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THE MOST RELEVANT FACTORS AND TRENDS IN ENERGY COOPERATION BETWEEN KAZAKHSTAN AND CHINA, FOCUSED ON RENEWABLE ENERGY SOURCES (RES)

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Abstract: *This paper analyses the good political and legal environments, mutually beneficial strategic policy, along with level of economic development and growth, superior geographical conditions and cultural integration degree of the important effecting factors of the energy cooperation between Kazakhstan and China. By using the main points listed above this article refers to related trade and investment theories, and it's divided into two aspects: Kazakhstan's export of Chinese energy products with time series data 1998-2014 and China's investment in Kazakhstan's energy sector with time series data 1998-2016 to construct the vector autoregressive model (VAR).We selected relevant variables and data to construct an econometric model from the perspectives of trade and investment to make an empirical analysis on the influencing factors of energy cooperation between Kazakhstan and China. Our results show that China's demand for large-scale market and for opening to the outside world as well as Kazakhstan's great energy potential are the most important factors their cooperation. It can be stated that in our days Kazakh legislation is suitable for promoting the Chinese energy investments, but in the long run it would be beneficial to mobilize national capital especially in RES investments and research. In the end, we found the most important reserves in competitiveness of electricity and heat (both from fossil and renewable energy sources) are power grid consolidation and waste heat utilization in the short run.*

Keywords: *Energy Cooperation; Foreign Trade; FDI; Energy Sector; VAR*
JEL Code: F14; Q43

1. INTRODUCTION

Kazakhstan has a huge potential on renewable energy utilization such as solar installations, wind energy and biomass. According to a report from the Ministry of Energy of Kazakhstan, green energy generated 2.4 billion kWh, which shows an increase of 77.8% over the same period in 2018. Renewable energy accounts for 2.3% of the total power generation. In 2019, 22 renewable energy facilities were put into use, renewable energy projects attracted investments amounted of 613 million US dollars, bringing total capacity of 1050 MW. In 2020, there are also plans to build 18 renewable energy facilities with a total capacity of 605,5 MW. The total capacity of installed renewable energy has boosted from 178 MW to 1635 MW between 2014 and 2020. There are 116 renewable energy projects in Kazakhstan, including 29 wind power stations, 44 photovoltaic power stations, 38 hydropower stations and 5 biomass power stations. During the long-term target period, the proportion of renewable energy power generation will increase to 6% by 2025, 10% by 2030, and 50% by 2050 in Kazakhstan (Forbes, 2020).

The most challenging year for Kazakhstan's economy was Covid-19 pandemic situation in the last two decades. COVID-19 pandemic has impacted the economy highly than the crises in 2018 and 2015. The spread of pandemic has stopped the global activity and reduced global demand and price of oil, it's the main export product. The domestic economic activity is significantly reduced due to the COVID-19 pandemic. The national economy is projected to contract by 2.5 percent in 2020 (World Bank, 2021).

In terms of energy reserves, Kazakhstan has abundant energy reserves. Structurally, oil, gas and oil are the main energy reserves of Kazakhstan. 30% of the oil and gas in Central Asia and 3% of the world's oil are stored in Kazakhstan. Coal accounted for main share of power generation for 68%, natural gas accounting for 20%, large hydroelectric power plants for 8.8% and renewable energy and small hydropower stations for 2.8% (IAEA, 2021). Rich energy reserves make Kazakhstan a very high position in the international community and have very important strategic significance for its position on the international stage. To sum up, the energy cooperation between Kazakhstan and China plays an important role in the economic development of both countries. Therefore, the research on the influencing factors of energy cooperation between Kazakhstan and China is of great significance.

1.1. Possible limitations of the paper

While some research results have been achieved, this paper also has some limitations. First, the development data of many renewable energy industries, especially local new energy, are not fully published sometimes some years later and mostly not free service, and some analysis lacks systematic data, which affects the making analysis. Second, because the renewable energy industry is an emerging industry, there are not many empirical research literatures in this field, of which there are relatively few foreign literatures, which affects the author's vision. Third, due to the lack of provincial data on renewable energy consumption, this paper only makes an empirical analysis based on the annual data obtained from 1998 to 2014 on Kazakhstan's energy products export to China and China's investment in Kazakhstan's energy sector from 1998 to 2016. In the empirical analysis part, the selected time series variables are limited by relevant statistical data, and only a limited time series can be selected for empirical analysis. Since in our days the significance of RES is negligible both in Kazakhstani and the in the Chinese investments towards Kazakhstan, we did not make any statistical analysis in this area. However, since it has a great potential in the future, therefore we introduce some literature and our expectations in this area for the next years.

2. LITERATURE REVIEW

2.1. Energy characteristics and energy policy in Kazakhstan

Regarding energy consumption, both Kazakhstan and China has been considered as coal-dominated countries in a global cluster analysis. The potential and the expectable advantages in establishing new RES capacities are favorable in both countries, but the chance of realization is differential, since the importance of RES (excluding hydro energy) is statistically correlate with the national GNI and HDI (Tóth-Magda, 2017). The economic results of the RES projects strongly depends on the price fluctuation of fossil energy sources (especially of oil and gas prices), which are affected many times by political decisions (Pápay, 2015) and it makes uncertain the viability of renewable systems, too.

In terms of energy in Kazakhstan, it expounded and analyzed the status of oil and gas raw material base, exploitation, transportation facilities, demand, and export in Kazakhstan through descriptive statistics (YanPing, 2006; YanPing, 2007). Kazakhstan's energy development from the perspective of policy and finds that Kazakhstan's energy law tends to domestic interests, ecological security, utilization efficiency, interest control and optimizing energy structure (Li, 2012). The energy utilization efficiency of Kazakhstan is gradually rising, and the energy structure and industrial structure have an important impact on the energy utilization efficiency. The energy utilization efficiency of Kazakhstan by using the relevant energy data of Kazakhstan and the method of empirical analysis compared it with China (Pei, 2015).

