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Climate change, co2 emission, and economic development: evidence from Kazakhstan

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ABSTRACT

This study aims to identify the relationship between CO2 emissions and economic growth to assess the influence on climate change.
Design: The algorithm was chosen for research provision: statistical and comparative analysis, correlation, and regression analysis. The data for 1999-2020 was obtained from the World Bank and the Bureau of National Statistics.
Results: After looking at the conditions and factors that affect Kazakhstan's energy system, we believe it is essential to study how different factors affect economic growth, with a focus on environmental change. The results of modeling with regression models back this up. The model demonstrated that energy consumption has the most significant influence on CO2 emissions; however, in the GDP model, all factors, such as urbanization, energy consumption, and energy pricing, had an equal impact.
Research limitations: Although testing suggests the significance of the acquired results, it is envisioned that the research will be expanded to include other factors, particularly those connected to technological progress and country analysis.
Conclusions: After looking at the conditions and factors that affect Kazakhstan's energy system, we believe it is essential to study how different country-by-country factors affect economic growth, with a focus on environmental change. The study's findings may be utilized to gain a more profound knowledge of the situation and to produce actionable suggestions for formulating public policy.

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1. Introduction

Many experts today call attention to climate change, which has an ever-growing impact on economic growth. At the same time, this impact is measured in both direct and indirect short-term effects. At this time, it is difficult to assess the negative impact of economic growth on the ecological state because this relationship is multidirectional due to the different technological structure of each country, their mutual dependence, and the numerous indirect variables that must be incorporated into the analysis.

In this regard, the results of several previous research are essential for understanding the link between climate change and Kazakhstan's economic development. For example, the World Bank's experts (Lecocq et al., 2007), after reviewing the literature on the relationship between climate change and economic growth, came to the conclusion that due to the constraints of economic policies in the developing nations, climate change has a significant impact on long-term growth. The same consistent effect is seen worldwide, not just in developed economies. This is supported by data from 174 countries between 1960 and 2014, as analyzed in research (Kahn et al., 2019) that evaluates the global macroeconomic effects of climate change. In conclusion, it is emphasized that climate change can affect production indicators, as well as the potential of the economy for long-term growth.

However, it is essential to note that climate change is a common phenomenon involving a large number of factors and variables, among which average air temperature variations are frequently differentiated. On a global scale, the environment and the processes that occur there are already being severely impacted by more dramatic changes. And the next step in how this affects society is, of course, reflected in the indicators of economic development. Therefore, climate change means a decline in yields, a complication of farming circumstances, and a detrimental influence on people's mental and physical health. According to Melissa et al. (2012), in the second half of the twentieth century, an increase in the average temperature of 1°C per year in the United States resulted in a 1.4 percent loss in per capita GDP.

We may deduce from the foregoing that the average worldwide temperature reflects climate change, and such changes have global economic ramifications. Even though the climate change does not have a negative influence on the total level of wealth, it impacts the social component, resulting in a rise in inequality and making the poor suffer even more. Over the past decade, the number of people living in extreme poverty decreased, but slower than in the 20 years before. Meanwhile, the number of people suffering severe food shortages, that is, those who have run out of food or have been forced to go without food for a day or longer and require critical humanitarian aid, is increasing (Chandy, 2023).

This is explained by the fact that the economic impact of climate change is usually measured as the extent to which the climate of a given period affects social welfare in that period. This static approach ignores the dynamic effects through which climate change may affect economic growth and hence future welfare (Samuel & Richard, 2005). In an endogenous growth context, these two effects may be exacerbated through changes in labor productivity and the rate of technical progress. Simulations using a simple climate-economy model suggest that the capital accumulation effect is important, especially if technological change is endogenous, and may be larger than the direct impact of climate change. The savings effect is less pronounced. The dynamic effects are more important relative to the direct effects if climate change impacts are moderate overall. This suggests that they are more of a concern in developed countries, which are believed to be less vulnerable to climate change. The magnitude of dynamic effects is not sensitive to the choice of the discount rate.

The analysis of the influence of climate change on economic development is critical because researchers predict that with a temperature increase of 3.2 degrees Celsius by the middle of the century and if no action on climate change is taken, the world economy could lose more than 18%. This expected impact on GDP could increase to 37% in vulnerable regions such as Asia and ASEAN (Swiss Re Institute, 2021). As stated previously, this will result in further stratification of society and, consequently, a rise in discontent and conflicts. Meanwhile, taking into consideration the country’s climatic and natural aspects in modeling is critical when producing recommendations for decision-makers and policymakers in general. Thus, for example, the studies of Farajzadeh et al. (2022) in developing nation settings - Iran, as a developing country in a tropical location - help us to define ways to model processes. At the same time, it is important to clearly understand how changes in Iran’s arid and semi-arid climate affect the economy and the risks of long-term economic growth.

