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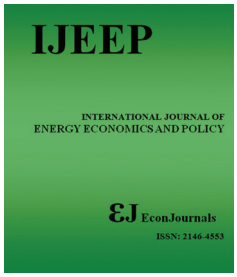

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Analysis of the Relationship between Energy Consumption, Foreign Direct Investment, and Labor Force Participation by Vector Error Correction Model: The Case of Kazakhstan

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ABSTRACT

This study examines the relationship between energy consumption, foreign direct investment, and labor force participation rate in Kazakhstan for the 1991-2021 period. Data on energy consumption are retrieved from the enerdata website, and data on foreign direct investment and labor force participation rate from the World Bank website. The vector error correction model (VCEM) method was used for data analysis. Research findings have shown that foreign direct investments have an effect on energy consumption for Kazakhstan both in the long run and the short run. The study found that although the labor force participation rate has an effect on energy consumption in the short term, it has no effect in the long term. These results are also important in terms of indirectly showing the long-term effects of foreign direct investments on the economy. The study used annual series for all three variables. Another important subject of study for explaining this relationship may be the use of series in different periods (especially quarterly).

Keywords: Kazakhstan, Energy Consumption, Foreign Direct Investment, Labor Force Participation Rate
JEL Classifications: C13, C20, C22

1. INTRODUCTION

This study examines the relationship between energy consumption, foreign direct investment, and labor force participation in Kazakhstan using the vector error correction model (VCEM) method. Kazakhstan, the ninth largest country in the world and the second largest among the former USSR countries after the Russian Federation, with an area of 2.724.900 km², gained its independence in 1991 after the dissolution of the USSR. After independence, Kazakhstan has undergone a rapid restructuring process to recover and develop its economy and integrate with the global markets. Due to the richness of its 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 investments in these natural resources, as well as the successful decisions of its managers, Kazakhstan successfully and quickly completed this transitional process (Mudarissov and Lee, 2014; Xiong et al., 2015; Myrzabekkyzy et al., 2022; Bolganbayev et al., 2022). Due to its geographical location, Kazakhstan is very rich in terms of renewable energy resources such as hydroelectric, solar, wind, geothermal, and biofuels, as well as fossil energy (Xiong et al., 2015; Ongarova, 2018; Sabenova et al., 2023; Taibek et al., 2023). Therefore, it is an attractive country for foreign capital investment. According to the Kazakhstan National Bureau of Statistics (https://stat.gov.kz/en/), Kazakhstan has a current population

of 19.832.737 people and is one of the leading countries in terms of economic development among developing countries (Mukhtarov et al., 2020).

Energy consumption rates have become an essential indicator of economic growth after the industrial revolution in the 19th century. Energy consumption is the driving force behind production and essential in economic growth and development. As an extremely important production factor, an increase in energy consumption brings high growth, while a decrease in energy consumption results in an economic slowdown (Siddiqui, 2004). With the developing technology and the increase in production and demand, a great increase in energy consumption has been observed globally (Alshehry and Belloumi, 2015; Abidin et al., 2015; Matei, 2018). De Vita et al. (2021) found that foreign direct investment has a significant effect on energy demand in a study titled "The inward FDI - Energy intensity nexus in OECD countries: A sectoral R&D threshold analysis."

Foreign direct investment is vital among many capital flows that support national economies. The first foreign direct investment dates back to the 18th century, when Britain invested in the extraction of raw materials, oil, and precious metals necessary for the production of its colonies. In the second half of the 19th century, the capital surplus created by the Industrial Revolution led large companies to pursue new investment areas that would maximize their profits, especially in Western countries. This pursuit has often taken the form of foreign direct investment (Çütçü and Enez, 2018). Investment areas were independent developing countries with cheap labor and natural resources to provide the raw materials needed by European industry and their colonies at the time. When the forces of globalization emerged after World War II, the importance of foreign direct investments increased and foreign direct investments expanded further. Foreign direct investment flows increased rapidly worldwide in the 1980s and 1990s, especially with the spread of liberal policies (Mahmoodi and Mahmoodi, 2016).

