The Northern Sea Route as an alternative container shipping route: A hypothetical question or a future growth path?

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Commercial ship financing is a century old, yet a risky business. It typically involves high leverage, with up to 80% of the vessel's building cost financed by loans (Stopford, 2009; Verny and Grigentin, 2009), and is mostly organized by establishing a *one-ship company* that only holds one large asset (the ship itself) in its books. To securitize his loans, the financer will typically encumber this ship with a mortgage. Many one-ship companies (including their ship managers) do not have access to the vessel's cargo. Their revenue is generated only by the operation and chartering of the vessel they own. Therefore, often not only does the ship itself but also the charter party contract serve as collateral for the loan. Unless a vessel can be assigned to a shipping company with access to the vessel's cargo a financer will usually not authorize shipbuilding until a long-term charter party contract can be signed. Moreover, since the global financial crisis, the traditional banks specializing in ship financing have become more conservative; they now demand larger equity buffers, reduced credit portfolios, or even exit the market (Mietzner, 2013), implying that providers of alternative finance in the business, such as private wealth funds or investment banks, are likely to demand superior risk-return ratios.

Indeed, the operative risks that can reduce charter revenue are manifold; they encompass both technical aspects (e.g., nautical risks, collision, corrosion, mechanical or engine failure) and commercial hazards (e.g., construction delays, changes in national regulatory and tax regimes, piracy). In particular, the risk of being unable to arrange for alternative charter party contracts once a particular contract has expired can be significant (Kummerow, 2005).

As a result, the profitability of a particular vessel will decisively depend on the extent to which it can be chartered over its lifespan. Therefore, *charter risk control* is at the center of any profitability calculations in ship finance. A charterer will not conclude a long-term charter party contract with any ship owner unless the ship can be operated more efficiently than others on a given route or profitably on new route. For the case of the Northern Sea Route (NSR), this implies that a shipping company will have to demonstrate that container shipping in the NSR is profitable, even if compared to the Suez Canal route. The remainder of this chapter attempts to assess the extent to which this can be demonstrated.

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Traffic volume and operative aspects

In 2009, the first commercial transit of non-Russian ships[1] through the NSR took place. Commercial traffic volume in the NSR steadily increased between 2007 and 2013, but decreased in 2014 (cf. Table 1).

Year	Number of vessels transiting the NSR
2007	2
2008	3
2009	5
2010	10
2011	41
2012	46
2013	71
2014	53

Table 1: Traffic volume in the NSR (Northern Sea Route Information Office, 2014)

A detailed analysis of all transits completed in 2013 revealed that the majority of vessels transiting were dry and liquid bulk carriers. Generally, these do not operate according to scheduled services, but engage in tramping on the basis of voyage charter party contracts. This is not surprising, given that the relative geographic proximity between resource-abundant Scandinavia and commodity-hungry Japan and South Korea predestines the NSR to be a bulk cargo route that connects commodity suppliers and consumers. Still, the structure of completed transits (cf. Table 2) suggests that the NSR is still a long way from what might be considered a regular shipping route.

Type of vessel or voyage	Number of transits in 2013
Liquid bulk carrier (tanker)	31
Dry bulk carrier	4
Liquefied natural gas (LNG) carrier	1
General cargo vessel	13
Empty trip	15
Positioning trip	7

Table 2: NSR transits in 2013 by voyage and vessel (Own calculation using data from Northern Sea Route Information Office, 2014)

1 This was by M/V *Beluga Transit* and M/V *Beluga Fraternity*, operated at the time by the now bankrupt German heavy-lift shipping company Beluga Shipping.

Given these transit data, how (if at all) could a scheduled liner service by container operators be commercially viable? The answer to this question is possibly a function of economies of scale and slot costs (i.e., costs per homogenous TEU capacity[2]). Today, the shipping industry is characterized by tough cost competition and continuously decreasing bunker fuel consumption.[3] At the same time, low freight rates and continuously increasing bunker costs lead to increasing cost pressures for ship owners and operators.