Another important factor affecting both climate change and economic development is the increase in CO_2 emissions. Despite the many studies analyzing the dynamics of the relationship between growth and CO_2 emissions, European countries should not be overlooked as a major player in the global market, a major contributor to global greenhouse gas emissions, and an important source of experience in analyzing and predicting this situation. Given that the European Union produced around 2.54 billion metric tons of carbon dioxide emissions in 2020, it is very crucial to understand how the research findings might influence the EU’s Strategy for removing more carbon emissions from the air.

For example, the findings of Onofrei et al., 2022 analyzing panel data for these countries show that increasing income levels raise demand for environmental protection, emphasizing the importance of developing environmental policies that can cut emissions during periods of economic expansion.

The offered study results allow us to draw the conclusion that, despite the progress made in the country's economy, it remains necessary to formulate a plan that may have a positive impact in the near and medium terms. It should be remembered that using panel data alone can only cover a part of the key aspects. So, the use of the dynamic panel threshold model is based on Panayotou's (1997) observation that quicker economic development and higher population density (beyond a certain point) might moderately increase the environmental cost of economic expansion. Furthermore, such a method adds by assessing the relationship separately in the reliability study for middle- and low-income groups in developing nations, where the latter comprises both low- and lower-middle-income countries according to the World Bank classification. At the same time, experts advise that a wider variety of variables, such as energy consumption, financial development, and population size, be included in the study and modeling.

Kazakhstan is a member of the global community; hence global issues cannot circumvent it. Furthermore, given the current state of affairs, it is clear that climate change is posing a major threat to the national economy. As a result, analysts stress that, on the one hand, Kazakhstan committed in December 2020 to achieving carbon neutrality by 2060, which requires the transformation of a modern resource-based economy, and therefore Kazakhstan contributes to mitigating global warming. Kazakhstan, on the other hand, is experiencing long-term climatic changes such as rising temperatures as well as more frequent, severe, and recurrent extreme weather events (EWE) such as droughts and floods. Long-term economic planning should consider both adaptation to climate change and mitigation of its effects. To mitigate any potential harm, the transition to a green economy necessitates massive investments that must also be robust to climate change.

There are useful models in this approach that enable the development of evidence-based policies and tactics (GIZ, 2022). In conjunction with scenario analysis ("what if"), the model by Aye & Edoja, (2017) serves to minimize uncertainty and raise awareness about the potential economic consequences of climate change. This enables us to construct several scenarios for the development of the situation in order to establish priorities and select the most effective ones to create a productive strategy. Consequently, the described approach can apply a methodical strategy for resolving a worldwide issue by recognizing significant connections between the economy, CO2 emissions, and the nation's energy sector.

This is consistent with the opinions and recommendations of the World Bank's experts. Thus, according to a World Bank report (World Bank Group, 2022), effective climate action to reduce carbon emissions could help Kazakhstan diversify its fossil fuel-dependent economy and open up new drivers of economic growth and prosperity for its people.

According to the Kazakhstan Country Climate and Development Report (CCDR) (World Bank Group, 2022), transitioning to a more sustainable economy can open up three potentially important areas of opportunity for Kazakhstan: 1) energy efficiency and clean energy production; 2) extraction of minerals critical for the low carbon transition globally; and 3) greater participation in global trade value chains that are increasingly becoming "green." Furthermore, the researchers examined how the negative impact of climate change could affect the country's economy. Hence, climate shocks could shrink Kazakhstan's economy by 1.6% by 2050, increase poverty by 3%, and decrease real wages by 2.1%. If the rest of the world decarbonizes and Kazakhstan does not, it could suffer a consistent long-term contraction in growth of 2-2.5% a year.

Given the foregoing, it is worth noting that this study represents an attempt to combine multiple research and forecasting approaches in order to estimate the influence of climate change and CO2 emissions on Kazakhstan's economic growth. An attempt will be made to present and verify the conclusions of the proposed models for the creation of recommendations based on the valuable prior experience of other researchers. In turn, with the identification of essential components, these recommendations can be used in the future to gain a better understanding of the processes that can impact the formulation of good political decisions.

2. Literature review

Battistini et al. (2022) studied how an increase in energy prices affects European households. Households with low incomes are most affected by the price increase as they considerably cut savings or put off scheduled payments. Accordingly, the bigger the number of low-income families in the economy, the more sensitive it will be to rising energy prices.

Li and Leung (2021) reviewed data for European countries over a 34-year period. They examined the relationship between economic growth and renewable energy consumption, and it was found that economic growth and non-renewable energy pricing have a beneficial impact on the transition to renewable energy sources. To provide a more complete picture, the price indices for coal and gas as non-renewable energy sources were added to the list of studied components within the context of the presented study.

Muhammad et al. (2022) investigated the impact of carbon emissions, real oil prices, income inequality, economic growth, and trade openness on renewable energy consumption (REC) in twenty-three (23) OECD economies. This study confirms the above-mentioned experts' opinion that economic growth is positively related to the increase in renewable energy consumption, oil prices, and income inequality. The presented study also makes an important methodological conclusion, namely that the use of weighted indices of fossil fuel prices can help limit the varied implications of changes in coal and natural gas prices.

