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The Relationship between Energy Consumption (Renewable Energy), Economic Growth and Agro-Industrial Complex in Kazakhstan

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ABSTRACT

This study analyzes the relationship between energy consumption (renewable energy), economic growth, and developments in Kazakhstan's agricultural industry complex (agriculture and livestock outputs) between 1991 and 2021 and the interaction of these factors. Analysis data were retrieved from the databases of our world in data, the World Bank, and the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan. The study examines energy consumption over two variables. The first is the share of energy obtained from renewable energy sources in the total energy consumption, and the second is the total energy consumption. It is only natural to expect an increase in agricultural production due to new technologies in the industry. However, it is also essential to examine whether the country's economic growth, agricultural fields, and employment in agriculture play a role in energy consumption. One of the significant indicators of the developments in the agricultural industry is the reflection of the production in agriculture and animal husbandry on internationally valid indices. Therefore we deemed it appropriate to compare the input variables with the food index produced by the World Bank. The effects of agricultural industry assets and agricultural developments on energy consumption were examined using the hierarchical regression analysis approach. The findings showed that agricultural developments affect energy consumption, especially renewable energy consumption. This study concludes that it is necessary to examine the causality of this effect and whether it transforms into a short-term or long-term effect.

Keywords: Kazakhstan, Energy Consumption, Economic Growth, Agro-Industrial Complex, Agriculture, Livestock
JEL Classifications: C13, C20, C22

1. INTRODUCTION

Energy consumption, economic growth, and the agriculture and livestock sector are critical factors for a country's sustainable development. The interrelationship of these sectors is enormously influential in determining energy policies and economic strategies. Understanding the relationships between these variables through the example of Kazakhstan will provide a vital source of information to policy-makers and academics in shaping energy policies and development strategies. Moreover, evaluating the effects of renewable energy usage on the agriculture sector will help determine strategies for Kazakhstan to achieve its sustainable economic growth and development goals.

Kazakhstan, which gained its independence in 1991, is restructuring itself in many areas, such as technology, agriculture, and energy production, to integrate its economy with the world economy. Kazakhstan is on the way to completing this restructuring process despite all its difficulties and has come a long way in the 32 years from its independence to the present day (Xiong et al., 2015; Myrzabekkyzy et al., 2022; Bolganbayev et al., 2022; Taibek et al., 2023). After its independence, Kazakhstan's economy has survived four major economic crises. The first is the crisis that emerged in the early 1990s and resulted in the disintegration of the USSR. Kazakhstan's economy had been able to overcome this crisis only in 1997-1998. Although economic recovery was achieved in this period, the desired targets, namely growth and development, could not be achieved. The second was the Asian crisis in 1998. The third is the 2007-2008 global financial crisis that started in Europe (Özdil and Turdalieva, 2015). The fourth and final is the crisis due to the Covid-19 pandemic, which affected the whole world in 2019. These crises harmed the Kazakhstan economy, as all transitional economies, and caused a slowdown in economic growth. However, only by increasing exports was it possible to eliminate the negative effects of these crises and ensure economic growth. The continuous and high growth rates that Kazakhstan has achieved, the good position in international markets, the realization of appropriate structural reforms in the economy, and the existence of an innovative and socially strong economy have allowed the solution of the main problems in the country (Özdil and Turdalieva, 2015).

