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A CARBON-INTENSITY BASED ARDL ANALYSIS INCORPORATING INSTITUTIONAL EMISSIONS TRADING MECHANISMS IN KAZAKHSTAN

Abstract

The Republic of Kazakhstan sets the goal of achieving carbon neutrality by 2060 and the transition to a green economy. The aim of this work is to study the impact of energy intensity, the use of renewable energy sources and the launch of an emissions trading system (ETS) on carbon intensity in the Republic of Kazakhstan for the period 1992–2022. To achieve this goal, the method of autoregressive distribution lags was used. The research makes scientific contribution by considering carbon intensity as a target variable in econometric analyses. The practical importance lies in integrating in the model the ETS dummy variable as a determinant of the explained variable. The results of the study showed that there is a long-term relationship between the selected variables, and energy intensity is the main driver of carbon intensity in the long term. The impact of RES has not been statistically confirmed. Verification of the results by including GDP per capita variable, as controlling variable confirmed the correctness of the conclusions of the base model. The results of the work emphasize the importance of enhancing the design of the emissions trading system and improving energy intensity to increase its effectiveness in reducing the carbon intensity of the country's economy.

Keywords: carbon intensity, energy intensity, renewable energy sources, autoregressive distributed lags model, emissions trading system, greenhouse gas emissions.

Introduction

Climate change is now a global environmental and economic threat.

Under international agreements, countries commit to reducing greenhouse gas emissions, and introduce carbon trading systems and carbon taxation as economic incentives.

The key aspect of the ecological economy is to ensure balanced sustainable economic development, taking into account natural limitations. Central to this section of economic science is the theory of the Environmental Kuznets Curve (EKC), which assumes an inverted U-shaped relationship between economic growth and pollutant emissions. According to this theory, in the early stages of economic development income and pollution both increase up to some average income threshold. That threshold is a turning point at which degradation starts to decline as wealthier society forces governments to implement stricter policies, investments in more efficient and eco-friendly technologies increase, and economies shift from polluting towards cleaner industries.

To determine the key causes of changes in greenhouse gas emissions, the method developed in 1993 by Japanese economist Yoichi Kaya is used. The Kaya identity disaggregates data into four factors: population size, level of well-being (GDP per capita), energy intensity of the economy and carbon intensity of energy consumption [1]. As long as population and GDP per capita in most countries are growing emissions reduction can be achieved by the remaining two factors – cleaner energy technology and lower energy consumption.

Along with Kaya's identity, the IPAT model is used. The model was formulated by scientists John Holdren and Paul Enrlich in the 1970s and shows that the level of pollution (Influence) can be influenced by the size of the population (Population) and its well-being (Affluence), as well as the technologies used (Technology) [2]. The equation highlights the idea that ecological crises are not just a result of overpopulation but the interaction of all three factors. For instance, even when population grow slowly if their consumption increases at a high pace and technology used to produce consumption is noneffective then the total damage due to multiplying effect will be great.

A slowdown in the growth of emissions or even their reduction can be achieved by increasing the level of technological development, which is provided by the concept of decoupling. This concept is aimed at separating economic growth from the depletion of used resources and the negative impact on the environment. Based on the goals, decoupling can be divided into two types: resource decoupling and impact decoupling. The first type is aimed at reducing the use of primary resources used to produce a unit of GDP, while the second focuses on reducing environmental damage associated with increased well-being. There is also a distinction between absolute and relative decoupling. Absolute decoupling means that there is resource consumption and emissions decrease despite economic growth. In case of relative decoupling the growth rate of the economy is higher than the growth rate of resource use and negative environmental impact [3].

In oil-rich countries, there is a negative effect on environmental sustainability due to a change in the structural composition of consumption in favor of energy and carbon-intensive technologies [4]. Mukhtarov et al. (2023) in their study note that in Azerbaijan, a 1% rise in per capita GDP increases CO_2 emissions based on consumption by 0.46% and a 1% rise in the share of renewable energy (RES) consumption reduces emissions by 0.26% [5]. According to the findings of Kuziboev et al. (2024) in the countries of Central Asia, the positive effect of energy intensity on CO_2 emissions is confirmed [6].

In Kazakhstan, most studies focus on the Environmental Kuznets Curve and absolute CO_2 emissions.

Akbota and Baek (2018) consider the impact of economic growth on CO_2 emissions in Kazakhstan, taking into account energy consumption. The ARDL model results obtained by the authors show that CO_2 emissions decrease with a higher income level confirming the presence of EKC for Kazakhstan and highlight the adverse effect of energy consumption on emissions level [7]. Issayeva et al. (2024) expand the EKC concept by including in the ARDL model variables such as production of the industrial and agricultural sectors, energy consumption from renewable energy sources. The findings of the research also confirm the EKC with industrial production and consumption of energy from RES reducing CO_2 emissions [8].

