamburg
Xu et al. (2011)	10,000	No	Seasonal (30 days)	Various

Table 1: Literature analyzing container vessel operation on the NSR

Attribute	Specification
Manufacturer	Daewoo Shipbuilding & Marine Engineering Co., Ltd
Ship owner	A. P. Møller-Mærsk A/S (Mærsk Line)
Cost to build	Approx. US$ 190 million (estimate)
Nominal capacity	18,270 TEU
Homogenous capacity[2]	13,500 TEU
LOA	399 meters
Beam	59 meters
Draft	14.5 meters
GT	194,849 tons
NT	79,120 tons
Propulsion	Two MAN B&W S80ME-C9-TII engines
Design speed	23 knots
Energy efficiency	168 grams of fuel oil per kWh

Table 2: Technical specification of the Mærsk Mc-Kinney Møller (American Bureau of Shipping, 2013; Maersk, 2013a, 2013b; MAN Diesel & Turbo, 2010; World News, 2011)

2 Defined as the maximum load-bearing capacity given an average weight of 14 tons for a twenty-foot container.

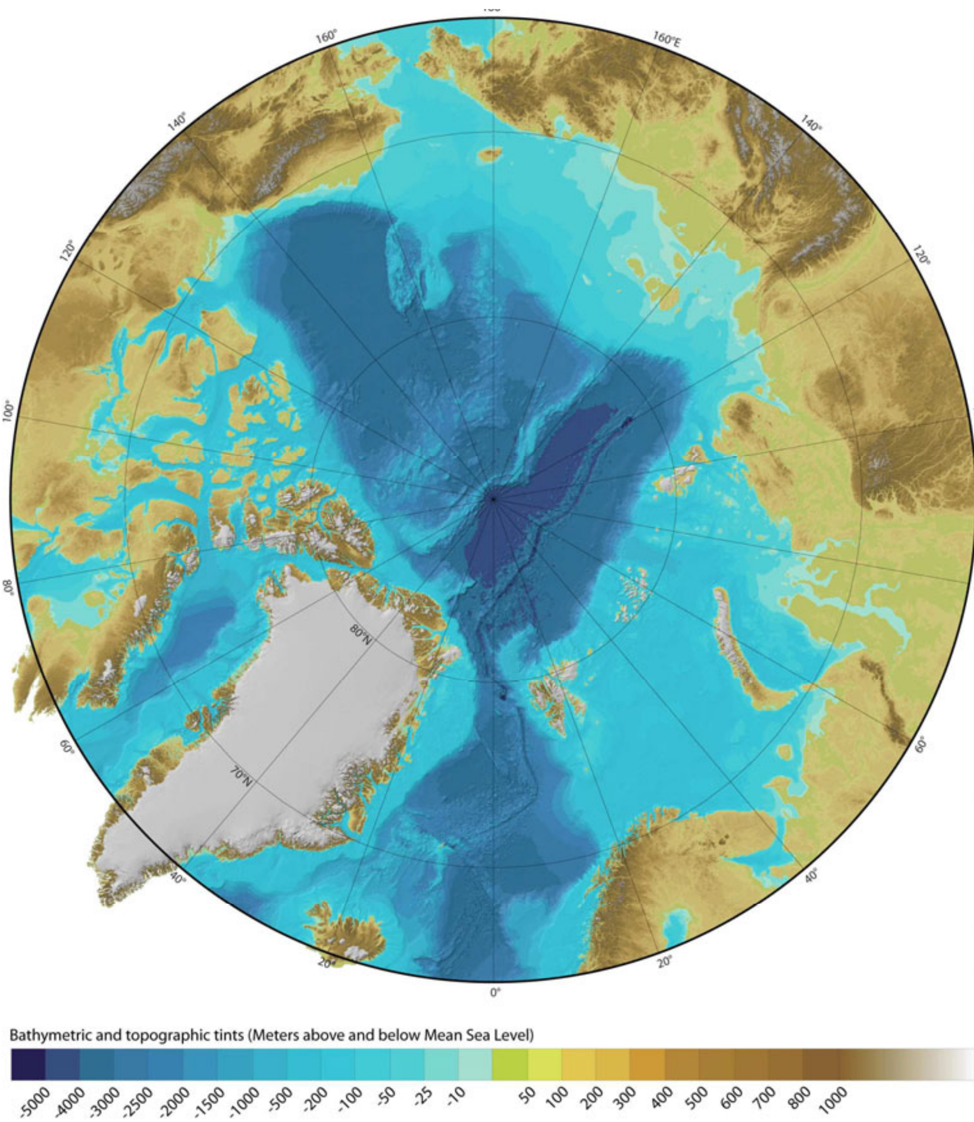

Exhibit 1: Bathymetric map of the Arctic Ocean (Jakobsson et al., 2012)

The extreme shallowness of the Pechora Sea implies that large container vessels will have to take the more northerly route along the coast of Novaya Zemlya and around Cape Zhelaniya, which Svahn (2015, this book) describes. Navigation in the De Long and La Pérouse straits may prove difficult in adverse weather since no more than five meters of the water head remain to cushion the ship from hitting the seabed when it rides high waves. The most critical points, the Sannikov and Laptev Straits share the same longitude and present alternatives to navigate through the New Siberian Islands (viz. Exhibit 2).