Yuan et al. (2022) examined the relationship between energy pricing among South Asian countries, CO2 emissions, and a set of policies and public policy measures across a thirty-year time frame. For this purpose, they utilised intensive methods like fixed effect (FE), panel quantile regression (PQR) of econometrics, and T.O.P.S.I.S. method from operational research. Eventually, it was concluded that indicators of energy pricing and carbon emission contribute positively to the process of household consumption. When the government employs a policy mix, household consumption is positively associated with inflation while negatively with the tax rate.

As part of a multiyear research effort, Sharma et al (2019) examined the supply and demand of 55 types of energy across 30 sectors in some 146 countries. The outcomes suggest that the axiom of a positive relationship between economic growth and the energy consumption is undergoing changes, which has a tendency to be pronounced in recent years. Despite the fact that the demand for energy will grow, new technologies cause the energy demand curve to flatten. The researchers also identified 4 forces affecting this process: a marked increase in energy efficiency as a result of technological improvements; a decline in energy intensity in fast-growing countries (India, China); the growing use of renewables; the rise of electrification.

The data presented in the review of the World Economic Forum (2022) indicate a sharp increase in global prices after the outbreak of the Ukraine-Russia war. As a result, OECD countries began to actively utilise their strategic oil reserves, while European countries sought to increase coal consumption in order to equalize prices. Experts expect three effects of a sharp increase in energy prices: further acceleration of global inflation; slowdown in global economic growth; and an increase in the potential for social upheaval and greater food insecurity. This suggests that the level of energy costs is critical to the global economy and should be regularly researched in order to develop appropriate countermeasures.

Guénette & Khadan (2022) make an important conclusion that the energy price shocks may affect economic activity through a variety of channels. — with direct as well as indirect effects on energy-importing and -exporting economies. The indirect effects can occur through trade and other commodity markets, through monetary and fiscal policy responses, and through investment uncertainty. Through these channels, energy prices can also have immediate repercussions — even absent discretionary policy responses — on fiscal and external balances. In the current circumstances, experts believe that the function of the state monetary and fiscal policy in bringing the world back into balance is significant. These findings are supported by the findings of a 2013 research undertaken by other experts.

Ýstemi & Hakan (2013) developed a two-sector endogenous growth model to test the role of energy prices in the processes of restraining or stimulating economic growth. They found significant co-integration between energy prices and real GDP per capita as well as between energy prices and energy consumption per capita. Moreover, long-run elasticity estimates reveal a negative and significant impact of composite energy prices on both GDP per capita and energy consumption per capita.

Huntington & Liddle (2022), applying a new data set for country-level energy prices since 1960, evaluated the effects of energy prices on economic growth in 18 OECD countries. Thus, the following elasticity indicators were obtained. Mean-group estimates that control for cross-country correlations are used to emphasize average responses across nations. Averaged across all nations, results suggest that a 10% increase in energy prices dampened economic growth by about 0.15%. Moreover, some evidence exists that this response may be larger for more energy-intensive economies. As a result, it was concluded that countries with a high degree of energy intensity would be most affected by the negative impacts of rising energy prices.

Climate change is one of the major factors influencing economic growth, according to experts. Chae et al. (2020) investigated the climate change impact on socio-economic development using three pathways. This method allowed researchers to quantify the impact of variables like population, economic development, and land use on climate change. Such an approach can aid in the development of management strategies that are based on scenario development rather than prediction. It should be noted that scenarios, unlike predictions, are one of the essential components of long-term planning since they allow you to work through many situations. The researchers found that implementing an integrated strategy to reach the Sustainable Development Goals, such as SDG 13 and SDG 17, can help to alleviate the negative effects of climate change.

Febriandika & Rahayu (2021) investigated the relationship between changes in the tropical climate and the country's economic growth, where the consequences of negative influence are felt more acutely. Especially strong changes may occur in agricultural sectors of the economy, where the scope and magnitude of the negative effects of climate change might be calamitous. This research was carried out during 2016-2018 using all provinces in Indonesia. The authors of the study used the panel data regression method, and the chosen model was the fixed effect model (FEM), by displaying the effects of each region. The results of this study show that changes in temperature, increased rainfall, and increased air quality index partially have no effect on GDP. Only the extent of agricultural land area partially has a positive effect on GDP.

Molarius et al. (2015) implemented a scenario-based approach to analyze the impacts of climate change. The presented method is distinctive in that it combines scenario and risk-based methods in order to successfully plan activities within the framework of strategies. Hence, scenarios are created that consider significant risks that may have a negative impact on the company's actions when accomplishing planned goals. The paper presents the results of climate risk analysis prepared for two Finnish hydropower plants. At the macro level, the use of such an approach allows for decision-making based on an understanding of the impact of climate change and the negative repercussions if risks are realized. This makes it easier to adapt to changing climatic conditions.

Diaz et al. (2021) employ barometric analysis of McCarthy and regression models to investigate climate change challenges. This made it possible to understand the effects of climate change on the sustainable development of the Peruvian economy based on data from 2006 to 2018. Thus, it was concluded that Peru's sustainable development can be rated as average and is moderately influenced by factors such as temperature fluctuations, precipitation, and climate change in general.

