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Energy, Urbanization, and Sustainability Indicators: Empirical Data from Kazakhstan

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ABSTRACT

The sustainable strategies are required by integrating energy, urbanization and environmental factors for sustainable development-maximizing human well-being in the current time without depriving future generations to meet their needs. This paper intends to identify the short-run and long-run causal relationship between Kazakhstan's sustainability indicators (CO_2 emissions and solid waste), urbanization, economic development, and energy. Time-series data for the years 1990 to 2021 have been used in the paper; the data have been derived from the World Bank database. The methodology of this paper applies the Vector Error Correction Model based on the various econometric techniques such as Panel Unit Root Test, Granger Causality Test, Johansen Cointegration Test. The results of the Granger Causality Test confirms that a causal relationship has CO_2 emissions from GDP, waste from population as share of urban population and a weak dependence on energy consumption, but on the contrary CO_2 emissions affect energy consumption and a similar interrelation of urbanization with CO_2 emissions. The empirical finding of Johansen Cointegration Test indicates that there is evidence that, in the long term, both urbanization and energy consumption contribute to CO_2 emissions in Kazakhstan and in addition, the results demonstrate that urbanization contribute to energy consumption (it statistically significant as its absolute t-value is 3.89 >2). Results of Vector Error Correction Model confirm that explanatory variables are statistically significant in the long run. Therefore, policies are required to reduce the effects of urbanization by boosting public instruments to preserve environmental quality and use more energy in sustainable manner. In addition, regulations for energy conservation are required across all industries, but particularly in the transportation and energy sector. These policies must also promote and maximize the use of alternative energy sources.

Keywords: Energy Consumption, Urbanization, CO_2 Emissions, Empirical Data, Kazakhstan
JEL Classifications: P18, P28, Q43

1. INTRODUCTION

According to World Bank data, Kazakhstan demonstrates positive economic growth from 1991 to 2021, with an average growth rate of 4.5% (WB, 2022). This is consistent with increase in the urban population, which averaged 3.7% (UN, 2022), energy consumption, which was 6.7%, and CO_2 emissions, which were 4.1% annually (Figures 1-4). Such situation has led to environmental degradation and increase of climate temperature across all regions of Kazakhstan (Karatayev et al., 2022). In line with the Kyoto Protocol and Paris Agreement, Kazakhstan's economy has been growing for the past 20 years and has made obligations to cut greenhouse gas emissions and develop renewable energy sector (Karatayev et al., 2021; Zhakiyev et al., 2022). This requires making trade-offs between the long-term sustainability of the economy, the quality of the environment (Karatayev and Hall, 2017), and the efficient use of energy (Kelesbayev et al., 2022). With 17.3 tons per person, Kazakhstan had the highest emissions in 2021 (ADB, 2022). 82% of Kazakhstan's total emissions of greenhouse gases are related to the generation of energy (Koshim et al., 2018; Moldabekova et al., 2022). As part of the collaboration for market preparedness of the trust fund, the international organizations have been offering Kazakhstan technical assistance to promote the implementation of carbon trading scheme and necessary measures to mitigate climate change (UNDP, 2021, Darke et al., 2022). The nation adopted the idea of a green economy transition (Alibekova et al., 2019; Grabara et al., 2021), which entails actions to increase energy efficiency, create renewable energy sources, reduce air pollution, and change public attitudes to green energy systems etc. (Rivotti et al., 2019; Tulaganov et al., 2022; Tishkov et al., 2022).

Figure 1: GDP growth from 1990 to 2021, in USD

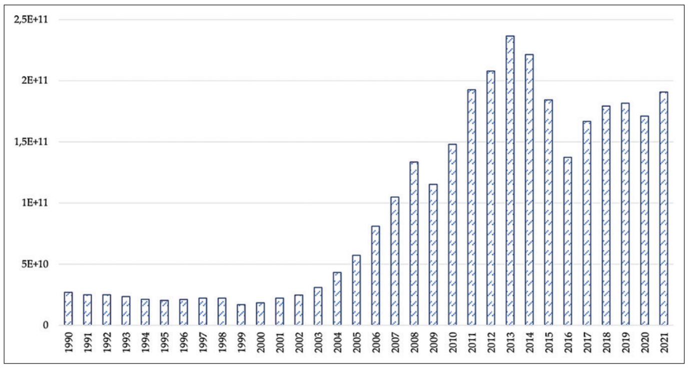
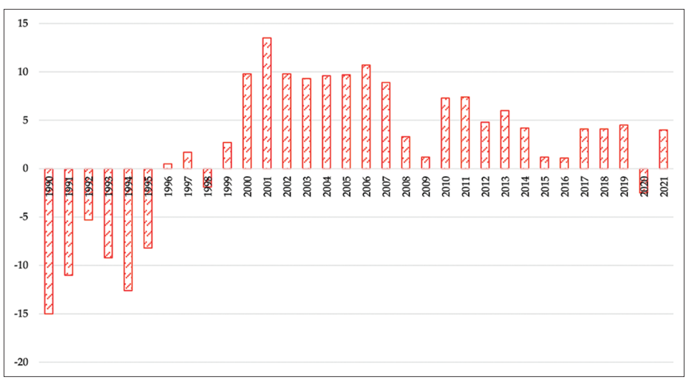


