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ESG Sustainable Evaluation of the Silk Road on Ice Based on Entropy Weight TOPSIS Method

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Abstract: As an international economic and trade cooperation project, "Ice Silk Road" is of excellent research significance to the sustainable development construction strategy proposed by China. Based on the ESG sustainable evaluation framework, this paper constructs a sustainable evaluation index system for the "Ice Silk Road" project from three dimensions: society, environment and governance. Then, the entropy weight method and TOPSIS model were used to sort and evaluate the sustainable development performance of relevant countries along the "Ice Silk Road" project from 2013 to 2019, and suggestions were put forward for the research on ESG sustainable development construction of the "Ice Silk Road" project. The results showed that the environmental dimension accounted for a large part of the sustainable development performance from 2013 to 2019, and there were differences in the level of sustainable development infrastructure construction among countries along the "Ice Silk Road" project. Finland, Denmark, Sweden, Japan and the United Kingdom ranked top in comprehensive strength. Denmark, Norway and South Korea have the highest level of sustainable development, while China has the lowest overall score, but China has a large room for improvement in the future from the social and environmental dimensions of development; China needs to strengthen exchanges and cooperation to promote the sustainable development of the "Ice Silk Road" project.

Keywords: Entropy weight method (EWM); Approximate ideal solution sorting method (TOPSIS); ESG; "Ice Silk Road"; Sustainable development.

1. Introduction

The "Ice Silk Road" initiative was proposed during the leaders' meeting of China and Russia in 2017. It refers to the maritime route through the Arctic Circle, connecting the three economic centers of North America, East Asia and Western Europe. It is also the Arctic extension of the "Belt and Road" Initiative and a blue economic channel connecting Europe and North America via the Sea of Japan and the Arctic Ocean[1]. The sustainable development of all areas and regions along the "Ice Silk Road" initiative and the participating countries is an important issue.

In recent years, sustainable development, as a globally recognized value concept, has been widely used in various fields and development plans and developed and evolved based on theoretical support. In 2015, the United Nations held the Sustainable Development Summit and issued the 2030 Agenda for Sustainable Development, which put forward 17 Sustainable Development Goals (SDGs) for all countries to guide sustainable development. Based on the concept[2].

For sustainable development of the United Nations, ESG adds governance, environment and society as essential dimensions of sustainable evaluation. Based on corporate financial reports, ESG can be used to evaluate countries and other economic entities, and it can be used to study the existing results of national sustainable development. The ESG sustainable development assessment system can propose practical suggestions for national policy reform.

It is of great significance to build an ESG evaluation system to evaluate the performance of countries along the "Ice Silk Road." Firstly, 14 index data of participating countries are collected from central databases. Secondly, an ESG index evaluation system is established to calculate the evaluation weights of indicators in three dimensions: society, environment, and governance, using the entropy weight method. Based on the results obtained, TOPSIS is used to calculate the closeness degree to put forward opinions on the sustainable development goals and paths of the "Ice Silk Road" from the perspectives of each country's contribution to social value, environmental value and governance value.

2. Dimensions of ESG performance evaluation of countries along the "Ice Silk Road"

This paper constructs the "Ice Silk Road" ESG performance evaluation system from three dimensions: governance, society and environment.

2.1. Construction of ESG index system of "Ice Silk Road"

The ESG sustainability evaluation system of the "Ice Silk Road" involves three dimensions: society, environment and governance. Countries differ in terms of development level, national strength and economic demand. Therefore, indexes are selected by comprehensiveness, comparability and objectivity. The sustainable development capacity evaluation system with 17 indicators in three dimensions of governance, society and environment should be constructed according to each country's commonness of sustainable development. The governance dimension is necessary to evaluate a country's sustainable development. The governance capacity of each country's government and the favorable domestic investment environment are essential foundations for the cooperation among countries along the "Ice Silk Road." The specific indicators are shown in Table 1. The environmental dimension is a necessary dimension to evaluate sustainable development. To measure the ecologically sustainable development of the Arctic region and other countries through constructing the "Silk Road on Ice," the relevant index data of the environmental dimension should be selected. The specific indicators are shown in Table 1.

The social dimension is a necessary dimension to evaluate sustainable development. The joint construction of the "Ice Silk Road" needs the support of social resources in the Arctic region, and the purpose of joint construction includes promoting harmonious and sustainable development of population and society in the Arctic region. The specific indicators are shown in Table 1.

