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Impact of Good governance Indicators on Green Growth: Evidence from Kazakhstan

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ABSTRACT

The functioning of the country's institutions, and ultimately all socio-economic well-being, depends on the effective work of state governance. The state's involvement has also taken center stage in recent years when it comes to putting rules and programs into place that safeguard the environment and maximize the economical and effective use of minerals. The purpose of the research work is to evaluate effect of six government indicators on some green growth variables of Kazakhstan. For those 3 autoregressive distributed lag models were applied. In the short term, the lag variable of regulatory quality has a positive effect on production-based CO_2 intensity, whereas the lag variable of control corruption lowers it. Additionally, the rule of law slows the increase of production-based CO_2 intensity. The gap between the values of the lagged variables rule of law and control of corruption has a substantial negative short-term influence on energy intensity per capita. When the lagged factors of political stability, the absence of violence or terrorism, and the control of corruption all rise, so does energy intensity per capita. The rule of law and voice and accountability, two lagged variables, have adverse effects. An rise in the lagged variable significantly reduces the current Energy intensity per capita. The availability of renewable energy is positively impacted by voice and accountability. An increase in the lagged variable Voice and Accountability also significantly slows down the growth of energy intensity per capita in the short term.

Keywords: Governance Indicators, Autoregressive Distributed Lag, Production-Based CO_2 Emissions, Renewable Energy Supply, Energy Intensity
JEL Classifications: P4, Q43, O1

1. INTRODUCTION

Today Environmental and economic interactions, including climate change (Gerling et al., 2023), rising food prices (Stone et al., 2024), biodiversity and ecosystem degradation (Isbell et al., 2022), reduced access to water resources (Zheng et al., 2016), increasing number of man-made disasters and increasing costs (Cutter and Finch, 2008), and many other issues, are leading the world to a standstill. Countries are unable to fully transition to a green economy due to disparities in socioeconomic conditions, knowledge availability, and the growth of different regions of the world. Countries should coordinate their environmental protection strategies since, despite the boundaries separating states, the globe is one. The effectiveness of state authority is called into doubt in such a scenario. Coordinating efforts to safeguard the environment and reduce damage to it is a critical function of the state (Yu et al., 2025; Dwivedi et al., 2025). The effective production, utilization, import, and export of energy resources is largely dependent on state governments and it effective work. Energy security has never been more crucial (Trosman, 2010; Dobrowolski, 2021; Rahman et al., 2025). High depreciation of fixed assets in the energy, oil and gas production, transportation, and processing sectors necessitates a strategic plan for restructuring in the energy sector. There is also a notable depreciation of communications in the energy sector, as well as a lack of development in many state regulatory mechanisms in the energy saving sector.

Although there is promise for renewable energy sources, minerals make up more than half of Kazakhstan's energy mix. Kazakhstan intends to raise the proportion of renewable energy to 50% by 2050 as part of its strategic socioeconomic plan, as approximately 90% of electricity is generated using fossil fuels (Rivotti et al., 2019). The ninth largest country in the world, Kazakhstan is characterized by its vast geographical area and vast natural resources such as oil, gas, uranium and copper. Kazakhstan has a large hydrocarbon reserve that have attracted foreign investors (Orazgaliyev, 2018). In such circumstances, in order to preserve and promote national interests, the intervention of the state and its effective work in this direction sift through the sieve of justice. Many scientists have always been concerned about the efficiency of the state's operations. Six governance indicators developed by Kaufmann et al. (1999; 2003; 2008; 2009; 2010; 2011) will help shed some light on this issue.

The research aims to evaluate impact of six good governance indicators on energy indicators. Thus, the article is organized as follows: Introduction, Literature review, Methodology, Data and Findings, and Conclusion.

2. LITERATURE REVIEW

Many researchers from all corners of the world have been constantly examining the association between governance quality and energy metrics (Wang et al., 2022; Hadj et al., 2023; Yasmeen et al., 2023; Rout and Gochhayat, 2024). From 1990 to 2019, climate change causes natural catastrophes influencing energy consumption and carbon emissions in 111 nations. CO_2 dynamics shifted around 2004, resulting in climate-driven disaster surges globally. Storms and severe temperatures have different effects on energy use and emissions (Kirat et al., 2024). Rising to a new record of over 36.8 Gt, worldwide energy-related CO_2 emissions grew by 0.9% or 321 Mt in 2022 (IEA, 2023).

