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Do Fluctuations in Energy Sector Matter for Monetary Policy? An ARDL and NARDL Approach

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ABSTRACT

The relationship between monetary policy and the energy industry in the Republic of Kazakhstan was examined using statistical indicators from the official website of the World Bank spanning 29 years (1994-2022). The following variables were used: Domestic credit to private sector by banks, Official exchange rate, Inflation, Alternative and nuclear energy, Combustible renewables and waste, Electric power consumption, Renewable energy consumption, Fossil fuel energy consumption, Electricity production from coal sources, Energy use, Electricity production from oil sources, and Foreign direct investment. In the estimation, Autoregressive Distributed Lag and Non-Linear Autoregressive Distributed Lag models were applied and appropriate tests were conducted. The models yielded findings indicating a number of interrelations between the variables. As observed, monetary policy is closely linked to the energy industry, if not connected directly. Namely, it was found that a number of energy indicators affect inflation. We hope these levers can be used to shape the nation's inflation policy. This study and findings will be useful for other academics, as there is a lack of research in this area.

Keywords: Monetary Policy, Energy Use, Renewable Energy, Inflation, Exchange Rate
JEL Classifications: E5, E52, P28, Q42, Q43

1. INTRODUCTION

According to a majority of analysts, monetary policy is one of the leading influences on the trajectory of energy futures prices (Tong, 2024; Paceskoski and Taskovski, 2024). Numerous researches have covered the effects a monetary policy plays in different areas of the energy business (Hammoudeh et al., 2015; Qingquan et al., 2020; Altavilla et al., 2024). Monetary policy plays a critical role in transitioning a green economy and the alleviation of energy sources' impacts on climate change (Song and Fang, 2024; Tervala and Watson, 2025). Monetary policy is one aspect of any comprehensive economic policy program that regulates the money supply and credit to achieve macroeconomic targets (e.g., price stability and economic growth). Demand for energy resources along with the investment costs of energy firms are significantly influenced by the energy industry: Interest rates, as well as the currency rate which are the main tools of monetary policy, fluctuate and affect energy firms' operations costs. For example, if the industry relies heavily on foreign capital, monetary policy increases the importance of the investment (with respect to capital intensity) in determining economic behavior (Choi et al., 2024). Supply chain constraints and monetary policy play a major role in determining energy costs but their effects are unequal (Wang and Peng, 2025), thus it was the policy environment. The link between monetary policy and energy resources is rarely investigated. For example, the cost of benchmark oil is now widely recognized to be affected more directly by US monetary policy variables (Tenkovskaya, 2023). Indulgent resources like sunlight and wind have developed over the past decades, drastically evolving energy production (IRENA, 2022). But because capital-intensive enterprises require investments, the metal and other building materials used to build stations using different energy sources are in some ways depending on exchange rates in the market, investments, interest rates, inflation, etc., or on the prevailing monetary policy. In exchange, generation of the right energy resources helps avert climate change. Therefore, this study seeks to assess nexus between monetary policy and energy sector and answer the following research questions:

- Research question 1: How closely does the energy industry relate to monetary policy?
- Research question 2: What aspect of monetary policy affects the energy industry the most?

The research paper organized as follows: Introduction, Empirical literature review, Methodology, Data and Findings, and Conclusion.

2. LITERATURE REVIEW

Auclert et al. (2023) studied macroeconomic consequences of energy price shocks in energy-importing economies using a heterogeneous-agent model. Monetary tightening alone has little impact on imported inflation; however, when combined with other energy importers, it can have a significant impact by reducing global energy demand. Individual energy importers can be shielded from the shock by fiscal policy, especially energy price subsidies, but other economies experience considerable externalities. Mbassi et al. (2025) studied inflation targeting with monetary policy in the context of energy consumption and their effect in a global sample of 145 different countries covering the period 1980-2017. Results suggest that energy consumption is notably increased by inflation targeting, as well as the degree to which this is attenuated through FDI and macroeconomic volatility. Second, strengthening the institutional architecture mitigates further the effect of inflation targeting. The findings highlight the importance of central bank experience: inflation targeting translates to a relatively large reduction in energy consumption with persistence over time. Finally, the authors found that inflation targeting is not particularly strong in affecting the use of renewable energy. Using a VAR approach, Gordo et al. (2024) researched the link between monetary policy and renewable energy. Since the alternative monetary policies in the recent past have proved to have no impact on renewable energy stocks, the findings conclude that monetary policy has little overall effect on renewable energy stocks. Abakah et al. (2024) studied the association of monetary policy uncertainty with energy sector environmental, social, and governance (ESG) performance. The authors of this study used imbalanced panel data of 3991 firm-year observations of 35 countries from 2002 to 2021 for empirical analysis. Their baseline findings, based on their model with the Shadow Short Rate as a proxy for monetary policy uncertainty, show the relationship of uncertainty and ESG performance in the energy industry remains negative. Rifa'i (2023) examined monetary policy responses and economic growth in Indonesia, Malaysia, and the Philippines against the backdrop of US unconventional monetary policy, global commodity prices, and oil price shock. ASEAN's monetary policy was changed due to shock from US unconventional monetary policy (based on empirical evidence). Monetary policy response of ASEAN to the volatile price of crude oil and other commodities is notably influenced by world prices. Priya and Sharma (2024) examined the influence of monetary policy shocks and unexpected rise of energy prices on household consumption decisions. Both shocks, as reported by the authors, have an adverse impact on both total consumption and its subcategories.