2.2. Sample selection and indicator meanings

The connotation of "Silk Road on Ice" includes strengthening the economic and trade links between Europe and Asia to promote sustainable development in the Arctic region. This paper selects potential cooperation countries, including Russia, Norway, Finland, Denmark, Sweden, Iceland, Britain, Germany, France, Italy, Spain, the Netherlands, Japan and South Korea, as research objects. On the one hand, these countries are geographically Arctic and near-Arctic, with the advantage of participating in economic exchanges along the Arctic shipping routes. On the other hand, as observers of the Arctic Council, these countries have issued Arctic strategies and participated in the environmental and social sustainable development projects of the working group under the framework of the Arctic Council. They intend to bring their experience in political governance into play within the framework of Arctic governance and geopolitics. Aiming at the determined environmental assessment index system for sustainable development of the "Silk Road on Ice," this paper collected data from 15 selected major projects covering each secondary index of countries along the route from 2013 to 2019. The detailed data are shown in Table 1.

Table 1. Sources of indicator data

Dimensions	Indicator name	Indicator meaning	Indicator Sources
Governance	Voice and accountability	The degree to which a country's citizens participate in the election of their government, and freedom of association, expression, and press	Lu Chunlong et al[3]
	Political stability and nonviolence	Political stability in a country, including a low risk of terrorism	Lu Chunlong et al[3]
	Government effectiveness	The ability of a government to formulate and implement policies and provide public services	Lu Chunlong et al[3]
	Regulatory quality	The quality of competence and implementation of a country's regulatory system and regulators	Lu Chunlong et al[3]
	Legal regulation	The soundness, transparency, efficiency and reliability of a country's legal environment and legal system	Lu Chunlong et al[3]
	Corruption control	A country's anti-corruption laws and regulations, and the level of corruption control by anti-corruption agencies	Lu Chunlong et al[3]
Environment	Climate change mitigation inventions in maritime transport	Technological innovation and policy support of a country in reducing greenhouse gas emissions and environmental pollution in the field of maritime transport	Zhang Liwei et al [4]
	Area of Marine protected areas by country	The area of Marine protected areas established by a country as a result of Marine environmental protection measures and policies	Zheng Miaozhuang et al[5]
	Amount of patent technology	The number of patents applied by a country in the field of Marine pollution abatement technology	Zhang Liwei et al[4]
	development for Marine pollution reduction CO2 emissions from international Marine fuel oil	The total amount of CO2 emitted by a country from the use of fuel oil in international shipping	Liang Yanru et al [6]
	AMAP and evaluating the number of planned projects	The number of projects undertaken by a country within the Arctic Council's Arctic Monitoring and Assessment Program to detect and assess environmental change and pollution in the Arctic	Luo Xi et al[7]
	Number of environmentally motivated Marine subsidies	The number of subsidies provided by a country in the Marine field for environmental protection, such as Marine resource conservation, Marine pollution prevention and control	Xu Ruiheng et al [8]
Society	Number of courses or programs offered within the Arctic University Consortium	The number of programs and results established by a country within the Arctic University Alliance to promote Arctic personnel training and scientific research achievements	Liu Sisi et al [9]
	Human Development Index	The United Nations Development Programme's comprehensive indicator of a country's level of development in health, education, economy, etc	Li Xiaoxi et al [10]

3. Construct the "Ice Silk Road" ESG performance evaluation model

3.1. Construction ideas of ESG performance evaluation model

As an objective weighting method, the entropy weight method calculates the entropy weight of an evaluation index based on the information utility of the index represented by the variability of the information entropy of the evaluation index. The greater the information entropy, the greater the variability, the greater the information utility and entropy weight, and the greater the importance in the overall evaluation. This paper chooses this method to analyze the proportion and importance of the three dimensions of society, environment and governance in the sustainable development of ESG on the "Ice Silk Road." The entropy-topics method calculates the distance between the evaluation object and the positive and negative ideal solution based on the operation results of the entropy-weight method. It obtains the closeness degree to judge the merits of the evaluation object. This paper uses this method to evaluate and rank the ESG sustainable development performance of the countries along the "Ice Silk Road" to analyze further the sustainable development of the "Ice Silk Road."

3.2. TOPSIS-entropy weight method ESG performance evaluation model

(1) Partial missing data processing

In the process of data collection, it is found that some countries are missing some year data. This paper uses the grey prediction GM (1,1) model to complete the missing data. The GM (1,1) Y = BU model can be represented to obtain the predicted value of the corresponding year.

