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Article

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Analysis of Causality Relationship Between the Economic Growth and the Energy Production and Technological Investments in Kazakhstan

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ABSTRACT

This study analyzes the causality relationship between economic growth and energy production (Electricity and Thermal Energy) and technological investments in Kazakhstan between 1993 and 2020 using Cointegration and Vector Error Correction Models, and also performs impact analysis. Cointegration analysis was used to determine whether there is a long-term relationship between the variables that became stationary after the first difference. Energy production proved to be an important contributor to the economic growth of Kazakhstan. Compared to energy production, technology investments have a more decisive effect on economic growth. Therefore, the importance of technology investments for countries has been emphasized once again.

Keywords: Kazakhstan, GDP, Cointegration, Causality, Vector Error Correction Models
JEL Classifications: C01, C21, C22

1. INTRODUCTION

One of the most important indicators of a country's development is economic growth. Determining the factors that cause economic growth has critical importance in terms of taking the right decisions that will lead to growth. Causality analysis is one of the high-level analysis methods for determining the econometric relationship between periodically observed variables. The method was conceptually and methodologically developed by Granger in 1969 (Granger, 1969) and is based on the analysis of whether the present value of one variable is explained by the lagged value of the other. It is a widely used method because it provides both scientifically sound interpretations and decision support to decision makers. Another positive aspect of the method is that it is easy to implement in terms of data analysis methodology. Another positive aspect is that it is methodologically easy to implement.

This study deals with the causal relationship between economic growth and energy production (Electricity and Thermal Energy) and technological investments in the Republic of Kazakhstan.

Kazakhstan gained its independence after the collapse of the Soviet Union and, like other ex-Soviet countries, experienced a transition period to recover its economy and raise its welfare level. After the stagnation period that lasted until 2000, its economic growth gained momentum. Compared to other Central Asian Republics, Kazakhstan has natural energy resources (about 3% of the world's total oil reserves, about 1.1% of natural gas reserves, and about 3.3% of coal reserves), and thanks to these, it has become the fastest growing ex-Soviet country since the disintegration of USSR (Mudarissov and Lee, 2014; Xiong et al., 2015). In terms of GDP, Kazakhstan has managed to become the second largest country among ex-Soviet countries (Mukhtarov et al., 2020). This led to an increase in the number of studies on the economy of Kazakhstan.

The years 1992-2020, on which the study is based, are also important in terms of the fluctuations in the economic development and development of Kazakhstan after independence. The global economic developments in this period (Kelesbayev et al., 2022a), especially the fluctuations in oil prices (Bolganbayev et al., 2021; Kelesbayev et al., 2022b; Aldıbekova, 2018) deeply affected the economy of Kazakhstan.

The data are obtained from the website of the World Bank and the Bureau of National Statistics of the Agency of Strategic Planning and Reforms of the Republic of Kazakhstan.

2. LITERATURE REVIEW

Many academic studies have analyzed Kazakhstan's economic growth and each examined different sets of variables.

Mukhtarov et al. (2020) examined the relationship between energy consumption, financial development, economic growth, and energy prices in Kazakhstan using the data from 1993 to 2014. They determined that 1% increases in financial development and economic growth in Kazakhstan increased energy consumption by 0.11% and 0.39%, respectively.

The study of Xiong et al. (2015) focused on the relationship between energy consumption and economic growth and explored the possibility of a low-carbon economic development strategy in Kazakhstan. They examined the relationship between energy consumption and economic growth using the data for the period 1993-2010 and emphasized that a low-carbon economy is the best strategic choice for Kazakhstan in terms of eliminating the effects of the problems created by global climate change.

Mudarissov and Lee (2014) attempted to determine the relationship between energy consumption and economic growth in Kazakhstan using the data between 1990 and 2008. They concluded that Kazakhstan has to increase its energy production to sustain its economic growth in the long term.

Mukhamediyev and Spankulova (2020) examined the effects of innovation and oil prices on the economic growth of regions in Kazakhstan. They found that changes in oil prices and the costs of technological innovations and changes in their interregional spread had the same effect, whereas the impact of health costs and socio-economic conditions on regional growth was significantly weaker.

Raihan and Tuspekova (2022) examined the dynamic effects of changes in economic growth, energy use, urbanization, agricultural productivity, and forest area on carbon emissions. They presented some policy recommendations for Kazakhstan in the areas of the low carbon economy, renewable energy, sustainable urban development, and smart agriculture.

Khan et al. (2012) examined the relationship between electricity consumption and economic growth in Kazakhstan. They found that increased electricity consumption is a positive indicator of economic growth in Kazakhstan. They also presented new and comprehensive proposals in the fields of economic, trade, and energy policy so that Kazakhstan can sustain long-term economic growth.

Alagöz et al. (2011) analyzed the macroeconomic data of the Republic of Kazakhstan between 1992 and 2008 and tried to determine its economic performance. They revealed that Kazakhstan's worst economic performance years were 1994, 1993, and 1995, and its best economic performance year was 2004.

