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Impact of Renewable Energy use, CO_2 Emissions, Oil Production and Oil Prices on Sustainable Economic Growth: ARDL Approach from Kazakhstan

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ABSTRACT

The coexistence of humanity with nature, not harming the last one is one of the dilemmas that has existed since ancient times. The environment is deteriorating every year due to damage caused by human activities. The objective of this research work is to evaluate the importance of key indicators such as renewable energy use, CO_2 emissions, oil production and oil prices for sustainable economic growth using Autoregressive Distributed Lag (ARDL) model. Years cover 2000-2021 period. A worldwide literature review was conducted and hypotheses to be tested were identified. Based on a literature review, the influence of indicators on the Kazakh economy was selected and assessed. According to model results, the impact of fossil CO_2 emissions per capita (tons) emissions on GDP per capita is negative in short-term and long-term terms. Renewable energy use has a positive short-term and long-term positive impact on GDP per capita. In addition to the above, crude oil production impact on GDP per capita is positive in the short and long term. In addition, the crude oil price has a positive short-term and long-term impact on GDP per capita.

Keywords: Renewable Energy, CO_2 Emissions, Oil Production, Oil Price, Sustainable Development
JEL Classifications: B23, O44, Q20

1. INTRODUCTION

Ecology, environment and its conservation are vital for humanity. Human beings, being an integral part of nature, use its gifts to live and develop. The impact of human activities has a significant impact on the planet. Froehlich et al. (2022) have stated that the threat of climate change represents a potential risk to food security, sustainable economy, and global peace. Severe consequences of the 2020 pandemic, geopolitical conflicts, and climate change have slowed down the implementation of sustainable development goals (SDG report, 2024). The dilemma of this millennium is to develop in tandem while preserving our flora and fauna. Affordable and clean energy, and Climate action are among 17 goals of Sustainable development. Consequently, environmental degradation has taken to the forefront of the debates in emerging and developed economies (Li et al., 2023).

One of main essential components of economic growth is energy (Liu and Hao, 2018). The energy mix of many countries around the world is dominated by fossil fuels, which have a strong impact on the global climate, as three-quarters of global greenhouse gas emissions are the result of burning fossil fuels for energy (Hannah et al., 2020; Zhao et al. (2023). For instance, from gate to gate, one ton of crude oil production produces net CO_2 emissions of −1.68 tons (Liu et al., 2019). Renewable energy is a source of low-carbon energy and important solution to reduce CO_2 emissions (Güler and Aydinbaş, 2024). In terms of energy transitions for countries around the world, low-carbon electricity systems have become a key goal for a reason (Islam et al., 2024).

Renewable energy consumption is only partially affected by oil supply shocks; in particular, demand shocks in the global oil market have a significant impact on renewable energy (Esmaeili et al., 2024). Li et al. (2022) state that the use of green technologies, that is, environmentally friendly technologies, can reduce carbon emissions, improve resource sustainability and the possibility of economic diversification. Also, in addressing greenhouse gas emissions and the challenges of climate change, such as "green finance," an approach combining financial services and products that confront a wider range of sustainability issues has emerged (Li and Umair, 2023). However, the results of Kakizhanova et al. (2024) study proved that CO_2 emissions have a positive effect on investment inflow.

2. LITERATURE REVIEW

2.1. Renewable Energy Consumption, CO_2 Emissions and Economic Growth

In the new global energy system, clean energy becomes the center of attention, not only because this sector employs more than 36 million people worldwide and accounts for 10% of global economic growth in GDP for 2023, but it is also one of the most important elements of environmental conservation, a step towards a green economy and one of the 17 principles of sustainable development (IEA, 2024). Bercu et al. (2019) are of the opinion that energy problems in developing countries are exacerbated by poor energy management and scarcity.

