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# The Commercial Potential for LNG Shipping Between Europe And Asia Via the Northern Sea Route

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*ABSTRACT*

Thawing sea ice in the arctic due to global warming has opened up new horizons for an environmentally friendly and cost-efficient trade route between Europe and Asia. As an alternative to the Suez Canal, the Northern Sea Route (NSR) offers a 50% shorter sailing distance between Northwestern Europe (Hammerfest, Norway) and Northeast Asia (Tobata, Japan). The shorter distance via the Northern Sea Route comparatively accelerates the route's cost efficiency. In comparison to the traditional route of Suez Canal, cost savings by using the (NSR) could be as large as about 4.7 million US dollars for a full round voyage between the mentioned ports. This may attract the maritime actors to make the required investments. The contribution of this paper is a comparison of transport cost components for the full round voyage of an LNG carrier traversing the Northern Sea Route and the Suez Canal between Europe and Asia. The total savings made in respect of cost by using the Northern Sea Route are determined by citing the most recent interviews with arctic shipping experts and the existing literature. Sensitivity analyses are conducted to assess the impact of key cost components on the overall shipping cost picture. The main research question is "How much is the economic potential of using the Northern Sea Route as an alternative to the Suez Canal for LNG transportation between Europe and Asia?"



## 1. Introduction

### *1.1. Background*

Shipping lanes or maritime transport routes are a substantial strategic part of the maritime transport system. A maritime route is a passage over the sea that connects two different geographical points, where land transport is incompetent to provide an efficient and effective means of transport. Maritime routes follow a defined way of voyage and are subject to certain geographical, natural and political limitations (Rodrigue et al., 2009).

At present, the seaborne trade between Europe and Far East Asia takes place through the traditional route of Suez Canal and Cape of Good Hope. This paper, however, focuses on the Suez Canal route and its emerging alternative, the Northern Sea Route (NSR).

Suez Canal is a 119-mile long artificial waterway that has been serving the global trade over the last one and half century. The canal connects the Mediterranean Sea with the Gulf of Suez providing navigational access to Far East Asian countries. At present, about 50% of the total traffic of the canal is based on container vessels, and the LNG tonnage makes up approximately 6% of the entire traffic volume. The Suez Canal can handle up to 25000 ships per year, and the current traffic is an average of 20000 vessels per year, which constitutes 15 percent of the entire maritime trade (SCA, 2013; Rodrigue et al., 2009).

The maritime route from west of the Kola peninsula through the Bering Strait in the east along the coast of Siberia has been named the Northern sea Route (Schoyen and Brathen, 2011).The Northern Sea Route is not a specific or fixed shipping lane; rather, it is an arrangement of several different shipping routes.

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Table 1: Distance (in nautical miles) of alternative maritime routes between ports in Europe and Asia 1nm=1.852km

| Ports | Northern Sea Route | Suez Canal |
|---|---|---|
| Hammerfest_ Tobata | 6 132 | 12 144 |
| Hamburg _Yokohama | 6 920 | 11 073 |
| Hamburg_ Hongkong | 8 370 | 9 360 |

Source: Adapted from (Falck, 2013; Ragner, 2000)

The passage is spread over around 2200 to 2900 nautical miles of icy water and traverses different straits and seas such as the Kara Sea, the Laptev Sea, the East Siberian Sea, and the Chukchi Sea (Ostreng et al., 2013).

The emergence of the Northern Sea Route has reduced the distance by 50% between Hammerfest and Tobata in comparison to the traditional royal route through the Suez Canal (Falck, 2013), see Figure 1 and Table 1.

The following Table 1 presents an overview of the distance between the ports located in Asia and Europe through the Northern Sea Route and the Suez Canal route (see Table 1).

Over the last three decades there has been a considerable decline in the amount, the coverage area and the thickness of the sea ice cap in the northern hemisphere, resulting in a longer navigational season of 129 days in 2006, which was amounted to just 84 days in 1979 (Schoyen and Brathen, 2011). The declining pattern of the summer sea ice will lead to an ice-free arctic ocean during the summer months by the end of this century (Ragner, 2000). Some researchers believe that the blue arctic sea in summer could appear even earlier between 2026 and 2046 (Ho, 2010).

The stated climatic changes in the arctic may stimulate substantial exploration and maritime activities in the region. The feasibility of NSR is evident, as in 2012 more than 45 vessels navigated this route; this number reflects a tenfold growth in the route traffic since 2010 (Carbonnier, 2013).

### *1.2. The research problem*

In recent years, the topic of the Northern Sea Route has ignited debates and discussions both at domestic and international level. Several research studies have been carried out to assess the commercial potential of the NSR as a competitor to the Suez Canal, with the container-shipping segment being the primary focus of the earlier research studies in this respect. The paper explores the feasibility to gain lower voyage costs for the LNG carriers sailing between Europe and Asia via the NSR, and addresses the following research questions:

1. How much is the economic potential of using the Northern Sea Route as an alternate to the Suez Canal, for LNG transportation between Europe and Asia?
2. How does any variation in the key shipping cost components influence the economic efficiency of the Northern Sea Route as an alternative to the Suez Canal?

In order to answer the above research questions, case study methodology (Yin, 2009; Denscombe, 2010) is applied. The total cost sustained on a full round voyage of an LNG carrier, navigating from Hammerfest, Norway to the port of Tobata, Japan via the NSR is compared with the cost of the round trip through the Suez Canal using the same loading and discharging ports. A sensitivity analysis is also performed to analyze the impact of variations in the key cost components on the overall shipping cost picture.

The paper is structured as follows: In the first section, after an introduction the research problem of the study is presented, followed by Section 2, which focuses on the methodology. Section 3 reviews the relevant existing literature, followed by Section 4 where a case study is conducted to answer the research questions. Section 5 contains a discussion of the results; Section 6 offers a conclusion, and finally Section 7 rounds off the paper with the limitations of this research, and provides the directions for further research on the topic.

## 2. Methodology

Case study research strategy is adopted in this paper. The case study approach depends on multiple sources of data, and focuses on distinctive events, which contain several variables. In order to collect and analyze the data, this methodology also draws on the already existing theory (Yin, 2009).