Pirmanova et al. (2025) through a NARDL model estimated the impact of greenhouse gas emissions, PM2.5 particles, and renewable energy use on sustainable development. The results show that emissions and PM2.5 exposure have an asymmetric impact, and RES energy consumption does not affect the sustainability index [9].

Smagulova et al. (2025) investigate the impacts of economic growth, population size, RES, fossil fuels, and nuclear energy on Kazakhstan's CO_2 emissions based on the STIRPAT model. Estimates of the ARDL method suggest that population growth and renewable energy consumption significantly influence CO_2 growth in the long term. A 1% population growth drives 3.3% increase of emissions. A 1% increase in RES consumption, in contrast, reduces emissions by 0.2% [10].

Chigarkina et al. (2025) using the autoregressive distributed lag method confirmed that oil prices, oil production and renewable energy consumption have positive impact on GDP growth in long and short term. Conversely, the hypothesis that CO_2 emissions positively affect economic growth in short and long run was not confirved [11].

Tleppayev and Zeinolla (2023) consider the relationship between energy consumption and environmental effect. The authors note that energy consumption is the most significant factor determining the amount of CO_2 emissions with a 0.7% increase in carbon dioxide emissions caused by 1% growth of energy consumption [12].

The selection of this topic is motivated by the need to fill the gap in the existing literature by building an autoregressive distributed lags model using carbon intensity as a dependent variable and including an emissions trading system launch dummy variable (ETS dummy).

The aim of the study is to empirically assess the impact of energy intensity, renewable energy sources and the introduction of a national emissions trading system (ETS) on the carbon intensity of the economy of Kazakhstan using the ARDL bounds testing approach method.

The object of the study is the carbon intensity of the economy of Kazakhstan and factors determining its dynamics. The subject of the study is the estimation of the relationship between carbon intensity (dependent variable) and energy intensity, renewable energy sources share, ETS dummy variable (explanatory variables).

To achieve the goal of the study, the following tasks are set:

- review theoretical and empirical studies of the influence of various factors on carbon intensity;
- collect the necessary data, including indicators of carbon intensity, energy intensity and RES share in total energy consumption;
- based on the results obtained, formulate recommendations for further improvement of research.

As part of the study the following hypotheses were formulated and tested:

H1: There is a long-term relationship between the target and selected explanatory variables.

H2: Energy intensity increases the carbon intensity.

H3: Share of renewable energy sources in energy consumption contributes to decarbonization.

H4: Emissions trading system in Kazakhstan has a weak effect on reduction of CO_2 emissions intensity.

The theoretical significance of the work lies in the transition from the analysis of a quantitative indicator of greenhouse gas emissions in CO_2 equivalent to a qualitative indicator of carbon intensity. The practical significance of the study is to quantify the emissions trading system triggering effect by adding ETS dummy variable to the model.

Materials and methods

Data and variables.

Based on the literature review, the following variables are used:

- dependent variable – carbon intensity;
- independent variables – energy intensity, RES share, ETS dummy variable denoting the launch of the Emissions Trading System;
- control variable – GDP per capita.

Table 1 – Data used and its sources

Variable	Description	Source
Carbon intensity	Carbon intensity of GDP (kg CO2e per constant 2015 US$ of GDP)	databank.worldbank.org
Energy intensity	Energy intensity measured in terms of primary energy and GDP (MJ/$ 2017 PPP GDP)	www.iea.org
Share of RES	Renewable energy consumption (% of total final energy consumption)	www.iea.org
GDP per capita	GDP per capita (constant 2015 US$)	databank.worldbank.org
Note: Compiled by the authors based on data from [13–14].		

For empirical analysis, annual data for the period from 1992 up to 2022 were used. The choice of this period is explained by the availability of data. In particular, in terms of energy intensity and the share of renewable energy sources, data is available only until 2022. All data are from international sources according to table 1.