The authors examined the long-term correlation between energy consumption, government, and economic growth in 14 Central and Eastern European countries from 1995 to 2017, and found proof that energy shortages result in a deceleration of economic growth. Agbanike et al. (2019) analyzed causal directions between oil price, energy consumption and carbon dioxide (CO_2) emissions in Venezuela using Innovative accounting approach. Results demonstrated that crude oil price causes energy consumption in the economy and energy consumption causes CO_2 emissions. Excessive use of fossil fuels is harmful to the environment, and efficient use of energy is one of the prerequisites for economic development, and since renewable energy emits less greenhouse gases, countries around the world are increasingly seeking to increase the share of renewable energy sources (Bhuiyan et al., 2022).

Using panel data, Konuk et al. (2021) analyzed relationship of biomass energy consumption and economic growth of NEXT-11 countries and found their positive effect in long run. Upon investigating the causal relationship between renewable energy and sustainable economic growth in EU-28 countries over the period 2003-2014, the authors proved that an increase in primary production of solid biofuels by 1% increases GDP per capita by 0.16% (Armeanu et al., 2017). By applying Technique for Order of Preference by Similarity to Ideal Solution methodology, Esfandiary Abdolmaleki et al. (2023) assessed renewable energy and ranked 17 autonomous communities of Spain. Authors The authors came to conclusion that for sustainable energy development of Spanish regions, it is necessary to increase the self-sufficiency of energy communities and reduce government interference. Situma et al., (2024) examined how renewable energy consumption affected economic growth in Kenya from 1980 to 2017 using the Neo-Classical Solow-Swan growth model. The authors arrived at the conclusion that investing in renewable energy would aid in achieving desired levels of economic growth. The relationship between renewable energy consumption and economic growth is negative and significant, as shown by panel data analysis of Titalessy's (2021) study.

Nonetheless, renewable energy and fuel waste have a significant and positive impact on economic growth. Applying ordinary least squares, fixed effects, random effects, and the generalized method of moments in first differences, Madaleno and Nogueira (2023) investigated effects that CO_2 (carbon dioxide) emissions and renewable energy consumption have on economic growth for 27 EU countries for period of 1994-2019.The study showed gross fixed capital, human development, and trade contribute to an increase in renewable energy consumption, which is caused by an increase in CO_2 emissions. Magazzino et al. (2023) analyzed relationship among CO_2 emissions, energy use, and GDP in Russia using annual data ranging from 1990 to 2020. The results of their study highlight the bidirectional flow of cause and effect between energy use and CO_2 emissions and the unidirectional relationship between CO_2 emissions and real GDP. Lu et al. (2024) calculated and quantified the projected efficiency and potential impact of carbon-related factors on GDP growth. Using ARDL, Vu and Rahman (2020) examined the relationship between renewable energy use, economic growth, and CO_2 emissions for the countries of Australia and Canada over the period 1960-2015. Their VECM causality tests show a long-run bidirectional causality between CO_2 emissions, economic growth, and renewable energy consumption.

Also, by employing ARDL model, Maâlej and Cabagnols (2022) studied relationship between gross domestic product, renewable and non-renewable energy consumption, innovation, and carbon dioxide (CO_2) emissions of countries Denmark, Germany and Finland. According to results, it is obvious that renewable energy consumption and innovation significantly reduce pollution and play a major role in reducing CO_2 emissions. Abid et al. (2024) studied relationship between economic growth, CO_2 emissions and energy intensity in Gulf cooperation countries and found economic growth leads to CO_2 emissions growth. According to authors, it is suggested to adopt sustainable energy practices to reduce energy intensity and boost economic growth.

Thus, in this article the authors will test the following hypothesis:

H_0: Renewable energy consumption effects positively on economic growth on short and long run terms.

H_1: CO_2 emissions effects positively on economic growth on short and long run terms.

