An assessment of the potential feasibility for Oil Transit using the Arctic Northern Sea Route compared to the the Suez Canal

Dimitrios Theocharis, Stephen Pettit, Anthony Beresford, Vasco Sanchez Rodrigues,
Cardiff Business School, Cardiff University
Email: Theocharis@cardiff.ac.uk; pettit@cardiff.ac.uk; beresford@cardiff.ac.uk;
sanchezrodriguesva1@cardiff.ac.uk;

Introduction

In this study, the Arctic polar routes are examined, and more specifically the Northern Sea Route (NSR) and its potential value in terms of commercial viability and environmental effectiveness. This study aims firstly to present the background to forthcoming developments inoil exploration and transfer from the Arctic Russian region to South Korea. Secondly, to assess the feasibility of the NSR in both economic and environmental terms as an alternative to the conventional routes. A third objective is to evaluate how a shift in one or more dependent variables influences the basic scenario used for the comparative analysis. While many researchers have examined the polar passages and constructed case studies that examine the route against the conventional ones, these mainly rely upon trades and commodities other than crude oil and its transfer through the Arctic passages. For instance, Lasserre (2014) found 26 models from 1991 to 2013 that investigate the polar passages as alternatives to the Suez and Panama Canal, for markets such as containers, bulk and general cargo. The LNG market has also been examined (Raza, 2013). This paper extends the comparative analysis of the environmental consequences found in the literature including not only the CO_2 emissions but also the SO_2 and NOx emissions respectively (Schøyen and Bråthen, 2011).

The Northeast Passage, the Northern Sea Route and the Suez Canal Route

The Northern Sea Route is part of the so-called Northeast Passage, which is the connecting corridor between the Atlantic and the Pacific Oceans. The NSR is officially defined by the Russians as the region that extends from the Novaya Zemlya islands to the Bering Strait (Ragner, 2000). Before the official declaration of the NSR opening to foreign traffic in 1987 and its confirmation in 1991, the route was mainly utilized for intra-Arctic destinations along the Russian coastline. However, there had been few cargo transits until 2010, a year that is recorded as a landmark in the history of NSR. Various ships sailed through the NSR with the suezmax tanker Vladimir Tikhonov being the largest so far (162,362 dwt), transferring 120,843 tonnes of gas condensate from Honningsvaag (Norway) to Map Ta Phut (Thailand).

Transits reached a maximum cargo volume of 6.58 million tonnes in 1987, with a decline since then. However, numbers have been increasing since the first two foreign vessels crossed the route in 2009. The total cargo volumes transferred were 1,261,545 and 1,355,897 tonnes in 2012 and 2013 respectively (NSR Information Office, 2014). Arctic shipping routes are important both for transit and for resource exploitation. The combination of Russian oil and gas reserves and Russia's willingness to exploit them with the high demand from Eastern countries such as China, South Korea and Japan will lead to new markets and trade routes (Keil, 2012).

Arctic Operations: environment
Schøyen and Bråthen (2011), examined two case studies regarding the transfer of nitrogen fertilizers from south Norway to southern China and the transfer of iron ore from north Norway to northern China, comparing three main routes: the NSR, the route via the Suez Canal, and the route via the Cape of Good Hope. In the first case they found that operating with a Handymax size bulk carrier, the fuel consumption savings per single trip are 51% through the NSR compared to the route via the Suez Canal. Consequently, the CO_2 emissions were reduced by half when it comes to the NSR. When it comes to the comparison with the route via the Cape, the fuel consumption savings were 970 mt and the CO_2 emissions reduction was 3,021mt. In the second case study, they found that operating with a Panamax size bulk carrier, the fuel consumption was 1,250 mt via the Suez and 200 mt via the NSR, while the CO_2 emissions reduction was 3,270 mt.

Raza (2013) examined the economic and environmental potential of a round voyage transit of LNG from Hammerfest (Norway) to Tobata (Japan). In terms of fuel consumption savings he found that the LNG fuel consumption through NSR is 40% of the fuel consumption through the Suez Canal while the marine diesel oil (MDO) consumption is 47.7% of that operating through the Suez canal. The CO_2 emissions savings per round voyage were identified as 52% through the NSR. The operational speed through the NSR was 12 knots in ice prone waters and 19.9 knots in non ice prone waters while that via the Suez Canal was 19.9 knots.