Another process the globalization; it can be claimed that there are no closed economies anymore. Both globalization and energy consumption have a huge impact on the environment (Azam and Abdullah, 2022). The degree of the economic openness does indicate negative and significant relations with the environmental pollution also (Dadgar and Nazari, 2016). Nevertheless, some researches (Girlovan et al., 2025) demonstrate effectiveness of trade openness in term of greenhouse emissions decreasing, as it opens door to new technology. The energy is an essential input in almost every sector of the economy and plays a vital role in economic development (Zhong et al., 2025). Energy governance plays a mediatorship role between energy security and National security (Moghani and Loni, 2025). Alsaleh et al. (2021) assessed interdependence of world government indicators and bioenergy industry and revealed that with increasing regulatory quality, increase in voice and accountability, increase in government effectiveness the bioenergy is growing too. In their sturdy Akhtar et al. (2024) found evidence of co-relation of industrialization, renewable energy, transportation, and corruption control. Aziz et al. (2023) claim that one of the best tools to lower carbon emissions is education; educated people know about the effects on the surroundings.

In improving governance effectiveness, it is vital to improve cross-regional collaboration (Wu and Qiao, 2025). Study of Tergu et al. (2024) suggests that thorugh political stability, voice and accountability, controlled corruption, and enforcement of rule of law lowering of CO_2 emissions can be achieved. Naseer et al. (2025) investigated environmental sustainability across different economies including influence of renewable and non-renewable energy use, governance quality, and economic growth. Whereas non-renewable energy use shows a negative relationship, the results show a favorable link between renewable energy consumption and governance quality with environmental sustainability.

Al-Tal and Al-Tarawneh (2021) evaluated impact of political stability and governance effectiveness on energy consumption in MENA countries and revealed that both has positive effect on it. In their research Simionescu et al. (2021) revealed that government efficiency lowers greenhouse gas emissions both now and in the long run. Anwar et al. (2021) investigated effect of good governance indicators on environment quality. They came to conclusion that improvement in governance indicators will lead to reduction in degradation and a reduction in the environmental quality. Vo and Vo's (2021) empirical findings indicate that economic growth generally augments renewable energy consumption, with the impact being either dampened or amplified by various indicators of good governance. Mukhtarov et al.'s (2023) examination findings showed that the usage of renewable energy is positively and empirically significantly influenced by income, CO_2 emissions, and corruption perceptions index. As we see institutional quality has imposing weight.

This aim of this research is to assess impact of good governance indicators on some energy indictors which related to green growth. Thus, 3 Autoregressive Distributed Lag (ARDL) models will be used and all necessary tests will be done.

By this, authors will try to answer following research questions (RQ):
RQ 1: Do governance indicators effect on CO_2 emissions?
RQ 2: Do governance indicators effect on Energy intensity?
RQ 3: Do government indicator effect on Renewable energy?

3. METHODS

Given In view of the results of reviews presented in the previous section, we study the relationship between indicators of green growth in the period of 2002-2023 with Governance indicators of the Republic of Kazakhstan, that are Voice and Accountability, Political stability and absence of violence/terrorism, Government effectiveness, Regulatory Quality Rule of Law and Control of Corruption. For the following indicators of green growth, the variables Production-based CO_2 intensity (PBCO2I), Energy intensity per capita (EIPC), Renewable energy supply (RES) were taken, and their corresponding regression equations (1-3) were considered:

$$PBCO2I = f\ (VA, PSAV, GE, RQ, RL, CC) \quad (1)$$

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

Next, *EIPC and RES are* assessed by following regression model:

$$EIPC = f\ (VA, PSAV, GE, RQ, RL, CC) \quad (2)$$

$$RES = f\ (VA, PSAV, GE, RQ, RL, CC) \quad (3)$$

All of the variables under investigation, with the exception of EIPC, were determined to be stationary at the level of I (0) or first differences I (1) during the study, according to the findings of the ADF test (Table 2). Furthermore, EIPC is not stationary unless there is a first discrepancy between the trend and the intercept. In order to ascertain whether the ARDL model is appropriate for the study, the ARDL technique is applied, the order of variable integration is taken into account, and a special test is employed to pick no more than two lags (Table 3).

