BULK SHIPPING VIA THE NORTHERN SEA ROUTE VERSUS VIA THE SUEZ CANAL: WHO WILL GAIN FROM A SHORTER TRANSPORT ROUTE?

AN EXPLORATIVE CASE STUDY.

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ABSTRACT

The sailing distance via the Northern Sea Route (NSR) from a Northwest-European port to the Far East is approximately 40% shorter as compared to via the Suez Canal. Due to NSR uncertainty in schedule reliability it should primarily be explored for bulk shipping (tramp) rather than for liner shipping. A more than doubling of the vessel fuel efficiency may appear as one of the drivers for exploring the NSR for commercial transits. A major disadvantage with the NSR is its seasonality. Summer operations on the NSR may already today be profitable. Additional shipping routes may give more flexibility, and the NSR route choice option may facilitate supply chain agility and adaptability. Russian political impediments and custom clearance appear to represent the main present uncertain and decisive planning issues; whereas technical and nautical issues encountered by the vessels' crew and ship managers during the period of the voyage itself may represent comparably less challenges.

Keywords: Northern Sea Route, International bulk shipping, Green logistics, Energy efficiency, Supply chain

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1. INTRODUCTION

1.1 Background

Transport is the most environmental detrimental of logistics activities, and transport distances are perhaps the most direct driver of emissions from logistics systems (Aronsson et al., 2008). Global maritime transportation represents about 2.7 % of world green house gas (GHG) emissions. Carbon dioxide is the most important GHG from ships (Buhaug et al., 2009) . Numerous measures are suggested to make ships more energy efficient (Corbett, 2010, IMO, 2009). As emissions from ships mainly correlate to travel distances, shorter ocean shipping routes may result in less environmental impact as well as corporate savings. Green logistics may emerge as one of the drivers for the development of NSR as a route between Europe and the Far East.

The Northern Sea Route (NSR) is the shipping route along the coast of Siberia; from west of the Kola Peninsula through the Bering Strait in the east. Shipping along the NSR began in 1935, first in the summer-autumn season; since the late 1970s as a year round used Russian internal transport corridor. The NSR reached its up till now largest cargo transit volume in 1987, with about 7 million metric tonnes (mt). After the collapse of the Soviet Union, the commercial use of NSR has steadily declined. In 1991 NSR was formally opened to non-Russian vessels. NSR uncertainty and risk are among others caused by limited accident preparedness as a ship in distress might have difficulties receiving assistance from rescue teams and ice-breakers within time, and vessel repair facilities may be located thousands of kilometres away. (Kitagawa, 2008, Ragner, 2000b, Ho, 2009).

The five possible route choices between North West Europe and the Far East and approximate transport distances are given in Table 1.

Table 1 Ocean route alternatives between Northwest Europe and Far East, with respective approximate navigation distances, in nautical miles (nm). 1 nm = 1.852 km

Route	Panama Canal	North West Passage	Northern Sea Route	Suez Canal	Cape of Good Hope
North West Europe (London) to Far East (Yokohama)	12,580	8,600	7,200	11,400	14,750
Relative distance	175 %	119 %	100 %	158 %	205 %

Adapted from: (Ragner, 2000a, Christensen, 2009)

The present predominant shipping routes between Europe and Far East are via Suez Canal and Cape of Good Hope (South of Africa). The commercial annual shipping transit volumes via the NSR and North West Passage are at present negligible. This paper focuses on the NSR and the Suez alternatives; NSR as it is operational and is the shortest distance alternative, Suez because it is a part of many present logistics structures facilitating trade between Europe and Asia.

The decline of the Arctic sea ice and changes in political environment enables the possible opening and commercialization of the NSR for transits. The latest decades reduced ice cover in the Russian Arctic is one of the most striking environmental changes in the northern hemisphere. From 1979 to 2006 the length of the ice-free season in all seas and straits in the Russian Arctic increased in average from 84 to 129 days (J. Rodrigues, 2008). Near real-time sea ice monitoring and operational forecasting is available (Johannessen et al., 1996). Verny and Grigentin (2009) impart predictions of a navigable Arctic Ocean all year-round in year 2015, including the Russian Arctic coast. The Arctic geographical area spans territories of Russia, Norway, USA, Canada and Greenland (Denmark). These nations are “developed” although having different governmental cultures. (UN, 2009) rank these nations on a Human Development Index as “very high” and for Russia “high”. Many of the coast states neighboring the Suez route are developing nations, and the Middle East is a politically tense area. Both route alternatives could be challenged and threatened by more or less sudden shifts in politics and by turmoil.

1.2 The research problem

This paper explores whether benefits achievable through energy efficiency improvements due to a shorter route (the NSR) might offset the disadvantages caused by uncertainty linked to both the NSR and the route via the Suez Canal. The explorative approach is from the ship operator’s perspective, and includes possible consequences to other members in the supply chain, e.g. cargo owners and Russian authorities. Bulk shipping (tramp), and not liner shipping is focused on. The main reason for this choice is that in liner shipping, schedule reliability is crucial (Notteboom, 2006). High schedule reliability can at present not be achieved via the NSR and this will be further elaborated in section 5.2.

The research questions are:

1) Which players in a global supply chain may gain from a shorter transport route?
2) What are the potential gains in respect of costs and potential GHG-emissions savings?
3) Does the NSR, as a possible complementary route to Suez, represent an opportunity to improve agility and adaptability in supply chains?

Supply chain members having a stake in developing the NSR for transits will be indentified and discussed. The case study (Yin, 2009, Eisenhardt, 1989) methodology is applied for exploring the research questions. Three shipping cases are presented. The first is about navigational and logistics experiences of a western shipping company transiting the NSR in the summer of 2009 (Beluga, 2009). The two other cases are from tramp shipping of raw materials in bulk, where the potential gains in vessel fuel consumption and CO_2 emissions are illustrated.

The next section is a literature review focusing on supply chain (SC) uncertainty and risk distribution among the members and on corporate social responsibility (CSR) and energy use. In section 3 maritime transport routes and their impact on the SC is focused on. The three cases are presented in section 4, while the research method and data collection are described in section 5. Analysis and findings are stated in section 6; conclusions, research limitations and future research directions are given in section 6.

2 LITERATURE REVIEW

2.1 Supply chain uncertainty and risk

Competitiveness achieved through cost effectiveness and great speed is a common objective in the global industry. Lee (2004) pinpoints that a high speed and low cost supply chain is incapable of responding to unexpected shifts in demand and supply. Further, competitiveness and long term survival is achieved through *agility*, *adaptability* and *alignment*. Risk categories and drivers related to *agility* and *adaptability* are discussed in 2.1.1, *alignment* of supply chain member's interests in 2.1.2.

2.1.1 Supply chain risk categories and drivers

Knemeyer *et al.* (2009) claims there is today less "slack" available in supply chains to deal with catastrophic events. Chopra and Sodhi (2004) lists the supply chain risk categories disruptions, delays, systems, forecasts, intellectual property, procurement, receivables, inventory and capacity. Each of these nine categories has corresponding conditions and events, which are caused by states of environmental and behavioral uncertainty. We focus on the first two categories; disruptions and delays. In (Vasco Rodrigues et al., 2008) is presented a logistics triad model where uncertainty related to suppliers, customers and transport operations are reflected. Three kinds of freight transport delays related to carriers were identified in (Fowkes et al., 2004): i) delay resulting from an increased journey time with fixed departure time, ii) an increase in the spread in arrival times for a fixed departure time and iii) schedule delay, where the departure time is behind schedule.

Byrne (2007) suggests dividing risk into uncontrollable risk, somewhat controllable risk and controllable risk. He claims that controllable events are often the source of the most disruptions, and the risks with the largest impact tend to be the most controllable ones. Wilson (2007) identified the impact of transportation disruptions on supply chain performance. Transport disruptions have received less attention than supply chain disruptions. Transport disruptions is defined as an interruption in the flow of goods, and can be caused by a natural disaster, labor dispute, dependence on a single supplier, bankruptcy, terrorism, war and political instability. The results can be such as long lead-times, stock-outs, inability to meet customer demand and increased costs, and there is a lack of preparedness of most companies to handle crisis or disruptions (Wu et al., 2007). Further transport delays and disruptions, in combination with e.g. information distortions in the supply chain, may result in bullwhip effects (Lee et al., 1997).