Over the last years, historically low new building prices, the Panama Canal extension, increasing bunker costs,[4] and global excess liquidity have triggered a wave of new building orders. For shipping companies offering scheduled liner services, these orders are meant to realize economies of scale. While size growth in container shipping has not yet reached its peak rate, particularly if compared to that of other vessel types such as tankers, alternative measures by which slot costs can be reduced are becoming increasingly attractive. Shipping in the NSR might provide such an alternative means of reducing slot costs.

A model for estimating the slot cost of an NSR transit

The commercial viability of container shipping in the NSR is influenced by many factors, including the route, fuel consumption curves, travel speed, charter rates, bunker costs, insurance rates, transit fees, etc. To deliver a clear yet significant analysis, the following discussion assumes that additional insurance premiums, port dues, and auxiliary motor fuel consumption are equal for both routes and all vessel types; thus, they will not influence the results.[5] In reality, these costs will, inter alia, depend on the vessel type, age, and shipping route. However, the share of these factors as a fraction of slot cost is relatively insignificant, such that they only have a minor effect on the results.

This section proposes a self-developed model to estimate slot cost as a joint function of speed and charter rates. The model merely considers the essential determinants of slot cost: bunker costs, transit fees, asset costs, and operation expenses. The best indicator to estimate the latter two is the charter rate for the respective ship category.[6] Bunker cost (i.e., bunker fuel consumption) depends on speed and ship-specific consumption profiles, yet it accounts for between 30 and 80% of the total voyage cost. Due to expected future supply shortages, bunker costs are likely to gain relevance. The results presented here are based on an assumed bunker cost of US$650 per metric ton. Slot cost is calculated as follows (B: bunker

2 This is defined as a vessel's twenty-foot equivalent unit (TEU) carrying capacity at a weight of 14 tons per container.

3 Hence the technical term 'bunker cost' refers to the volume of bunker fuel (consumption in metric tons times price per metric ton) a vessel consumes during its voyage.

4 Even though oil and hence bunker prices significantly decreased since the second half of 2014, it is possible that prices of fossil fuels will rise again in the medium term.

5 Insurance costs for protection and indemnity (P&I) and ship damages are covered by the charter rate. Additional insurance for NSR transit likely has only a marginal influence on slot cost.

6 Charter contracts for any given timeframe are negotiated in the time charter market. Normally, the resulting charter rates will cover both the ship's operating expenses (staff, lubricants, insurance, maintenance, miscellaneous costs of operation) and capital expenditure.

cost; *C*: charter cost; *T*: transit cost; *TEUh*: homogenous TEU capacity; *kn*: speed in knots; *d*: distance; *mt*: consumption in metric tons per day; *bp*: bunker fuel price; *c*: charter rate):

$$Slot\ cost_i(kn) = \frac{B + C + T}{TEUh} = \frac{\left(\left(\frac{d}{kn \cdot 24}\right) \cdot mt(kn)\right) \cdot bp + \left(\frac{d}{kn \cdot 24}\right) \cdot c + T}{TEUh} \tag{1}$$

with

$$mt(kn) = \alpha \cdot kn^x \tag{2}$$

where α and x are auxiliary parameters determined by the ship's engine configuration. While formula (2) shows that bunker fuel consumption exponentially grows with speed, *increasing* slot cost, formula (1) shows that speed also *reduces* slot costs by diminishing the cost-driving influence of the charter rate. Thus, for any given set of parameters an optimal travel speed that minimizes slot cost can be calculated.[7]

It goes without saying that compared to the Suez Canal route, shipping in the NSR establishes a relative geographic proximity between Northern Europe and Northeast Asia; thus, slot cost reductions can be expected due to smaller voyage distances. However, this comparison is incomplete since the contemporary construction of ultra large container ships (ULCS)[8] does not permit them to transit the NSR. Therefore, to generate a realistic slot cost comparison the largest ice-classed vessel existing today with its capacity of 2,800 TEU must be compared to a standard 14,000 TEU container vessel. Implementing formulae (1) and (2), Table 3 below shows the results of this comparison for a voyage from Hamburg to Tokyo, both inclusive and exclusive of transit fees.