Site	Approximate position	Minimum depth (meters)
Pechora Sea	69° N, 54° E	6
Sannikov Strait	74.5 N, 140° E	12.6
Laptev Strait	73 N, 142° E	12 to 15

Table 3: Exceptionally shallow waters in the NSR (Arctic Council, 2009; Eger, 2010; Rottem and Moe, 2007; Belkin, 2015)

The Laptev Strait in the south will most probably be too shallow to traverse for the *Mærsk Mc-Kinney Møller*. The same can be said for the Strait of Sannikov, situated farther to the north, except that two bypasses to the extreme North, with a respective minimum depth of at least 25 meters, exist by which the Strait of Sannikov can be circumnavigated. The feasibility of this option, however, depends on whether or not the local ice conditions make those northern routes accessible (Belkin, 2015). To guarantee safe operations, the *Mærsk Mc-Kinney Møller* would probably have no choice but to rely on one of these bypasses. In a worst-case scenario, this implies she would have to wait until local ice conditions or icebreaker support would allow her to pass. The greatest part of the NSR waters lies to the north of the 70th parallel. Beyond this boundary, radio and GPS communications are significantly restricted due to magnetic and solar phenomena, interference, and geostationary satellite geometry (Emmerson and Lahn, 2012); however, this problem is expected to be largely mitigated with the update of the Iridium satellite network and the novel installation of the mobile user objective system (MUOS) network (Magnuson, 2014). Still, as of 2014, marine communication and navigation are difficult, and internet access is often impossible. There is dense fog along the route in June and July. Weather conditions can change abruptly, there are hardly any meteorological offices along the route, with satellite-based weather prediction often inaccurate; in addition, vessels may collide with drifting sea ice. Further, when the large surface area of a container ship freezes and subsequently becomes covered with ice (*icing*), the vessel's center of gravity can shift, implying increasing roll and a lack of stability (Emmerson and Lahn, 2012; Pollock, 2009; Roberts, 2012; Svahn, 2015 - this book). For a large and heavy ship, such as the *Mærsk Mc-Kinney Møller*, these navigational risks are a serious concern.

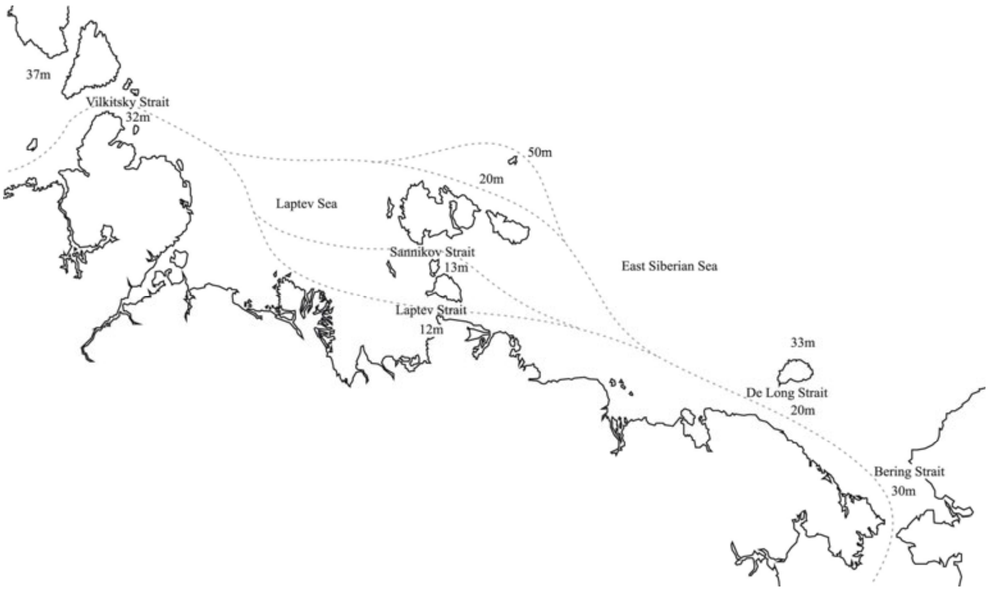

Exhibit 2: Key bottlenecks of the NSR (authors' creation)

As of 2014, marine support and rescue infrastructure is rudimentary. For the whole NSR, there are only three established marine rescue coordination centers: Dikson, Tiksi, and Pevek[3]. Each center is staffed with a lifeboat, rescue ship, and long-range aircraft; additionally, the station at Tiksi has one medium-range helicopter and that Pevek one light helicopter. These two centers are manned from July through September only. Icebreakers operating along the NSR can be mobilized for rescue operations (Northern Sea Route Administration, 2013). At the end of 2014, Russia opened a third search and rescue center in Arkhangelsk. The German shipbuilder *Nordic Yards* completed the construction of two new search and rescue vessels, the *Beringov Proliv* (based in the Sakhalin region) and the *Murman* (based in the Murmansk region), in February 2015. Case study reports of known incidents suggest that search and rescue operations may take considerable time (Emmerson and Lahn, 2012; Pettersen, 2013); further, to the best of our knowledge, no search and rescue exercises simulating a large cargo ship in need of support have been performed yet. In case of an emergency, the *Mærsk Mc-Kinney Møller* would probably be on her own for several days until local rescue operations could be organized.