The literature suggests a variety of approaches to quantify the expected consequences of occurrences. The challenge is to estimate the probability of occurrence of specific events in certain preselected locations. Catastrophic event probability estimation methods span from various variants of expert opinions, via game theory to simulation modeling. The availability of historical data will be decisive for choosing an appropriate methodology (Knemeyer et al., 2009).

Lee and Whang (2005) claim the ocean segment of a supply chain to be the one most vulnerable to security threats, and describes how TQM can be used to assure supply chain security. Kristiansen (2005) draws the lines of the maritime transportation risk picture and accident phenomena. Accidental causes are human causes, technical causes (mechanical, fire and explosion, structural) and weather–related causes, e.g. a ship trapped in ice in the Arctic Ocean. Any one failure might lead to different consequences which ranked by seriousness can be categorized as an accident, an incident, an operating disturbance or a non-conformance. There is a broad range of aspects and perceptions in the risk concept, psychological, values/ethics, legal, complexity and randomness.

2.1.2 Supply chain members interests and relations

Emerson (1962) developed theories of power-dependence relations applicable to small groups and more complex community relations where mutual dependence binds actors together. There can be a power balance or imbalance in a relationship, and structural changes in power-dependence relations tend to reduce power advantage, being a balancing operation. Such balancing operations are withdrawal (denial of dependence), extension of power networks, coalition formation (for example two weaker against the one stronger) and emergence of status. In the latter the least dependent member of a group will be the first to break from the group, and these members are the most valued members.

Successful supply chain management requires cross-functional integration (Lambert and Cooper, 2000). Alignment is achieved when a maximization of each of the players own interests optimizes the chain's performance as well (Lee, 2004). Collaboration among supply chain members is at the centre of SCM and will be the key to its future success. Channel collaboration will require trust and information sharing, a boundary-spanning information system, inter-organizational metrics and ways of benefits identification and sharing (Ballou, 2006). A revenue generation strategy for the supply chain is just as important as a cost reduction one and this is challenging to perform, as there might be conflicts of interest. Developing NSR into an alternative route is challenging in respect of aligning the interests for the involved channel members, as there are conflicts of interest, as will be discussed in section 6.

In a literature review on supply chain coordination Kanda and Deshmukh (2008) distinguish between coordination across different functions of the supply chain and coordination at interfaces of the supply chain. Changes in for example transportation affect the decisions regarding inventory policy. Some factors related to inventory policy are changing market condition, supply uncertainty, different and conflicting inventory policies among SC members, and unavailability of inventory information. 14 various difficulties in supply chain coordination are identified. Three examples are *conflicting objectives, dominance of one member in taking decisions* (Emerson, 1962)), and *independent cost evaluation of activities and processes,* more on this in section 6.

2.2 Corporate social responsibility (CSR) in the supply chain

CSR is increasingly viewed as a necessity rather than an option in corporate strategy (Murphy et. al, 2002). Sustainability in the SCM context is defined as the management of SCs where all the three dimensions of sustainability (economic, social and environmental) are taken care of. (Ciliberti et al., 2008, Kovács, 2008, Aronsson et al., 2008). Kovács (2008) conducted a multiple cross-industrial case study of Finnish trans-national companies with international SCs. Observed were that customers tend to try to make a better image of themselves than their actual purchasing behavior would reflect. Further, a social desirability bias in SCs leads to an overstatement of environmental responsible measures in the purchasing process. Companies face environmental demands, and also have the means to require environmental responsibility from their suppliers. The environmental demand varies, and may be disrupted somewhere in the chain, mainly because of lack of alignment among SC members. Closer investigations of these environmental demands found that disruptions arise at the interface of different industries. Environmental demand spillover from other industries means that customers may force suppliers to accept and enforce requirements, legislation and standards not targeted on them.

Hargett and Williams (2009) explored the depth of integration of CSR in a deep sea shipping company where social responsibility and to contribute to sustainable development explicitly is defined in the company policy. They identified an awareness, initiative and practice of elements of environmental and corporate social responsibility. For example their ocean fleet of ships were fuelled on oil with a maximum content of 1.5 % sulphur, while the international shipping regulations currently allow for 4.5%, except for some coastal areas (Emission control areas). This measure is said to cost the company about 15 million $ annually. A limitation with their study is that no data from frontline workers (e.g. ship officers) were collected.

3. MARITIME TRANSPORT ROUTES AND THEIR IMPACT ON SUPPLY CHAIN MANAGEMENT

Stopford (2008) identifies parcel size, price, speed, reliability and security as factors for product differentiation in shipping; all of which are linked to route choice. There are two categories of services in shipping, tramp and liner trade (Ragner, 2000a). In a commercial and logistics perspective, liner shipping business is very different from bulk shipping in respect of service attributes, and this affects NSR potential for each of them in the short term, when the NSR service level for commercial shipping is not clear.

3.1 Lead times impacts on route choice

As given in Table 1, the difference navigational distance from North West Europe (London) to Far East (Yokohama) is 4,200 nm, which for 15 knots sustained speed equals a difference in time at sea of about 12 days, all other factors being identical for the two routes.

(Hummels, 2001) examined the importance of time as a trade barrier for imports to the USA with ocean and air freight. The willingness to pay for time savings varies with exporting country and commodity. One finding in Hummel's econometric study was that each day of increased ocean transit time between two countries (USA being the importer) reduced the probability of trade by 1 % (all goods) and 1.5% (manufactures); except for certain bulk material categories, including fertilizers, which is the commodity dealt with in the case in section 5.3. Another finding was that one day saved in shipping time is worth 0.8% of the value for manufactured goods. In the econometric work leading to the above numbers, data on shipment length and not on arrival variability were available. The value of time savings were identified from transport modal choice. 0.8% per day and 12 days saved at sea by sailing via NSR would then be equivalent to 9.6% of the final costs of manufactured goods, for equal WTPs. A further finding was that greater distance increased the probability of trade. These numbers may not be applicable to the NSR case, however we can derive from Hummel's work that reduced days at sea may have quite different impacts on the various commodity categories. It is e.g. likely that reduced days at sea will not facilitate for increased trade with bulk materials.

A shorter distance via NSR may result in either reduction in days at sea or reduced speed, as shown in Table 2, or a combination of both.

Table 2 Comparing days at sea and vessel speeds

	North West Europe (London) to Far East (Yokohama)	Equal speeds Corresponding days at sea	Days at sea Corresponding speeds
Via Suez	11,400	32 days 15 knots	32 days 15 knots
Via NSR	7,200	18 days 15 knots	32 days 9 knots

Table 2 shows that if the sustained speed for the route via Suez is 15 knots, this voyage's duration will be 32 days steaming, plus possible waiting time and time in port. 32 days steaming via the NSR will require 9 knots sustained speed.

The scope of doing a comparison with vessel speed as the variable and keeping days at sea fixed (Table 2, column most to the right) for the two route alternatives is supported by the findings in (Hummels, 2001) and this paper's focus on energy efficiency. The differences in fuel consumption for propulsion for the two routes will be explored. In terms of energy efficiency, it is tempting to explore reduced NSR speed and identical days at sea for both route alternatives. Fuel consumption for propulsion per day is directly proportional to the cube of the speed; the fuel consumption per distance unit is directly proportional to the squares of the speed (Dykstra, 2005). This gives that the daily fuel consumption at 9 knots is theoretically 22% of the consumption at 15 knots. Reduced fuel consumption by sailing via the shorter NSR route could emerge as a driver for improving energy efficiency. The savings in consumptions can be relatively higher than the distance reduction, and simultaneously keeping the days at sea the same as via Suez. Identical days at sea gives that several logistics attributes will be identical for the two route choices, making conceptual exploration easier to conduct:

- As transit times for deep sea steaming are identical, cargo inventory costs may also be assumed to be identical.
- Ship fuel consumption other than for propulsion is more or less the same.
- Port loading and discharging time are the same, for same vessel type and size.
- Vessel positioning and timing for possible back haul cargo is similar.

