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Economic Impact of Consumer Determinants on Household Energy Use: Evidence from Kazakhstan

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ABSTRACT

The quality and productivity of human capital are influenced by household consumption factors, such as spending on health care, education, and better living conditions. Households support the reproduction of the labor force as the main factor of production and invest in the development of human capital through the consumption of goods and services. As technology advances and smart homes emerge, and as demand for services and goods increases, household energy consumption is also increasing. The aim of the study is to assess the economic impact of consumer determinants on household energy consumption. The study used the following indicators: Consumer price index of Housing services and other fuels, Real money income index of population, Annual inflation rate, Percentage of internet users, Employment rate. To assess the impact of factors on the level of household final energy consumption in Kazakhstan using the ARDL model, data covering 2001-2024 were obtained from the National Bureau of Statistics of the Republic of Kazakhstan and the official website of the World Bank. The findings indicated that the Consumer price index of housing services and other fuels has no effect on the Households final energy consumption (1000 t o.e.) component in either the long or short run. Whereas real money income, inflation rate, internet users have a positive influence in both the long and short run, employment rate has a negative effect in both the long and short run.

Keywords: Households' Final Energy Consumption, Fuels, Internet Users, Real Money Income, Inflation, Employment Rate
JEL Classifications: D1, D14, K32

1. INTRODUCTION

Due to the shift of socio-economic realities, characterized by crises, inflation surges, and an unpredictable macroeconomic environment fraught with uncertainty, households must adjust their spending patterns, savings, and employment strategies (Koirala et al., 2024; Coibion et al., 2024). The world is currently dealing with a number of challenges (Đukić, 2022). Energy is always a crucial component in making a breakthrough in the age of industry and modernization (Thi Thuy Duong et al., 2025). According to Sahu and Narayanan (2011), industrialization, electricity, and the quick expansion of infrastructure frequently accompany economic growth. The energy sources we employ have a major impact on sustainable economic development (Chigarkina et al., 2025). The conventional function of households in the economy has been to supply resources for production and consumption. Nowadays, the ideas and inventiveness that determine its significance in reproduction processes can be attributed to a modern household's roles as a taxpayer, investor, entrepreneur, borrower, and custodian of intellectual property. A novel consumer lifestyle in which the absence of digital technologies renders household's invisible; contemporary realities necessitate that households prioritize education and skill enhancement, digitalization. In formulating socio-economic policy, it is essential to quantify the number of households, both large and small, as they impact resource consumption levels (Murphy, 1991; O'Neill and Chen, 2002). The proportion of household income allocated to expenditures and the capacity to save substantially influence class formation within a nation (Wisman, 2008; Tekenov et al., 2017; Alfaro and Park, 2025).

Households are one of the main users of energy (Gram-Hanssen, 2011; Chen et al., 2023; García-López et al., 2023). The need for energy in homes has increased multiple times due to technological advancements, digitalization, and smart home systems (Paetz et al., 2012; Strielkowski et al., 2022; Vindegg and Julsrud, 2025). Although the use of renewable energy sources is also linked to the development of a green economy, the implementation of sustainable development goals and the energy-related principles of a green economy (Aubakirova et al., 2023; Zeng et al., 2024) is somewhat hampered by the disparate levels of development among nations (Sinha et al., 2022) and the world's population growth (Ahmed et al., 2023).

Both internal and external factors affect how households fulfill their growing energy needs. Therefore, the purpose of this study is to evaluate the consumer factors that affect household energy use. The paper is organized as follows: Introduction, Literature Review, Methodology, Data and Findings, and Conclusion.

2. LITERATURE REVIEW

The mix of households and the selection of energy sources have a major impact on the rate of rise in energy consumption (Matsumoto, 2025). Since fossil fuels are becoming increasingly scarce and the effects of climate change are getting worse, it is more important than ever to alter energy systems and adopt more sustainable lifestyles (IPCC, 2022). Households' effective and efficient use of energy is obviously influenced by a number of factors (Han and Wei, 2021; Guo et al., 2023; Wang et al., 2024). Behavioral changes, investments into energy-efficient technologies might help reduce househods energy consumption (Eisele and Schubatzky, 2025). However, both approaches involve time and effort, and it is obviously difficult to put them into practice without a broad awareness of the need for handling energy (Piao and Managi, 2023; Shahin et al., 2024).

