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ORIGINAL RESEARCH PAPER

The Impact of Removing Four Zeros from the National Currency on Household Energy Consumption in Iran: A Nonlinear Autoregressive Distributed Lag Model

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P A P E R I N F O

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A B S T R A C T

The macroeconomic literature documents extensively the profound influence of monetary policies on consumption behaviors, including energy demand, primarily through transmission channels such as inflation expectations and household balance sheets. This study investigates the impact of Iran's currency redenomination policy—the removal of four zeros—on household energy consumption, extending this analysis to encompass the roles of the Consumer Price Index (CPI) and Energy Price Index (EPI). Building upon theoretical underpinnings, the core hypothesis posits that redenomination can reshape household energy consumption patterns by altering economic agents' expectations via macroeconomic variables, including exchange rates, inflation, CPI, energy prices (EPI), Gross Domestic Product (GDP), and population. Utilizing annual data for the Iranian economy from 1980 to 2024 and employing the Nonlinear Autoregressive Distributed Lag (NARDL) econometric model, this research quantifies these effects. The estimation results reveal that the policy of removing four zeros exerts a negative and statistically significant influence (-0.067) on household energy consumption, suggesting a reduction in money illusion and an enhanced household price sensitivity, thereby inducing an adjustment in energy consumption. Crucially, the findings underscore that the long-term efficacy and stability of this redenomination effect are intrinsically linked to the concurrent implementation of a comprehensive reform package. This package integrates monetary stabilization (inflation/exchange rate control), structural financial reforms (energy subsidies), and improved institutional quality (governance, transparency in energy policy), while managing CPI and EPI for positive energy consumption patterns.



1. Introduction

Persistent macroeconomic challenges in Iran, including rapid currency depreciation and hyper-inflation, have compromised the traditional functions of money and increased transactional friction. Amidst this instability, the policy of currency redenomination has emerged as a potential mechanism to mitigate these systemic inefficiencies and stabilize the monetary framework [1-4].

Redenomination, as conceptualized by Karnadi & Adijaya [5], involves altering the nominal scale of currency without affecting its real value. Its primary objectives include simplifying calculations, reducing transaction figures, enhancing accounting transparency, and minimizing currency issuance and maintenance costs. However, empirical evidence across nations suggests that zero removal transcends a mere technical or symbolic gesture. It carries significant economic and psychological [6] ramifications, deeply intertwined with prevailing macroeconomic conditions and the existing monetary policy framework. Successful implementations, typically following inflation stabilization and the establishment of economic equilibrium, have demonstrably boosted public confidence in the national currency and improved

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monetary system efficiency. In contrast, attempts at redenomination amidst high inflation and fiscal mismanagement have historically proven unsustainable, often intensifying economic volatility[7].

Monetary and currency reforms influence household consumption patterns through various channels, primarily by altering price levels, inflation expectations, interest rates, and exchange rates, which directly impact real purchasing power. Within this framework, household energy consumption—as a critical component of the expenditure basket—demonstrates significant sensitivity to these monetary fluctuations [8]. Household perceptions of monetary value and economic stability directly influence the demand for final energy carriers like electricity, gas, and fossil fuels, leading to significant economic, social, and environmental repercussions [9]. Recent research indicates that monetary policy, including inflation targeting frameworks, extends its influence beyond traditional macroeconomic variables to impact energy consumption [10-11]. A comprehensive study by Mbassi et al. [12] across 145 countries (1980-2017) found that inflation targeting significantly boosts energy consumption. This effect is primarily channeled through reduced macroeconomic volatility and stimulated energy-intensive investments and economic activities, underscoring that price stability-focused monetary policies can have substantial indirect effects on energy consumption patterns.

Given Iran's household energy intensity exceeding the global average [13], understanding the impact of monetary policy and currency redenomination on energy consumption is crucial. Monetary reforms [14-16] can modify household expenditure through expectations and psychological channels, influencing energy use. However, empirical evidence on this nexus, particularly in developing, high-inflation economies, is scarce.