The approach explained above is applied in the single leg calculations in the cases in sections 5.3 and 5.4. Possible differences in voluntarily and involuntarily speed losses due to for example wind, current, seaway, ice, congestion, waiting etc are not discussed nor taken into account, and will not be taken into account in the cases in section 5.3 and 5.4. A bulk ship operating within a speed variation interval as given in Table 2 (9-15 knots) may need to have a purpose designed propulsion system, which is not elaborated on in this paper.

3.2 Uncertainty, impacts on reliability and route choice

Reliability is a key in most logistics system, and liner shipping versus tramp shipping should be distinguished in this respect. Liner shipping consolidates cargoes from various shippers. Liner ships usually operate at strict scheduled service between ports, transporting cargo at fixed prices for each commodity. Container shipping is often a part of a complex hub-and-spoke logistics network, where reduced sailing distances do not appear as a major subject, while efficient cargo handling and terminal operations are. The bulk shipping industry transports large parcels of raw materials and semi-manufactures. For bulk shipment of raw materials, the logistics concept appears to be comparably simpler as compared with container shipping; the ships usually load full shipload in port A and discharge all at port B. For many bulk commodities, like ore, oil or coal, vessel schedule reliability appears to be a less important factor, as compared with liner shipping (Stopford (2009).

In dry bulk shipping, there are four markets and corresponding contract types for buying and selling transport capacity: Bare boat charter, time charter, voyage charter and contract of affreightment (COA), each having its characteristics of distribution of costs and operational control). The bulk cargo owner (buyer or seller) sometimes run his own shipping fleet for carrying out a proportion of their transport requirements. The situation where the industry company outsources ocean freight to ship operators or ship owners are the most common, as external transport is not defined as a core activity. (Stopford, 2008). The outsourcing strategy and contractual matters may influence on CSR environmental demand and which supply chain member(s) that will be the driver for exploring operational issues like speed variations and alternative navigation routes, motivated by corporate benefits and possible CRS.

Two conditions of "acceptable risk" appear to be of especially relevance for the NSR. These are *the voluntary balance condition*, where the risk is deemed by a risk-taker as worth the benefits and *the regulatory condition*, where a regulator with responsibility for health and safety has established an acceptable risk level. In the case of NSR, this may be a Russian authority.

The challenge with disruption and delay risk assessment of commercial shipping on the NSR is threefold; firstly the scarce availability of data, making it more difficult to both identify and quantify risks compared to the alternative shipping routes. Secondly, the identification of supply chain risk distribution is challenging due to the globalization giving increased complexity in supply chain management (Rodrigue et al., 2006). The attitude to risk among the supply chain risk-takers may be different, rooted in for example culture. Thirdly, the broad range and widespread nature of NSR environmental and behavioral uncertainty in future Russian policy and ice-season variations, makes the risk issue complex. A sensible initial step in a risk assessment approach is the identification of the risk-takers and their relationships in the supply chain and thereafter a discussion on how their interests and gains from NSR operations could be aligned. Power can be gained by increasing the level of certainty and thus be able to assess risks.

3.3 CSR policy on GHG-emissions and the impact on route choice

CO_2 emissions from commercial shipping are unregulated (Psaraftis and Kontovas, 2009a). The CO_2 emissions per mt transported by sea have been reduced the latest decades as a result of economy of scale (larger ships) and more energy efficient ships (Endresen et al., 2007). According to Eyring *et al.* (2009), the most effective way to reduce fuel consumption and green house gas emissions from shipping, is to reduce and optimize vessel speed and to adjust ship routes. The meaning of "optimizing vessel speed" is not defined or clear and may be different in a port-to-port approach and in an SC context. In the latter there are more actors involved, with possible conflicting interests, making it difficult to establish criteria required for conducting an optimization. Speed reduces both the inventory costs for cargo in transit and the required level of safety stock.

Various tradeoffs and possible ramifications to the supply chain due to speed reductions are discussed by Psaraftis and Kontovas (2009b), where an increase of number of ships in the fleet is identified as a trade-off to speed reduction. Added transit inventory costs are another trade-off. However if speed reduction and shorter route innovations (like the NSR) are implemented in concert, being a strategic move, the days at sea can be more or less the same, and the fleet will not necessarily have to be increased, nor will the inventory costs necessarily change. This will be illustrated in cases in sections 5.3 and 5.4.

CO_2 emissions are directly proportional to the amount of fuel consumed; one mt of fuel burned will produce 3.17 mt of CO_2. In a possible future CO_2 emissions trading scheme (ETS) for shipping, a monetary value would be put on a per mt basis, for example $ 30/mt of CO_2 emissions averted (Psaraftis and Kontovas, 2009b). Some professionals in one leading deep sea shipping company (the same company as in (Hargett and Williams, (2009), see section 2) have the hypothesis that the costs for burning fuel will be 1000 $/mt in a not too distant future. At present, the fuel price for Rotterdam deliveries is 469 $/mt for heavy fuel oil and 716 $/mt for distillates (MGO) (Shipping bunker prices, 2010). Included in the 1000 $/mt cost is the possible enforcement or policy to run on distillates, costs for technical installations onboard, like investments and running expenses for exhaust scrubbers and catalysts, as well as possible ETS or other taxation on emissions, hence the fuel cost of $ 1000/mt can be seen as a cost included a “CSR surcharge” external costs (from global and local environmental impacts), and will be the cost used in calculations in the cases in sections 5.3 and 5.4. .
If the NSR is to be a feasible route in a CSR context, the global benefits of reduced CO_2 emissions from shipping and possible other environmental benefits, should compensate for the added external costs caused by operating on the NSR. Examples of such external costs in the Arctic sea are effects from increased air pollution (like soot), deposition of various materials, and ship incidents and accidents with oil spill in highly vulnerable areas. Ships fuelled with LNG, being a proven propulsion technology, might reduce the environmental costs on the NSR.

3.4 Suez Canals role as “regulator”

The Suez Canal Authorities (SCA) pricing policies are “flexible” and aim at increasing the combined canal revenues, which in 2008 totalled $ 5.4 billion. The philosophy of SCA tolls is based on seven criteria (The Suez Canal Authority, 2010)), these criteria appear to reflect the need for yield management, see e.g.(McGill and Van Ryzin, 1999{Llácer, 2005 #343) (Llácer and Francisco, 2005).

Griffiths (1995) illustrates how Suez Canal throughput and delays to some extent are in conflict. Assessments and studies of the “true” capacity of the Suez Canal are not elaborated on here; however a brief literature review uncovers little academic work available on this subject. According to (Mostafa, 2004) little research has been done into forecasting Suez Canal traffic flows. 0.9% of the cases of schedule unreliability in container liner shipping in 2004 were due to “Suez convoy missed” (Notteboom, 2006). The SCA has increased canal physical capacity step by step during the years. After the latest deepening, completed in

January 2010, the canal can accommodate ships with a beam up to 50 meters (164 ft) and draught up to 20 meters (66 ft), hence now also the largest bulk vessels (Capsize) may transit the canal fully laden (The Suez Canal Authority, 2010). The NSR can be a business opportunity for e.g. the Russians, and the SCA's role and policy in a competitive market could be an ideal for how the Russian might organize and facilitate for transits thorough the NSR in their territorial waters. The possible future internalization of external costs for ocean shipping, by for example a global bunker levy or CO_2 emissions-trading scheme (Corbett and Bray, 2009) may influence on the demand for the NSR as an alternative transit route.

The Asia to Europe trade is today dependent of the well functioning shipping route via Suez, questioning the level of supply chain agility and adaptability. The traffic statistics published by SCA is not transparent on bulk flows between Northwest-European ports and the Far East. According to (Laulajainen, 2009) there were 143 dry bulk vessels shipments (36 Handysize, 23 Panmax and 3 Capesize) in 1997 between Northwest Europe (referenced ports Rotterdam and Hamburg) and Asian Pacific coast down to Shanghai, totally transporting 8.0 million mt of cargo. Further he claims that the figures for 2004 can safely be estimated as 10 million mt, and that most of it went via Suez. We question the realism in claiming that most of this dry bulk traffic was via Suez in 2004 as well as at present due to e.g. piracy attacks (Elbeck and Tirtiroglu, 2010); this will be further enlightened in the case in section 5.3. Updated dry bulk flows statistics including route choice has not been found, however it is generally know that the dry bulk imports to China has boomed after 2004.