Kazakhstan is at the forefront of the world in terms of its fossil energy resources (about 3.2% of the global total oil reserves, about 1.5% of natural gas reserves, and about 3.3% of coal reserves), as well as with its wide and rich geography (Mudarissov and Lee, 2014; Xiong et al., 2015; Bolganbayev et al., 2022; Myrzabekkyzy et al., 2022; Mashirova et al., 2023). It also has great potential in terms of renewable energy sources such as hydroelectricity, wind energy, solar energy, geothermal energy, and biofuels (Xiong et al., 2015; Ongarova, 2018; Taibek et al., 2023; Sabenova et al., 2023; Niyetalina et al., 2023). However, although it has rich renewable energy resources, Kazakhstan is heavily dependent on fossil fuels for energy production. Kazakhstan meets 75% of its total energy production from coal power plants. This causes Kazakhstan to be at the forefront of greenhouse gas emissions compared to GDP (Syzdykova, 2020). Kazakhstan's turn to potentially very rich renewable energy sources is of great importance in terms of both environmental sustainability and diversification of energy sources. The Kazakhstan administration is aware of this situation and has adopted policies to diversify energy resources and promote renewable energy resources. For example, electricity generation from renewable energy sources such as small hydroelectric power plants, wind, biogas, and solar power plants was 1470 million kWh in the first quarter of 2020 alone, while it reached 2005.5 million kWh with an increase of 1.4% in the first quarter of 2021. In addition to fossil fuels and renewable energy sources, Kazakhstan also has the potential for nuclear energy production, as it ranks first in the world in uranium production, which is essential for nuclear fuel production (Smagulova et al., 2023).

Kazakhstan, with an area of 2,724,900 km^2, ranks 9th among all countries in terms of land size. 40% of its territory is desert, 23% semi-desert, 20% steppe, 7% forest, and 10% mountainous region (Timor et al., 2018). Kazakhstan has a continental climate with a wide variety of terrain, including open plains and mountains. The annual rainfall in the plains is around 100-300 mm, and it can reach up to 800-1500 mm in the mountains. Its geographical environment and natural ecological conditions encourage the growth of pastures, which are indispensable for livestock. Grasslands cover approximately 184 million hectares, accounting for 67.53% of the country's total land area (Liang et al., 2020). Before the collapse of the Soviet Union, Kazakhstan was the biggest agriculture and livestock producer in the union. Since the agriculture and livestock sector was neglected after independence, its share in GDP has decreased over the years. For example, the share of the agricultural sector in GDP dropped from 34.9% in 1990 to 10.9% in 1997. However, the sector has increased its production with the latest regulations and technological innovations in agriculture (Timor et al., 2018). Even after this increase, the agriculture and livestock sector ranks third in exports after the energy (oil, natural gas) and mining sectors. The share of grain, cotton, milk, and tobacco exports in total exports was 2.3% as of 2017. Its most important agricultural products are wheat, cereal derivatives, and cotton (Delice, 2019).

The agriculture and livestock sector plays an important role in Kazakhstan's economy and supports various national objectives such as food production, export potential, and rural development. In this context, the impact of energy consumption and renewable energy sources on the agricultural sector bears great importance. Increased usage of renewable energy can offer various advantages, such as ensuring sustainability in agriculture, reducing energy costs, and reducing environmental impacts.

The food production index (2014-2016=100) covers food products that are edible and nutritious. Coffee and tea, although edible, are excluded because they lack nutritional value. The agricultural production index was created by the Food and Agriculture Organization of the United Nations (FAO). The agricultural production indices of FAO show the annual total agricultural production volumes compared to the base period 2014-2016. It is the sum of the price-weighted quantities of different agricultural commodities after weighing the amounts used as seed and feed. All indices (at national, regional, and global levels) are calculated with the Laspeyres formula. The production quantities of each commodity are weighted with the average international commodity prices of 2014-2016 and are calculated for every year. The index is calculated by dividing the total for a given year by the average for the 2014-2016 base period (https://databank.worldbank.org/metadataglossary/world-development-indicators/series/AG.PRD.FOOD.XD.)

This study analyzes the relationship between energy consumption (renewable energy), economic growth, and developments in Kazakhstan's agricultural industry complex (agriculture and livestock outputs) and the interaction of these factors for the 1991-2021 period. The data used in the analysis were obtained from the websites https://ourworldindata.org/, https://data.worldbank.org/indicator/, and https://old.stat.gov.kz/official/.

2. LITERATURE REVIEW

There are many studies in the literature on the different dimensions of the economy of Kazakhstan, which draws attention due to its rapid transformation and development among the economies of developing countries. Here, we will only mention the major ones related to this study.

