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Research on the Arctic Northeast Passage from the Perspective of Economy

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Abstract

Research Purpose. This paper analyzes the feasibility and economy of the Northeast Passage in the Arctic.

Research Method. This paper uses the comparative analysis and empirical case analysis.

Research Content. With global warming, the area of the Arctic Ocean has gradually decreased, the thickness of the ice layer keeps thinning. What's more, the area and thickness of ice floes in summer are greatly reduced. At the beginning of this century, due to rising fuel prices and increased demand for natural resources in East Asian countries, the Arctic Waterway has attracted worldwide attention and its commercial value has become increasingly prominent. The paper summarizes the current status of shipping in the Northeast Waterway of the Arctic from the commercial perspective, discusses the actual seaworthiness of the cargo ships along the route, and analyzes the operating costs and the development trend of multipurpose bulk carriers in the Northeast Waterway of the Arctic based on the current characteristics of China's cargo ships in the Northeast Waterway.

Conclusion. Compared with the Suez Canal route, the Northern Sea Route not only reduces the shipping distance and travel time between Europe and East Asia greatly. Running through the Arctic shipping routes can not only reduce transportation costs, but also reduce political risks in sensitive areas along the way, such as the Strait of Malacca and the waters off Somalia. If the Arctic shipping route is opened regularly, it will greatly change the global maritime shipping pattern.

Keywords: Northeast Waterway, Economical Efficiency, Capital Cost, Operating Cost.

Introduction

The Arctic shipping routes refer to the sea routes connecting East Asian countries to Europe and North America via the Arctic Ocean. Generally, they can be divided into three shipping routes, namely the Northeast Arctic Shipping Route, the Central Arctic Shipping Route and the Northwest Arctic Shipping Route. The Arctic Northwest Passage is a maritime shipping route connecting the Pacific Ocean and the Atlantic Ocean, starting from Finn Island in northern Canada in the east, passing through Davis Strait and Baffin Bay, and going west through the waters of northern Canada and northern Alaska in the United States. The Central Arctic Passage is a shipping route from the Bering Strait directly through the heart of the Arctic Ocean to Europe. The central area of the Central Passage is covered by thick ice all the year round, so it has no commercial navigation value in the short term, and is limited to scientific investigation at present. The Arctic Northeast Passage is a shipping route across the Pacific Ocean from northwest Europe in the northern tip of Norway, along the northern shores of Eurasia and Siberia, to the Bering Strait. This paper only studies the development and utilization of the Northeast Passage.

Since most of the Northeast Passage is located near the Russian coast, Russia calls it the Northern Sea Passage. At

present, the international community recognized the Northeast Passage is a maritime passage connecting the Atlantic and Pacific Ocean. However, there is no uniform definition on the starting point and end point of the Arctic Northeast Passage, but it is generally believed that the shipping route of the Arctic Northeast Passage starts from the Bering Strait and passes through the Chukchi Sea, East Siberian Sea, Laptev Sea, Kara Sea and Barents Sea to the northeastern part of Northern Europe. There are 11 main straits along the North-East Arctic Passage, connecting five sea areas, and five ports along the way for sea replenishment [1].

In the Soviet Union period, in order to develop the natural resources in the Arctic region, a large number of ports and infrastructure were built along the coast of the Arctic continent, and the Northeast Passage was fully developed and utilized. At this stage, domestic cargo transportation was the main purpose. In July 2009, two German cargo ships set off from South Korea, crossed the Bering Strait after replenishing in Vladivostok and headed west. On September 7, they arrived at the Siberian port of Yangborg, where they rested for 5 days. On September 12, they set off again and finally reached the Dutch port of Rotterdam [2]. This voyage is of great significance. It is a model of international commercial navigation in the