2.2. Oil Production, Oil Price and Economic Growth

Countries around the world are trying to implement policies aimed at speeding up energy consumption. For countries that export raw materials, this could be an economic blow. The COVID-19-induced recession has reduced energy consumption, thereby slowing economic growth in energy-exporting countries (Khalilnezhad and Eslamloueyan, 2024; Chikonkolo Mwewa et al., 2024). Whatever the onset of a crisis, rising renewable energy resources, technology development, in historical terms we see that global oil consumption is growing in absolute terms (Gurbanov, 2021). Oil production and world oil prices affect all sectors directly or indirectly. Countries where policies are increasingly built on an export-oriented model are highly dependent on global oil crises and on fluctuations in any indicators. Ready (2017) analyzed the effects of increased long-run oil supply uncertainty on macroeconomics and asset prices. Alkofahi and Bousrih (2024) investigated relationship between oil prices, oil consumption and economic growth in Saudi Arabia for the period of 1991-2021. Research results support the existence of a long-term direct correlation between the variables and oil consumption. Applying PARDL model, Musikavanhu and Gamariel (2024) examined the relationship between oil prices and economic growth in certain African economies over the period 1990-2020 due to the quality of institutions. According to the findings, the short-term economic growth of African oil-importing countries is significantly impacted by oil price increases.

These results are consistent with Norouzi (2021) and Kudabayeva et al. (2024) research findings. Bias-corrected least squares dummy factors, generalized methods of moments, feasible generalized least squares and random coefficients methods were used by Wang et al. (2022) to study relationship between oil price volatility, inflation rate and economic growth in top importers and exporters countries for period of 1990-2019 years. Authors found that the financial development and economic growth of oil-importing and exporting countries is greatly impacted by oil price volatility, which is both negative and measurable. Furthermore, oil-exporting countries are vulnerable to the volatility of oil prices. Incorporating with unemployment rates, interest rates, and inflation, Taiwo et al. (2024) assessed impact of oil price volatility on economic growth in the United States. Results show crucial impact of oil price stability and labor market regimes on economic performance of the country. Nguyen (2020) studied nexus between oil production, energy consumption, CO_2 emissions and economic growth in 5 OPEC countries for period of 1978-2017.

Author found that GDP per capita is negatively impacted by CO_2 emissions per capita. GDP per capita has a negative impact on oil production, but energy consumption per capita is positively related to oil production. Moreover, per capita CO_2 emissions are positively correlated with oil production. Per capita energy consumption has a negative impact on CO_2 emissions per capita. Bernard et al. (2024) applied NARDL model, to find evidence of crude oil price impact on Nigerian economic growth. Research results show that the economy is vulnerable to oil price shocks. Employing Vector Error Correction Model Richard and Muba (2024) investigated relationship between oil price fluctuations and economic growth in Tanzania.

Authors proved that in the short term the relationship between GDP and oil price fluctuations is not significant, but in the long term there is a negative relationship between them. Sama et al. (2024) studied nexus between Human development index, CO_2 emissions, inflation, crude oil production and economic growth in Cameroon for period of 1977-2019. Authors identified an asymmetrical impact of the human development index and economic growth on crude oil production in the short term and the same impact of CO_2 emissions and inflation in the long term. Based on the classical growth model, Deryag and Khalifa (2024) studied the dynamic relationship between oil production and economic growth, taking into account indicators such as gross capital formation, labor force, trade openness, and financial development for several Arab countries. The results indicated that oil production is heart of nation's economy.

Authors then will test following hypothesizes:

H_2: Oil price has positive impact on economic growth on both terms.

H_3: Oil production has positive impact on economic growth on both terms.

3. METHODS

Taking into account the results of the literature revie in the previous section, we used a regression model to check the relationship between GDP per capita (GDPPC) and Fossil CO_2 emissions per capita (tons), Renewable energy consumption, Crude oil production, Crude oil price in the Republic of Kazakhstan in the period 2000-2021. As a result, the following econometric model was used to achieve the research objectives:

$$GDPPC_t = f(F\,CO_2EPC_t, REC_t, COProd_t, COPrice_t) \quad (1)$$

Where all of their definitions and measurements are given in the Table 1 below.

During the study, based on the results of the ADF test, it was found that all the studied variables are stationary at level I (0) or first differences I (1) (Table 2). The ARDL methodology is also used, the order of integration of variables is considered to determine the suitability of the ARDL model for the study, and a maximum of two lags are selected using a special test (Table 3).