Figure 2: GDP growth from 1990 to 2021, in %



Along with greenhouse gas emissions (Figures 5-7), the problems of formation and accumulation of municipal solid waste in Kazakhstan are among the most acute environmental issues (Abylkhani et al., 2021). In Kazakhstan, today the volume of accumulated municipal solid waste is more than 100 million tons (WB, 2022). At the same time, 5-6 million wastes are generated in the country every year. Until 2030, their volume will gradually increase and approach the mark of 8 million tons annually (Smagulova, 2022). Since the 20th century, a colossal amount of persistent organic pollutants has been accumulated in the country. The country has accumulated about 31.6 billion tons of industrial waste (Noya et al., 2018) and about 1 billion tons are formed annually (Smagulova et al., 2015). These are mainly technogenic mineral formations. Harmful compounds cause enormous damage to the environment (Valeyev et al., 2019).

Regarding urbanization (Figure 8), the cities of Kazakhstan were formed in the Soviet years as a result of industrialization, the discovery and development of minerals, the development of virgin lands, and transport construction (Gentile, 2004). From 1920 to 1983, the number of cities grew from 19 to 82 (Nyussupova et al., 2017). A characteristic feature of urban development was the predominance of small towns. In 2021, out of 87 cities, 60 are small towns with a population of up to 50 thousand inhabitants, in which about 1.4 million people live (Nyussupova and Rodionova, 2011). The forecast scheme of the territorial and spatial development of the country places emphasis on the development of agglomerations (Junussova and Beimisheva, 2021). The basis of the Forecast Scheme of the Country's Territorial and Spatial Development until 2050 was the thesis of the dependence of economic growth on concentration (Rowland, 2001). According to data, the economic density of Kazakhstan is significantly inferior to the economic density of such countries of Eastern Europe as Hungary, Poland, as well as CIS countries like Russia. The formation of agglomerations will become a key form of territorial organization of Kazakhstan with a low population density (Aringazina et al., 2012). By