7 For the sake of clarity, the operationalization of some factors is omitted. Further information is available from the author of this chapter.

8 This class designates vessels with a nominal volumetric capacity of 10,000 TEU and above.

Speed (knots)	Slot cost inclusive of transit fees		Slot cost exclusive of transit fees	
	NSR	Suez Canal	NSR	Suez Canal
20	768.34	394.17	476.43	366.70
19	748.09	379.76	456.18	352.30
18	730.90	367.94	438.99	340.47
17	717.32	358.79	425.41	331.32
16	706.23	352.25	414.32	324.78
15	698.77	348.25	406.86	320.78
14	694.34	346.89	402.43	319.43
13	693.64	348.57	401.73	321.11
12	695.22	353.54	403.31	326.07
11	703.18	362.13	411.27	334.67
10	716.56	375.16	424.64	347.69

Table 3: Slot costs (in US$) for the route Hamburg–Tokyo

The direct comparison of slot costs inclusive of transit fees shows that fees for icebreaker support and the transit permit are significantly higher than the fees incurred for a Suez Canal transit. The 2,800 TEU vessel has an optimal travel speed of about 13 knots compared to an optimal 14 knots for the 14,000 TEU container vessel. Both inclusive and exclusive of transit fees, the Suez Canal route is significantly cheaper than the NSR. The disadvantage of the NSR with respect to profitability is due to the limited economies of scale that a 2,800 TEU vessel can realize, implying the business case is even worse for any port south of Tokyo.

However, this raises the question, for which vessel size would the NSR constitute a profitable alternative route? If larger ice-classed vessels were constructed, the results would likely change. Therefore, the model is now extended to consider four hypothetical ice-classed vessels. Table 4 details their possible building parameters. For the sake of comparability, these hypothetical types are contrasted with an existing container vessel type (CV14,000) that corresponds to a standard 14,000 TEU ship traveling from Asia to Europe through the Suez Canal.

	Vessel				
Attribute	HT3,600	HT5,000	HT6,600	HT8,800	CV14,000
Draft (meters)	11.70	13.60	14.00	14.50	16.00
Capacity (TEU)	3,538	5,000	6,612	8,800	14,000
Homogenous capacity (TEU)	2,950	3,600	4,975	7,100	10,640
LOA (meters)	240.39	294.10	305.60	299.95	365.80
Beam (meters)	32.20	32.20	40.00	48.20	51.20
DWT (tons)	42,686	66,700	81,000	110,300	166,000
GT (tons)	40,827	48,400	69,809	95,390	151,963
NT(tons)	24,146	29,000	39,534	56,260	90,033

Table 4: Hypothetical technical parameters of larger ice-classed container vessels. LOA: length overall; DWT: deadweight tonnage; GT: gross tonnage; NT: net tonnage.

The parameters of these hypothetical vessels were chosen such that they correspond to the existing ship designs in the industry. For example, type HT3,600 corresponds to an older generation of Panamax vessels. Type HT5,000 corresponds to a Panamax-Max vessel. This design is one of the largest vessels that can still pass the old locks of the Panama Canal. Type HT6,600 mirrors a second-generation Post-Panamax vessel which due to its beam of 40 meters can no longer pass these locks; yet its homogenous capacity of roughly 5,000 TEU significantly surpasses the capacity of smaller Panamax vessels. Type HT8,800 represents a latest-generation Post-Panamax vessel, which can be deployed since its length is relatively short compared to larger Neo-Panamax vessels. This vessel type is also known as Handy-Neo-Panamax, since its beam just allows it to pass the new Panama Canal locks, which are due to be completed in 2016. Further, the model is extended to consider additional destinations south of Tokyo. Their nautical distances from Hamburg are detailed in Table 5.