Starting from the legal system, first described the current situation and forms of energy cooperation between China and Kazakhstan, analyzed the prospects of energy cooperation between the two countries based on the analysis of the current situation, and finally discussed the role of Kazakhstan's laws on China and Kazakhstan energy cooperation (Fang, 2012). Kazakhstan's energy cooperation is in line with China's strategy of diversified energy import and urges Russia to weigh its own interests and losses in the fierce competition for Kazakhstan's participation in China's energy market. In the past, Kazakhstan mostly relied on energy pipelines in Russia to export its own energy, but Kazakhstan's energy exports to China increased, it will certainly affect the export ratio through Russia and Russia's transit energy income, which will lead Russia to put China in the first place of energy cooperation, which will inevitably lead to the situation of China Kazakhstan energy cooperation towards mutual benefit and win-win (BingYin, 2004).

The investment environment in Kazakhstan's oil and gas field published to analyze many conditions affecting the investment environment in Kazakhstan's oil and gas field, such as Kazakhstan's oil and gas foundation and development conditions, domestic market demand and international market prices, transportation infrastructure and its development space, relevant domestic economic policies, and laws. The following conclusions are drawn: for some foreign companies investing in Kazakhstan's energy field, the investment environment is worse than before, which is reflected in: the Kazakh government gradually improves the mining technology of foreign energy companies, reduces or will cancel customs taxes and other taxes, and stipulates that foreign companies must hire a certain proportion of local labor force, using local oil and gas exploitation, some high-tech refining equipment and other tools, the state has the right to buy the equity sold by foreign investors, etc (Korzhubaev and Eder 2007).

Although renewable energy policies and governance have been institutionalized since 2006, progress has been slow. Many investors choose to leave, because they were concerned with numerous gaps and inconsistencies in the governance structure. The article concluded that the use of active power by the central government does not seem to be sufficient to achieve results in policy design and governance. Yet another conclusion is that largely disregarded the role of renewable energy in providing a safe and clean energy supply, although the need to preserve the cleanliness of the environment recognized in Kazakhstan (Mouraviev, 2021). However, in the long run, Kazakhstan's energy projects are still attractive to foreign investors. Under the current circumstances, the ideal way of investment cooperation is to cooperate with Kazakhstan national oil and gas company to establish a joint venture and jointly develop and operate projects.

The Chinese government's loans and assistance are a key part of the conditions that the Kazakhstan government cannot refuse. Kazakhstan gets benefits from the geographical conditions. The Kazakhstan government must equate its so-called "multi-vector" foreign policy of diversity in foreign relations with the benefits of Chinese financial flows in the form of investments, aid and loans (O'Neill, 2014).

2.1.1. Possibilities in renewable energy areas

Biogas production in wastewater treatment is a recommendable technology for every municipalities having large-scale plants. If an upgrading technology can be financed, the biomethane, as end product can be filled in the national natural gas network, or can be used as transportational fuel, especially in the local public transport. Due to financial issues, the biogas is tipically converted into electricity and waste heat by a cogeneration technological process, which can cover the majority of energy costs of the wastewater treatment plants (Gabnai, 2017). The effectiveness of the system could be enhanced via co-utilization of chopped biomass chips produced in special energy plantations. In this case the lowest nitrogan fertilization level resulted the best efficiency, according to the experimental results of Wajszczuk et al (2016). The significance of local renewable energy systems thanks to the elimination of transportational and production costs was also emphasized by Fogarassy-Nábrádi, (2015).

Kazakhstan's carbon emissions are comparatively lower with large emitters such as China and the United States. Russia and China are the main consumers of Kazakhstan's energy and related emissions, in which the construction industry plays the most important role. It is also confronted with great pressure on CO2 emission decrease and sustainable development. Both technical and policy actions should be considered to decline CO2 emissions and "Belt and Road Initiative" is a good opportunity for Kazakhstan to develop a „Green Economy" (Wang et al. 2019).

2.2. The Kazakh-Chinese energy relations

According to REN21 (2016), China was globally the first in the order of establishing solar and wind power capacities. However, these investments operate inland, the foreign capital investment into the energy sector is exclusively towards fossil energy sources.

In terms of energy cooperation between China and Kazakhstan, the obstacles, and difficulties in energy cooperation between Kazakhstan and China from the perspective of law and from the perspective of domestic and international legal systems and mechanisms (MengMeng, 2017). The legal conflicts and obstacles of energy cooperation between China and Kazakhstan based on the international legal, including the investment barriers in the energy field of Kazakhstan, the legal conflicts caused by the customs union and the legal shortcomings of China in energy cooperation. Finally, policy suggestions on China and Kazakhstan energy cooperation are put forward from the perspective of law (Lei et al. 2014). Taking Kazakhstan as an example, first introduced the current situation of energy in Kazakhstan, summarized the fields and ways of China's energy investment in Kazakhstan, and then analyzed the problems and challenges in energy cooperation between Kazakhstan and China from the perspective of foreign direct investment (Bin and Ying 2014). The evolution of oil and gas relations between China and Kazakhstan, evaluated their long-term development prospects, discussed how China's demand for oil and natural gas transferred Kazakhstan's oil and gas resources from other energy markets, and used empirical methods to evaluate the prices provided by China to other producers in Kazakhstan. It is found that Chinese-Kazakh energy and economic cooperation can create a good foundation for the free economic zone and the development of mutually beneficial relations between the two countries (Kalyuzhnova, 2014).

Since the strategic goal of policymakers is to raise domestic companies to the level of international competitiveness. The increased state intervention in Kazakhstan's oil sector is due to long-term capacity-building, not just the economic reason of rising rent. In contrast to nationalization, the principle of participation does not give priority to asset expropriation and/or the replacement of foreign investors (Orazgaliyev, 2018).