3 Maps of their locations, areas of operation, and radio frequencies are available from http://nsra.ru/en/pso/

Regulatory issues

Irrespective of the juridical discussions about the NSR's legal status as a whole and that of particular straits (see Kastner, 2015–this book), navigation in the NSR is *de facto* regulated by the Northern Sea Route Administration (Northern Sea Route Administration), an agency of the Russian state, and permission must be obtained for every passage[4]. The requirement for permission is independent of the ship's build, technical configuration, route, or ice class. Since January 17, 2013, the regulatory framework has been considerably liberalized. As a result, in theory, *any* vessel may now pass the NSR (cf. Table 4) even without ice-breaker support (ice class, sea ice, and open water conditions permitting)[5]. The reader should note that, in stark contrast to the passage of the Suez Canal, no transit fees are incurred for navigating the NSR (Ministry of Transport of Russia, 2013). However, the *mode by which* a particular vessel may *navigate* the NSR will be determined by the Northern Sea Route Administration. Its decision depends on both the local ice conditions in the sea area(s) the vessel intends to pass and on the ice classification of the vessel. The latter is assessed according to the Russian ice classification as defined by the Russian Maritime Register of Shipping, of which Wallin and Åkerström (2012) provide detailed documentation as well as a comparison with other classificatory schemes. The decision is not arbitrary; on the contrary, it is made according to highly formalized and objective checklists that are publicly available from the Northern Sea Route Information Office[6]. In all cases, an ice pilot[7] and additional insurance to cover the risks of environmental pollution are mandatory.

A closer analysis of these tables reveals two important facts. First, vessels with any of the ice classes Ice 1, Ice 2, or Ice 3 *(non-Arctic ships*) as well as those without any ice class may only pass between the beginning of July and November 15. Second, the extent to which icebreaker support is mandatory is primarily a function of sea ice conditions. Applying these criteria to the *Mærsk Mc-Kinney Møller*, we find that she could only operate in the NSR during the above timespan since, as of her current build, she has no reinforced hull and, thus, no ice classification. Additionally, even during that short time window, the Northern Sea Route Administration will grant her the right of independent navigation only under *open water* conditions; otherwise, icebreaker support is mandatory, implying navigation is not free but guided (see Svahn, 2015–this book, for a documentation of traveling in such a convoy)[8].

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4 Non-compliant vessels are publicly denounced at *http://nsra.ru/en/non_compliant_vessels/*

5 However, in contrast to the written regulations, Rosatomflot insists that independent navigation for non-ice-classed vessels is prohibited. Further, Rosatomflot does not recommend that non-ice-classed vessels enter the NSR on their own due to past incidents (hull damage, environmental concerns) and suggests that underwriters are reluctant to provide coverage for vessels with an ice class below 1A (Belkin, 2015; Sekretev, 2013). This would imply that vessels without any ice class would likely encounter *de facto* regulatory and insurance problems once they attempt to pass the NSR even if they may be eligible to pass on a *de jure* basis.

6 See *http://www.arctic-lio.com/nsr_iceclasscriteria*

7 At a rate of US$ 673 per pilot and day (Furuichi and Otsuka, 2014). Note that larger ships often require two pilots (Roberts, 2012). Still, compared with the cost of operations and transit fees, this cost seems negligible.

8 *Open water* conditions correspond to a large area of freely navigable water in which sea ice is present in concentrations of less than 1/10th and ice of land origin is absent (World Meteorological Organization, 2012).

Aspect	Before	After
Registration	Ship must be pre-registered at least four months before passage and it will be inspected at the owner's cost before entry.	Ship must be pre-registered at least 15 days before passage. No inspection.
Administrative authority	Shared between two marine operation headquarters.	Northern Sea Route Administration handles all administrative issues.
Technical requirements	Vessel must have at least Arc 4 ice class. Other vessels may only pass by way of exception. Double bottom floor and propeller with at least four blades required. Switching from *full ahead* to *crash back* must not take more than 45 seconds.	All vessels may enter and pass the NSR irrespective of their ice class, including those that have no ice class at all. The extent of mandatory icebreaker support is determined by the vessel's ice class (if any) and local sea ice conditions.
Staff requirements	Vessel must have enough crew members to organize continuous watch in three shifts. Captain must have at least 15 days of NSR navigation experience; else, an ice pilot is mandatory.	No particular staff requirements. An ice pilot is always mandatory.
Mandatory Insurance[9]	n/a	Vessel must have liability insurance covering environmental pollution.

Table 4: Liberalization of NSR regulatory framework since January 17, 2013 (Belkin, 2015; Ministry of Transport of Russia, 2013; Northern Sea Route Administration, 2013; Østreng et al., 2013; Russian Federation, 1996)

This will probably restrict her effective period of operation to between the end of August and beginning of October, when ice conditions in the NSR are easiest (Belkin, 2015). If icebreaker support in the NSR is required, then the *Mærsk Mc-Kinney Møller* would likely obtain it from the *Federal State Unitary Enterprise Atomflot*, or *Rosatomflot* for short, a state-controlled company that currently operates four nuclear-powered icebreakers in the

9 However, these regulatory requirements may strongly differ from the requirements that private underwriters put forward. Industry practice suggests that underwriters are quite reluctant to provide coverage unless the vessel has at least ice class 1A (Belkin, 2015).

NSR area[10]. Their technical specifications are presented in Table 5. Only icebreakers under Russian flag may escort vessels through the NSR (Ministry of Transport of Russia, 2013). Thus, we believe it is highly unlikely that Russia would ever allow other nations' icebreakers, such as China's *Snow Dragon*, to operate in the waters of the NSR.

It goes without saying that icebreaker support does not come for free. Escort fees depend on the ship's gross tonnage, its ice class (if any), and the time of year[11]. According to the official list of fees, the *Mærsk Mc-Kinney Møller*, having no ice class and a gross tonnage that exceeds 100,000 tons, would have to pay between 268 and 536 rubles (between US$4.32 and US$8.64 at the time of writing) per ton of gross tonnage, depending on the number of sectors along the NSR for which she requires support (Federal Tariff Service of Russia, 2014)[12]. Given her gross tonnage of 194,849 tons, the shipowner can expect an *official* fee in the range of US$1–2 million for a single icebreaker[13].