The linear ARDL model was estimated using first difference, respectively, and long-term and short-term analysis of the relationship between the variables was carried out. According to the linear ARDL model, all independent variables were confirmed to be in a causal relationship with the changes in the dependent variable GDPPC. Based on the results of the Granger causality test (Table 4), a linear ARDL model was estimated and long-term and short-term analysis of the relationship between the variables was performed.

Table 1: Model variables and sources

Variables	Definitions	Sources
GDPPC	GDP per capita	World development indicators (WDI)
FCO_2EPC	Fossil CO_2 emissions per capita (tons)	World development indicators (WDI)
REC	Renewable energy consumption (% of total final energy consumption)	World development indicators (WDI)
COProd	Cude oil production (Mln t)	Ourworldindata.com
COPrice	Crude oil price	Statista.com

Source: Authors

Table 2: ADF unit root tests

Variables	Intercept			Trend and intercept			None		
	Level	First diff.	Order of integration	Level	First diff.	Order of integration	Level	First diff.	Order of integration
GDPPC	−3.48** (0.019)	−3.11** (0.042)	I (0)	−0.711 (0.959)	−5.016** (0.006)	I (1)	1.527 (0.964)	−1.964** (0.049)	I (1)
F CO_2EPC	−1.926 (0.315)	−4.23*** (0.004)	I (1)	−1.471 (0.807)	−4.743*** (0.006)	I (1)	0.331 (0.772)	−4.242*** (0.000)	I (1)
REC	−1.902 (0.325)	−4.182** (0.004)	I (1)	−1.760 (0.688)	−4.183** (0.019)	I (1)	−0.271 (0.576)	−4.249** (0.000)	I (1)
COProd	−3.418** (0.022)	−3.101** (0.043)	I (0)	−1.641 (0.741)	−3.936** (0.030)	I (1)	1.099 (0.923)	−2.521*** (0.015)	I (1)
COPrice	−1.846 (0.357)	−3.915* (0.008)	I (1)	−1.421 (0.824)	−5.262*** (0.003)	I (1)	−0.800 (0.357)	−4.012*** (0.000)	I (1)

1) *, **, *** denote statistically significant at the 10%, 5% and 1% levels, respectively P-value is inside brackets
Source: Authors. GDPPC: Gross domestic product per capita, F CO2EPC: Fossil CO2 emissions per capita, REC: Renewable energy consumption, COProd: Cude oil production, COPrice: Crude oil price

Table 3: Selection order criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	−195.0142	NA	334.4382	20.00142	20.25035	20.05001
1	−111.0252	117.5846*	1.008363	14.10252	15.59612*	14.39408
2	−76.66741	30.92199	0.712602*	13.16674*	15.90500	13.70128*

Table 4: Noncausality tests in the sense of Granger for the vector autoregressive (1) (2000-2021)

Direction of causality	F-statistic	Prob.
GDPPC		
FCO_2EPC does not granger cause GDPPC	0.69301	0.5154
REC does not granger cause GDPPC	0.38719	0.6856
COPROD does not granger cause GDPPC	1.49054	0.2568
COPRICE does not granger cause GDPPC	0.34196	0.7158

Source: Authors. GDPPC: Gross domestic product per capita, FCO2EPC: Fossil CO_2 emissions per capita, REC: Renewable energy consumption, COProd: Cude oil production, COPrice: Crude oil price

$$GDPPC_t = \beta_0 + \sum_{k=1}^{m}\beta_1 GDPPC_{t-k} + \sum_{k=0}^{n}\beta_2 FCO2EPC_{t-k} + \sum_{k=0}^{p}\beta_3 REC_{t-k} + \sum_{k=0}^{q}\beta_4 COProd_{t-k} + \sum_{k=0}^{r}\beta_5 COPrice_{t-k} + \gamma_1 FCO2EPC_{t-i} + \gamma_2 REC_{t-i} + \gamma_3 COProd_{t-i} + \gamma_4 COPrice_{t-i} + \varepsilon_t \quad (2)$$

Where, operator Δ represents the differencing operation.