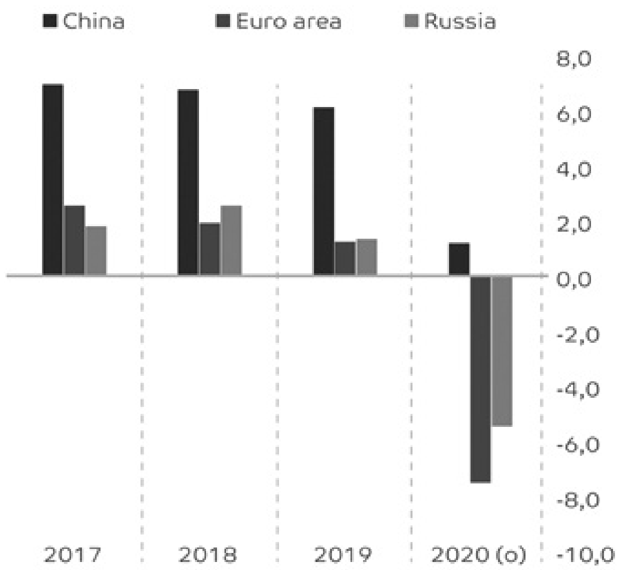
Kazakhstan actively attracts foreign investments and the country had received significant Chinese foreign direct investment (FDI) in Kazakhstan's mining, oil, transport, and agriculture sectors, reflecting increased bilateral trade and cooperation. Kazakhstan seeks to: (1) diversify its economy by getting rid of overdependence on the extractive sector; (2) Kazakhstan, as the world's largest landlocked country, is well positioned to expand connectivity with international markets to become one of the larger beneficiaries of China's Belt and Road Initiative (BRI) (Žuvela, 2021).

2.3. The impact of the COVID-19 on energy production sector

The country's natural gas exports in the Caspian Sea and Central Asia are already in a leading position, with more than 70% of exports going to China, Russia and Iran. Although the facts and figures on the economic impact of COVID-19 are limited, the plunge in energy prices also has economic impacts (Yasmin et al. 2020). The shock of oil prices and the COVID-19 pandemic has shown as an unorthodox intervention to the energy market and global cooperation to support recovery. The immense oil price shock provides an opportunity to implement long-term diversification strategies, and to move towards a safe energy system to reach SDG (Azubike, 2020; Ajami, 2020).

The rapid economic decline of Kazakhstan's main trading partners in the export market reflects the impact of the COVID-19 pandemic (Figure 1). At the beginning, the epidemic caused a sharp slowdown in China's economic growth, and then spread to major areas in East Asia and Europe. (World Bank Group, 2020).

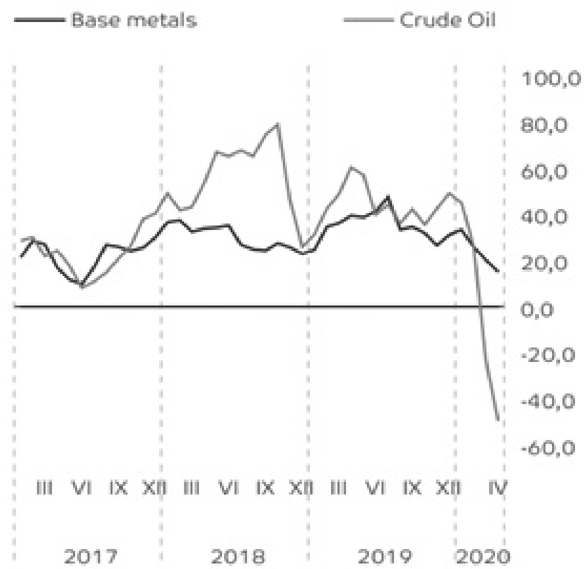
Figure 1: Decreased growth in key foreign markets (year-on-year, percent).



Source: World Bank, 2020

In March, oil prices depressed to a 17-year low at around $ 25 per barrel, reflecting OPEC + partner countries' divergence on production cuts and weak demand expectations (Figure 2). The economic impact of the coronavirus pandemic is a sharp drop in oil demand, leading to oversupply and overcapacity. Metals prices also reduced, reflecting weak demand for manufactured goods, especially from China. Tide trade and investment ties with the Eurozone, China, and Russia, as well as a high dependence on oil exports make Kazakhstan particularly vulnerable to the negative side effects of falling demand and commodity prices. While oil prices remain well below last year's levels as countries began to lift containment measures and reopen their economies, the recent recovery in demand pushed oil prices to $ 40 a barrel in early June (World Bank Group, 2020). The results show that oil price rise leads to increase in Azerbaijani international reserves. However, the results of Kazakhstani foreign exchange reserves are insignificant (Czech and Niftiyev, 2021).

Figure 2. Tendency of commodity prices (index, 2016=1).



Source: World Bank, 2020

3. MATERIALS AND METHODS

3.1. An empirical analysis on the influencing factors of Kazakhstan's energy trade with China

In this section, Kazakhstan's energy exports to China will be selected as the explanatory variables, and China's market demand, China's institutional environment and China's trade dependence will be selected as the explanatory variables to build a vector autoregressive model (VAR) to analyze the influencing factors of Kazakhstan's energy exports to China.

3.2. Variable selection and data source

The variables and data sources selected in this section are shown in Table 1. The selected variable data are time series data. When doing regression analysis for time series data, we should choose a longer time range as much as possible. In view of the availability of data, the time series period range of each variable selected in this paper is from 1998 to 2014.

Table1: Variable selection and data source

Variable properties	Variable name	Indicator selection	Variable symbol	Data sources
Dependent variable	Kazakhstan's energy production exports to China	Value of foreign trade	Trade	Unctad Database, 2018
Independent variables	Chinese market demand	GDP per capita	GDP/capita	Unctad Database, 2018
	China's political background	Perfection of legal system	Claw	World Bank Worldwide Governance Indicators, 2018
	China's trade openness	Foreign trade degree of dependence (FTD)	COP	Unctad Database, 2018

Table 2: Variable selection and data source

Variable properties	Variable name	Indicator selection	Variable symbol	Data sources
Dependent variable	China's investment in Kazakhstan's energy sector	Foreign Direct Investment	FDI	National bank of Kazakhstan website, 2018
Independent variables	Kazakhstan market size	GDP per capita	KperGDP	Unctad Database, 2018
	Kazakhstan's political background	Perfection of legal system	Klaw	World Bank Worldwide Governance Indicators, 2018
	Kazakhstan's trade dependence	Foreign trade degree of dependence (FTD)	KOP	Unctad Database, 2018

3.3. Empirical analysis on the influencing factors of China's investment in Kazakhstan's energy industry

This section will select China's direct investment in Kazakhstan's energy sector, Kazakhstan's market size, Kazakhstan's institutional environment, Kazakhstan's trade dependence and other indicators to build a vector autoregressive model (VAR) to empirically analyze the influencing factors of China's direct investment in Kazakhstan's energy sector.