Arctic Operations: Economic perspective
The main cost component considered in these cases was the fuel cost and the relevant advantages that entails for the shipping companies. Sensitivity analysis was conducted in many ways among these models, using various parameters – from the speed and fuel consumption to the NSR fees and various rates that applied as well as the operating period through the Arctic Routes – in order to define whether operating through the Arctic is profitable or not. These parameters vary widely among the models with speed, season of operations, different assumptions for capital costs and building costs premiums being some of them. Some of the most recent case studies are presented in order to explain the different approaches that were applied.

Liu and Kronbak (2010), examined a one-year trip between Rotterdam and Yokohama for a container vessel (4,300 TEU) comparing the NSR with the route via Suez. Two scenarios applied, namely, a whole year service via the Suez and a service through NSR during the summer period with the rest of the winter period diverted via Suez. The sensitivity analysis included three scenarios of navigable and non navigable days in the Arctic and three scenarios of reduced NSR ice breaking fees. They found the NSR to not be competitive with the current ice breaking fees, although other cost components such as fuel costs are decreased. Container vessels are not yet suitable for the Arctic due to the reliability of the liner services required and the additional profit that the route via Suez can generate through multiple port calls. Schøyen and Bråthen (2011) have also mentioned that harsh conditions in the Arctic prevent container vessel operators to utilize these routes, while it is predicted that part-year container transit in large amounts of capacity could be feasible between 2030 and 2050 through the Arctic (Eide et al., 2010).

Schøyen and Bråthen (2011) found a marginal cost difference between NSR and Suez route for nitrogen fertilizers transit from Norway to China (1.5%) but a larger one when comparing the NSR with the route via the Cape (17.4%). For the iron ore transit with a Panamax vessel they found a cost difference of 43% between NSR and the route via the Cape. This is mainly because of the economies of scale that large quantities of iron ore transit entail for a low-value commodity with an average ocean transportation cost of $10-20/mt loaded in Panamax vessels.

South Korean Seaborne Oil Imports

Substantial Asian demand for energy resources is likely to integrate further the relationship of countries in that region with Russia over the next few years. To begin with, the fact that China surpassed the USA's oil imports in 2013 as well as the recent $400 billion gas agreement between China and Russia, indicates the aspirations of the Chinese government for the Arctic Region and the close relations between the two countries. Russia's strategy is well defined in the Ministry of Energy Strategy report as the gradual disengagement from the European markets and the closer cooperation with the Asian countries. The final phase of the strategy forecasts an increase in oil exports to the Asian region from the current 6% to 22-25% in 2030 and an increase in gas exports from 0% to 20%. The combination of this strategy with the intention to exploit the NSR for the development of the Russian Federation are gradually leading to new seaborne trades between Russia and Asia.

South Korea's energy demand depends on imports of approximately 97% due to inadequate national resources and the lack of infrastructure e.g. pipelines, that forces the country to import oil and gas through by sea. When it comes to the oil consumption, South Korea was the fifth largest importer of oil and oil products in 2013. However, the country has state of the art refineries, some of the best globally. The Middle East is the main supplier of the country's oil imports, and in 2013 more than 87% came from that region. Besides, the country's ambition is to become an oil refining and storage center in Asia that will supply the neighboring countries with oil products. For that reason, the country plans to add about 60 million barrels of crude and oil products up to 2020 utilising among others the NSR, thus enabling the country to exploit the considerable advantages of the distance and costs savings. Nine ships have already used the route to transfer oil and gas condensate as well as naptha from the Arctic to South Korea since 2012.

Oil Transport from the Russian Arctic (Murmansk) to the Far East (Ulsan)

A round voyage of a trip charter from Murmansk to Ulsan is used in this case through a comparative analysis of the two routes in terms of distances, overall and per tonne costs as well as of CO_2 and GHG emissions contribution respectively. The port of Murmansk is located on the Kola Peninsula in the Barents Sea, one of the largest and unfrozen Russian ports during the whole year. It is strategically located because of its deep and ice-free waters. Thus, it will have a key role in the supply chain of oil exports for the next few years (NSR Information Office, 2014). Among the plans for future development of the port is the construction of a new oil and oil products terminal located in the west coast of the Kola Peninsula, which will take up to eleven years to develop, adding to the existing capacity 35 million tonnes per year. For all these reasons it was selected as the loading port of crude oil in Russia in this case study. The port of Ulsan is a strategic point for the development of South Korea as a competitive oil hub countering Singapore, thus it was chosen as the discharging port of the crude oil transfer from Murmansk. The return voyage consists of jet fuel transit back to Murmansk (Leander, 2013).