Garcia-Miranda et al. (2024) investigated the social and economic determinants of energy usage in the area. The study's findings demonstrated that the population's income level, way of life, and technology use all significantly affect how much energy is consumed in rural areas. Moreover, size of households too effect positively on residental enery consumption (Karatasou and Santamouris, 2019). Kuhe and Bisu (2020) examined into the effects of situational factors on home energy usage patterns. Households continue to utilize inefficient, conventional energy sources and technologies in spite of energy-efficient technical advancements and understanding of the health and environmental consequences of utilizing certain energy sources and technologies. Cihan and Değirmenci (2025) investigated at how average income and educational attainment affected household energy use. The results indicate that, on a panel basis, income level has a favorable impact on household energy consumption, but the long-term average schooling rate has a negative influence. Financial risks also play a major role in household decisions, as income level, debt levels, and expenses are of great importance in everyday life (Yergasheva et al., 2020). By assessing consumption patterns and flows and analyzing relationships and their impact on energy usage among 620 urban families in Seremban, Malaysia, Ali et al. (2021) investigated the key factors influencing household electricity consumption. The most important element influencing power usage, according to the study's empirical findings, is the number of rooms. Therefore, initiatives to improve energy efficiency, preserve resource sustainability, and reduce the threat posed by greenhouse gases to the urban ecology are essential. Karunarathna et al. (2023) believe that measures incorporating subsidies, low interest rates, and government loan programs could encourage people to buy energy-efficient equipment. Qi et al. (2025) investigated the elements that influence home energy usage in Beijing's high-density residential zones and suggested specific energy-saving measures. Their study improved the use of energy-saving devices, promoted low-carbon lifestyles, and provided refined data support for regulating energy in highly dense residential areas.

Kazakhstan is particularly renowned as an energy producer and supplier in the Central Asian region; it possesses abundant energy reserves. The country is the world's leading uranium producer and ranks among the top 10 coal producers and top 20 oil producers. Over the past two decades, it has doubled its oil production, while uranium production has increased nearly 30-fold (Burkitbaev, 2024). Kazakhstan has experienced difficulties in its energy sector in recent years (Mouraviev, 2021). In addition to a lack of investment inflow, the energy sector's fixed asset depreciation is between 60% and 70%, which lowers thermal efficiency, raises logistics costs for the delivery of energy raw materials, deteriorates the environment, and stops the nation's economy from growing further (Nurgaliuly and Smagulova, 2025). Deteriorating energy infrastructure and fast increasing consumption are the two main causes of the nation's electricity shortfall. Traditional energy sources are still used in households (Table 1), while differences in average fuel and energy consumption by household size and energy source are illustrated in Graph 1. Additionally, the way power is now priced makes it impossible to use tariff earnings to upgrade energy infrastructure. However, modernization initiatives are being vigorously carried out by the authorities. However, new facilities are required to keep up with growing consumption; modernization alone is no longer adequate (Mussin and Mussina, 2023). In this sense, the growth of the renewable energy sector necessitates significant expenditures in the energy sector (Aubakirova et al., 2021; Aubakirova et al., 2023).

3. METHODS

We Based on the literature review, we propose the following theoretical model (Equation 1) that examines the influence of important factors on Households final energy consumption in the Republic of Kazakhstan:

$$HFEC= f\,(CPIHSF, RMIIP, Inf, IUP, Emp) \quad (1)$$

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

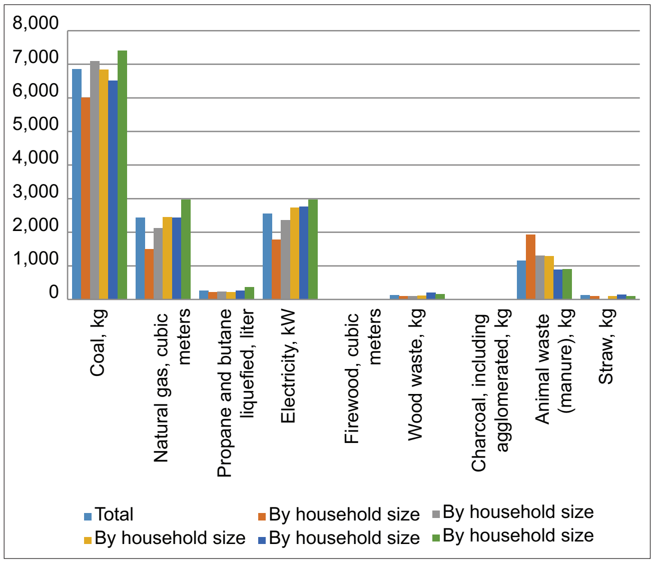
Based on the ADF test results, all the variables under study were