The ARDL model was selected during the time stability of the coefficients of the model evaluated according to the results of the CUSUM and CUSUMSQ stability tests (Graph 1). In a linear autoregressive distributed lag ARDL model, the procedure also determines the presence of cointegration between sample variables. The bounds test examines long-term relationships, and the results of the bounds test are presented in Table 5.

4. DATA AND FINDINGS

4.1. Data

This study examines the influence of the main factors on GDP per capita (GDPPC) in the Republic of Kazakhstan. The study uses data for the period from 2000 to 2021, which was obtained using the World Data Bank (WDI), ourworldindata.org., statista.com and ourworldindata.com The explanatory variables in this study are Fossil CO_2 emissions per capita (tons), Renewable energy consumption (% of total final energy consumption), Cude oil production (Mln t) and Crude oil price.

The dynamic change of all indicators presented in the table in the period 2000-2021 is depicted in the following graph:

It is clear from the analysis shown in Graph 2 that the variables under study are suitable for analysis. This is because graphs show clear, consistent, and stable temporal patterns, indicating that changes in variables are suitable for further investigation.

4.2. Descriptive Statistics

In this study, descriptive statistics, which provide insights into various aspects of the data set, and the ARDL model were used to test the hypothesis. The descriptive statistics results presented in Table 6 show the pooled means such as mean and median, as well as measures of spread and variation such as standard deviation minimum, maximum, skewness, and Jarque-Bera statistic for each variable used in our model.

According to the descriptive statistics, for the GDPPC indicator, the mean is 8.4783, the median is 8.9640, and the standard deviation is 2.1369, which indicates relatively stable values. The Jarque-Bera statistic value is 2.1330, the probability of tie is 0.3442, which is >0.05, so it can be concluded that the series is uniformly distributed. The standard deviation for all other indicators also exceeds 0.10. The Jarque-Bera statistic of 0.4484 is close to the probability of 0.7991, which means that the hypothesis of zero normal distribution of FCOE is confirmed at the 5% significance level. In Table 6, we see that for the REC, COPrice indicators, the skewness coefficient of the time series is greater than zero, that is, they have right skewness, and the rest of the GDPPC, F CO_2EPC, COProd are left skewed. The kurtosis value for all indicators shows that the distribution is almost normal, without excessive kurtosis.

4.3. Unit Root Test

Before studying the long-term relationship between the series, it is necessary to determine their stationarity. Augmented Dickey-Fuller (ADF) unit root tests were used to test the levels or differences of time series variables for stationarity. All variables are stationary at Level I(0) or first difference I(1). Therefore, the ARDL cointegration technique is the best way to estimate or test the long-run relationship between research variables.

The unit root results are consistent with the main assumptions that require the use of the ARDL model test to confirm the existence of long-run relationships between Kazakhstan's GDP per capita (GDPPC) and the significant explanatory factors proposed in the study.

4.4. Granger Causality Test

The study used pairwise Granger causality analysis to determine the causal relationships between variables as shown in Table 4 to increase the reliability of the stability test. To study the causal relationship between the selected variables and the GDP per capita level, the Granger test is used, which tests the null hypothesis that changes in the dependent variable are not causal (Noncausality).

The study found a causal relationship from FCO_2EPC REC COProd COPrice to GDPPC.

4.5. Co-Integration Test

The ARDL bounds testing procedure is used in this study to examine the long-term relationship between FCO_2EPC REC COProd COPrice and GDPPC in the Republic of Kazakhstan. To explore the long-term association of variables, ARDL method was chosen using a small sample size (2000-2021). Before a test for cointegration can be performed, it is important to define a lag length criterion.

The lag length criterion is determined based on LR, FPE, AIC, SC and HQ. Table 3 presents the results of the selected lag. As can be seen from Table 5, the selected lag length is 2 because it has more stars and was used throughout the study.