Furthermore, instead of hitting the relatively inelastic components of such household consumption as gasoline and food, rising cost of energy, and monetary tightening policies have a greater effect on relatively elastic pieces of household spending such as varied services. Chen and Lin (2024) studied the relationship between the renewable and monetary policy sectors with the US quarterly data from 1990:Q1 up to 2023:Q2. The findings showed that, depending on the sources of these shocks, monetary policy could counteract or intensify other structural consequences of an external shock on the production of renewable energy: Findings from a counterfactual policy experiment. Nga (2021) discussed the effect of energy and money use, which affected Vietnam's economic development. With the findings, it suggests a correlation between economic growth of the country, renewable energy and monetary policy. The money supply in particular and the impact of renewable energy are particularly positive factors (positive for the same direction) and have a great impact on economic growth, in contrast to the country exchange rate which has no association with economic growth, and the negative consequences by the interest rate. Conducted in 2024, and as the key tools of economic policy and energy transformation, respectively, Akan (2024) aimed to investigate the influences of monetary policy and renewable energy on climate change. Based on his research, the following two significant findings emerged: (1) There is an indirect linear and nonlinear effect of monetary policy on climate change. These effects vary from −0.05% to 0.10%, from −0.78% to 1.14%, and from −0.04% to 0.03% in the industrial sector, residential sector, and transportation sector, respectively; and (2) not only sectoral effects but also energy-, effect-, shock-, finance- and time-varying. Alongside the study of energy, technology, monetary, and fiscal policies, Bildirici et al. (2023) studied relations between fossil fuels, renewable energy and the environment, environmental pollution and economic growth. The authors of their study employed new NBARDL and NBARDL Granger Causality for annual data assessments in the USA. The empirical results of the paper showed us asymmetrical short- and long-term effects of fiscal and monetary policy. And it's worth noting that fiscal policy expansion or contractionary policies both increase CO_2 emissions. When monetary policies are contractionary they lower CO_2 emissions whereas expansionary monetary policies harm the environment. Du et al. (2025) recommended studying first how monetary policy affected energy poverty in 122 developing countries since 2000-2021. Research applying the Instrumental Variable Method using central bank independence as a monetary policy tool showed that expansionary monetary policies such as raising the money supply improve access to electricity and thus reduce energy poverty. Huang et al. (2025) utilized annual time-series data for China for the period 1986-2020, exploring the short- and long-run association between changes in monetary policy and renewable energy usage (REN). In the case of NARDL, REN is reduced by MP-P (positive monetary policy fluctuation), or contractionary monetary policy. Then, there is an inverse relationship between REN and expansionary monetary policy, or negative movement in monetary policy (MP-N). Yin et al. (2022) explored and extensively substantiated the impact of expansionary monetary policy changes on green innovation in a panel of 133 countries from 1960 to 2018. Through a static or dynamic model, those authors found that such measures significantly enhance the effect of green innovation. In poorer countries, no independence of central banks and more limited property rights protection than in developed countries might obstruct the easy transfer of the influence of monetary policy to green innovation projects.

Kazakhstan seeks sustainable growth and energy security through gradual transition to renewable energy and energy efficiency, capitalizing on the country's large hydrocarbon reserves. The energy policy is a key focus of the government of Kazakhstan (Mouraviev, 2021; Hor et al., 2023) and plays a crucial role in shaping the nation's international, social, and economic policies. Problems such as dated infrastructure, lack of domestic production, and ambiguous rules are major hindrances to the development of renewable energy in Kazakhstan. Bordering countries of Kazakhstan are still associated with energy policies (Giritlioglu, 2025). Even with the government efforts to promote green finance schemes, systemic barriers persist in the financial, technological, policy, and social fields (Zhakiyev et al., 2025). Within many different sectors of people's lives, central bank policy and financial stability are important (Yergasheva et al., 2020). Previous research has been carried out for the linkage of good governance and energy (Andabayeva et al., 2025), energy and food security (Kakizhanova et al., 2024), employment in the energy sector (Kaliyeva et al., 2025), economic growth and energy security (Nurgaliuly and Smagulova, 2025), and oil price, inflation, and economic growth (Kakizhanova et al., 2024) of Kazakhstan; but, the correlation among Kazakhstan's monetary policy and energy sector has been limited.

3. METHODS

Based on our literature review, we propose the following theoretical models related to Domestic credit to private sector by banks, Official exchange rate, Inflation, consumer prices (equations 1-3).

DCPSB= f (ANE, CRW, EPC, REC, FEC, EPCS, EUOE, EPS, FDI) (1)

OER= f (ANE, CRW, EPC, REC, FEC, EPCS, EUOE, EPS, FDI) (2)

INF= f (ANE, CRW, EPC, REC, FEC, EPCS, EUOE, EPS, FDI) (3)

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

We use the autoregressive distributed lag (ARDL) method to estimate our models. The rationale for using ARDL is that it allows us to simultaneously examine both long-run and short-run relationships between the modeled variables.

Based on the results of the ADF test, given the dynamic nature of these variables and the need to account for both short-run and long-run effects, the autoregressive distributed lag (ARDL) model was deemed adequate. Linear ARDL1 and nonlinear logarithmic NARDL2-3 models were estimated. The NARDL2-3 regression coefficients can be interpreted as percentage changes, indicating elasticity.

The generalized versions of the ARDL models, equations (1)-(3), are respectively as follows:

Model 1 - ARDL1:

$$
\begin{aligned}
DCPSB_t = {} & \beta_0 + \sum_{k=1}^{l}\beta_1 \Delta DCPSB_{t-k} + \sum_{k=0}^{m}\beta_2 \Delta ANE_{t-k} + \\
& \sum_{k=0}^{n}\beta_3 \Delta CRW_{t-k} + \sum_{k=0}^{p}\beta_4 \Delta EPC_{t-k} + \\
& \sum_{k=0}^{q}\beta_5 \Delta REC_{t-k} + \sum_{k=0}^{r}\beta_6 \Delta FEC_{t-k} + \\
& \sum_{k=0}^{s}\beta_7 \Delta EUOE_{t-k} + \sum_{k=0}^{u}\beta_8 \Delta EPS_{t-k} + \\
& \sum_{k=0}^{v}\beta_9 \Delta FDI_{t-k} + \gamma_0 DCPSB_{t-i} + \gamma_1 ANE_{t-i} + \gamma_2 CRW_{t-i} \\
& +\gamma_3 EPC_{t-i} + \gamma_4 REC_{t-i} + \gamma_5 FEC_{t-i} + \\
& \gamma_6 EUOE_{t-i} + \gamma_7 EPS_{t-i} + \gamma_8 FDI_{t-i} + \varepsilon_t
\end{aligned} \tag{4}
$$