3.4. Variable selection and data source

The variable data and indicators involved in the empirical analysis in this section are listed in table 2. In view of the availability of data, this section selects the longest possible time series for regression analysis, and the period is the annual data from 1998 to 2016. The specific empirical steps and results will be introduced below.

3.5. Model building

This section describes how the time series for energy cooperation to the Kazakhstan and China is construct. Usually, time series is non-stationary on the level:

y_t~non-stationary I (1)

Where I(1) denotes that after taking the first difference, the time series will be stationary if the largest root θ of the equation (in the complex variable y)

$$\Delta y_t = \log (y_t) \sim \log (y_{t-1}) \sim \text{stationary I} \quad (1)$$

contents θ< 1. Stationary is associated with the location of the roots of equation (1). In general, we say that a time series $\{y_t\}$ is included of first difference, denoted I (1), if $\{y_t\}$ is nonstationary but I (1) $\{y_t - y_{t-1}\}$ is stationary. If $\{y_t\}$is I (1), it is concerned about important to difference the data, mainly we might use all the methodologies developed for stationary time series to construct a model.

For an instance of a second-order difference process, take into account the VAR (2) series, $y_t=2y_{t-1}-y_{t-2}+\varepsilon_t$. This process is nonstationary. Equation (1) turn into y_t 2= 2log (y_{t-1}), y_t 2-2 y_t+1=0. This gives (y-1) (y-1) =0, the equation gets two-unit roots. This is shown that the first difference is nonstationary. The second difference is:

$$y_t - y_{(t-1)} - [y_{(t-1)} - y_{(t-2)}] = y_{t-2} y_{(t-1)} + y_{(t-2)}$$

which is $\varepsilon_t$equal to by the definition of our VAR (2) formula. Since the second difference is stationary, $\{y_t\}$ is I (2). Actually, however, the only integer values for VAR(p) that seem to be common are I (0) and I (1). Here we restrict our discussion to whether the data needs to be distinguished once.

According to the empirical methods, the research methods of Liu Ping et al. (2019) and Eviews software method of Zhang Xiaodong (2007) mechanical industry press are used for analysis. In order to meet the needs of research and ensure the continuity and availability of data, GDP per capital, FDI, trade, perfection of law, and foreign trade degree of dependence of Kazakhstan and China to analyze the effecting factors of energy cooperation between China and Kazakhstan by establishing VAR model. At present, China's energy consumption is very large. Compared with energy, the consumption of new energy is less. Therefore, the consumption of energy and new energy alone cannot control the world energy price. Here, the energy price is analyzed as an exogenous variable. Therefore, the VAR model is as follows:

$$y_t=\beta_1 y_{t-1}+\cdots+\beta_n y_{t-n}+\varphi X_t+\varepsilon_t \quad (2)$$

y_t is a six-dimensional endogenous variable vector, y_t=(CperGDP,Claw,COP,KperGDP,KLaw,KOP).Among the six-dimensional endogenous variables, CperGDP, Claw, COP, KperGDP, Klaw, KOP represents exogenous variable; X_t=(Trade,FDI), where t represents time, N is the log order, ϕ represents the estimated coefficient matrix, ε is the error matrix, and $\beta_1 \ldots \beta_n$ is the coefficient vector. The endogenous variables in the model have n-order lag, which can be called a VAR(n) model.

4. EMPIRICAL RESULTS AND DISCUSSION ON THE INFLUENCING FACTORS OF KAZAKHSTAN'S ENERGY TRADE WITH CHINA

4.1. Results of the Unit Root Test

In this paper, the unit root test method used ADF. Stationary test (ADF test) in order to verify whether the original data of time series Kazakhstan's energy production export to China (Trade), China's demand for energy products (CperGDP), China's legal perfection index (Claw) and China's foreign trade dependence index (COP) are stable. Here, the unit root test is performed on the data by using Eviews7.2 software, and the following results are obtained (Table 3).

Table 3: ADF unit root test results

Variable index	ADF- unit root test t-statistics	P value	Test results
LnTrade	-2.5900	0.1178	Not
LnTrade（1）	-4.4748	0.0043	Stationary
LnTrade（2）	-4.4594	0.0058	Stationary
LnCperGDP	-1.9004	0.3218	Not
LnCperGDP （1）	-2.2976	0.1848	Not
LnCperGDP （2）	-4.0657	0.0099	Stationary
LnClaw	-2.7245	0.0916	Not
LnClaw（1）	-5.4652	0.0006	Stationary
LnClaw（2）	-5.5800	0.0000	Stationary
LnOP	-1.9559	0.3010	Not
LnCOP（1）	-2.9838	0.0594	Not
LnCOP（2）	-6.0132	0.0003	Stationary

Note: (1) and (2) represent the first-order difference and second-order difference of variables respectively.

Before the regression of time series data, it is usually required that all variables are of the same order, that is, different variables pass the unit root test after making the difference of the same order. It should be noted that in order to eliminate the influence of variable heteroscedasticity on regression results, all-time series variables are taken as logarithmic regression in this section, and the accuracy of regression results will not be affected after taking variance. Table 3 reports the unit root test results of the time variables involved in this section. Although some variables failed to pass the test in the unit root test of the original time series and the first-order difference series, the p value of the second-order difference of all-time series variables is less than 5%, which is stable. Therefore, all-time series in this section are second-order single integer, which can be recorded as I (2).