This research commenced with the secondary data comprising the literature about the NSR such as research articles, reports, journals, books, maritime newspapers and so on. As the available literature, however, did not purvey the essentially required information to answer the main research questions of this study, several interviews were conducted in this respect. The results of this study rely heavily on the primary data obtained through personal interviews, multiple telephone and email conversations with shipping professionals, underwriters, fuel experts, charterers and shipping agents located worldwide.

The selection criteria for the participants of this paper were based on the following key elements (Denscombe, 2010);

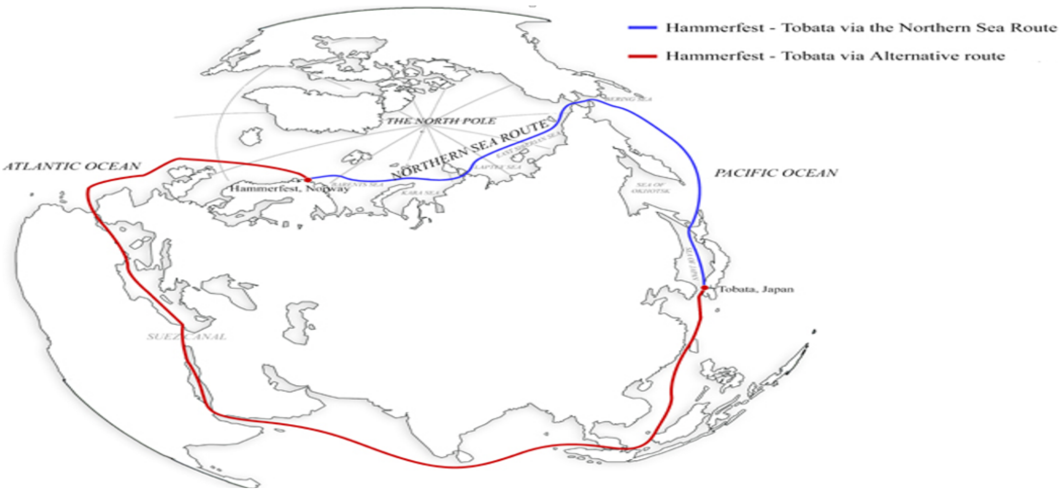
1. The nature of the research question and the goal of the study
2. Knowledge of the authors
3. Relevant experience and position of the participants
4. Availability of the participants

The interviews were recorded and transcribed, and some of the transcripts and calculations were sent to the concerned interviewees for quality check and comments.

## 3. Literature review

Based on the research problem and questions posed in this paper, this section aims at developing a theoretical framework. Section 3.1 reviews the existing literature regarding the economic aspects of the NSR.

Figure 1: Overview of the sailing distance between Hammerfest and Tobata via the NSR and via the Suez Canal




Source: (Dynagas, n.d)

### 3.1. *Comparative economic potential of routes*

Several research studies have compared the economic aspects of transit shipping along the NSR and its other alternatives. Some of the most relevant studies are briefly reviewed here to provide the readers with a background of the existing work and to develop a better understanding of this paper.

Schoyen and Brathen (2011) investigated the economic potential for the trans-arctic shipping of bulk cargo of iron ore and nitrogen fertilizers. They compared the $CO_2$ emissions from the bulk carriers navigating between Europe and Far East Asia through the NSR, the Suez Canal, and the Cape of Good Hope. Their study ranks the NSR as 100% and the Suez Canal as 22% in terms of energy efficiency. The per metric ton shipping cost of iron ore was calculated as 39 and 37 US dollars for shipping via the Suez Canal and the NSR respectively. Their results demonstrate that reduced number of sailing days, fuel cost savings and lower $CO_2$ emissions are the main advantages of sailing through the Northern Sea Route in comparison to the Suez Canal (Schoyen and Brathen, 2011).

Liu and Kronbak (2010) conducted an extensive economic feasibility analysis for the container shipping from Europe to Asia via the Northern Sea Route. The total annual shipping cost was set up against the revenues to determine the commercial potential of the NSR under the different scenarios. Their study took into account a single container vessel sailing on an annual basis through the NSR during the navigable period, and via the Suez Canal during the rest of the year. The study relies on three major variables: the NSR fees, the fuel cost and the sailing period. Scenario analysis was performed to analyze how the reduced NSR fees affected the total cost and revenue structure under the varying bunker prices. Calculations were made for different sailing periods, such as 3 months, 6 months, and 9 months. The bunker price was set as low bunker price (350$/ton), medium bunker price (700$/ton) and high bunker price (900$/ton). The reduction in NSR fees was assumed as 50%, 85%, and 100%. Their research concluded that due to the huge NSR fees it is not economically feasible to carry profitable container shipping operations along the NSR. Conversely, the lower the fees, the higher the competitiveness of the NSR route (Liu and Kronbak, 2010).

In their book 'Shipping in Arctic Waters', Ostreng et al (2013) presented an extensive economic comparison of different arctic routes, namely the Northern Sea Route (NSR), the Northwest Passage (NWP), the Transpolar Passage (TTP) and the Suez Canal. Their study compared a general cargo ship with the same features as the Beluga Fraternity, which navigates between Yokohama-Hamburg via the NSR and through the Suez Canal. The icebreaker fee was not taken into account while making calculations, because it was assumed that the NSR might be navigated without the icebreaker assistance in the future. The comparison concluded that the NSR is more attractive in terms of fuel cost savings - nearly $160300 - and reduction in number of sailing days, which is 11. The findings pertaining to the NWP and the TPP are not discussed here as they are beyond the scope of this paper (Ostreng et al., 2013).

Summing up, the above research studies present the economic picture of navigating through the NSR for the different shipping segments. The NSR fees, the ice conditions and the bunker prices appear to be the critical factors in most of the studies, which influence the economic feasibility of the route.

## 4. Case Study

This chapter intends to illustrate the economic potential of the NSR as an alternative to the Suez Canal, for a round voyage of an LNG tanker sailing between Norway and Japan.

Ostreng et al (2013) point out that there are three main approaches widely used to make comparisons and analyze the economic feasibility. The first method suggests calculating the total transportation cost for each route to obtain the dollar per ton ($/ton) cost of cargo for each route. The second approach proposes to calculate the total cost of starting up a regular service based on the assumed annual quantity of cargo shipment.

The third and final approach merely compares the cost differences among the alternative routes (Ostreng et al., 2013).