	50 Let Pobedy	*Yamal*	*Vaygach*	*Taymyr*
In service since	2007	1992	1990	1989
Gross tonnage	23,439	20,646	20,791	20,791
Propulsion power (MW)	55.2	55.2	36.8	36.8
LOA (meters)	159.6	150.0	149.7	149.7
Beam (meters)	30.0	30.0	28.9	28.9
Draft (meters)	11.0	11.0	9.0	9.0
Speed (knots)	21.0	21.0	20.0	20.0
Icebreaking capacity (thickness in meters)	2.8	2.0	1.77	1.77

Table 5: Rosatomflot's nuclear icebreakers operating in the NSR[14] *(Russian Maritime Register of Shipping, 2015; Rosatomflot, 2015b; Northern Sea Route Administration, 2015)*

This fee seems prohibitively high, particularly so in comparison with the US$230,000 the shipowner pays when a fully laden and northbound *Mærsk Mc-Kinney Møller* passes the

10 Since 2008, Atomflot is a subsidiary of the state nuclear corporation *Rosatom* (Rosatomflot, 2015a). Two other state-controlled companies also offer icebreaker assistance in the waters of the NSR (*Rosmoport* with the vessel *Kapitan Drantisyn* and *Fesco* with the vessels *Krasin* and *Admiral Makarov*). However, these vessels are restricted to offshore support operations with close bunker fuel proximity. To date, all international transits through the NSR have been accompanied by Rosatomflot's nuclear icebreakers (Belkin, 2015).

11 Detailed lists of fees (termed 'tariffs') are publicly available from http://www.arctic-lio.com/nsr_tariffsystem

12 Given the development of the dollar–ruble exchange rate in the wake of the sanctions imposed against Russia during the Crimea and Ukraine crises of 2014, these fees have, *de facto*, been cut in half. In November, 2013, one US dollar was worth 33 rubles; by January, 2015, it was worth 67 rubles.

13 These fees decrease significantly once the vessel is ice-classed. For example, a ship of the same size and GT as the *Mærsk Mc-Kinney Møller*, with an Arctic 4 ice class, would pay about 50% less.

14 The vessel *50 Let Pobedy* is also known under its translated name: *50 Years of Victory*. As of 2015, it is the largest and most powerful icebreaker in the world. A fifth nuclear icebreaker operated by Rosatomflot, the *Sovetskiy Soyuz*, has been out of service since 2007 and is scheduled for break up; however, in 2014 it was reported she will be recommissioned. A new generation of icebreakers is currently under construction, with completion planned for 2017 (Staalesen, 2014).

Suez Canal[15]. However, in practice, these official fees are not final but, rather, subject to negotiation. Real rates paid by the German firm *Beluga Shipping* while it was shipping in the NSR suggest a realistic dimension of about US$2.25 per dwt for the complete passage (Østreng et al., 2013), implying that the shipowner of the *Mærsk Mc-Kinney Møller* should negotiate for a rate of about US$437,000 for icebreaker support along the complete route. It needs to be noted, however, that the *Mærsk Mc-Kinney Møller* may require the assistance of two icebreakers since her wide beam of 59 meters surpasses the maximum canal width of about 40 to 42 meters that any single icebreaker operating in the NSR area can create; however, this problem may be mitigated by the arrival of a new class of icebreakers expected to become operative from 2017 (Belkin, 2015).

Finally, calculating and negotiating the premium for the mandatory insurance to cover the special risks of traveling in the NSR, such as pollution of the sensitive Arctic ecosystem, injury to persons, and costs of potential salvage operations *(Arctic premium)* are highly complex tasks. These potential liabilities are likely to increase the premium for the vessel's protection and indemnity (P&I) insurance. Further, statistics analyzing 40 years of vessel movements in Arctic waters suggest that navigation in shallow and ice-infested waters, as well as movements behind icebreakers, significantly increase the risk of hull damage. Given that ordinary hull and machinery (H&M) insurance does not cover operation in ice-infested waters, underwriters will likely charge a supplement to cover these risks (Chernova and Volkov, 2010; Emmerson and Lahn, 2012; Østreng et al., 2013). The operationalization of the Arctic premium as a multiple of the Suez Canal excess insurance cost, as proposed by Østreng et al. (2013), is not really helpful since underwriters do not publish the war risk insurance rates they charge[16]. Even if these rates were known, they are still subject to contemporary geopolitical events and are, therefore, extremely volatile. Hence, attempts to directly compare the insurance cost for the Suez Canal route against that for the NSR remain extremely speculative. Suffice it to say that, geopolitically speaking, the NSR has been unaffected by either war or piracy to date, implying a certain rate trade-off calculation between the routes should be possible.

Considerations for the NSR's future container shipping potential

For large container vessels, the cost for icebreaker support is likely to exceed any Suez Canal transit fees, particularly when vessels with a wide beam, such as the *Mærsk Mc-Kinney Møller*, may require the assistance of two icebreakers along more than one or two sectors of the NSR. However, this situation is likely to change in favor of the NSR as unrelenting climate change increases the number of days with open water conditions. During

15 To calculate this fee, we used the online toll calculator provided by the Suez Canal Authority (http://www.suezcanal.gov.eg/calc.aspx) with the following specifications: Container ship, northbound, 8 tiers on deck, laden, NT = 79,120, GT = 194,849, draft = 48 feet, beam = 194 feet, SDR = 0.683269 per USD.