4.2. Results of the Cointegration Test

The time series variables that pass the unit root test can be used for cointegration test. The purpose of cointegration test is to test whether there is a long-term equilibrium relationship between time series variables. If there is a long-term equilibrium relationship, the time series can be regressed. If there is no long-term equilibrium relationship, the data is invalid. In this paper, Johansen cointegration test is used. The results of cointegration test are reported in Table 4. The trace statistic p value rejects the original assumptions of up to three cointegration equations at the 5% significance level. Therefore, there is a long-term equilibrium relationship between the time series selected in this section, and regression analysis can be carried out on the time series data.

Table 4: Johansen cointegration test

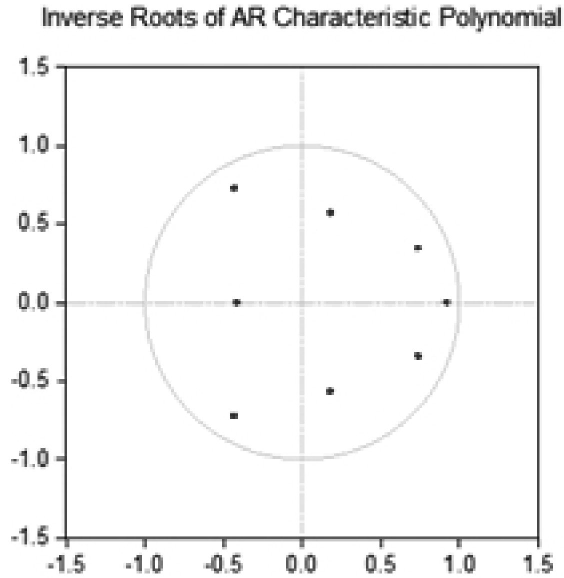
Number of cointegrating equations	Trace statistics	P value
None	132.2477	0.0000
At most one	29.7911	0.0000
At most two	15.4941	0.0330
At most three	6.6159	0.0101

Note: the trace test results show that there are four cointegration equations at the 5% significance level.

4.3. Results of the AR Unit Root Test

The purpose of AR unit root test is to verify the stability of VAR model, and the stable model is effective. The AR unit root of the effective model is less than 1, and the graph shows that all inspection points are in the unit circle. Figure 1 shows the AR unit root test results of the VAR model in this section. Obviously, all points are in the unit circle, which proves that the VAR model established in this section is stable and effective. At the same time, it also shows that there is a long-term stable equilibrium relationship between variables.

Figure 3: AR unit root test



4.4. Results of the Granger causality test

Table 5 reports the Granger causality test between the variables in this section. It can be seen from the table that the test results reject the original hypothesis that LnCperGDP is not the Granger cause of LnTrade and lncop is not the Granger cause of LnTrade at the significance level of 1%. Therefore, it can be said that LnCperGDP is the Granger cause of LnTrade; LnCOP is the Granger reason for LnTrade. The p value of other variables in the table is not significant, that is, the original hypothesis cannot be rejected. Therefore, there is no Granger causality between variables.

Table 5: Granger causality test results

Null Hypothesis	Chi-square	P value	Remarks
LnCperGDP is not the Granger reason for LnTrade	16.6641	0.0002	Reject
LnClaw is not the Granger reason for LnTrade	3.3341	0.1888	Do not reject
LnCOP is not the Granger reason for LnTrade	12.9339	0.0016	Reject

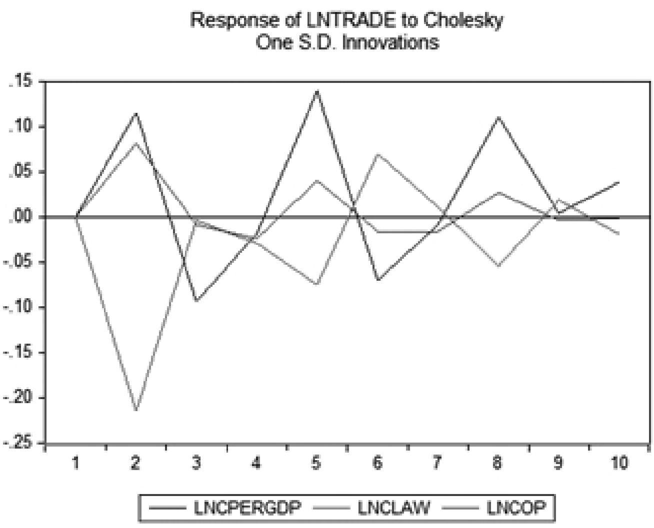
Based on the above Granger causality test results, China's market demand and China's high trade openness are the reasons for Kazakhstan's energy exports to China. Next in this section, the impulse response function and variance decomposition methods will be used to analyze the impact of China's market demand and China's trade opening in China.

4.5. Analysis based on Impulse response function

In this section, we will set the error term orthogonalization impulse response function, i.e., the Cholesky decomposition method, to analyze the impact of China's openness and China's market demand on Kazakhstan's export of Chinese energy products. The impulse response function analysis method is very intuitive, and the influence of various variables can be observed from the curve of impulse response function.

Figure 4 shows that China's large-scale market demand and China's high degree of foreign trade opening are important factors leading to the continuous expansion of Kazakhstan's energy export trade to China. In the short term, China's market demand and China's degree of foreign trade opening play a strong role in promoting Kazakhstan's export of Chinese energy products. In the long term, although the effect of China's market demand on Kazakhstan's export of Chinese energy products becomes smaller, it is still significantly positive. The degree of China's foreign trade openness does not significantly promote Kazakhstan's export of Chinese energy products. Obviously, China's strong market demand is a strong support to ensure Kazakhstan's increasing energy exports to China.