This research juxtaposes the different cost components for the transportation of LNG cargo between Hammerfest, Norway and Tobata, Japan on a round voyage basis, ultimately deriving the per ton and MMBtu cost of LNG for both routes. In addition, this study performs the sensitivity tests based on certain cost components to assess the impact of critical cost elements on the total cost structure, therefore following the first and the third research approach outlined above.

### 4.1. LNG shipping from Hammerfest (Norway) to Tobata (Japan)

In this section, the characteristics of loading and discharging ports selected for the case study are briefly described. The ice-classed vessel 'Ob River' completed the world's first LNG transit voyage through NSR in 2012. Vessel Ob River loaded her cargo from Hammerfest, Norway and discharged in Tobata, Japan by traversing through the NSR. For the purpose of this case study, the ports touched are assumed to be the same as those actually used by 'Ob River'.

Hammerfest is located at the gateway to the Northern Sea Route. The annual export of LNG from Melkoya gas terminal located in Hammerfest is 5.75 billion cubic meters, and nearly 70 LNG consignments are shipped from this facility each year, with most of the output being transported to the US and Spain (Offshore Technology, 2013). The opening of the NSR, as (Lauritzen, 2013) maintains, has increased the competitiveness of Norwegian gas in the Asian market.

According to (Kumar et al., 2011), Japan is the largest consumer of LNG in the world. The shutdown of nuclear power plants in Japan has accelerated the demand for LNG in the country (Ostreng, 2013). Tobata gas terminal is located in northern Japan and is operated by Kitakyushu LNG Corporation. The first delivery to this terminal was made in 1977; Sakhalin gas facility in Russia and Bontang in Indonesia are its main suppliers of LNG. Ships with 287.5 meters of length and 47.2 meters width can deliver LNG to this LNG terminal. Three LNG loading arms at the Tobata LNG terminal can support the flow of 4,100 cubic meters per hour (Zeus, 2006).

### 4.2. Evaluation of routes' potential

A conceptual model adapted from (Schoyen and Brathen, 2010) is applied in this study to determine the economic potential for a round trip of the LNG carrier navigating between Hammerfest and Tobata via the NSR and via the Suez Canal, see Figure 2.

#### 4.2.1. Case input data

This case study explores the extent of savings that can be generated in terms of cost by sailing through the NSR as an alternative to Suez Canal. An LNG carrier with similar characteristics to the 'Ob River' is selected for this study, and all the calculations are made by the authors based on the data gathered from relevant experts in the respective fields; it should be noted that these calculations do not represent Dynagas Ltd. or any other participant who provided information to accomplish this research (Raza and Schoyen, 2014).

Table 2: LNG shipping. Case input data including the vessel specifications

| Case input data | |
|---|---|
| Vessel type | LNG carrier (Mark 3 membrane) |
| Ice class | Lloyd's 1A (Arc4) |
| Gross tonnage | 1 00 244 tons |
| Dead weight tonnage (DWT) | 84 682 tons |
| Size | Length : 28 meters & beam : 44 meters |
| Draft | 9.3 meters |
| Capacity | 1 50 000 cubic meters |
| Cargo on board | 1 35 000 cubic meters or about 67 500 tons |
| Vessel Displacement | 1 16 325 tons |
| Propulsion | DFDE (Dual Fuel Diesel Electric Propulsion) |
| Port of load | Hammerfest, Norway |
| Port of discharge | Tobata, Japan |

Source : Based on (ShipSpotting, 2013) and (Lauritzen, 2013)

It is assumed that the vessel sails through the NSR during the navigable months depending on the ice conditions in the NSR, while navigating in other regions during the winter season. The calculations in this study are made for a full round voyage between Hammerfest and Tobata. The vessel makes a laden voyage from Hammerfest towards Tobata gas terminal, and after discharging the cargo at the port of Tobata it set sails on ballast back towards the loading point in Hammerfest.

The following Table 2 illustrates the vessel particulars. Some of the components may slightly differ from the actual vessel 'Ob River', such as capacity: whereas 'Ob River' has a capacity of 149,755 cubic meters, the assumed vessel for this case study can contain up to 150,000 cubic meters of LNG. It is assumed that the cargo on board is 135,000 cubic meters, which is equivalent to around 67,500 metric tons.

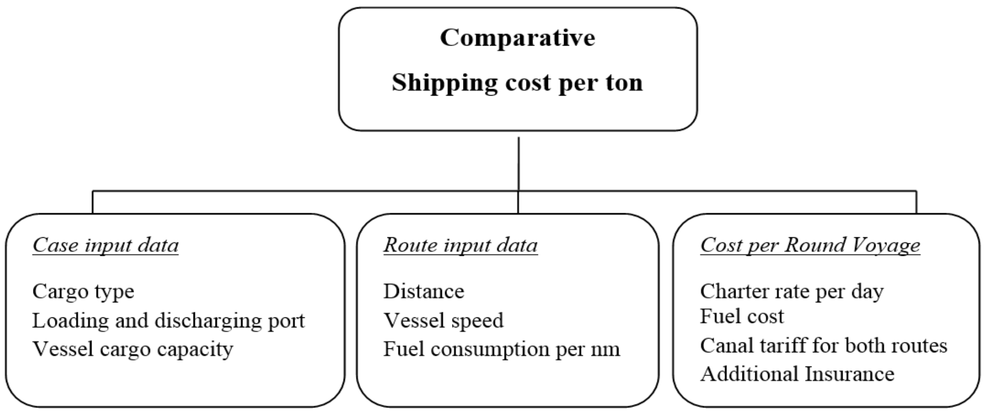
#### 4.2.2. Route input data

Based on the case input data presented in Table 2, the total fuel cost is calculated for the voyage between Hammerfest and Tobata through the NSR and the Suez Canal, as shown in Table 3.

*Distance*: The distance between Hammerfest and Tobata through the Suez Canal is 12146 nautical miles, while through the NSR it is 6132 (Falck, 2013). In Table 3, the distance through the NSR is split into ice water and non-ice water, because in ice water the vessel navigates at a reduced speed, which affects the vessel's fuel consumption. The recent experience about the NSR navigations shows that the LNG carriers traversed the NSR in an average of 10 days at a medium speed of 12 knots (Lauritzen, 2013; Falck, 2013). On this basis, the distance of 2880 nautical miles is calculated for sailing in ice water. Any possible delays due to bad weather or administration are not taken into consideration for the calculations in the table.