(2) Standardized treatment

Each index has different impacts on the ESG of the "Ice Silk Road," so the index is divided into positive and negative indexes. The larger the positive index is, the higher the performance of this index is, while the more significant the negative index is, the worse the performance of this index is. Therefore, this paper chooses to reverse and positive to standardize the data, positive index and negative index. Thus, the objective influence of numerical value, unit, and positive and negative direction is eliminated, as well as the influence of maximum and minimum value of data on the results.

Let the number of countries along the "Ice Silk Road" be *n*, the evaluation index be *m*, and B_{ij} be the standardized value of the jth index for the i-th country (i=1,2,..n,j=1,2,...m); A is its original value; 11. 11 respectively represent the maximum and minimum values of indicator J within the evaluation area, and the standardized processing formulas for positive, negative, and interval are (1) and (2):

$$B_{ij} = \frac{a_{ij} - a_{j\min}}{a_{j\max} - a_{j\min}} \tag{1}$$

$$B_{ij} = \frac{a_{j\max} - a_{ij}}{a_{j\max} - a_{j\min}} \tag{2}$$

(3) Index weight and entropy calculation

Firstly, based on the calculation of the proportion of indicator *j* in the i-th country, calculate the entropy value of the *j*-th evaluation indicator:

Specific gravity:

$$D_{ij} = \frac{B_{ij}}{\sum_{i=1}^{m} B_{ij}} \tag{3}$$

Entropy value:

$$U_j = \frac{1}{\ln m} \sum_{i=1}^{m} D_{ij} \ln D_{ij} \tag{4}$$

Secondly, the entropy weight *j* of H_j is calculated based on calculating the coefficient of variation G_j of the evaluation index. The greater the coefficient of variation, the greater the entropy value and the greater the entropy weight, indicating that the more significant the proportion of this index to the ESG sustainable development performance evaluation of the "Silk Road on Ice."

Coefficient of variation:

$$G_j = 1 - U_j \tag{5}$$

Weight:

$$H_j = \frac{G_j}{\sum_{j}^{n} G_j} \tag{6}$$

(4) Weighted decision matrix

Let Z_{ij} be the weighted value of the standardized value of the *j* index in *i* country, then the weighted decision matrix is as follows:

$$Z = (Z_{ij})_{m\times n} \tag{7}$$

(5) Positive and negative ideal solutions

Calculate the gap between each evaluation index and the optimal vector represented by the positive i d_i^+ ideal solution d_i^+ and the gap between the

vector represented by the negative ideal solution d_i^+ Z_i^+ Z_i^- as the calculated positive ideal solution and Z_i^+ Z_i^- negative ideal solution respectively. The positive ideal solution, Z_i^+ is the optimal index data for countries along the route to participate in the "Ice Silk Road" to achieve the "Ice Silk Road" construction and sustainable development. In contrast, the negative ideal solution, Z_i^- is the worst index data for countries along the route to participate in the "Ice Silk Road" to achieve the "Ice Silk Road" construction and their sustainable development. Z_i^+ Z_i^- The smaller the d_i^+ d_i^-, the better the country's sustainable governance capacity and the greater the possibility of sustainable participation in the "Ice Silk Road"; the smaller the negative ideal solution d_i^-, the I worse the country's sustainable capacity and the less possibility of sustainable participation in the "Ice Silk Road."

$$d_i^+ = \sqrt{\sum_{j=1}^{n} H_j (Z_{ij} - Z_i^+)^2} \quad (8)$$

$$d_i^- = \sqrt{\sum_{j=1}^{n} H_j (Z_{ij} - Z_i^-)^2} \quad (9)$$

(5) Proximity degree

Calculate the proximity degree of the first country, where the more significant the proximity degree d_i, the smaller the distance between the evaluation object and the positive ideal solution, and the better the quality.

$$D_i = \frac{d_i^-}{d_i^- + d_i^+} \quad (10)$$

4. Results and Empirical Research

4.1. Weight of evaluation index of "Ice Silk Road"

By applying the data to Formula 1-6 and calculating above, we can get the weight of the impact of evaluation indicators on the ESG performance of "Ice Silk Road" from 2013 to 2019.

Table 2. 2013-2019 "Polar Silk Road ESG Indicator Weighting."