Figure 4: Effect diagram of impulse response function

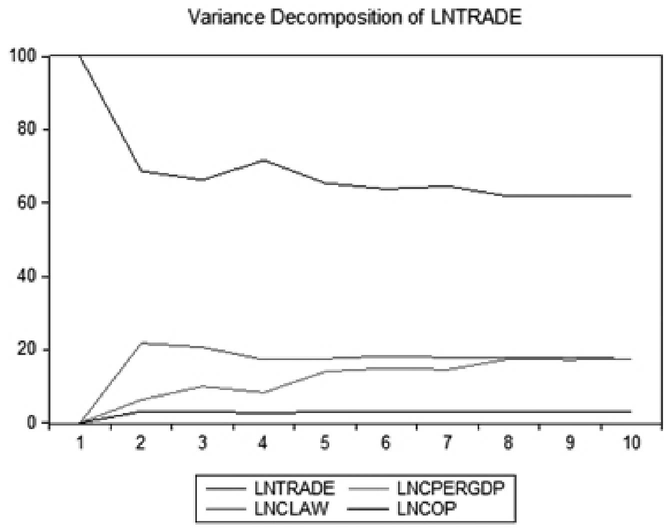


4.6. Results of the Variance decomposition analysis

The purpose of variance decomposition analysis is to determine the influence of various influencing factors on the explained variables. Its principle is to calculate the contribution of different structural shocks to the changes of different variables. In this section, the VAR model is decomposed into variance to analyze the impact of China's market demand and China's opening to the outside world on Kazakhstan's export of Chinese energy products.

Figure 5 shows the variance decomposition results of LnTrade variables. It is obvious from the figure that LnTrade contributes more to itself than other variables, and the contribution of other variables is relatively small, among which LnCOP has the lowest contribution to LnTrade. Specifically, the contribution of LnTrade to itself generally decreases with the number of periods. The decline is more obvious in the first two periods, from 100% to about 65%. From the second period to the tenth period, the impact of LnTrade on itself tends to be gentle, and finally decreases to about 60%. The contribution of LnperGDP to lntrade fluctuated from the first phase to the tenth phase, and remained stable after the eighth phase, stabilizing at the contribution rate of nearly 20%. The contribution rate of LnCOP to LnTrade is relatively stable, basically stable at 3% ~ 5% from phase I to phase X, with a small contribution.

Figure 5: Variance decomposition results



It shows that Kazakhstan's export of energy products to China is most affected by itself, which is easy to understand. Among the sectors with more energy exports, the import of oil and natural gas requires special investment from Kazakh enterprises, that is, the laying of relevant pipelines and transportation equipment by natural gas products.

4.7. Summary Findings and Discussion on Kazakhstan's energy trade with China

Considering the references in the literature chapter, MengMeng (2017) analyzed the difficulties and obstacles in the energy cooperation between China and Kazakhstan from the legal perspective. The deepening of Kazakhstan and China energy cooperation depends on overcoming the legal barriers to trade and investment in Kazakhstan's energy field, the legal conflicts caused by the customs union, and China's legal weaknesses within the framework of international law on energy cooperation (Lei et al. 2014). Scholars mostly discuss it from legal system, and the methods used are only limited to the basis of qualitative analysis. Kalyuzhnova, Y. (2014) evaluated the Sino-Kazakh energy and economic cooperation for their long-term prospects, which is completely in line with the results with ours. On this basis, this paper further quantifies the energy cooperation between Kazakhstan and China, to analyze the energy cooperation between Kazakhstan and China from the perspective of trade and investment, to make an empirical analysis on the influencing factors of energy cooperation between the two countries, to quantify economic, strategic, policy and institutional factors. The effects of these factors on energy cooperation between the two countries are investigated. Our empirical results show the following:

- China's market demand and China's high trade openness are the reasons for Kazakhstan's energy exports to China.
- China's large-scale market demand and China's high degree of foreign trade openness are important factors leading to the continuous expansion of Kazakhstan's energy export trade to China.
- The degree of China's foreign trade openness does not significantly promote Kazakhstan's export of Chinese energy products.
- China's dependence on foreign trade plays a small role in promoting China's import of energy products from Kazakhstan.

5. EMPIRICAL RESULTS AND DISCUSSION ON THE INFLUENCING FACTORS OF CHINA'S INVESTMENT IN KAZAKHSTAN'S ENERGY INDUSTRY

5.1. Results of the Unit Root Test

Since the principle and steps of unit root test have been described in detail above, relevant contents will not be stated in this section. In addition, in order to eliminate the influence of heteroscedasticity on regression results, this section still uses the method of logarithm of time series variables to process the data. The ADF unit root test results of the variable indexes involved in this section are reported in table 3. As shown in the table, the p value of the unit root test t statistic of the second-order difference of all-time series variables is significant at the significance level of 1%. After passing the unit root test, the time series variables are stable and second order mono integer, which is recorded as I (2). Therefore, cointegration test can be done.

5.2. Results of the Cointegration Test

As show in Table 6, Johansen cointegration test is still used for cointegration test, and the test results are reported.

Table 6: ADF unit root test results

Variable index	ADF- unit root test t-statistics	P value	Test results
LnFDI	-1.4832	0.5188	Not Stationary
LnFDI (1)	-5.2453	0.0007	Stationary
LnFDI (2)	-8.8783	0.0000	Stationary
LnKperGDP	-2.4698	0.1394	Not
LnKperGDP (1)	-2.1612	0.2257	Not
LnKperGDP (2)	-5.1406	0.0010	Stationary
LnKlaw	-3.1464	0.0409	Stationary
LnKlaw (1)	-3.9523	0.0088	Stationary
LnKlaw (2)	-4.9789	0.0013	Stationary
LnKOP	-1.2209	0.6413	Not
LnKOP (1)	-4.2003	0.0054	Stationary
LnKOP (2)	-5.8090	0.0003	Stationary

Note: (1) and (2) represent the first-order difference and second-order difference of variables respectively.

The p value of trace statistics shown in Table 7 rejects the original hypothesis of up to two cointegration equations at the significance level of 5%, and the test results show that there are three cointegration equations between variables at the significance level of 5%, that is, the time series variables involved in this section have a stable equilibrium relationship for a long time, and a vector autoregressive model (VAR) can be constructed for correlation analysis.