The well functioning of the Suez Canal route appears to have emerged as a resource taken for granted in some supply chains. The Suez Canal was reopened in year 1975, after eight years closure, and we have not been able to identify supply chain members contingency plans if the Suez Canal for some reason is closed down for a period of time. The present alternative to Suez is via Cape of Good Hope, more than the double distance compared to NSR (Table 1).

Establishing the NSR as an alternative shipping route (see sections 6 and 7) to Suez and Cape could contribute to more flexible, agile and adaptable supply chains, because more route choices will give a higher capacity, and may reduce chances for disruption and congestion. Figure 1 is a conceptual model for exploring the research questions, and is based on the content in sections 2, 3 and (Stopford, 2008).

3.5 Propositions

Based on the research questions and the literature review we list the following propositions:

Proposition 1:
Minor dry bulk is the shipping segment most prosperous to NSR in the short term due to suitable parcel sizes and less time-sensitive commodities.

Proposition 2:
Russian authorities are key in re-establishing the NSR as a well functioning transport route in supply chains, dry bulk cargo buyers or sellers or the shipping community in general are not.

Proposition 3:
The SCA tolls philosophy is applicable for Russia for developing the NSR as a business case.

4. METHOD AND DATA COLLECTION

The methodology used for collecting the data throughout this study consists of literature reviews, e-mail interviews with one shipping company (case 5.2), a in-depth interview of an industrial raw material producer (case 5.4), and e-mail and phone call communication with shipping professionals in Europe (all three cases).

The intention for the in-depth interview was to identify how a large purchaser of deep sea bulk shipping capacity views possible future gains in shorter navigation routes, with emphasis on the NSR, and also their strategies, practices and policies addressing sustainability in maritime logistics. The firm selection criteria for the in depth interview was threefold: i) A seller or buyer of raw material shipped in bulk between the Northern Europe and Asia, ii) Preferably one of the companies identified and interviewed in (Heggeli et al., 1995) and iii) A company where the maritime logistics manager or decision maker is located in southern Norway, to keep interviewing costs at minimum. The interview was recorded and transcribed.

5. CASES

5.1 Introduction

For all three cases ocean shipping appears to be the only practical transport mode choice alternative. Case 5.2 is highlighting SC uncertainty and risk and present challenges in aligning SC member's interests. Case 5.3 is from minor bulks trade (mineral fertilizers) and case 5.4 is from the major bulk trades (iron ore). Figure 1 illustrates the conceptual model that has been applied for the calculations in cases 5.3 and 5.4.

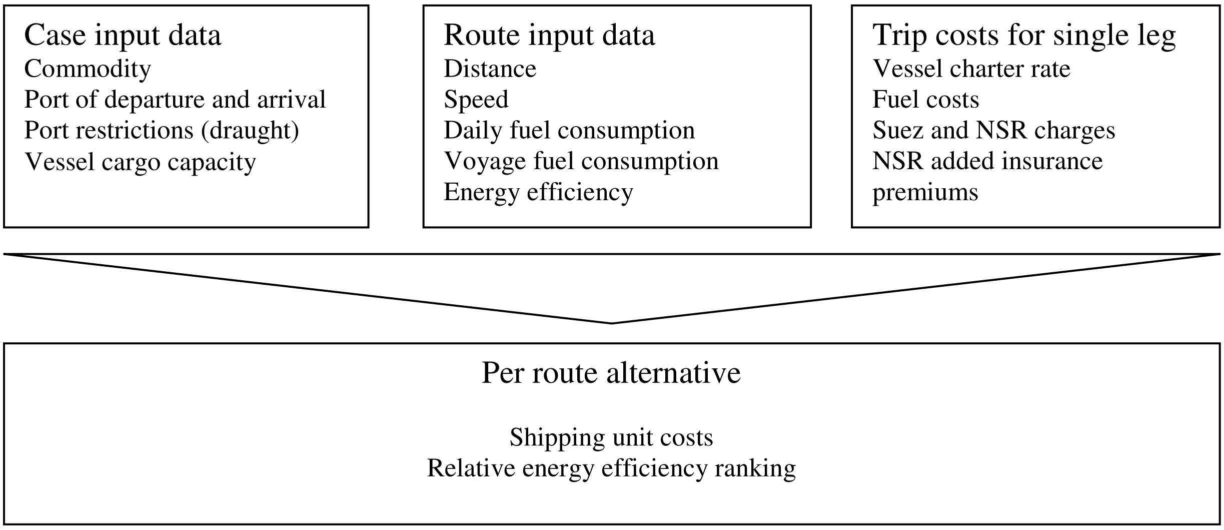

Figure 1 Conceptual model for calculation of costs and ranking of energy efficiency.
Adapted from (Hjelle, 2010).

The assumptions for the calculations in cases 5.3 and 5.4 are as follows:

The NSR type bulk carrier modified is an ice-classed special purpose newbuilding, capable of actually operating at slow steam speeds as stated in each of the cases. This ship will operate on the NSR only a part of the year, when NSR is free of ice, and in other trading areas world wide the rest of the year, at any speed within its design interval (about 8-15 knots). The ship sailing via Suez is a standard design bulker, as given in e.g. (Stopford, 2008). If the Arctic Ocean is navigable all year round the ship may operate here continuously. Calculations for one single leg fully loaded voyages are done in 5.3 and 5.4. All shipping and cost calculations are based on free available information from the data compilation performed as stated in section 5 and done by the authors. They do not necessarily reflect Yara's or LKAB's actual or planned operations or costs. Possible backhaul cargo may be taken via any shipping route, and possible backhaul cargo will affect both revenue and costs, and may improve profitability. Round trip voyages may be between the two same ports, or in for example triangular trade. The NSR type Bulk carrier is flexible to any route choice, and will only trade on NSR when ice-conditions and possible other navigation obstacles, endangers safety or makes this route choice uneconomical.

5.2 The 2009 Beluga transit of the NSR

Knowledge about recent commercial navigation along the Siberian coastline has been sparse. According to our knowledge, the Beluga Shipping transit gives the most updated available information on commercial NSR operations and lead time variations. In September and October 2009, two heavy lift project carriers belonging to the German shipping company Beluga Shipping GmbH made a transit voyage through NSR, demonstrating that such Arctic navigation is possible for non-Russian shipping. The purpose of the voyage was to deliver heavy lift modules to a power plant in Siberia, the modules were manufactured in South Korea. The voyage commenced in South Korea in July and ended with exiting the NSR September. The Beluga Shipping 2009 transit is by many seen as pioneer voyage, as it is believed to be the first non-Russian commercial transit voyage ever. According to Very and Grigentin (2009) and Ragner (2000a) the Russian Administration of NSR (ANSR) is ruling the access to NSR. The initial step towards organising a vessel passage through the NSR is to obtain official permission at least 4 months in advance (Liu and Kronbak, 2009). However, according to Beluga (2009), access to NSR was in 2009 somewhat more cumbersome:

> “We were well prepared and had been intensively working on the realisation of this project for far more than a year…Russian captains for instance, had been an obligation. […]The authorization was granted…after the Russian Ministry of Agriculture, the Russian Ministry of Defence, the Russian Secret Service and finally the Russian Government had approved and the several hundred documents had been sealed. […] However, only one general approval was required from Moscow. […] there was nothing missing from the Russian side during our commercial transit of the Northeast-Passage in 2009” (Beluga, 2009).

About the ice conditions and the need for ice-breaker escort vessels:

> “Even though the ice is melting in summer or in most areas disappears, cold temperature and drifting ice fields, little icebergs or ridges can produce a risk to vessel and crew in the worst case […] For matters of safety and security we arranged for ice breaker assistance from the Russian Atomflot which partly escorted the transit with two of their ice breakers, so that the ice-breaker and our vessels formed a little convoy…especially through the Vilkizki Strait. Since the end of August, the vessels encountered some small ice bergs, ice floes and remaining ice fields with a maximum of 50 percent ice concentration which due to the ice breaker assistance and the vessels’ construction with ice class E3 could be safely navigated through. When the convoy entered the Kara Sea the ice breakers departed” (Beluga, 2009).