Özdil and Turdalieva (2015) examined the sources of economic growth in Kazakhstan between the years 2010-2013 with the Input-Output Analysis approach. They identified eight representative sectors (Agriculture, Mining, Industries Producing General Consumption Goods, Industries Producing General Exploration, Industries Producing Investment Goods in General, Energy, Construction, Services), determined the economic situation of Kazakhstan through these sectors, and made suggestions for the future.

Aldıbekova (2018) examined the effects of oil price fluctuations on the Kazakhstan economy and found that the declines in oil prices in 2009, 2014, 2015, and 2016 led to declines in GDP.

As can be seen from the scientific studies published recently, Granger causality analysis is still the preferred method, especially in modeling the relationship between variables. Two sample applications using Kazakhstan's econometric data are given below.

Nurmakhanova (2019) examined the interaction between exchange rate sensitivity and the stock market in Kazakhstan through cointegration and Granger causality analysis. The Ganger causality test showed a strong bidirectional relationship between these two variables.

Dikkaya and Doyar (2017), in their study in which they analyzed the oil industries of Azerbaijan and Kazakhstan, found that there is a causal relationship between oil prices and GDP in both Kazakhstan and Azerbaijan.

As the research examples given here show, Granger causality analysis is an effective method for determining the factors affecting economic growth and the direction and magnitude of these factors.

3. ECONOMETRIC METHOD AND ANALYSIS

In this study, variables Y, X1, X2, and X3 represent logarithms of GDP (LOGGDP), electrical power (mln. kWh), thermal energy (thsd. Gcal), and Technical cooperation grants (BoP, current US$) data, respectively. The period between 1993 and 2020 is examined and the data are taken from the website of the Bureau of National Statistics of the Agency of Strategic Planning and Reforms of the Republic of Kazakhstan (https://stat.gov.kz/).

This study analyzed the causality between energy production and technology investment and economic growth and performed an impact analysis. In time series analysis, when the series is not stationary, the results do not reflect the truth and are misleading. In addition, in the analysis of the relationship or effect between the variables, the relevant variables should be at the same level and stationary. The Enhanced Dickey-Fuller (ADF Augmented Dickey-Fuller) test was used to examine the stationarity of the series. Test results are obtained via equation (1) below:

$$\Delta Y_t = \beta_0 + \beta_1 t + \delta Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Y_{t-i} + \varepsilon_t \tag{1}$$

In the ADF test, if the null hypothesis is rejected for the values, the series is considered stationary for the relevant level (Sevüktekin and Çınar, 2014).

The causality relationship between any two variables in the time series is an important research question and is examined by Granger causality analysis. The matrix representation of the bivariate and p-lag VAR model for Granger causality analysis is as follows:

$$\begin{bmatrix} r_t^y \\ r_t^z \end{bmatrix} = \begin{bmatrix} \alpha_{10} \\ \alpha_{20} \end{bmatrix} + \begin{bmatrix} \alpha_{11}^1 & \alpha_{12}^1 \\ \alpha_{21}^1 & \alpha_{22}^1 \end{bmatrix} \begin{bmatrix} r_{t-1}^y \\ r_{t-1}^z \end{bmatrix} + \ldots + \begin{bmatrix} \alpha_{11}^p & \alpha_{12}^p \\ \alpha_{21}^p & \alpha_{22}^p \end{bmatrix} \begin{bmatrix} r_{t-p}^y \\ r_{t-p}^z \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \tag{2}$$

Table 1: ADF unit root tests of series

	Level		First Diference		Conclusion
	Critical values	P-value	Critical values	P-value	
X1	1.188402	0.9357	−2.91377	0.0052	I (1)
X2	−1.20595	0.2030	−3.61405	0.0008	I (1)
X3	0.895002	0.8957	−6.40013	0.0000	I (1)
Y	1.175427	0.9340	−2.87568	0.0057	I (1)
Test critical values					
1% level	−3.689194		−2.653401		
5% level	−2.971853		−1.953858		
10% level	−2.625121		−1.609571		

X1: The amount of electricity produced, X2: The amount of thermal energy produced, X3: The amount of technology investment, Y: The economic growth, GDP

The equation representation of the model is as follows:

$$r_t^y = \alpha_{10} + \alpha_{11}^1 r_{t-1}^y + \alpha_{12}^1 r_{t-1}^z + \alpha_{11}^2 r_{t-2}^y + \alpha_{12}^2 r_{t-2}^z + \ldots + \alpha_{11}^p r_{t-p}^y + \alpha_{12}^p r_{t-p}^z + \varepsilon_{1t}$$
$$r_t^z = \alpha_{10} + \alpha_{21}^1 r_{t-1}^y + \alpha_{22}^1 r_{t-1}^z + \alpha_{21}^2 r_{t-2}^y + \alpha_{22}^2 r_{t-2}^z + \ldots + \alpha_{21}^p r_{t-p}^y + \alpha_{22}^p r_{t-p}^z + \varepsilon_{2t} \tag{3}$$

The coefficients on the right show the lagged effects of the model variables on the variable on the left. If the coefficients on the right are all zero, the lagged values of the variables are not Granger causes (Sevüktekin and Nargeleçekenler, 2007; Yavuz, 2014).