Model 2 - NARDL2:

$$
\begin{aligned}
\Delta LOG(OER_t) = {} & \beta_0 + \sum_{k=1}^{l}\beta_1 \Delta LOG(OER_{t-k}) + \\
& \sum_{k=0}^{m}\beta_2 \Delta LOG(ANE_{t-k}) + \sum_{k=0}^{n}\beta_3 \Delta LOG(EPC_{t-k}) \\
& + \sum_{k=0}^{p}\beta_4 \Delta LOG(REC_{t-k}) + \sum_{k=0}^{q}\beta_5 \Delta LOG(FEC_{t-k}) \\
& + \sum_{k=0}^{r}\beta_6 \Delta LOG(EUOE_{t-k}) + \sum_{k=0}^{s}\beta_7 \Delta LOG(EPS_{t-k}) \\
& +\gamma_o LOG(OER_{t-i}) + \gamma_1 LOG(ANE_{t-i}) \\
& +\gamma_2 LOG(EPC_{t-i}) + \gamma_3 LOG(REC_{t-i}) + \\
& \gamma_4 LOG(EPCS_{t-i}) + \gamma_5 LOG(EUOE_{t-i}) \\
& +\gamma_6 LOG(EPS_{t-i}) + \varepsilon_t
\end{aligned} \tag{5}
$$

Where, operator Δ represents the differencing operation, *LOG* - Natural logarithm.

Table 1: Model variables and sources

Variables	Definitions	Sources
Dependent variables		
DCPSB	Domestic credit to private sector by banks (% of GDP)	World development indicators (WDI) (2025)
OER	Official exchange rate (LCU per US$, period average)	World development indicators (WDI) (2025)
INF	Inflation, consumer prices (annual %)	World development indicators (WDI) (2025)
Independent variables		
ANE	Alternative and nuclear energy (% of total energy use)	World development indicators (WDI) (2025)
CRW	Combustible renewables and waste (% of total energy)	World development indicators (WDI) (2025)
EPC	Electric power consumption (kWh per capita)	World development indicators (WDI) (2025)
REC	Renewable energy consumption (% of total final energy consumption)	World development indicators (WDI) (2025)
FEC	Fossil fuel energy consumption (% of total)	World development indicators (WDI) (2025)
EPCS	Electricity production from coal sources (% of total)	World development indicators (WDI) (2025)
EUOE	Energy use (kg of oil equivalent per capita)	World development indicators (WDI) (2025)
EPS	Electricity production from oil sources (% of total)	World development indicators (WDI) (2025)
FDI	Foreign direct investment, net inflows (BoP, current US$)	World development indicators (WDI) (2025)

Source: Compiled by authors

Model 3 - NARDL3:

$$\begin{aligned}\Delta LOG(INF_t) = \beta_0 + \sum_{k=1}^{l}\beta_1 \Delta LOG(INF_{t-k}) + \\ \sum_{k=0}^{m}\beta_2 \Delta LOG(ANE_{t-k}) + \sum_{k=0}^{n}\beta_3 \Delta LOG(CRW_{t-k}) \\ +\sum_{k=0}^{p}\beta_4 \Delta LOG(EPC_{t-k}) + \sum_{k=0}^{r}\beta_5 \Delta LOG(REC_{t-k}) \\ +\sum_{k=0}^{s}\beta_6 \Delta LOG(FEC_{t-k}) + \sum_{k=0}^{u}\beta_7 \Delta LOG(EUOE_{t-k}) \\ +\sum_{k=0}^{v}\beta_8 \Delta LOG(EPS_{t-k}) + \sum_{k=0}^{w}\beta_9 \Delta LOG(FDI_{t-k}) \\ +\gamma_o LOG(OER_{t-i}) + \gamma_1 LOG(ANE_{t-i}) + \\ \gamma_2 LOG(CRW_{t-i}) + \gamma_3 LOG(EPC_{t-i}) \\ +\gamma_4 LOG(REC_{t-i}) + \gamma_5 LOG(FEC_{t-i}) \\ +\gamma_6 LOG(EUOE_{t-i}) + \gamma_7 LOG(EPS_{t-i}) \\ +\gamma_8 LOG(FDI_{t-i}) + \square_t\end{aligned} \quad (6)$$

4. DATA AND FINDINGS

4.1. Data

This study examines the influence of the main factors on domestic credit to the private sector by banks, official exchange rate, inflation, consumer prices in the Republic of Kazakhstan. The study uses World Data Institute (WDI) data covering the period from 1994 to 2022. All definitions and units of measurement are presented in the Table 1.

The dynamic change of all indicators presented in the table in the period 1994-2022 is depicted in the Graph 1.

It is clear from the analysis of the graph shown in Graph 2 that the study variables are suitable for analysis. The graph shows obvious, consistent and stable time patterns, indicating that changes in the variables are suitable for further study.

4.2. Empirical Findings

We can look more closely at a number of a data set's attributes thanks to descriptive statistics. Table 2 presents descriptive statistics for each variable. The properties of mean, median, skewness, kurtosis, Jarque-Bera, and probability were used in the study to analyze the variables.