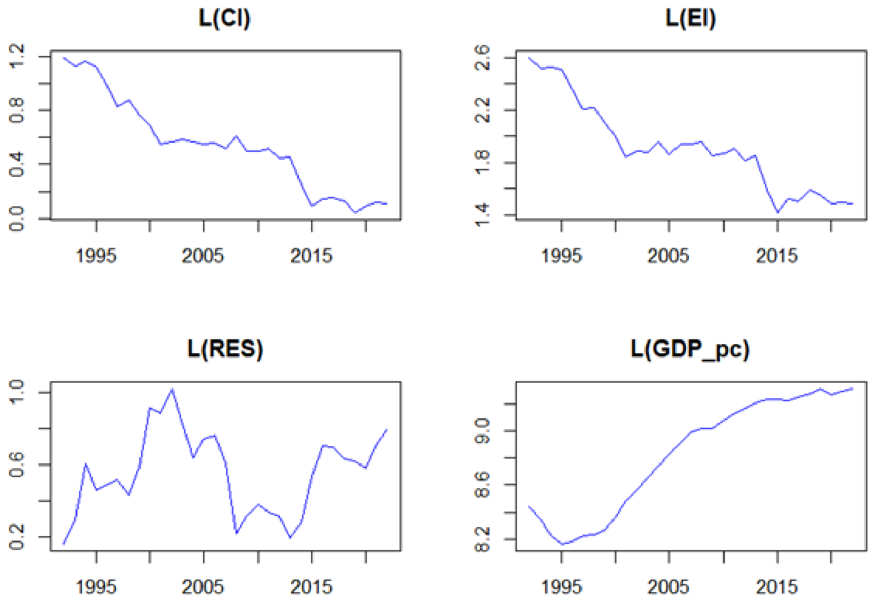

Figure 1 – Time series plots of the variables
*L is the natural logarithm.

Note: Compiled by the authors in R software environment.

All variables are transformed into the form of a natural logarithm, graphs are shown in Figure 1. The ETS dummy variable has values of 0 until the launch of the carbon trading system in 2013, and 2016–2018, when the system was suspended or there was no trading [15]. In 2014–2015 and 2019–2022 the value of the ETS dummy variable was 1.

Model specification.

The relationship between variables was tested by using the ARDL bounds testing approach and testing two model specifications:

Model 1 – Base Model: Dependent and Independent Variables.

Model 2 – Extended model: Dependent, independent and control variables.

The mathematical structures of the models are represented in formulas (1) and (2) for the basic and extended models respectively.

$$CI_t = f(EI_t, RES_t, ETS_t) \tag{1}$$
$$CI_t = f(EI_t, RES_t, ETS_t, GDPpc_t) \tag{2}$$

Where:

EI_t – Energy intensity in period t,
RES_t – Share of renewable energy consumption in period t,
ETS_t – value of ETS dummy variable in period t,
$GDPpc_t$ – GDP per capita in period t,
ARDL model evaluation and diagnosis.

ARDL model evaluation and diagnosis.

The ARDL approach allows evaluation of long-term and short-term relationships under a mixed order of integration of variables I (0) and I (1).

The first preparatory step before modeling is to check the stationarity of the variables using the ADF test and by plotting the ACF function of variables. The optimal lag structure is then selected based on the AIC criteria.

After determining the optimal lag structure, a Bounds F test is performed to identify the long-term relationship between variables, the model adjustment rate and short-term effects are determined using an error correction model (ECM), long-term coefficients are calculated by using long-term multipliers. Model diagnostics consist of residual diagnostic plots, tests for autocorrelation of residues (Breusch-Godfrey), for heteroscedasticity (Breusch-Pagan), for the normality of the distribution of residuals (Jarque-Bera), for the correctness of the model specification (Ramsey RESET), for verification of the stability of model parameters (CUSUM).

All calculations and graphical visualization are performed in R software environment.

Results and discussion

ACF function plots and unit root test results

The null hypothesis of the ADF test assumes non-stationarity of the series (presence of a unit root). The null hypothesis is rejected if the t-statistic is less than the critical value.

The results obtained showed the absence of stable stationarity of variables in the levels. However, for some variables the results were ambiguous and depended on the model specification (with constant, with constant and trend, without constant).

In the ADF level test RES and GDP_pc variables showed no stationarity in all specifications, for CI and EI, the series nonstationarity hypothesis was rejected in a simple specification without constant and trend, and in more realistic specifications, the null hypothesis was not rejected.

The test results for the first differences showed the stationarity of the series in all specifications for all variables.

Thus, it can be concluded that all variables are I (1) or I (0). The ADF test results are shown in table 2.

Table 2 – ADF test results for stationarity

Variable	Constant			Trend			None		
	Level	First difference	Result	Level	First difference	Result	Level	First difference	Result
LN_CI	-1.42	-4.07***	I(1)	-2.09	-4.30***	I(1)	-2.78***	-3.03***	I(1)
LN_EI	-1.58	-3.69***	I(1)	-2.12	-3.85**	I(1)	-2.27**	-3.04***	I(1)
LN_RES	-2.47	-4.60***	I(1)	-2.42	-4.43***	I(1)	-0.30	-4.68***	I(1)
LN_GDP_pc	-1.57	-3.80***	I(1)	-2.19	-3.89**	I(1)	1.71	-2.44**	I(1)
Note: Compiled by the authors based on R software environment output. *, * *, * * * significance at 10%, 5%, and 1%.									

The results from ADF test were further supported by the ACF function plots of explanatory variables. In case of a nonstationary series if there is a trend in the data the coefficients of ACF function are large and positive for small lags and decrease slowly as lags increase.

The ACF plots for all 4 variables are consistent with ADF test results and show: 1) at levels there are positive autocorrelation values above the bound that decrease slowly as the lags increase (Figure 2), 2) after first differencing autocorrelations decline rapidly and are within confidence bounds (figure 3).