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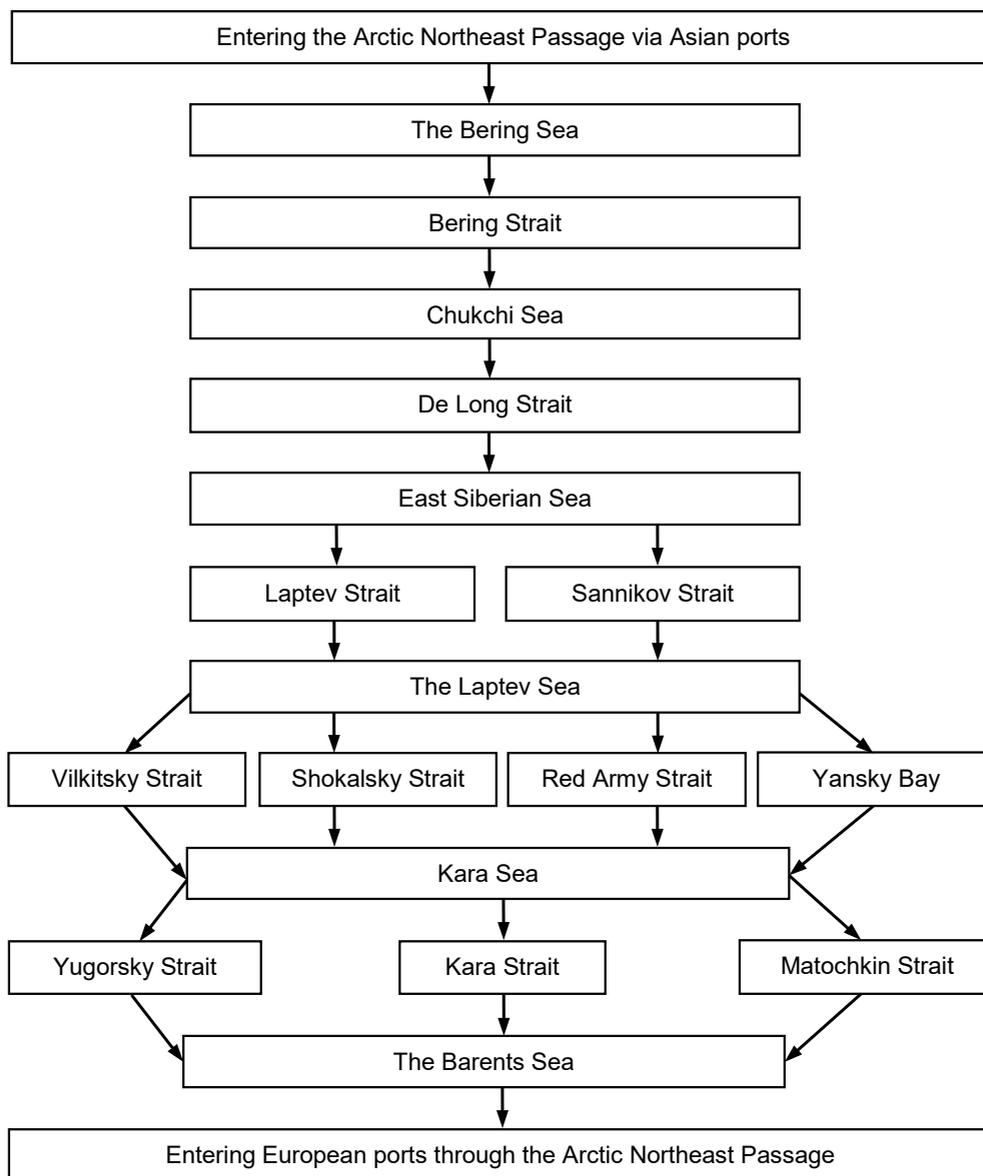


Figure 1. Schematic Diagram of the Arctic Northeast Passage
Рисунок 1. Схема Северного морского пути

Northeast Arctic Passage, which was completed independently without the Russian icebreaker to lead the voyage. Between 2010 and 2013, the number of international commercial vessels passing through the Northeast Arctic Passage increased, with 71 voyages taking place in 2013 [3]. After 2014, the number of international commercial ships passing through the Northeast Passage of the Arctic decreased, which is directly related to the sharp drop in international energy prices.

Navigation Environment of the Northeast Passage

Navigable environment refers to the environment that ships face when they sail at sea, including natural geographic environment and social environment. The natural geographical environment includes meteorology, hydrology, etc. The social environment includes the navigation regulations of the coastal countries through which ships pass and the issues of international treaties.

Most of the Northeast Passage is located north of 70 degrees north latitude. It is an extremely cold region, covered by ice for three seasons a year. Sea ice is one of the main factors

affecting the passage of the Arctic Northeast Passage, and it is also the main feature that distinguishes the traditional shipping route. Ships sailing in Arctic waters require special construction and, in some cases, auxiliary equipment to help them navigate because sea ice can do a lot of damage to ships. The main factors affecting visibility in the Arctic are fog and snowstorms. Due to the great temperature difference in the air over the sea (sea ice) in the Arctic in summer, it is easy to fog. The characteristics of fog in the Arctic are large in scope and long in duration. In winter, the North Pole Passage is covered with snow, and the snow above the ice is very soft and easy to be blown by strong winds, forming blizzards and reducing visibility.