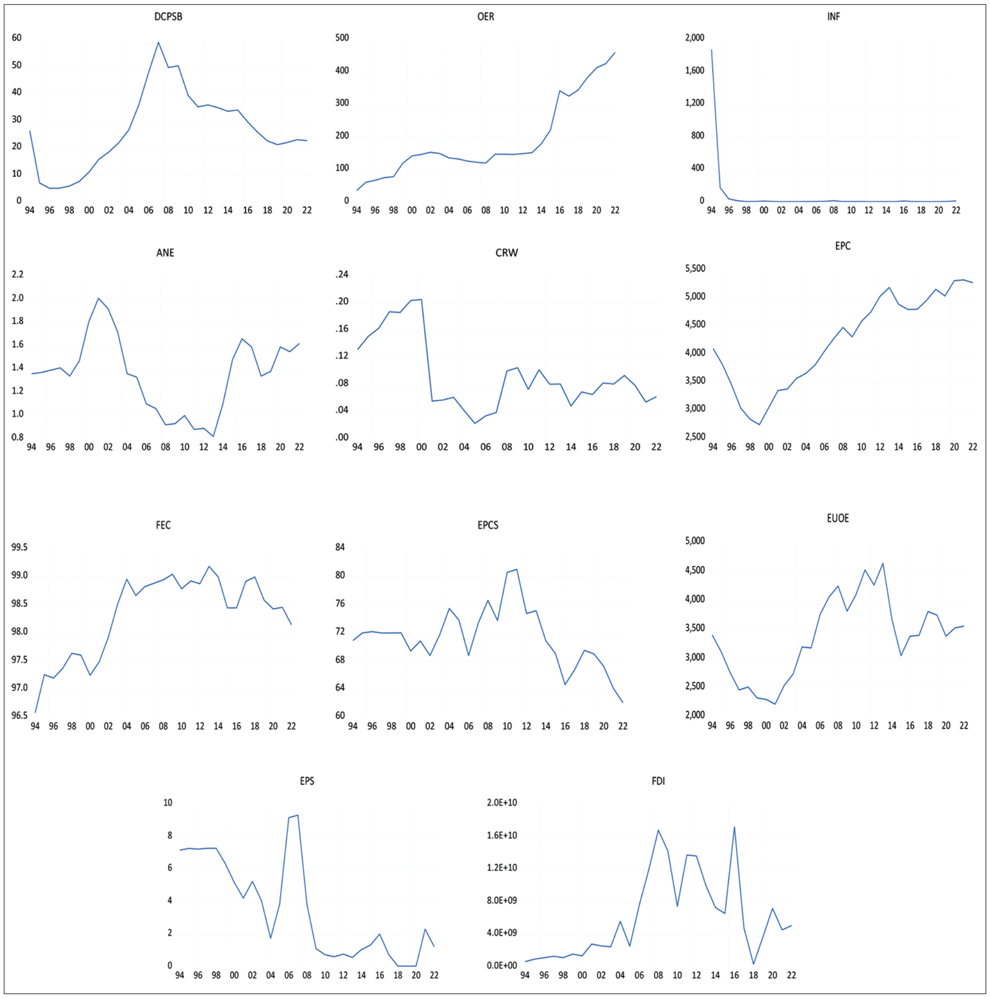
In the Table 2, the average values of the DCPSB, OER, INF, ANE, CRW, EPC, REC, FEC, EPCS, EUOE, EPS, and FDI indicators are 26.7% of GDP, 189.8 LCU per US$, 80.1%, 1.4% of total energy use, 0.1% of total energy, 4239.8 kWh per capita, 1.8% of total final energy consumption, 98.3% of total, 71.4% of total, 3372.7 kg of oil equivalent per capita, 3.5% of total, 6.09E + 0.09 BoP, and current US$, respectively. The standard deviations of DCPSB, OER, INF, ANE, CRW, EPC, REC, FEC, EPCS, EUOE, EPS, and FDI are 14.4% of GDP, 120.1 LCU per US$, 347.1%, 0.3% of total energy use, 0.1 kWh per capita, 819.4 of total final energy consumption, 0.4%, 0.7 of total, 4.3 of total, 688.1 kg of oil equivalent per capita, 3.0% of total, 5.15E + 09 BoP, and current US$. The value of the standard deviation shows that CRW has low variability, while FDI has very high variability. All indicators except EPC and FEC show positive skewness, while LAFI and GSU have negative skewness.

4.3. Unit Root Test

Before examining long-term relationships between series, it is necessary to assess their stationarity. In this study, augmented Dickey-Fuller (ADF) unit root tests were used to examine the levels or differences of stationary variables before estimating equations (4)-(5). Some variables can be used at the I(0) level; all other variables are integrated at the I(1) level at a significance level of 1-10%, except for the ANE factor, which is nonstationary in the case of Trend and intercept (Table 3).

Therefore, we may estimate ARDL models with or without the intercept and trend using these parameters. Since the unit root results support the initial hypotheses, we must test the ARDL model to verify the existence of long-term relationships between

Graph 1: Evolution of all variables for Kazakhstan (1994-2022)



Source: Compiled by authors

Table 2: Values of descriptive statistics of the displayed series

Values	DCPSB	OER	INF	ANE	CRW	EPC	REC	FEC	EPCS	EUOE	EPS	FDI
Mean	26.7	189.8	80.1	1.4	0.1	4239.8	1.8	98.3	71.4	3372.7	3.5	6.09E+09
Median	25.8	147.4	7.6	1.4	0.1	4306.3	1.8	98.5	71.8	3404.2	2.3	4.76E+09
Maximum	58.9	460.2	1877.4	2.0	0.2	5321.5	2.8	99.2	81.1	4645.8	9.3	1.72E+10
Minimum	5.1	35.5	5.2	0.8	0.0	2741.5	1.1	96.6	62.1	2217.6	0.1	3.53E+08
Standard deviation	14.4	120.1	347.1	0.3	0.1	819.4	0.4	0.7	4.3	688.1	3.0	5.15E+09
Skewness	0.3	1.0	5.0	0.0	0.9	−0.3	0.2	−0.8	0.2	0.0	0.5	0.826957
Kurtosis	2.5	2.7	26.6	2.3	2.7	1.8	2.4	2.4	3.3	2.1	1.8	2.488397
Jarque-Bera	0.7	5.0	795.2	0.7	4.2	2.2	0.6	3.5	0.2	1.0	2.8	3.621581
Probability	0.7	0.1	0.0	0.7	0.1	0.3	0.7	0.2	0.9	0.6	0.2	0.163525
Sum	773.3	5505	2321.5	39	2.7	122955	53	28513	2070	97807	102	1.77E+11
Sum Sq. Dev.	5795.0	403766	3373590	2.9	0.1	1880040	5.0	14.5	524	13255730	254.9	7.42E+20
Observations	29	29	29	29	29	29	29	29	29	29	29	29