In addition to the physical capital factor, human capital also affects energy use. Odhiambo (2010) examined the dynamic causal relationship between electricity consumption and economic growth in Kenya during the 1972-2006 period and found a unidirectional causality between energy consumption and Labor Force Participation Rate. He found that the labor force participation rate not only affects energy consumption but also foreign direct investments. Nguyen (2021), on the other hand, found that the labor force plays an important role in attracting foreign direct investment in both developed and developing countries.

This study analyzed the relationship between energy consumption, foreign direct investment, and labor force participation rate in Kazakhstan for the 1991-2021 period. Energy consumption data is from the Enerdat website, and foreign direct investment and labor force participation rate data are from the World Bank website. The Vector Error Correction Model (VCEM) method was used for data analysis.

2. LITERATURE REVIEW

The literature contains many studies that examine the causal relationship between energy consumption, labor force participation rate, and foreign direct investment (FDI) using different variables. Here we will only mention some of the relevant ones.

Wayhudi and Palupi (2023) examined the relationship between energy consumption, foreign direct investment, and labor force participation rate in OECD countries using the VECM model. Their research showed bidirectional causality between energy consumption and foreign direct investment, bidirectional causality between energy consumption and labor force participation rate, and bidirectional causality between foreign direct investment and labor force participation rate. Moreover, in the long term, FDI has a significant positive effect on energy consumption, and the labor force participation rate has a negligible negative effect. But in the short term, FDI and labor force participation rates had no effect.

Polat (2018) used Dynamic Panel Data analysis in his study on the effect of foreign direct investments on energy consumption in developed and developing countries. The research determined that foreign direct investments affect energy consumption in developed countries, whereas there was no such effect in developing countries.

Dai et al. (2022) analyzed the relationship between economic growth and energy consumption in terms of sustainable development and the relationship between energy consumption and economic growth according to the energy Kuznets curve. They examined the future trend of China's sustainable development through a comparative analysis of the energy Kuznets curve of the United States and Germany. The results showed that at the energy consumption milestone, China's energy economic growth rate was higher than that of Germany and the United States. Moreover, they introduced the concept of energy consumption milestone by empirically analyzing the relationship between energy consumption and economic growth in OECD countries to provide a theoretical basis to coordinate China's energy consumption and economic growth.

Çetin (2019) examined the long-term effect of foreign direct investment on women's labor force participation rate in emerging market economies in the 2001-2016 period using the panel autoregressive distributed lag (ARDL) method. The gross domestic product (GDP) was the most important factor in increasing the women's labor force participation rate. Moreover, the long-term results of the panel ARDL analysis on the emerging market economies showed that increases in foreign direct investment had a statistically significant and positive effect on the women's labor force participation rate.

Gharaibeh (2015) conducted a study to identify the main determinants of FDI inflows into a host country. The study showed that general government consumption expenditures, inflation rate, economic stability represented by annual interest

rate, labor force, openness to trade, public education, and welfare of the country represented by the population have statistically significant effects on the foreign direct investment inflows to Bahrain. Furthermore, this study found that export potential, market size, and exchange rate were statistically insignificant but positively related to FDI inflows, whereas national welfare was negatively related to FDI inflows, but this relationship was statistically insignificant.

Nguyen (2021), on the other hand, analyzed the impact of the workforce and several other factors on attracting FDI to Vietnam. The study analyzed the effects of labor force, real gross domestic product, inflation, job freedom index, and investment freedom index on Vietnam's FDI attractiveness using a secondary time series for the 1995-2018 period. The research found that both labor force and inflation have a positive effect on FDI at a 5% significance level, whereas the job freedom index has an effect at a 10% significance level, and the real gross domestic product and investment freedom index have an effect at 1% significance level.

Bekhet and Othman (2011) analyzed the causality between electricity consumption, consumer spending, gross domestic product (GDP), and foreign direct investment (FDI) in Malaysia by using the vector error correction model (VECM). They used time series data for the 1971-2009 period. The research found cointegration and long-term relationship between all variables. They also found that long-run causality from electricity consumption to FDI, GDP growth, and inflation is statistically significant.