Arctic navigation regulates the power and structure of sailing vessels. The International Association of Classification Societies classifies ships sailing in the ice area into seven classes, PC1–PC7. The higher the number, the stronger the anti-ice ability of the ship [4]. The classification of Russian ice class ships is slightly different from that of the International

Association of Classification Societies. Ice class ships are also divided into seven classes, namely CIE1–CIE3 and ARC4–ARC7. CIE1–CIE3 is PC1–PC3, and ARC4–ARC7 is PC4–PC7. According to the International Code for Ships in Polar Waters issued by the International Maritime Organization (IMO) in 2014, there are requirements on damage control, exhaust emissions, navigation regulations and construction structures of ice class ships.

Comparison of Arctic Northeast Passage Icebreaker Cost and Suez Canal Cost

Expenses for Icebreakers in the Northeast Arctic Passage

Russia divides the Arctic sea route into seven sections, and the navigational fees are determined according to the class of ice class ship and the number of times that the ice condition requires the navigational times of the icebreaker (table 1). For example, if a 40,000-ton ICE1 class freighter needs to be guided by an icebreaker once during its voyage in the ice area, the cost will be about \$230,000, \$280,000 for the second time, \$330,000 for the third time, \$380,000 for the fourth time, and \$470,000 at most. The ARC4 ice class ship needs about \$170,000 for one pilotage, \$200,000 for two pilotages, \$240,000 for three

pilotages, \$270,000 for four pilotages, and about \$340,000 for 6–7 pilotages (table 2).

Suez Canal Toll Rates

The basic tolls of Suez Canal are calculated on the basis of the net tonnage of the vessel on the canal¹, and are calculated on an excess progressive basis. The canal basic tolls vary for different types of vessels and vessels in different loading states (empty or loaded) [5]. Since the opening of the canal, the Egyptian Canal Authority has made several adjustments to canal passage rates, with new rates implemented for large

¹The Suez Canal is located in northwest Egypt, the west side of the Sinai Peninsula, the intersection of Asia and Africa, a north-south direction of the artificial canal. It is the shortest channel connecting the Atlantic Ocean, the Mediterranean Sea, the Indian Ocean, the Pacific Ocean, one of the world's busiest water routes. The Suez Canal has been in operation for 150 years since it opened in 1968.

The Suez Canal is about 191 kilometers long, 19.5 kilometers from the fairway buoy to the Port Said Lighthouse; 8.5 kilometers from the waiting area to the south entrance; 78.5 kilometers from Port Said to Ismailia; from Ismailia to Port Taufik: 83.5 kilometers. Water surface width (north/south): 345–280 meters; width between buoys (north/south): 215–195 meters; canal depth: 22.5 meters; maximum allowable ship draught: 19 meters; maximum tonnage: 210,000 tons; The speed limit of a fully loaded tanker: 13 km/h; the speed limit of a cargo tanker: 14 km/h. (*In Chin.*). URL: <https://baike.baidu.com/item/>

Table 1. Navigability of ice class ships (summer and autumn)

Таблица 1. Судоходство судов ледового класса (лето и осень)

Ice class ship model	Kara Sea			Laptev Sea			Siberian Sea			Chukchi Sea	Transit Time
	Southeast		Northeast	Southeast		Northeast	Southeast		Northeast		
	H	M L	H M L	H M L	H M L	H M L	H M L	H M L			
ICE1	Independent	– – +	– – +	– – +	– – +	– – +	– – +	– – +	– – +	July 1–November 15	
	Piloted	– – +	– – +	– – +	– – +	– – +	– – +	– – +	– – +		
ICE2	Independent	– – +	– – +	– – +	– – +	– – +	– – +	– – +	– – +		
	Piloted	– – +	– – +	– – +	– – +	– – +	– – +	– – +	– – +		
ICE3	Independent	– – +	– – +	– – +	– – +	– – +	– – +	– – +	– – +		
	Piloted	+ + +	+ + +	– – +	– – +	– – +	– – +	– – +	– – +		
Arc4	Independent	– + +	– + +	– – +	– – +	– – +	– – +	– – +	– + +		
	Piloted	+ + +	+ + +	– + +	– + +	– + +	– + +	– + +	– + +		
Arc5	Independent	+ + +	+ + +	– + +	– + +	– + +	– + +	– + +	– + +		
	Piloted	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +		
Arc6	Independent	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +		July 1–November 30
	Piloted	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +		
Arc7	Independent	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +		
	Piloted	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +		

Note: 1. H, M, and L respectively indicate high, medium, and low ice conditions; + means passable; – means impassable.

