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The Analysis and Research on Cost Advantages of Ships Sailing on Arctic NEP

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Abstract: The cost advantage of Arctic NEP (Northeast Passage) is mainly analyzed. The traditional southern route through the Suez Canal between the East Asia and the Europe is referred as benchmark route, general cargo ship and container ship are respectively selected as benchmark ships, which are analyzed and compared with Arctic NEP from fuel consumption, insurance, icebreaker fees and cost for SOLAS amendment, etc. The study reveals that Arctic NEP highly reduces general cargo ships' sailing time, container ships' fuel consumption, and contributes to shipping's sustainable development.

Key words: Arctic NEP, cost advantages, shipping, analysis and research, sustainable development.

1. Introduction

In recent years, the opening of Arctic NEP (Northeast Passage) in summer makes the maritime transport from east Asia to Europe more fast, economic, and brings great convenience for east-west trade and development of world economy. With global warming, the melting speed of the Arctic sea ice is accelerating. The latent traffic strategic value in the Arctic area has become increasingly prominent: the NEP connecting the Atlantic Ocean and the Pacific Ocean is becoming navigable throughout the year at a very fast speed [1].

Once the Arctic sea ice melts totally, the Arctic NEP will be completely navigable and significantly change the world pattern of economy, trade and maritime transport. The north of our country is located within the extension of the Arctic NEP, so the changed of the Arctic NEP are closely related to China, especially the shipping industry of our country. This paper takes the Arctic NEP as the research object comparing with the traditional passage via the Suez Canal, and analyzes the commercial value of the Arctic NEP [2-5].

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2. Research Method

The purpose of this paper is to look at the commercial aspects of using NEP to a similar trip using the Suez Canal. There are many ways one could make comparisons, but the main three usual approaches are:

- Calculating the total transportation costs for using each route to obtain a $/ton cost estimate for each route;
- Calculating the total cost of setting up a regular service based on an assumed yearly quantity to be shipped;
- Focusing on cost differences among the route alternatives.

The first approach focuses on cost savings for the end user of transport. The second approach takes into consideration that saving time makes it possible to service a given amount of cargo with fewer vessels (trips) and is thus taking into consideration the capital costs of investing in vessels. The third approach is more used in a first commercial feasibility study, i.e. one explores the order of magnitude of cost savings to get a feeling for cost differences and to be able to do simple sensitivity tests.

Since this paper is considering a hypothetical future where ice conditions have greatly changed in the

Arctic, the starting point for a comparison will be to assume Arctic transit without icebreaker support. By then calculating the cost advantage of the northerly routes vs. a southern route through the Suez Canal, the implicit willingness to pay for icebreaker support will also be given.

The research therefore uses the third approach and looks at the main cost components where there will be differences. The comparison would be relevant for a ship owner with a given ship and a choice of which route to sail. So general ship and container ship are recognized as the typical type of ship, and the routes between the Far East area and the Europe are taken as the typical routes. The benchmark ships and routes are as follows:

- Benchmark ships: general ship: Beluga Fraternity (sailing in the Arctic northeast passage in September 2009) and her sister ship; container ship: CSCL Hamburg;
- Benchmark routes: Yokohama to Hamburg via Suez; Shanghai to Hamburg via Suez;
- Arctic NEP: Yokohama-Hamburg via NEP; Shanghai-Hamburg via NEP.

3. Costs Analysis on Benchmark Routes

3.1 Yokohama to Hamburg via Suez

The main data for benchmark general ship are given by IHS in Table 1.

The route specific data are given in Table 2.

The Suez Canal toll has been calculated on the basis of the calculator provided by the Suez Canal authorities, using current exchange rates for SDR5/$.

The insurance figures are based on figures from Drewry [6], where yearly figures have been converted to $/day figures. The comparison of insurance costs is, however, a tricky one. Currently the insurance costs for ships passing the Gulf of Aden towards Suez have soared since 2008 due to the piracy risk. It is claimed that the insurance has increased tenfold for this coastal area between September 2008 and March 2009. After 2015, if the situation of the globe shipping market persists like now, the shipping costs will maintain the present level, such as insurance cost. On the contrary, if the insurance cost raises dramatically, it will increase the advantage of Arctic passages. It is claimed this is one important motivating factor for China’s increased interest in the Arctic [2-4].

Table 1 General cargo ship characteristics.

Gross tonnage GRT	9,611
Net tonnage NRT	4,260
Deadweight ton DWT	12,672
Suez Canal Net Tonnage SCNT	12,915
Draught in meter	8
Service speed in knots	14
Gram fuel per kwh	190
Power in kw	5,400
Ton fuel per day at service speed	24.624

Table 2 Route specific data Yokohama-Hamburg via Suez.

Distance in nautical miles (nm)	11,430
Journey days at service speed	34
Fuel consumption in tons	838
Suez canal toll in $	51,168
Hull and machinery insurance $/day	360
P&I P&I insurance, $/day	340

3.2 Shanghai to Hamburg via Suez

As the benchmark container ship, CSCL Hamburg with a capacity over 4,000 TEU, main ship data are given by IHS in Table 3.