An ice-class suezmax tanker was chosen as the basis for the calculations and the sensitivity analysis. Sovcomflot's suezmax tanker Vladimir Tikhonov was the first ever ship of its size to sail across the NSR, loaded with 120,843 tonnes of gas condensate from Honningsvaag (Norway) to Map Ta Phut (Thailand) with an average speed of 14 knots in 2011. The calculations are based on data obtained from primary and secondary sources as well as from experts of the maritime sector. The vessel was assumed to sail at the speed of 10 knots in the NSR due to regional bottlenecks of ice presence and at 14 knots in open water. The operating speed in the route via the Suez was set at 15 knots. The type, class and hull dimensions of the suezmax tanker were obtained from Sovcomflot. The vessel can carry 1 million oil barrels on board, which is the equivalent of 140,000 tonnes (Sovcomflot, 2014). It is an Ice 1A ice-class

vessel which is equivalent to IA Finnish-Swedish classification standards which in turn equals to Arc 4 Russian register classification of shipping.

The draught of the vessel is 16.50m loaded, and not considered an obstacle for sailing through the Arctic. Suezmax tankers like the Vladimir Tikhonov can deviate form the normal NSR route and sail above the New Siberian Islands taking the deepwater track (15+ m) instead of cruising through the Sanikov (12.8m) or Dmitry Laptev Straits (7.0m) (Eger, 2013). The vessels of this ice class are permitted to navigate during the summer/autumn period with icebreaker escort in all the Arctic Seas with an increased risk of damage in the Laptev and East Siberian Seas, while in some navigation is not typically allowed. The engine type selected was a Wärtsilä X generation engine, namely the W6X72 which is an efficient and low emissions production engine suitable for suezmax tankers, that meets the IMO Tier II criteria. Moreover, it can meet the IMO Tier III criteria for NOx emissions, while it can reduce the SOx emissions to 0.1% independently of the sulphur levels of the fuel used after specific modifications.

Comparative Analysis
A comparative analysis was conducted for fuel consumption and CO_2 emissions as well as other GHG emissions (NOx and SO_2) between the two routes on a round voyage from Murmansk (Russia) to Ulsan (South Korea). The operating speed applied in the basic scenario is 15 knots in the Suez Canal route and a combination of 10 and 14 knots respectively in the two parts of the NSR. The duration of the voyage varies relatively with the distances and the operational speed on each route.

The distances and days from Murmansk to Ulsan under each route were calculated on dataloy.com, a distance calculations provider. The NSR was divided in two distinct parts i.e. from Murmansk to Bering Strait and from Bering Strait to Ulsan, separating the ice prone region and the non ice prone regions of the route. The total days for each part of the route were calculated according to the distances and the speeds selected. It is assumed that the vessel sails in icy waters at 10 knots and in open water at 14 knots, giving a weighted average of 12.15 knots. This is quite accurate if we take into account the average operational speed in the NSR from real operations, though the actual trip of Vladimir Tikhonov lasted for about 7.5 days on the NSR with a speed record of 14 knots on average in 2011 (Gunnarsson, 2013).

The fuel consumption is proportional to the cube of speed (Stopford, 2009), while for the ice prone part of the NSR is proportional to the square of the sailing speed, indicating the increased fuel consumption due to the ice constraints and the heavier construction of an ice-class vessel that requires extra propulsion power (Brown, 2012 ; Omre, 2012 ; Furuichi and Otsuka, 2013). The CO_2 emissions formula adopted from the IMO principles for the optional application of the Energy Efficiency Design Index (EEOI). The Heavy Fuel Oil (HFO) and Marine Gas Oil (MGO) consumptions were multiplied by specific factors, while the same applied for the estimation of the SO_2 and NOx emissions as well (Winnes and Fridell, 2012).

Moving from the longer (Suez) to the shorter distance (NSR), the fuel consumption decreases respectively. The CO_2 emissions as well as the GHG total emissions (NOx and SO_2) are proportionate to the fuel consumption. Not only are the CO_2 emissions reductions directly proportionate to the fuel consumption savings on the NSR, but also the GHG emissions have the same trend (Laporte, 2013). It was found a 62.3% cut on fuel consumption which in turn means equal emissions reductions when sailing through the NSR. Moreover, the NSR provides a substantial 61.6% cut in fuel costs compared with the route via the Suez.