This study investigates how monetary policy and currency redenomination affect household energy consumption in Iran, focusing on inflation expectations, macroeconomic stability, and behavioral factors. The findings aim to enhance the understanding of the monetary-energy policy nexus, facilitating coordinated strategies for household welfare and energy intensity reduction. Therefore, analyzing the effect of removing four zeros from Iran's currency extends beyond monetary policy, impacting macroeconomic and energy economics by influencing consumption behavior through modified inflation expectations and reduced money illusion, and by altering the relative cost of energy via exchange rate and price level adjustments.

The remainder of this paper is structured as follows: first, the theoretical framework regarding the removal of four zeros from the national currency and its relationship with household energy consumption are discussed. Subsequently, the literature review is presented. The following section outlines the study's methodology and modeling, and the paper concludes with the presentation of results and policy recommendations.

2. Theoretical Framework

2.1. Theoretical Framework of Consumer Behavior and Energy Demand

The household sector is a key monetary policy transmission channel, as consumption is sensitive to inflation expectations, monetary stability, and real income/debt values. Currency redenomination, a monetary-fiscal tool, can bolster perceived economic stability through reduced nominal figures and positive psychological effects, consequently influencing consumption patterns, including household energy use [17-19].

Formally modeling this transmission involves a microeconomic utility maximization framework where households select an optimal bundle of goods and services, including energy, under budget and price constraints. Energy demand, a derived demand, is a function of real income (y_{it}), energy prices (P_{et}), other goods' prices (P_{ot}), and demographic/structural factors (Z_{et}): $E_{it} = f(y_{it}, P_{et}, P_{ot}, Z_{et})$. Changes in real income or relative prices thus alter the consumption bundle and energy use. Empirical studies confirm significant income and price elasticities for household energy demand [20-22], indicating that variations in purchasing power or price structures influence consumption patterns. Consequently, policies affecting real income or relative prices indirectly shape household energy consumption.

2.2. Redenomination as a Monetary Shock and Its Effects on Real Variables

Redenomination, a nominal reform, is typically viewed in monetary literature as a means to enhance monetary stability, cut transaction costs, and boost confidence in the currency [23, 7]. While it doesn't alter real fundamentals, theoretical and empirical evidence suggests real effects arise via expectations, inflation dynamics, and credibility. Monetary policy influences consumption mainly through inflation expectations and household balance sheets. For instance, rising inflation expectations can decrease the real interest rate and devalue nominal debts, potentially stimulating consumption of durables and energy-intensive goods among indebted households [24-25]. Conversely, credible redenomination as a stabilization signal can reduce uncertainty, anchor expectations, and lead to more rational household consumption and energy-related investment decisions [26-27]. Monetarist views and the quantity theory of money posit that inflation expectation changes and price dynamics impact real activity, especially with nominal rigidities [28]. Similarly, New Keynesian models highlight expectations' crucial role in consumption and investment [29], suggesting enhanced monetary credibility can lead to greater real income certainty and modified consumption patterns.

Inflationary instability raises capital costs and erodes purchasing power, hindering household energy productivity [12], whereas monetary stability promotes investment in efficient technologies and lowers energy intensity [30]. Empirical evidence shows that redenomination affects real energy use only when supported by inflation control, fiscal discipline, and transparent central bank communication; otherwise, it may heighten inflation expectations and energy demand [31-33]. Thus, its real effects are conditional, transmitted through credibility, expectations, and macroeconomic stability channels.

Monetary policy shapes household energy use through three channels: real income, expectations and uncertainty, and price perception. Credible redenomination that reduces inflation and stabilizes currency enhances purchasing power, and given the positive income elasticity of energy demand [34], may raise consumption [35-36]. Inflation expectations affect perceived real interest rates and debt values, influencing durable and energy-intensive consumption, while credible stabilization anchors expectations [24, 37-39]. Through price perception, money illusion can distort responses to nominal price changes. Overall, outcomes hinge on credibility: weak discipline and poor communication exacerbate inflation and instability [40, 23], whereas sustained stability improves energy productivity and the growth–energy nexus [41].