Table 7: Johansen cointegration test

Number of cointegrating equations	Trace statistics	P value
None	63.0495	0.0010
At most one	29.7970	0.0407
At most two	15.4971	0.0395
At most three	6.8415	0.1107

Note: trace test results show that there are three cointegration equations at the 5% significance level.

5.3. Results of the AR Unit Root Test

Figure 6: AR root test results

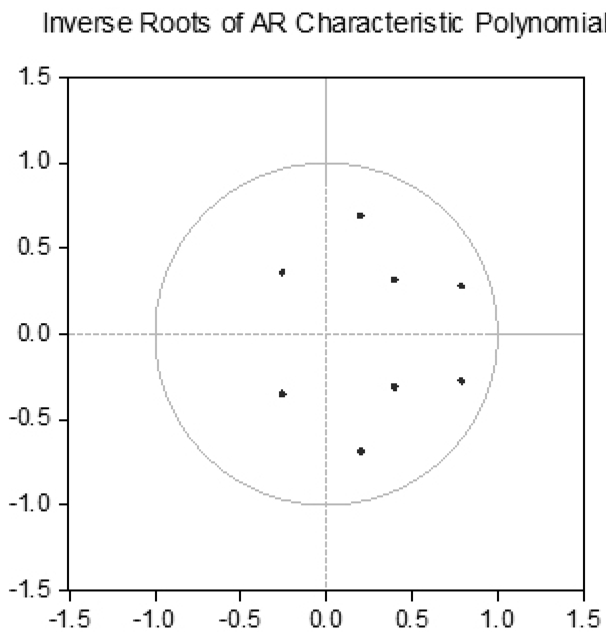


Figure 6 shows the results of AR unit root test of VAR model. It can be intuitively observed from the figure that all points are in the unit circle, which proves that the VAR model based on the time series variables in this section is stable and the analysis of the relationship between variables is also effective.

5.4. Results of the Granger Causality Test

The Granger causality test results of the time series variables involved in this section are reported in Table 8. As shown in the test results, the p value of chi square statistics rejects the original assumption that LnKperGDP is not the Granger cause of LnFDI at the significance level of 5% and proves that LnKperGDP is the cause affecting lnfdi and cannot be excluded from the VAR model. Similarly, the p value of chi square statistics rejects the original hypothesis that LnKlaw is not the Granger cause of LnFDI at the significance level of 5%, and proves that LnKlaw is the cause affecting LnFDI, but the direction of the effect is uncertain; The p value of chi square statistics rejects the original hypothesis that LnKOP is not the Granger cause of LnFDI at the significance level of 1%, that is, lnkop has a significant effect on LnFDI.

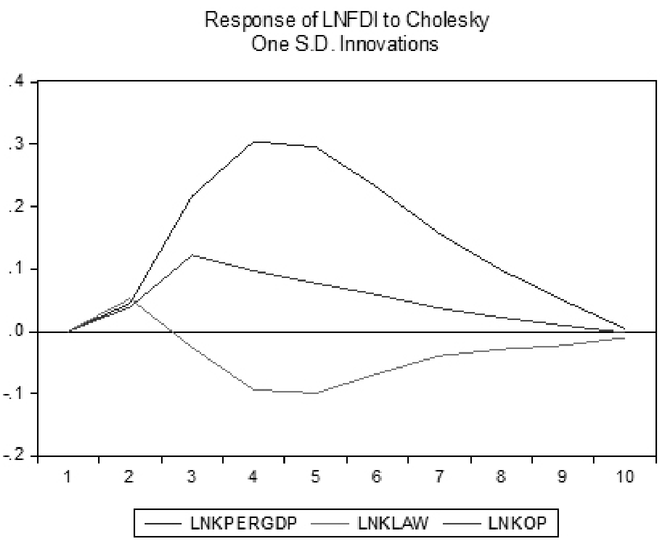
Table 8: Granger causality test results

Null Hypothesis	Chi-square	P value	Remarks
LnKperGDP is not the Granger reason for LnFDI	8.5059	0.0480	Reject
LnKlaw is not the Granger reason for LnFDI	25.0054	0.0264	Reject
LnKOP is not the Granger reason for LnFDI	108.7751	0.0096	Reject

5.5. Results of Impulse response function analysis

Based on the characteristics of the above impulse response function, it can be concluded that Kazakhstan's market scale and high openness are important factors to attract China's investment in Kazakhstan's energy sector, and Kazakhstan's market scale effect is always higher than Kazakhstan's openness in the long term or short term. Although Kazakhstan's institutional factors can promote China's investment in Kazakhstan's energy sector in the short term, Kazakhstan's institutional factors have an adverse impact on China's investment in Kazakhstan's energy sector in the long term (Figure 7).

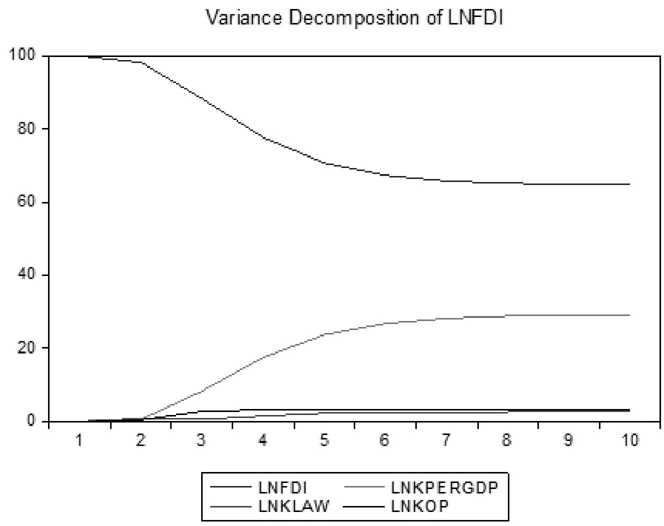
Figure 7: Impulse response function diagram



5.6. Results of the Variance decomposition analysis

Figure 8 shows that China's investment in Kazakhstan's energy sector is greatly affected by itself, that is, China's investment in Kazakhstan's energy sector in the current period will affect its investment behavior in the next period. Obviously, the investment of multinational enterprises is a gradual process. Some enterprises are in the process of investing in foreign markets, If the branches of multinational corporations show good profitability, the enterprises will make additional investment. On the other hand, the investment in some large engineering projects cannot be completed in one year but is a continuous process. Some investment projects can even reach the investment period of more than five years or even ten years. Kazakhstan's market size is an important factor to attract China's investment in Kazakhstan's energy sector, and over time, the attraction of market size to investment behavior becomes more and more obvious. Although Kazakhstan's institutional factors and openness have an impact on China's investment in Kazakhstan's energy sector, the impact is not great. Although institutional factors have been a factor hindering China's energy investment in Kazakhstan for a long time, the hindering effect is not great.