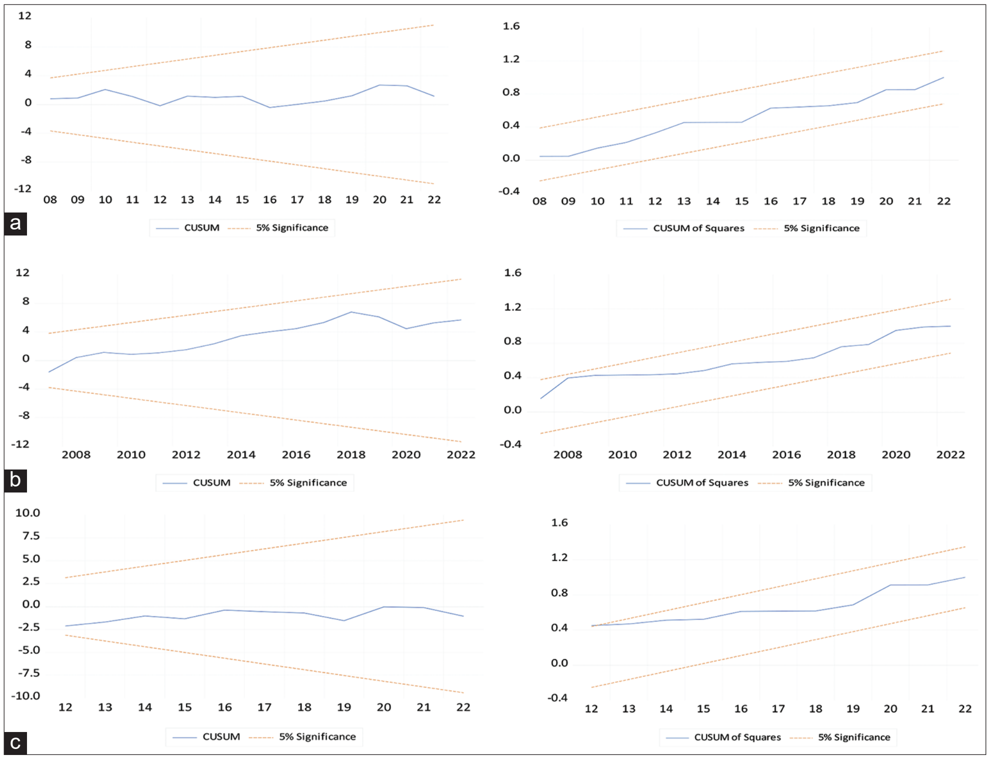
Source: compiled by authors

the explanatory variables proposed in the study, the official exchange rate, inflation, consumer prices in Kazakhstan, and domestic bank credit to the private sector.

4.4. Co-Integration Test

In this study, the ARDL bounds testing procedure is used to examine the long-run relationships between the selected explanatory variables and domestic credit to the private sector by banks, official exchange rate, inflation, and consumer prices in the Republic of Kazakhstan. Before conducting the cointegration test, it is important to determine the lag length criterion. To examine the long-run relationships between the variables, the ARDL method was selected using a small sample. The lag length criterion is determined based on LR, FPE, AIC, SC, and HQ. Table 4 presents the results for the selected lag of the linear ARDL1 and nonlinear NARDL2-3 models. As can be seen from the table, the selected lag length is 1, as it has more stars and was used throughout the study.

Graph 2: CUSUM and CUSUMSQ. (a) Model 1 - ARDL1 (1, 1, 0, 0, 1, 0, 1, 1, 0) estimation DLOG (DCPSB). (b) Model 2 - NARDL2 (1, 0, 1, 1, 0, 0, 0) estimation DLOG (OER). (c) Model 3 – NARDL3 (1, 1, 0, 1, 1, 1, 1, 1, 1) estimation DLOG (INF)



Source: Compiled by authors

In this study, the ARDL1 (1, 1, 0, 0, 1, 0, 1, 1, 0) linear model (Equation 4) was estimated using first-difference analysis to conduct long-run and short-run analyses of the relationship between variables. The results of the cointegration F-test for ARDL1 (Table 5) show that the obtained F-statistic (14.70706) exceeds the upper limit of 3.79 and is statistically significant at the 1-10% significance level. The results indicate that the selected variables are cointegrated, and in the case of Kazakhstan, there is a long-run relationship between them. In the study, NARDL2 (1, 0, 1, 1, 0, 0, 0) (Equation 5) and NARDL3 (1, 1, 0, 1, 1, 1, 1, 1) (Equation 6) nonlinear models were estimated using natural logarithms. The results of the cointegration F-test for NARDL1-2 show that the obtained F-statistics (11.73978 and 9.056671, respectively) exceed the upper limit of 4.05 and 4.1, and they are statistically significant at the 1-10% significance level. The results similarly indicate that the selected variables are cointegrated.

We can move on to the following phase, which entails estimating the long-run and short-run coefficients, since the chosen variables are cointegrated over the long term. We may estimate the long- and short-term effects of changes in the explanatory factors on the dependent variable using the linear ARDL1 and nonlinear NARDL2-3 models.

4.5. Results of Long- and Short Run Relationship

The long-term and short-term correlation coefficients are presented in Tables 6-8.

The results of the ARDL1 (1, 1, 0, 0, 1, 0, 1, 1, 0) model (Table 6) show that all coefficients for the explanatory variables, except EPS, that influence the level of domestic credit to the private sector by banks in Kazakhstan in the long term are significant. EPC, REC, FEC, and FDI have a positive and significant impact on the growth of domestic credit to the private sector by banks in Kazakhstan, all other things being equal. An increase in EPC, REC, FEC, and FDI leads to an increase in D(DCPSB) for Kazakhstan (coefficients of 0.020175, 63.75393, 2.151962, and 1.38E-09, respectively). ANE, CRW, and EUOE have a negative and significant impact on D(DCPSB), with corresponding coefficients of −154.8833, −159.6935, and −0.051910.