Figure 1 shows how monetary policy shapes inflation expectations and household consumption, especially of durable goods.

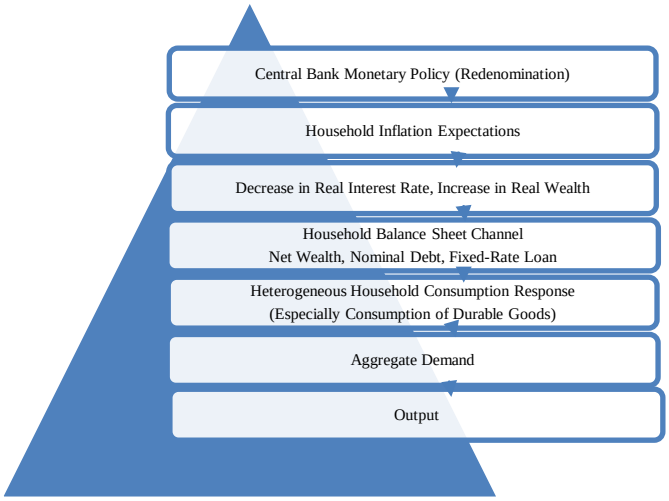


Figure 1. Monetary policy transmission channel.

Figure 1 shows that monetary policy shapes household consumption—especially durable and energy-intensive goods—through balance sheet and inflation expectations channels, by changing expected inflation, real interest rates, and the real burden of debt [38-39]. Figure 2 summarizes the study's conceptual framework: redenomination, as a monetary policy shock, affects household energy consumption indirectly via inflation expectations, economic uncertainty, real income, and energy price perception, highlighting a multi-stage, mediated causal process. The process of currency redenomination, commonly referred to as "removing zeros," is theoretically expected to mitigate *money illusion* by simplifying nominal expressions of value and enhancing the transparency of price changes. This adjustment enables economic agents to perceive real purchasing power more accurately, thereby aligning nominal and real evaluations in transactions and expectations. Since money illusion arises when individuals concentrate on nominal rather than real values, a reduction in numerical magnitude can lessen cognitive biases and improve rational price assessment [42].

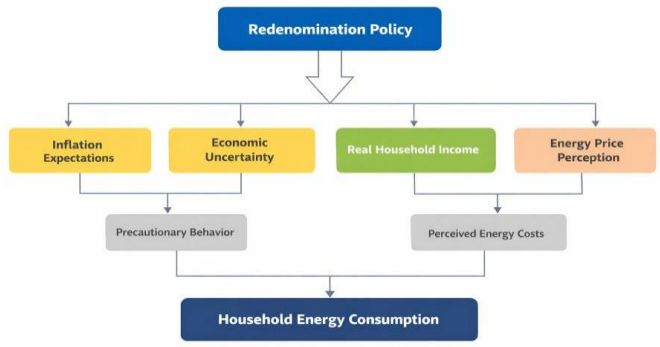


Figure 2. Conceptual model of redenomination and household energy consumption

2.3. Structural and Institutional Determinants of Household Energy Consumption

Household energy consumption is driven by structural and institutional factors beyond income and prices. Distorted price signals from below-market energy subsidies encourage overconsumption [43-44, 41]. Policy credibility and governance quality are crucial for effective reforms, reducing uncertainty and improving policy transmission [45-46]. Macroeconomic stability, particularly low inflation volatility and exchange rate certainty, influences real income expectations and consumption patterns [47-49]. Additionally, regulatory design, urban form, housing quality, and financial development play significant roles in determining energy intensity and long-run demand elasticity [44, 50]. Formally, household energy consumption can be expressed as:

$$hc = f(Y^{real}, P_e, sub, urb, fdi, inf, cpi, pop, er, omz) \quad (1)$$

In this function, hc represents household energy consumption, which is determined by Y^{real} (real output, Gross Domestic Product or real income), P_e (price of energy), sub (subsidy), urb (urbanization), fdi (financial development index), inf (inflation rate), cpi (consumer price index), pop (population), er (exchange rate), and omz (the removal of four zeros from the national currency).

