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Analysis of the Effect of Renewable Energy Consumption and Industrial Production on CO_2 Emissions in Turkic Republics by Panel Data Analysis Method

Ainur Yergazievna Yesbolova[1], Tolkyn Abdulova[2], Murat Nurgabylov[3], Sapargul Yessenbekova[4], Svetlana Turalina[5], Gulnara Baytaeva[6]*, Kundyz Myrzabekkyzy[7]

[1]M.Auezov South Kazakhstan University, Shymkent, Kazakhstan, [2]Zhangir Khan West Kazakhstan Agrarian-Technical University, Uralsk, Kazakhstan, [3]International Taraz innovative institute named after Sherhan Murtaza, Taraz, Kazakhstan, [4]Peoples' Friendship University named after Academician A. Kuatbekov, Shymkent, Kazakhstan, [5]Tashenov University, Shymkent, Kazakhstan, [6]Zhetysu University named after I. Zhansugurov, Taldykorgan, Kazakhstan, [7]Khoja Akhmet Yassawi International Kazakh-Turkish University, Turkestan, Kazakhstan. *E-mail: gulnarabaytaeva@gmail.com

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ABSTRACT

This study aims to analyze the impact of energy consumption and industrial production on CO_2 emissions in the Turkic Republics using the Panel Data method for the period 2000-2020. However, Turkmenistan was excluded from the analysis because the relevant data could not be accessed. Data from Kazakhstan, Azerbaijan, Kyrgyzstan, and Uzbekistan were analyzed. CO_2 emission creates problems in terms of environment and sustainability and is a parameter that all countries and international organizations carefully monitor and try to reduce. Using panel data regression, this study examined whether renewable energy and industrial production and countries impact CO_2 emissions. The findings revealed that as renewable energy consumption increases, CO_2 emissions decrease. However, the effect of industrial production on CO_2 emissions was not statistically significant. These results demonstrate that the industrial development of selected countries does not pose a CO_2 emission problem. A comparison of countries showed that the high CO_2 emission value for Kazakhstan was also reflected in the panel data regression findings, and among the four countries, the country effect was positive only for Kazakhstan. This study is noteworthy in revealing the effect of renewable energy consumption on CO_2 emissions. To reduce CO_2 emissions and gain a better understanding of the impact of renewable energy consumption on CO_2 emissions, future studies should include both developing countries and OECD countries, and compare the results obtained from them.

Keywords: Panel Regression Analysis, Turkic Republics, Kazakhstan, Renewable Energy, CO_2 Emission, Industrial Production Index
JEL Classifications: C13, C20, C22

1. INTRODUCTION

With the dissolution of the USSR, Kyrgyzstan on August 31, 1991, Uzbekistan on August 31, 1991, Azerbaijan on October 18, 1991, Turkmenistan on October 27, 1991, and Kazakhstan on December 16, 1991 gained their independence and entered a new political and economic era. With the attainment of independence, the five Turkic Republics embarked on a significant process of restructuring in the economic field, prioritizing the welfare and development of their nations as per their internal dynamics. In the economic literature, this restructuring process is called the "transition period" or "transitional economy" (Niyetalina et al., 2023). Although these countries adopted different development strategies, they were primarily founded on natural resources and raw materials exports. It is oil and natural gas for Kazakhstan and Azerbaijan, natural gas for Turkmenistan, and gold, oil, and natural gas for Uzbekistan.

Kyrgyzstan does not have oil and natural gas resources and depends economically on the export of gold and other minerals as well as remittances from abroad, especially from Russia. In addition to the economic difficulties brought about by post-independence restructuring, global economic crises (1998 Asian crisis; 2007-2008 global crisis; Covid-19) also negatively affected their economies. The positive results of the restructuring initiated amid the economic difficulties experienced after independence began to be seen since the 2000s, and these countries have achieved a rapid economic growth trend (Kasım, 2022; Syzdykova, 2019).