Based on data from the Vojvodina region, Pavlović et al. (2021) determined how climate change affects sustainable development. In their analysis, they paid special attention to factors such as changes in air temperature and floods. To support sustainable development, the

Vojvodina region needs to strive for the integral concept of flood protection, which includes harmonization of the “human” demands component and “environmental” demands components. Various approaches to estimating the impact of climate change make it possible to include a multitude of variables in the study, depending on the country-specific circumstances.

Experts include CO2 emissions in the category of significant factors influencing climate change, both as a determining component and an indicator of the magnitude of the negative impact. In their study, Mundaca et al. (2015) conducted an empirical assessment of the degree of climate change based on indicators collected for the period 1971-2011 for the Swedish energy sector. The core methodology is based on three complementary quantitative methods, namely energy-economy-environment indicators, econometric analyses, and a multi-regional input-output (MRIO) sectoral model. The results of econometric modeling show that the Swedish emissions trading balance is negative when we talk about the content of emissions in import and export (i.e., embodied CO2 emissions in imports are higher than embodied emissions in exports).

The EEE Technical Report (2007) contains important information on European policy and its development and covers the main issues related to climate change. This work makes a significant contribution to the methodology of analyzing and forecasting climate-related economic expenditures (expenses). The assessment approach divides data into eight sectors of the economy in order to compare indicators and identify the most problematic regions in need of prompt effect measures. Data analysis was conducted for European countries using an integrated assessment model (IAM). It brings together the scientific and economic components of climate change in a unified analytical structure. The benefit of these models is that they allow you to correlate many components that influence climate change, such as emissions, and then calculate the degree of impact on economic development.

Wang et al. (2022) examined the impact of digital transformation on low-carbon development and the role of public awareness (support) in this relationship. Experts worked with data from 247 cities from 2011 to 2019, and calculations were performed using a panel threshold model. The study enabled general conclusions about the favorable impact of digitalization on the progress of economic decarbonization; however, there are disparities by city. The necessity of raising public awareness about decarbonization issues is emphasized since this has a substantial positive effect on its acceleration regardless of regional conditions.

3. Research Methods

The study made use of the following types of data: The data for 1999-2020 was obtained from the World Bank and the Bureau of National Statistics. The study aims to identify the relationship between CO2 emissions and economic growth to assess the influence on climate change, for which purposes statistical research methods were used.

As a result, this study employs correlation analysis as well as traditional regression based on the ordinary least squares (OLS) method. This approach is consistent with the logic of the above-mentioned studies, which relied heavily on descriptive statistics and OLS.

The Pearson linear correlation coefficient identifies the presence of a linear link between two variables. This coefficient is used to investigate the relationship between two variables measured on the same sample in metric scales.

According to the research, the following functional form of the model is proposed:

$$CO2=f(GDP, ElCons, Price, URBAN) \quad (1)$$

with the log-linear form of both sides of equation (1), we obtain the following equation

$$\ln CO2 = \beta_0 + \beta_1 \ln GDP + \beta_2 \ln ElCons + \beta_3 \ln Price + \beta_4 \ln URBAN + \varepsilon_{it} \quad (2)$$

where ln – natural logarithm. The parameters ß1, ß2, ß3, and ß4 reflect the long-term elasticities of energy consumption in relation to GDP per capita, energy consumption, energy prices, and urbanization level. ln ElCons – logarithmic value of electricity consumption per capita, lNGDP – logarithmic value of GDP per capita, and lNPrice – logarithmic value of electricity price. ln URBAN – level of urbanization. Data on annual energy consumption is recorded in kWh per capita, while GDP per capita is measured in current US dollars.

We will use the following functional form to assess the impact of factors on economic growth:

$$GDP = f(ElCons, Price, URBAN) \quad (3)$$

with the log-linear form of both sides of equation (3), we obtain the following equation:

$$\ln GDP = \beta 0 + \beta 1 \ln ElCons + \beta 2 \ln Price + \beta 3 \ln URBAN + \varepsilon_{it} \quad (4)$$

where ln – natural logarithm. The parameters ß1, ß2, ß3, ß4 reflect the long-term elasticities of GDP per capita, energy consumption, energy prices, and urbanization level.

Therefore, this research hypothesis can be formulated as follows:

In the course of the study, the following main hypotheses were tested:

Hypothesis 1 (H1): Increased energy consumption leads to increased CO2 emissions and GDP.

Hypothesis 2 (H2): Per capita GDP variable has a positive relationship with CO2 emissions.

Hypothesis 3 (H3): Per capita GDP variable has a negative relationship with energy prices.

4. Analysis and Results

4.1 Analysis

The Kazakhstani economy has been growing over the past two decades, and in accordance with the Kyoto Protocol, Kazakhstan has pledged to minimize greenhouse gas emissions. This entails a trade-off between efficient energy use, including environmental quality, and stable long-term economic growth.

Early in the twentieth century, global temperature and carbon dioxide emissions increased relatively slowly, as illustrated in Figure 1. However, the atmosphere is very sensitive to changing levels of CO2. Even though this gas makes up less than 0.1% of the atmosphere, it can have a huge effect on how much heat the planet's surface retains.