In the short term, DCPSB growth in Kazakhstan declines as Alternative and Nuclear Energy and Energy Use increase (coefficients of −58.58557 and −0.021872). The coefficients of the lagged variables ANE (−1), EUOE (−1), and CRW also confirm their negative impact on D(DCPSB). Conversely, EPS growth is negatively correlated with DCPSB growth in the short term (−1.164907). Furthermore, all else equal, the coefficients on lagged REC (−1), as well as on EPC and FEC, are positive (with coefficients of 36.42764, 0.011528, and 1.229585, respectively) in the short run, consistent with the long-run result.

The change in the lagged variable DCPSB (−1) is negatively and significantly correlated with D(DCPSB) in the short run (−0.571379).

Table 3: ADF unit root tests

Variables	Intercept			Trend and intercept			None		
	Level	First difference	Order of integration	Level	First diff.	Order of integration	Level	First difference	Order of integration
DCPSB	−2.119 (0.239)	−4.60*** (0.0011)	I (1)	−1.099 (0.911)	−4.822*** (0.003)	I (1)	−0.349 (0.550)	−4.669*** (0.000)	I (1)
OER	1.058 (0.996)	−4.33*** (0.002)	I (1)	−0.478 (0.979)	−4.716*** (0.004)	I (1)	3.179 (0.999)	−3.528*** (0.001)	I (1)
INF	−378*** (0.000)	−320*** (0.000)	I (0)	−360*** (0.000)	−309*** (0.000)	I (0)	−181*** (0.000)	−332*** (0.000)	I (0)
ANE	−2.263 (0.190)	3.209** (0.031)	I (1)	−2.178 (0.482)	−3.174 (0.111)	>I (1)	−0.276 (0.570)	−3.264*** (0.002)	I (1)
CRW	−1.818 (0.364)	−5.34*** (0.000)	I (1)	−2.133 (0.506)	−5.237*** (0.002)	I (1)	−1.196 (0.206)	−5.396*** (0.000)	I (1)
EPC	−0.105 (0.935)	−3.31** (0.024)	I (1)	−3.479* (0.061)	−3.186 (0.108)	I (0)	−0.716 (0.864)	−3.209*** (0.002)	I (1)
REC	−1.853 (0.349)	−4.68*** (0.001)	I (1)	−1.789 (0.683)	−4.583** (0.006)	I (1)	−4.750 (0.621)	−3.209*** (0.000)	I (1)
FEC	−2.696*(0.087)	−4.63*** (0.001)	I (0)	−1.408 (0.836)	−5.02*** (0.002)	I (1)	−0.904 (0.903)	−4.730*** (0.000)	I (1)
EPCS	−1.342 (0.596)	−5.38*** (0.000)	I (1)	−1.725 (0.713)	−5.475*** (0.001)	I (1)	−0.612 (0.443)	−5.51*** (0.000)	I (1)
EUOE	−1.364 (0.585)	−4.75*** (0.001)	I (1)	−1.829 (0.663)	−4.65*** (0.005)	I (1)	−0.192 (0.608)	−4.84*** (0.000)	I (1)
EPS	−0.105 (0.940)	−3.314** (0.024)	I (1)	−3.479* (0.061)	−3.186 (0.108)	I (0)	0.979 (0.908)	−3.209*** (0.002)	I (1)
FDI1	−3.165** (0.033)	−5.52*** (0.000)	I (0)	−3.739** (0.036)	−5.66*** (0.001)	I (0)	−0.936 (0.302)	−5.63*** (0.000)	I (1)
FDI	−2.523 (0.121)	−5.81*** (0.000)	I (1)	−2.529 (0.313)	−5.85*** (0.000)	I (1)	−1.382 (0.152)	−5.91*** (0.000)	I (1)

(1) *, **, *** denote statistically significant at the 10%, 5% and 1% levels, respectively. *P* value is inside brackets. Source: Compiled by authors

NARDL2 (1, 0, 1, 1, 0, 0, 0) estimation. Table 7 presents the empirical results of the Official exchange rate OER model.

The Table 7 shows that four variables, EPC, REC, EPCS and EPS, have a long-run negative impact on the Official exchange rate OER, the corresponding elasticity coefficients are −2.647870%, −2.561509%, −5.937900%, −0.148089%. Moreover, the marginal effect of EPCS is almost forty times higher than the effect of EPS. In contrast, the variables ANE and EUOE with a positive coefficient (4.329084, 5.127930, respectively) have a positive impact on OER growth in the long run. Moreover, if the coefficient of the lagged variable LOG (OER (−1)) in the period t-1 in the short term turned out to be negative (−0.339102), all other things being equal, the positive effects of LOG(ANE)), LOG(EUOE) and DLOG(OER) were confirmed with the corresponding coefficients of 1.468000, 1.738890. LOG(EPCS) and the logarithms of the lagged variables LOG (EPC (−1)), LOG (REC (−1)) correlate negatively with DLOG(OER) (with coefficients of −2.013552, −0.897897, and −0.868612, respectively) in the short run, consistent with the long-run result.

Table 8 shows that the coefficient for LOG(CRW) is insignificant, while all other estimated long-run coefficients for the selected NARDL2 (1, 1, 0, 1, 1, 1, 1, 1, 1) model are significant at the 10% significance level.

In the Table 8, the coefficient for LOG(ANE) is positive and significant at the 1% significance level, confirming the assertion that alternative and nuclear energy have a significant positive impact on inflation, with a coefficient of 9.154886, all other factors being equal. The EPS and EUOE variables also have a positive coefficient (0.454578 and 13.22731, respectively) and a positive impact on INF in the long run. EPC, REC, FEC, and FDI have a negative long-run impact on DLOG(INF), with the corresponding elasticity coefficients of −3.792314%, −5.223239%, −89.63244%, and −0.504728%.