4.6. Results of Long- and Short Run Relationship

In the study, linear ARDL (1, 0, 0, 0, 2) (Equation 2) was estimated from the results and to conduct long-term and short-term analysis of the relationship between the variables, the results obtained are presented in the following Table 5.

The results of the cointegration F-test for the model (Table 5) indicate that the obtained F-statistic - 44.23946 exceeds the

Table 5: Bounds of cointegration test

Model	F-statistics	Critical bounds		Decision
		I (0)	I (1)	
Model-ARDL (1, 0, 0, 0, 2)	44.23946	1.9 2.26 3.07	3.01 3.48 4.44	Cointegration

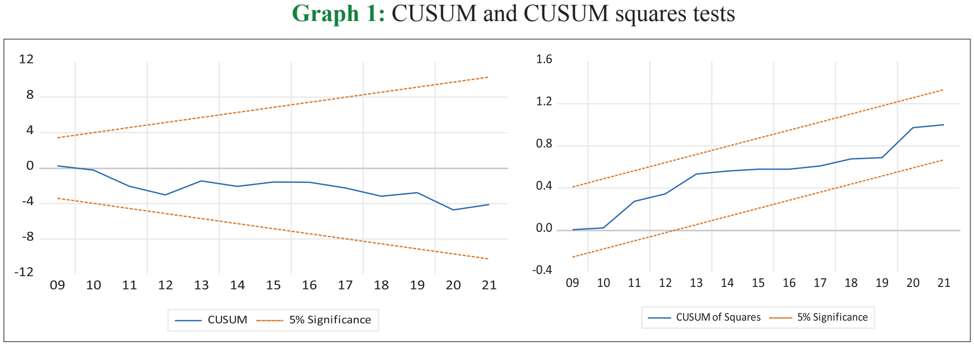
Critical bounds are reported at 1% (***) and 10% (**) level of significance.
Source: Authors. ARDL: Autoregressive Distributed Lag