When it comes to the total costs between the two routes, these were found $8.86 million and $7.09 for the Suez Canal route and the NSR respectively. Thus, the cost per tonne is 63.3 $/tonne and 50.7 $/tonne respectively. In a trip charter, the charterer pays the voyage costs (bunkers, port costs etc) while the shipowner pays the operational and the capital costs. The latter two are included in the charter rate that the charterer pays in the round trip charter (Stopford, 2009).

In order to assess the time charter rate, a benchmark route of Middle East Gulf (MEG) – China (Huizhou) was selected and considered as the most relative to that examined in the case study. As Falck (2014) stated, the Arctic trades are immature, thus there is no such thing as a spot market so far. Moreover, there is a 20% premium in the NSR's charter rate reflecting the building costs and the increased operational costs of an ice-class vessel (Schøyen and Bråthen, 2011). The Suez canal tolls were calculated for both southbound and northbound for the round voyage as suggested by Falck (2014).

In this study, we use the current tariff provisions of the NSR Authority in order to calculate the ice breaking tariffs because the tariff of 5 $/tonne charged in the recent past by the Russians and used widely in the literature is not valid anymore.

The total insurance costs that are evaluated in a subjective basis and they are often excessively high due to insufficient information and lack of statistics regarding the Arcti maritime operations (Eger, 2013). According to Falck (2014), in the current state of the market the two premiums of these routes are equal due to the high piracy insurance costs, thus counterbalancing the relevant premiums of the NSR. Therefore, in order to overcome this limitation, it is assumed that the insurance premiums are the same on each route (premiums for the ice conditions/NSR–premium for the piracy/Suez).

The NSR is cheaper than the route via the Suez by 12.6 $/tonne or 20% in terms of total costs. The competitiveness of the NSR mainly relies upon the lower charter rate and the substantial fuel cost savings in this route. From the interview with Falck (2014), in the question of which are the main factors that make the NSR more competitive compared to the route via the Suez, he indicated that the lower time charter cost mainly contributes to the competitiveness of the route, while in some other cases, the fuel cost is the biggest cost-saving element and then the time charter rate. It should be noted that the trip charter rate is even lower if the 20% added premium for the increased operating and capital costs is excluded. If the insurance premiums that are applied for the two routes are included, the outcome will be the same proportionally. The main factor that increases the costs in a great extent in the NSR is the current tariff regime. Therefore, it is essential to examine the total outcome when the icebreaking tariffs are discounted by half and by 100% discount in case there will be no need for ice breaker assistance in the future.

Sensitivity Analysis
In this section it is assumed that the vessel completes its trip in the same time while traveling with different operating speeds in the two routes. Thus, the corresponding speed of completing the voyage in approximately 35 days – the duration via the Suez with an operating speed of 15 knots – through the NSR, is a weighted average of 7.1 knots. Again, a set of two speeds is applied, namely 7 and 7.2 knots respectively for the two parts of the NSR in order to highlight the increased fuel consumption on the icy part of the NSR .

In this scenario, the fuel costs are decreased by 77.3% while at the basic scenario the figure was 61.3%. According to Stopford (2009), this is mainly due to the reduction in fuel consumption that "is proportional to the cube of the proportional reduction in speed". However, on the icy part the fuel

consumption is more than 50% higher at the same speed due to the different assumption made. The fuel consumption is decreased by 80.4% in this scenario compared to the basic scenario, contributing a further 20% in fuel consumption savings. It has already been mentioned that the reduction of the CO_2 and GHG emissions is proportionate to the reduction of the fuel consumption (Laporte, 2013). Thus, an 84% in fuel savings means that CO_2, NOx and SO_2 are all equally reduced at about 84% respectively. However, the route via the Suez is now more competitive than the NSR. The extremely high fuel cost savings are counterbalanced by a 20% increase in the charter cost as a consequence of the longer trip, thus making the NSR more expensive by 6.1% compared to the Suez Canal route.

Although the fuel costs decreased dramatically under this scenario, the charter rate increased by 20% because the daily charter rate is applied to a voyage which is 14 days longer. Comparing the competitiveness of the NSR under the scenario of the weighted 7.1 knots with the basic scenario, we would clearly presume that NSR becomes less competitive. The higher charter rate offsets any fuel costs gains and contributes negatively in the overall costs albeit more eco-friendly. Besides, the companies involved in Arctic shipping prefer to operate at an increased speed to save distance and time (Rosatomflot, 2012 ; Falck, 2012).