First difference was used to estimate linear ARDL models, and both short- and long-term evaluations of the correlation between the variables were carried out. Long-run and short-run analyses of the relationship between the variables were performed, and a linear ARDL model was estimated using first difference based on the Granger causality test results (Table 4). In the variable's mean value, the CC-value of the PBCO2I dependence on the coefficient of variation was 0. Changes in the dependent variables EIPC and RES were not causally related to the GE and RQ values.

The results of the limits test, which verifies the long-term association, are shown in Table 5. The process ascertains whether cointegration exists between the chosen variables in the lagged distributed autoregressive linear (ARDL) model.

Three primary models were built. The ARDL process ascertains whether cointegration exists between the chosen variables in these distributed lag linear autoregressive models. When the ARDL structure of models 1-3 is described by equations 4-6, respectively,

Table 1: Model variables and sources

Variables	Definitions	Sources
PBCO2I	Production-based CO_2 intensity, energy-related CO_2 per capita, Tons of CO_2-equivalent per person	The Organisation for Economic Co-operation and Development https://data-explorer.oecd.org/
EIPC	Energy intensity per capita, Tons of oil equivalent per person	The Organization for Economic Co-operation and Development https://data-explorer.oecd.org/
RES	Renewable energy supply, Percentage of energy supply	The Organization for Economic Co-operation and Development https://data-explorer.oecd.org/
VA	Voice and accountability	World Bank Group
PSAVT	Political stability and absence of violence/terrorism	World Bank Group
GE	Government effectivness	World Bank Group
RQ	Regulatory quality	World Bank Group
RL	Rule of law	World Bank Group
CC	Control of corruption	World Bank Group

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
PBCO2I	−2.426 (0.147)	−4.42*** (0.003)	I(1)	−2.174 (0.479)	−4.447** (0.011)	I(1)	0.485 (0.812)	−4.436*** (0.000)	I(1)
EIPC	−2.546 (0.120)	−4.23*** (0.004)	I(1)	−2.310 (0.411)	−4.509*** (0.009)	I(1)	0.208 (0.737)	−4.375*** (0.006)	I(1)
RES	−1.957 (0.302)	−2.781* (0.079)	I(1)	−3.069 (0.140)	−3.228** (0.109)	>I(1)	−0.676 (0.412)	−2.877** (0.006)	I(1)
VA	−1.908 (0.322)	−5.09*** (0.000)	I(1)	−1.386 (0.835)	−3.972** (0.029)	I(1)	−0.228 (0.551)	−5.216*** (0.000)	I(1)
PSAV	−1.665 (0.434)	−3.85*** (0.009)	I(1)	−4.079 (0.024)	−3.721** (0.045)	I(1)	−1.779 (0.075)	−3.907*** (0.000)	I(1)
GE	−0.886 (0.771)	−6.88*** (0.000)	I(1)	−4.290** (0.014)	−6.677*** (0.000)	I(1)	−2.566** (0.013)	−6.083*** (0.000)	I(1)
RQ	−2.139 (0.232)	−7.14*** (0.000)	I(1)	−3.285 (0.096)	−6.892*** (0.000)	I(1)	−2.268** (0.011)	−6.790*** (0.000)	I(1)
RL	−1.264 (0.622)	−4.35** (0.004)	I(1)	−0.595 (0.966)	−5.620*** (0.002)	I(1)	−2.929** (0.006)	−4.754*** (0.000)	I(1)
CC	−0.170 (0.929)	−4.48*** (0.002)	I(1)	−1.739 (0.697)	−4.616* (0.008)	I(1)	−1.733* (0.079)	−4.054*** (0.000)	I(1)

*, **, ***denote statistically significant at the 10%, 5% and 1% levels, respectively

P-value is inside brackets

Source: Authors

PBCO2I0: Production-based CO_2 intensity, EIPC: Energy intensity per capita, RES: Renewable energy supply, VA: Voice and accountability, PSAVT: Political stability and absence of violence/terrorism, GE: Government effectivness, RQ: Regulatory quality, RL: Rule of Law, CC: Control of corruption

Table 3: Selection order criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
ARDL1 PBCO2I						
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	16.87437	NA	1.36e-08	−1.087437	−0.788717	−1.029124
1	107.0758	117.2618*	7.23e-11	−6.507576	−4.416538	−6.099383
2	161.9235	38.39341	4.11e-11*	−8.392349*	−4.508993*	−7.634277*
ARDL2 EIPC						
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	16.94289	NA	2.09e-07	−1.194289	−0.945356	−1.145695
1	88.04117	99.53759*	2.28e-09	−5.804117	−4.310518*	−5.512551
2	121.6573	30.25454	1.74e-09*	−6.665732*	−3.927469	−6.131195*
ARDL3 RES						
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	4.030777	NA	0.058792	−0.003420	0.194441	0.023863
1	11.83744	11.27629	0.027803	−0.759716	−0.512390	−0.725613
2	14.80328	3.954452*	0.022606*	−0.978142*	−0.681352*	−0.937219*