Distance to Hamburg	via Suez Canal route	via NSR
Tokyo	11,811	7,102
Busan	11,401	7,380
Shanghai	11,041	7,825
Ningbo	10,969	7,875
Keelung	10,712	8,089
Hong Kong	10,330	8,505

Table 5: Nautical distances from Hamburg to selected East Asian ports. All distances are given in nautical miles (Port World, 2014)

The model now compares the slot costs of the 14,000 TEU container vessel CV14,000 traveling the Suez Canal route with those of the four hypothetical ice-classed vessels, HT3,600, HT5,000, HT6,600, and HT8,800, each of which is traveling the NSR. Travel speed varies between 10 and 20 knots, the port of destination varies, and the port of call in Europe is Hamburg. Results of these calculations per port of destination are presented in Tables 6 through 8.

For the routes Hamburg–Tokyo and Hamburg–Busan, the slot costs of vessel HT8,800 are significantly lower than those of vessel CV14,000, implying that profitable container shipping via the NSR would be possible. Further, the model suggests that any hypothetical ice-classed vessel with a lower capacity than HT8,800 would not operate profitably due to a lack of economies of scale (viz. Exhibits 1 and 2). Thus, any ice-classed vessel with conventional engines would have to have a capacity of at least 8,800 TEU to compete with ships traveling via the Suez Canal.

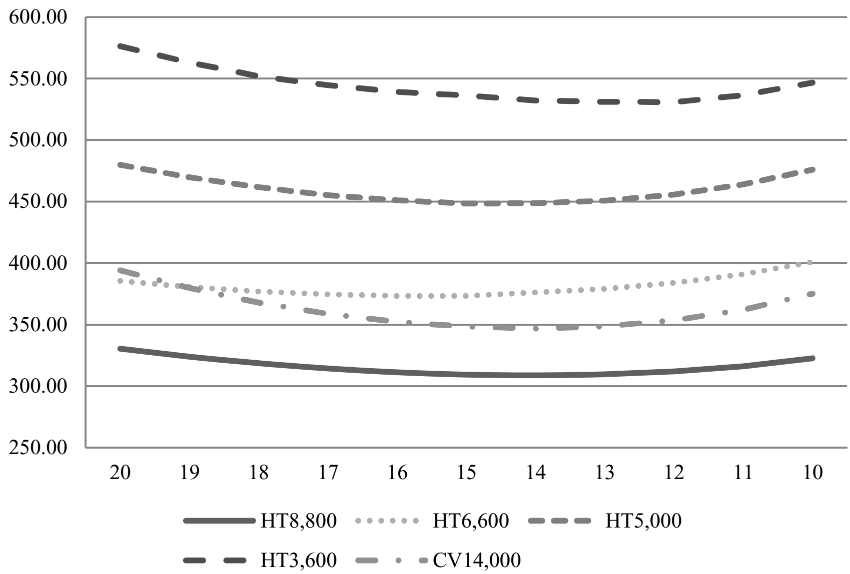

Exhibit 1: Slot costs for the route Hamburg–Tokyo as a function of vessel type and speed

Finally, the break-even point where the slot costs of HT8,800 and CV14,000 are approximately equal is located some nautical miles north of Shanghai implying that given the underlying assumptions of the model, the NSR is only an attractive container shipping route as long as the port of destination is north of Shanghai (viz. Exhibit 3).

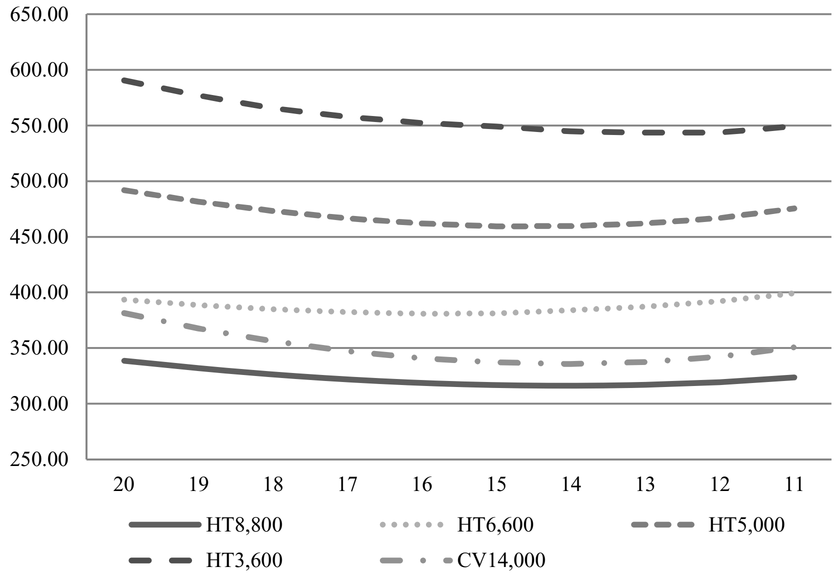

Exhibit 2: Slot costs for the route Hamburg–Busan as function of vessel type and speed