Syzdykova (2020) analyzes the renewable energy potential of Kazakhstan and provides information on Kazakhstan's fossil energy resources (oil, natural gas, coal, and uranium). Then, he evaluates Kazakhstan's renewable energy sources and potential and analyzes the factors that hinder the development of renewable energy in Kazakhstan. In the concluding part, he offers suggestions on the measures that can be taken to overcome these obstacles.

Liang et al. (2020) focus on Kazakhstan's livestock sector, the consumption of animal products, and environmental factors affecting the livestock sector. They analyzed the data on animal products in Kazakhstan and factors such as regional economic developments, grassland resources, grassland degradation, livestock, the trade balance of animal products, and population distribution. This study determined that the most consumed animal product in Kazakhstan is milk, followed by meat and eggs, especially beef consumption is very high. They emphasized that the alternating use of large pastures is vital for protecting the ecosystem and a sustainable livestock sector.

Smagulova et al. (2023) focused on the organization of Kazakhstan's electrical power industry and agro-industrial complex and formulated an econometric model to identify patterns and determine the impact of electricity generation and digital farms on increased agricultural production. They suggested building new energy facilities compatible with the environment and increasing investment projects for alternative energy sources. They also found that the digitization of the energy and agro-industrial complex sectors is a contributing factor to Kazakhstan's economic growth.

Özdil and Turdalieva (2015) discussed the sources of economic growth in the economy of Kazakhstan and carried out their analysis on the input-output tables for the 2006-2013 period. They divided economic growth into four principal sources calculated using the Syrquin decomposition model: The expansion of domestic demand, the volume of exports, the substitution of imports with domestic products, and technological change and evaluated these factors. They identified the primary source of economic growth as the expansion of domestic demand, followed by export volume.

Timor et al. (2018) examined the history of agricultural activities in Kazakhstan. They provided information on agriculture and animal husbandry activities, especially from 1991 on, and presented solutions for identified problems.

Dai et al. (2022) analyzed the relationship between energy consumption and economic growth according to the Kuznets curve. They predicted China's economic future with a comparative analysis of the Kuznets curves of the USA and Germany. They found that at the turning point of the energy consumption curve, China's energy economy was higher than that of Germany and the United States. They also found that although China has increased its urbanization level and industrial structure, it is still proportionally lower than Germany and the United States. However, progress is especially significant in urbanization.

3. DATA AND ECONOMETRIC METHOD

The hypothesis that a country's energy consumption is affected by developments in the agricultural sector, as well as economic growth, is a research subject that deserves scientific analysis. This study investigated the effect of agricultural industry complexes on energy consumption and examined energy consumption using two variables. The first is the share of renewable energy in total energy consumption, and the second is total energy consumption. It is natural to expect an increase in production depending on technological developments in the agricultural sector. Another issue is the effect of a country's economic growth, agricultural land, and employment in agriculture on energy consumption. One of the indicators of developments in the agriculture sector is the reflection of agricultural and livestock production on internationally valid indices. Therefore we deemed it appropriate to compare the input variables with the food index produced by the World Bank. The study variables and their brief descriptions are presented in Table 1.

Production in the agricultural industry has been examined using three series, i.e., agricultural production, livestock production, and general production. We aimed to analyze the effects of developments in agriculture and animal husbandry separately. All three variables are measured in price. Logarithms of all three series were used in the analysis phase. The research period is 1991-2021. Data are retrieved from the websites https://ourworldindata.org/, https://data.worldbank.org/indicator/, and https://old.stat.gov.kz/official.

Stationarity is defined as the mean and variance being constant respective to the time variable, and the covariance being dependent on the time point difference of only two data, and plays a vital role in the analysis of time series. Especially in regression-based analysis, all series must be stationary at the same level. The stationarity of the time series is examined using unit root tests or the correlogram graph method. This study used the ADF (Augmented Dickey-Fuller) test. The test statistic is provided by:

$$\Delta Y_t = \beta_0 + \beta_1 t + \delta Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Y_{t-i} + \varepsilon_t \tag{1}$$

The null hypothesis of the ADF test is "there is a unit root in the series," and if the null hypothesis is rejected for the value, the series is deemed to be stationary for the relevant level (Sevüktekin and Nargeleçekenler, 2007).

