Competitiveness Analysis of Arctic LNG Channel Based on Factor Analysis Method

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Abstract. In recent years, the opening of Arctic shipping routes and their close integration with Arctic resources have made Arctic shipping routes a new factor affecting the global economy and changes in energy trade patterns. As a new channel for China's LNG international transportation, the Arctic shipping route will change the pattern of China's foreign energy trade to a certain extent. Considering the influencing factors such as China's natural gas supply and demand, political factors and economic factors of Arctic natural gas resource development, the factor analysis method is used to analyze the competitiveness of Arctic LNG channels. The results show that the status of the Arctic LNG channel in China's natural gas foreign trade will rise .

Keywords: LNG · energy channels · Arctic routes · Factor analysis

1 Introduction

At present, many scholars have recognized the feasibility and importance of the Arctic route. Cui Jian [1] made the judgment that the Arctic route will have an important impact on the world energy pattern. Li Zhenfu [2] discusses the evolution of the global energy trade pattern. He Yiming et al. [3] explored the possible impact and pathways of Arctic oil development based on location theory analysis from the perspective of supply chain. Du Xingxing [3] systematically analyzed the impact of Arctic oil and gas resource development on energy maritime transportation in terms of economic aspects. Ma Xiaoxue [4] and Liu Tongchao [5] have focused more on the safety of Arctic shipping routes. There is little literature specifically on the impact and competitiveness of Arctic gas channels. This paper will focus on analyzing the impact of the Arctic channel on China's natural gas import channel, in order to provide reference for China's natural gas channel construction.

1.1 China's Natural Gas Supply and Demand Situation

Since entering the 21st century, China's total natural gas consumption and its proportion in the primary energy consumption structure have shown a rapid growth trend. According to the prediction of the China Petroleum Research Institute of Economics and Technology

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in the "2050 World and China Energy Outlook", the proportion of LNG will rise to 17.4% and 14.2% in 2035 and 2050 respectively. You can find China's primary energy structure in Table 1 below.

Under the influence of comprehensive factors, the supply capacity of natural gas is difficult to meet the demand of the market. China's LNG imports have grown rapidly. As of 2021, China surpassed Japan to become the world's largest LNG importer. You can find China's natural gas imports in the recent years in Table 2 below.

1.2 The Main Source of Natural Gas in China

China's imported LNG mainly comes from Australia, Southeast Asia, the Middle East, North America, Africa and other regions. In 2021, China imported 168 billion cubic meters of natural gas. Among them, the Australia, Turkmenistan, Russia, the United States, Qatar and Malaysia imported a total of 129 billion cubic meters, accounting for 77%. You can find China's main LNG import sources structure in Table 3 below.

Table 1. China's primary energy structure.

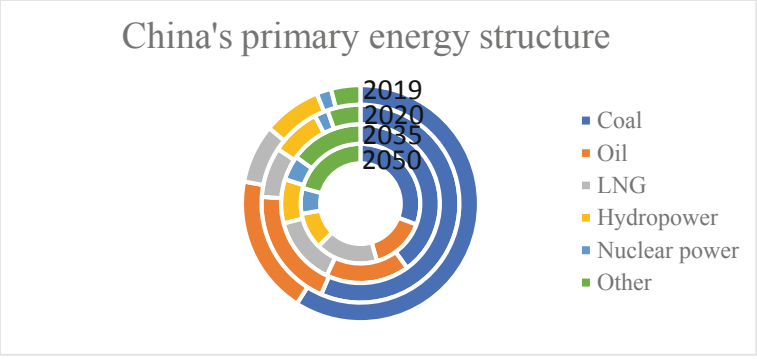

Table 2. China's natural gas imports from 2010–2020.

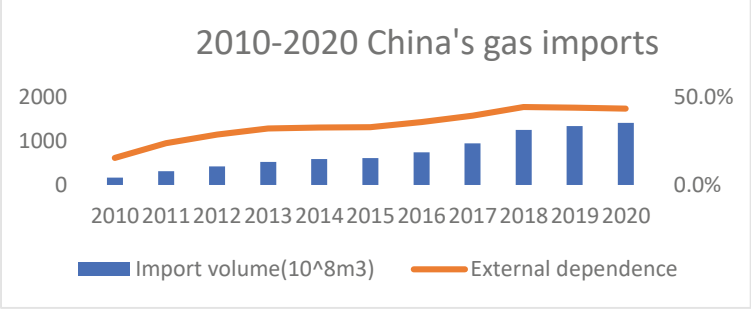

Table 3. Main Structure of China's main LNG import sources from 2016 to 2020(%)

Import country	2016	2017	2018	2019	2020
Australia	45.6	46.7	44.6	42.9	44.6
Qatar	19.7	19.9	17	19.5	11.7
Malaysia	10.4	11	11	9.1	9.1
Indonesia	10.6	7.9	9.1	6.7	8.3
Papua New Guinea	7.5	5.1	4.3	5.8	4.3
Nigeria	1.3	0.9	2	5.8	3.7
United States	0.8	4.1	4.2	1.6	4.8

2 Introduction and Modeling of Factor Analysis

Factor analysis is a multivariate statistical analysis method that uses a few new variables to explain the original variables on the basis of retaining as much of the original information as possible, and is more suitable for indirectly analyzing various influencing factors to draw conclusions about a thing.

2.1 Model Determination

The main computational steps of factor analysis include the following four steps:

First, select the appropriate influencing factors as appropriate factor analysis; Second, construct factor variables for suitable influencing factors; Third, the rotation technique is used to make the constructed factor variables interpretable; Fourth, the technical factor score for the factor variable.