The route specific data are given in Table 4.

4. Increased Costs of Ships Sailing on Arctic NEP by SOLAS Amendment

SOLAS Chapter XIV “SAFETY MEASURES FOR SHIPS OPERATING IN POLAR WATERS” includes the requirements about ship structure and machinery, manning and training, navigation and communication, fire safety and life-saving appliance and arrangements for ships sailing in the polar waters [7, 8].

- ships shall be ice strengthened [7, 8];
- ships constructed on or after 1 July 2017, ice strengthened shall have either two independent echo-sounding devices or one echo-sounding device with

Table 3 Container vessel data.

Gross tonnage GRT	39,941
Net tonnage NRT	24,458
Deadweight ton DWT	50,790
TEU	4,253
Suez Canal Net Tonnage SCNT	57,387
Draught in meter	12.6
Service speed	23
Gram fuel per kwh	190
Power in kw	36,515
Ton fuel per day at service speed	166.5

Table 4 Route specific data Shanghai-Hamburg via Suez.

Distance in nautical miles (nm)	10,857
Journey days at service speed	20
Fuel consumption in tons	3,275
Suez canal toll in $	135,145
Hull and machinery insurance $/day	750
P&I insurance, $/day	460

two separate independent transducers [7, 8];

- ships shall have two non-magnetic means to determine and display their heading. Both means shall be independent and shall be connected to the ship's main and emergency source of power [7, 8];
- ships proceeding to latitudes over 80 degrees shall be fitted with at least one GNSS compass or equivalent, which shall be connected to the ship's main and emergency source of power [7, 8];
- with the exception of those solely operating in areas with 24 hours day light, ships shall be equipped with two remotely rotatable, narrow-beam search lights controllable from the bridge to provide lighting over an arc of 360 degrees, or other means to visually detect ice [7, 8];
- ships involved in operations with an icebreaker escort shall be equipped with a manually initiated flashing red light visible from astern to indicate when the ship is stopped. This light shall have a range of visibility of at least two nautical miles, and the horizontal and vertical arcs of visibility shall conform to the stern light specifications required by the International Regulations for Preventing Collisions at Sea [7, 8];
- for ships intended to operate in extended periods of darkness, searchlights suitable for continuous use to facilitate identification of ice shall be provided for each lifeboat [7, 8];
- masters, chief mates and officers in charge of a navigational watch on board ships operating in polar waters shall have completed training to attain the abilities that are appropriate to the capacity to be filled and duties and responsibilities to be taken up, taking into account the provisions of the STCW Convention and the STCW Code, as amended [7, 8];
- equipped with such means for removing ice as the Administration may require; for example, electrical and pneumatic devices, and/or special tools such as axes or wooden clubs for removing ice from bulwarks, rails and erections [7, 8].

Ships sailing in the polar waters shall increase the costs for satisfying the requirements of SOLAS amendments, as given in Table 5.

Through the data collection from involved party of the costs, such as: the maritime safety administration, equipment suppliers, shipyard, etc., and maintenance for hull, machinery and equipment every 5 years, the additional cost is $32.6 a day on average in 20 year period of ship service.

5. Costs Analysis on Arctic NEP

There are three parameters that will change if the general cargo ship decides to go via the NEP:

(1) The distance (which will affect total bunker consumption);

(2) The speed (expected speed reduction during NEP);

(3) The insurance costs.

Table 5 Increased costs of ships sailing on Arctic NEP by SOLAS Amendment (unite: $).

Hull and machinery(maintenance, every 5 years)	200,000
Crew training	3,000
Navigational equipment	28,328
Communication equipment	3,500
Life-saving & Fire-fighting equipment and system	2,840
Total	237,668
Average (day, 20 year period)	32.6

For the moment the research will disregard icebreaker costs, as assuming that the NEP in the future may be navigated without icebreaker support. The research could include the additional cost of an ice-navigator, but this is a minor cost element in the big picture.

5.1 Ship Yokohama-Hamburg via NEP

The distance will depend on which route is taken through the NEP. Since the ship has a draught of 8 meters, the research will assume it will go the shortest route of 2,700 nm [9]. The total distance will then be 7,400 nm, or a reduction of almost 35%, as given in Table 6.

The research will assume that the average speed is reduced somewhat during the NEP to 12 knots on average. This will on the other hand reduce the fuel consumption on this leg. The research will further assume without any particular justification other than the assumption that although one could pass without icebreaker support, there might still be drift ice on this leg, so hull insurance will increase. The research just assumes it is tripled compared to the benchmark route. The results of these assumptions are summarized in Table 7.

It should be clear from Table 7 that the main savings from using the NEP are the reduction in fuel consumption in addition to cutting sailing time from 34 to 23 days. Fuel consumption is reduced by some 40%. How much this is worth in US$ will of course depend on the oil price.