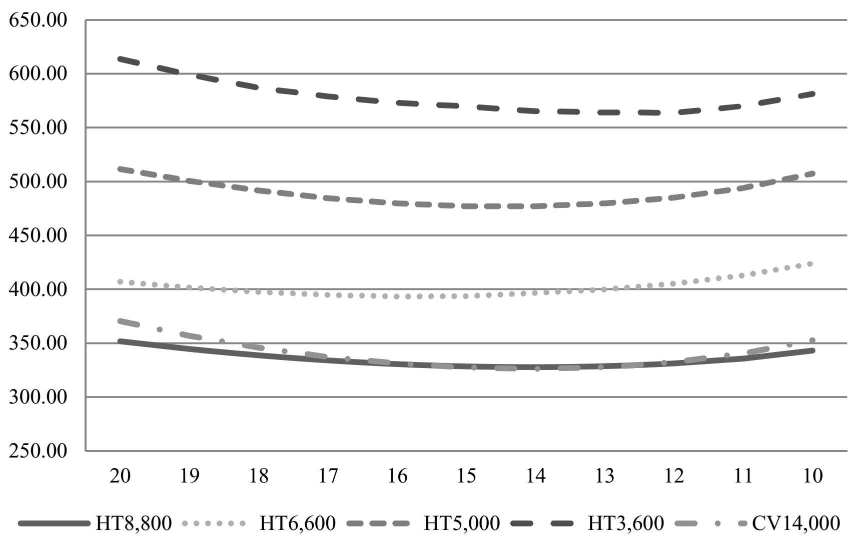

Exhibit 3: Slot costs for the route Hamburg–Shanghai as a function of vessel type and speed

While naval architects should be able to realize a vessel such as HT8,800, the more pressing question is the extent to which it could freely operate in Arctic waters. Presently, ice conditions in the Sannikov Strait limit the maximum draft to between 11 and 14 meters. Thus, they impede the passage of a Post-Panamax vessel such as HT8,800. In theory, two solutions are available by which this bottleneck could be overcome.

First, the deployment of alternative engine configurations or propulsion technology (e.g., burning LNG instead of bunker fuel) might allow shipowners to profitably construct and operate smaller vessels with less draft. This alternative propulsion could cause less pollution to the sensitive Arctic ecosystem; further, the cost efficiency of LNG is significantly greater than that of the conventional heavy fuel oil, intermediate fuel oil, or marine gas oil.

Second, two alternative routes with respective drafts of 20 and 50 meters exist by which ships can bypass the New Siberian Islands on a northerly course (rather than going straight through them by sailing the Sannikov Strait). Yet, the navigability of these alternative routes depends on ice conditions. Since the draft of a ship increases with its size, the more economies of scale a ship owner desires, the more these northerly bypasses of the Sannikov Strait will become attractive.