The need for renewal and expansion of the Russian ice-breaker fleet is identified in (Ragner, 2000b). However ice-breakers do not necessarily need to be financed by the Russian State. Vessel physical dimensions in minor dry bulk shipping are within the beam constraints of vessels in the existing ice-breaker fleet.

About voyage planning, and reliability in forecasts for sailing time, experienced by the two vessels:

> "We had to wait at Vladivostok for clearance and custom formalities for about four weeks. […] Our vessel was at anchor at Vladivostok for 22 days. We had not expected to stay so long in the port to do all the formalities" (Beluga, 2009).

We did not learn from Beluga why clearance and custom formalities had to be done in Vladivostok and why it took such a long time. Their experience is in line with Russia's particular low score on customs performance (nation number 115) in the survey performed for the Logistics Performance Index (The Logistics Performance Index, 2010).

Vessel and cargo insurance – Which special arrangements have to be made, for example could Protection & Indemnity (P&I) and Hull & Machinery (H&M) insurance be obtained through the providers otherwise used for these vessels?

> "The details of our planning and preparation processes, the routing proposal, technical details of the vessels et cetera have been presented to the underwriters who have then decided on the extra premium applicable for these particular cases" (Beluga, 2009).

The amount of the extra premium has not been revealed to us.The study of (Somanathan et al., 2007) identified the two general areas that most impact shipping costs for an Arctic shipping route to be ship capital costs and fuel costs. The costs for H&M and P&I were identified to relatively low impact on shipping costs. Cases 5.3 and 5.4 include NSR added insurance premiums.

About NSR transit fees:

> "For Beluga…the whole passage fees arose to only a comparably moderate five digit figure in US-Dollars. The ice breaker hire was a regular service component included in the "Charterers Agreement". It had been arranged that the client covered the costs for ice breaker assistance and possible delays caused by the weather" (Beluga, 2009).

The identity of the client is not revealed; however the end-customer must have been the owner of the Siberian power plant.

Further, noteworthy opinions from the Russian captains of the two vessels are:

Why is this job more stressful than other ship navigations? Only because of ice?

> "The route entails plenty of stress because we will most probably face ice but also because of the new terrain as well as the special area with new port state authorities and coast guards for instance […] Such include remaining ice which is perhaps drifting, low depths of water in certain areas or a lot of fog that we have already faced so far […] But on the other hand it is a shortcut between Europe and Asia which avoids the passage through pirates' areas offshore Asia and Africa" (Beluga, 2009).

Were you surprised about how your journey evolved?

> "The only bad surprise, however, was the amount of time we had to spend on anchorage at Vladivostok' […] 'Everything else just goes according to our precise planning. Maybe another surprise, though not fully unexpected, is that we face remarkably few areas with ice" (Beluga, 2009).

What is your opinion as a captain of the safety of this route for frequent journeys during summer, for example, as a transit route between Asia and Europe?

> "For the summer period, I believe, sailing is well possible but one should always obtain utmost precaution due to ice bergs sometimes appearing which could bring breach of safety and mean a threat to crew, cargo and vessel" (Beluga, 2009).

The Beluga vessels made a transit, their cargo did not. Probably no domestic Russian shipping company were or are capable of doing the same job for the power plant as Beluga did. Russian political impediments and custom clearance appeared to represent the uncertain and decisive planning issues; whereas technical and nautical issues encountered by the vessel's crew and ship manager during the period of the voyage itself, represented comparably less challenges. The planning and fulfilment of the pioneer voyage may have to some extent cleared the road in the Russian bureaucracy, certainly for Beluga Shipping with a similar transport task. Whether other foreign companies than Beluga Shipping can develop efficient relations to the right Russian Authorities for transit cargoes remain to be seen.

5.3 Shipping Nitrogen fertilizer (NPK) from Porsgrunn (Southern Norway) to Shekou (Southern China)

The company Yara International ASA (from here on called Yara) is the world largest supplier of nitrogen fertilizers. It is a global company, both regarding manufacturing and marketing, with operations in more than 50 countries. In the nitrogen fertilizer value chain, 91 % of the energy is consumed in production, 2 % is for logistics and transport and 7 % for application. Yara aims at connecting its social responsibility to its core business (Yara ASA, 2010).

An in-depth interview with the maritime logistics manager is done. Ocean freight of dry bulk is not considered to be a core business; the company is not directly involved in ownership or operations of dry bulk vessels. Dry bulk shipping is outsourced, and they buy dry bulk freight capacity on Contract of Affreightment (COA) terms, with a typical contract time horizon of one to three years. Yara does not define social responsibility as the main determining factor when deciding its dry bulk shipping; this is confirmed both from their webpage and in the interview.

Annually Yara ships 300,000 – 500,000 mt of nitrogen fertilizer (NKPs) in full shiploads from the production plant in Porsgrunn, Southern Norway to Shekou in Southern China (close to Shenzen). There is a vessel draft restriction of 10.8 meters along the berth in Porsgrunn, allowing for Handymax bulkers of approximate 40,000 mt cargo load. For this particular trade, ocean freight in COA terms accounts to 15-20 % of the NKP cost and freight (CFR) value in Southern China.

NKPs may physically also be distributed in bulk in containers, and is done so from Porsgrunn to markets in South East Asia. As the quantities of 300,000 – 500,000 mt to Southern China are rather large, compared to South East Asia, it is the opinion of the maritime logistics department that economy of scale effects from full Handymax shiploads outperforms containerized freight. The average cargo size for bulk shipments of fertilizers in the spot market is 26,000 mt (Stopford, 2008). Storage facilities capacities both at terminals for sending and receiving nitrogen fertilizers are dimensioned for parcel size equal to a Handymax bulker. Port restrictions in Porsgrunn and in the NSR coastal route alternatives, are giving the parcel size limits - both point to utilize the same size of ship – a large Handysize / small Handymax, which hull and size characteristics can be as stated in (Stopford, 2008). The calculations below are done by the authors, and hence they do not necessarily reflect Yara's actual or planned operations or costs.

Table 3a Mineral fertilizer. Distances and sailing time for a single leg voyage via Suez and via the NSR

Porsgrunn-Shekou	Distance (nm)	Equal transit time Corresponding speed
via Suez	10,320	30 days 14.4 knots
via NSR	8,280	30 days 11.5 knots
Difference	2,040	

Adapted from: (Ragner, 2000a, Christensen, 2009, UK Hydrographic Office, 1980)

Table 3b Mineral fertilizer. Comparison of vessels particulars via Suez and via the NSR

	via Suez	via NSR
Ship type	Handymax (Stopford, 2008)	NSR type Bulk carrier modified (Ragner, 2000a)
Draft laden (m)	10.8	10.8
Cargo Capacity (mt)	40,000	40,000
Speed in calm water (knots)	14.4	11.5
Daily fuel consumption for propulsion (mt/d)	31.3	15.9 According to Section 3.1
Fuel consumption for propulsion, per single leg trip (mt)	940	480
Relative energy efficiency ranking	100 %	51 %

Thus, the NSR route is about twice as (51% versus 100 %) fuel efficient as Suez.

Table 3c Mineral fertilizer. Cost comparison for a single leg voyage via Suez and via the NSR

	via Suez	via NSR
Vessel charter rate	600,000 $	720,000$
Fuel costs for propulsion	940,000 $	480,000 $
Suez Canal charge	190,000 $	
NSR charges		380,000 $
NSR added insurance premium		125,000 $
Sum costs	1,730,000 $ 43.3 $/mt	1,705,000 $ 42.6 $/mt

Comments to the table:
A cost difference of 25,000 $ (1.5 %) is marginal.
Vessel charter rate. Average trip charter rate for Handymax bulkers was for years 2008 and 2009 in average about 20,000 $/day (Platou, 2010), which for a 30 days trip gives 600,000 $. Included in the vessel trip charter rate are capital costs and operational expenses (opex). Voyage expenses, like fuel and transit fees, are not included in the trip charter rate. The NSR type bulker is given the rate of a Handymax, plus a surcharge for design and construction for ice-class, and for Arctic operations. Included in (Liu and Kronbak, 2009) are 20% extra building costs for ice-class, and we have used this number for estimating the market price for a trip charter rate as well. We assume 20 % added operational expenses (opex) for NSR operations, which totally gives an estimated added 20% higher trip charter than for an ice-classed Handymax, compared to a standard Handymax. A combined 20 % extra on a Handymax gives a trip charter rate of 24,000 $/day; for 30 days 720,000$.
Fuel costs for propulsion. As discussed in Section 3.3.