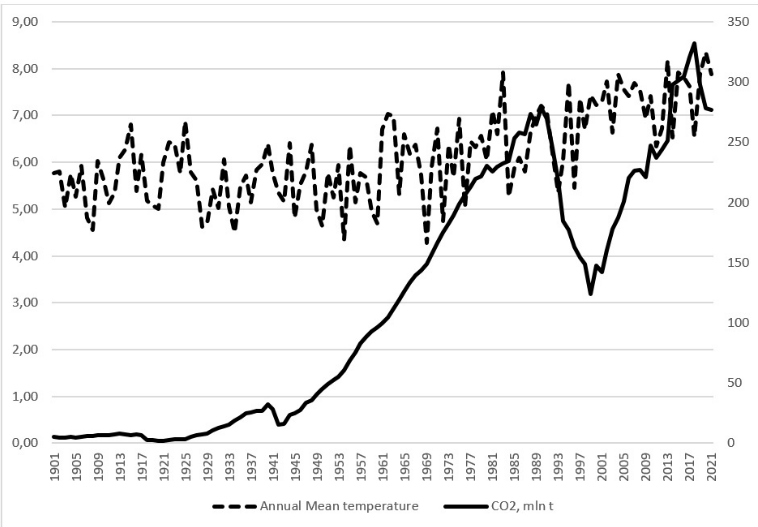

Figure 1. Carbon dioxide (CO_2) emissions from fossil fuels and industry
Source: Our World in Data based on the Global Carbon Project (2022),
OurWorldInData.org/co2-and-greenhouse-gas-emissions

The Kyoto Protocol on Climate Change, according to which the country has committed to reducing greenhouse gas emissions, was adopted in Kazakhstan in 2009. The National Quota Plan was developed in 2013. Only select economic sectors, including energy, coal mining, oil and gas, and industry, are subject to carbon dioxide emission restrictions under the plan.

The National Distribution Plan, which was adopted in January 2018, establishes total emissions for 129 enterprises for the years 2018-2020. Until 2020, quotas are distributed in accordance with the national plan. Kazakhstan expects to reduce greenhouse gas emissions by 15-25% across the entire economy by 2030.

The combustion of fossil fuels for energy production and the industrial manufacturing of materials such as cement account for the majority of CO2 emissions. Figure 2 depicts annual CO2 emissions from several sources, including coal, oil, gas, cement manufacture, and associated gas flaring.

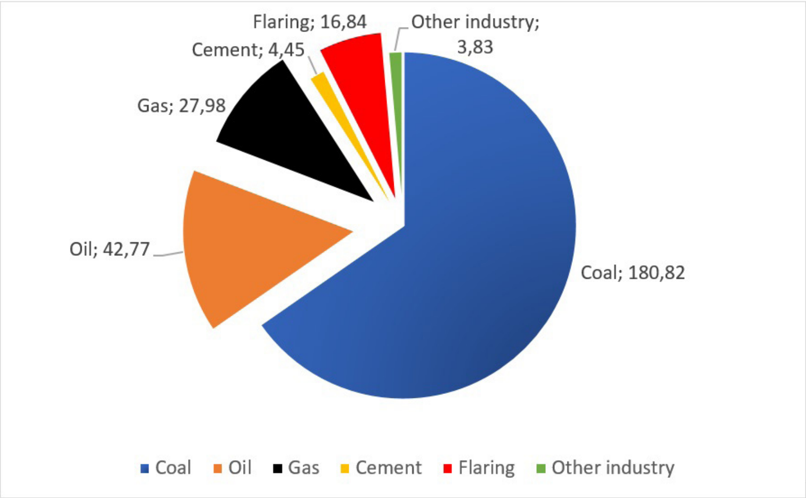

Figure 2. CO_2 emissions by fuel type or industry, 2021 (million tons)
Source: Our World in Data based on the Global Carbon Project (2022),
OurWorldInData.org/co2-and-greenhouse-gas-emissions

The information above is focused on carbon dioxide (CO2). But CO2 is not the only greenhouse gas. Others, like methane and nitrous oxide, have had a substantial impact on global warming up to this point. This is measured as the sum of all greenhouse gases and is estimated by an indicator termed “carbon dioxide equivalent.” "Carbon dioxide equivalents" attempt to compensate for the fact that one unit (for example, a ton) of this gas does not have the same warming effect as another. As a result, each gas emissions are multiplied by the value of its ‘global warming potential” (GWP), which assesses the degree of heating of one ton of this gas in comparison to one ton of CO2. Gases other than CO2 are weighted by the amount of warming they cause over a 100-year time scale (according to Our World in Data based on Climate Analysis Indicators Tool).

Figure 3 depicts 2019 greenhouse gas emissions by sector, measured in carbon dioxide equivalent (CO2eq, million tons). This means non-CO2gases are weighted by the amount of warming they cause over a 100-year timescale. In the context of these industries, the largest contribution is made by the production of electricity and heat, and the disparity with other sectors is considerable, being three times greater than in agriculture or manufacturing and construction. This may imply the employment of environmentally aggressive technology in energy production, but we must also consider the substantial equipment wear and tear, which has a detrimental impact on not just productivity.