1.1. Kyrgyzstan

Kyrgyzstan has the smallest territory in Central Asia and is poorer than other Turkic Republics in natural resources such as oil and natural gas. Kyrgyzstan is the first among former-USSR Turkic Republics to print its national currency and become a member of the World Trade Organization. Like other former USSR republics, Kyrgyzstan has made major economic structural reforms to ensure economic growth by ensuring stability. Since it does not have natural resources such as oil and natural gas, it is at a disadvantage compared to other Turkic Republics (Syzdykova, 2022). Since Kyrgyzstan produces 90% of its energy from hydroelectric sources, it is in a better situation in CO_2 emissions, but it is also vulnerable to the effects of seasonal weather changes. It is the country with the lowest GDP rate among the Turkic Republics (Köse, 2020).

1.2. Uzbekistan

Like other Turkic republics, Uzbekistan has made radical economic reforms to achieve stability and grow its economy. Although Uzbekistan does not have as rich natural gas and oil deposits as Kazakhstan, Azerbaijan, and Turkmenistan, its economy is better than Kyrgyzstan (Putz, 2017). In addition to its potential in natural resources such as oil, natural gas, and coal, Uzbekistan is also important in gold and uranium production (Köse, 2020). As in other Turkic Republics, economic growth has accelerated since the 2000s. In recent years, its collaborations with international organizations such as the World Bank, IMF, and European Bank for Reconstruction have relieved the country financially (Syzdykova, 2022).

1.3. Azerbaijan

Like other Turkic republics, Azerbaijan has made significant structural reforms to transition to a free market economy (Rzali, 2022). Although the occupation of the lands in Nagorno-Karabakh by Armenia and the difficulties brought by structural reforms caused social and economic problems in Azerbaijan, these problems were overcome over time. Azerbaijan's oil reserves are estimated at 7 billion barrels (or 17.5 billion, according to SOCAR), which constitutes around 0.6% of the global reserve. Additionally, Azerbaijan has natural gas reserves of 2.5 trillion cubic meters. Compared to other Turkic Republics, Azerbaijan ranks second after Kazakhstan in terms of oil and natural gas resources. These oil and natural gas resources contribute significantly to the economic development of Azerbaijan (Süleymanov and Hasanov, 2013; Şahin and Konak, 2019).

1.4. Kazakhstan

Kazakhstan, which gained its independence last among the Turkic Republics, made major structural reforms to accelerate its economic growth by switching to a free market economy like others (Taibek et al., 2023; Bekzhanova et al., 2023; Sartbayeva et al., 2023). Kazakhstan has approximately 3% of the global oil reserves, approximately 1.1% of natural gas reserves, and approximately 3.3% of coal reserves. And it ranks second in the world in terms of uranium reserves. These rich natural resources have helped Kazakhstan complete an otherwise painful economic transition relatively with ease (Mudarissov and Lee, 2014; Xiong et al., 2015; Bolganbayev et al., 2021; Kelesbayev et al., 2022a; Mashirova et al., 2023). Kazakhstan is an attractive country in terms of direct foreign investment with its rich natural energy resources, and it has become even more attractive among developing countries with the economic growth rate it achieved with reforms and investments after independence (Sabenova et al., 2023; Mukhtarov et al., 2020; Kelesbayev et al., 2022b; Dyussembekova et al., 2023). Kazakhstan has the highest GDP rate in the CIS after Russia (Syzdykova, 2022).