3. DATA AND ECONOMETRIC METHOD

This study examines the effect of foreign direct investment and labor force participation rate on energy consumption in Kazakhstan. The data and variables used in the study are given in Table 1. Annual data for the period 1991-2021 were used in the analysis.

This framework enables the use of two candidate methods for data analysis: the first is the vector autoregressive (VAR) method and the second is the vector error correction model (VECM) method. In this case, to decide on the method, first of all, the cointegration between the series is investigated. If there is, the VECM method is used.

Cointegration is a method used to determine the existence of a long-term relationship in a series (Wahyudi and Papuli, 2023). Johansen's cointegration test was used in this study. In the cointegration test, the null hypothesis argues that there is no cointegration in the related series. Moreover, for testing, the series must be stationary at the same level.

Examining the existence of a causal relationship in the series constitutes an important step of the analysis. The bivariate model investigates the causal effect of each variable on the other. The multivariate model, on the other hand, tests the causal effect of each variable, as well as whether other variables collectively have a causal effect on a variable.

The first step of the analysis is the stationarity analysis of the series. The stationarity of the series is investigated with Augmented Dickey-Fuller (ADF) unit root test. In the ADF test, the null hypothesis argues that the series contains a unit root. According to the unit root test findings, data analysis was performed using the series that is stationary at the same level.

In the second step, the optimal lag length is determined. For optimal lag length, econometric analysis programs use the following methods: LR: sequential modified LR test statistic (each test at 5% level), FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information, and HQ: Hannan-Quinn information criterion (Widarjono, 2018). This study determined the optimum lag length by comparing the optimum lag lengths obtained with each test method.

The stability of the VAR model is determined by examining whether the inverse roots of the AR characteristic polynomial are within the unit circle (less than one in absolute value). Thus, the impulse response and variance decomposition analysis results become econometrically meaningful (Firdaus, 2020). The

Table 1: Variable names and definitions

Variable	Definition
X1	Total energy consumption/GDP
X2	Foreign direct investment, net inflows (% of GDP)
X3	Labor force participation rate, total (% of total population ages 15+)

Table 2: Descriptive statistics of research series

Statistics	X1	X2	X3
Mean	104.6405	6.323174	70.52523
Median	106.7138	5.405182	70.50800
Maximum	126.6756	13.01286	71.57100
Minimum	85.77120	0.196995	69.20000
SD	11.11805	3.956885	0.628655
Skewness	0.104415	0.321274	−0.24519
Kurtosis	2.238165	2.001456	2.349049
Jarque-Bera	0.806005	1.821196	0.857944
Probability	0.668311	0.402284	0.651178
Observations	31	31	31

Table 3: ADF unit root test findings

Series	Constant		Constant and trend	
	t-Statistics	Prob.*	t-Statistics	Prob.*
X1 (1 st diff.)	−7.49306	0.0000	−7.35694	0.0000
X2 (1 st diff.)	−8.12954	0.0000	−4.32317	0.0122
X3 (2 nd diff.)	−5.49454	0.0001	−5.29933	0.0010
Test critical values	**1st diff.**	**2nd diff.**	**1st diff.**	**2nd diff.**
1% level	−3.67932	−3.68919	−4.30982	−4.32398
5% level	−2.96777	−2.97185	−3.57424	−3.58062
10% level	−2.62299	−2.62512	−3.22173	−3.22533