Table 1: Research variables and definitions

Variable	Definition
y01	Renewables (% electricity)
y02	Primary energy consumption (TWh)
y03	Food production index (2014-2016=100)
x01	GDP growth (annual %)
x02	Agricultural land (% of land area)
x03	Employment in agriculture (% of total employment)
x04	Gross output
x05	Plant growing
x06	Animal husbandry

Table 2: Descriptive statistical findings for research series

Statistics	x01	x02	x03	x04	x05	x06	y01	y02	y03
Mean	2.871	79.862	28.905	1858031.0	1037742.0	813943.9	11.118	632.571	84.788
Median	4.100	79.814	31.535	825557.0	413666.9	407545.2	10.843	638.147	84.330
Maximum	13.500	82.138	36.502	7515433.0	4387237.0	3116974.0	15.241	858.537	117.050
Minimum	12.600	78.077	15.049	77.8	38.7	36.6	8.256	369.747	45.990
Standard deviation	6.677	1.116	7.967	2011525.0	1148075.0	863681.5	2.028	152.810	20.361
Skewness	0.756	0.534	0.652	1.208	1.305	1.095	0.292	0.131	0.010
Kurtosis	2.873	2.913	1.846	3.636	4.007	3.212	2.085	1.714	1.811
Jarque-Bera	2.975	1.482	3.917	8.068	10.111	6.251	1.522	2.224	1.827
Probability	0.226	0.477	0.141	0.018	0.006	0.044	0.467	0.329	0.401

Hierarchical regression is one of the multivariate regression methods, and in this method, the independent variables are entered into the equation in the order determined by the researcher. Thus, it is possible to reach more detailed answers. This model allows researchers to decide the number and the order of variables. This decision may be based on the researcher's logical or theoretical prior knowledge, or the researcher can add the variables that are naturally present in the research area to the model in the previous step. Thus, one can investigate the contribution of a specific variable in detail (Tabachnick and Fidell, 2020).

Parameter estimates obtained using the regression model are based on the assumption of no correlation between independent variables. A multicollinearity problem exists when there is a high linear correlation between independent variables. Many criteria indicate the presence of multicollinearity. This study used tolerance value and variance inflation factor (VIF) criteria. The tolerance value is calculated as $1-R_i^2$. Here R_i^2 x_t is the coefficient of multiple determination between the independent variable and the remaining independent variables. The diagonal elements of the inverse of the correlation matrix for the independent variables are called VIF. VIF is also calculated with tolerance values using the following equation:

$$VIF_j = 1/\text{tolerans} = 1/(1-R^2) \quad (2)$$

Some approaches argue that there is a strong multicollinearity between independent variables when VIF_j values are above 30 (Alpar, 2013, Montgomery et al., 2013).

This study analyzed the effects of developments in the agricultural industry on energy consumption and food index using the hierarchical regression method. The first model only examined the effect of a change in GDP for each variable. The second stage adds the agricultural area and employment in agriculture variables, as well as GDP, to the model. The third stage added the agricultural industry variable to the model. Since the three variables used for the agricultural industry are closely related, we examined three models to see the effect of each variable separately. Thus, the following models were obtained.

Model 1: $y0i_t = \alpha + \beta_1 x01_t$ (3)

Model 2: $y0i_t = \alpha + \beta_1 x01_t + \beta_2 x02_t + \beta_3 x03_t$ (4)

Model 3: $y0i_t = \alpha + \beta_1 x01_t + \beta_2 x02_t + \beta_3 x03_t + \beta_4 x04_t$ (5)

Model 4: $y0i_t = \alpha + \beta_1 x01_t + \beta_2 x02_t + \beta_3 x03_t + \beta_4 x04_t + \beta_5 x05_t$ (6)