16 The excess insurance cost for the Suez Canal route is primarily determined by the requirement to buy *war risk insurance* to cover the risks of piracy, terrorism, and war-related damage when passing 'listed areas', such as the Horn of Africa (Skuld, 2009, 2013). The reader should note that this insurance only covers the vessel (but not the loss or damage of any cargo it carries).

such days, in theory any vessel can operate independently on the NSR, which saves the cost of retrofitting to comply with ice classification[17] as well as any Suez Canal transit fees. Against the backdrop of these savings, the cost for a mandatory ice pilot seems negligible and the cost of additional liability insurance to cover the risk of environmental pollution may be more than offset by saving expenses for war risk insurance. Additionally, open water conditions allow the shipowner to better plan and predict itinerary times and, thus, reduce the often-quoted imponderabilities of Arctic shipping due to unpredictable weather and ice conditions. At the same time, these benefits can only be fully reaped when the *complete* NSR has open water conditions; otherwise, the benefits diminish when only some sectors of the NSR can be navigated independently while others require icebreaker support. Finally, the effective administration of NSR regulations may enforce the use of icebreaker support for vessels without ice classification even under open water conditions. Technically speaking, this *de facto* policy is contradictory to the letter of these regulations (cf. footnotes 5 and 6).

Further, climate change is only unrelenting when *long-term averages* are considered. When the sea ice extension in the Arctic Ocean between 1979 and 2013 is regressed to the mean, *average* ice coverage is clearly shrinking; however, the standard deviation suggests that *year-to-year* coverage is erratic and volatile (National Snow & Ice Data Center, 2015). Particularly, a reduction of the overall ice coverage in the Arctic Ocean need not imply the NSR will be ice-free. Indeed, the NSR can be partially or completely ice-infested while other areas of the Arctic Sea have open water conditions (National Snow & Ice Data Center, 2013a, 2013b). Personal communication with Belkin (2013) suggests that today the NSR has about 30 days with open water and 30 days with easy ice conditions per year. Since the latter condition requires mandatory icebreaker support for vessels that are not ice-classed, shipowners should closely monitor the number of days with open water conditions over the coming years. Once a critical number of open water days has been reached, and once these days are not isolated events but occur in coherent time segments, the business case for shipping in the NSR is likely to become very attractive.

Additional potential for cost savings can result from deliberate slow-steaming when shipping in the NSR. For example, the Rotterdam–Shanghai route via the NSR (approx. 8,200 nautical miles) is about 2,300 nautical miles shorter than the Suez Canal route (approx. 10,500 nautical miles)[18]. Assuming constant travel at her design speed of 23 knots, the *Mærsk Mc-Kinney Møller* reaches either destination about 100 hours earlier if she travels via the NSR.

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17 Retrofitting the *Mærsk Mc-Kinney Møller* would require costly adaptions, such as installing protection for the rudders and propellers, hull enforcements, and ice-proof sealing of cooling water openings in the hull (MAN Diesel and Turbo, 2012). Since such retrofitting for largo cargo ships has not yet been done, the extent to which the associated investments would amortize is unknown. However, the existence of newly built ice-classed bulk vessels and tankers operating in the NSR suggests that profitable operation of ice-classed ships is essentially possible (cf. Mietzner, 2015 – this book, and Keupp and Schöb, 2015 – this book).

18 Distance for the Suez Canal route was calculated with data from *http://www.sea-distances.org* and rounded; distance for the NSR was calculated by adding the distance between Rotterdam and Hamburg (305 nautical miles as calculated by this website) to the distance between Hamburg and Shanghai given by Mietzner (2015, this book) and rounding the technical result of 8,130 nautical miles to 8,200.

Alternatively, if time is not of the essence, her owner might deploy a slow-steaming strategy, implying she reaches her destination at the same time as a vessel traveling through the Suez Canal route, but with less fuel consumption and, hence, lower bunker cost. The advantage of 100 hours is equivalent to a minimum slow-steaming speed of 18 knots[19].

The main cost driver of container shipping is bunker cost, incurred as a result of fuel oil consumption. At her design speed of 23 knots, the *Mærsk Mc-Kinney Møller* can expect to burn almost 240 tons of fuel oil during a 24-hour period of operation, or approximately 10,000 liters per hour[20]. Since her capacity exceeds 10,000 TEU, according to Notteboom and Cariou (2009), this consumption is reduced by approximately 38% at 20 knots and by 46% at 18 knots. Her engines can burn most commercially available heavy fuel oils as long as their viscosity is below 700 centistokes at 50° Celsius (MAN Diesel & Turbo, 2010), implying prices of the most common type of bunker fuel, IFO 380, can be used for calculation. The price of IFO 380 is highly volatile and depends, *inter alia*, on the port where it is bunkered and the situation of the global oil-producing industry[21]. Assuming an average price of US$420 per metric ton, slow-steaming in the NSR corresponds to significant bunker cost reductions of 29% and 31%, respectively (cf. Table 6). These savings would either increase her owner's profit (assuming constant charter rates) or allow the owner to outcompete others in contested markets by offering lower charter rates.