*Speed*: The normal speed for LNG carriers is 19.5 knot (Olsen, 2013). According to Lauritzen (2013), the speed of the vessel entirely depends on the ice conditions in the NSR during the voyage; however, the vessel speed for first LNG transit

Figure 2: Conceptual model applied for Cost calculations




Source: Adapted from (Schoyen and Brathen, 2010)

Table 3: LNG shipping. Calculation of fuel cost via NSR and via Suez Canal

| Data | Suez Canal | Northern Sea Route | |
|---|---|---|---|
| | | Ice Water | Non-Ice Water |
| Distance between Hammerfest-Tobata (nm) | 12 146 | 2 880 | 3 252 |
| Speed (knot) | 19.5 | 12 | 19.5 |
| LNG fuel Consumption (tons per nm) | 0,28 (for laden Trip)<br>0,27 (for ballast Trip) | 0,16(for laden Trip)<br>0,15(for ballast trip) | 0,28(for laden Trip)<br>0,27(for ballast Trip) |
| LNG fuel Consumption (tons) per round voyage | 6 680 | 893 | 1 789<br>= 2 682 |
| LNG wastage in GCU in NSR (tons) | | 500 | |
| LNG fuel cost per round voyage ($505/MT FOE) | 3 373 400 | 1 606 910 | |
| MDO pilot fuel (tons) | 67 | 32 | |
| MDO pilot fuel cost per round voyage ($ 900/MT) | 60 300 | 28 800 | |
| Total fuel cost ($) per round voyage | 3 433 700 | 1 635 710 | |

Source : Authors' own calculation based on interviews with relevant experts from the sector voyage of 'Ob River' in the ice water of the NSR was 12 knots on ballast and laden voyages. At the beginning and end of such voyage between Hammerfest and Tobata, the vessel navigates at its full speed (Lauritzen, 2013).

*Fuel Consumption*: Considering the vessel fuel consumption, the authors assume that in normal waters the vessel navigates at its full speed of 19.5 knot, whereas in ice-infested water the vessel sails at an average of 12 knots. All the fuel consumption calculations are made in accordance with the guidance and information obtained from experts (Olsen, 2013; Rokstad, 2013; Devik, 2013). After completing the fuel calculations for this vessel, the authors sent it to (Olsen, 2013) and (Falck, 2013) for a quality check, which resulted in a few subsequent changes according to their comments.

*Pilot Diesel Consumption*: Since the hypothesized vessel has DFDE propulsion allowing the use of different fuels for sailing, and a DFDE vessel can use LNG or diesel (Rokstad, 2013), it can be assumed that the vessel burns LNG for propulsion on the laden and ballast voyages. The DFDE LNG carriers also consume a small amount of pilot diesel, which makes up around 1 percent of the total fuel consumption (Olsen, 2013), (Devik, 2013) and (MAN, 2013).The bunker price of 900 USD per ton for diesel oil has been used for the calculations in Table 3 (Bunkerworld, 2013).

*LNG Fuel Consumption*: The LNG fuel consumption for the vessel estimated in this paper is 130 metric tons per day at 19.5 knots, and 45 tons per day at 12 knots on a laden voyage. For the ballast voyage, the vessel consumes 126 metric tons of LNG per day at 19.5 knots, and about 42.5 tons per day at 12 knots (Olsen, 2013). Consequently, our calculation of LNG fuel consumption per nautical mile varies slightly for the laden and ballast voyage.

*Gas Wastage in Gas Combustion Unit (GCU)*: According to (Olsen, 2013), during the laden voyage the vessel must consume at least 95 tons of fuel per day at 0.14 percent of boil off gas (BOG) rate. However, due to low speed of 12 knots in ice water through the NSR, the vessel can consume only 45 tons of LNG per day; therefore, the rest of 50 tons BOG per day is wasted in the Gas Combustion Unit (Olsen, 2013; Rokstad, 2013). The total BOG wastage for this trip is 500 tons for ten days on the laden voyage, as there would not be such any wastage on the ballast trip. An important factor in this respect is that some modern LNG vessels have the ability to re-liquefy the boil off gas (BOG) by using the advanced technology, which can prevent the gas wastage in GCU; therefore, it is supposed that the vessel utilized in this paper does not have any such technology on board (TimeraEnergy, 2013)

*Bunker Price of LNG*: According to (Olsen, 2013), the current LNG price is 12 US dollars per Million British Thermal Unit (MMBtu) in Europe, where one cubic meter is equivalent to 20 MMBtu. Using a fuel oil equivalent (FOE) factor of 0.475 cubic meter LNG/per fuel metric ton, which is commonly used in LNG industry, the fuel price per ton of LNG is derived as 505 US dollars per ton (Olsen, 2013).

Table 4: LNG shipping. Cost comparison of a round voyage via the Suez Canal and via the NSR (Hammerfest-Tobata)

| Cost Components | Suez Canal | NSR |
|---|---|---|
| Vessel charter cost per round voyage ($) | 7 396 700 | 3 735 400 |
| Total Fuel Cost ($) | 3 433 700 | 1 635 710 |
| Canal tariff per round voyage ($) | 1 71 693 | 8 07 975 |
| Additional piracy insurance in Suez Canal per round voyage | 1 58 204 | |
| Additional insurance premium for Increased Values (IV) in NSR ($) | | 20 250 |
| Additional H&M insurance for NSR navigation ($) | | 2 81 250 |
| Total Costs per round voyage ($) | 11 160 297 | 6 480 585 |
| Total Savings ($) | 4 679 712 (42%) | |
| Cost per ton ($) (1MMBtu = 0.0192ton) | 165 $ /ton (3.2 $ / MMBtu) | 96 $ / ton ( 1.8 $ / MMBtu) |
| Savings per ton ($) | 69 $ / ton (42%) | |

Source : Authors' own calculation based on interviews with relevant experts from the sector

### 4.2.3. Shipping cost per round voyage

In Table 4 below, the major LNG shipping cost components are calculated and compared in accordance with the experts' opinions and market information. Based on these cost components, the total shipping cost per round voyage and per ton between the assumed ports is hereby calculated.

*Vessel Charter Cost*: For the calculations in Table 4, the spot charter rate is used to calculate the total charter cost for the voyage. The spot charter rates are comparatively higher and more instable in contrast to long-term charter rates (Rokstad, 2013; Drewry, 2006).