The extent of natural disasters caused by global warming due to industrialization, population growth, and the use of fossil fuels in energy production and consequent global climate changes forces humanity to rethink issues such as natural resources, production, and consumption. Countries have faced the severe consequences of global climate change and have begun to look for solutions to slow down or stop it. Environmental awareness began to awaken in the 1960s as a reaction to the damage caused to the environment by industrialization and industrial production and later turned into a global movement. After the UN conference in 1972 on the environment, many international meetings were organized on environmental problems and climate change. The 1997 Kyoto Climate Change Conference and the Kyoto Protocol signed afterward, which included a series of decisions to reduce CO_2 and other greenhouse gas emissions; likewise, the climate change conference organized by the UN in Paris in 2015 and the agreement signed on reducing greenhouse gases were significant steps towards a livable environment regarding environmental problems and climate change (Klarin, 2018). At this point, sustainable economic development issues such as the climate crisis, energy production and consumption, agricultural production, industrial production, and economic growth have taken on immense significance for both developed and developing countries (Nugraha and Osman, 2019; Issayeva et al., 2023). Academic research has shown that energy is one of the most fundamental factors in the development of countries — especially with its contributions to industrial production, agricultural production, services, and transportation (Javid and Sharif, 2016; Yazdi and Shakouri, 2014; Hinrichs and Kleinbach, 2013). In addition, CO_2 emissions during the production and consumption of energy are one of the main contributors to global warming and climate change. Therefore, countries need to reconsider their energy and economic strategies to reduce CO_2 emissions at the global level. Industry, agriculture, and service sectors are the basic development sectors of a country. Since these three sectors are largely dependent on energy as input in their activities, they indirectly increase CO_2 emissions (Nugraha and Osman, 2019; Issayeva et al., 2023).

The industrial production index is an economic indicator used to monitor and evaluate production activities in the industrial sector of a country. It shows how much the industrial production in a certain period has changed as a percentage compared to the previous one or a particular reference period. The reference period used in the study is 2010. The industrial production index is an indicator that allows comparative monitoring of the status of the industrial sector and the increase or decrease in production activities over the years (Koç et al., 2016; Issayeva et al., 2023).

This study aims to analyze the impact of energy consumption and industrial production on CO_2 emissions in the Turkic Republics that gained independence after the collapse of the USSR using the Panel Data method for the period 2000-2020. However, Turkmenistan was excluded from the analysis because the relevant data could not be accessed. Data from Kazakhstan, Azerbaijan, Kyrgyzstan, and Uzbekistan were analyzed with the Panel Data method for the period 2000-2020. Research data was retrieved from the websites https://www.imf.org/, https://ourworldindata.org/and https://datacatalog.worldbank.org/.

2. LITERATURE REVIEW

Although the academic literature is littered with studies on the relationship between different economic activities and CO_2 emissions, as well as on the economic indicators of the five Turkish Republics that gained independence after the USSR, we will only mention the ones related to the research topic.

Hossain (2011) examined the relationship between CO_2 emissions, energy consumption, economic growth, trade openness, and urbanization rate in newly industrializing countries between 1971 and 2007 (Brazil, China, India, Malaysia, Mexico, Philippines, South Africa, Thailand, and Turkey). This study used panel data and Granger causality analysis and identified a cointegration relationship between the variables. No long-term causal relationship was found in Granger causality tests. However, in the short term, a Granger causality relationship has been determined moving from economic growth and trade openness to CO_2 emissions, moving from economic growth to energy consumption, moving from trade openness and urbanization to economic growth, and moving from trade openness to urbanization.

Ergün and Polat (2015) analyzed the relationship between CO_2 emissions, economic growth, and electricity consumption in 30 OECD countries for the 1980-2010 period using panel cointegration and panel error correction model tests. They found a cointegrated relationship between CO_2 emissions, economic growth, and electricity consumption, and a statistically significant relationship between CO_2 emissions and energy consumption in most of these countries in the long run. They also found a unilateral causality relationship between economic growth and CO_2 emissions in the short term and a bilateral causality relationship between economic growth and electricity consumption.

Issayeva et al. (2023), in their study titled "The relationship between renewable energy consumption, CO_2 emissions, economic growth, and industrial production index: The case of Kazakhstan", analyzed the relationship between the industrial production index, economic growth, and the percentage of energy produced from renewable energy sources in energy consumption and CO_2 emissions in Kazakhstan, based on data from the 1990-2021 period. Research data were analyzed using the Johansen cointegration test, Vector Autoregressive (VAR) analysis, Granger causality analysis, and VECM model methods. They determined that the industrial production index, economic growth, and energy consumption factors explained 16.1% of the variability in CO_2 emissions. Yet they found no statistically significant relationship between CO_2 emissions and industrial production index and between CO_2 emissions and economic growth.