Optimal Lag Structure selection and Model evaluation

An important step in evaluating the models in the ARDL approach is the selection of the optimal lag structure. The number of lags was selected based on the minimization of the Akaike information criterion (AIC), and the maximum length of lags was set at 2 by analogy with Akbota and Baek (2018) [7]. Table 3 shows the optimal lag structure and AIC value.

As can be seen from Table 3, the optimal structure for the basic model is defined with one lag for the dependent variable and GDP_pc variable and zero lags for the rest of the independent variables.

For the extended model, a structure is defined with one lag of the dependent variable and ETS dummy variable and zero lags for the remaining variables. Both models are statistically significant with high values of F-statistics and coefficients of determination.

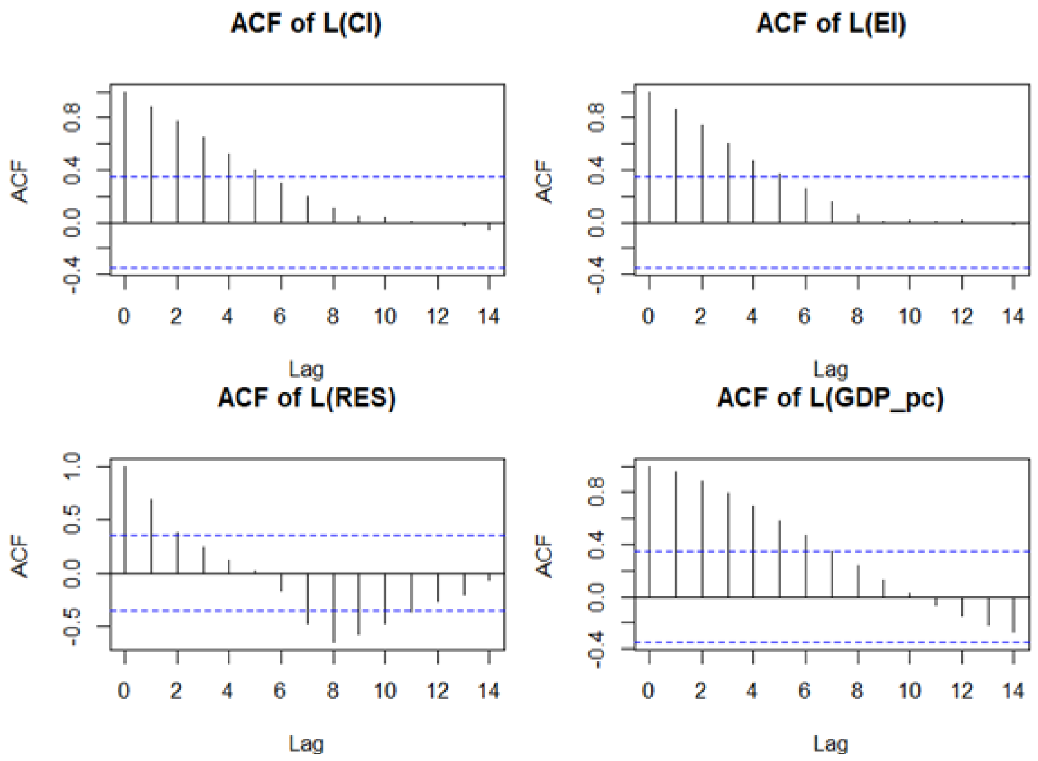

Figure 2 – ACF plots for explanatory variables at levels

Note: Compiled by the authors in R software environment.