Graph 1: Time path plot for research series

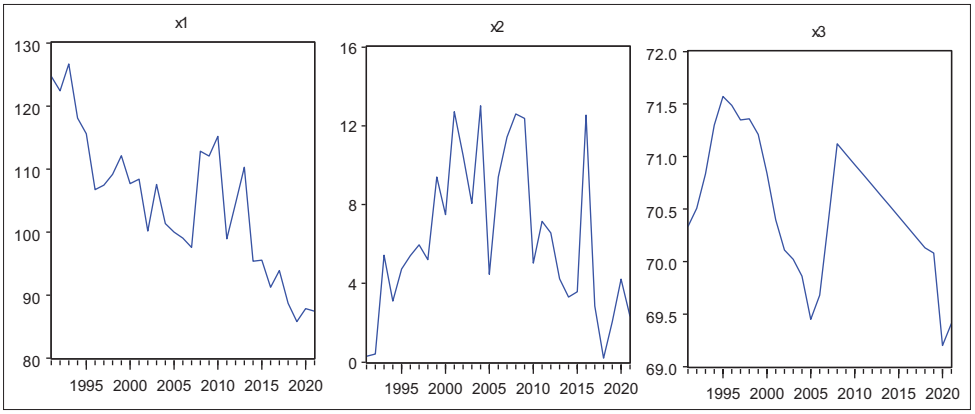


Table 4: Optimal lag length findings for the VAR model

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	−189.15	NA	951.9391	15.37200	15.51827	15.41257
1	−173.976	25.49239	585.6778	14.87808	15.46314	15.04035
2	−154.46	**28.10370***	**262.2309**	**14.03676**	**15.06062***	**14.32074**
3	−143.78	**12.81515**	**252.3163***	**13.85949***	**15.36507**	**14.30810***
4	−134.244	**9.155172**	**294.0934**	**13.90242**	**15.76094**	**14.38687**

*İndicates lag order selected by the criterion (each test at 5% level)

econometric significance of the model is further evaluated by examining the existence of serial correlation and varying variance problems in the VAR model.

4. FINDINGS

This study examined the effect of foreign direct investment and labor force participation rate on energy consumption through VAR and VECM models. In the study, first of all, the explanatory statistics and graphics of the series were interpreted, then the stationarity was examined using the unit root test, and data series that is stationary at the same level were used in the analysis.

In the analysis phase, the optimum lag length was determined by creating a VAR model. The suitability of the VAR model produced according to the determined lag length was also proved by examining the inverse roots of the AR characteristic polynomial in terms of serial correlation and varying variance. Then, the existence of a long-term relationship between the series was examined using the cointegration test. In addition, the causal effects of foreign direct investments and labor force participation rate on energy consumption were examined using Granger causality analysis. This effect was estimated and interpreted using the VECM model performed in line with these findings. At the last stage of the analysis, the effect was interpreted in detail using the impulse response function and variance decomposition values.

The descriptive statistics are given in Table 2, and the timeline graph of the series is in Graph 1. According to average values, energy consumption is 104.64, foreign direct investments are 6.32 and the labor force participation rate is 70.53. In addition, according to the Jarque-Berra test, all three series fit the normal distribution. The line graph shows that energy consumption tends to decrease over the years.

Table 5: Serial correlation and varying variance findings for the research model

Residual serial correlation LM tests			
Lag	**LRE* stat**	**df**	**Prob.**
1	6.052360	9	0.7347
2	4.446187	9	0.8797
3	6.351583	9	0.7043
4	9.646466	9	0.3799
Residual heteroskedasticity tests			
Chi-square		**df**	**Prob.**
125.6635		120	0.3435

According to the ADF unit root test findings in Table 3, the X1 and X2 variables are stationary at the first difference and the X3 variable at the second difference level. Following these findings, the analysis used the second difference for all series.

The appropriate lag length criterion findings for the VAR model are given in Table 4. The lag value (3) obtained for the FPE and AIC criteria was taken as the optimum lag value.

The graphical representation of the inverse roots of the AR characteristic polynomial calculated to determine the fitness of the VAR model is given in Graph 2. As explained in the method section, the inverses of all roots were within the unit circle.