Source: Authors. ARDL: Autoregressive distributed lag, LOG: Logarithm

Table 4: Noncausality tests in the sense of granger for the vector autoregressive (1) (2002-2023)

Direction of causality	F-statistic	Probability
PBCO2I		
VA does not granger cause PBCO2I	2.973103	0.2262
PSAVT does not granger cause PBCO2I	1.425348	0.4903
GE does not granger cause PBCO2I	2.969222	0.0266**
RQ does not granger cause PBCO2I	0.486958	0.7839
RL does not granger cause PBCO2I	1.736405	0.4197
CC does not granger cause PBCO2I	0.445591	0.8003
EIPC		
VA does not granger cause EIPC	8.413509	0.0149
PSAVT does not granger cause EIPC	2.069063	0.3554
GE does not granger cause EIPC	4.663280	0.0971*
RQ does not granger cause EIPC	5.482774	0.0645*
RL does not granger cause EIPC	2.102536	0.3495
CC does not granger cause EIPC	1.254671	0.5340
RES		
VA does not granger cause RES	3.193168	0.2026
PSAVT does not granger cause RES	2.290645	0.3181
GE does not granger cause RES	6.803084	0.0333**
RQ does not granger cause RES	6.514547	0.0385**
RL does not granger cause RES	2.298060	0.3169
CC does not granger cause RES	1.985288	0.3706

Source: Authors. PBCO2I0: Production-based CO_2 intensity, EIPC: Energy intensity per capita, RES: Renewable energy supply, VA: Voice and accountability, PSAVT: Political stability and absence of violence/terrorism, GE: Government effectivness, RQ: Regulatory Quality, RL: Rule of law, CC: Control of corruption

the limits test verifies the long-term relationship. Here, the Granger causality test results are also considered.

Thus, the ARDL1 structure of model 1 is expressed in a linear form 3, like all the others:

$$\Delta PBCO2I_t = \beta_0 + \sum\nolimits_{k=1}^{m} \beta_{1k} \Delta PBCO2I_{t-k} + \sum\nolimits_{k=0}^{n} \beta_{2k} \Delta VA_{t-k} + \sum\nolimits_{k=0}^{p} \beta_{3k} \Delta PSAVT_{t-k} + \sum\nolimits_{k=0}^{q} \beta_{4k} \Delta RQ_{t-k} + \sum\nolimits_{k=0}^{r} \beta_{5k} \Delta RL_{t-k} + \sum\nolimits_{k=0}^{s} \beta_{6k} \Delta CC_{t-k} + \gamma_1 VA_{t-i} + \gamma_2 PSAV_{t-i} + \gamma_3 RQ_{t-i} + \gamma_4 RL_{t-i} + \gamma_5 CC_{t-i} + \varepsilon_t \quad (4)$$

where, operator Δ represents the differencing operation.

ARDL2 is estimated as follows:

$$\Delta EIPC_t = \beta_0 + \sum_{k=1}^{m} \beta_{1k} \Delta EIPC_{t-k} + \sum_{k=0}^{n} \beta_{2k} \Delta VA_{t-k} + \sum_{k=0}^{p} \beta_{3k} \Delta PSAVT_{t-k} + \sum_{k=0}^{q} \beta_{4k} \Delta RL_{t-k} + \sum_{k=0}^{r} \beta_{5k} \Delta CC_{t-k} + \gamma_1 VA_{t-i} + \gamma_2 PSAV_{t-i} + \gamma_3 RL_{t-i} + \gamma_4 CC_{t-i} + \varepsilon_t \quad (5)$$

ARDL3 is expressed as follows:

$$\Delta RES_t = \beta_0 + \sum_{k=1}^{m} \beta_{1k} \Delta RES_{t-k} + \sum_{k=0}^{n} \beta_{2k} \Delta VA_{t-k} + \sum_{k=0}^{p} \beta_{3k} \Delta PSAVT_{t-k} + \sum_{k=0}^{q} \beta_{4k} \Delta RL_{t-k} + \sum_{k=0}^{r} \beta_{5k} \Delta CC_{t-k} + \gamma_1 VA_{t-i} + \gamma_2 PSAV_{t-i} + \gamma_3 RL_{t-i} + \gamma_4 CC_{t-i} + \varepsilon_t$$