Speed (knots)	Hours to either destination	Fuel consumption (tons/24 h)	Total fuel consumption (tons)	Associated bunker cost (US$)
23	357	240.00	3,570.00	1,499,400
20	410	148.80	2,542.00	1,067,640
18	456	129.60	2,462.40	1,034,208

Table 6: Bunker cost reduction potential of the Mærsk Mc-Kinney Møller by slow-steaming on the relation Rotterdam–Shanghai via the NSR (own calculation)

The potential savings from slow-steaming should be considered when future business cases concerning the NSR are calculated. Ship owners might consider offering 'fast track' services that capitalize on the shorter travel time, or 'economy' shipping at slow-steaming rates.

Finally, the logistics and scheduling aspects of global container shipping operations are likely to influence the extent to which the NSR will be perceived as a viable alternative to the Suez Canal route. Container ships do not tramp but operate as liner services, i.e., they

19 At this speed, travel time in hours is equivalent, assuming the given distances and constant 24-hour operation at identical speed without any calls at intermediary ports.

20 Her engines require 168 grams of fuel oil to produce 1 kWh (Maersk, 2013c) and one hour of operation at her design speed of 23 knots requires 59,360 kW of energy (Maersk, 2013a, 2013b; MAN Diesel & Turbo, 2010).

21 Prices for the average 380 centistoke fuel oil per metric ton bunkered at the largest European ports bottomed at US$192 in December, 2008 and topped at US$707 in March, 2012. In November, 2014, the price had declined to US$420 (Bunker Index, 2014).

travel bidirectional itineraries, with fixed start and end points and pre-defined intermediate ports along the route (*loops*). A loop defines fixed travel times between any two ports. As a result, customers are being given a reliable structure by which they can synchronize their production to maritime logistics (Stopford, 2009; Verny and Grigentin, 2009). The *Mærsk Mc-Kinney Møller* sails the loop AE 10 between Northern Europe and Asia (Maersk, 2013d).

Due to this tight scheduling and synchronization, ships must travel pre-defined routes at pre-defined times. Reliability and predictability are key for the profitability of such container operations, such that any given vessel cannot be spontaneously redirected to travel the NSR instead of the Suez Canal route, not even when weather conditions should be highly favorable. For the same reason, a vessel will stop at all intermediate ports that its loop defines, irrespective of whether or not it can load additional cargo. A more intensive utilization of the NSR would require the planning of (if seasonal) loops. Given the nautical and weather difficulties described further above in this chapter, predictability will probably be hard to attain for such loops.

To assess the shipping potential of the NSR under these circumstances, we analyzed data on 18 loops between East Asia and Northern Europe operated by Maersk Line, CMA-CGM, and MSC (Maersk Line, 2015; MSC, 2014; CMA-CGM, 2015). Structurally, these 18 loops are very similar. Eastbound, they connect the ports of Northern Europe, i.e., those located northeast of Brest, to those of East Asia[22]. All loops pass through the Suez Canal and the regional hubs Singapore–Tanjung Pelepas[23] and Kelang. Westbound, the same ports are called on the return journey. However, the loops differ regarding the intermediate ports they call at during either eastbound or westbound journeys. The 18 loops we examined call at between nine to 23 ports during their itinerary. All loops call at least at two intermediate ports, or at least at the Hong Kong region or Southeast Asian ports. There is no loop that only calls at ports in Northeast Asia and in Northern Europe; further, there is no direct eastbound or westbound connection between these two regions. Thus, the NSR cannot serve as a direct substitute for any loop; instead, independent planning with the establishment of new loops specifically designed for northern travel would have to be established.

Further, we transformed the published structural information about the 18 loops into a binary matrix that assigns a value of 1 whenever a port is called at during any eastbound or westbound journey (including the start and end of that voyage), and a value of 0 otherwise. While this procedure may inflate the number of calls at the start or end point if the vessel is turned around immediately, it removes potential bias from arbitrary removal of double counting since the start and end points of the loops differ across the shipping companies, and since no information is given about handling times. For the sake of clear presentation, we aggregated the data by port into three geographical regions. The region *Northern Europe* includes all ports located in Europe but northeast of Brest. The *Intermediate Region* includes all ports that are located between Brest and Port Kelang along the Suez Route. The

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22 Within East Asia, calls concentrate on the Hong Kong region (ports of Hong Kong, Chiwan, Yantian, Shekou, Xiamen, Nansha, and Taipeh) and the Northeast (ports of Ningbo, Shanghai, Tianjin, Xingang, Qingdao, Dalian, Busan, Kwangyang, Kobe, Nagoya, and Yokohama).

23 Due to the immediate vicinity of these ports, our analysis combines them into one port area.

region *East Asia* summarizes Port Kelang and all ports to the east. It is further differentiated into the three sub regions: *Southeast Asia*, *Hong Kong Region*, and *Northeast Asia*[24].

The numerical results of our analysis are presented in Table 7 and suggest that, in total, the importance of calls at regional ports is somewhat mitigated, since the 41 calls at intermediate ports only account for 10.2% of all port calls. Tanger and Colombo are most frequently called at, with six calls each. These results suggest that, except for the opportunity to load or unload additional cargo at an intermediate port, trade via the Suez Canal route is, by and large, direct traffic between East Asia and Northern Europe. However, a large part of this direct traffic is routed via the hubs of Singapore–Tanjung Pelepas and Kelang, both in eastbound and in westbound directions.