Dimensi ons	Indicators	2013 Weight coefficien t w	2014Weight coeffici ent w	2015Weight coeffici ent w	2016Weight coeffici ent w	2017Weight coeffici ent w	2018Weight coeffici ent w	2019 Weight coeffici ent w
Environ ment	Inventions to mitigate climate change in maritime transport	12.90%	16.68%	15.97%	14.48%	15.83%	7.05%	12.51%
	Number of patented technologies developed for Marine pollution reduction	14.80%	16.70%	17.47%	16.37%	17.92%	11.24%	12.51%
	Area of Marine protected areas by country	10.92%	9.62%	10.33%	10.17%	14.63%	11.56%	14.31%
	Co_2 emissions from international Marine bunkers	1.44%	1.63%	2.16%	2.93%	4.73%	3.68%	3.85%
	Number of AMAP projects	26.90%	24.78%	22.16%	23.04%	0.00%	27.58%	12.87%
Society	Number of environmentally motivated	8.79%	8.10%	8.72%	8.92%	12.82%	10.51%	12.63%
	Number of Arctic courses and programs by National Arctic University	12.82%	12.21%	12.59%	13.07%	18.56%	15.15%	17.82%
	Consortium Human Development Index	1.14%	1.05%	1.15%	1.18%	1.69%	1.39%	1.71%
Governa nce	Voice and accountability	1.37%	1.26%	1.37%	1.47%	2.13%	1.76%	2.02%
	Political stability and absence of violence/terroris m	1.92%	1.46%	1.50%	1.64%	2.37%	2.40%	2.48%
	Government effectiveness	1.58%	1.43%	1.39%	1.43%	2.24%	1.93%	2.41%
	Regulatory quality	2.02%	1.84%	1.71%	1.85%	2.32%	1.91%	2.41%
	Legal regulations	1.69%	1.56%	1.68%	1.56%	2.17%	1.76%	2.23%
	Corruption control	1.71%	1.68%	1.78%	1.89%	2.60%	2.09%	2.51%

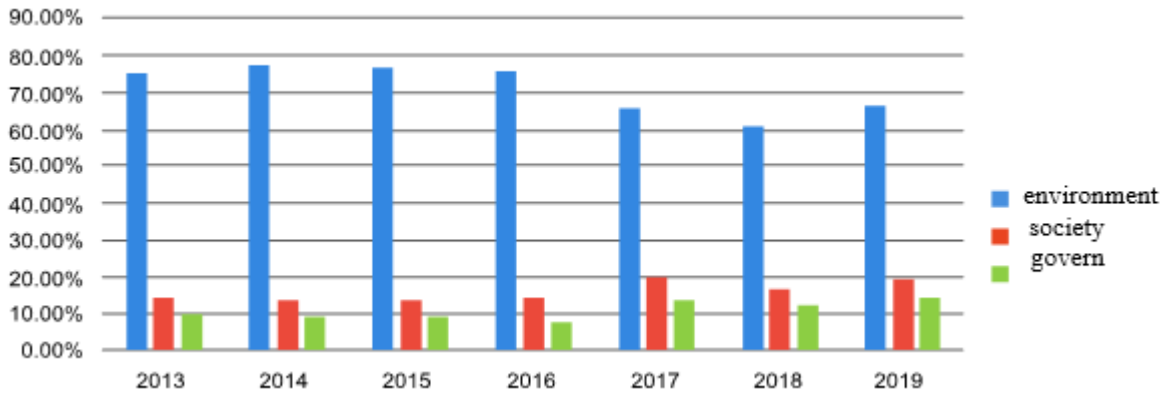

Figure 1. Weights of ESG indicators on the Ice Silk Road, 2013-2019

As can be seen from Table 2 and Figure 1, the environmental dimension accounted for a large proportion in ESG performance of the Ice Silk Road from 2013 to 2019, maintaining at about 70%. Further analysis shows that the proportion of the social dimension and governance dimension increased from 2017 to 2019. They reflected the increasing importance of social and governance performance in evaluating sustainable development. In addition, in the environmental dimension, the number of inventions to mitigate climate change, the number of patented technologies to reduce Marine pollution and the number of AMAP projects accounted for a relatively large proportion, maintaining at

about 10%, 15% and 20%, respectively. In the social dimension, the weight of the number of Arctic courses and projects of the Arctic University Alliance of North countries was always high, maintaining about 15% respectively.

4.2. Proximity and ranking of countries along the "Ice Silk Road"

Drawing results based on entropy weight by bringing the new data into formulas 7-10, the closeness degree of ESG sustainable development performance of countries along the "Ice Silk Road" from 2013 to 2019 can be obtained, as shown in Table 3. Countries' ESG sustainable development performance can be ranked according to the degree of closeness.