Table 6: Cointegration test findings for research series

Unrestricted cointegration rank test (trace)				
Hypothesized No. of CE(s)	**Eigenvalue**	**Trace statistic**	**0.05 Critical value**	**Prob.****
None*	0.710169	48.26927	29.79707	0.0001
At most 1*	0.371919	17.30787	15.49471	0.0264
At most 2*	0.203262	5.680725	3.841466	0.0171
Unrestricted cointegration rank test (maximum eigenvalue)				
Hypothesized No. of CE(s)	**Eigenvalue**	**Max-Eigen statistic**	**0.05 Critical value**	**Prob.****
None*	0.710169	30.96140	21.13162	0.0015
At most 1*	0.371919	11.62715	14.26460	0.1254
At most 2*	0.203262	5.680725	3.841466	0.0171

Table 7: Granger causality analysis findings for research series

Dependent variable	Independent variable	Chi-square	df	Prob.
D2X1	D2X2	8.736629	3	0.0330
	D2X3	6.463657	3	0.0911
	All	21.27631	6	0.0016
D2X2	D2X1	8.197572	3	0.0421
	D2X3	1.581949	3	0.6635
	All	11.21121	6	0.0821
D2X3	D2X1	1.496977	3	0.6830
	D2X2	6.082609	3	0.1077
	All	6.525447	6	0,3670

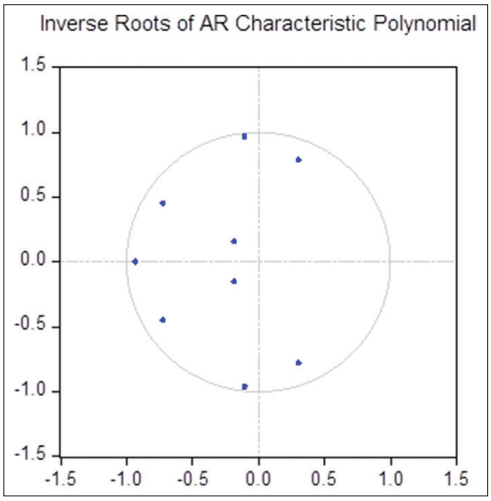
The test findings regarding the serial correlation and varying variance problems are given in Table 5. There were no serial correlation and varying variance problems.

The cointegration test findings for the research series are in Table 6. There are at least three cointegrations according to the Trace statistics and at least one according to the Max-Eigen statistics. The findings show that it is appropriate to analyze the relationship structure between research variables with the VECM model.

The Granger causality analysis findings of the research series are given in Table 7. The Granger causality analysis findings of the research series are given in Table 7. The model, in which energy consumption is taken as dependent and foreign direct investments and labor force participation rate as independent variables, shows that foreign direct investments have a causal effect on energy consumption, while the labor force participation rate has no causal effect. The causal effect of foreign direct investments and labor force participation variables on energy consumption was statistically significant. As in Table 6, the Granger causality analysis findings also show that it would be more accurate to analyze the relationship structure between research variables using the VECM model.

VECM estimation findings are given in Table 8. The first part of the table presents the long-term estimation values, and the second part presents the short-term estimation values. Long-term forecast values show that foreign direct investments have a negative and statistically significant effect, while the effect of labor force participation rate is statistically insignificant. The findings show that 1 point increase in foreign direct investments causes a 1.62 point decrease in energy consumption.

Graph 2: Graph of the inverse roots of the AR characteristic polynomial for the VAR model



The short-term effect findings in the second part show that the three-term lagged value of foreign direct investments has a statistically significant and negative effect. On the other hand, only the two-period lagged value of the labor force participation rate was found to be statistically significant and positive.

The response of the energy consumption variable to the shocks in the variables is given in Table 9. The response of energy consumption to a shock on it is positive in the first period, negative in the second period, and positive in the third period. The shocks in foreign direct investments were positive in the second and third periods and negative in the fourth period. The shocks in the labor force participation rate were positive at the end of the third period and negative at the end of the fourth period.

The variance decomposition findings of the energy consumption variable are given in Table 10. In the first period, all variance decomposition is on itself. However, at the end of the tenth period, 38.67% of the decomposition is on its own, 20.89% is on foreign direct investments and 40.44% is on the labor force participation rate.