3. Literature Review

Foreign and domestic studies on redenomination, inflation, exchange rates, GDP, and energy consumption are reviewed. While literature on currency redenomination is scarce, country experiences suggest implementation timing and economic conditions are key to success. Soleh & Herianingrum [51] analyzed Indonesia's rupiah redenomination through an Islamic economics lens, defining it as a process to simplify currency, improve financial recording efficiency, boost competitiveness, and increase the rupiah's value, rather than solely controlling inflation. Their qualitative study concluded that redenomination is permissible in Islamic economics and can be successful.

Pramytha et al. [52] identified inflation rate, redenomination risk, public understanding, banknote changes, and public psychology as key factors influencing the success of redenomination policies, based on a review of 30 Indonesian articles. They concluded that a simple numerical change (removing zeros) without addressing structural and mental conditions has no significant impact on money value or inflation control. Comprehensive policy design, including public information dissemination, monetary stability, and psychological acceptance, is crucial for successful redenomination.

Du et al. [53] found that expansionary monetary policies generally reduce energy poverty in developing countries by increasing money supply, though with regional heterogeneity, and this effect is transmitted through investment, economic growth, and energy price channels. Doh et al. [54] observed that while household inflation expectations are largely anchored near the 2% target, contractionary monetary policy shocks significantly reduce these expectations, especially among lower-income groups with less anchored expectations, thereby affecting household energy consumption decisions.

Bobasu et al. [55] found that energy price shocks decrease total consumption, disproportionately affecting low-wealth households, and that while active monetary policy responses exacerbate this decline, they aid saver households in wealth rebuilding. Joesoef and Sulistiyanti [56] concluded that rupiah redenomination does not alter purchasing power if monetary units and prices are adjusted proportionally, but it necessitates a societal shift in habits and the official adoption of the term "redenomination" to prevent misinterpretation.

Yangailo [57] concluded that redenomination, when integrated with monetary, fiscal, and institutional reforms, can lead to significant improvements in macroeconomic indicators like GDP growth, foreign investment, inflation, and exchange rate stability, as demonstrated by analyses in Ghana, Turkey, Zambia, and Zimbabwe. Priya & Sharma [26] found that unexpected energy price shocks and monetary policy in India reduce household consumption, particularly affecting services and durable goods, while fuel and food consumption are less impacted. Interestingly, they also noted that the combined shocks can bolster household confidence and positively influence consumption decisions, operating through channels such as expectations and energy price volatility.

Akan [58] demonstrated that monetary policy indirectly impacts environmental outcomes, specifically renewable energy consumption, through financial assets and various economic sectors. Sarhadi (2022) and Shabanzadeh [25] both concluded that currency redenomination, or changing the unit of currency, is not inherently inflationary and can be successful without causing price increases, provided it is implemented alongside proper economic management, monetary discipline, and stability. Shabanzadeh [25] further noted that redenomination can enhance monetary transparency and simplify transactions but will be ineffective without broader structural reforms.

Zarra-Nezhad and Maqsoudi Shorabi [59] assert that redenomination's effectiveness hinges on fundamental economic and monetary reforms, including central bank independence, liquidity control, budget deficit reduction, production growth, and overall economic stability. Ashrafi et al. [60] highlight that redenomination also carries psychological impacts on national identity and public trust, but it does not inherently reduce inflation or boost employment without supporting factors. Tomas [61] points to the redenomination of the Iraqi dinar as a key reform for restoring stability by reducing management costs and increasing liquidity circulation, contingent upon central bank independence and structural economic reforms. Rezaei Mirghaied et al. (2020) found that currency unit reform alone is insufficient for inflation control, with success dependent on implementing five specific economic reforms—central bank independence, reduced government budget deficit, lower market exchange rate volatility, increased GDP growth, and decreased government net debt to the banking system—prior to the reform.