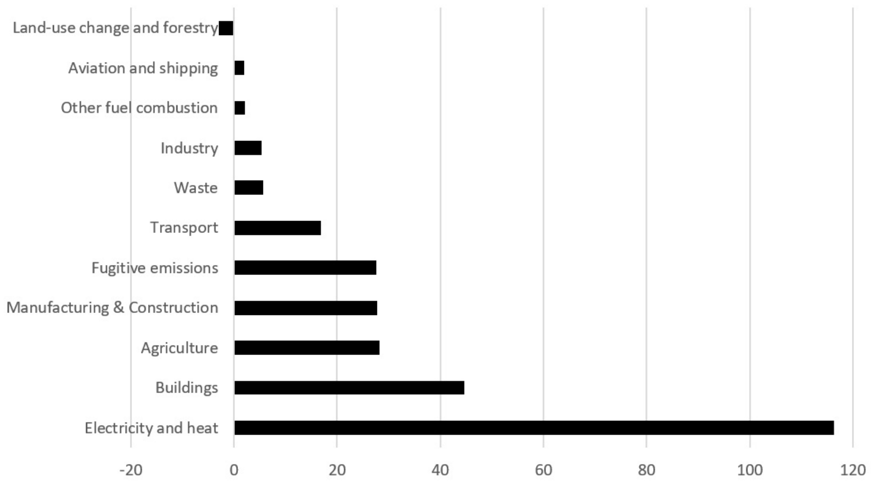

Figure 3. Greenhouse gas emissions by sector, 2019 (million tons)
Source: Our World in Data based on the Global Carbon Project (2022), *OurWorldInData.org/co2-and-greenhouse-gas-emissions*

The electric power industry is one of the major producers of greenhouse gas emissions, according to the International Energy Agency, and urbanization has a significant impact on energy consumption.

There are 138 diversely owned power plants in Kazakhstan that generate electricity. Figure 4 shows data on the dynamics of heat and electricity generation, measured in thousand Gcal and million kWh, respectively, according to the methodology of the Statistics Agency of the Republic of Kazakhstan. Thus, Figure 2 demonstrates that electricity generation decreased by over 2 times during the 1990s, with the lowest value recorded in 1999 (47,497.1 million kWh) compared to 1990 (87,379.2 million kWh). The slow leveling and steady annual rise that follows will allow 115,079.2 million kWh to be generated in 2021. It should be emphasized that despite the consistent production dynamics, it was not until 2011, when electricity output reached 86,585,5 million kWh, that it was possible to approach 1991 figures.

The annual electricity consumption per resident followed a similar pattern. Domestic consumption decreased from 5,641 kWh in 1991 to approximately 2,561 kWh in 1999. Since 1999, consumption has increased at a consistent rate and will reach over one thousand kWh in 2021.

It should also consider the fact that power consumption is also affected by the rise in urban population, which, like per-capita electricity consumption, has increased steadily since 1999 and continues to do so.

In terms of thermal energy, the country was unable to achieve the indicators of 1990 - 125,969 thousand Gcal until this year, while the maximum indicator was noted in 2012 - 103,350.3 thousand Gcal. Since then, a gradual decrease has occurred, with an increase to 95,844.3 thousand Gcal in 2021.

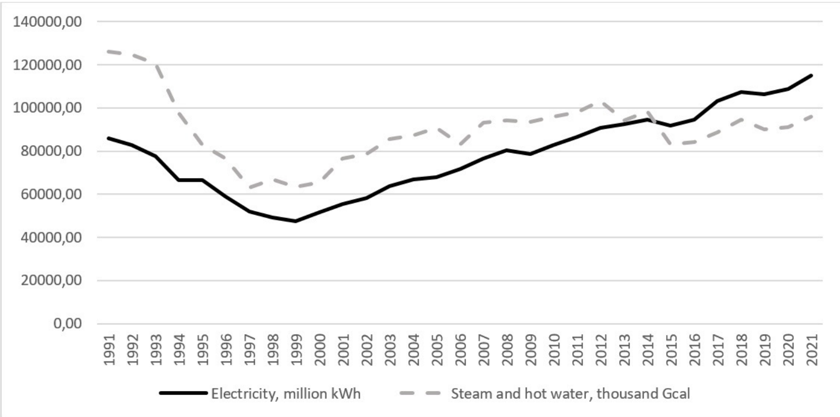

Figure 4. Dynamics of industrial output in the Republic of Kazakhstan for the years 1991 to 2021 in the subsections of power, gas, steam supply, and air conditioning.

Source: Bureau of National Statistics (*https://stat.gov.kz/*)

The National Wind Energy Development Program sets wind generation targets of 5 TWh in 2024. According to Strategy 2050 (2013), which aims to help Kazakhstan transition to a green economy, non-fossil energy (nuclear, hydro, solar, and wind) should make up 3% of the nation's total energy consumption by 2020, around 30% by 2030, and 50% by 2050. In May 2021, the government increased the goal for renewable energy sources' proportion in the energy balance from 10% to 15% by 2030. (11% was reached in 2021).