Table 3: ADF unit root test findings for research series

Variable code	Level		First diference	
	t-Statistics	P-value	t-Statistics	P-value
x01	−2.44457	0.1387	−5.77308	0.0001
x02	−2.17315	0.2196	−4.68639	0.0008
x03	0.28063	0.9731	−4.89144	0.0005
x04LOG	−3.26033	0.0265	−3.56483	0.0131
x05LOG	−3.58542	0.0125	−4.36778	0.0018
x06LOG	−8.18051	0.0000	−3.35411	0.0227
y01	−1.9863	0.2909	−4.44489	0.0015
y02	−1.21201	0.6559	−2.98909	0.0361
y03	−0.60607	0.8544	−7.91204	0.0000
Test critical values:				
1% level	−3.67017		−3.68919	
5% level	−2.96397		−2.97185	
10% level	−2.62101		−2.62512	

Model 5: $y0i_t = \alpha + \beta_1 x01_t + \beta_2 x02_t + \beta_3 x03_t + \beta_4 x04_t + \beta_5 x05_t + \beta_6 x06_t$ (7)

(i = 1, 2, 3)

4. FINDINGS

In this section, the developments in the agricultural industry, agricultural industry assets, and the effect of economic growth on energy consumption and food index are examined using the hierarchical regression method. Following the scientific research methodology, we first gave the explanatory information of the research variables. Then, the stationarity of the series was examined with unit root tests as the fundamental condition of an econometric time series analysis. In the last step, the first differences of all series were taken using unit root tests, and hierarchical regression analysis findings were interpreted.

Explanatory statistical findings for the research series are given in Table 2. Our findings (Jarque-Bera test) show that the dependent variables fit the normal distribution.

The time path graph of the research series is given in Graph 1. The graph shows an exponential increase in the x04, x05, and x06 series that represent the agricultural industry data. This result indicates that taking the logarithms of the relevant variables is a correct decision.

The stationarity of the series was examined with the ADF unit root test, and the results are given in Table 3. These results show that the x04, x05, and x06 series are stationary at the level, and