From the alteration between speed and days on the NSR, a remarkable finding revealed regarding the fuel costs and the charter rate. That is, when the vessel's speed is lowered to cut the fuel costs on the NSR while keeping the same schedule as in the route via the Suez (same days in both routes), on the other hand, the charter rate is increased as a consequence of adding more days in the trip, resulting in higher rather than lower total costs.

For that reason, there is a trade-off between the fuel costs and the charter rate when comparing the NSR with the route via the Suez. As the former falls, the latter rises while we move from a short trip to a longer one in order to reach the same schedule. The aftereffect depends on which of the two cost components is larger in absolute terms. Due to the fact that the charter rate is more than 50% of the total costs while the same figure for the fuel costs is 13%, the total outcome will be a negative one when applying the same schedule in both routes. However, this is valid only if the largest cost component is the charter rate, and if the specific relation between speed and consumption is in accoradance with this of the case study. The break-even point of the alteration between days and speed on the NSR is at approximately 8 knots. However, if the vessel lowers its speed to 7.1 knots, the total costs are higher than those ones on the break-even point, thus making the NSR uncompetitive.

Discussion
From the basic scenario, it is clear that the NSR is cost effective due to the shorter distance by 52% approximately. The biggest cost saving factor is the fuel costs, followed by the charter rate. Fuel costs reduction is found 62% while the charter rate reduction is found 28%. Fuel consumption as well as CO_2 and GHG emissions (NOx, SO_2) reductions are estimated at 62% respectively. The overall contribution of operating through the NSR is 20% decrese in total costs. The exhaust emissions are proportionate to the fuel consumption reductions (Laporte, 2013). However, the overall cost effectiveness is negatively influenced by the high ice breaker fees that the NSR Authority charges, mainly due to the new tariff regime that applied recently. Thus, ice breaker fees are 29.3% of the total costs on the NSR while the Canal tolls on the route via the Suez are only 8.6%.

Liu and Kronbak (2010), found the NSR to be uncompetitive with the current ice breaking fees, although other cost components are decreased (e.g. fuel costs). This is not a surprise, since they applied a $40/tonne tariff, which is extremely high and offsets any competitive cost component of the NSR. A

bunker price of $300/tonne makes the NSR profitable in their scenario, but losses are occurred when they apply a 500$/tonne or a 900$/tonne bunker price even with a 100% discount on the ice breaking fees. All year container vessel transits are not encouraged in the Arctic due to possible delays, the lack of intermediate calling ports as well as weak schedule reliability but part-year container vessel traffic could be feasible around 2030 and 2050 through the Arctic (Eide et al., 2010).

The results show that even with a $11.94/ton tariff the NSR is still 20% more competitive than the conventional route. In the senstitivity analysis three similar scenarios with those of Liu and Kronbak (2010) applied, that consider the NSR more competitive as we move from a 50% to 100% discount on the NSR tariff. Lasserre (2014) concluded in his study that the average speed and the load factors play the most important role when it comes to the potential profitability of the Arctic routes and especially for the containership sector. The results of Schøyen and Bråthen's (2011) study are in accordance to the conclusions of this study, as they find the NSR commercially viable. The author used their assumption regarding the 20% premium to the charter rate for the additional operating and capital costs of an ice-class vessel. Østreng et al. (2013), gave emphasis to the reduction of the NSR ice breaking tariffs, using examples of high prices that occurred back in 2003. The bunker prices they selected are very close to those applied in this study. They consider the NSR to not be competitive with an ice-braking tariff of $16/tonne for a general cargo ship transit, while the break-even point for the suezmax tanker of this case study that makes the route via the Suez an alternative one, is a $22.13/tonne approximately.

The findings of this study and those of Raza (2013) are similar. In this study it was found that a 62% cut on fuel costs and a 40% reduction in total costs could be achieved. Raza (2013) found 52% savings on fuel costs by using the NSR, but 42% total savings if insurance premia (to cover ice via NSR and piracy risk via Suez) are included. Particular emphasis was given to the NSR ice breaking tariffs. The price of $5/tonne, is the usual one in the literature as it was the ordinary one before the establishment of the new tariff regime by the NSR Authority (Furuichi and Otsuka, 2013 ; Falck, 2014). Thus, it was applied as the most attainable and commercially viable one in the sensitivity analysis too.