Source: THE NORTHERN SEA ROUTE ADMINISTRATION. URL: <http://www.nsr.ru/files/fileslistf>

Table 2. Expense standard for escort of Russian icebreakers (4000-ton freighter). Unit: USD

Таблица 2. Норма затрат на сопровождение российских ледоколов (грузовое судно 40 000 т). Единица: USD

Ice class ship model	1 st Leg	2 nd Leg	3 rd Leg	4 th Leg	5 th Leg	6 th Leg	7 th Leg
ICE1	235 292	282 351	329 409	376 468	423 526	470 585	470 585
ICE2	218 486	262 178	305 877	349 575	393 274	436 966	436 966
ARC4	168 068	201 680	2 413 634	268 905	302 517	336 129	336 129

Note: The currency unit of the original data of Russian escort fee is ruble, which is calculated by the author according to the central parity rate between ruble and US dollar published by the Central Bank of Russia on December 6, 2019.

Source: THE NORTHERN SEA ROUTE ADMINISTRATION. URL: <http://www.nsr.ru/files/fileslistf>

Table 3. Suez Canal rate of 4,000 tons of bulk carrier (SDR/Canal net ton)
Таблица 3. Расход Суэцкого канала на 40 000 т балкера (СПЗ/чистая тонна)

Ship type	Below 5000 tons		5000–10000 tons		10000–20000 tons		20000–40000 tons		40000–70000 tons		Above 70000 tons	
	Loaded	Empty	Loaded	Empty	Loaded	Empty	Loaded	Empty	Loaded	Empty	Loaded	Empty
Oil tanker	7.88	6.7	4.49	4.2	4.02	4.32	1.75	1.49	1.55	1.3	1.44	1.23
Bulk carrier	7.88	6.7	5.36	4.55	4.53	4.38	1.22	1.23	1.34	1.14	1.29	1.09
Container	7.88	6.7	5.15	4.38	4.12	3.5	2.88	2.45	2.68	2.28	2.11	1.78
Semi-submerged ship	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55

Source: Wang Mingliang: "Shipping Company Suez Canal Expenditure and Countermeasures for Savings", in "Containerization". Issue 5, 2012.

Table 4. Basic Suez Canal passage costs of 40,000 tons of bulk carrier
Таблица 4. Стоимость прохода через Суэцкий канал для балкера 40 000 т

Tonnage/Canal net ton	Charged tonnage/canal net tonnage	Rate, %	Cost, SDR	Cost, USD
Below 5000 tons	5000	7.88	39 400	54 057
5000–10000	5000	5.36	26 800	36 770
10001–20000	10 000	4.53	45 300	52 151
2001–40000	20 000	1.44	28 800	39 513
Total			140 300	192 492

Table 5. Comparison of the cost of ice class ships and ordinary ships
Таблица 5. Сравнение стоимости судов ледового класса и обычных судов

Ice class ship	ICE1	ICE3	Arc4	Arc5	Arc6	Arc7
Increased cost, %	5–10	9–15	10–20	20–37	70–200	100–200

Source: Luo Qiaoyun, etc.: "Research on the Economics of Container Transport Based on the Impact of Sea Ice on Arctic Routes", published in "Polar Research". Issue 4, 2019.

cruise ships in 2015 [6]. At present, most of the ships transported through the Northeast Passage in China are multifunctional bulk carriers. In order to facilitate the comparison with the passage cost of the Northeast Passage, the passage cost of the Suez Canal is calculated by taking 40,000 tons of bulk cargo as an example.

The Suez Canal Basic Charge uses SDR (Special Drawing Rights), which is charged according to the exchange rate against US dollars. Based on the rates in the table, the base charge for a 40,000t bulk carrier fully loaded is SDR, which is equivalent to US \$192,492 at the exchange rate on March 29, 2019. This is just the base charge.

In addition to the basic canal tolls, ships passing through the Suez Canal are charged lighthouse fees, port fees, sanitation and quarantine fees, pilotage fees and other miscellaneous fees. Most of these miscellaneous fees must be paid. Only a few items, such as garbage disposal and sea trial fees, can be said "no". These fees are charged in U.S. dollars, and the other costs of transporting 40,000 tons of bulk ships through the Suez Canal add up to about \$14,645. Including the basic navigable charges, the total cost for a 40,000 tonne bulk carrier through the Suez Canal is \$207,137.

According to the rules of the Suez Canal, ships must form a formation when they arrive at the Suez Canal rather than pass through upon arrival. If it doesn't pass during normal working

hours, additional charges will be required. If you are anxious to pass early, you need to apply to the canal authority, and after paying a certain amount of fees, you can jump the queue and pass early. The cost of queue jumping varies according to the time of queue jumping and the direction of navigation. From south to north, for example, from 1:00 to 3:00, the charge rate is 3%, with a maximum of 7000 SDR; 3:00 to 4:00 the charge rate of 5%, up to 10500 SDR; After 4:00, the charge rate is 10%, capped by 20,00 SDR. That is to say, ships passing through the Suez Canal may have to pay some formation fees.