Graph 1: Time path plot for research series

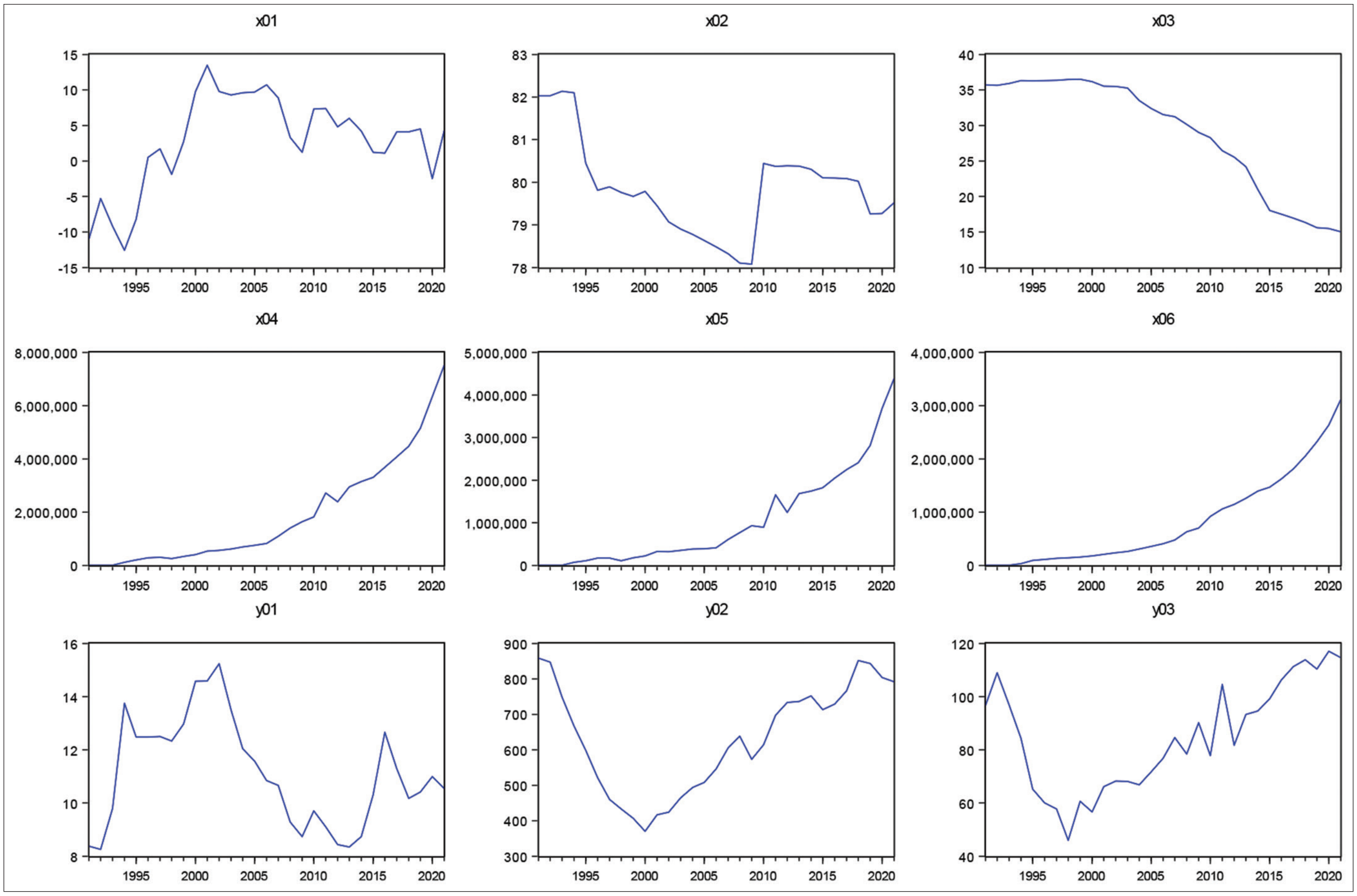

Table 4: Collinearity Statistics results of independent variables

Variables	Model 3		Model 4		Model 5	
	Tolerance	VIF	Tolerance	VIF	Tolerance	VIF
d×01	0.949	1.054	0.954	1.048	0.923	1.083
d×02	0.981	1.019	0.981	1.019	0.981	1.019
d×03	0.832	1.203	0.858	1.166	0.792	1.262
d×04	0.865	1.156				
d×05			0.890	1.124		
d×06					0.817	1.224

the others are at the first difference. By these results, the first difference of all series was taken, and the difference variables were used in the analysis.

The results of the multicollinearity analysis between the independent variables through Tolerance and VIF criteria are given in Table 4. x04, x05, and x06 variables are not employed in the same model because they are related by definition. The findings obtained for the variables used in the same model do not show the problem of multicollinearity between the variables.

The findings for the effect of economic growth, agricultural industry assets, and agricultural industry developments on renewable energy consumption are given in Table 5. Models 3, 4, and 5 include the development variables in the agricultural industry and are found to be statistically significant. In all three models, the significance depends on the agricultural industry variables. General agricultural outputs, agricultural outputs, and livestock outputs, according respectively to Model 3, Model 4, and Model 5, have a positive effect on renewable energy consumption. Depending on this effect, the coefficients of determination and the increase in the coefficients of determination of all three models were found to be statistically significant.

The findings regarding the effects of economic growth, agricultural industry assets, and developments in agriculture on energy consumption are given in Table 6. The results showed that Models 3 and 5, which include the variables regarding developments in the agricultural industry, were statistically significant. In both models, the significance depends on the agricultural variables. According to Model 3, general agricultural outputs and according to Model 5, livestock outputs negatively affect energy consumption. Therefore, the determination coefficients and the increase in the determination coefficients in both models were found to be statistically significant.