4. DATA AND FINDINGS

4.1. Data

This study examines the influence of 6 Governance indicators on green growth indicators in Kazakhstan. The study uses data from 2002 to 2023, which was obtained through the World Data Bank and The Organization for Economic Co-operation and Development. The explanatory variables in this study are Voice and Accountability, Political stability and absence of violence/terrorism, Government effectiveness, Regulatory Quality, Rule of Law, Control of Corruption.

The definitions and measurements of all indicators are given in Table 1 below.

The dynamic change of all indicators presented in the table in the period 2002-2023 is depicted in the following graph:

From the analysis of the graph presented in Graph 1, it is clear that the variables under study are suitable for analysis. The graph shows clear, consistent, and stable time patterns, indicating that changes in the variables are suitable for further study.

Graph 1: Evolution of all variables for Kazakhstan (2002-2023)

Source: Authors

4.2. Descriptive Statistics

This study used descriptive statistics, and ARDL model to test the hypothesis. Descriptive statistics provide insight into various aspects of a data set. The descriptive statistics results presented in Table 2 show aggregate means such as mean and median, as well as measures of dispersion and variation such as standard deviation minimum, maximum, skewness, and Jarque-Bera statistics for each variable used in our model.

Green growth indicators like production-based CO_2 intensity, energy intensity per capita, and renewable energy supply have mean values of 11.279, 3.645, and 1.383, respectively, and median values of 11.075, 3.615, and 1.415, respectively, according to descriptive statistics. The standard deviations are 1.743, 0.537, and 0.325, indicating relatively stable values. All probability values are >0.05, indicating that the series are uniformly distributed. The Jarque-Bera statistics values are 0.247, 0.137, and 1.636, respectively, while the probabilities of association are 0.884, 0.934, and 0.441, respectively. Additionally, all indicators' standard deviations are higher than 0.10. Table 6 shows that the time series' coefficient of asymmetry is >0 for the RES, VA, PSAV, and CC indicators, indicating that they have a right asymmetry. The excess value for each indication shows that there is not too much surplus and that the distribution is nearly normal.

4.3. Unit Root Test

The levels or differences of time series variables were tested for stationarity using the Augmented Dickey-Fuller unit root tests (ADF). It is crucial to ascertain whether series are stationary before looking at their long-term interactions. While certain variables are ideally stationary at the first difference I(1) level, others can be employed at the I(0) level. The majority of the study series are not steady at level, according to the ADF results, as indicated in Table 2. When there is a first discrepancy between the trend and the intercept, only RES is non-stationary. Therefore, the ARDL cointegration approach is the most effective strategy to estimate or evaluate the long-term relationship between the study variables in this situation if RES is not utilized.

The ARDL model test must be used to verify whether there are long-term correlations between the Kazakhstani governance indicators and the green growth indicators, as the unit root results are in line with the study's primary assumptions.

Table 5: Results of cointegration test

Model	F-statistics	Critical bounds	Decision
ARDL1	6.258180	2.93-4.21	Cointegration
ARDL2	5.059309	3.01-4.44	Cointegration
ARDL3	5.443327	3.01-4.44	Cointegration

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

4.4. Granger Causality Test

To study the causal relationship between 6 Governance indicators and Production-based CO_2 intensity (PBCO2I), Energy intensity per capita (EIPC), Renewable energy supply (RES), the Granger test is used, which tests the null hypothesis that changes in the dependent variable are not causal (Noncausality).

To increase the accuracy of the stability test, this study also used pair-to-pair Granger causation to determine the causality between variables as shown in Table 4.

The study revealed a causal relationship from all variables except CC to PBCO2I, and from all variables except GE, RQ to EIPC and RES.