Table 3. Relative proximity and ranking of countries along the Ice Silk Road from 2013 to 2019

2013-2019 Calculation results of TOPSIS evaluation

Country	2013 Relative close C	2013Sort results	2014relative close C	2014Sort results	2015relative close C	2015Sort results	2016relative close C	2016Sort results	2017relative close C	2017Sort results	2018relative close C	2018Sort results	2019relative close C	2019Sort results
Norway	0.276	3	0.514	1	0.491	1	0.291	3	0.403	2	0.326	2	0.49	1
Finland	0.523	1	0.117	10	0.132	10	0.144	11	0.209	10	0.17	10	0.304	7
Denmark	0.173	7	0.159	6	0.458	3	0.481	1	0.271	6	0.576	1	0.399	3
Russia	0.145	10	0.123	9	0.147	9	0.155	10	0.217	9	0.193	8	0.287	8
Sweden	0.212	6	0.196	5	0.215	6	0.224	6	0.309	5	0.253	7	0.381	5
Iceland	0.094	14	0.088	14	0.101	13	0.113	13	0.164	12	0.134	13	0.193	13
Japan	0.249	4	0.223	3	0.251	4	0.253	4	0.354	4	0.268	5	0.366	6
Korea	0.383	2	0.445	2	0.46	2	0.433	2	0.491	1	0.291	4	0.382	4
Germany	0.102	11	0.093	12	0.101	14	0.185	7	0.164	13	0.151	11	0.196	12
Britain	0.229	5	0.219	4	0.244	5	0.252	5	0.376	3	0.297	3	0.435	2
Italy	0.098	13	0.091	13	0.101	12	0.11	14	0.16	14	0.124	14	0.161	14
Spain	0.102	12	0.099	11	0.11	11	0.114	12	0.167	11	0.146	12	0.204	11
Netherlands	0.161	8	0.149	7	0.161	7	0.166	8	0.233	8	0.188	9	0.254	10
China	0.021	15	0.028	15	0.033	15	0.03	15	0.055	15	0.04	15	0.051	15
France	0.149	9	0.135	8	0.152	8	0.156	9	0.246	7	0.265	6	0.285	9

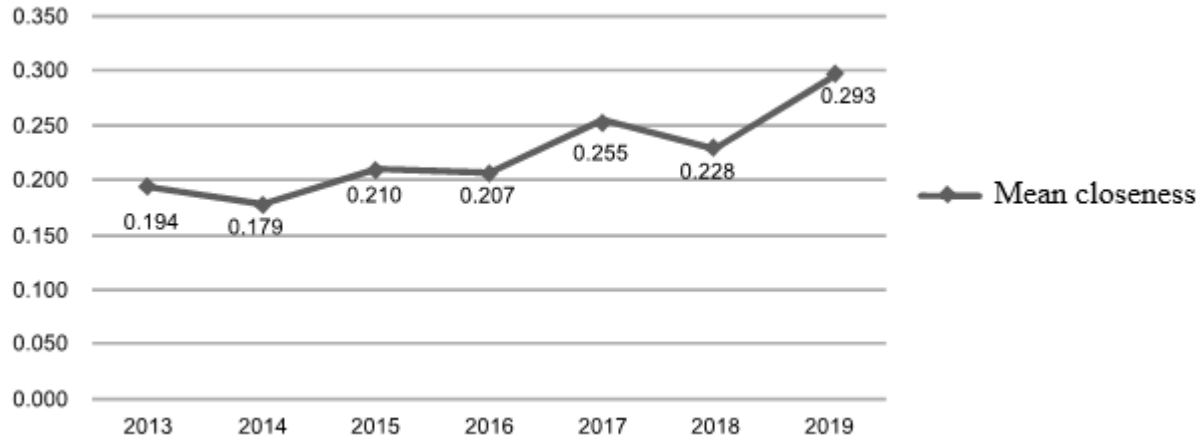

Figure 2. Average proximity of countries along the Ice Silk Road from 2013 to 2019