Suez Canal charge. Calculated according to (*The Suez Canal Authority*).
NSR charges. According to (Verny and Grigentin, 2009), for comparable ships, NSR charges are about two times more expensive compared to Suez Canal charges. The NSR charges include escort of ice-breakers during parts of the NSR voyage, if required by the Russian authorities. The total amount depends on season of passage and type of ice-class on the cargo ship.
NSR added insurance premium. One of the larger marine insurance companies indicate an added H&M and P&I premium of 125,000 $ per trip, for a GL E3 ice-classed Handymax bulker. An assumption is that the ship operator can demonstrate acceptable plans, crew competences and risk management systems for the voyage. Rebates on this amount will be granted if there are several voyages, several ships (fleet) and the ship operator over time manages to prove successful Arctic operations. Cargo insurance is not included.

At present, the ship operators selling capacity to Yara, are not willing to pass Gulf of Aden due to hijacking risks, thus the route via Cape of Good Hope is used. According to Suez Canal Authority's pricing policy the expected cost per mt should not be very different from Suez. The relative energy efficiency ranking will change, as via Cape of Good Hope is, as stated in Table 1, 3350 nautical miles longer than via Suez. A similar cost calculation is made for this case, with the same assumptions as above.

Table 3d Mineral fertilizer. Distances and sailing time for a single leg voyage. Via Cape of Good Hope and via the NSR

Porsgrunn-Shekou	Distance (nm)	Equal transit time Corresponding speed
via Cape of Good Hope	13,670	40 days 14.4 knots
via NSR	8,280	40 days 8.7 knots
Difference	5,390	

Adapted from: (Ragner, 2000a, Christensen, 2009, UK Hydrographic Office, 1980)

Table 3e Mineral fertilizer. Comparison of vessels particulars. Via Cape of Good Hope and via the NSR

	via Cape of Good Hope	via NSR
Ship type	Handymax (Stopford, 2008)	NSR type Bulk carrier modified (Ragner, 2000a)
Draft laden (m)	10.8	10.8
Cargo Capacity (mt)	40,000	40,000
Speed in calm water (knots)	14.4	8.7
Daily fuel consumption for propulsion (mt/d)	31.3	6.9 According to Section 3.1
Fuel consumption for propulsion, per single leg trip (mt)	1250	280
Relative energy efficiency ranking	100 %	22 %

Thus, the NSR route is four to five times as (22% versus 100 %) energy efficient as Suez.

Table 3f Cost comparison for a single leg voyage

	via Cape of Good Hope	via NSR
Vessel charter rate	800,000 $	960,000$
Fuel costs for propulsion	1,250,000 $	280,000 $
Suez Canal charge		
NSR charges		380,000 $
NSR added insurance premium		125,000 $
Sum costs	2,050,000 $ 51 $/mt	1,745,000 $ 44 $/mt

It is worth noting that the NSR speed of 8.7 knots is lower than the economic speed for this combination of trip charter rate and fuel price, as the costs increased compared to the 11.5 knots situation used when compared NSR to Suez.

To summarize this case, the NSR relative energy efficiency ranking by going via NSR is 51% as compared to via Suez and 22% to via Cape of Good Hope. The cost calculation indicates that NSR is competitive, given the stated assumptions.

5.4 Shipping iron ore from Narvik (North Norway) to Qingdao (Northern China)

Annually, about 16 million mt of iron ore are shipped out from Narvik, a port located in Northern Norway. The ore is sold on FOB terms. The ore mines are in Kiruna (Northern-Sweden), where the iron ore is transformed to pellets or fines before being transported to Narvik by rail. Port of Narvik is the selected export port for iron ore, as it is always ice-free, whereas the Baltic is encumbered with ice in the winter. This amount is shipped in 200-250 Capsize or Panamax shiploads. Qingdao in Northern China is one of the country's largest iron ore import ports. Compared to Case 1, economy of scale will play a role, with larger ships on the southerly routes, if the NSR coastal routes draught and ice-breaker beam still apply as constrains.

Iron ore is a low value commodity, its market value is typically 35 $/mt (FOB). The ocean freight cost is typically 10-20 $/mt. Thus, the transport costs equals to about 1/3 of the CIF value. The average cargo size for bulk shipments of iron ore in the spot market is 147,804 mt. We have in Table 4b selected the Panmax size (and not the larger type Capesize), this is supported by Laulajainen's flow data (Laulajainen, 2009) indicates very few Capesizers trade between Northwest Europe and The Far East. The cost savings by using a Capesize over a Panmax on a 11,000 nm round voyage is 3.6 $/mt, according to (Stopford, 2008). Iron ore is always carried in bulk; containerization is not an option due to the high density of the ore (Stopford, 2008).

Table 4a Iron ore. Distances and sailing time for a single leg voyage

Narvik -Quingdao	Distance (nm)	Equal transit time Corresponding speed
via Suez	11,800	34 days 14.4 knots
via NSR	6,800	34 days 8.3 knots
Difference	5,000	

Via NSR 42% shorter distance compared to via Suez.

Table 4b Iron ore. Comparison of vessels particulars

	Via Suez	via NSR
Ship type	Panamax bulk carrier (Stopford, 2008)	NSR type Bulk carrier (Ragner, 2000a)
Draft laden (m)	13.4	12.5
Cargo Capacity (mt)	68,000	50,000
Speed in open water (knots)	14.4	8.3
Daily fuel consumption for propulsion (mt/d)	36.7	6.0 According to Section 3.1
Fuel consumption for propulsion, per single leg trip (mt)	1250	200
Relative energy efficiency ranking	100 %	22 %

Adapted from: (Ragner, 2000a, Christensen, 2009, UK Hydrographic Office, 1980)

Table 4c Iron ore. Cost comparison for a single leg voyage

	Via Suez	via NSR
Vessel charter rate	1,224,000 $	1,156,000 $
Fuel costs for propulsion	1,250,000 $	200,000 $
Suez Canal charge	203,000 $	
NSR charges		380,000 $
NSR added insurance premiums		125,000 $
Sum costs	2,677,000 $ 39 $/mt	1,861,000 $ 37 $/mt

The cost calculation shows that NSR is competitive for the stated assumptions. However a larger vessel, e.g. a Capesize via either Suez or South of Africa, with even stronger economy of scale effects than with a Panmax ship, will probably outperform cost wise the NSR type bulk carrier. The two ports allow for Capesize vessels. In terms of energy efficiency, the NSR with 50,000 mt parcels will be competitive to also Capesize carriers going via one of the southern routes.

6. ANALYSIS AND FINDINGS

Due to uncertainty in schedule reliability on the NSR in the short term, this route should first be of viable interest and explored for bulk shipping (tramp), rather than for liner shipping. The gains from shipping operations on an ice-free NSR, appears to be *reduced days at sea* and a more than doubling of the *vessel fuel efficiency.* For the corporate players in bulk shipping of relative low value raw materials, cost savings for fuel may appear as a driver for exploring the NSR for commercial transits, and not necessarily reduced lead time. Speed reduction will always result in a lower fuel bill and lower emissions, even if the number of ships is increased to meet demand throughput, according to (Psaraftis and Kontovas, 2009b).

Summer operations on the NSR may already today be profitable, ref. costs per mt freight as shown in cases 5.3 and 5.4. The NSR coastal route alternatives, with vessel draught and beam limitation, are a hindrance to allow for large vessels, and thus achieve same economies of scale in shipping as via Suez. Environmental demand, caused by e.g. applying CSR policy also for shipping companies, may as well emerge as one of the drivers for developing the NSR, subject to among others more knowledge about environmental benefits and costs, for both the NSR and Suez.