4.5. Co-Integration Test

The ARDL boundary testing procedure is used in this study to investigate long-term relationship between Voice and Accountability, Political stability and absence of violence/terrorism, Government effectiveness, Regulatory Quality, Rule of Law, Control of Corruption and green growth indicators in the Republic of Kazakhstan. And the ARDL model was chosen to study the long-term relationship between the variables under consideration and GDPPC. Before the co-integration test can be performed, it is important to determine the criteria for the length of the lag. The delay length criterion is determined based on LR, FPE, AIC, SC and HQ. Table 3 shows the results of the selected lag. As shown in Table 5, the chosen length of the lags 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, the linear models ARDL1, ARDL2 and ARDL3 were estimated using the first difference of the ADF test, and to conduct a long-run and short-run analysis of the relationship

Table 6: Values of descriptive statistics of the displayed series

Values	PBCO2I	EIPC	RES	VA	PSAVT	GE	RQ	RL	CC
Mean	11.279	3.645	1.383	−1.142	0.054	−0.342	−0.195	−0.728	−0.784
Median	11.075	3.615	1.415	−1.148	0.013	−0.459	−0.254	−0.669	−0.926
Maximum	14.190	4.650	1.980	−1.004	0.777	0.147	0.155	−0.447	−0.186
Minimum	7.640	2.540	0.900	−1.245	−0.468	−1.075	−0.694	−1.202	−1.114
Standard deviation	1.743	0.537	0.325	0.067	0.369	0.354	0.229	0.256	0.310
Skewness	−0.042	−0.057	0.050	0.286	0.431	−0.156	−0.043	−0.565	0.916
Kurtosis	2.488	2.631	1.668	2.211	2.126	1.934	2.260	1.821	2.219
Jarque−Bera	0.247	0.137	1.636	0.871	1.382	1.131	0.509	2.444	3.638
Probability	0.884	0.934	0.441	0.647	0.501	0.568	0.775	0.295	0.162
Sum	248.130	80.200	30.430	−25.128	1.180	−7.529	−4.289	−16.026	−17.249
Sum of squared deviations	63.818	6.055	2.212	0.095	2.858	2.634	1.097	1.374	2.019
Obs	22	22	22	22	22	22	22	22	22

Source: Authors. PBCO2I0: Production-based CO_2 intensity, EIPC: Energy intensity per capita, RES: Renewable energy supply, VA: Voice and accountability, PSAVT: Political stability and absence of violence/terrorism, GE: Government effectivness, RQ: Regulatory quality, RL: Rule of Law, CC: Control of corruption

Table 7: Results of ARDL and ARDL estimation (2002-2023)

Variable	Model 1- results of ARDL1 (1, 0, 2, 2, 0, 2) estimation ΔPBCO2I Coefficient (t-Stat.)	Model 2- results of ARDL2 (1, 1, 1, 2, 2) estimation ΔEIPC Coefficient (t-Stat.)	Model 3- results of ARDL3 (1, 2, 1, 0, 2) estimation ΔRES Coefficient (t-Stat.)
Short run			
PBCO2I (−1)*	−0.123 (−0.758)		
EIPC (−1)*		**−0.248 (−2.088)***	
RES (−1)*			**−0.218 (−2.109)***
VA**	3.354 (0.953)		
VA (−1)		**−1.120 (−2.608)****	**−0.434 (−2.213)***
PSAVT (−1)	−1.735 (−1.470)	**0.549 (1.997)***	−0.068 (−0.702)
RQ (−1)	**13.043 (2.421)****		
RL (−1)		**−0.851 (−1.853)***	
CC (−1)	**−6.045 (−1.880)***	**0.987 (1.996)***	−0.234 (−1.096)
Δ (VA)		**−4.540 (−2.257)***	0.838 (1.457)
Δ (VA(−1))			**0.888 (1.924)***
Δ (PSAVT)	**−2.112 (−2.694)****	−0.399 (−1.479)	0.161 (1.520)
Δ (PSAVT(−1))	**2.556 (2.485)****		
Δ (RQ)	−1.450 (−0.600)		
Δ (RQ(−1))	**−8.718 (−4.032)*****		
Δ (RL)		−1.112 (−0.880)	
Δ (RL(−1))		**−2.169 (−2.598)****	
Δ (CC)	**−7.371 (−2.206)***	0.686 (0.992)	**−0.736 (−2.848)****
Δ (CC(−1))	**−4.336 (−2.180)***	**−2.100 (−2.589)****	0.378 (1.117)
Long run			
VA	27.228 (0.433)	**−4.524 (3.408)***	**−1.991 (−3.458)*****
PSAV	−14.088 (−0.546)	2.220 (1.342)	−0.315 (−0.650)
GE			
RQ	105.884 (0.609)		
RL	−46.907 (−0.628)	−3.437 (−1.357)	2.547 (1.499)
CC	−49.0747 (−0.587)	3.988 (1.354)	−1.072 (−0.810)
Diagnostic	**F-statistics (P-value)**	**F-statistics (P-value)**	**F-statistics (P-value)**
Serial correlation	1.308709 (0.3375)	2.493770 (0.1530)	0.027031 (0.8730)
Heteroskedasticity	1.300513 (0.3761)	0.688740 (0.7229)	0.360956 (0.9359)
Jarque-Bera	0.821607 (0.6631)	1.999708 (0.3679)	0.492655 (0.7817)