Comparison of Navigation Costs between the Northeast Arctic Route and the Suez Canal Route

Shipping cost refers to the sum of the expenses that a shipping company provides for the transportation, supply and service of enterprises in need of transportation. It is the main basis for shipping companies to set freight rates. Although different shipping companies calculate voyage cost differently, generally speaking, voyage cost is divided into three parts, namely, capital cost, operating cost and voyage cost [7].

Comparison of Capital Cost

Capital cost is the cost for shipping company to buy or produce ships, which is the most basic cost of ship. The cost of capital is actually the cost of ownership of the ship itself. It depends on how the ship is financed, mainly including loan, interest, taxes and ship depreciation.

Table 6. Salary of ocean-going freighters in August 2019
Таблица 6. Зароботная плата морских судовладельцев в августе 2019 г.

Shipping Area, Position	Deep sea (USD/Month)			Near sea (USD/Month)		
	Bulk cargo	Container	Petrochemical cargo	Bulk cargo	Container	Petrochemical cargo
Captain	7400	7600	10 000	6400	6900	9000
First mate	6200	6500	8400	5400	5900	7800
Second mate	2600	3000	3600	2500	2700	3400
Third mate	1800	1900	2600	1600	1800	2500
Cadet officer	200	300	400	200	300	400
Chief engineer	7200	7300	9200	6400	6600	8300
First engineer	6200	6500	8500	5500	6100	7800
Second engineer	2600	3000	3500	2500	2700	3300
Electrical engineer	2700	2900	3600	2500	2700	3300
Third engineer	1800	1900	2600	1600	1700	2500
Trainee engineer	200	300	400	200	300	300
Bosun	1550	1600	1800	1450	1500	1750
Master mechanic	1550	1600	1800	1450	1500	1750
Sailor	1350	1350	1600	1250	1300	1500
Mechanic	1350	1350	1600	1250	1300	1500
Electrician	1700	1700	1900	1500	1600	2000
Chef	1400	1600	1700	1300	1500	1600
Steward	600	700	700	500	600	700

Source: http://crew.sol.com.cn/SSPI_V_cfkbi.html

For the same tonnage ship, the construction cost of ice class ship sailing in ice area is much higher than that of ordinary ship. The cost of ice-class ships varies with their anti-ice grades. The cost of ice-class anti-ice ships is about 10% higher than that of ordinary ships, and the cost of higher ice-class anti-ice ships is much higher than that of ordinary ships (table 6). According to COSCO's 2019 annual report, the cost of the ICE 40,000-ton ICE class bulk carrier is about 3,200 US dollars, 4 million US dollars more than that of the ordinary 40,000-ton bulk carrier, or about 15% higher [8]. The construction experience of the Arc7 polar deck transport ship shows that the cost of the Arc7 ship in the ice area is more than two times higher than that of the ship in the non-ice area.

In addition, in the service life, ice class ships are much less than ordinary ships. In general, ice class ships have a service life of 15 years, while the life of ordinary ships is 20 years, which makes the depreciation cost of ice class ships much higher than that of ordinary ships [9].

Comparison of Operating Costs

Operating costs are the recurrent maintenance expenses incurred by a ship in order to maintain its seaworthiness. This includes crew costs, insurance, regular maintenance, consumer goods and supplies, daily repair and maintenance, management, etc.

The standard configuration of a 40,000-ton cargo ship is 18 people. As shown in table 7, the crew salary of an ocean-going multi-purpose cargo ship, namely a bulk carrier, on a conventional route is about 48,400 US dollars per month. The crew salary of an ice class ship on the Arctic route is 10–20% higher than that of a conventional route.

Compared with land transport and air transport, sea transport is more risky. It is often confronted with the natural disasters of typhoon, hurricane and man-made risks such as piracy and unrest. Therefore, insurance is also essential for ocean transportation, and the insurance system can transfer these risks to the shipping company to apportion the overall transportation cost. Marine insurance is an important service for shipping companies. The traditional Marine insurance system is very mature and has rules to follow. However, the voyage of the Arctic Northeast Passage has been tested for not a long time and has not yet formed a large scale. For the insurance industry, the Arctic Northeast Passage is a strange shipping route, so there are no rules to follow for the insurance accounting, and the insurance business of this route is very cautious.