If the causality relationship in an econometric time series is to be analyzed in the long term, this examination should be done with cointegration and Vector Error Correction Model (VECM). In the first step, the lag length is calculated and a cointegration test is performed depending on the lag length obtained. If the test result shows cointegration, the long-term causality relationship is analyzed with the VECM model (Çelik et al., 2020).

4. RESULTS

ADF Unit Root Test showed that the amount of electricity production (X1), the amount of thermal energy production (X2), technology investment (X3), and economic growth GDP (Y) variables are not stationary at the level values. X1, X2, X3, and Y variables were stationary at their first difference (Table 1).

The lag length is "2" according to the LR Test Statistics (LR), Final Prediction Error (FPE), and Akaike Information Criterion (AIC) values obtained from electricity production amount, thermal energy production amount, technology investment amount, and economic growth data (Table 2).

Since electricity production amount, thermal energy production amount, technology investment amount, and economic growth (GDP) are stationary at first order, the Johansen cointegration

Table 2: Statistics on determining the number of lags

Lag	LogL	LR: Sequential modified LR test statistic (each test at 5% level)	FPE: Final prediction error	AIC: Akaike information criterion	SC: Schwarz information criterion	HQ: Hannan-Quinn information criterion
0	−204.8369	NA	6675.846	17.31974	17.46699	17.35880
1	−185.1662	**32.78439***	2769.171	16.43052	**17.01954***	16.58679
2	−174.5207	15.08120	2520.163*	16.29339	17.32419	16.56686
3	−166.4083	9.464372	3027.947	16.36736	17.83993	16.75803
4	−152.7519	12.51845	2577.971	15.97932*	17.89366	16.48720*

*: indicates significance at p<0.05 level

Table 3: Cointegration test

	Trace Statistic			Maximum Eigenvalue		
	Statistic	%5 Critical value	Probability	Statistic	Critical value	Probability
r=0 r≥1	70.95365	47.85613	0.0001	37.60940	27.58434	0.0019
r≤0 r≥1	33.34426	29.79707	0.0187	18.24694	21.13162	0.1209

Table 4: Vector error correction model results

	Coefficent	t- Statistics	
Constant	**−0.004587**	**−0.43556**	**0.0240**
D (FARKX1(-1))	3.27E-06	0.78133	0.4377
D (FARKX1(-2))	−9.44E-07	−0.24101	0.8104
D (FARKX2(-1))	−9.36E-07	−0.45754	0.6489
D (FARKX2(-2))	1.81E-06	1.07102	0.2885
D (FARKX3(-1))	**−0.14409**	**−2.58373**	**0.0122**
D (FARKX3(-2))	0.069160	1.13157	0.2623
D (FARKY(-1))	−0.024889	−0.11192	0.9113
D (FARKY(-2))	**−0.362744**	**−2.35264**	**0.0219**
ECM_{t-1}	−1.88E-06	−2.31664	0.6647
R-squared	0.780087		
Adj, R-squared	0.648140		
F-statistic	5.912098		**0.002**

Bold numbers indicate significance at the p<0.05 level

method is used. Results are given in Table 3. The cointegration test revealed at least 2 cointegrating vectors (P<0.01). Trace statistics were found to be 70.95365 and 33.34426, respectively, and the largest eigenvalue statistics were found to be 37.60940 and 18.24694, respectively.

A cointegration vector is seen in the model. According to the cointegration test result, there is a long-term relationship between economic growth (GDP) and the amount of electricity production, thermal energy production, and technology investment. According to the results obtained for k=2 delay in the amount of economic growth (GDP), electricity production, thermal energy production, and technology investment, the rank number is 2 according to the λ trace statistics (P<0.01), and the λ max statistics (P<0.01).

Error correction findings according to the VECM model are given in Table 4. In parallel with the cointegration test findings, only the one-term lagged values of technology investments and economic growth are effective on economic growth in the long run.

5. CONCLUSION AND RECOMMENDATIONS

In terms of macroeconomic indicators, energy production is considered an important variable that shows economic growth. In this study, when considered together, it has been seen that technology investments are more dominant in economic growth than energy production. Therefore, the importance of countries' investments in technology is emphasized once again.

This study analyzed the causality between energy production and technology investment and economic growth and performed an impact analysis. When the long-term structure of economic developments is examined, we see that there may be structural changes in economic series due to stagnation periods, crisis periods, or changes in global trade structures. In this study, the period 1993-2020 was analyzed. In terms of macroeconomic indicators, this period is long enough to observe structural breaks. In this respect, it will be important to support our research with methodologies that add structural breaks to the model and that examine the effect of structural breakpoints on causality, if any.

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