In addition, if the coefficient of the lagged variable LOG (INF (−1)) in the period t-1 in the short run turned out to be negative (−0.967347). All other things being equal, the positive effects of LOG (ANE (−1)), DLOG(EPS), LOG (EUOE (−1)) on DLOG(INF) were confirmed with the corresponding coefficients of 8.855950, 0.212490, 12.79539. The change in LOG(REC), the logarithms of the lagged variables LOG (EPC (−1)), LOG (REC (−1)), LOG (FEC (−1)) correlate with DLOG(INF) negatively (with the coefficients of −1.936518, −3.668483, −5.052683 and −86.70566, respectively) in the short run, which is consistent with the long-term result.

4.6. Diagnostic Tests

To confirm the robustness of the linear ARDL1 and nonlinear NARDL2-3 models, diagnostic tests were conducted (Table 9). These tests include testing for serial correlation, normality, and heteroscedasticity. For this model, the null hypotheses of absence of serial correlation, homoscedasticity, and normality are not rejected.

Finally, all diagnostic tests for serial correlation with Lagrange multiplier, Jarque-Bera normality test and heteroscedasticity test

Table 4: Selection order criteria

ARDL1 (1, 1, 0, 0, 1, 0, 1, 1, 0)						
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	−1146.903	NA	5.82e+24	82.56451	82.99272	82.69541
1	−934.6846	272.8524*	6.66e+20*	73.19175*	77.47384*	74.50083*
NARDL2 (1, 0, 1, 1, 0, 0, 0)						
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	−1254.667	NA	8.07e+26	90.33334	90.80913	90.47880
1	−1001.382	307.5600*	2.21e+22*	79.38444*	84.61810*	80.98442*
NARDL3 (1, 1, 0, 1, 1, 1, 1, 1, 1)						
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	−1243.173	NA	3.55e+26	89.51239	89.98818	89.65784
1	−972.7521	328.3689*	2.87e+21*	77.33943*	82.57309*	78.93941*

Source: Compiled by authors

Table 5: Results of cointegration test

Model	F Statistics	Critical bounds I (1)	Decision
ARDL1 (1, 1, 0, 0, 1, 0, 1, 1, 0)	14.70706***	2.79-3.79	Cointegration
NARDL2 (1, 0, 1, 1, 0, 0, 0)	11.73978***	2.87-4.05	Cointegration
NARDL3 (1, 1, 0, 1, 1, 1, 1, 1, 1)	9.056671***	3.06-4.1	Cointegration

Critical bounds are reported at 1% (***) and 10% (**) level of significance. Source: Compiled by authors

Table 6: Results of Model 1 - ARDL1 (1, 1, 0, 0, 1, 0, 1, 1, 0) estimation D (DCPSB) (1994-2022)

Long run			Short run		
Variable	**Coefficient**	**t-Statistic**	**Variable**	**Coefficient**	**t-Statistic**
			DCPSB(−1)*	−0.571379***	−5.668204
ANE	−154.8833***	−4.756757	ANE(−1)	−88.49701***	−7.630212
CRW	−159.6935***	−4.946461	CRW**	−91.24545***	−3.845205
EPC	0.020175***	3.332510	EPC**	0.011528***	3.952946
REC	63.75393***	4.141270	REC(−1)	36.42764***	6.593000
FEC	2.151962***	4.395125	FEC**	1.229585***	6.374860
EUOE	−0.051910***	−3.437679	EUOE(−1)	−0.029661***	−4.876614
EPS	0.987228	1.555801	EPS(−1)	0.564081	1.409530
FDI	1.38E-09***	3.742686	FDI**	7.89E-10***	4.297341
			D (ANE)	−58.58557***	−6.139742
			D (REC)	27.65052***	6.933924
			D (EUOE)	−0.021872***	−4.563100
			D (EPS)	−1.164907**	−2.743624

(1) coefficients are statistically significant at ***1%, **5%, *10% level of significance, in parentheses (t-values). (2) compiled by the authors

Table 7: Results model 2 - NARDL2 (1, 0, 1, 1, 0, 0, 0) estimation DLOG (OER) (1994-2022)

Long run			Short run		
Variable	**Coefficient**	**t-Statistic**	**Variable**	**Coefficient**	**t-Statistic**
			LOG (OER(−1))*	−0.339102***	−4.806054
LOG (ANE)	4.329084**	2.824078	LOG (ANE)**	1.468000***	3.596272
LOG (EPC)	−2.647870*	−1.813431	LOG (EPC(−1))	−0.897897**	−2.113458
LOG (REC)	−2.561509**	−2.553000	LOG (REC(−1))	−0.868612***	−3.442462
LOG (EPCS)	−5.937900***	−3.425038	LOG (EPCS)**	−2.013552***	−3.408888
LOG (EUOE)	5.127930**	2.609278	LOG (EUOE)**	1.738890***	3.122072
LOG (EPS)	−0.148089***	−3.063089	LOG (EPS)**	−0.050217**	−2.543940
			DLOG (EPC)	−0.181923	−0.349358
			DLOG (REC)	−0.257260	−1.252025

(1) Coefficients are statistically significant at ***1%, **5%, *10% level of significance, in parentheses (t-values). (2) Compiled by the authors

were successful, indicating the robustness of the ARDL1 and NARDL2-3 models.

4.7. Stability Tests

To assess the dynamic stability of our model, we used the CUSUM and CUSUMSQ tests. The graphical representations of these tests, presented in Graph 2, demonstrate the overall stability of the ARDL1 and NARDL2-3 models.

Since CUSUM and CUSUMSQ in the graphs of Graph 2 remain within the 5% critical boundary, the model parameters are considered stable.