Table 1: Model variables and sources

Variables	Definitions	Sources
HFEC	Households final energy consumption (1000 t o.e.)	Bureau of National statistics of the RK (2025)
CPIHSF	Consumer price index of Housing services and other fuels	Bureau of National statistics of the RK (2025)
RMIIP	Real money income index of population	Bureau of National statistics of the RK (2025)
Inf	Inflation rate, annual	World Development Indicators (WDI) (2025)
IUP	Internet users (% of population)	World Development Indicators (WDI) (2025)
Emp	Employment to population ratio, 15+, total (%) (modeled ILO estimate)	World Development Indicators (WDI) (2025)

Source: Compiled by authors

Graph 1: Avarage fuel and energy consumption per household, 2022



Source: Compiled by authors based on data of Bureau of National statistics of the RK (BNS, 2022)

found to be stationary at the I(0) or first difference I(1) level (Table 2), only in the case of the first difference with Intercept. Therefore, to examine the dynamic nature of these variables and account for both short- and long-run effects, the autoregressive distributed lag (ARDL) model was deemed appropriate for this case. We use the ARDL method to estimate the following model (Equation 2):

$$\Delta HFEC_t = \beta_0 + \sum_{k=1}^{m} \beta_1 \Delta HFEC_{t-k} + \sum_{k=0}^{n} \beta_2 \Delta CPIHSF_{t-k} + \sum_{k=0}^{p} \beta_3 \Delta RMIIP_{t-k} + \sum_{k=0}^{q} \beta_4 \Delta Inf_{t-k} + \sum_{k=0}^{r} \beta_5 \Delta IUP_{t-k} + \sum_{k=0}^{s} \beta_6 \Delta Emp_{t-k} + \gamma_0 HFEC_{t-i} + \gamma_1 CPIHSF_{t-i} + \gamma_2 RMIIP_{t-i} + \gamma_3 Inf_{t-i} + \gamma_4 IUP_{t-i} + \gamma_5 Emp_{t-i} + \varepsilon_t \quad (2)$$

Where, operator Δ represents the differencing operation.

4. DATA AND FINDINGS

4.1. Data

This study examines the impact of the consumer price index of housing services and other fuels, real money income index of population, annual inflation rate, internet users, and employment-to-population ratio on household final energy consumption in the republic of Kazakhstan. The study uses data from the Bureau of National Statistics of the Republic of Kazakhstan and the World Data Bank (WDI), covering the period from 2001 to 2024.

The following graph shows the dynamics of changes in all indicators presented in Table 1 for the period 2001-2024:

Graph 2 shows clear, consistent and stable time patterns, indicating that the changes in the variables are suitable for further study.

4.2. Empirical Findings

Descriptive statistics allow for a more detailed examination of many characteristics of a data set. The properties of mean, median, skewness and kurtosis, Jarque-Bera, and probability are used in the study to analyze the variables.

Table 3 presents the descriptive statistics of each variable. The mean values of HFEC, CPIHSF, RMIIP, Inf, IUP, Emp are 8068.082 t o.e, 107.8208, 106.5933, 8.595349%, 48.26050% of population, 66.89438% respectively. The standard deviations of HFEC, CPIHSF, RMIIP, Inf, IUP, Emp are 4562.874 t o.e, 4.510180, 5.384375, 3.341097%, 36.84934% of population, 2.158430% respectively. The value of standard deviation shows that Emp has low variability, and HFEC has very high variability. All indicators except IUP and Emp show positive asymmetry.

4.3. Unit Root Test

In this study, augmented Dickey-Fuller (ADF) unit root tests were used to examine the levels or differences of stationary variables before estimating equation (2). This is because it is necessary to assess whether the variables are stationary before examining long-run relationships between the series. All variables are integrated to order I(0) or I(1) at a significance level of 1-10%, in the case of the intercept (Table 2).

The unit root results are consistent with the initial assumptions, which means we need to test the ARDL model to confirm the existence of long-term relationships between Kazakhstan's Households final energy consumption and the explanatory variables. Therefore, we can use these indicators to estimate the ARDL model only for the case with Intercept.