Table 6: Values of descriptive statistics of the displayed series

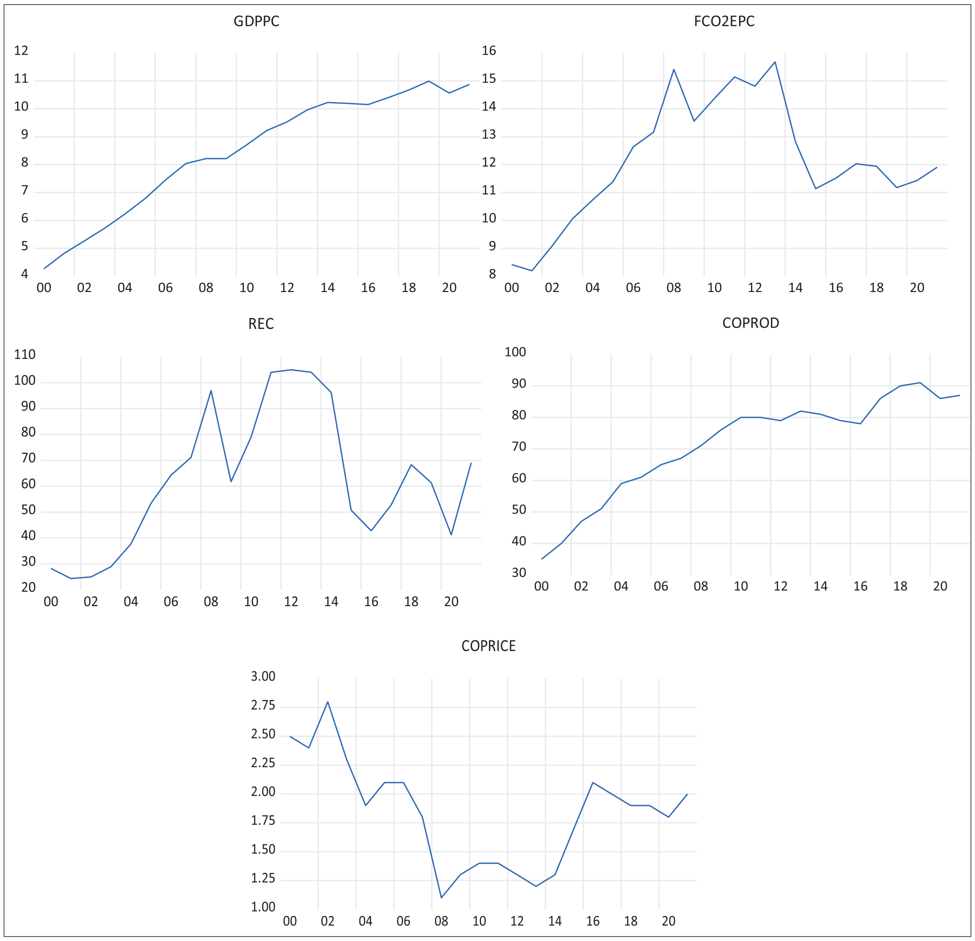
Values	GDPPC	FCO_2EPC	REC	COPROD	COPRICE
Mean	8.4783	12.1200	62.1150	71.4091	1.8318
Median	8.9640	11.9250	61.5850	78.5000	1.9000
Maximum	10.9900	15.6800	105.0100	91.0000	2.8000
Minimum	4.2690	8.2000	24.3500	35.0000	1.1000
Std. Dev.	2.1369	2.1438	26.6830	16.2968	0.4571
Skewness	−0.5918	−0.0449	0.2570	−0.8687	0.1538
Kurtosis	2.0378	2.3063	1.9376	2.6550	2.2894
Jarque-Bera	2.1330	0.4484	1.2768	2.8759	0.5496
Probability	0.3442	0.7991	0.5281	0.2374	0.7597
Sum	186.5220	266.6400	1366.5300	1571.0000	40.3000
Sum Sq. Dev.	95.8891	96.5152	14951.6200	5577.3180	4.3877
Obs	22	22	22	22	22

Source: Authors. GDPPC: Gross domestic product per capita, FCO2EPC: Fossil CO_2 emissions per capita, REC: Renewable energy consumption, COProd: Cude oil production, COPrice: Crude oil price, SD: Standard deviation

Graph 1: CUSUM and CUSUM squares tests



Graph 2: Evolution of all variables for Kazakhstan (2000-2021)



upper limit of 4.44 and is statistically significant at the 1%-10% level of significance. The results show that the selected variables are cointegrated and in the case of Kazakhstan, a long-term relationship between the variables is found.

Given that the selected variables are cointegrated in the long run, we can proceed to the next step, which requires estimating the long-run and short-run coefficients. Linear ARDL was estimated using first difference, we can estimate how a 1 unit change in the explanatory variables affects the dependent variable in both the long and short run.

In Kazakhstan, in the long term, Fossil CO_2 emissions per capita (FCO_2EPC) negatively correlates with GDP per capita (GDPPC) with a coefficient of −0.247514, ceteris paribus. The obtained results indicate that the remaining explanatory variables correlate positively with REC, COPrice, COProd (respectively with coefficients (0.041842, 1.09727, 0.107556) under other equal conditions.

The obtained empirical data (Table 7) indicate that in Kazakhstan in the short term the amount of FCO_2EPC also negatively and significantly correlates with GDPPC, with a coefficient of −0.071125. It is noteworthy that the growth of COPRICE (D[COPRICE]) has a positive effect on GDPPC in the short term, with a corresponding coefficient of 0.307199. REC (0.012024) and COPROD (0.030907) have a positive correlation in the short term. In addition, in the short term, the negative effect of GDPPC (−1) lag variable in period t-1 on the level of GDPPC in period t was proved (0.287357), the positive (0.315311) dependency of COPRICE(−1) was confirmed.