Table 8: Results Model 3- NARDL3 (1, 1, 0, 1, 1, 1, 1, 1, 1) estimation DLOG (INF) (1994-2022)

Long run			Short run		
Variable	Coefficient	t-Statistic	Variable	Coefficient	t-Statistic
			LOG (INF(−1))*	−0.967347***	−5.579029
LOG (ANE)	9.154886***	5.643860	LOG (ANE(−1))	8.855950***	3.663254
LOG (CRW)	−0.257344	−1.351521	LOG (CRW)**	−0.248941	−1.196772
LOG (EPC)	−3.792314**	−2.416589	LOG (EPC(−1))	−3.668483*	−2.142620
LOG (REC)	−5.223239***	−4.393931	LOG (REC(−1))	−5.052683**	−3.048317
LOG (FEC)	−89.63244**	−3.077739	LOG (FEC(−1))	−86.70566**	−2.232065
LOG (EUOE)	13.22731***	5.851527	LOG (EUOE(−1))	12.79539***	3.566132
LOG (EPS)	0.454578***	5.213938	LOG (EPS(−1))	0.439734***	3.818932
LOG (FDI)	−0.504728***	−3.324575	LOG (FDI(−1))	−0.488247**	−2.499784
			DLOG (ANE)	5.823877***	3.756379
			DLOG (EPC)	1.982063	0.910297
			DLOG (REC)	−1.936518**	−2.925244
			DLOG (FEC)	−36.06864	−1.184158
			DLOG (EUOE)	7.667361***	3.963360
			DLOG (EPS)	0.212490**	2.637659
			DLOG (FDI)	−0.182747	−1.850334

(1) Coefficients are statistically significant at ***1%, **5%, *10% level of significance, in parentheses (t-values). (2) compiled by the authors

Table 9: Short-run diagnostics

Model 1 - ARDL1 (1, 1, 0, 0, 1, 0, 1, 1, 0)			
Test	F-statistics	P-value	Conclusion
Serial correlation LM	0.710071	0.5097	Normality exists
Heteroskedasticity	1.213815	0.3609	No serial correlation
Jarque-Bera	0.414712	0.8127	No heteroskedasticity
Model 2 - NARDL2 (1, 0, 1, 1, 0, 0, 0)			
Test	F-statistics	P-value	Conclusion
Serial correlation LM	1.533985	0.3656	Normality exists
Heteroskedasticity	1.547779	0.2054	No serial correlation
Jarque-Bera	4.461508	0.1074	No heteroskedasticity
Model 1 - NARDL2 (1, 1, 0, 1, 1, 1, 1, 1, 1)			
Test	F-statistics	P-value	Conclusion
Serial correlation LM	2.289743	0.1571	Normality exists
Heteroskedasticity	1.426886	0.2786	No serial correlation
Jarque-Bera	3.772441	0.1516	No heteroskedasticity

Source: Compiled by authors

5. CONCLUSION AND SOME POLICY IMPLICATIONS

5.1. Conclusion

The relation of monetary policy and the energy sector has been debated in the literature over the last years. The relationship between the energy sector and monetary policy using Kazakhstan as an example is analyzed in this study. The analyses were performed using data between 1994 and 2022. The domestic loans from banks to the private sector (DCPSB), the official exchange rate (OER), and the consumer price index (INF) were analyzed as dependent variables. In this context, alternative and nuclear energy (ANE), combustible renewable energy sources and waste (CRW), per capita electrical energy consumption (EPC), renewable energy consumption (REC), fossil fuel energy consumption (FEC), electricity generation from coal resources (EPCS), energy use (EUOE), electricity generation from petroleum resources (EPS), and foreign direct investment (FDI) were regarded as independent factors in our forecast models. ADF unit root tests were performed mostly in the analyses to assess the stationarity of the variables. Second, the Autoregressive Distributed Lag (ARDL) and Nonlinear Autoregressive Distributed Lag (NARDL) econometric models were used to examine the relationship between the variables. The findings of this analysis suggest that alternative and nuclear energy performance indicators exert a positive influence on official exchange rate and inflation in the short and long term. Renewable energy consumption in the short and long run has a positive indirect effect on domestic loans issued by banks to the private sector. In contrast, the consumption of fossil fuel energy has a positive effect on domestic loans issued by banks to the private sector in both the short and long run. Moreover, it is noted that the energy in its use promotes the short and long-term effective performance of the official exchange rate and inflation rate. In this study, electricity generation from petroleum resources was positively affected in the short and long term by domestic bank loans to the private sector, while in the short as well as long term, it had a positive effect on the inflation indicator as well. Additionally, for the long and short term, the positive impact of foreign direct investment on domestic loans from banks to private sector is established. Based on analysis findings in the analysis above, we can answer the research questions that we pose in the introduction as follows:

The DCPSB dependent variable is under-effects of the above explained variables, except for EPC and EPCS. ANE, EPC, REC, EPCS, EUOE and EPS are important in affecting the OER factor. Out of these explanatory variables all except EPCS significantly affect the dependent variable, INF. In analyzing the elasticity coefficients to ascertain the most influential monetary policy factors for the energy sector, the OER, EPCS (−5.937900), INF, FEC (−89.63244) and energy indicator FEC (elasticity coefficient of 3.28%) were confirmed to have the highest impact on DCPSB.

5.2. Policy Implications

From an economic point of view, the effect of loans from banks to private firms in relation to the adoption of monetary policies and the use of fossil fuels and renewable energy is examined. However, the results of the analysis show that since such loans tend to exert a positive effect for the variables that are regarded with their dependency variables on forecast models in short and long durations, the study results support the hypothesis. It can ultimately be said that low-interest loans from the banking sector will facilitate renewable energy resource utilization and build up greener technology. Regular monitoring of energy resource prices is important in this respect. In addition, keeping the links between energy consumption, electricity generation as well in petroleum resource, alternative and nuclear power sources of energy, on a continuous basis is subject to the level of academic attention at that particular section. In the long run, the monetary policy instruments are viewed as important instruments for the efficient utilization of Kazakhstan's renewable energy resources.

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