1) coefficients are statistically significant at ***1%, **5%, *10% level of significance.
Source: Authors. PBCO2I0: Production-based CO_2 intensity, EIPC: Energy intensity per capita, RES: Renewable energy supply, VA: Voice and Accountability, PSAVT: Political stability and absence of violence/terrorism, GE: Government effectivness, RQ: Regulatory Quality, RL: Rule of Law, CC: Control of Corruption

between the variables, the results obtained are presented in the following Table 7. The results of the cointegration F-test for these models (Table 5) show that the obtained F-statistics (6.258180, 5.059309 and 5.443327) are greater than the upper limit of 4.44 and are statistically significant at the 1-10% significance levels. The results indicate that the selected variables are cointegrated and in the case of Kazakhstan, there is a long-run relationship between them.

Authors can assess the long- and short-term effects of changes in the explanatory factors on the dependent variable because the ARDL model was calculated using first difference. We can move on to the following phase, which entails estimating the long-run and short-run coefficients, since the chosen variables are cointegrated over the long term.

Diagnostic tests were conducted to make sure the linear ARDL1-ARDL3 models were robust (Table 7). These consist of tests for heteroscedasticity, normalcy, and serial correlation. The null hypotheses of normality, homoscedasticity, and no serial correlation cannot be disproved for any model. This suggests that serial correlation and heteroscedasticity are absent from the model.

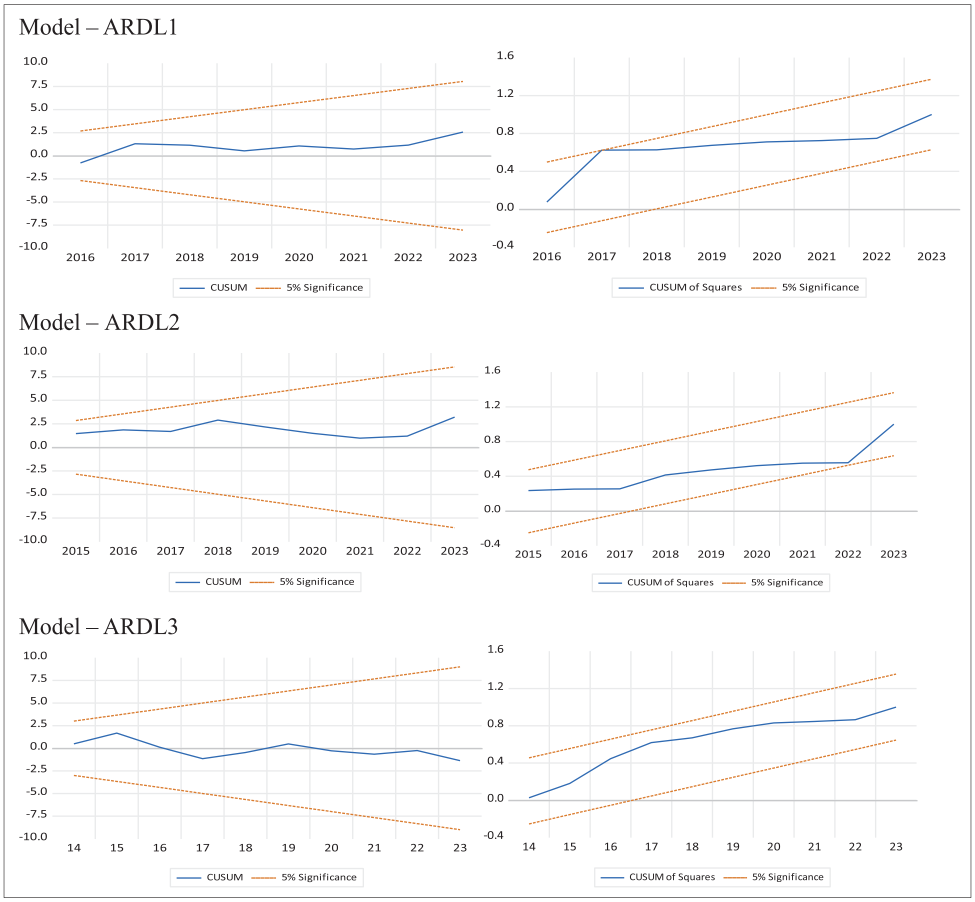
The diagnostic test results are shown in Table 7. The probability value for the ARDL1 model is 0.3375, and the LM statistic is 1.308709. Therefore, we conclude that there is no serial correlation in the model and accept the null hypothesis in this study. According to heteroscedasticity tests, the model is homoscedastic since the F statistic is 1.300513 and the probability is 0.3761, both of which are higher than the 0.05% significance level.