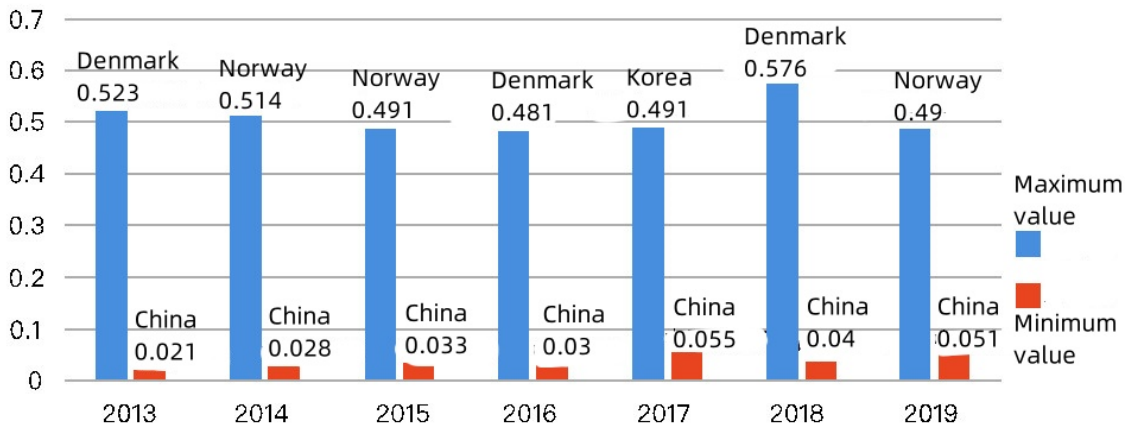

Figure 3. Extreme values of countries along the "Ice Silk Road" from 2013 to 2019

As can be seen from Figure 3, there is a large difference between the maximum and minimum values of proximity from 2013 to 2019. In addition to 2017, the closeness of South Korea is the largest, the closeness of Arctic countries Denmark and Norway is the largest in other years, and China maintains the minimum value continuously. However, China's proximity shows an overall increasing trend. This indicates that the performance level of participating countries in the sustainable development construction of the "Ice Silk Road" is uneven. However, there is a trend of improvement in

some countries. In addition, it can be seen from Table 3 and Figure 2 that the overall closeness value from 2013 to 2019 is low, with the average value remaining around 0.2 but increasing year by year. It can be seen that the level of participation in the sustainable construction of the "Ice Silk Road" is low, and there is a large room for improvement, among which Norway and South Korea remain in the top five. It indicates that the two countries have a high level of ESG sustainable development performance and greater potential to participate in the sustainable development of the "Ice Silk Road." Finland, Denmark, Sweden, Japan and the United Kingdom have all ranked in the top five, indicating that these countries have a good level of sustainable development and are more likely to participate in and promote the sustainable development of the "Ice Silk Road."

5. Suggestions

Based on the above results, the following suggestions are put forward to promote the "Ice Silk Road" 's sustainable development further. (1) Based on the "Ice Silk Road," we will promote the integration of the ESG concept and the sustainable development of Arctic society. The "Ice Silk Road" aims to promote economic and trade exchanges among countries along the route, make contributions to economic globalization, and integrate ESG concepts into the process of building the "Ice Silk Road." Under a sound geopolitical environment, countries along the route can participate in developing natural resources in the Arctic region, join the construction of higher education in the Arctic region, and improve the quality of the population in the Arctic region. Moreover, it creates more job opportunities for the Arctic labor force. (2) Promote the contribution of the "Ice Silk Road" to the sustainable development of the Arctic environment under the Arctic governance mechanism. The "Ice Silk Road" development is based on the development of Marine resources and shipping routes in the Arctic. Therefore, the Arctic ecological environment should be protected when developing the "Ice Silk Road." Countries participating in the development and construction of the "Ice Silk Road" should, under the framework of international environmental governance such as the Arctic Environmental Protection Strategy, the Nuuk Declaration, the Inuvik Declaration, the International Convention for the Prevention of Pollution from Ships and the International Code for the Operation of Ships in Polar Waters, avoid accidents such as fire and oil spills on ships in the Arctic route and reduce the discharge of pollutants. They should conduct business and trade to respect the cultural practices of the indigenous peoples of the Arctic. (3) Strengthen ESG sustainable development exchanges among countries along the "Ice Silk Road." The "Ice Silk Road" refers to the ice passage connecting China with Europe and Asia and is also an important strategic concept for China to participate in global governance in the new era. In this strategic context, ESG (Environment et al.) has become one of the key elements of sustainable development among countries along the route and has also become one of the topics of exchange between countries. Therefore, many countries have begun to explore ways to strengthen ESG exchanges and cooperation on the "Ice Silk Road." For example, China, Finland, Russia and Norway have all signed memorandums of understanding on cooperation on the Ice Silk Road, including cooperation in areas such as enhancing environmental protection, promoting clean energy and promoting regional economic development. On this basis, all countries should further strengthen exchanges and cooperation in ESG and promote the sustainable development of the "Ice Silk Road."

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