The spot charter rate used for the calculations in Table 4 covers the capital cost and the vessel running cost, while it does not include the extra insurance premiums and the voyage costs that are mentioned separately in Table 4. The spot charter rate varies for steam vessels and DFDE vessels; since the vessel in the study is a DFDE, the current spot rate of 95 000 is used for both route calculations (Platou, 2013). In the current market situation, the spot rate would almost be same regardless of the sailing route choice for the vessel (Dahl, 2013 and Rokstad, 2013). The total charter cost for a round voyage is derived by multiplying the charter rate by the number of sailing days for each route, i.e. 19.66 days via the Northern Sea Route and 39.93 days via the Suez Canal.

*Fuel Cost*: After the chartering cost, the bunker expenditures constitute the second largest cost component in the overall shipping cost structure. The bunker price varies from region to region around the globe (TimeraEnergy, 2013). Although bunker prices may well change in the future, these calculations are made according to the current approximate rates. The fuel cost calculations are elaborated in Section 4.2.2.

*Canal Costs*: LNG carriers obtain a 35% discount on the total Suez Canal fees, and due to the lower tonnage the Membrane LNG vessels pay less in terms of transit dues in comparison with the Moss type LNG vessels (Drewry, 2006). For the purpose of this strudy, the Suez Canal cost is calculated by using the Suez Canal Authority (SCA, 2013) calculator and a 35% rebate (Drewry, 2006) is deducted from the total fee.

The NSR fee for this particular LNG transit voyage is obtained from an arctic shipping expert, as there was no firsthand information in this respect to be extracted from the literature. According to Falck (2013), for the laden voyage the NSR fee is 6.80 US dollars per ton cargo loaded, while for the ballast voyage the rate is 3 US dollars per ton of vessel's full displacement (Falck, 2013). The NSR fee secures access to different additional services such as icebreaker support, maintenance of the passage, reconnaissance flights, satellite communication, pilotage, meteorological service and so on. The NSR fee mainly depends on the vessel particulars, e.g. vessel and cargo type, ice class, size, ice conditions and crew experience (Ostreng et al., 2013).

*Port Charges*: One of the most significant and complex voyage cost is represented by the port charges. Port charges cover various small cost expenses; some of these are paid by the cargo owners, and the rest by the charterer (Drewry, 2006). For the calculations in this study, port charges are assumed to be similar for both routes, and therefor are not included in this paper.

*Additional Insurance*: When making such calculations for a transit voyage, the marine insurance for the vessels navigating along the NSR is a critical factor to be considered. The extra insurance premiums for sailing along the NSR may increase the overall shipping cost. The marine insurance depends on multiple factors such as the vessel's gross tonnage, the insured value of the vessel, the time of sailing and the climatic conditions, the vessel owners' historical record and the competition level in the insurance market (Mulherin, 1996).

Underwriters do not charge extra Protection and Indemnity (P&I) insurance premium for the trans-arctic shipping between Europe and Asia via the NSR, as confirmed by (Skuld, 2013) and (Gard, 2013). Since the P&I cover is same for the shipping through the northern and southern routes, it is not taken in to account for the shipping cost calculations in this paper.

Only the Hull and machinery insurance and insurance for increased values (IV) for the NSR shipping is added in the total cost calculations in Table 4. The total insured value of this assumed ice-classed LNG carrier is 2 25 000 000 USD, which is split into the Hull & Machinery and Increased Value (IV).

According to an anonymous underwriter, the vessel owners install various types of additional equipment on board for sailing through the NSR, and there is extra insurance for such equipment referred to as the increased values (IV). The values for the insurance cost used in Table 4 are provided by an anonymous underwriter, whose name, along with the insurance calculation method for this assumed vessel, are treated confidentially in this paper. The additional insurance cost for this vessel is subject to the following assumptions:

*"The first and foremost requirement is that the voyage is made in good ice conditions. The vessel must use the icebreaker or ocean-going tug services during the voyage. The vessel must follow the icebreakers at a safe distance - at least more than 1 meter for waters shallower than 30 meters and greater width if breaking solid sea ice...in case of any incident, the underwriter must be informed immediately for any claim under the H&M or IV policy"*

*Piracy Insurance*: Falck (2013) advocated that due to piracy in the Gulf of Aden the insurance cost for transit shipping through the Suez Canal has increased, and therefore it should also be considered for shipping cost comparisons.

The same anonymous underwriter who provided the H&M and IV insurance figures for the vessel estimated the extra piracy insurance cost for the transit shipping via the Suez Canal. The piracy insurance for Suez Canal trip covers the round voyage between the studied ports, and is subject to the following assumptions:

*"The price of armed guards and kidnap and ransom (K&R) premium is unknown for this assumed vessel, but if the ship owner buys such services, he will get rebate on the war premium. Ship owners do not buy the loss of hire insurance for this voyage. It must be ensured that the vessel passes through the Internationally Recommended Transit Corridor (IRTC) as part of Gulf of Aden Group Transit (GOA GT), that the vessel or the owner is registered with the Maritime Security Centre Horn of Africa (MSC HOA) and that it follows recommended Best Practice (BMP 4). The additional discount for K&R is warranted that a K&R policy is in place with ransom and cost limits of (minimum) USD 5 million, and containing full waiver of subrogation against War Risks underwriters. The vessel is subject to 48 hours' notice / 7 days cover and must be certified to carry no weapons, nor ammunition or military equipment as cargo on board, and must be subject to the Sanction Limitation and Exclusion Clause (JW2010/004)"*

According to (Gard, 2013), the Norway-based marine underwriter, the insurance plays a minor role in the overall cost picture of the arctic shipping. In future, if the ice conditions are favorable and the sufficient search and rescue facilities are provided along the NSR, the underwriters would most likely not charge any additional premiums for the transit shipping through the NSR. Most of the insurance premium is not related to the ice but to the remoteness of the area, because any incident may bring consistent loss. The political uncertainty is also another critical factor that can hamper the process of claims handling in case of any contingent situation. Shipping through the NSR is a relatively new type of trade, and the risk / price is not yet fully established. Since currently, due to only few voyages carried out through this route, no any reliable statistics are available yet (Gard, 2013), there may be great variations in the future insurance premiums for arctic shipping, depending on the incidents and how they are coped with.