	Hamburg–Tokyo				
Speed (kn)	HT8,800	HT6,600	HT5,000	HT3,600	CV14,000
20	330.46	385.40	479.74	576.17	394.17
19	324.00	380.59	469.73	562.98	379.76
18	318.63	376.97	461.57	551.95	367.94
17	314.37	374.52	455.27	544.61	358.79
16	311.28	373.20	450.87	539.21	352.25
15	309.41	373.26	448.37	536.13	348.25
14	308.81	376.09	448.56	532.14	346.89
13	309.58	379.06	450.85	531.05	348.57
12	311.83	383.81	455.73	530.86	353.54
11	315.97	390.83	463.94	536.57	362.13
10	322.56	400.80	475.92	546.68	375.16
	Hamburg–Busan				
Speed (kn)	HT8,800	HT6,600	HT5,000	HT3,600	CV14,000
20	338.59	393.63	491.95	590.61	381.44
19	331.88	388.63	481.54	576.91	367.53
18	326.29	384.87	473.06	565.45	356.12
17	321.88	382.32	466.53	557.82	347.28
16	318.66	380.96	461.95	552.20	340.97
15	316.71	381.02	459.35	549.00	337.11
14	316.09	383.96	459.55	544.86	335.81
13	316.89	387.04	461.92	543.72	337.43
12	319.23	391.98	467.00	543.53	342.22
11	323.53	399.27	475.53	549.46	350.52
10	330.38	409.63	487.98	559.96	363.09

Table 6: Slot costs (in US$) for hypothetical ice-classed vessels vis-à-vis a standard 14,000 TEU container vessel (Hamburg–Tokyo and Hamburg–Busan)

	Hamburg–Shanghai				
Speed (kn)	HT8,800	HT6,600	HT5,000	HT3,600	CV14,000
20	351.61	406.80	511.50	613.72	370.26
19	344.49	401.51	500.46	599.19	356.80
18	338.57	397.52	491.47	587.04	345.74
17	333.88	394.81	484.54	578.96	337.19
16	330.48	393.37	479.69	573.00	331.07
15	328.41	393.43	476.93	569.61	327.33
14	327.75	396.55	477.15	565.21	326.07
13	328.60	399.82	479.66	564.01	327.64
12	331.08	405.05	485.04	563.80	332.28
11	335.64	412.79	494.08	570.09	340.31
10	342.91	423.77	507.29	581.23	352.49
	Hamburg–Ningbo				
Speed (kn)	HT8,800	HT6,600	HT5,000	HT3,600	CV14,000
20	353.07	408.28	513.69	616.32	368.02
19	345.91	402.95	502.59	601.70	354.65
18	339.95	398.94	493.54	589.47	343.66
17	335.23	396.22	486.56	581.33	335.17
16	331.81	394.76	481.68	575.34	329.09
15	329.73	394.83	478.91	571.92	325.38
14	329.06	397.97	479.12	567.50	324.12
13	329.92	401.26	481.65	566.29	325.68
12	332.41	406.52	487.07	566.08	330.29
11	337.00	414.31	496.17	572.41	338.27
10	344.31	425.36	509.45	583.62	350.37

Table 7: Slot costs (in US$) for hypothetical ice-classed vessels vis-à-vis a standard 14,000 TEU container vessel (Hamburg–Shanghai and Hamburg–Ningbo)

Speed (kn)	Hamburg–Keelung HT8,800	HT6,600	HT5,000	HT3,600	CV14,000
20	359.33	414.62	523.09	627.43	360.04
19	351.97	409.14	511.69	612.42	346.98
18	345.85	405.02	502.39	599.86	336.26
17	341.01	402.22	495.23	591.50	327.96
16	337.49	400.73	490.21	585.34	322.03
15	335.35	400.80	487.36	581.83	318.40
14	334.67	404.02	487.58	577.29	317.17
13	335.55	407.40	490.18	576.04	318.69
12	338.11	412.81	495.75	575.83	323.19
11	342.83	420.81	505.09	582.33	330.99
10	350.34	432.16	518.74	593.84	342.80

Speed (kn)	Hamburg–Hong Kong HT8,800	HT6,600	HT5,000	HT3,600	CV14,000
20	371.50	426.93	541.36	649.04	348.18
19	363.76	421.18	529.37	633.25	335.59
18	357.33	416.84	519.60	620.05	325.24
17	352.24	413.90	512.07	611.26	317.24
16	348.53	412.33	506.79	604.78	311.52
15	346.29	412.40	503.80	601.09	308.02
14	345.57	415.79	504.03	596.32	306.84
13	346.49	419.35	506.76	595.01	308.31
12	349.19	425.03	512.61	594.79	312.65
11	354.15	433.44	522.44	601.62	320.17
10	362.04	445.38	536.79	613.73	331.56