Currently the price of low sulphur heavy fuel in Rotterdam is $169 per ton, while diesel oil is $328. With the much stricter regulations for sulphur contents in bunker oil coming into effect in 2020, it could be that in the future more ships will be using diesel fuel, which currently is 50% more expensive than heavy fuel. At the current price of $169, the savings in our example is $58,305 or more than 14 times the increased insurance costs in order of magnitude. In addition there come the savings of the Suez Canal toll of $51,168,

Table 6 Distances in nm Yokohama-Hamburg via the NEP.

Yokohama to the Bering Strait	2,700
Bering Strait to Novaja Zemlja	2,700
Novaja Zemlja to Hamburg	2,000
Total	7,400

Table 7 General cargo ship Yokohama-Hamburg via the NEP.

Distance NEP in nm	2,700
Distance outside NEP in nm	4,700
Speed in NEP in knots	12
Speed outside NEP in knots	14
Fuel consumption at 12 knots tons/day	15.5
Days in the NEP	9
Days outside NEP	14
Total days	23
Fuel consumption in the NEP in tons	135
Fuel outside NEP in tons	344
Total fuel consumption in tons	479
Fuel consumption reduction in tons	345
Increased insurance costs in $	4,160
Increased costs by SOLAS amendment ($)	750
Saved Suez canal toll ($)	51,168

so the total savings amount to about $109,473.

Now the bunker prices are low, but the general sentiment is that they are more likely to be higher than today than lower.

The reduction in bunker consumption will also reduce emissions of CO_2. More use of Arctic passages would, ceteris paribus, contribute to more sustainable transport.

A saving of around $109,473 for a ship of almost 13,000 dwt implies that the willingness to pay for icebreaker assistance is limited. A fee of $9 or more per ton will cancel out the cost saving effect. The icebreaker fee for carrying mechanical engineering products (which seems relevant for this ship type) was $86 in 2015. This is clearly unrealistic from a commercial point of view, as it would imply a cost almost twice that of the Suez Canal toll.

5.2 Shanghai-Hamburg via NEP

The research assumes the same sailing distance in the NEP of 2,700 nm. In addition there comes the increased distance Shanghai to the Bering strait compared to Yokohama—Bering Strait of 814 nm. The Arctic route is thus 8,214 nm, or a reduction of 24%.

There is no way a container ship can go through the NEP in 23 knots if there is any ice there at all, so the research assumes that the average speed through the NEP is 14 knots. This will substantially reduce the bunker consumption and the research has used the Admiralty formula (Fuel consumption = k * speed^3) to calculate the consumption.

The results are summarized in Table 8.

If the research again uses the March 2016 price of low sulphur heavy fuel oil of $169 per ton, the fuel cost savings are $220,376. The total cost savings for the container ship sums to $344,874, or $81 per container. The saving in sailing time is only 2 days, however.

It is assumed that a loaded container weighs 24 tons. If that were the case, our container ship would only be able to carry around 2,100 TEU or half its TEU capacity. If the research then, more realistically, assumes an average weight for a loaded container of 11 tons, our ship fully loaded would be willing to pay around $7 per ton for eventual icebreaker assistance. The NSR Administration stipulated a fee for container cargo to $43 per ton in 2015.

Table 8 Container ship Shanghai-Hamburg via the NEP.

Distance NEP in nm	2,700
Distance outside NEP in nm	5,514
Speed in NEP in knots	14
Speed outside NEP in knots	23
Fuel consumption at 14 knots tons/day	37.6
Days in the NEP	8
Days outside NEP	10
Total days	18
Fuel consumption in the NEP in tons	302
Fuel outside NEP in tons	1,669
Total fuel consumption in tons	1,971
Fuel consumption reduction in tons	1,304
Increased insurance costs in $	10,060
Increased costs by SOLAS amendment ($)	587
Saved Suez canal toll ($)	135,145

6. Conclusions

The two dominant cost savings factors in the research are the fuel savings and the saved Suez Canal toll.

6.1 Time Savings of General Ship Are Substantial by Using Arctic NEP

Time savings of general ship are substantial by using Arctic NEP. A reduction in sailing time from 34 to 22 days will free up capacity that has a value for the ship owner as the ship can faster be put into new contracts. This value would have been explicit if the research had chosen a total yearly service approach. The value is difficult to stipulate, however, as it will totally depend on the actual market situation at the time of the sailing. Time savings could also have a value for the cargo owners. Commodities in transport tie up capital, which is an implicit cost for the cargo owners. For high value cargo, this cost element could be significant.

6.2 Fuel Savings of Container Ship Are Massive by Using Arctic NEP

Fuel savings of container ship are massive by using Arctic NEP. The reduction in fuel consumption implies a reduction in emissions of greenhouse gases and other substances [10]. Using the Arctic routes rather than the Suez route contributes to more sustainable transport networks, ceteris paribus. Emissions will be proportional to the actual fuel consumption. In a future where environmental concerns are more prominent, this is also an advantage that could be used commercially [3, 11].

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