Assessments and quantifications of the relevant aspects of supply chain transport risks via the NSR and Suez may for both be difficult to achieve, and such a situation, combined with the argument that in the overall picture added shipping route alternative gives more transport route alternatives and flexibility, the NSR route choice option may possible increase supply chain agility and adaptability. Below supply chain members are identified and commented on, based on the findings in the previous chapters in this paper:

6.1 The cargo owner

The cargo owner can play different roles in the supply chain; it can be the manufacturer of the goods, the seller or the buyer. In cases 5.3 and 5.4 in this paper, ocean freight is not a core activity for the industrial companies, and hence it is outsourced. We could not identify any environmental demand spillover effect (section 2.2) to shipping from e.g. production (a core activity) in the value chains in case 5.3. For the cases 5.2 and 5.4 we cannot conclude on environmental demand. The outsourcing may give that cargo owner is influencing maritime shipping attributes on the operational and tactical level only, and to a less extent on the strategic level, where decisions affecting green logistics are rooted. Choices for fuel quality, ship designs and route appears to be the ship operator's choice in the bulk industry. The ship operator and the cargo owner may have different goals, and act differently. Inventory costs for the bulk commodities in transits appeared in case 5.3 to be not essential as long as it is at the same magnitude as today; planning and flexibility are. Added inventory costs caused by one to two extra weeks of transport time on a long haul voyage appears to be not included in the freight cost calculations in case 5.3, and appears to be negligible, as long as this extra time can be included in the planning. This was one of the findings from the interview with Yara. One or two weeks shorter sailing time on the NSR, due to shorter distance, is not a major gain for this business, reduced fuel cost may be the motivator for the cargo owner.

6.2 Russian authorities

This study reveals that NSRA is not the only Russian authority to cooperate with for a foreign company's planning and commencement of commercial NSR transits (Beluga, 2009). Permissions, time and costs a ship operator is facing for a NSR transit, are uncertain, Russian authorities representing an external uncertainty in the logistics triad model of (Vasco Rodrigues et al., 2008) presented in section 2. Possible future fee revenues from NSR are a business opportunity for Russia, which in combination with e.g. cost sharing with the oil and gas industry for developing logistics infrastructure in Siberia, may generate substantial profits. Flexible marketing policies, as applied by the Suez Canal Authorities, is a possible market approach for pricing of NSR fees for various ships and cargoes. The imagination of the Russian government taking the front seat in developing and promoting the NSR; and thus acting as an efficient supply chain channel leader, is maybe not realistic at present but can be in the future.

6.3 Ship operators

If climate change cuts transport distances, this will be a big, one-time loss for most ship owners. Also, if climate policy regulations to international shipping were introduced, like for example an taxations of CO_2 emissions added to the fuel price, vessel speed will go down, which could imply a big, one time gain for most ship owners. Historically, shorter transport routes are not beneficial for the ship owners in the short term, as demand for shipping is created by the product of travel distances and cargo volumes. (Eskeland, 2008).

For a shipping operator there are barriers to enter NSR, as demonstrated in the case in section 5.2. A shorter transport route might be a threat to ongoing business for the existing bulk shipping providers operating standard vessels. Today, some ship operators avoid the Gulf of Aden, by going Cape of Good Hope instead of via Suez, this means about 10-12 added days of voyage each leg – and probably added profit for them. The rationale for the longer distance voyage is to protect crew, ship and cargo from Somali hijackers, but could alternative precautions and measures than going South of Africa be more reasonable? The argument of shorter distances being a business threat to ongoing businesses may be especially applicable for the major and minor bulk shipping segments, where ships designs and ship operations are fairly standardized. Bulk shipping on the NSR route may be a prosperous market segment for existing niche shipping companies like Beluga, Murmansk Shipping Company (www.msco.ru) and FedNav (www.fednav.com). NSR operations require willingness to invest in ice-classed vessels, and a specialized and competent staff ashore and onshore for Arctic Ocean operations. For innovators and risk takers in ship operations and technology, the NSR appears as a possible market niche and opportunity to have market power. This might represent an added financial and operational risk most bulk ship operators are not willing to carry in present market conditions.

In any case, cargo owners and ship operator relationships, as buyer and sellers, will play a role for a possible development of NSR transits. Business terms ordinary in the transactions today, for example duration of freight contracts and financial guarantees, may be unsatisfactory for the nature of freight transport that both cargo owners and operators will face on the NSR operations. This topic should be further explored. It may not be expected that the shipping community itself, in general, will represent the driving force for developing NSR as an alternative to Suez. Other supply chain channel members than large existing bulk shipping operators or other shipping companies appears to be just as likely possible focal points in developing NSR.

7. RESEARCH LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

A limitation of this paper is the limited extent of primary data collection, exemplified by those Russian authorities has not been approached for data collection, other than via Internet. The chosen case study methodology has a weakness in particular with regard to the ability to generalize the results to populations. However, as pointed out by (Yin, 2009), generalizations of results from case studies should be made to theory, not to populations. We believe this paper is a contribution to the development of logistics management theory related to supply chains where deep sea bulk shipping is a part of the chain.

We suggest future research in a supply chain management context should be along a line constituted by the following questions.

Firstly, further research is needed for assessing weather and ice conditions in the Arctic Ocean, required to assess the level of certainty and uncertainty, and objective risk. Budget costs for H&M and P&I insurance premiums are shown in the cases in sections 5.3 and 5.4, however these premiums only cover incidents and accidents caused by the ship. Thus only a limited extent of cost consequences rooted in the nine categories of risk stated in (Chopra and Sodhi, 2004) are included in the calculations. In future research the assessment of all nine risk categories and e.g. possible available insurance premium market prices should be explored.

Secondly, how does the organisation and nature of relationships (e.g. outsourcing, JIT and time-based distribution) between manufacturing industry and the various shipping industry segments influence the demand for developing NSR for transits? The outsourcing of transport, in combination with the fact that energy efficiency elsewhere in the supply chain (especially production) is more influential to the overall energy efficiency, might influence the cargo owner's awareness, knowledge and incentives for targeting green logistics, and this should be further explored. Environmental demand from the shipping industry itself, due to e.g. shipping regulations (like ETS) or via spillover (ref. Section 2.2) from other industries, may influence the development of the shortest ocean transport route.

Thirdly, what are the potential gains and costs for the Russian Federation if they in an active and professional manner develop and manage the NSR to be a market oriented and energy-efficient route in a Europe to Asia supply chain system? If the NSR is developed to be a competitor to the Suez Canal, how may this distort power–dependence structures in ocean freight?

Finally, how are gravity centres of economic activity changing in Europe and the Far East, especially in China? Manufacturing industry in Europe relocating from west to east, in China from south to north? How does this affect the combined shipping demand and consequently Suez Canal operations and the NSR potential as a shipping route?

REFERENCES

Aronsson, H., Brodin, M. H. & Kohn, C. (2008). Logistics structures - drivers of environmental impact. Copenhagen Business School Press. (Northern Lights in Logistics and Supply Chain Management)

Ballou, R. (2006). The evolution and future of logistics and supply chain management. Produção, 16, 375-386.

Beluga (2009). email interviews regarding the planning and completion of year 2009 NSR transit passages of "Beluga Fraternity" and "Beluga Foresight". .

Buhaug, Ø., Corbett, J., Endresen, Ø., Eyring, V., Faber, J., Hanayama, S., Lee, D., Lee, D., Lindstad, H. & Markowska, A. (2009). Second IMO GHG study 2009. International Maritime Organization (IMO) London, UK.

Byrne, P. M. (2007). Impact and ubiquity: two reasons to proactively manage risk. Logistics Management, April.

Chopra, S. & Sodhi, M. (2004). Managing risk to avoid supply-chain breakdown. MIT Sloan Management Review, 46, 53-61.

Christensen, S. A. (2009). Are the northern sea routes really the shortest? Maybe a too rose-coloured picture of the blue Arctic Ocean. Danish Institute for International Studies [internet] Available at: www.diis.dk [read: 04.01.2010].