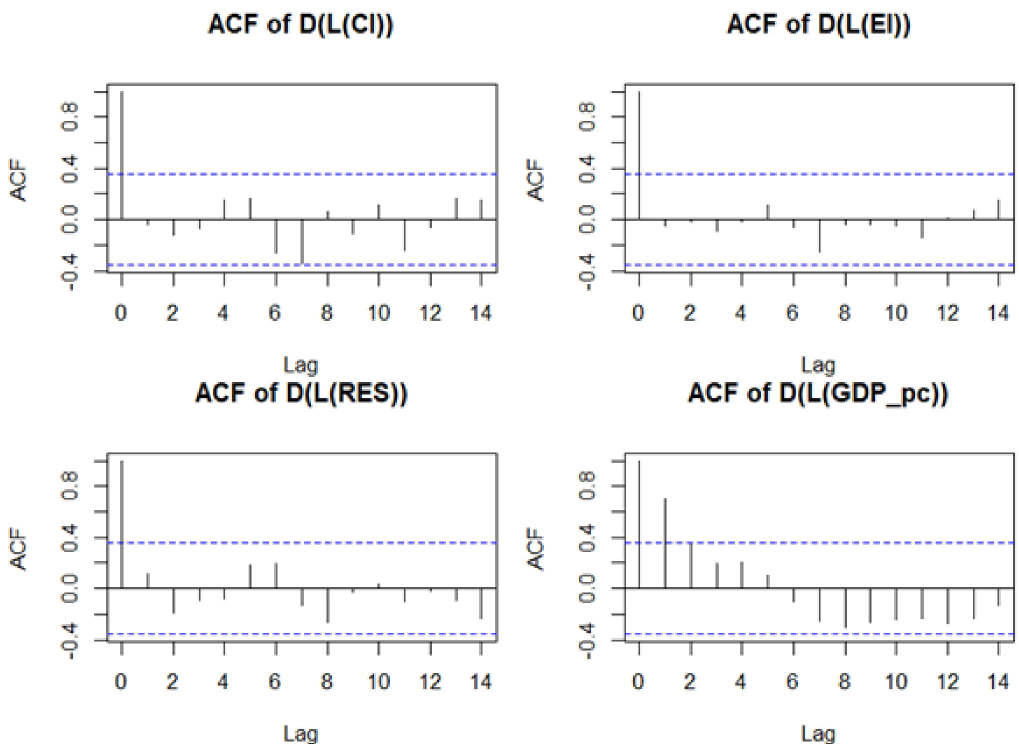

Figure 3 – ACF plots for explanatory variables at first differences

Note: Compiled by the authors in R software environment.

Table 3 – Values of selection criteria and evaluation of the ARDL model quality

Model	Selected specification	AIC	Adj. R2	F-statistic	p-value
Basic model	ARDL (1,0,0,1)	-109,8	0.989	528.5	< 2.2e-16
Extended model	ARDL (1,0,0,1,0)	-108.6	0.989	433.2	< 2.2e-16
Note: Compiled by the authors based on R software environment output.					

Table 4 shows the analysis of ARDL models.

In both model specifications the dependent variable's lag and EI variable coefficients were positive and of high significance. The ETS dummy variable was statistically significant and negative in both specifications as well. The lag of the ETS dummy variable was highly significant and positive in the basic model, but statistically weakened in the extended model (at 10% level). Income growth (GDP_pc) and RES variables are not statistically significant.

Table 4 – ARDL Model Analysis

Variable	Basic model	p-value	Extended model	p-value
L(LN_CI,1)	0.33130	0.000138	0.28011	0.00954
LN_EI	0.67282	1.62e-08	0.66718	3.22e-08
LN_RES	0.03569	0.265803	0.00855	0.85776
ETS	-0.06106	0.017156	-0.06025	0.01986
L(ETS,1)	0.05131	0.049385	0.04709	0.07865
LN_GDP_pc	-	-	-0.04506	0.44644
Note: Compiled by the authors based on R software environment output.				

Bounds test for cointegration

The null hypothesis of the cointegration test suggests no long-term relationship between the dependent and independent variables. If the value of the F-statistic is less than the lower bound, then the hypothesis of the absence of a long-term connection is not rejected, and if it exceeds the upper critical bound, then the null hypothesis is rejected.

Table 5 – Bounds F-test results

Measures	Basic model		Extended model	
	Value	к*	Value	к*
F-statistics	31.19	3	5.32	4
Critical value	lower bound	upper bound	lower bound	upper bound
10%	2,72	3,77	2.45	3,52
5%	3,23	4,35	2.86	4,01
1%	4,29	5,61	3.74	5,06
Result Cointaegration confirmed Cointaegration confirmed				
Note: Compiled by the authors based on R software environment output. * - number of independent variables.				

The F-statistics of the models considered in the work exceed the upper critical values (given in table 5), which means that there is a long-term relationship between carbon intensity and explanatory variables.

Long-term effects analysis

The next step after the confirmation of cointegration is the analysis of long-term coefficients. In both models, the RES and ETS variables were not statistically significant, high statistical significance was noted for the EI variable. In the basic model, an increase in energy intensity leads to an almost proportional increase in carbon intensity, and in the extended model a 1% increase in EI leads to a 0.9% increase in CI. In the extended model, the GDP_pc variable was not significant. Detailed data are given in table 6.

Table 6 – Long-term effects results

Variable	Basic model		Extended model	
	Coefficient	P-value	Coefficient	P- value
EI	1.006	1.116803e-18	0.9268	5.413517e-09
RES	0.0534	2.616871e-01	0.0119	8.592885e-01
ETS	-0.0146	6.808596e-01	-0.0183	5.863314e-01
GDP_pc	-	-	-0.0626	4.145636e-01
Note: Compiled by the authors based on R software environment output.				

An analysis of long-term coefficients indicates that an increase in energy intensity is the main factor affecting the growth of carbon intensity, and the emissions trading system does not have statistical strength, albeit a negative sign.

Short-term dynamics and speed of error correction.