Figure 3: Fossil fuel energy consumption from 1990 to 2021, in % of total

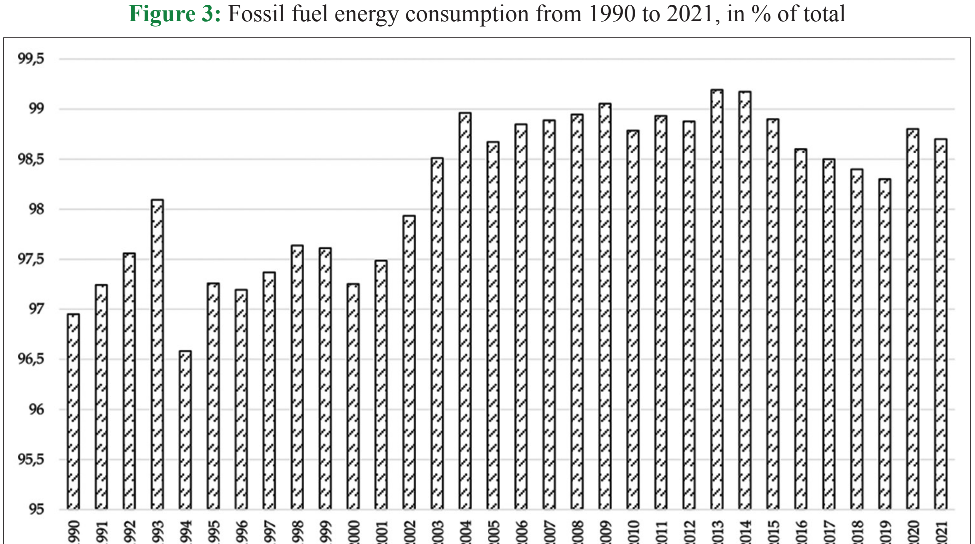


Figure 4: Electric power consumption from 1990 to 2021, in kWh per capita

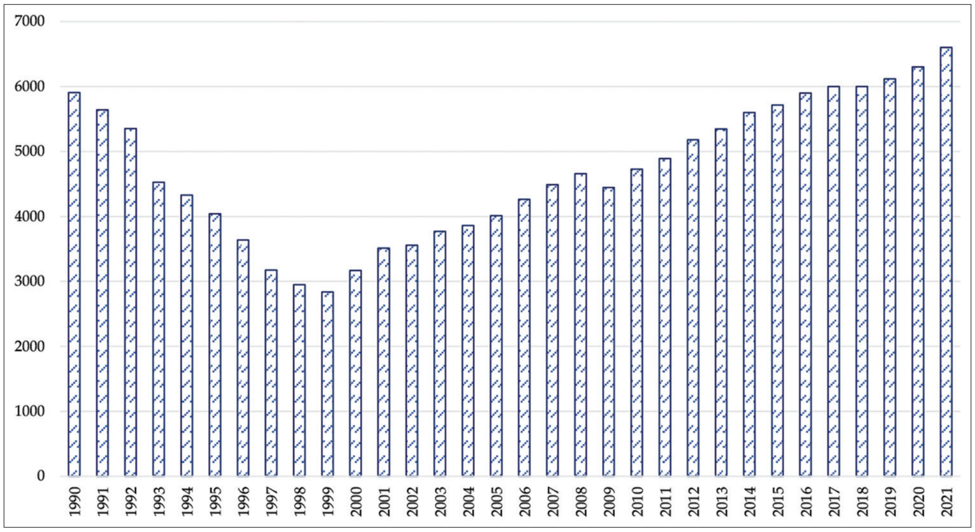


Figure 5: CO_2 emissions dynamics from 1990 to 2021, in kiloton

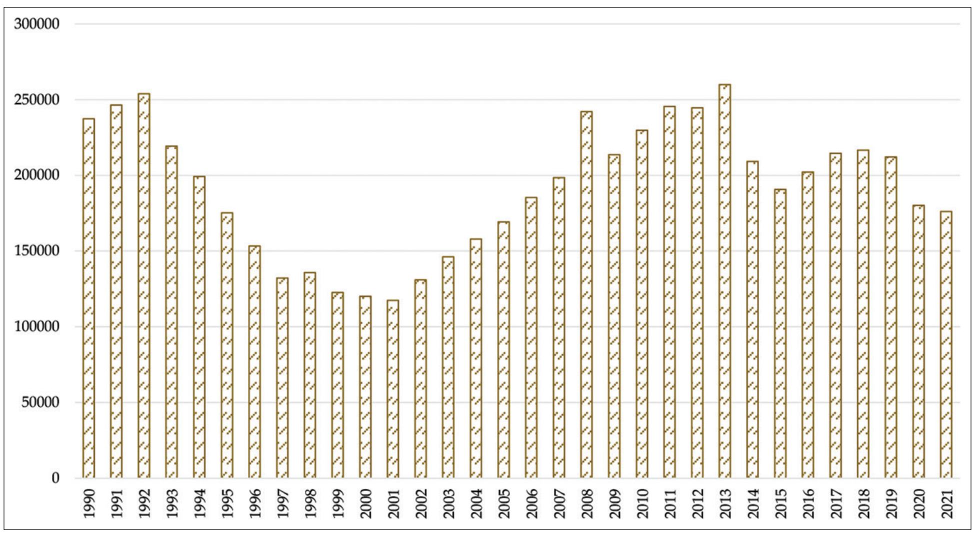
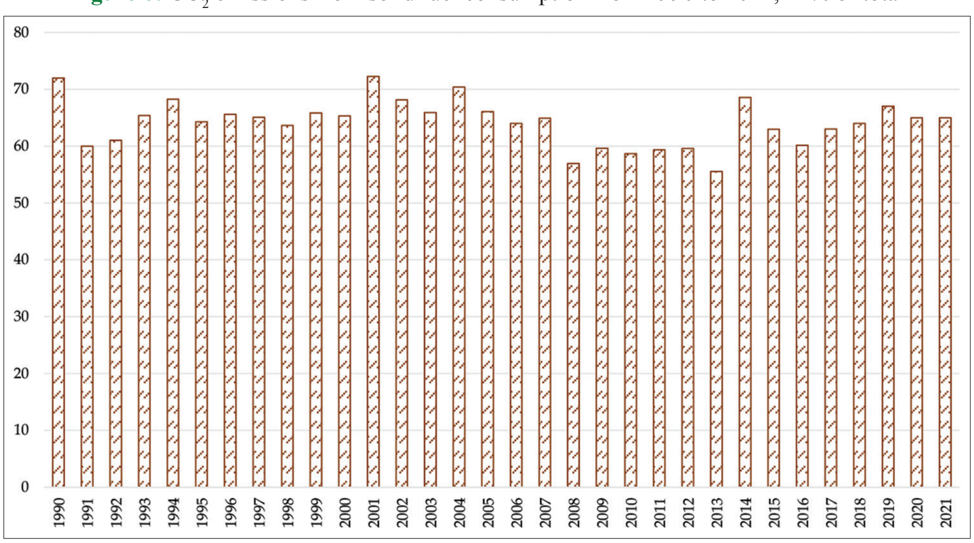


Figure 6: CO_2 emissions from solid fuel consumption from 1990 to 2021, in % of total



2040, 75% of the population will live in cities, the government believes (Nyussupova and Sarsenova, 2012). The government is trying to influence urbanization through the adoption of new programs (Spankulova et al., 2020). Recommendations in the