Using Indonesia's annual data for the period 1975-2014, Nugraha and Osman (2019) analyzed the causal relationship between CO_2 emissions, energy consumption, the added value of three development sectors, and household final consumption expenditures with ADF and PP unit root tests, Johansen cointegration test and Granger causality test based on vector error correction modeling. They found that CO_2 emissions and energy consumption have a mutual effect in Indonesia, and as energy consumption increases, CO_2 emissions increase.

Erdoğan and Ganiev (2016) analyzed the relationship between CO_2 emissions, economic and financial development, and fossil fuel energy consumption for Azerbaijan, Kazakhstan, Kyrgyzstan, Georgia, Tajikistan, Turkmenistan, Uzbekistan, and Armenia, using the panel econometric methods for the 1992-2013 period. They determined the validity of the inverted-U-shaped environmental Kuznets curve for these countries. They also found that energy consumption and urbanization positively affect CO_2 emissions.

Li et al. (2023) analyzed the relationship between energy usage, economic growth, and CO_2 emissions using time series data from the USA, China, Russia, Japan, and India for the 1975-2015 period. They mainly used ADF, PP unit root test, and ARDL methods in data analysis. Their analysis showed that energy consumption in these countries affects CO_2 emissions positively. They also found that the coefficient of economic growth positively affects CO_2 emissions in these countries in both the short and long term.

Osobajo et al. (2020) analyzed the impact of energy consumption and economic growth on CO_2 emissions in 70 countries for the 1994-2013 period using regression, Granger causality, and panel cointegration tests. They identified a mutual interaction between population, capital accumulation, economic growth, and CO_2 emissions, but energy consumption has a unidirectional effect on this relationship. They also observed a long-term relationship between energy consumption, and economic growth, and CO_2 emissions. Using combined OLS and fixed effects method analyses, they found that energy consumption and economic growth positively affect CO_2 emissions.

3. METHOD

Panel data are data sets containing observations from different cross-sections within an examined period. Periods are time periods, but cross-sections can be groups of demographic characteristics of countries, companies, or individuals. If there is an equal number of data in each section in a panel data set, this set is called a balanced panel data set. In the balanced panel dataset, there is a total of N × T observation units, where T are time periods (t = 1, 2. T) and N are number of individuals (i = 1, 2. N). Combining time series with cross-sections can increase the quality and quantity of data in ways that would make it impossible to use only one of these two dimensions (Gujarati, 2003). Panel data analysis allows analyzing the effect of both variables observed as time series and units as cross-sectional data on the dependent variable (Írataş et al., 2013; Coşkun and Güngör, 2015). Since analyses conducted with only cross-sectional data or time series cannot control heterogeneity, there is a risk of bias in the estimates. Panel regression analysis provides more reliable results by reducing the linearity between variables (Baltagi, 2008; Saatçi and Arslan, 2007). In other words, panel regression models can measure effects that cannot be detected when only time series or cross-sectional data analysis methods are used.

In a panel regression analysis, the fixed effect model or the random effect model can be used. If regression coefficients vary according to units or units and time, then the model is called the fixed effects model. If there are different trends for each cross-sectional unit and the trends remain constant throughout the analysis period, then the model is called the random effects model (Akıncı et al., 2014; Coşkun and Güngör, 2015).

The following equation gives the fixed effects model in its general form (Judge, 1985):

$$y_{it} = \overline{\beta} + \alpha_i + \beta_1 X_{1it} + \beta_2 X_{2it} + ... \\ + \beta_k X_{kit} + \varepsilon_i \left(t = 1,2,...,T; i = 1,2,...,N\right) \quad (1)$$

The following equation gives the random effects model (Wooldridge, 2009):

$$y_{it} = \beta_0 + \alpha_i + \beta_1 X_{1it} + \beta_2 X_{2it} + ... \\ + \beta_k X_{kit} + \varepsilon_{it} \left(t = 1,2,...,T; i = 1,2,...,N\right) \quad (2)$$

In the fixed effect model, the term refers to the predictable conditional mean of all cross-sectional units (Green, 2003). In the random effects model, the effect of cross-sectional units is not constant. Therefore, differences are included (Green, 2003; Burhan, 2012; Toramanoğlu and Görmüş, 2018; Erdugan and Özçelik, 2020).