Region	Sub region	Number of calls at ports (region)	Number of calls at ports (sub region)	% share of total calls per region
East Asia	-	207	-	51.5% *(of which)*
-	Northeast Asia	-	109	*(27.1%)*
-	Hong Kong Region	-	64	*(15.9%)*
-	Southeast Asia	-	34	*(8.5%)*
Northern Europe	-	154	-	38.3%
Intermediate	-	41	-	10.2%
Total		402	207	100%

Table 7: Port calls across all examined loops between Northern Europe and Asia. Own calculation using data from Maersk Line (2015), MSC (2014), and CMA CGM (2015)

These results confirm the analysis of Ho (2011) who suggested that more than 50 per cent of the total Far East–Europe trade has to pass through Singapore. To not call at these ports may, therefore, imply high opportunity costs, and these would have to be factored in when the cost of traveling the NSR is calculated. The lack of any intermediate ports or hubs along the NSR effectively reduces the competitive advantage of the NSR to shortening the geographical *distance* (and, hence, reducing fuel cost) for itineraries between Northern Europe and East Asia, since travel *speed* may be subject to weather conditions.

Thus, opportunity costs of not calling at the hubs of Singapore–Tanjung Pelepas and Kelung have to be offset against bunker cost (and possibly travel time) savings.

Finally, the NSR may be thought of as a *fast return route for underutilized vessels*, whereby ships that have unloaded their cargo in Northern Europe would return to Asia via the NSR. Thus, a ship could call at any intermediate port during its westbound journey and capitalize on either shorter travel time (weather permitting) or bunker cost savings on its

24 Due to limitations of space, the data matrix is not presented here. It is available on request from the first author.

return journey. Such a novel north–south loop may mitigate known load factor problems in the container shipping industry, since westbound transport volume from Asia to Europe by far exceeds the corresponding eastbound transport volume. As a result, eastbound load factors are only between 30% and 55% of the westbound ones, and many vessels return laden with empty containers, implying that eastbound charter rates are about 60% lower than westbound rates (Schönknecht, 2009; Verny and Grigentin, 2009). Shipping via the NSR may provide an opportunity to neutralize this disadvantage. Further, since reduced cargo tonnage would also result in shallower draft, some of the navigational challenges of the NSR might be mitigated for eastbound voyages.

References

American Bureau of Shipping. 2013. *Record for Maersk Mc-Kinney Møller.* Online at https://www.eagle.org/safenet/record/record_vesseldetailsprinparticular?ImoNum=9619907

Arctic Council. 2009. The Russian maritime Arctic and Northern Sea Route, in: Arctic Council, 2009, *Arctic marine shipping assessment report 2009*, second printing, April, 2009, p. 23.

Eger, K.M. 2010. *Comparison of operational conditions along the Arctic route*. Kirkenes (Norway): Centre for High North Logistics.

Belkin, M. 2015. Personal e-mail communication between the second author and Mikhail Belkin, Assistant to General Director, Head of Office Rosatomflot, January 2015.

Bunker Index. 2014. *Lowest Rotterdam 380 cSt monthly average since July 2010*. Online at http://www.bunkerindex.com/news/article.php?article_id=14170

Chernova, S., Volkov, A. 2010. *Economic feasibility of the Northern Sea Route container shipping development.* Unpublished Master's thesis, Høgskolen i Bodø (Norway).

CMA CGM Group. 2015. *New 2015 CMA CGM East–West services*. Company presentation. Online at https://www.cma-cgm.com/products-services/line-services

Emmerson, C., Lahn, G. 2012. *Arctic opening: Opportunity and risk in the High North*. London: Lloyd's and Chatham House.

Federal Tariff Service of Russia. 2014. *Order No. 45/1 on approval of the tariff rates for provision of icebreaking pilotage services provided by the FSUE «Atomflot» on the Northern Sea Route water area.* Published by the Ministry of Justice, registration number N 31774.

Ferrari, C., Tei, A., Parola, F. 2012. Facing the economic crisis by cutting costs: The impact of slow-steaming on container shipping networks. Paper presented at the 2012 International Association of Maritime Economists (IAME) Conference, Taipei (Taiwan).

Furuichi, M., Otsuka, N. 2014. Proposing a common platform of shipping cost analysis of the Northern Sea Route and the Suez Canal Route. *Maritime Economics & Logistics*, 17(1): 9-31.

Ho, J. 2011. The Northern Sea Route: Is it really ice-free? *RSIS Commentaries*, no. 121/2011.

Jakobsson, M., L. A. Mayer, B. Coakley, J. A. Dowdeswell, S. Forbes, B. Fridman, H. Hodnesdal, R. Noormets, R. Pedersen, M. Rebesco, H.-W. Schenke, Y. Zarayskaya A, D. Accettella, A. Armstrong, R. M. Anderson, P. Bienhoff, A. Camerlenghi, I. Church, M. Edwards, J. V. Gardner, J. K. Hall, B. Hell, O. B. Hestvik, Y. Kristoffersen, C. Marcussen, R. Mohammad, D. Mosher, S. V. Nghiem, M. T. Pedrosa, P. G. Travaglini, and P. Weatherall, 2012. *The International Bathymetric Chart of the Arctic Ocean (IBCAO) Version 3.0, Geophysical Research Letters, doi: 10.1029/2012GL052219. [Auxiliary Material].* http://www.ibcao.org, maintained by: NOAA/NGDC & World Data Service for Geophysics. The map is available from http://www.ngdc.noaa.gov/mgg/bathymetry/arctic/

Liu, M., Kronbak, J. 2010. The potential economic viability of using the Northern Sea Route (NSR) as an alternative route between Asia and Europe. *Journal of Transport Geography*, 18(3): 434–444.