When evaluating short-term dynamics, statistical significance and the sign of the error correction term (ect) are of key importance. If the coefficient is negative, the transition of the system to long-term equilibrium after short-term shock is confirmed [7].

As can be seen from Table 7, in both models, ect coefficients were statistically significant and with a negative sign.

In particular, in the basic model, a value of – 0.6687 means that during one period about a 67% deviation from long-term equilibrium is eliminated. For the extended model, this value is 72%. In both specifications the coefficient of difference of the ETS dummy variable is negative and significant.

Table 7 – Results of evaluation of error correction models

Variable	Basic model		Extended model	
	Coefficient	Prob	Coefficient	Prob
	-0.0611	0.004**	-0.0602	0.00405**
	-0.6687	2.40e-10***	-0.7199	1.69e-10***
Model quality measurements				
R2	0.8256		0.83	
Adjusted R2	0.8127		0.8174	
F-statistic	63.9		65.92	
p-value	5.779e-11***		4.081e-11***	
Note: Compiled by the authors based on R software environment output. * * = 5% significance level, * * * = 1% significance level, Δ is the first difference (short-term changes).				

Model diagnostics results.

This section provides the results of the main diagnostic tests.

First, analysis of the residual plots of both models was performed. Visual analysis did not reveal obvious signs of systemic violations (figure 4): time series graphs show fluctuations around the zero-expectation value with stable variance. Graphs of autocorrelation functions (ACF) show that all coefficients, starting from the first lag, are strictly inside the confidence intervals. To confirm these conclusions, formal statistical tests were conducted, which are consistent with graphical analysis.

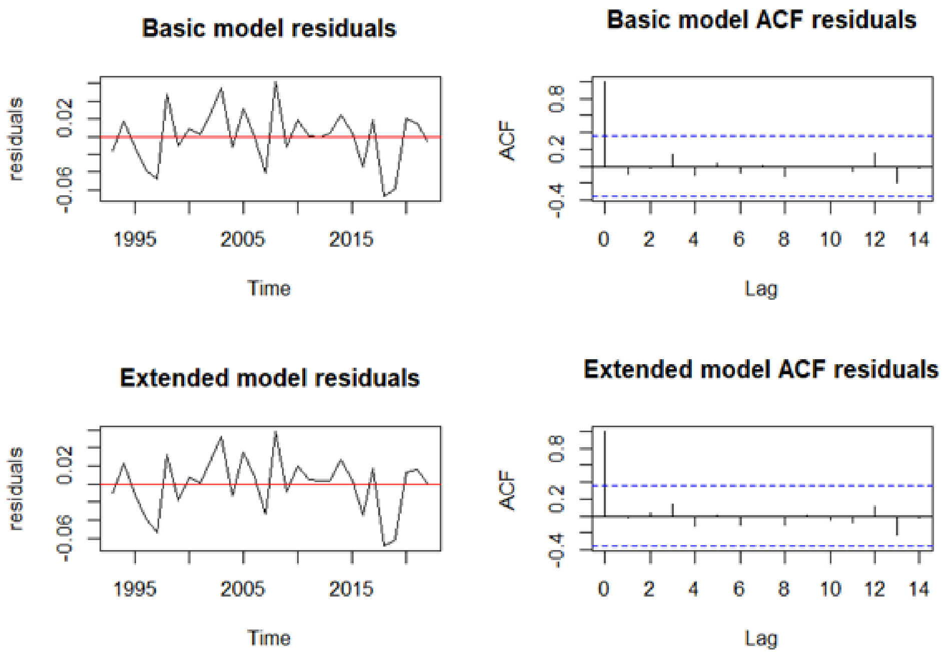

Figure 4 – Basic and extended models residuals diagnostic plots

Note: Compiled by the authors in R software environment.

The autocorrelation test was based on the Beusch-Godfrey serial correlation LM test. The null hypothesis assumes no serial correlation and is accepted if the p-value > 0.05.

Next, a heteroscedasticity test was performed using the Breusch-Pagan test. The null hypothesis states homoscedasticity, which is rejected at p-value < 0.05.

The functional form of the models was tested using the RESET test. The null hypothesis of the test implies the correct specification of the model, which is accepted if the p-value > 0.05.

The check for the normality of residuals was carried out through the Jarque-Bera test. The null hypothesis assumes a normal distribution that is not accepted when the p-value < 0.05.

A summary of the test results is provided in table 8. As can be seen from the table, both models successfully passed the test for autocorrelation, homoscedasticity, correct specification and normality of residuals.

Table 8 – Diagnostic test results (p-values)

Test	Basic model	Extended model	Result
Beusch-Godfrey LM test for autocorrelation	0.55	0.876	Null hypothesis is not rejected – no autocorrelation
Breusch-Pagan for heteroscedasticity	0.2778	0.2112	Null hypothesis is not rejected – no heteroscedasticity
Model specification test (RESET)	0.5513	0.6549	Null hypothesis is not rejected – model specification is correct
Normality of residuals (Jarque-Bera)	0.857	0.5966	Null hypothesis is not rejected – residuals are normally distributed
Note: Compiled by the authors based on R software environment output.			