The damage risk of a ship sailing in ice area is much higher than that of a conventional route, and once it encounters an accident, the cost of repair and maintenance is very high. In addition, the Arctic Northeast Passage is located in the cold and the extreme cold climate will cause damage to the temperature requirements of the goods. Almost all the northeast shipping routes in the Arctic are off the coast of Russia, but the infrastructure of the Russian Arctic region is weak. Although there are many ports along the coast, few are suitable for large ships to dock, and even fewer can carry out rescue. Unfortunately, no official information has been collected about the premium rates for the Arctic Northeast Passage, but it can be confirmed that the premium rates for the Arctic Northeast Passage are much higher than those for traditional routes.

The insurance rate of conventional route is estimated by annual report generally, annual insurance rate is generally 0.5–0.7%, and its specific rate depends on the old and new degree

Table 7. Navigation of COSCO Shipping Carriers in Northeast Passage from 2013 to 2018

Таблица 7. Навигация судовых перевозчиков COSCO на Северном морском пути с 2013 по 2018 г.

Voyage	Year	Departure Ports	Arrival Ports	Vessel	Cargo
1	2013	Taicang	Rotterdam, the Netherlands	Yongsheng (Arc4)	Mechanical and electrical equipment, steel, etc.
2	2015	Jiangyin	Walberg, Sweden	Yongsheng (Arc4)	Mechanical and electrical equipment, steel, etc.
3	2105	Hamburg, Germany	Tianjin New Harbour	Yongsheng (Arc4)	Elected ore, steel pipe, etc.
4	2016	Tianjin	Glasgow, England	Yongsheng (Arc4)	Wind power equipment, etc.
5	2016	Tianjin New Harbour	Sabetta, Russia	Xiazhiyuan (non-ice class ship)	Yamal project module
6	2016	Kotka, Finland	Dalian	Tianxi (non-ice class ship)	Pulp
7	2016	Sabetta, Russia	Dalian	Xiangheokou (non-ice class ship)	Ballast voyage
8	2016	Tsingtao	Sabetta, Russia	Xiangheokou (non-ice class ship)	Yamal project module
9	2016	Sheerness, England	Dalian	Yongsheng (Arc4)	Ore concentrate
10	2017	Lianyungang	Espyo, Denmark	Lianhuasong (non-ice class ship)	Shield machine, wind power equipment
11	2017	Tianjing	Espyo, Denmark	Tian'am (Ice1)	Shield machine, wind power equipment
12	2017	Lianyungang	Espyo, Denmark	Tianjian (Ice1)	Shield machine, wind power equipment
13	2017	Nansha Port, Guangdong	Huixia Harbor, Norway	Tianle (Ice1)	Catamaran passenger ship, agricultural products
14	2018	Emden, Germany	Huangpu new port	Tianhui (Arc4)	Wind power equipment
15	2018	Dafeng Port, Yancheng	Walberg, Sweden	Tianyou (Arc4)	Wind power equipment, steel
16	2018	Kotka, Finland	Tsingdao	Tianjian (Ice1)	Pulp
17	2018	Lianyungang	Rouen France	Tian'en (Arc4)	Wind power equipment
18	2018	Kotka, Finland	Tsingdao	Tianqi (Ice1)	Pulp
19	2018	Tsingdao	Hull, England	Tianlu (Ice1)	The sea wind towers
20	2018	Lianyungang	Oskarshavn, Sweden	Tianhui (Arc4)	Wind power equipment
21	2018	Kotka, Finland	Nansha Port, Guangdong	Tianyou (Arc4)	Pulp, Catamaran Clipper

of the ship, the tonnage of the ship, the distance of the voyage, the cargo category that carries, navigation area conditions and so on. If a ship is in a war zone or a pirate infested area, the premium rate will be increased accordingly. According to the calculation results of the International Arctic Shipping Program, the insurance rate of the Northeast Arctic Passage is twice that of the traditional shipping route. In addition, the regular maintenance costs of ice-class ships sailing in ice areas are also higher than those of ships sailing in traditional routes, and the annual regular maintenance costs are about 1.1% of the ship's cost [10].

By the above ratio, the 40,000-ton ICE1 class ship cost is about 32 million yuan, and its annual maintenance and maintenance costs are about 352,000 US dollars.

Voyage Cost

The cost of the voyage mainly includes fuel fee, water fee, canal fee (ice-breaking pilot fee), port fee and cargo handling fee. A 40,000-ton multipurpose freighter consumes 23 tons of fuel per day. An ice-class ship of the same tonnage consumes 10 percent more fuel than a ship on a conventional route, about 25 tons per day [11]. Fuel consumption is about 10% of the cost of fuel. The cost of shipping 40,000 tons of cargo through the Suez Canal is about \$200,000. The pilot fee of the Northeast

Passage icebreaker shall be determined according to the number of pilotage required each time, and the specific fee shall be negotiated with the icebreaker service company.