There are several main factors influencing the development of Kazakhstan's energy sector: decrease of electricity consumption through energy efficiency measures; modernisation of existing capacity; and the cost competitiveness of various electricity generation technologies at the present moment. Figure 5 shows that the cost of energy remains relatively low. Figure 5 depicts the dollar equivalent cost of 1 kWh and the cost of 1 liter of gasoline.

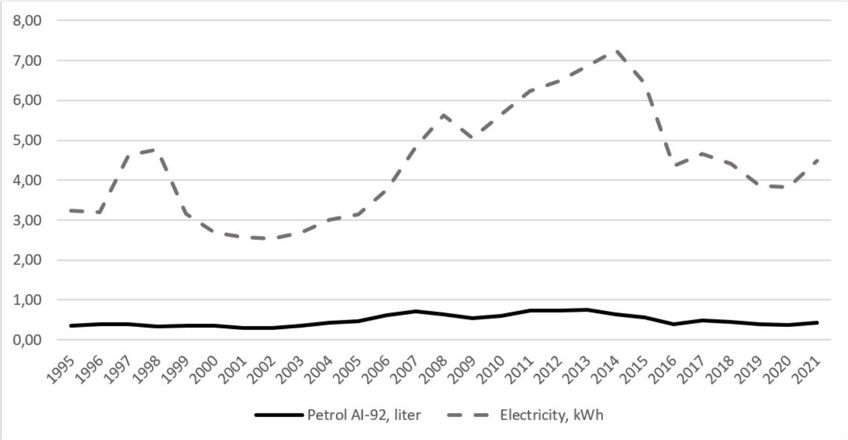

Figure 5. Electricity cost dynamics in the Republic of Kazakhstan from 1995 to 2021, in US dollars

Source: Bureau of National Statistics (*https://stat.gov.kz*)

The analysis of the energy system helps us believe it is essential to study how different factors affect economic growth, with a focus on environmental change. This will enable us to make recommendations for improving energy policy to support economic growth, as well as for increasing environmental quality and the country's standard of living.

4.2 Factors analysis

According to correlation analysis data, GDP has a substantial relationship with CO2 emissions, urban population increase (urbanization), energy consumption, and energy pricing (Table I). CO2 emissions are strongly connected with economic growth, urbanization, and energy consumption but less with energy pricing.

The significance level in Table 1 is a measure of the statistical validity of the calculation result, correlation in this case. If the study found that the correlation level did not surpass 0.05, it means that the correlation is random with a probability of 5% or less. This is typically the basis for the conclusion regarding the statistical reliability of the correlation. If (if $p > 0.05$), the relationship is considered statistically unreliable and cannot be interpreted meaningfully.

Table I. Assessment of correlation coefficients (Pearson Correlation)

Correlations					
	GDP	CO2	Urban	Consumption	Price
GDP	1	0,848**	0,849**	0,896**	0,823**
CO2	0,848**	1	0,870**	0,911**	0,594**
Urban	0,849**	0,870**	1	0,940**	0,439*
Consumption	0,896**	0,911**	0,940**	1	0,583**
Price	0,823**	0,594**	0,439*	0,583**	1
**. Correlation is significant at the 0.01 level (2-tailed).					
*. Correlation is significant at the 0.05 level (2-tailed).					

On the basis of the correlation analysis results, a regression model of the relationship between these variables will be developed (Table II).

Table II. Regression model variables for CO2 emissions

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-4,159	1,476		-2,82	0,010		
GDP	0,088	0,043	0,366	2,03	0,053	0,138	7,25
Consumption	0,708	0,214	0,595	3,31	0,003	0,138	7,25

Standardized regression coefficients indicate the relative significance of the independent variables included in the regression model and the unique contribution of each independent variable to the regression model. They indicate the extent to which the studied variables (independent variables) affect the final value (dependent variable).

According to the model's estimations, the identified factors have the following effect:

Table III. Impact of factors in the regression model.

1% growth of factors causes:	% change of CO2 emissions
GDP	+ 0.088
Energy consumption	+ 0.71

The results indicate that energy consumption has a significant impact on consumption (the per capita indicator is utilized in the calculations), and this indicator also reflects urban population increase. According to standardized coefficients, the energy consumption indicator accounts for 60% of the total impact of the two indicators.

The GDP model results are presented in Table IV.

Table IV. Regression model variables for GDP

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-150,066	42,644		-3,52	0,002		
Urban	36,001	11,915	0,396	3,02	0,006	0,148	6,778
Consumption	1,657	0,729	0,335	2,27	0,033	0,117	8,548
Price	0,790	0,147	0,364	5,37	0,000	0,553	1,808

According to the model's estimations, the identified factors have the following effect.