Mærsk Line. 2015. *East–west network. All schedules.* Online at http://www.maerskline.com/ar-so/shipping-services/routenet/maersk-line-network/2015-east-west-network

Mærsk. 2013a. *Manning the world's largest ship*. Online at http://www.worldslargestship.com/manning-the-worlds-largest-ship/

Mærsk. 2013b. *Triple-E*. Online at http://www.maerskfleet.com/#vessels/Maersk_Line/Triple-E

Mærsk. 2013c. *Efficient propulsion*. Online at http://www.worldslargestship.com/facts/efficient-propulsion/

Mærsk. 2013d. *The first Triple-E has a name*. Online at http://www.worldslargestship.com/the-first-triple-e-has-a-name/

Magnuson, S. 2014. New satellite systems to boost communication coverage in Arctic. *National Defence Magazine*, August 2014.

MAN Diesel & Turbo. 2010. *MAN B&W S80ME-C9-TII Project guide*. First edition. Copenhagen: MAN Diesel & Turbo.

MAN Diesel & Turbo. 2012. *Ice classed ships. Main engines.* Copenhagen: MAN Diesel & Turbo.

Ministry of Transport of Russia. 2013. *Rules of navigation on the water area of the Northern* Sea Route. Online at http://www.nsra.ru/en/pravila_plavaniya/

MSC. 2014. *2015 East–West Services*. MSC Mediterranean Shipping Company S.A.

Niini, M., Arpiainen, M., Kiili, R. 2006. *Arctic shuttle container link from Alaska, US to Europe*. Aker Arctic Technology Inc., Report K-63.

Notteboom, T., Cariou, P. 2009. Fuel surcharge practices of container shipping lines: Is it about cost recovery or revenue making? *Proceedings of the 2009 International Association of Maritime Economists (IAME) Conference*, Copenhagen (Denmark).
National Snow & Ice Data Center. 2015. *Arctic sea ice news & analysis*. Online at http://nsidc.org/arcticseaicenews/
National Snow & Ice Data Center. 2013a. *A better year for the cryosphere*. Online at http://nsidc.org/arcticseaicenews/2013/10/
National Snow & Ice Data Center. 2013b. Arctic sea ice reaches lowest extent for 2013. Online at http://nsidc.org/arcticseaicenews/category/analysis/page/3/
Northern Sea Route Administration. 2013. Federal State Institution. Online at http://www.nsra.ru/
Northern Sea Route Administration. 2015. *Recommendations about the communication for the period of the Arctic navigation*. Online at http://nsra.ru/en/recomend_po_svyazi/
Østreng, W., Eger, K., Fløistad, B., Jørgensen-Dahl, A., Lothe, L., Mejlænder-Larsen, M. & Wergeland, T. 2013. *Shipping in arctic waters*. Berlin, Heidelberg: Springer-Verlag.
Pettersen, T. 2013. Damaged tanker waiting for help on Northern Sea Route. *BarentsObserver,* September 10, 2013.
Pollock, R. 2009. *Economic feasibility of shipping containers through the Arctic*. Unpublished Master's thesis, Massachusetts Institute of Technology.
Roberts, N. 2012. *The Northern Sea Route. An information paper*. Lloyd's Market Association, Joint Hull Committee paper JH2012/004.
Rosatomflot. 2015a. *Russian atomic fleet.* Online at http://www.rosatomflot.ru/index.php?menuid=5&lang=en
Rosatomflot. 2015b. *Atomic icebreakers technical data*. Online at http://www.rosatomflot.ru/index.php?menuid=35&lang=en
Rottem, S.V., Moe, A. 2007. Climate change in the north and the oil industry. *FNI Report 9/2007*, Lysaker (Norway): Fridtjof Nansen Institute.
Russian Federation. 1996. Requirements for the design, equipment and supplies of vessels navigating the Northern Sea Route. In: Russian Federation. 1996. *Guide to navigating through the Northern Sea Route*, pp. 317–323.
Russian Maritime Register of Shipping. 2015. *Register Book*. Online at http://info.rs-head.spb.ru/webFS/regbook/regbookVessel
Sekretev, Y. 2013. Personal communication by e-mail with Yuri Sekretev, Director & Member of the Board, Arctic Bulk, November 12 and December 18, 2013.
Skuld. 2009. *An introduction to P&I Insurance for mariners*. Third Edition. Oslo: Skuld Assuranceforeningen.
Skuld. 2013. *Hull war, strikes, terrorism and related perils listed areas*. Oslo: Skuld Assuranceforeningen.
Staalesen, A. 2014. The "Sovetsky Soyuz" back in icy waters. *BarentsObserver*, May 27, 2014.
Stopford, M. 2009. *Maritime economics*. London et al.: Routledge.
Schönknecht, A. 2009. *Maritime Conatinerlogistik–Leistungsvergleich von Containerschiffen in intermodalen Transportketten*. Berlin, Heidelberg: Springer-Verlag.
Verny, J., Grigentin, C. 2009. Container shipping on the Northern Sea Route. *International Journal of Production Economics*, 122(1): 107–117.
Wallin, F., Åkerström, C. 2012. *Ice class requirements on side shell structures.* Unpublished Master's thesis, Chalmers University of Technology, Gothenburg (Sweden).
World News. Maersk orders 10 additional mega ships. *Journal of Commerce*, June 27, 2011.
World Meteorological Organization. 2012. *WMO sea-ice Nomenclature*. Terminology Volume I, WMO/OMM/BMO - No.259, edition 1970–2014.
Xu, H., Yin, Z., Jia, D., Jin, F., Ouyang, H. 2011. The potential seasonal alternative of Asia-Europe container service via Northern sea route under the Arctic sea ice retreat. *Maritime Policy & Management*, 38(5): 541–560.