Summing up Table 4, the total shipping cost for the LNG transit voyage between Hammerfest and Tobata via the Northern Sea Route is lower than the shipping cost for the Suez Canal transit, under the abovementioned assumptions of this study. The LNG shipping cost per ton is respectively 96 and 169 US dollars for the NSR and the Suez Canal, which yields a saving of around 42 percent for sailing through the NSR with the given conditions. On the basis that one MMBtu is equivalent to 0.0192 ton; the LNG cost per Million British thermal units (MMBtu) thus calculated results in a considerably lower amount for the NSR transit shipping in comparison to Suez Canal.

The cost components discussed in Table 4 are also demonstrated in the following Figure 3. Figure 3 shows that the vessel chart rate and the fuel cost make up the largest part of the shipping cost for this voyage, and that these costs, when compared to the voyage through the NSR, are nearly 50% less. For this typical LNG transit voyage between Norway and Japan under the assumed parameters, however, the canal fee and the additional insurance appear to be respectively 80% and 48% higher for the NSR compared to its alternative the Suez Canal - see figure 3.

The overall result of the shipping cost calculations demonstrates that, due to the 50% shorter sailing distance between the loadings and discharging ports, the NSR is around 42 % more cost efficient and 52% more energy efficient than its competitor, the Suez Canal.

### 4.3. *Sensitivity analysis*

This section aims to answer the second research question of this paper, i.e. how a variation in the key shipping cost components affects the efficiency of the NSR as an alternative to the Suez Canal. There are of course multiple cost components, but this section mainly considers the NSR fee and charter rate to assess their impact on the routes' overall cost efficiency.

#### 4.3.1. *NSR tariff and route efficiency*

(Liu and Kronbak, 2010) applied the scenario analysis in their investigation to assess the impact of varying bunker prices and reduced NSR fee on the overall profitability of the container service between Europe and Asia. There are certain significant factors which will determine the future NSR fee for the transit vessels, such as the amount of cargo volume, the Russian economy and the Russian state policy for the promotion of the Northern Sea Route (Liu and Kronbak, 2010).

Ostreng et al (2013) argued that the NSR fee seems to be negotiable; for instance, in 2009 Beluga shipping paid only 2.25 USD per dead weight for the project cargo, and in the future the NSR may be navigated without the icebreakers' assistance when the ice will vanish. Vukmanovic and Koranyi (2013) report that Russian authorities have shown intentions to reduce the transit fee in order to attract more cargo and investments. In a future perspective, the increasing traffic through the route may play its role in bringing down the NSR charges.

In the total cost calculations carried out in Table 4, the NSR fee appears as a significant component, being about 80% higher than the Suez Canal fees. Table 5 demonstrates how a reduction in NSR tariff will affect the total shipping cost per ton of LNG cargo. The cost efficiency of the NSR is evaluated by taking three different NSR fee levels into account, assuming that the total shipping cost for the Suez Canal remain constant (see Table 5).

Table 5 shows that a future reduction in the NSR fee will increase the competiveness of the route as an alternative to Suez Canal. Moreover, it indicates that the lower the NSR fee, the more competitive the route is, under the given conditions as portrayed in the figure 4. It is quite visible from Figure 4 that the NSR tariff will affect the per ton LNG shipping cost at a nominal rate. The 0% NSR tariff reduction in Figure 4 represents the current rate, whereas a reduction by 50% will save more $6 per ton of LNG shipping cost for NSR transit shipping. A 100% reduction can increase the NSR cost efficiency potential by 12 USD per ton of LNG shipping cost in relation to the current rate - see Figure 4.

#### 4.3.2. *Charter rate and route efficiency*

Falck (2013) indicated that the charter rate per day is the most influential cost component that may alter the total cost picture for the transit shipping through the NSR. As stated earlier, the spot charter rate is relatively volatile and it depends on various factors such as vessel availability, natural gas production levels, oil and gas prices, long term charter agreements, deregulations of gas markets in Europe and US, world economic growth , competition for alternate energy sources and so on (Drewry, 2006).

The charter market has seen a quite diversified trend in the day rate over the last few years. In the past, the charter rate was as low as 20 000 USD per day and as high as 150 000. The year 2012 was important for the charter market because the daily charter rate was at its highest level since the last thirteen years, as shown in Figure 5.

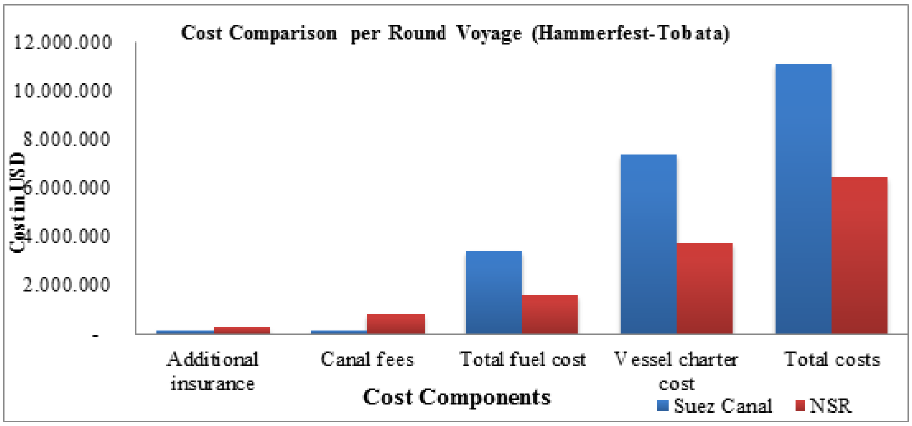
Based on the market trend depicted in Figure 5, three charter rates - low (35 000), medium (75 000) and high (1 50 000) - are used to evaluate the influence of the charter rates on the routes competiveness, see Table 6.

Table 6 above shows that the charter rate has a robust impact on the shipping cost of LNG cargo through both passages. At the low charter rate, the Northern Sea Route is not as attractive as it is at the higher charter rate in terms of cost efficiency, which is 37 % and 44 % at low and high rates respectively with the stated assumptions. Based on Table 6, the following chart has been plotted to illustrate the comparative effect of the charter rate on the per ton LNG shipping cost, see Figure 6.

Figure 6 presents the per ton LNG shipping cost at four different charter rates for the Northern Sea Route and the Suez Canal. A low charter rate (35 000) gives a saving of 35 dollars and the high rate (1 50 000) results in 101 dollars savings per ton of LNG shipping cost. The trend of the charter rate in Figure 6 shows that the higher charter rate would result in larger savings by sailing through the NSR.