4.4. Lag Selection Criteria

In this study, the ARDL bounds testing procedure is used to examine the long-run relationship between the selected explanatory variables and household final energy consumption in the Republic of Kazakhstan. It is important to determine the lag

Table 2: ADF unit root tests

Variables	Intercept			Trend and intercept			None		
	Level	First diff.	Order of integration	Level	First diff.	Order of integration	Level	First diff.	Order of integration
HFEC	0.554 (0.984)	−3.96* (0.008)	I (1)	−4.395 (0.012)	−3.734** (0.046)	I (1)	−3.572 (0.999)	−1.177 (0.212)	>I (1)
CPIHSF	−2.259 (0.193)	−4.29** (0.003)	I (1)	−2.251 (0.441)	−3.593* (0.055)	I (1)	0.436 (0.800)	−4.367*** (0.000)	I (1)
RMIIP	−2.341 (0.169)	−5.55*** (0.000)	I (1)	−3.192 (0.111)	−5.039** (0.004)	I (1)	−0.656 (0.421)	−5.61*** (0.000)	I (1)
Inf	−3.36** (0.024)	5.64*** (0.000)	I (0)	−3.403* (0.076)	−5.45** (0.001)	I (0)	−1.005 (0.273)	−5.77*** (0.000)	I (1)
IUP	−0.968 (0.745)	−2.648* (0.099)	I (1)	−2.659 (0.261)	−2.585 (0.290)	>I (1)	−0.044 (0.657)	−1.385 (0.150)	>I (1)
Emp	−3.19** (0.037)	−2.924* (0.059)	I (0)	−0.361 (0.998)	−3.117 (0.128)	>I (1)	−1.609 (0.970)	−2.89* (0.006)	I (1)

1) *, **, *** denote statistically significant at the 10%, 5% and 1% levels, respectively. P-value is inside brackets. 2) compiled by the authors

length criterion before conducting the cointegration test. Table 4 presents the results for the selected lag length of the linear model. The lag length criterion is determined based on LR, FPE, AIC, SC, and HQ. As can be seen from the table, the selected lag length is 2, as it has more stars and was used throughout the study.

4.5. Co-Integration Test

In this study, the ARDL(2, 2, 2, 2, 2, 1) linear model (Equation 3) was estimated to conduct a long-run and short-run analysis of the relationship between variables using the first difference. The results of the cointegration F-test for ARDL (Table 5) show that the obtained F-statistic (13.145455) exceeds the upper limit of 4.68 and is statistically significant at the 1% 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.

We can proceed to the next step, which requires estimating the long-run and short-run coefficients, since the selected variables are cointegrated in the long run. Given the linear ARDL model, we can estimate how changes in the explanatory variables affect the dependent variable in both the long and short run.

4.6. Results of long- and short run relationship

The long-term and short-term relationship coefficients are presented in Table 6.

The results of the ARDL(2, 2, 2, 2, 2, 1) model (Table 6) show that all coefficients for the explanatory variables, except CPIHSF, that influence Kazakhstan's long-term household final energy consumption are significant. RMIIP, INF, and IUP have a positive and significant impact on the growth of Kazakhstan's household final energy consumption, all other things being equal. An increase in RMIIP, INF, and IUP leads to an increase in Kazakhstan's D(HFEC) (coefficients of 104.8177, 259.2360, and 166.6525, respectively). EMP has a negative and significant impact on D(HFEC), with a corresponding coefficient of −666.4941.