Figure 8: Variance decomposition



5.7. Summary Findings and Discussions on China's investment in Kazakhstan's energy industry

According to relevant international studies, Pei (2015) selected four factors: technological progress, industrial structure, energy price and energy consumption structure to explore their impact on energy efficiency based on the energy related data of Kazakhstan from 1992 to 2013, which do not match our results. In the studies of YanPing (2006) and YanPing (2007) the investment environment in oil and gas in Kazakhstan depends on natural, economic, organizational and other factors. The most important ones are raw material base, mining capacity, export prospects and market prices considering domestic demand, transportation facilities and development direction, as well as national economic policies, including export policies and legal regulation. According to their model analysis, Kazakhstan and China energy cooperation mechanism from economic and political level, at the same time, in the view of the problem exciting in the Kazakhstan and China energy cooperation mechanism, taking the institutional guarantee of international law as the starting point. In line with our interpretation of the empirical aspect, this paper studied the influencing factors of energy cooperation between Kazakhstan and China by using comparative advantage theory and factor endowment theory. Comparative advantage theory is the foundation of mainstream international trade theory. Kazakhstan's export of energy products to China largely depends on the comparative advantages of its energy industry. In fact, Kazakhstan is relatively rich in energy resources reserves. According to the factor endowment theory, Kazakhstan will export energy products with high resource factor abundance, Moreover, a large amount of investment and development in the energy industry has produced economies of scale in Kazakhstan's energy sector. At the same time, the energy sector is an industry with the characteristics of natural monopoly, which determines the characteristics of diminishing marginal cost. Our empirical results show that:

- Kazakhstan's market scale, Kazakhstan's institutional environment and Kazakhstan's degree of opening to the outside world are the factors affecting China's investment in Kazakhstan's energy sector.
- The market scale of Kazakhstan and the degree of opening to the outside world have a positive impact on China's investment in Kazakhstan's energy sector, that is, the expansion of Kazakhstan's market scale and the improvement of Kazakhstan's degree of opening to the outside world will significantly promote China's investment in Kazakhstan's energy sector.
- Institutional factors promote the level of China's investment in Kazakhstan's energy sector in the short term, but they are an obstacle for Kazakhstan to attract China's investment in its energy sector in the long term.
- Among the many factors affecting China's investment in Kazakhstan's energy sector, the most influential is Kazakhstan's market scale, and its institutional factors and market openness have little effect on China's investment in Kazakhstan.

6. CONCLUSIONS

In order to verify the impact of the above factors on the energy cooperation between Kazakhstan and China, there are mainly the following paths:

First, overcoming the power grid consolidation technology and promoting the grid connection of new energy would be necessary. Both renewable energy consumption and non-renewable energy consumption are mostly in the form of power generation when serving the economy and society. At present, Kazakhstan's power generation, including photovoltaic and wind energy, has an enormous potential. However, due to technical and financial difficulties, it is still unable to be connected to the grid, resulting in a waste of a large amount of energy, which is called "waste electricity". At present, in addition to nuclear energy, other new energy sources cannot be connected to the grid due to unstable power generation and financial problems. However, two economic factors might be considered as significant reserves for the future RES investments in Kazakhstan. Firstly, renewable technologies are cheaper and cheaper, their efficiency is better and better, their investment and operation costs are more and more competitive with the maintenance and repair costs of the old coal technologies in power plants and with the investment and operation costs of new coal-fuelled plants. In this case the critical factor is how to be financed. Secondly, the waste heat should be effectively utilized locally, near to the power plant in the central heating, or (as a better alternative) for technological purposes of industrial plants. In the latter case, it would be possible to use the waste heat not only in the winter period, but also in summertime. Thanks to the effective byproduct utilization, the unit cost of the green electricity would be reduced significantly in both cases.

The large distances in Kazakhstan and the associated serious losses in the electricity network can raise the necessity of establishing local systems not only in waste heat utilization, but also in electricity use, too for the reduction of transport losses.

Regarding technological aspects and considering the existing capacities, the anaerobic fermentation of the communal sludge might be the first step, which can use the produced biogas to reduce the electricity and heat demand of the sludge management or enable even the total energy self-sufficiency. Changing the coal fired stoves in the existing power plants to biomass burners is also a relatively simple, widely used and capital-saving technology.

Although there is significant interest from Chinese investors in RES capacities (e.g. Central Asia's largest wind farm in 2021), since Kazakhstan has a great potential, it would be recommended to take small steps in realization and for the sake of mobilization of the national investment capital with state contribution. Considering the macroeconomic advantages (environment, employment, rural development, capital attraction) it would result a win-to-win economic situation.

Finally, increasing R&D investment is inevitable in new energy sources. The development of science and technology must rely on R&D investment. In order to ensure our country's energy security, it should invest in new energy R&D for a long time and continuously. The initial cost of any new energy R&D is very high. Enterprises, governments, universities, and scientific research institutions should communicate and coordinate to jointly promote technological progress.

From the analysis conclusion, we found that since Kazakhstan's market scale is the most significant factor affecting China's energy investment and cooperation with Kazakhstan, it should strengthen the promotion of Kazakhstan's economic development and enhance the degree of opening to the outside world, to further improve the market scale and potential and lay a solid foundation for bilateral energy corporations.

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