One crucial stage in panel data regression is model selection. The Hausman test is one of the commonly used methods for this (Green, 2003). The H0 (zero) hypothesis for the Hausman test is that the random effects model is appropriate. Accordingly, the Hausman test statistic should have a chi-square distribution with k degrees of freedom (Baltagi, 2008).

Another pre-processing step of panel data regression is to examine the stationarity of the series. Before the stationarity test, cross-sectional dependence is examined. Cross-section dependence is determined by using the Berusch and Pagan (1980) LM and Peseran, Ullah and Yamagata (2008) LM_{adj} tests when the number of time series periods (T) is larger than the number of cross-sectional units (N) (T > N), and when it is small (T < N) by Pesaran (2004) $CDLM$ or Peseran (2004) CD test. The H_0 null hypothesis of the tests is "There is no cross-sectional dependence." Depending on the result, one of the first-generation or the second-generation unit root tests is applied (Baltagi, 2008).

First-generation unit root tests when it is decided that there is no cross-sectional dependence are Levin et al. (2002), Breitung (2005), Hadri (2000), Maddala and Wu (1999), Im et al. (IPS, 2003), and Choi (2001). The most commonly used second-generation unit root tests are Bai and Ng (2004), Taylor and Sarno (MADF, 1998), Breuer, Mcknown and Wallace (SURADF, 2002), Pesaran (CADF; 2006, 2007) and Carrion-i Silvestre et al. (PANKPSS, 2005) (Yıldırım et al., 2013; Pesaran, 2006; Bal et al., 2023).

4. FINDINGS

The effect of renewable energy consumption and industrial production on CO_2 emissions and the differences in this effect according to countries is worth investigating as a scientific hypothesis. In this study, this effect was examined in the Turkish republics using panel regression analysis, taking into account geographical proximity and socio-economic similarities. The renewable energy variable was included in the model as the share of renewable energy in total energy consumption, and the industrial production as the industrial production index published by OECD. Research Variables and Descriptions are given in Table 1. The expressions in parentheses show the first difference of the variables. Country codes are written following international notation used in the World Bank database. Data were retrieved from the websites https://w3.unece.org/PXWeb2015/pxweb/en/STAT/and https://datacatalog.worldbank.org/. Annual data from the 2000 to 2020 period was used as the analysis period. Since data for Turkmenistan could not be accessed during the analysis phase, the country was excluded from the cross-sectional data.

The research findings first present descriptive statistics tables and time path graphs separately for each country. These tables and graphs illustrate the changes over time for relevant variables in each country. Furthermore, the relationship between the variables was examined with the Pearson correlation coefficient. The second step examined the cross-sectional dependence and stationarity of the research series. The third step presented the research model analysis findings.

Table 1: Research variables and descriptions

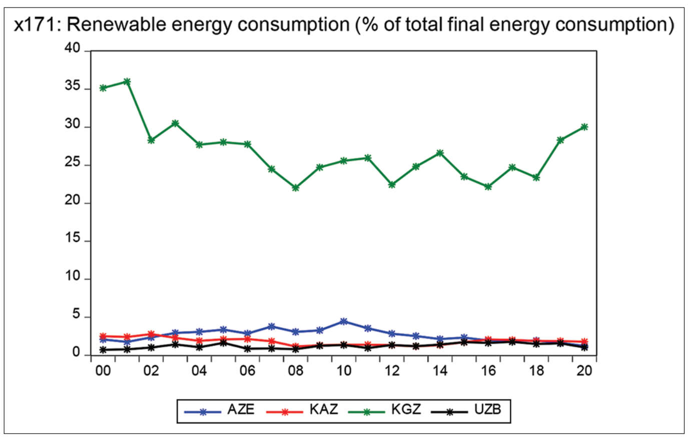
Code	Country	Variable	Description
AZE	Azerbaijan	x171 (d×171)	Renewable energy consumption (% of total final energy consumption)
KAZ	Kazakhstan	x172 (d×172)	Industrial Production index, 2010=100
KGZ	Kyrgyzstan	y171 (dy171)	CO_2CO2 emissions (metric tons per capita)
UZB	Uzbekistan		