Figure 7: Solid waste growth from 1990 to 2021, in %

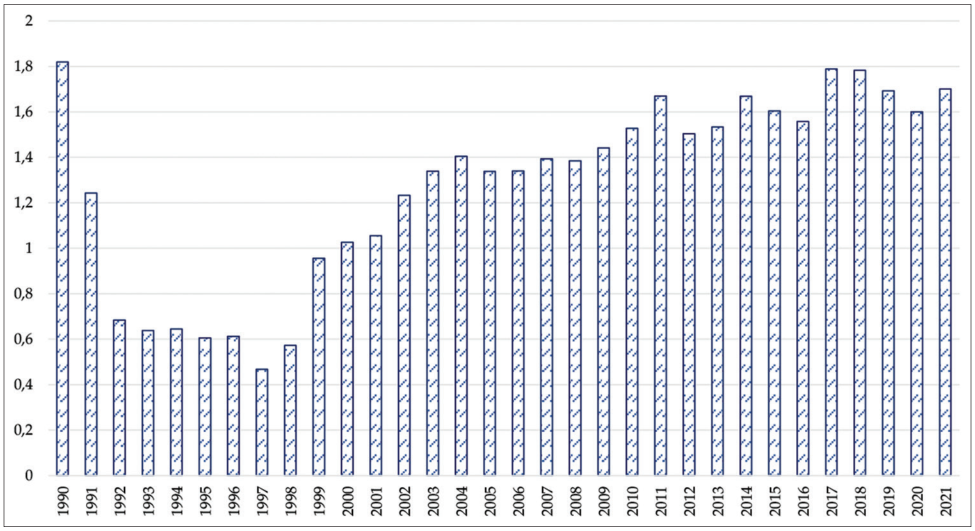
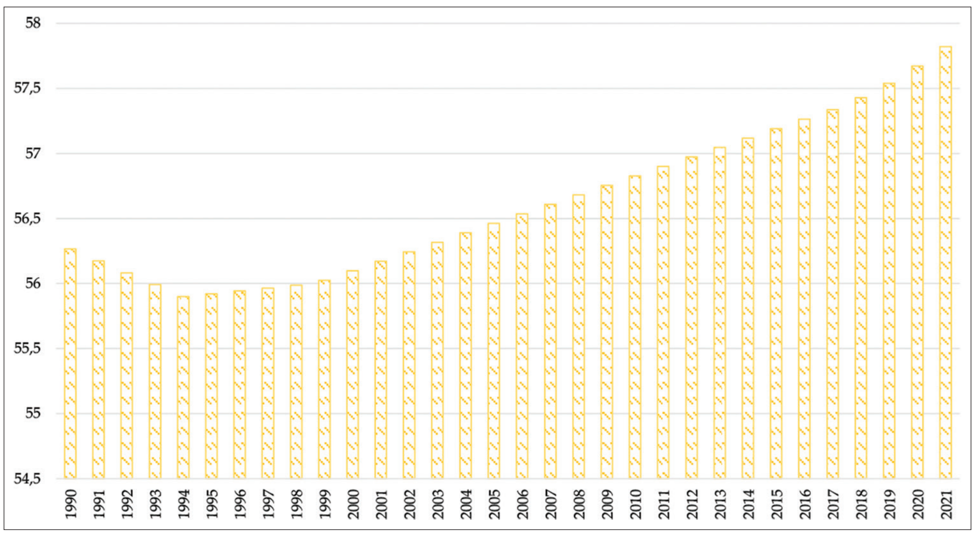


Figure 8: Urban population growth from 1990 to 2021, in % of total population



field of urbanization policy and development of the territory were proposed by various international development organizations, most likely, almost all of them remain relevant (Rowland, 1999). As for the situation of changing priorities in the policy of territorial development, one main idea arises here: world experience shows that economic development in the modern world is somehow connected with a high level of urbanization, that is, Kazakhstan needs to increase the pace of urbanization, since it has been observed for almost 30 years. In post-Soviet Kazakhstan, the dynamics says that even by 2040 the level of urbanization will reach 75% (Sidorenko et al., 2018).

Discussions concerning the current ecological constraints harming the environment among economists served as the inspiration for this study. The goal of this paper is to examine the long- and short-term relationships between energy consumption, economic growth, investment, urbanization, and environmental indicators (CO_2 emissions and solid waste) in Kazakhstan because there is currently a dearth of empirical data there. This paper adds to the body of knowledge in the field of energy economics and is anticipated to help formulate green economic policies in the design of future environmental policies. The research techniques that will address the study objectives are discussed and provided in the next section. The analysis and discussion of the research findings are presented in the third section. Conclusion is presented in the last part.