Ciliberti, F., Pontrandolfo, P. & Scozzi, B. (2008). Investigating corporate social responsibility in supply chains: a SME perspective. Journal of Cleaner Production, 16, 1579-1588.

Corbett, A. (2010). Green ratings push. Trade Winds, February 19.

Corbett, A. & Bray, J. (2009). Shipping facing $25bn annual CO_2 tax. Trade Winds, December 4.

Dykstra, D. L. (2005). Commercial Management in Shipping. The Nautical Institute, London UK.

Eisenhardt, K. (1989). Building theories from case study research. Academy of management review, 14, 532-550.

Elbeck, M. & Tirtiroglu, E. (2010). The threat of piracy on maritime transportation. International Journal of Society Systems Science, 2, 125-133.

Emerson, R. (1962). Power-dependence relations. American sociological review, 27, 31-41.

Endresen, Ø., Sørgård, E., Behrens, H., Brett, P. & Isaksen, I. (2007). A historical reconstruction of ships' fuel consumption and emissions. Journal of Geophysical Research-Atmospheres, 112, D12301.

Eskeland, G. S. (2008). Managing the commons: is the atmosphere the last frontier? And the maritime industry the last frontiersman? ,

Eyring, V., Isaksen, I. S. A., Berntsen, T., Collins, W. J., Corbett, J. J., Endresen, O., Grainger, R. G., Moldanova, J., Schlager, H. & Stevenson, D. S. (2009). Transport impacts on atmosphere and climate: Shipping. Atmospheric Environment, doi:10.1016/j.atmosenv.2009.04.059.

Fowkes, A., Firmin, P., Tweddle, G. & Whiteing, A. (2004). How highly does the freight transport industry value journey time reliability—and for what reasons? International Journal of Logistics Research and Applications, 7, 33-43.

Griffiths, J. (1995). Queueing at the Suez Canal. Journal of the Operational Research Society, 1299-1309.

Hargett, T. & Williams, M. (2009). Wilh. Wilhelmsen Shipping Company moving from CSR tradition to CSR leadership. Corporate Governance(Bradford), 9, 73-82.

Heggeli, T. J., Wergeland, T. & Andersen, Ø. (1995). Assessment of potential cargo from and to Europe via the NSR. Fritjof Nansen Institute. (INSROP - Discussion Paper. Sub-programme III. Project III.10.1)

Hjelle, H. M. (2010). Short Sea Shipping's Green Label at Risk. Transport Reviews, 1, 24.

Ho, J. (2009). The implications of Arctic sea ice decline on shipping. Marine Policy*,* 34, 713-715.

Hummels, D. (2001). Time as a trade barrier. Global Trade Analysis Project (GTAP)*,* Working paper No. 18.

Imo (2009). Guidance for the development of a ship energy efficiency management plan (SEEMP). The Marine Environment Pretection Committee MEPC.1/Circ.683.

Johannessen, O. M., Sandven, S., Pettersson, L. H., Miles, M., Kloster, K., Melentyev, V. V., Bobylev, L. P. & Kondratyev, K. Y. (1996). Near-real-time sea ice monitoring in the northern sea route using ERS-1 sar and DMSP SSM/I microwave data. Acta Astronautica*,* 38 1996/4//, 457-465.

Kanda, A. & Deshmukh, S. (2008). Supply chain coordination: Perspectives, empirical studies and research directions. International Journal of Production Economics*,* 115, 316-335.

Kitagawa, H. (2008). Arctic Routing: Challenges and Opportunities*.* World Maritime University. (Impacts of Climate Change on the Maritime Industry)

Knemeyer, A., Zinn, W. & Eroglu, C. (2009). Proactive planning for catastrophic events in supply chains. Journal of Operations Management*,* 27, 141-153.

Kovács, G. (2008). Corporate environmental responsibility in the supply chain. Journal of Cleaner Production*,* 16, 1571-1578.

Kristiansen, S. (2005). Maritime Transportation: Safety Management and Risk Analysis*.* Elsevier Butterworth-Heinemann.

Lambert, D. M. & Cooper, M. C. (2000). Issues in Supply Chain Management. Industrial Marketing Management*,* 29, 65-83.

Laulajainen, R. (2009). The Arctic Sea Route. International Journal of Shipping and Transport Logistics*,* 1, 55-73.

Lee, H. (2004). The triple-A supply chain. Harvard Business Review*,* 82, 102-113.

Lee, H., Padmanabhan, V. & Whang, S. (1997). Information distortion in a supply chain: the bullwhip effect. Management Science*,* 43, 546-558.

Lee, H. & Whang, S. (2005). Higher supply chain security with lower cost: Lessons from total quality management. International Journal of Production Economics*,* 96, 289-300.

Liu, M. & Kronbak, J. (2009). The potential economic viability of using the Northern Sea Route (NSR) as an alternative route between Asia and Europe. Journal of Transport Geography.

Llácer, M. & Francisco, J. (2005). Panama Canal Management. Marine Policy*,* 29, 25-37.

The Logistics Performance Index (2010). [internet] Available at: www.worldbank.org [read: 15. april 2010].

Mcgill, J. & Van Ryzin, G. (1999). Revenue management: Research overview and prospects. Transportation science*,* 33, 233.

Mostafa, M. (2004). Forecasting the Suez Canal traffic: a neural network analysis. Maritime Policy & Management*,* 31, 139-156.

Notteboom, T. (2006). The time factor in liner shipping services. Maritime Economics & Logistics*,* 8, 19-39.

Platou, R. (2010). RS Platou Monthly [internet] Available at: http://www.platou.com [read: 20.01.2010].

Psaraftis, H. & Kontovas, C. (2009a). CO2 Emissions Statistics for the World Commercial Fleet. WMU Journal of Maritime Affairs*,* 8, 1-25.

Psaraftis, H. & Kontovas, C. (2009b). Ship Emissions: Logistics and Other Tradeoffs. 10th Int. Marine Design Conference (IMDC 2009), Trondheim, Norway, 26-29 May.

Ragner, C. L. (2000a). The 21st Century—Turning Point for the Northern Sea Route. Oslo, 18-20 November 1999, Kluwer Academic Publishers.

Ragner, C. L. (2000b). Northern Sea Route cargo flows and infrastructure–present state and future potential*.* The Fridtjof Nansen Institute, Norway. Available on www.fni.no.

Rodrigue, J., Comtois, C. & Slack, B. (2006). The geography of transport systems*.* Routledge.

Rodrigues, J. (2008). The rapid decline of the sea ice in the Russian Arctic. Cold Regions Science and Technology*,* 54, 124-142.
Rodrigues, V., Stantchev, D., Potter, A., Naim, M. & Whiteing, A. (2008). Establishing a transport operation focused uncertainty model for the supply chain. International Journal of Physical Distribution and Logistics Management*,* 38, 388-411.
Shipping bunker prices (2010). [internet] Available at: http://www.bunkerworld.com/ [read: April 13, 2010].
Somanathan, S., Flynn, P. & Szymanski, J. (2007). Feasibility of a Sea Route through the Canadian Arctic. Maritime Economics & Logistics*,* 9, 324-334.
Stopford, M. (2008). Maritime economics. Routledge.
The Suez Canal Authority (2010). [internet] Available at: http://www.suezcanal.gov.eg [read: March 8, 2010].
Uk Hydrographic Office (1980). "The World" navigation chart.
Un (2009). Human development reports [internet] Available at: http://hdr.undp.org [read: February 21, 2010].
Verny, J. & Grigentin, C. (2009). Container shipping on the Northern Sea Route. International Journal of Production Economics*,* 122, 107-117.
Wilson, M. (2007). The impact of transportation disruptions on supply chain performance. Transportation Research Part E*,* 43, 295-320.
Wu, T., Blackhurst, J. & O'grady, P. (2007). Methodology for supply chain disruption analysis. International Journal of Production Research*,* 45, 1665-1682.
Yara ASA (2010). [internet] Available at: http://www.yara.com/ [read: February 8, 2010].
Yin, R. (2009). Case study research: Design and methods. 4th ed., Sage Publications, Inc.