Table 8: VECM estimation findings

Cointegrating Eq	Coint. Eq1		
	Estimate	SE	t-stat.
D2X1(-1)	1.000000		
D2X2(-1)	−1.61692	0.45051	−3.58906
D2X3(-1)	1.030915	3.28291	0.31402
C	−0.100174		

Error correction	D(D2X1)			D(D2X2)			D(D2X3)		
	Estimate	SE	t-stat.	Estimate	SE	t-stat.	Estimate	SE	t-stat.
CointEq1	−2.57519	0.76368	−3.37207	−1.331432	0.45854	2.90362	−0.071559	0.04412	−1.62183
D(D2X1(-1))	0.738155	0.62940	1.17279	−1.137643	0.37791	−3.01032	0.051787	0.03636	1.42413
D(D2X1(-2))	0.104905	0.37101	0.28276	−0.995947	0.22277	−4.47081	0.024021	0.02144	1.12064
D(D2X1(-3))	−0.07912	0.17781	−0.44498	−0.492996	0.10676	−4.6177	0.007427	0.01027	0.72299
D(D2X2(-1))	−3.43453	1.13330	−3.03056	0.362469	0.68047	0.53267	−0.101987	0.06548	−1.5576
D(D2X2(-2))	−1.93769	0.87637	−2.21105	0.136197	0.52620	0.25883	−0.055038	0.05063	−1.08701
D(D2X2(-3))	−0.87006	0.41877	−2.07766	0.026380	0.25145	0.10491	−0.000296	0.02419	−0.01221
D(D2X3(-1))	3.046809	4.96431	0.61374	3.662294	2.98075	1.22865	−0.837958	0.28682	−2.92158
D(D2X3(-2))	11.16571	4.67025	2.39081	4.609453	2.80418	1.64378	−0.620526	0.26983	−2.29972
D(D2X3(-3))	1.558980	5.60397	0.27819	−1.278511	3.36482	−0.37996	−0.811863	0.32377	−2.5075
C	0.698343	1.41362	0.49401	0.230837	0.84879	0.27196	0.032788	0.08167	0.40145
R-squared	0.929929			0.940087			0.686661		
Adj. R-squared	0.879878			0.897292			0.462848		
F-statistic	18.57963			21.96724			3.068008		
Log likelihood	−76.7277			−63.97518			−5.448046		
Akaike AIC	7.018218			5.998014			1.315844		
Schwarz SC	7.554523			6.534320			1.852149		

Table 9: The response of energy consumption

Period	D2X1	D2X2	D2X3
1	6.959305	0.000000	0.000000
2	−4.64327	2.855542	0.149226
3	3.106131	2.081689	4.376872
4	−1.07623	−2.04088	−4.92804
5	3.820703	3.418787	1.540803
6	0.860251	−2.73433	−0.43292
7	−0.16724	4.127759	5.039229
8	0.791352	0.359765	−4.91127
9	1.853081	0.956850	2.384980
10	−0.18446	0.521715	−1.9021

Table 10: Variance decomposition findings of energy consumption variable

Period	SE	D2X1	D2X2	D2X3
1	6.959305	100.0000	0.000000	0.000000
2	8.841284	89.54002	10.43150	0.028488
3	10.55020	71.54996	11.21904	17.23101
4	11.87080	57.33793	11.81750	30.84457
5	13.02213	56.25567	16.71278	27.03155
6	13.34091	54.01514	20.12441	25.86045
7	14.84722	43.62366	23.97740	32.39893
8	15.66257	39.45529	21.59874	38.94597
9	15.97979	39.24913	21.10827	39.64260
10	16.10211	38.66821	20.89377	40.43801

5. CONCLUSION AND RECOMMENDATIONS

Energy consumption is one of the most important economic indicators. Therefore, it is essential to determine the variables affecting energy consumption, both for the economic life in a country and scientific literature. This study examines the impact of foreign direct investment and labor force participation on energy consumption as possible factors. Our findings show that, for Kazakhstan, foreign direct investment affects energy consumption in both the long and the short term. Although the labor force participation rate is effective on energy consumption in the short term, it does not seem effective in the long term. This is important as it shows the long-term indirect effects of foreign direct investments on the economy. The study used annual data series for all three variables. Another important subject of study for explaining this relationship may be the use of series in different periods (especially quarterly).

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