2. LITERATURE REVIEW

There are a large number of publications empirically explaining the cause-and-effect relationship between economic growth, energy consumption and environmental impact (Jafari et al., 2012; Tong et al., 2020). The environmental Kuznets curve postulates that the relationship between economic growth and CO_2 emissions is non-linear and takes the form of an inverted U (Cole et al., 1997; Dinda, 2004). This means that as per capita income increases, environmental degradation first increases and then as a certain level of wellbeing is achieved, it begins to decline (Shahbaz et al., 2013). As economic growth begins, starting with a low level of development and incomes in the country, nature exploiting sectors, the extensive use of natural resources in the extractive industry, agriculture and forestry, etc., come to the fore (Andreoni and Levinson, 2001). All this leads to a further depletion of natural resources and environmental pollution. Existing studies, including investigated the relationship between incomes and emissions and confirmed the existence of environmental Kuznets curve (Harbaugh et al., 2002). Recently, various studies have confirmed the Kuznets curve using data for ASEAN countries (Lean and Smyth, 2010); Central America and the Commonwealth of Independent States (Apergis and Payne, 2010); BRIC countries (Pao and Tsai, 2010); Denmark and Italy (Acaravci and Ozturk, 2010); Russia (Pao et al., 2011); and for 138 developing and developed countries (Wang, 2013).

However, there are other dimensions taking into account for environmental curve. For example, in the case of the United States, Soytas and Sari (2009) explored the dynamic relationship between CO_2 emissions, incomes and energy consumption. Their results showed that CO_2 emissions are Granger cause of income, and energy consumption contributes to CO_2 emissions. Similar research was conducted for France (Ang, 2007) and Malaysia (Ang, 2008). The results showed that economic growth is Granger cause of energy consumption and carbon emissions in France and in Malaysia; unidirectional causality is associated with economic growth and energy consumption. Chebbi (2010) collected data from Tunisia to investigate the causal relationship between energy consumption, income and CO_2 emissions. Empirical evidence suggests that energy consumption stimulates economic growth, which is Granger causing CO_2 emissions. Chang (2010) applied a multidimensional causality criterion to study the causal relationship between economic growth, energy consumption and CO_2 emissions using data from time series for China. The results of the study showed that economic growth is Granger cause of energy consumption, which leads to CO_2 emissions. Using data from Turkey, Halicioglu (2009) also reported a feedback hypothesis between economic growth and CO_2 emissions. In the case of South Africa, Menyah and Wolde-Rufeal (2010) concluded that energy consumption is Granger cause of CO_2 emissions, and as a result economic growth is Granger cause CO_2 emissions. Similarly, Alam et al. (2011) examined the relationship between energy consumption, economic growth and energy pollutants in the case of India. Their empirical data revealed a bi-directional causal relationship between energy consumption and CO_2 emissions, while there is a neutral hypothesis between CO_2 emissions and economic growth. In the case of Bangladesh, Alam et al. (2012) discovered a causal relationship between these variables and suggested that the variables are cointegrated for a long time. The analysis suggests a feedback hypothesis between energy consumption and CO_2 emissions, while unidirectional causality is associated with CO_2 emissions and economic growth. For the case of Greece, Hatzigeorgiou et al. (2011) applied the Granger causality test to investigate the causal relationship between energy intensity, income and CO_2 emissions using the Johansen multi-dimensional cointegration method. Their results concluded that there is a long-term relationship between the data. An analysis of the causal relationships showed that unidirectional causality is associated with economic growth towards energy intensity and CO_2 emissions.

In other series of energy economic literature, Tamazian et al. (2009) turned attention to testing the effects of other potential determinants of CO_2 emissions, such as economic, institutional, financial variables. Tamazian et al. (2009) investigated the impact of economic development and financial development on CO_2 emissions in the case of Brazil, Russia, India, China, the United States and Japan and then studied the impact of institutions on CO_2 emissions. The empirical evidence suggests that economic development, trade openness, financial development, and institutions play a role in controlling the environment from degradation, while simultaneously supporting the existence of the environmental Kuznets hypothesis. In addition, Claessens and Feijen (2007) explored the role of management in reducing CO_2 emissions and reported that with the help of better management, enterprises reduce the growth of CO_2 emissions. The financial development spur firms through the introduction of energy efficient technologies that reduce carbon emissions. In the case of China, Yuxiang and Chen (2010) argued that financial sector policies allow firms to use advanced technologies that emit less CO_2. Yuxiang and Chen (2010) argued that financial development promotes capitalization and financial regulation, which contributes to environmental quality. Jalil and Feridun (2010) checked the effect of economic growth, energy consumption and financial development on carbon emissions in the case of China. They revealed that energy consumption, economic growth and trade openness are harmful to the quality of environment. In contrast, financial development and foreign direct investment save the environment from degradation.

There was strong evidence of the influence of output growth on energy consumption growth in both the short-and the long-run. In another study for Malaysia, Husaini and Lean (2015) found a long-run relationship between electricity consumption, output, and prices in Malaysia. They found long-run unidirectional causality from manufacturing output to electricity consumption and a short-run unidirectional relationship from electricity consumption to output. A unidirectional causal relationship between carbon emissions and economic growth means that we have to sacrifice economic growth to reduce energy pollution. An effective energy policy must be implemented that cannot have a detrimental effect on economic growth if economic growth is Granger cause of carbon emissions. Thus, CO_2 emissions can be reduced without reducing economic growth. Environmental policy can be adopted to improve the environment quality. If there is no causal relationship between income and CO_2 emissions, then environmental policy does not adversely affect economic growth. But reducing CO_2 emissions can have negative impact on economic growth, if there is a feedback hypothesis between both variables. The existing literature review was not able to provide full information for assessing the relationship between the indicators of greenhouse emissions and economic growth in Kazakhstan, which was the reason for conducting this study. This study is an attempt to fill the gap in research in relation to Kazakhstan on the regulation of energy efficiency processes based on an analysis of the impact on economic growth and sustainable development of the country.