Finally, the stability of the model parameters was verified using the cumulative sum of recursion residuals (CUSUM) graphs shown in figure 2. Graphs were plotted for the 5% confidence interval (red dashed lines).

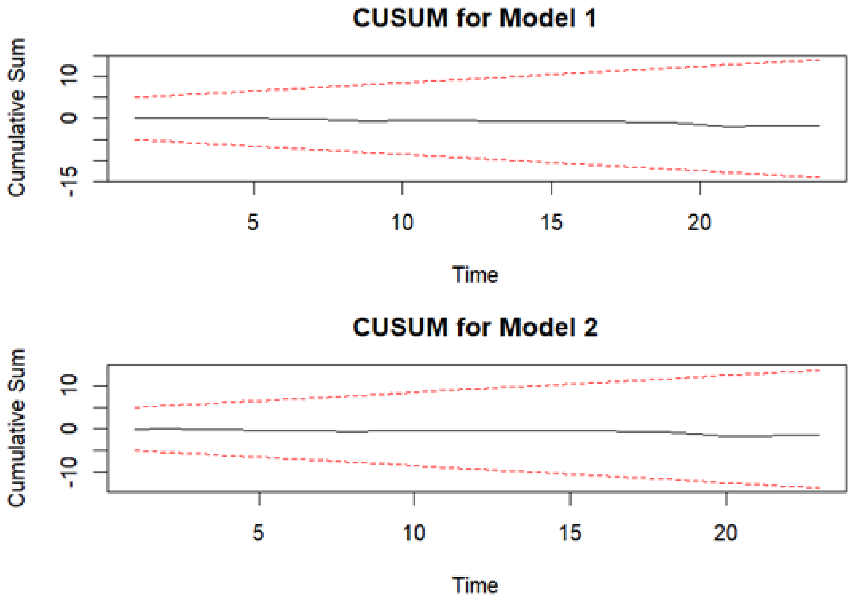

Figure 5 – CUSUM test graphs

Note: Compiled by the authors in R software environment.

In both models, the cumulative sums of recursion residuals (black line) are within the corridor of critical values, which means the stability of the model coefficients.

Both models confirm the long-term relationship between carbon intensity and explanatory variables which confirms hypothesis H1.

The hypothesis H2 (Energy intensity increases the carbon intensity) was also confirmed. In both models, the main factor in the carbon intensity of the economy of Kazakhstan in the long term is energy intensity. This indicates that the country's economy remains energy-intensive, and energy efficiency is a key condition for reducing carbon intensity. This finding is consistent with findings that increased energy consumption leads to increased greenhouse gas emissions and increased energy efficiency reduces carbon emissions [16–18].

A separate explanation requires the absence of a statistically significant effect of the RES variable on carbon intensity. However, this result does not necessarily contradict the existing literature. Altın (2024), analyzing the G7 countries, also reported an unexpected finding, revealing a statistically significant positive relationship between renewable energy consumption and CO_2 emissions [17]. Consequently, the impact of renewable energy on emissions is not universal and may depend on factors such as the stage of economic development, the scale and specifics of their use (replacement or addition to traditional sources). According to the obtained results, the H3 hypothesis (Share of renewable energy sources in energy consumption contributes to decarbonization) was rejected.

Interesting from a substantive point of view are the results of the impact of the Emissions trading system on carbon intensity. As mentioned in both models, the coefficients of the variable were negative and statistically significant only in the short term. These results reflect the specifics of the work of ETS in Kazakhstan with a low price for carbon units, a surplus and free distribution of carbon quotas. As a result, the signal to reduce emissions is weak and businesses lack the appropriate economic incentives in the long term. Thus, it can be concluded that the current design of ETS in Kazakhstan does not have a significant effect on reducing carbon intensity. The hypothesis H4 (Emissions trading system in Kazakhstan has a weak effect on reduction of CO_2 emissions intensity) is therefore confirmed only partially.

From a practical point of view, the results obtained are significant for improving economic policy in terms of revising the design of the Emissions Trading System in Kazakhstan, in particular, reducing the surplus of allocated quotas and switching to auction distribution. Also, improving energy efficiency due to its significant impact should be considered as one of the key areas of the country's climate policy.

Conclusion

The purpose of this study was an empirical assessment of the impact of energy intensity, renewable energy sources and the introduction of a national emissions trading system (ETS) on the carbon intensity of the economy of Kazakhstan. The use of the ARDL method has yielded following results.

First, a long-term relationship is confirmed between all the variables considered. Second, energy intensity is the main driver of carbon intensity in the long term. Third, in the short term ETS dummy variable has statistically significant negative effect. Fourth, the role of the share of renewable energy and GDP per capita in reducing carbon intensity has not been statistically confirmed.