Table 5: The impact of economic growth, agricultural industry assets, and developments in the agricultural industry on renewable energy consumption

Variables	Model 1		Model 2		Model 3		Model 4		Model 5	
	Beta	t	Beta	t	Beta	t	Beta	t	Beta	t
d×01	−0.102	−0.541	−0.166	−0.876	−0.132	−0.772	−0.161	−0.935	−0.082	−0.475
d×02			0.269	1.439	0.264	1.566	0.270	1.595	0.263	1.570
d×03			0.198	1.050	0.022	0.119	0.046	0.252	−0.013	−0.072
d×04					0.471**	2.624				
d×05							0.457**	2.571		
d×06									0.497**	2.710
F	0.293 (P=0.593)		1.079 (P=0.375)		5.714* (P=0.053)		2.636* (P=0.058)		2.842** (P=0.045)	
R2	0.01		0.111		0.303		0.297		0.313	
DR2			0.100		0.192**		0.186**		0.202**	

indicates the statistical significance for *: P<0.10 and **: P<0.05

Table 6: The impact of economic growth, agricultural industry assets, and developments in the agricultural industry on energy consumption

Variables	Model 1		Model 2		Model 3		Model 4		Model 5	
	Beta	t	Beta	t	Beta	t	Beta	t	Beta	t
d×01	−0.020	−0.105	0.020	0.109	−0.004	−0.021	0.017	0.094	−0.052	−0.305
d×02			0.203	1.127	0.207	1.193	0.203	1.148	0.208	1.250
d×03			−0.344*	−1.887	−0.220	−1.169	−0.252	−1.335	−0.162	−0.874
d×04					−0.332*	−1.801				
d×05							−0.277	−1.497		
d×06									−0.429**	−2.346
F	0.011 (P=0.917)		1.750 (P=0.182)		2.236* (P=0.094)		1.936 (P=0.136)		2.915** (P=0.042)	
R2	0		0.168		0.263		0.236		0.318	
DR2			0.168*		0.096*		0.068		0.150**	

indicates the statistical significance for *: P<0.10 and **: P<0.05

Table 7: The impact of economic growth, agricultural industry assets, and developments in the agricultural industry on the food index

Variables	Model 1		Model 2		Model 3		Model 4		Model 5	
	Beta	t	Beta	t	Beta	t	Beta	t	Beta	t
d×01	0.051	0.268	0.109	0.572	0.111	0.567	0.111	0.576	0.074	0.379
d×02			−0.036	−0.192	−0.036	−0.190	−0.036	−0.188	−0.034	−0.179
d×03			−0.308	−1.617	−0.316	−1.514	−0.359	−1.766	−0.218	−1.039
d×04					0.022	0.107				
d×05							0.153	0.765		
d×06									−0.212	−1.028
F	0.072 (P=0.791)		0.897 (P=0.456)		0.650 (P=0.632)		0.808 (P=0.532)		0.938 (P=0.458)	
R2	0.003		0.094		0.094		0.114		0.224	
DR2			0.091		0		0.021		0.13	

indicates the statistical significance for *: P<0.10 and **: P<0.05

In Model 2, one of the energy consumption models, the effect of agricultural employment, hence the change in the determination coefficient of the model was found to be statistically significant.

The findings on the effect of economic growth, agricultural industry assets, and agricultural industry developments on the index are given in Table 7. According to the findings, no model was found statistically significant, including the development variables in the agricultural industry.

5. CONCLUSION AND RECOMMENDATIONS

This study analyzed the relationship between energy consumption (renewable energy), economic growth, and developments in Kazakhstan's agricultural industry complex (agriculture and livestock outputs) between 1991 and 2021 and the interaction of these factors.

The effect of the developments in the agricultural industry on renewable energy consumption is positive, while the effect on general energy consumption is negative. These results show that Kazakhstan's agricultural industry is inclined to consume less energy and is turning to renewable energy.

The lack of relationship between Kazakhstan's agricultural industry variables and food index can be explained through two approaches. The first is based on the necessity of investigating the correlation of Kazakhstan's agricultural industry assets and outputs with international indices. The second approach may explain it through the insufficiency of the variables and index structure of the food index for reflecting the developments in the Kazakhstan agricultural industry.

This study examined the effects of agricultural industry assets and developments in the agriculture industry on energy consumption with a regression analysis approach. The findings showed that agricultural developments affect energy consumption, especially renewable energy consumption. This shows the necessity of examining the causality of this effect and whether it transforms into a short-term or long-term effect.

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