3. PRE-ANALYSIS METHODOLOGY

3.1. Data

This paper focuses on examining the long-and short-term interactions between Kazakhstan's energy consumption, economic development, investment, urbanization, and environmental indicators (CO_2 emissions and solid waste). The observation period for the time series data, which were used, is 1991 to 2021. The World Development Indicators database on the official World Bank website served as the data sources.

3.2. Empirical Model Specification

The model explores the relationship between economic growth, energy consumption, urban development, investment and environment indicators (CO_2 emissions and solid waste) using annual data of Kazakhstan since 1990. The general form of empirical model for CO_2 can be expressed as:

$$C=f(E,Y,I) \quad (1)$$

The general form of empirical model for solid waste can be expressed as:

$$W=f(I,U) \quad (2)$$

all the series are translated into logarithms to attain direct elasticities. The empirical equation is modelled as follows:

$$lnC_i = \alpha_0 + \alpha_1 lnE + \alpha_2 lnY + \alpha_3 lnI + \varepsilon_i \quad (3)$$

And

$$lnW_i = \alpha_0 + \alpha_1 lnI + \alpha_2 lnU + \varepsilon_i \quad (4)$$

Where *C*- CO_2 emissions per capita, *E* - energy consumption per capita, *F* - foreign direct investment, *Y* - GDP per capita is used as an indicator of economic growth, *U* - percentage of urban population, ε_i - error term assumed to be normally distributed with zero mean and constant variance. It is presumed that $\alpha_1 > 1$ a rise in energy intensity will increase carbon emissions and $\alpha_2 > 0$ an increase in economic growth with urban population is linked with high CO_2 emissions and solid waste.

3.3. Panel Unit Root Test

This study employs augmented Dickey-Fuller (ADF) unit root test. The ADF test that has been developed to test univariate time series for the presence of unit roots or non-stationarity. The extended maintained regression used in the ADF test can be expressed in its most general form as:

$$\Delta Y_t = \mu + \gamma Y_{t-1} + \sum_{j=1}^{p} \pm_j \Delta Y_{t-j} + \beta t + ɰ_t \quad (5)$$

Where ΔY_t represents the first difference of *Y*, μ is the drift term, t denotes the time trend, and *p* is the largest lag length used. The null and alternative hypothesis for unit root in variables Y_t is: H_0: $\gamma = 0$ and H_1: $\gamma < 0$ if the null hypothesis is not rejected, then there is a problem of unit root in the series.

3.4. Granger Causality Test

To study the causal relationship between the selected variables, the Granger test was used. The idea of the test is as follows: If changes in variable A cause changes in B, then changes in A precede changes in B. As a result of the Granger test, the null hypothesis "A is not the cause of change B" is tested. The criterion for accepting a hypothesis is P-value. If the $P < 0.05$, then the null hypothesis is rejected. At the same time, the presence of the opposite causal relationship is also checked. The presence of a two-sided causal relationship indicates the existence of a third variable, which is the real cause of the change in the two variables under consideration.

3.5. Johansen Cointegration Test

Economic time series may wander through time, that is, may have the characteristic of nonstationary in their level, there may exist some linear combination of these variables that converges to a long run relationship over time. If the series individually are stationary only after differencing but one finds that a linear combination of their levels is stationary, then the series are said to be cointegrated. Johansen (1988) and Johansen and Juselius (1990) full information maximum likelihood of a Vector Error Correction Model is as follows:

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta y_{t-i} + \mu + \varepsilon_t \quad (6)$$

Where, y_t is *a* (*n x l*) vector of the *n* modeled variables of interest, *μ* is *a* (*n x l*) vector of constants, Γ_i represents *a* (*n x* (*k–l*)) matrix of short-run coefficients, ε_t denotes *a* (*n x l*) vector of white noise residuals, and *Π* is *a* (*n x n*) coefficient matrix. If the matrix *Π* has reduced rank ($0 < r < n$), it can be split into *a* (*n x r*) matrix of loading coefficients α, and *a* (*n x r*) matrix of cointegrating vectors β. If *Π* is of zero rank (i.e., all the eigenvalues are not significantly different from zero), there is no cointegration, otherwise, the rank will give the number of cointegrating vectors.