Table 2 presents descriptive statistics on renewable energy consumption data in the Turkic republics. As seen from the table, the highest renewable energy consumption is in Kyrgyzstan, and the lowest consumption is in Uzbekistan and Kazakhstan, according to both average and median values.

Graph 1 presents the time path graph for renewable energy consumption data in the Turkic republics. As in Table 2, Kyrgyzstan has a high value in renewable energy consumption in all periods. It is also noteworthy that renewable energy consumption for all four countries followed a stable path in the examined period.

Table 3 presents descriptive statistics regarding industrial production index data in the Turkic Republics. As seen in the table, the country with the lowest index value according to both average and median values is Azerbaijan. The other three countries have index values that can be considered close to each other.

Graph 1: Time path graph for x171



Graph 2 presents the time path chart of the industrial production index data in the Turkic republics. When examined by country, the increasing trend is more evident for Uzbekistan. Although there was an increasing trend in Azerbaijan until 2010, the time path was stable in the following years. Kazakhstan has an increasing industrial production index value in all periods. Although Kyrgyzstan generally shows an upward trend, it also presents a more stable outlook than other countries.

Table 4 presents the descriptive statistics concerning CO_2 emissions in Turkic republics. Kazakhstan has the highest, whereas Kyrgyzstan has the lowest CO_2 emission value, according to average and median values. Azerbaijan's and Uzbekistan's emission values are close to each other.

Graph 3 presents the time path graph of CO_2 emissions in the Turkic republics. Kazakhstan had high CO_2 emission values in all periods, which increased seriously until 2008. However, CO_2 emissions have decreased and followed a stable path since 2014. Azerbaijan, Kyrgyzstan, and Uzbekistan followed a low and stable pattern.

Table 5 presents the correlation coefficient findings for the research variables. When the data from the four countries are evaluated together, it is seen that there is a statistically significant and negative relationship between renewable energy consumption and CO_2 emissions.

Table 6 presents cross-sectional dependency and unit root test findings of research data. Cross-sectional dependence was examined with the Breusch-Pagan LM test, and there were in all three variables. Hence, we used the CADF test method, one of the second-generation unit root tests, to examine stationarity. All three variables were determined to be stationary at the first difference.

Table 2: Descriptive statistics for X171

Code	Mean	Median	Maximum	Minimum	Standard Deviation	Skewness	Kurtosis
AZE	2.6176	2.5200	4.4500	1.2300	0.8063	0.3744	2.5533
KAZ	1.8219	1.8500	2.7700	1.1500	0.4591	0.2131	2.1928
KGZ	26.7748	25.9500	36.0000	22.0400	3.8225	0.9860	3.4773
UZB	1.2281	1.2500	1.7500	0.7200	0.3289	0.0099	1.6852
ALL	8.110595	2.070000	36.00000	0.720000	11.02344	1.249479	2.771634

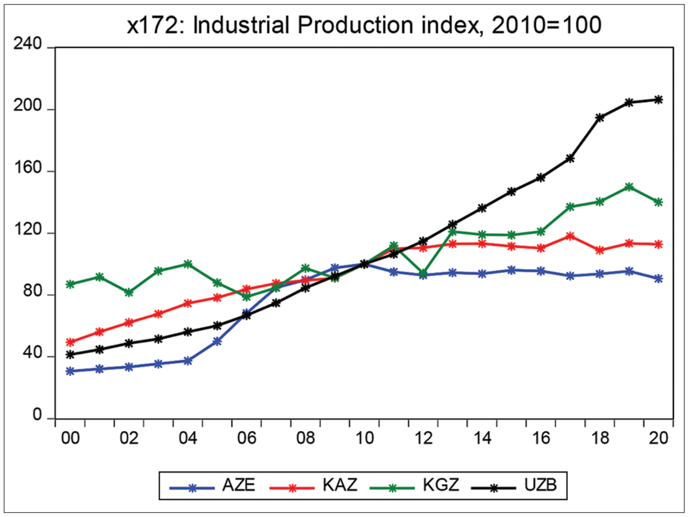
Table 3: Descriptive statistics for X172