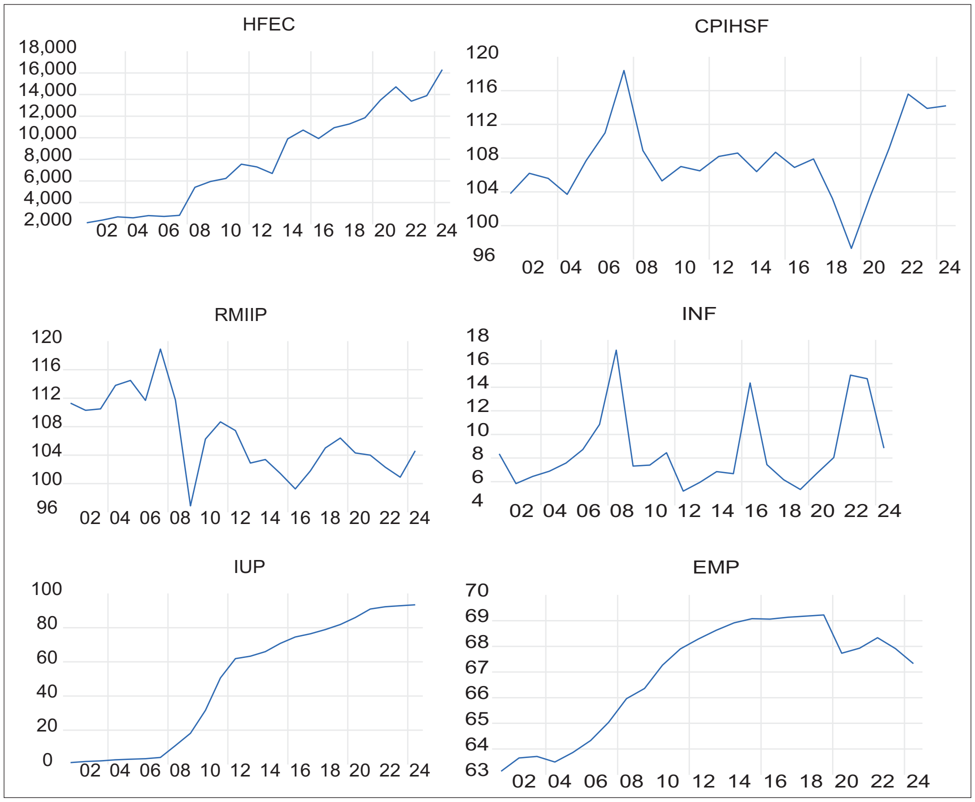
In the short run, the HFEC growth in Kazakhstan decreases as the lagged variable EMP(−1) increases (−1066.025), confirming the negative impact of Employment to population ratio and Energy use in the short run. Moreover, ceteris paribus, the coefficients of the lagged variables RMIIP(−1), INF(−1), IUP(−1), and D(IUP) are positive (with coefficients of 167.6508, 414.6354, 266.5525, and 435.4062, respectively) in the short run, consistent with the long-run result. Only the growth coefficients of the lagged variables D(RMIIP[−1]) and D(IUP[−1]) correlate negatively with HFEC growth in the short run (−85.92188 and −285.1630).

The change in the lagged variable HFEC(−1) is negatively and significantly correlated with D(HFEC) in the short run (−1.599451).

4.7. Diagnostic Tests

To confirm the robustness of the linear ARDL model, diagnostic tests were conducted (Table 7). These tests include serial correlation, heteroscedasticity, and normality. All diagnostic tests—serial correlation with the Lagrange multiplier, the

Graph 2: Evolution of all variables for Kazakhstan (2001-2024)



Source: Compiled by authors

Table 3: Values of descriptive statistics of the displayed series

Values	HFEC	CPIHSF	RMIIP	Inf	IUP	Emp
Mean	8068.082	107.8208	106.5933	8.595349	48.26050	66.89438
Median	7424.000	107.3500	105.6288	7.421563	62.60540	67.81750
Maximum	16305.40	118.4000	118.9000	17.13990	93.39170	69.22300
Minimum	2133.400	97.30000	96.86592	5.195684	1.006120	63.13300
Standard deviation	4562.874	4.510180	5.384375	3.341097	36.84934	2.158430
Skewness	0.142351	0.319339	0.362179	1.375118	−0.201429	−0.580664
Kurtosis	1.706962	3.618620	2.523596	3.658024	1.340476	1.781539
Jarque-Bera	1.753002	0.790601	0.751655	7.996793	2.916314	2.833331
Probability	0.416237	0.673478	0.686721	0.018345	0.232665	0.242521
Sum	193634.0	2587.700	2558.239	206.2884	1158.252	1605.465
Sum Sq. deviation	0.79E+08	467.8596	666.8044	256.7474	31231.09	107.1529

Source: Compiled by authors

Table 4: Selection order criteria

ARDL (2, 2, 2, 2, 2, 1)						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	−500.1052	NA	3.86e+12	46.00956	46.30712	46.07966
1	−398.8977	138.0102	1.18e+10	40.08161	42.16451	40.57228
2	−318.0562	66.14304*	5.03e+08*	36.00511*	39.87335*	36.91635*

Source: Compiled by authors

Table 5: Results of cointegration test

Model	F statistics	Signif.	Critical bounds		Decision
		(%)	I (0)	I (1)	
ARDL (2, 2, 2, 2, 2, 1)	13.145455***	10	2.26	3.35	Cointegration
		5	2.62	3.79	
		2.5	2.96	4.18	
		1	3.41	4.68	