Johansen Cointegration Test allows the testing of hypotheses by considering them effectively as restrictions on the cointegrating vector. The first thing to note is that all linear combinations of the cointegrating vectors are also cointegrating vectors. Therefore, if there are many cointegrating vectors in the unrestricted case and if the restrictions are relatively simple, it may be possible to satisfy the restrictions without causing the eigenvalues of the estimated coefficient matrix to change at all. The test statistic for testing the validity of these restrictions is given by:

$$-T\sum_{i=r+1}^{p}\left[\ln\left(1-\lambda_i^*\right)-\ln(1-\lambda_i\right] \sim \chi^{2(p-r)} \quad (7)$$

Where λ_i^* are the characteristic roots (eigenvalues) of the restricted model; λ_i are the characteristic roots (eigenvalues) of the unrestricted model; *r* is the number of non-zero (eigenvalues) characteristic roots in the unrestricted model; *p* is the number of variables in the system.

4. MAJOR EMPIRICAL FINDINGS

4.1. Granger Causality Test

The results of the Granger test are presented in Table 1. From the presented data it is clear that the direct ($m = 2$) is a causal relationship has CO_2 emissions from investment and GDP, waste from investment and population as share of urban population and a weak dependence on energy consumption, but on the contrary CO_2 emissions affect energy consumption and a similar interrelation of urbanization with CO_2 emissions.

4.2. Unit Root Test

The result of unit root test shows that all the five variables are non-stationary at the 5% level of significance (Table 2). Further, we investigated first-order difference series for all non-stationary series for stationarity. As the test results show, at first difference the variables are stationary. This implies that energy consumption, economic growth, CO_2, investment, solid waste and urbanization are integrated of order one.

4.3. Johansen Cointegration Test

Cointegration among the variables of model carbon emission is explored and the results are presented in Tables 3 and 4. Maximal Trace statistics is 59.4, which is greater than the 95% critical value of 40.175. Other the Max-Eigen test exhibits that statistics is 35.5, which is greater than the 95% critical value of 24.159. This implies that the null hypothesis r = 0 is rejected at 5% level of significance. The results for r ≤ 1, r ≤ 2, r ≤ 3 and r ≤ 4 shows that the null hypotheses cannot be rejected. As a result, the trace test and the maximum Eigen test detected the existence of a single cointegrating vector. Therefore, the study concludes that there is a long run relationship between energy consumption, CO_2 emissions, economic growth, investment.

From the obtained equations of cointegration, we have separated the equation:

$$\begin{aligned} \mathrm{LNCO}_2 &= 0.151\,LNINVESTMENT + 0.0725\,LNECONS \\ Se \quad & \quad (0.0388) \qquad\qquad (0.0199) \\ & + 0.326\,LNGDP \\ & \quad (0.0156) \end{aligned} \tag{8}$$

The dependent variable is CO_2 as carbon emission in model. The positive and negative signs of coefficients show the impact of independent variables on the dependent variable. The coefficient of LNGDP is positive as 0.33 and statistically it is significant as its absolute t-value is 20.9. Its coefficient value indicates that the GDP does add to carbon emission in long run. The coefficient of GDP suggests that a 1% increase in per capita GDP will lead to increase the per capita carbon emission by 0.33%.

The energy consumption (LNECONS) has positive coefficient as 0.07 and statistically it is significant as its absolute t-value is 3.64 which implies that the energy does contribute to the carbon emission in long run. Due to the positive coefficient of LNENUSE it is suggested that a 1% increase in energy consumption per capita tends to increase the carbon emission by 0.07%. In case of investment flows (LNINVESTMENT) the coefficient is positive and statistically it is significant as its value is 0.15. It implies that a 1% increase in foreign investment will raise per capita carbon emission by 0.15% in the long run as result capital flows are invested in primary industries with a high negative impact on the environment. It statistically significant as it's absolute t-value is 3.89 > 2.

Cointegration among the variables of solid waste is explored using the Johansen cointegration test and the results are presented in Tables 5 and 6. Maximal Trace statistics is 43.2, which is greater

Table 1: Granger-causality test

Null Hypothesis	F-statistic	Prob.
INVESTMENT does not granger cause CO_2	3.5535	0.0772
CO_2 does not granger cause INVESTMENT	1.0191	0.4810
ECONS does not granger cause CO_2	1.71253	0.2161
CO_2 does not Granger Cause ECONS	0.5301	0.5992
GDP does not granger cause CO_2	3.3255	0.0879
CO_2 does not granger cause GDP	0.78089	0.3885
URBAN does not granger cause WASTE	6.3849	0.0830
WASTE does not granger cause URBAN	0.3631	0.7224
INVESTMENT does not granger cause WASTE	6.0964	0.0877
WASTE does not Granger cause INVESTMENT	0.9953	0.4661

Table 2: Unit root tests

Variables	ADF Unit root test		PP Unit root test		Integration order
	Level	First difference	Level	First difference	
$lnCO_2$	0.142	−2.573	0.043	−3.196	I (1)
lnInvestment	−2.453	−7.187	−2.323	−7.187	I (1)
lnECONS	−0.691	−3.506	0.148	−3.587	I (1)
lnGDP	0.47	−3.005	0.233	−3.006	I (1)
lnW	−3.223	−5.183	−2.020	−3.643	I (1)
lnUrban	−0.749	−9.626	2.133	−6.882	I (1)