The mathematical models involved in the factor analysis method selected in this article are:

$$\begin{cases} x_1 = a_{11}\dot{f}_1 + a_{12}f_2 + a_{13}f_3 + \cdots + a_{1k}f_k + \varepsilon_1 \\ x_2 = a_{21}f_1 + a_{22}f_2 + a_{23}f_3 + \cdots + a_{2k}f_k + \varepsilon_2 \\ x_3 = a_{31}f_1 + a_{32}f_2 + a_{33}f_3 + \cdots + a_{3k}f_k + \varepsilon_3 \\ \qquad\qquad\qquad\qquad \cdots\cdots \\ x_p = a_{p1}f_1 + a_{p2}f_2 + a_{p3}f_3 + \cdots + a_{pk}f_k + \varepsilon_p \end{cases} \tag{1}$$

a_{ij} represents the relationship between the jth factor variable and the ith original variable.

Common variance, which reflects the ability of all factor variables to interpret total variance of X.

$$h_i^2 = \sum_{j=1}^{k} a_{ij}^2 \tag{2}$$

The variance contribution of factor variables, which reflects the ability of the same factor to explain the total variance of all the original variables.

$$S_j = \sum_{i=1}^{p} a_{ij}^2 \tag{3}$$

In general, the original variables with a value of less than 0.3 is not suitable.

Determine the principal component of factor variables, one by one, principal component analysis method.

$$\begin{cases} y_1 = \mu_{11}x_1 + \mu_{12}x_2 + \mu_{13}x_3 + \ldots \mu_{1p}x_p \\ y_2 = \mu_{21}x_1 + \mu_{22}x_2 + \mu_{23}x_3 + \ldots \mu_{2p}x_p \\ y_3 = \mu_{31}x_1 + \mu_{32}x_2 + \mu_{33}x_3 + \ldots \mu_{3p}x_p \\ \qquad\qquad \ldots\ldots \\ y_p = \mu_{p1}x_1 + \mu_{p2}x_2 + \mu_{p3}x_3 + \ldots \mu_{pp}x_p \end{cases} \tag{4}$$

Determine the factor variable

$$A = \begin{pmatrix} a_{11} & a_{12} & \ldots & a_{1p} \\ a_{21} & a_{22} & \ldots & a_{2p} \\ \ldots & \ldots & \ldots & \ldots \\ a_{p1} & a_{p2} & \ldots & a_{pp} \end{pmatrix} = \begin{pmatrix} u_{11}\sqrt{\lambda_1} & u_{21}\sqrt{\lambda_2} & \ldots & u_{p1}\sqrt{\lambda_p} \\ u_{12}\sqrt{\lambda_1} & u_{22}\sqrt{\lambda_2} & \ldots & u_{p2}\sqrt{\lambda_p} \\ \ldots & \ldots & \ldots & \ldots \\ u_{1p}\sqrt{\lambda_1} & u_{2p}\sqrt{\lambda_2} & \ldots & u_{pp}\sqrt{\lambda_p} \end{pmatrix} \tag{5}$$

Determine the number of factor variables.

It is determined according to the size of the feature value, and generally speaking, factor variables with feature values greater than 1 are selected.

Calculate the score of the factor variable

$$F_{ji} = \varpi_{j1}x_{1i} + \varpi_{j2}x_{2i} + \varpi_{j3}x_{3i} + \cdots + \varpi_{jp}x_{pi} (j = 1, 2, 3, \ldots, k) \tag{6}$$

2.2 Case and Result Analysis

According to the above model and calculation steps, the impact of Arctic shipping routes on China's natural gas imports was analyzed by using SPSS software.

There are 6 main LNG transportation routes in China. You can find the Main route details in the Table 4.

Five decision criteria are:

LNG prices. It is the economic standard to choose LNG imported gas source.

LNG reserves. It is indicated with reasonable certainty based on geological and engineering information to show the resource availability of LNG importing.

Stability of diplomatic relations. The stability level of relations between natural gas importing and exporting countries can be divided into alliance relations, strategic cooperative partnership, general relations, tense relations, and hostile relations, and the corresponding scores are 5, 4, 3, 2, and 1.

Table 4. Main LNG transportation routes in China

Route name	Route situation
Middle East Route	Persian Gulf - Sea of Hormuz - Strait of Malacca - Taiwan Strait - China Coast
Southeast Asia Route	Taiwan Strait - Coast of China
Oceania Route	Pacific Ocean- Coast of China
Africa Route	Gulf of Guinea - Cape of Good Hope, Indian Ocean - Strait of Malacca - Taiwan Strait - Coast of China
North American route	Panama Canal - Pacific Ocean - China Coast
Arctic route	Northeast Route- Bering Strait- China Coast

Security of transport corridors. In the same way as the stability of diplomatic relations, the security is divided into five levels with corresponding scores of 5, 4, 3, 2, 1.

Transportation distance. This paper uses the average route distance from the gas source country to China, that is, assuming that the longer the shipping distance, the greater the transportation risk.

After using SPSS software, we can get result. In terms of average shipping distance, the Arctic routes ranked high, but did not perform well in terms of the safety of the routes, mainly considering the natural environment of the Arctic and the thickness of sea ice. In terms of LNG price, considering our long-term contract with Yamal project, the price is very objective. The Arctic route ranks third in overall competitiveness, and there is always a great potential for development.

Acknowledgement. With the impact of the Arctic, the country has more options, less dependence on traditional shipping routes, and less tension that has been constrained by the shipping routes.At the same time, the status of the United States and Russia in the natural gas trade is rising, especially Russia's rich natural gas resources make it will be the main import object of many Eurasian countries.

For our country, the best way is to provide sophisticated technology and economic investment and participation, and actively participate in establishing peaceful and stable natural gas trade relations.

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