4.7. Diagnostic Tests

Diagnostic Tests are performed to ensure the stability of the non-linear ARDL model. These include normality, serial correlation and heteroskedasticity tests. For this model. The results of diagnostic studies shown in Table 8 show that the estimated model is free from serial correlation and heteroscedasticity. The LM statistic is 0.1130, the probability value is 0.8942, so we conclude that there is no serial correlation in the model. Heteroscedasticity tests revealed an F-statistic of 0.6315 and a probability of 0.7224, both exceeding the 0.05% significance level, indicating that the model was homoscedastic. The model accepts the null hypothesis of the normality test and concludes that the residuals are normally distributed, as evidenced by an F-statistic of 0.5942 and a probability value of 0.7430, with a probability significance level of >5% for all tests. Finally, all diagnostic tests for Langrage multiplier serial correlation test, Jarque-Bera normality test and heteroscedasticity test were passed, indicating the stability of the model.

4.8. Stability Tests

The CUSUM and CUSUM Squares tests are used to test whether the estimated models' coefficients remain constant over time,

Table 7: Results of ARDL (1, 0, 0, 0, 2) Estimation (2000-2021)

Estimation D (GDPPC)				
Variable	Coefficient	Standard error	t-statistic	Prob.
Short run				
GDPPC (−1)*	−0.287357***	0.055711	−5.158020	0.0002
FCO_2EPC**	−0.071125**	0.025665	−2.771299	0.0159
REC**	0.012024***	0.002537	4.738472	0.0004
COPROD**	0.030907***	0.008656	3.570472	0.0034
COPRICE (−1)	0.315311***	0.071653	4.400513	0.0007
D (COPRICE)	0.307199**	0.107769	2.850543	0.0136
D (COPRICE [−1])	0.173959	0.099755	1.743861	0.1048
Long run				
FCO_2EPC	−0.247514**	0.087408	−2.831713	0.0141
REC	0.041842***	0.012249	3.416040	0.0046
COPROD	0.107556***	0.011385	9.446883	0.0000
COPRICE	1.097279**	0.375505	2.922140	0.0119

1) coefficients are statistically significant at ***1%, **5%, *10% level of significance

2) compiled by the authors

Source: Authors. GDPPC: Gross domestic product per capita, FCO_2EPC: Fossil CO_2 emissions per capita, REC: Renewable energy consumption, COProd: Cude oil production, COPrice: Crude oil price

Table 8: Short-run diagnostics

Test	F-statistics	P-value
Serial correlation	0.1130	0.8942
Heteroskedasticity	0.6315	0.7224
Jarque-Bera	0.5942	0.7430

which is an indicator of model stability.

The results of the stability test of CUSUM and CUSUMSQ are shown in Graph 1. A plot of significance level tests at 5% shows that the significance of not exceeding the critical thresholds indicates that the model is stable. This test is also used to study the long-term dynamics of regression.

5. CONCLUSION

he purpose of the research is to assess the long-term and short-term impact of such important factors as Fossil CO_2 emissions, Renewable energy consumption, Crude oil production and crude oil price on the sustainable economic growth of Kazakhstan. The indicators of the variables for the period 2000-2021 were taken. As a result of the ARDL model, the following were determined: the impact of fossil CO_2 emissions per capita on GDP per capita is negative in short-term and long-term terms. Renewable energy use has a positive short-term and long-term impact on GDP per capita. In addition, crude oil production is positive in the short and long term, and the impact on GDP per capita is positive in the long term. The crude oil price has a positive short-term and long-term impact on GDP per capita. Thus, H_0, H_2 and H_3 hypothesizes are proven, and hypothesis H_1 is not.

Policy implications. In the economic growth of the Republic of Kazakhstan, mineral resources play a special role, they make up the majority of budget revenues. That is why it is very important to be able to combine sustainable economic growth and care for the environment. The huge potential of renewable energy sources in the country, particularly wind energy sources, must be properly utilized. In the process of oil production and refining, it is necessary to give priority to advanced technologies. In this course, increasing the environmental responsibility of foreign companies operating in this field and increasing tax contributions may improve the attention paid to the environment.

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