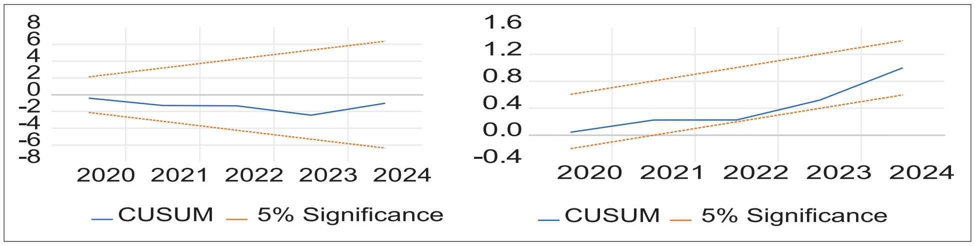
1Critical bounds are reported at 1% (***) and 10% (**) level of significance. Compiled by the authors

Jarque-Bera normality test, and the heteroscedasticity test—were successful, indicating the robustness of the ARDL model. For this model, the null hypotheses of no serial correlation, no homoscedasticity, and no normality are rejected.

4.8. Stability Tests

To assess the dynamic stability of our model, we used the CUSUM and CUSUMSQ tests. The graphical representations of these

Graph 3: CUSUM and CUSUMSQ
Model - ARDL(2, 2, 2, 2, 2, 1) estimation D(HFEC)



Source: Authors

Table 6. Results of ARDL (2, 2, 2, 2, 2, 1) estimation D (HFEC) (2001-2024)

Long run			Short run		
Variable	**Coefficient**	**t-statistic**	**Variable**	**Coefficient**	**t-statistic**
CPIHSF	−70.61497	−1.468389	C	61852.23*	2.470579
RMIIP	104.8177**	2.653500	HFEC(−1)*	−1.599451***	−4.859614
INF	259.2360**	3.269230	CPIHSF(−1)	−112.9452	−1.195014
IUP	166.6525***	20.62771	RMIIP(−1)	167.6508**	3.052560
EMP	−666.4941***	−6.036383	INF(−1)	414.6354*	2.091856
			IUP(−1)	266.5525***	5.373851
			EMP(−1)	−1066.025**	−3.808089
			D (HFEC[−1])	0.497206*	2.206991
			D (CPIHSF)	−26.06693	−0.650652
			D (CPIHSF[−1])	−40.86665	−0.827282
			D (RMIIP)	32.88934	0.743095
			D (RMIIP[−1])	−85.92188*	−2.460102
			D (INF)	121.6798	1.241221
			D (INF[−1])	−99.60919	−1.754019
			D (IUP)	435.4062***	10.43219
			D (IUP[−1])	−285.1630***	−8.331674
			D (EMP)	−174.0603	−0.623298

1) coefficients are statistically significant at ***1%, **5%, *10% level of significance, in parentheses (t-values); 2) operator D represents the differencing operation; 3) compiled by the authors

Table 7: Short-run diagnostics

Model - ARDL (2, 2, 2, 2, 2, 1)			
Test	**F-statistics**	**P-value**	**Conclusion**
Serial correlation LM	2.636599	0.2184	No serial correlation
Heteroskedasticity	0.301517	0.9697	No heteroskedasticity
Jarque-Bera	1.222175	0.5428	Normality exists

Source: Compiled by authors

tests, presented in Graph 3, demonstrate the overall stability of the ARDL model.

Since CUSUM and CUSUMSQ in the graphs of Graph 3 remain within the 5% critical boundary, the model parameters are considered stable.

5. CONCLUSION

The Household energy consumption is rising along with technological advancements, the emergence of smart houses, and the rise in demand for goods and services. The study's objective is to evaluate how consumer factors affect household energy use economically. The consumer price index of housing services and other fuels, the population's real money income index, the annual inflation rate, the percentage of internet users, and the employment rate were all employed in the study. These data, which came from the World Bank's official website and the National Bureau of Statistics of the Republic of Kazakhstan, were estimated for the years 2001-2024 using the Autoregressive distributed lag econometric modeling approach. The econometric evaluation revealed that the Consumer price index of housing services and other fuels has no effect on the Households final energy consumption (1000 t o.e.) factor in either the long or short run. Whereas real money income, inflation rate, internet users have a positive effect in both the long and short run, employment rate has a negative effect in both the long and short run.

Since the demand for energy increases consistently with real money income, population growth, inflation growth, smart home appliances volume growth, we assume that the consumer price index of housing services and other fuels has no effect on the amount of final energy consumed by families. Since every aspect of household life is now connected to the Internet, we think that an increase in Internet users will positively affect the amount of energy consumed by households. However, in order to stabilize the level of households' final energy consumption, alternative energy sources must be supported due to Kazakhstan's deteriorating power systems and the negative environmental effects of coal-derived pollutants.

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