Under the given assumptions, the comparisons demonstrate that the Northern Sea Route is more cost efficient in both the mentioned scenarios for the LNG transit shipping between Norway and Japan with respect to the alternative route of the Suez Canal, due to the shorter distance. Higher daily charter rate will enlarge the cost saving potential of the Northern Sea Route.

Figure 3: LNG shipping. Cost comparison of a round voyage via the Suez Canal and via the NSR (Hammerfest-Tobata)



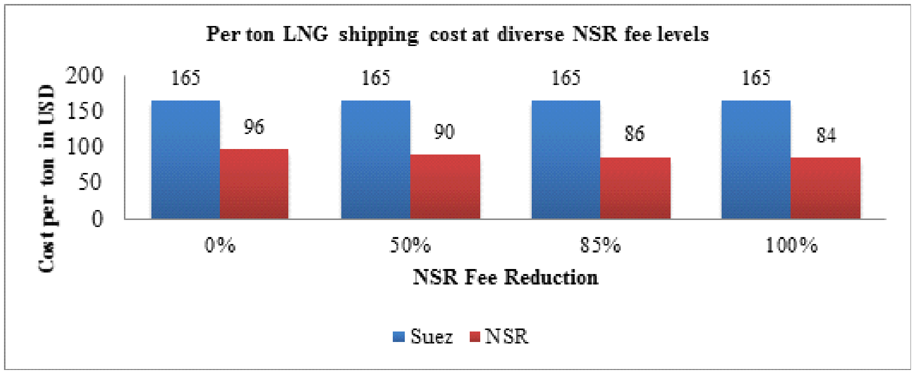

Source: Authors' own composition based on Table 4

Table 5: Sensitivity Analysis. Routes' Efficiency at diverse NSR tariff levels

| **Cost** | **Suez Canal** | **NSR** |
|---|---|---|
| NSR fee = 50% reduction | | |
| Total Costs per round voyage($) | 11 160 297 | 6 076 597 |
| Total Savings ($) | 5 083 700 (45%) | |
| Cost per ton ($) | 165$/ton | 90$/ton |
| Savings per ton ($) | 75$/ton (45%) | |
| *NSR fee= 85% reduction* | | |
| Total Costs per round voyage ($) | 11 160 297 | 5 793 806 |
| Total Savings ($) | 5 366 491(48%) | |
| Cost per ton ($) | 165$/ton | 86$/ton |
| Savings per ton ($) | 79$/ton (48%) | |
| *NSR fee= 100% reduction* | | |
| Total Costs per round voyage ($) | 11 160 297 | 5 672 610 |
| Total Savings ($) | 5 487 687 (49%) | |
| Cost per ton ($) | 165$/ton | 84$/ton |
| Savings per ton ($) | 81$/ton (49%) | |

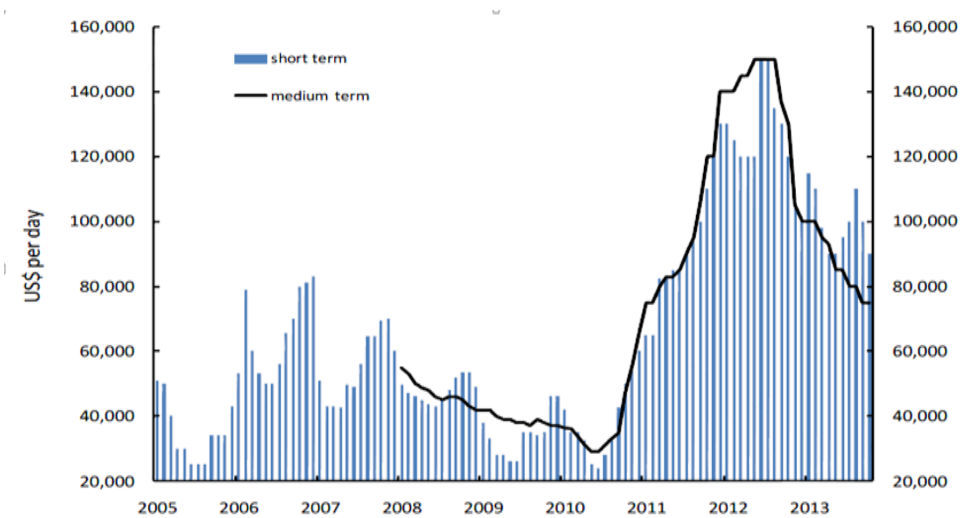
Source : Authors own composition

Figure 4: Sensitivity analysis. Impact of reduced NSR fee on the per ton LNG shipping cost



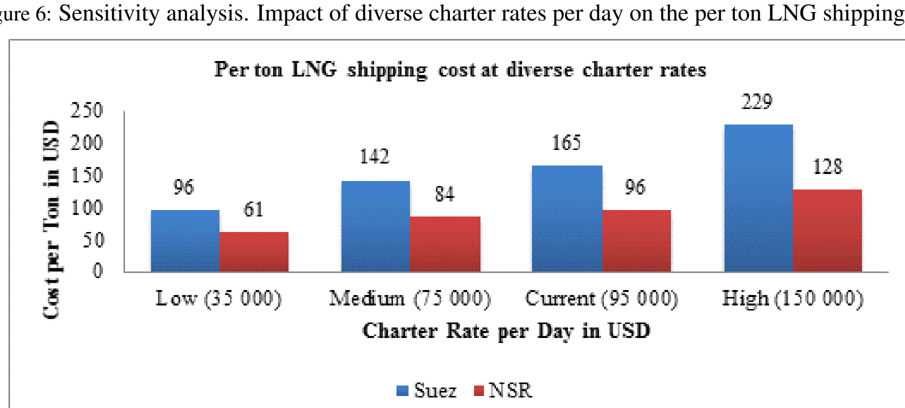

Source: Authors' own composition based on Table 5

Figure 5: Day charter rate history for DFDE LNG vessels




Source: (Platou, 2013)

Figure 6: Sensitivity analysis. Impact of diverse charter rates per day on the per ton LNG shipping cost




Source: (Platou, 2013)