Code	Mean	Median	Maximum	Minimum	Standard Deviation	Skewness	Kurtosis
AZE	76.1571	92.4000	100.0000	30.7000	26.6693	−0.8558	1.9161
KAZ	93.4333	100.0000	118.1000	49.4000	21.5909	−0.6412	2.0896
KGZ	107.1095	100.0000	150.0000	78.9000	21.5972	0.5529	2.0497
UZB	108.6476	100.0000	206.4000	41.4000	54.2876	0.4816	1.9969
ALL	96.33690	94.30000	206.4000	30.70000	35.76503	0.688341	4.25769

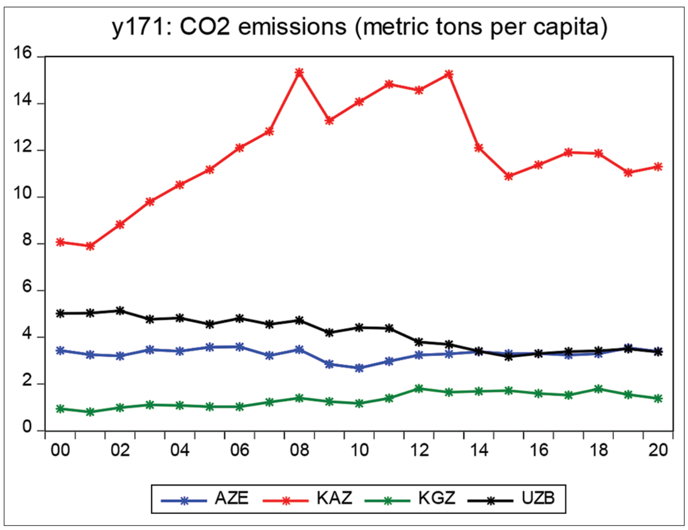
Table 4: Descriptive statistics for Y171

Code	Mean	Median	Maximum	Minimum	Standard Deviation	Skewness	Kurtosis
AZE	3.2921	3.2928	3.5934	2.6851	0.2282	−1.1127	3.9944
KAZ	11.8601	11.8676	15.3413	7.9042	2.1863	−0.0756	2.2965
KGZ	1.3405	1.3800	1.8095	0.8012	0.3050	−0.0035	1.7652
UZB	4.1675	4.3843	5.1396	3.1745	0.6799	−0.0985	1.4277
ALL	5.165021	3.430162	15.34125	0.801217	4.180831	1.130721	2.93386

Graph 2: Time path graph for x172



Graph 3: Time path graph for Y171



Graph 4: Graph of predicted, residual, and observed values of the research model

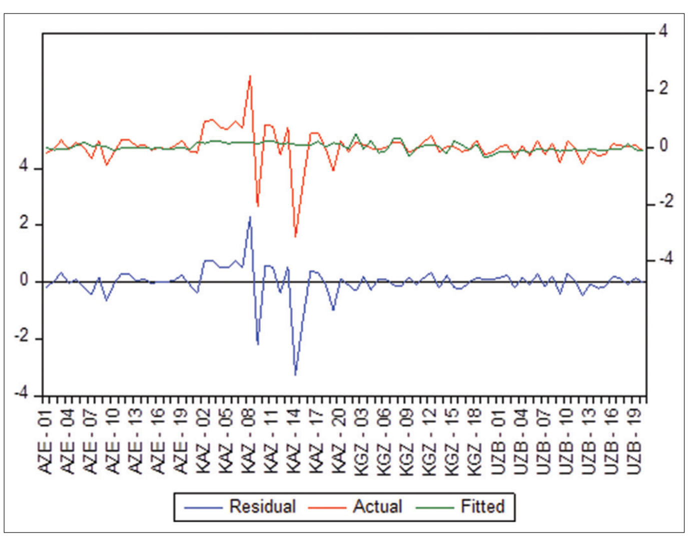


Table 7 presents the analysis findings of the research model. First, the Hausman test was used to determine the model: the fixed or