Table V. Impact of factors in the regression model of GDP

1% growth of factors causes:	% change of GDP
Urban population growth	+ 36
Energy consumption	+ 1.7
Change in energy resources price	+ 0.8

The results indicate that energy consumption has a significant impact on consumption (the per capita indicator is utilized in the calculations), urban population increase, and energy prices. The indicator of energy consumption in conjunction with urban population increase represents the overall impact of consumption growth caused by urban population growth. All three indicators have an equal impact on GDP by standardized coefficients.

All coefficients in the models are significant, at least at the 5% significance level. For the constructed model, t of each of the independent variables exceeds 2.

The standard error is increased for variables with a VIF score above 5. As a result, the multicollinearity in the regression model reduces the stability of the coefficients. The findings demonstrate the association between energy consumption and urban population growth, as well as the relationship between both variables and GDP. A larger sample could help reduce the standard error.

According to the results of the study, in the CO2 emissions model, energy consumption has the greatest impact; however, in the GDP model, all factors such as urbanization, energy consumption, and energy pricing, have an equal impact.

5. Discussion

Working hypotheses were presented within the context of the study, the test results of which coincide with previous studies and expert opinions and can be used to produce more thorough and effective recommendations. Based on the results of factor analysis, the hypothesis of a positive relationship between consumption, economic growth, and carbon emissions (Hypothesis 1 (H1): Increased energy consumption leads to increased CO2 emissions and GDP) is true. This is because the growth of urbanized population and industry causes an increase in energy demand and an increase in CO2 emissions due to the low technological level of economic development, where a large part of the share is occupied by either agriculture or industry. Accordingly, hypothesis 1 is accepted. Researchers Onofrei et al. (2022), who used data from European countries to perform a co-integration analysis, came to the same conclusions. At the same time, the researchers point out that the rise in income affects the rise in demand for more effective environmental protection policies. In their study, Chontanawat (2020) used co-integration and a causal approach to identify the relationship between CO2 emissions, energy consumption, and economic growth in the ASEAN region. The co-integration results show that these variables have a long-term relationship, demonstrating that energy consumption and economic activity are linked to CO2 emissions. This implies that multiple research based on data from different countries, using different approaches, come to the same conclusion about a considerable relationship between energy consumption, CO2 emissions, and economic growth. Similar conclusions have been confirmed by Grabara et al. (2021), Tleppayev & Zeinolla (2020) and Tleppayev et al. (2023).

The second hypothesis (Hypothesis 2 (H2): Per capita GDP variable has a positive relationship with CO2 emissions.) was confirmed. Hence, according to the results of the study, it was established that economic growth causes a rise in carbon dioxide emissions, which indicates a low technological level of the country's development. Caporale et al. (2021) examined the relationship between the logarithms of carbon dioxide (CO2) emissions and real Gross Domestic Product (GDP) in China by the co-integration method. As a result, it was concluded that their growth rates are linked together in the long run. Based on what has been discussed, the question of whether improving technologies or altering public awareness and attitude toward environmental conservation issues should take precedence in defining policy priorities in the field of emissions control arises.

Due to the commodity-driven nature of the country's economy, the third hypothesis (Hypothesis 3 (H3): Per capita GDP variable has a negative relationship with energy prices) was not confirmed. Thus, according to national statistics, the dynamics of the oil and gas industry, which accounted for a significant share of about 30% and half of exports in the first half of the 2000s, showed a trend of growth in world energy prices and coincided with an increase in energy prices in Kazakhstan, which repeats the dynamics of changes in GDP per capita.

The data obtained and the analysis of previous studies indicate that instead of encouraging the extraction of raw materials and the development of the construction sector, increasing the diversification of industry and the transition to environmentally friendly technologies along with the rational development of all territories of the country leads to a reduction in emissions in countries and can improve their economic well-being.

Conclusions

Addressing global challenges with the environmental impact of economic growth drivers is crucial for the global economy and Kazakhstan in particular. Despite of different conditions and levels of influence of the identified factors, it is feasible to discern certain patterns and trends that help us comprehend how public policy might be adjusted to mitigate the negative impact. As methodological analysis of global experience demonstrates, there is a range of techniques for assessing the current situation and anticipating its short- and long-term evolution.

After looking at the conditions and factors that affect Kazakhstan's energy system, we believe it is essential to study how different country-by-country factors affect economic growth, with a focus on environmental change. The results of modeling with regression models back this up. The resultant model demonstrated that per capita energy consumption has the biggest influence on $CO2$ emissions in Kazakhstan; however, in the GDP model, all factors such as urbanization, energy consumption, and energy pricing, had an equal impact.

The study's working hypotheses made it possible to more realistically evaluate the substantial impact of the country's technical growth on the relationship of variables such as energy consumption, GDP, and $CO2$. As a consequence, two of the three hypotheses were accepted, and one was rejected, which correlates to the findings of past expert studies.

The main limitation of this study is the lack of data with long time horizons and the lack of a number of indicators used in global statistics. Including more explanatory variables in this type of analysis could improve future research. Among such variables, we can include the investment level and the globalization index, since many previous researchers have demonstrated the significant impact of these variables on carbon emissions and economic activity. Another direction for further research could be to test the curve EKC for this group of countries.

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