Table 6: Sensitivity analysis. Routes' efficiency at diverse charter rates

| **Cost** | **Suez Canal** | **NSR** |
|---|---|---|
| Low Charter Rate = 35 000 $ / day | | |
| Total Costs per round voyage($) | 6 488 697 | 4 121 385 |
| Total Savings ($) | 2 367 312 (37%) | |
| Cost per ton ($) | 96$/ton | 61$/ton |
| Savings per ton ($) | 35$/ton (37%) | |
| *Medium Charter Rate = 75 000 $ / day* | | |
| Total Costs per round voyage ($) | 9 603 097 | 5 694 685 |
| Total Savings ($) | 3 908 912 (41%) | |
| Cost per ton ($) | 142$/ton | 84$/ton |
| Savings per ton ($) | 58 (41%) | |
| *High Charter Rate = 1 50 000 $ / day* | | |
| Total Costs per round voyage ($) | 15 442 597 | 8 643 185 |
| Total Savings ($) | 6 799 412 (44%) | |
| Cost per ton ($) | 229$/ton | 128$/ton |
| Savings per ton ($) | 101$/ton (44%) | |

Source : Source: Authors' own calculation

## 5. Discussion

The main objective of this research was to investigate the potential of the Northern Sea Route over the traditional route of Suez Canal in terms of shipping cost efficiency, for the LNG transit shipping between Europe and Asia.

According to the investigations of (Schoyen and Brathen, 2011; Ostreng et al, 2013) and (Furuichi and Otsuka, 2013), the seasonal shipping operations along the NSR rather than through the Suez Canal are profitable for the bulk and container cargo trades under certain assumptions. This research ascertained that, in comparison to the traditional route of the Suez Canal, the Northern Sea Route appears to be a 42% more cost efficient passage, with the potential to save about 4.7 million US dollars for a full round voyage of an LNG tanker navigating between Europe and Asia.

In their investigation, (Liu and Kronbak, 2010) performed a scenario analysis where they found that a reduced NSR fee would increase the efficiency of the NSR over its rival - the Suez Canal. This research confirms their finding about the impact of the NSR fee on the route's competitiveness: a reduced NSR fee increases the cost saving potential for the vessels traversing the NSR.

In their research, (Schoyen and Brathen, 2011) carried out the shipping cost comparison for a single leg trip from Norway to China. Since (Falck, 2013) argues that this type of cost comparison must always be made on a round voyage basis, otherwise it would give a wrong indication, in this paper the cost comparison for the vessel navigating between Europe and Asia is made for the full round voyage, therefore this research may stand in opposition to the study by (Schoyen and Brathen, 2011) in this respect.

Schoyen and Brathen (2011) assumed a 20% additional charter rate for the ice-classed vessels in their study, whereas Dahl (2013) and Rokstad (2013) revealed that the charter rate would be similar for ice-classed vessels and ordinary vessels. Based on (Dahl, 2013; Rokstad, 2013), this research may then disagree with the assumption made by (Schoyen and Brathen, 2011) regarding the charter rate per day for the cost calculations.

This research found that the charter rate per day seems to be the most important and largest cost component in the total shipping cost picture. Falck (2013) claimed that the charter rate affects significantly the cost efficiency of the routes. It was discovered that compared to the low charter rate per day, the higher charter rate increases the cost efficiency of the Northern Sea Route over the Suez Canal for the transit shipping of LNG between the northern ports of Europe and Asia.

Liu and Kronbak (2010) assumed a 25 % increased protection and indemnity (P&I) insurance premium for the ice-classed vessels. In their investigation, Furuichi and Otsuka (2013) used 10 dollars per gross tonnage per year as additional H&M and P&I insurance premium for the vessels crossing the NSR. Marine underwriters (Gard, 2013; Skuld, 2013) indicated that they do not charge extra P&I insurance premium for the NSR shipping. and therefore this research may oppose the assumption made by Liu and Kronbak (2010) and Furuichi and Otsuka (2013).

The vessels navigating through the Suez Canal face a piracy threat that has increased the insurance cost, as indicated by (Furuichi and Otsuka, 2013; Falck, 2013) and by an anonymous marine underwriter. The research studies by Liu and Kronbak (2010) and Schoyen and Brathen (2011) did not take into account the additional piracy insurance cost in their investigations and this may undermine the results of their investigations.

## 6. Conclusion

As described earlier, the overall purpose of this paper was to identify the potential of Northern Sea Route as an alternative to the Suez Canal for the LNG shipping. Altogether, two main research questions were formulated to meet the research goals of this study. Multiple sources of evidence including research articles, reports, interviews, and government documents have been used to meet the research objectives.

**Research question 1**: How much is the economic potential of using the Northern Sea Route as an alternative to the Suez Canal for LNG transportation between Europe and Asia?

By conducting a comparative case study, this research has found that the Northern Sea Route as an alternative to the Suez Canal offers a sailing distance reduced by 50% (about 20 days) between the ports in Northern Europe and Northeast Asia. The cost efficiency potential of the NSR over the Suez Canal is 42%, and the LNG carrier sailing between Norway and Japan offers a saving of 4.7 million dollars for a full round voyage. This may attract the industry players to make the required investments.

**Research question 2**: How does any variation in the key shipping cost components influence the efficiency of the Northern Sea Route as an alternative to the Suez Canal?

This research conducted a sensitivity analysis to answer this question. It emerged that the charter rate per day seems to be the most important and largest cost component in the total shipping cost picture. A higher charter rate increases the cost efficiency of the Northern Sea Route over the Suez Canal for the transit shipping of LNG between the northern ports of Europe and Asia. The insurance cost seems to have relatively less impact on the overall cost structure of the transit shipping via the NSR and via the Suez Canal, while a reduced canal tariff would increase the competitiveness of Northern Sea Route.

## 7. Limitations and future research

The viewpoint of potentially concerned gas companies such as Gazprom, Statoil etc, which may use the NSR in the future, is yet unknown, as all the efforts to contact to them went unattended. Another limitation of this research is that the vessel is assumed to use the boil of gas as a bunker fuel also on the ballast leg, but in reality the DFDE LNG vessels burn heavy fuel oil when they do not have cargo on board, and this may alter the values calculated with respect to cost. The distance in the ice water of the NSR is stipulated around 2 880 nautical miles, but in practice it may vary depending on the ice conditions and the route choice.

Future research can make cost calculations for the combined NSR-SCR LNG transit operations on a yearly basis. Further research is also required to analyze how the establishment of a standardized infrastructure as well as of search and rescue facilities along the NSR will affect the future insurance costs for the vessels using the NSR for transit shipping.

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