According to the results, the current climate policy of Kazakhstan should be focused on reducing the energy intensity of the economy. The revealed short-term effect of the emissions trading system indicates its potential in the processes of decarbonization of the economy. In order to achieve a stable reduction in emissions, modernization of the ETS is required, which includes improving market pricing, restricting quota limits and increasing business incentives to shift toward low-carbon technologies.

The applied value of the research lies in the possibility of using the findings in measures for improving the emissions trading system and developing measures to achieve carbon neutrality.

Future studies can be aimed at a comparative analysis of the design of Kazakhstan ETS with other trading systems in order to form proposals for improving its design, as well as to assess the impact of certain system parameters on the dynamics of emissions and the carbon intensity of the economy.

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ҚАЗАҚСТАНДАҒЫ ШЫҒАРЫНДЫЛАР САУДАСЫНЫҢ ИНСТИТУЦИОНАЛДЫҚ ТЕТІКТЕРІН ҚАМТИТЫН КӨМІРТЕГІ СЫЙЫМДЫЛЫҒЫНА НЕГІЗДЕЛГЕН ARDL ТАЛДАУЫ

Аңдатпа

Қазақстан Республикасы өз алдына 2060 жылға қарай көміртегі бейтараптығына қол жеткізу және «жасыл» экономикаға көшу мақсаттарын қойып отыр. Бұл зерттеудің мақсаты – Қазақстан Республикасындағы көміртегі сыйымдылығына энергия сыйымдылығының, жаңартылатын энергия көздерін пайдаланудың және шығарындылар саудасының жүйесін іске қосудың әсерін зерттеу. Осы мақсатта 1992–2022 жж. аралығындағы деректер және авторегрессиялық үлестірілген лагтар әдісі қолданылды. Зерттеудің ғылыми және практикалық үлесі эконометрикалық модельге көміртегі сыйымдылығын тәуелді айнымалы ретінде және шығарындылар саудасы жүйесінің жұмысын айқындайтын сапалы (фиктивті) айнымалыны енгізуде жатыр. Зерттеу нәтижелері пайдаланылған айнымалылар арасында ұзақ мерзімді байланыс бар екенін көрсетті. Бұл ретте көміртегі сыйымдылығының негізгі қозғаушы факторы энергия сыйымдылығы екені айқындалды, ал жаңартылатын энергия көздерінің әсері статистикалық тұрғыдан расталмады. Модель нәтижелерінің дұрыстығы оған жан басына шаққандағы жалпы ішкі өнім айнымалысын қосу арқылы тексерілді. Зерттеу нәтижелері ұлттық экономиканың көміртегі сыйымдылығын төмендетуде шығарындылар саудасының жүйесін жетілдіру мен энергия тиімділігін арттырудың маңыздылығын көрсетеді.

Тірек сөздер: көміртегі сыйымдылығы, энергия сыйымдылығы, жаңартылатын энергия көздері, авторегрессиялық таратылған лагтар моделі, шығарындылар саудасының жүйесі, парниктік газдар шығарындылары.

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ARDL АНАЛИЗ НА ОСНОВЕ УГЛЕРОДОЕМКОСТИ, ВКЛЮЧАЮЩИЙ ИНСТИТУЦИОНАЛЬНЫЕ МЕХАНИЗМЫ ТОРГОВЛИ ВЫБРОСАМИ В КАЗАХСТАНЕ

Аннотация

Республика Казахстан ставит перед собой цель достижения углеродной нейтральности к 2060 г. и перехода к «зеленой» экономике. Целью данного исследования является изучение влияния энергоемкости, использования возобновляемых источников энергии и запуска системы торговли выбросами (СТВ) на углеродоемкость в Республике Казахстан в период с 1992 по 2022 гг. Для достижения этой цели использовался метод авторегрессионных распределенных лагов. Исследование вносит научный вклад, рассматривая углеродоемкость как зависимую переменную в эконометрическом анализе. Практическая значимость заключается во введении в модель фиктивной переменной СТВ, объясняющей зависимую переменную. Результаты исследования показали, что существует долгосрочная связь между выбранными переменными и что энергоемкость является основным фактором углеродоемкости в долгосрочной перспективе. Влияние ВИЭ статистически не подтверждено. Проверка результатов путем добавления переменной ВВП на душу населения в качестве контрольной переменной подтвердила правильность выводов базовой модели. Результаты исследования подчеркивают важность совершенствования дизайна системы торговли выбросами и усиления мер по улучшению энергоемкости для снижения углеродоемкости экономики страны.

Ключевые слова: углеродоемкость, энергоемкость, возобновляемые источники энергии, модель авторегресионных распределенных лагов, система торговли выбросами, выбросы парниковых газов.

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