Table 5: Correlation coefficient findings for research variables

	X171	X172	Y171
X171	1	0,148373	−0.539**
X172	0,148373	1	−0.06177
Y171	−0.539**	−0.06177	1

**Correlation is significant at the 0.01 level (2-tailed)

Table 6: Cross-sectional dependence and unit root test findings of research data

Variable	Cross-section dependence		Level		1st difference	
	Statistic	Prob,	Statistic	Prob,	Statistic	Prob,
X171	17.5751	0.0074	13.9017	0.0844	29.1919	0.0003
X172	81.5134	0.0000	8.64206	0.3734	22.4034	0.0042
Y171	26.7087	0.0002	9.09716	0.3342	30.9145	0.0001

Table 7: Analysis findings of the research model

Variable	Coefficient	Standard Error	t-Statistic	Prob,
Fixed	6.3048	3.2482	1.9410	0.0557
d × 171	−0.1317	0.0628	−2.0952	0.0393
d × 172	−0.0007	0.0037	−0.1989	0.8429
Hausman test: chi2 (2) =0.9498; P = 0.6219				
R-squared	0.0553		F-statistics	4.7952
Adjusted R-squared	0.0437		Probability (F-sta.)	0.0314
D.W. Statistics	2.2184			

Table 8: Country effects according to the panel regression model

	Code	Effect
1	AZE	−0.0100
2	KAZ	0.1519
3	KGZ	−0.0007
4	UZB	−0.1412

the random effect model. The findings proved the random effect model to be more appropriate. The F-test also showed that the model was statistically significant. The DW statistic shows no autocorrelation between the residuals. Model coefficient findings showed that renewable energy consumption had a statistically significant and negative effect on CO_2 emissions. However, although negative, the effect of industrial consumption was not statistically significant. The adjusted R-square value shows that renewable energy consumption and industrial production explain 4.4% of the variability in CO_2 emissions.

Graph 4 shows the predicted, residual, and observed values of the research model. Kazakhstan exhibits the highest fluctuation in the data, with a significant difference between observed and predicted values, as well as large residual values in absolute terms. Three other countries showed more successful results.

Table 8 presents the country effects obtained from the panel regression model. Only Kazakhstan has a positive predicted country effect, while the country effect predictions of the remaining three countries are negative.

5. CONCLUSION AND RECOMMENDATIONS

This study analyzed the effect of industrial and renewable energy production on CO_2 emissions using data from the Turkic republics. CO_2 emission is a crucial parameter that all countries and international organizations closely monitor and work towards reducing. The data from the Turkic republics shows that Kazakhstan has a higher CO_2 emission value. This study examined the impact of renewable energy and industrial production, and countries on CO_2 emissions using panel data regression. Findings showed that as renewable energy consumption increases, CO_2 emissions decrease. However, the effect of industrial production on CO_2 emissions is also found to be not statistically significant. This reveals that industrial development (particularly in the Turkish republics) does not cause a CO_2 emission problem. The Turkic republics are prioritizing environmentally friendly industrial development. However, when analyzing the countries, it is clear that Kazakhstan's high CO_2 emissions are also reflected in the panel data regression findings. Among the four countries, the country effect was positive only for Kazakhstan.

This study revealed the effect of renewable energy consumption on CO_2 emissions. Future studies may compare the results by including developing countries or OECD countries to improve CO_2 emissions and understand the impact of renewable energy consumption on CO_2 emissions.

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