In China, only COSCO Shipping Special Shipping Company is engaged in Arctic sea route transportation. In the six years from the test voyage of Yongsheng in 2013 to 2018, 21 cargo ships have been transported through the Arctic sea route, including one in 2013, two in 2015, six in 2016, four in 2017 and eight in 2018. Of these 21 voyages, 13 went from China to Europe and 8 went from Europe to China. The economic analysis of the Northeast Passage in this paper mainly takes the 36,000-ton ice class ship of COSCO Marine Special Shipping Company as an example to compare and calculate the transportation cost of a single voyage.

There is not much difference in management fees between the conventional route and the northeast Arctic route. The difference is mainly in fuel, crew costs, insurance, canal tolls or icebreaker piloting fees.

Case 1: On July 20, 2019, "Tian'en" set sail from Taicang Port to Europe and arrived at the first unloading port, Jevle, Sweden, on August 17. It travelled about 8,500 nautical miles and took 27 days, saving about 3,000 nautical miles and about 9 days compared with the Suez Canal [12]. According to the

Table 8. Cost comparison between the Northeastern Arctic Route and the Suez Canal Route (case 1)
Таблица 8. Сравнение стоимости маршрута Северного морского пути и Суэцкого канала (пример 1)

Cost breakdown	The Suez Canal route	The Arctic route
Distance from Taicang Port to Yevre, nautical miles	10 500	8500
Voyage Time, days	36	27
Fuel oil, day/ton	23	25
Total fuel consumption, ton	828	675
Fuel price, US \$/ton	350	350
Total cost of fuel, US \$	289 800	236 250
Lubrication fees	28 980	23 625
The crew cost	57 960	49 950
Canal tolls, ice-breaking pilot fees	200 000	280 000
Insurance premium, maintenance fee, USD/day	1100	1300
blanket insurance	39 600	35 600
Armed escort fee	32 350	0
Total cost	648 690	625 425
Cost comparison	23 265	

Table 9. Cost comparison between the Northeastern Arctic Route and the Suez Canal Route (case 2)
Таблица 9. Сравнение стоимости маршрута Северного морского пути и Суэцкого канала (пример 2)

Cost breakdown	The Suez Canal route	The Arctic route
Distance from Lianyungang to Esbyo, nautical miles	11 060	7670
Voyage Time, days	35	31
Fuel oil, day/ton	23	25
Total fuel consumption, ton	805	775
Fuel price, US \$/ton	350	350
Total cost of fuel, US \$	281 750	271 250
Lubrication fees	28 175	27 125
The crew cost	56 350	57 350
Canal tolls, ice-breaking pilot fees	200 000	280 000
Insurance premium, maintenance fee, USD/day	1100	1300
Blanket insurance	38 500	40 300
Armed escort fee	32 350	0
Total cost	638 115	676 025
Cost comparison		37 910

preliminary calculation of COSCO Special Shipping Company, in August 2017, the voyage of “Tianjian” ship from Lianyungang to Esbyo via the Arctic Northeast Route was about 7,000 nautical miles, saving about 4,000 nautical miles, 15 days and 383 tons of fuel oil compared with the 11,000 nautical miles through the Suez Canal. According to this calculation, the average daily consumption of fuel 25 tons. Tianjian is an Ice1 class ship, and its fuel consumption is slightly lower than that of Tienen, which consumes at least 225 tons of fuel in nine days. The international crude oil price in September 2019 is about \$60/BBL, and 350 tons of fuel oil is about \$80,000. That is to say, compared with the Suez Canal, Northeast Passage fuel cost from Taicang to the port of Yevre is \$80,000 less, but the pilotage dues of Arctic route is \$80,000 more than the Suez Canal tolls. In addition, to fend off Somali pirates, shipping companies need to hire armed escorts, which cost about \$32,350 per shipment [13]. In theory, the Northeastern route via the Arctic takes nine days less than the Suez Canal route, saving

\$23,265 (table 7).

Case 2: “Lianhuasong” set off from Lianyungang on August 1, 2017 and arrived at the first unloading port, Dan Espyo, via the Arctic Northeast Passage on August 31. The journey covered 7,670 nautical miles and took 31 days². According to relevant information, the distance from Lianyungang through the Suez Canal, the Strait of Gibraltar to the port of Espyo is about 11060 nautical miles on the multi-purpose ship voyage at sea 35 days, including the time to line up through the Suez Canal. Table 8 shows that the Arctic route takes four days less than the Suez route, but costs about \$38,000 more.