Table 3: Cointegration rank test (trace)

Hypothesized	Trace			
No. of CE (s)	Eigenvalue	Statistic	Critical Value	Prob.
None*	0.845606	59.40562	40.17493	0.0002
At most 1	0.534774	23.90895	24.27596	0.0556
At most 2	0.334051	9.369530	12.32090	0.1486
At most 3	0.082947	1.645217	4.129906	0.2344

Trace test indicates 1 cointegrating equations at the 0.05 level

Table 4: Cointegration rank test (maximum eigenvalue)

Hypothesized	Max-Eigen			
No. of CE (s)	Eigenvalue	Statistic	Critical Value	Prob.
None*	0.845606	35.49667	24.15921	0.0010
At most 1	0.534774	14.53942	17.79730	0.1447
At most 2	0.334051	7.724312	11.22480	0.1928
At most 3	0.082947	1.645217	4.129906	0.2344

Max-eigenvalue test indicates 1 cointegrating equations at the 0.05 level

Table 5: Cointegration rank test (trace)

Hypothesized	Trace			
No. of CE (s)	Eigenvalue	Statistic	Critical value	Prob.
None*	0.907824	43.20102	24.27596	0.0001
At most 1	0.474575	9.824191	12.32090	0.1265
At most 2	0.056521	0.814532	4.129906	0.4229

Trace test indicates 1 cointegrating equations at the 0.05 level

Table 6: Cointegration rank test (maximum eigenvalue)

Hypothesized	Max-Eigen			
No. of CE (s)	Eigenvalue	Statistic	Critical Value	Prob.
None*	0.907824	33.37683	17.79730	0.0001
At most 1	0.474575	9.009659	11.22480	0.1196
At most 2	0.056521	0.814532	4.129906	0.4229

Max-eigenvalue test indicates 1 cointegrating equations at the 0.05 level

than the 95% critical value of 24.28. Other the Max-Eigen test exhibits that statistics is 33.38, which is greater than the 95% critical value of 17.8. This implies that the null hypothesis r = 0 is rejected at 5% level of significance. But the results for $r \leq 1$, $r \leq 2$, $r \leq 3$ and $r \leq 4$ shows that the null hypotheses cannot be rejected. As a result, the trace test and the maximum Eigen test detected the existence of a single cointegrating vector. Therefore, the study concludes that there is a long run relationship between solid waste, foreign direct investment and level of urbanization.

The dependent variable is waste as carbon emission in model. The positive and negative signs of coefficients show the impact of independent variables on the dependent variable. From the obtained equations of cointegration, we have separated the equation:

$$\begin{aligned} LNWASTE &= 0.234\ LNINVESTMENT + 1.889\ LNURBAN \\ Se \quad & \qquad (0.0249) \qquad\qquad (0.0140) \end{aligned} \tag{9}$$

The coefficient of LNINVESTMENT is positive as 0.234 and statistically it is significant as its absolute t-value is 9.4. Its coefficient value indicates that the GDP does add to carbon emission in long run. The coefficient of GDP suggests that a 1% increase in per capita GDP will lead to increase the waste by 0.234%.

5. CONCLUSION

The relationship between Kazakhstan's energy use, economic expansion, investment, urbanization, and environmental indicators (CO_2 emissions and solid waste) is comprehensively covered in this paper. Interesting findings from this study suggest that short-term urbanization and energy use may contribute to CO_2 emissions. According to estimates, urbanization will contribute a significant amount of CO_2 emissions during the next 10 years, or 53.2%, while energy use will contribute 48.4% to CO_2 emissions. In addition, there is evidence that short-term urbanization can increase energy consumption, which shows that short-term urbanization is unmanageable due to ineffective urbanization strategies. Urban dwellers are said to have the power to alter the environment's quality through lifestyle choices including production and consumption, which result in a variety of waste products that might harm the ecosystem. As a result, Kazakhstan continues to utilize a lot of fossil fuels, particularly in the areas of industry, power, and transportation. There is no connection between CO_2 emissions and economic growth in the short term. Although CO_2 emissions, energy use, and economic growth have no significant impact on urbanization, this shows that hopes for a better life, such finding employment and improved city amenities and infrastructure, are more important driving forces. Additionally, there is no proof that CO_2 emissions, urbanization, or energy consumption have a long-term impact on economic growth, suggesting that these variables cannot accurately predict changes in economic growth in the short term due to Kazakhstan's economic growth being driven by foreign direct investment, trade openness, and public spending. Additionally, the paper informs decision-makers about the connections in Kazakhstan between environmental indicators (CO_2 emissions and solid waste) and energy consumption, economic development, investment, and urbanization. Urbanization has long-term effects beyond just rising CO_2 emissions and energy use. As a result, measures are required to reduce the effects of urbanization through intense awareness-raising in order to preserve environmental quality and promote increased energy use. In addition, regulations for energy conservation are required across all industries, but particularly in the ones of transportation, industry, and power. These policies must also promote and maximize the use of alternative fuels.

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