Table 8: Slot costs (in US$) for hypothetical ice-classed vessels vis-à-vis a standard 14,000 TEU container vessel (Hamburg–Keelung and Hamburg–Hong Kong)

Conclusion

Given the analyses presented here, how likely is it that ship finance and charterers can be found who would be willing to finance new building orders for vessels that can operate in the NSR, such as the HT8,800 type? Till date, with very few exceptions, container shipping on the NSR barely exists.[9]

However, liner operators are closely watching the development of the NSR, seeking out new ways of reducing cost since the potential to further realize economies of scale by up-sizing container vessels is about to approach its physical boundaries.[10]

Economies of scale are still the main factor for the decision of whether or not to finance and build a ship. In summer 2014, the average nominal capacity of all container vessels traveling between Asia and Northern Europe was about 11,300 TEU. Since the completion of about 90 container vessels with a nominal capacity of between 13,000 and 19,000 TEU each is expected by the end of 2017 (Alphaliner, 2014), this average capacity will increase to about 14,000 TEU. Moreover, the Suez Canal route allows liner operators to call at ports in the Mediterranean Sea and the Indian Ocean, thus increasing capacity utilization vis-à-vis the NSR. Overcoming such economies of scale by shipping on the NSR, given the current inventory of ice-classed container vessels will be a virtually impossible challenge. Nevertheless, the shortening of the Hamburg–Tokyo sea route by 4,700 nautical miles holds a potential for cost reduction that should be considered not only from an entrepreneurial perspective but also with regard to its significance for the economy of Northern European and Northern Asian states as a whole.

Till date, the general framework of the NSR is still too unstable to establish a regular scheduled liner service. These instabilities regard both the timing and prediction of the Arctic summer in general and the minimum extension of sea ice in particular, the shortness of the window during which the NSR is free of ice, ecological and safety aspects, and the nautical difficulties of operating in ice-infested waters. The prospect of regular scheduled services between Northern Europe and Asian ports north of Shanghai will only be feasible if the NSR will be free of ice for longer periods of time. Rising temperatures could allow larger vessels to seek more northerly routes to circumvent shallow waters such as the Sannikov Strait, thus neutralizing their restrictions regarding maximum draft. On the other hand, such northerly headings exacerbate the known navigational challenges.

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9 In August 2013, the MV *COSCO Yong Sheng* traveled from Dalian to Rotterdam, completing one of the first ever known transits through the NSR by a container vessel. Since the vessel is a non-cellular (multipurpose) box ship, it is accounted for as a general cargo vessel in Table 2.

10 At the end of 2014, the two biggest container vessels in the world had a capacity of 18,980 TEU. By 2016, the biggest vessels will have a nominal capacity of over 19,000 TEU. While demand for vessels with a capacity exceeding 20,000 TEU exists, technological challenges and significant limitations regarding port infrastructures and canal sizes remain (Probst and Bergmann, 2014).

Presently, despite the temporary melting of drifting ice during the Arctic summer, ships traveling in the NSR should be built at least according to ice-classed standard C1 and ideally to standard A1 to guarantee safe operations.[11]

Finally, ship financers will want to assess the extent to which a vessel specifically designed for the NSR will be able to operate elsewhere. The commercial viability of a particular ship is not only assessed with respect to its current charter party contract but also regarding the risk of not finding a replacement charter once the original contract expires. If vessels are built according to the requirements of a niche route, it may be difficult to identify alternative charter options for routes elsewhere in the world. As a result, the asset specificity of ice-classed vessels built for operation in the NSR can be expected to be relatively high.

This consideration highlights the importance of expectations about both the stability of the NSR's political and general economic framework and the nautical implications of climate change for profitability calculations in ship finance.

11 A1 denominates the Swedish ice class for ice thickness up to 0.8 meters. This class approximately corresponds to the Russian Arc 4 and the German E3 ice classes. C1 is the Swedish ice class for ice thickness up to a maximum of 0.4 meters and corresponds to the Russian Ice 1 and the German E1 ice classes.

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