The F-statistic of 0.821607 and the probability of 0.6631 demonstrate that the residuals are normally distributed, and the model accepts the null hypothesis of the normality test. All values are significant at 5%. Lastly, the ARDL1 model's robustness is demonstrated by the successful completion of all diagnostic tests for serial correlation using the Langrange multiplier, the Jarque-Bera normalcy test, and the heteroscedasticity test. Accordingly, the ARDL2 and ARDL3 models' resilience is also described.

4.7. Stability Tests

The CUSUM and CUSUM Squares tests are used to test whether the estimated models' coefficients remain constant over time, which is an indicator of model stability.

Graph 2: CUSUM and CUSUM squares tests



Graph 2 displays the findings of the CUSUM and CUSUMSQ stability tests. The significance of not surpassing the crucial thresholds suggests that the model is stable at the 5% level of significance testing. Additionally, the long-term dynamics of regression are studied using this test.

5. CONCLUSION

To assess impact of good governance indicators on some green growth indicators, data covering 2002-2023 years were taken from World Data Bank and Organization for Economic Co-operation and Development websites. Three models evaluated the impact of six governance indicators, meaning Voice and Accountability, Political stability and absence of violence/terrorism, Government effectiveness, Regulatory Quality, Rule of Law, Control of Corruption on Production-based CO_2 emissions, Energy intensity per capita and Renewable energy supply.

According to Model 1-ARDL1(1, 0, 2, 2, 0, 2) (equation 4), all governance indicator coefficients are negligible over the long term and have no effect on the increase in production-based CO2 intensity.

In the short term, an increase in the lagged variable Control of Corruption also significantly lowers the Production-based CO2 intensity (-6.045), while the lagged variable Regulatory Quality has a positive effect on PBCO2I (13.043). In the short term, Rule of Law reduces the growth of PBCO2I (-5.778). In the short term, the Production-based CO2 intensity is positively and significantly impacted by the difference in the levels of the lagged variable Political stability and absence of violence/terrorism (PSAVT) (2.556), negatively and significantly by the difference in the levels of the lagged variables Control of Corruption (-4.336) and regulatory quality (-8.718).

The findings of Model 2-ARDL2(1, 1, 1, 2, 2) (equation 5) demonstrate that, over time, a higher degree of voice and accountability will result in a slower increase in energy intensity per capita. (-4.524)

In the short term, energy intensity per capita is significantly impacted negatively by the disparity between the levels of the lagged variables Rule of Law (-2.169) and Control of Corruption (-2.100). Energy intensity per capita grows significantly when the lagged variables Control of Corruption (0.987) and Political stability and absence of violence/terrorism (0.549) increase. Two lagged variables, VA (-1), and RL (-1) have negative effects, with coefficients of -1.120 and -0.851, respectively. The present energy intensity per capita (-0.248) is greatly decreased by an increase in the lagged variable.

Equation 6 of Model 3-ARDL3(1, 2, 1, 0, 2) estimation also verified that the expansion of Voice and Accountability has a favorable impact on the supply of renewable energy. The growth of energy intensity per capita is also considerably slowed down in the short run by an increase in the lagged variable Voice and Accountability (-0.434). The difference in the level of the lagged variable Voice and Accountability (0.888) has a positive and significant impact on the supply of renewable energy during this time. Short-term RES growth is boosted by the rule of law (0.556). The current Renewable energy supply is greatly decreased (-0.218) by an increase in the lagged variable Renewable energy supply.

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