It can be seen from the above two cases that compared with the Suez Canal route, the northeast Arctic route has reduced the journey by 20–40% and the time by 5–10 days. However,

² COSCO SHIPPING “Lianhuasong” successfully arrived in St. Petersburg (In Chin.). URL: https://www.sohu.com/a/191958140_433360

in terms of cost accounting, the northeast Arctic route does not have a great advantage. Shorter voyages and times can save a lot of money on fuel, but in the Arctic, where the climate is so variable, the cost of navigating icebreakers is the biggest unknown variable.

From the point of view of a single voyage, the economic difference between the northeast route and the Suez Canal route is not obvious. From the shipbuilding cost and depreciation of ships, a 40,000 ice-class bulk ship weighs about 15,000 tons sold as scrap steel. At present, the price of scrap steel is about 350 dollars per ton, and it can be sold for about 5.25 million dollars. The cost is \$32 million minus the selling price of scrap steel, which is \$5.25 million, leaving \$2675. The cargo ship worth \$3200 has lost \$27.65 million in 15 years from its completion to its scrap. The annual depreciation expense is about \$1.85 million, the monthly depreciation expense is about \$150,000, and the daily depreciation is about \$5,000.

Conclusion

Since 2009, more than 300 international shipping ships have sailed through the Arctic Northeast Passage, accumulating a large amount of experience and shipping information, which has been recognized by shipping companies. At present, the shipping cost of the Northeast Arctic Passage is no lower than that of the Suez Canal route, and the risk is higher than that of the traditional route. This is also one of the reasons for the decline of shipping routes to and from the Arctic in recent years.

The drop in prices of fuel, freight markets and natural resource since 2014 is likely to be an important reason for the decline in transit trips on the Northern Sea Route. Usually, fuel costs account for the largest portion of transportation costs, so lower fuel prices directly lead to lower transportation costs on the Suez Canal route and the Northern Sea Route, reducing the advantages of Northern Sea Route transportation.

Most of the goods trade between East Asian countries and European countries is carried in the form of containers. As mentioned above, the water depth in some areas of the Arctic Sea Passage restricts the passage of large container vessels, and the Arctic Sea Passage is suitable for container vessels under 4000TEU. At present, the upsized container ships prevails in the international shipping market. Large container ships such as 8000 TEU, 10000 TEU and 14000 TEU cannot pass through the Arctic sea route [14].

Other factors restricting the use of the Northeast Passage in the Arctic include detailed information about the weather, charts, ice conditions and hydrology of the Arctic region. In some sections, the ice conditions can change significantly within a day or two, making it difficult to predict accurately in advance. So far, the Arctic remains a strange and unexplored world. At this stage, it will only be available for four months. In theory, high-class ice-class ships can travel year-round, but the costs and dangers of passage are so great that shipping lines rarely operate between December and May.

With global warming, the area of the Arctic Ocean is shrinking, and the ice thickness is thinning, and the area and degree of floating ice in summer are decreasing significantly. At the beginning of this century, due to the rise of fuel prices and the increasing demand of East Asian countries for natural resources, the Arctic shipping route attracted the attention of the world, and the commercial value of the Arctic shipping route became increasingly prominent. In theory, compared with the Suez Canal route, the Northern Sea Route would not only shorten the distance and travel time between Europe and East Asia with the reduced transportation costs, but also lower political risks in sensitive areas along the way, such as the Strait of Malacca and the waters off Somalia [15]. If the Arctic shipping route is opened regularly, it will greatly change the global maritime shipping pattern.

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Исследование Северного морского пути с экономической точки зрения

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Аннотация

Цель исследования. Глобальное потепление вызывает быстрое таяние и утонение арктических льдов, уменьшение площади Северного Ледовитого океана. В начале 2000-х гг. Северный морской путь привлекал внимание всего мира в связи с ростом цен на топливо и увеличением спроса на природные ресурсы в странах Восточной Азии. Коммерческая ценность Северного морского пути усиливается.

Методы исследования. В данной статье проанализированы возможности и экономичность Северного морского пути. Используются методы сравнительного анализа и методы анализа реальных случаев. Суммируется статус-кво судоходства Северного морского пути с деловой точки зрения, обсуждается фактическая мореходность, аннулируются эксплуатационные расходы и тенденции развития Северного морского пути.

Выводы. По сравнению с маршрутом Суэцкого канала Северный морской путь не только значительно сокращает расстояние водных перевозок между Европой и Восточной Азией, но и время плавания тоже значительно сокращается. При этом не только снижается себестоимость перевозок, но и исключается политический риск, например такой, как при проходе через Малаккский пролив, акваторию Сомали и другие опасные зоны. Если Северный морской путь будет постоянно открыт, это кардинально изменит структуру мировых морских перевозок.

Ключевые слова: Северный морской путь, экономическая эффективность, капитальные затраты, эксплуатационные расходы.

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