The alternative option between days and operational speed examined in order to investigate how the fuel costs influence the NSR when the speed is reduced to 7.1 knots considering same scheduling between NSR and Suez Canal route. Although one could expect further costs savings, the result is inverse due to the high increase of charter rate as a result of operating more days on the NSR. The alternative option becomes competitive under the $5/tonne tariff, but is marginal compared to the same scenario of $5/tonne but with the increased speed.

References

Brown, H., 2012. Tanker owners hope for Baltic ice rates spike. <http://www.lloydslist.com/ll/sector/tankers/article388635.ece>

Eger, K.M., 2013. Shipping and Arctic Infrastructure. In Shipping in Arctic Waters: A Comparison of the Northeast, Northwest and Trans Polar Passages. 1st ed. Oslo: Springer. pp.177-232.

Eide LI, Eide M, Endresen Ø, 2010. Shipping across the Arctic Ocean - A feasible option in 2030-2050 as a result of global warming? <http://www.dnv.com/binaries/shipping%20across% 20the%20arctic% 20ocean%20position%20paper_tcm4-434419.pdf>

Falck, H., 2012. Some observations and calculations related to the Northern Sea Route. [Online] Available at: http://chnl.no/publish_files/Henrik_Falck.pdf

Falck, H., 2014. Personal communication (E-mail)

Furuichi, M. and Otsuka N., 2013. Cost Analysis of the Northern Sea Route (NSR) and the Conventional Route Shipping. In Proceedings of the IAME 2013 Conference, July 3-5 – Marseille, France. Marseille, 2013. IAME.

Gunnarsson, B., 2013. The Future of Arctic Shipping Routes. London: Int. Inst. of Strat. Studies.

Keil, K., 2014. Evaluation of the Arctic Shipping Season 2013. <http://www.thearcticinstitute.org/2014/ 01 /evaluation-of-arctic-shipping-season.html>

Laporte, G., 2013. Minimizing Greenhouse Emissions in Vehicle Routing.Northwestern University, Chicago <http://www.transportation.northwestern.edu/docs/2013/2013.04.18.Laporte_ Presentation.pdf>

Lasserre, F., 2014. Case studies of shipping along Arctic routes. Analysis and profitability perspectives for the container sector. Transportation Research Part A: Policy and Practice, 66, pp.144–61.

Leander, T., 2013. Could Asia support a northern oil hub alternative to Singapore? <http://www. lloydslist. com/ll/sector/tankers/article432584.ece>

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

NSR Information Office, 2014. Port Murmansk. < HYPERLINK "http://www.arctic-lio.com/murmansk" http://www.arctic-lio.com/murmansk >

Omre, A., 2012. An economic transport system of the next generation integrating the northern and southern passages. Trondheim: DIVA Portal Norwegian University of Science and Technology, Department of Marine Technology.

Østreng, W., 2013. The Transportation Passages of the Arctic Ocean and connecting corridors in southern waters. In Shipping in Arctic Waters: A Comparison of the Northeast, Northwest and Trans Polar Passages. 1st ed. Oslo, Høvik, Copenhagen: Springer. pp.11-42.

Ragner, C.L., 2000. Northern Sea Route Cargo Flows and Infrastructure – Present State and Future Potential. Report. Lysaker: The Fridtjof Nansen Institute

Raza, Z., 2013. A Comparative Study of the Northern Sea Rout (NSR) in Commercial and Environmental Perspective with focus on LNG Shipping. [Unpublished Dissertation] <http://brage.bibsys.no/xmlui/ bitstream/id/198820/Raza_Z_2013_Masteroppgave.pdf>

Rosatomflot, 2012. The Navigation on the Northern Sea Route Today & in the Future. In Norwegian-Russian Business Forum. Oslo, 2012. NRBF.

Schøyen H and Bråthen S, 2011. The Northern Sea Route versus the Suez Canal: cases from bulk shipping. Journal of Transport Geography, 19(4), pp.977–83.

Sovcomflot, 2014. Vladimir Tikhonov. <http://www.scf-group.com/npage.aspx?anim= 1&cs=4&cs2= 1& cid=3&parm=@id=111&templ=vessel>

Stopford, M., 2009. Maritime Economics. 3rd ed. London: Routledge.

Winnes H and Fridell E, 2012. Particle Emissions from Ships: Dependence on Fuel Type. Journal of the Air & Waste Management Association, 59(12), pp.1391-98.