Mirzaei et al. [62] found that countries successfully redenominated their currency after controlling inflation and achieving economic stabilization, while those that did so prior often faced repeated implementations and monetary instability. Mosley [7] identified high inflation as a primary driver for redenomination in developing countries, influenced by both economic and political factors, with the goal of enhancing credibility, managing inflation, and reinforcing national identity.

The latest research highlighted employs an advanced econometric model (NARDL) to analyze the asymmetric and non-linear effects of currency redesign (removing four zeros) on household energy consumption in Iran, considering macroeconomic variables like exchange rates, inflation, and energy prices, and aims to fill a theoretical gap by examining this relationship for the first time.

4. Research Methodology

The study utilizes the Nonlinear Autoregressive Distributed Lag (NARDL) model to investigate the relationship between currency redenomination (removal of four zeros), exchange rates, inflation, GDP, CPI, energy prices, population, and household energy consumption. The methodology, model specification, and variable descriptions are presented herein.

4.1. Research Method

The NARDL model, developed by Uzar & Eyuboglu [63], Alabdulrazag & Alshogeathri [64], and Shin et al. [65], is an extension of the linear ARDL approach. It allows for the analysis of asymmetric long-run relationships and the diverse reactions of economic systems to positive and negative shocks. A key feature of the NARDL model is its ability to incorporate a mix of stationary (I(0)) and non-stationary (I(1)) variables, while still providing valid evidence of a long-run equilibrium relationship.

Household energy consumption is sensitive to policy changes like currency redenomination, exchange rates, inflation, GDP, and demographics. These influences can be asymmetric, meaning positive and negative shocks have different effects, leading to a nonlinear relationship that might obscure long-run cointegration. To address this, the study employs Granger and Yoon's [66] "hidden cointegration" approach, which examines cointegration between decomposed components of time series. This allows for the identification of long-run equilibrium relationships even when aggregate series do not appear cointegrated, providing a more nuanced analysis of household energy consumption dynamics.

This method allows household energy consumption to react asymmetrically to shocks (like currency changes), meaning positive and negative shocks have different impacts. It also reveals "hidden cointegration" by analyzing the accumulated positive and negative changes (components) of time series, which

can identify long-run relationships missed by standard linear cointegration tests. This is useful when the relationship between variables is nonlinear.

$$z_t = z_{t-1} + \varepsilon_t = z_0 + \sum_{i=1}^{t} \varepsilon_i \quad (2)$$

$$s_t = s_{t-1} + \eta_t = s_0 + \sum_{i=1}^{t} \eta_i \quad (3)$$

Where z_0 and s_0, t=1,2,…,T are initial values, and ε_i and η_i are white noise disturbances with zero mean. If z_t and s_t are cointegrated with a cointegrating vector, a cointegration relationship exists; and when the changes in z_t and s_t are asymmetric, hidden cointegrations between them are possible [67].

Granger and Yoon (2002) define negative and positive shocks as follows.

$$\varepsilon_i^+ = \max(\varepsilon_i, 0), \varepsilon_i^- = \min(\varepsilon_i, 0), \eta_i^+ = \max(\eta_i, 0), \eta_i^- = \min(\eta_i, 0) \quad (4)$$

$$\varepsilon_i = \varepsilon_i^+ + \varepsilon_i^- \quad \text{و} \quad \eta_i = \eta_i^+ + \eta_i^-$$

Therefore, if the equations are expanded, we have:

$$z_t = z_{t-1} + \varepsilon_t = z_0 + \sum_i^t \varepsilon_i^+ + \sum_i^t \varepsilon_i^- \quad (5)$$

$$s_t = s_{t-1} + \eta_t = s_0 + \sum_i^t \eta_i^+ + \sum_i^t \eta_i^- \quad (6)$$

Finally, the sign can be simplified as:

$$z_t^+ = \sum_i^t \varepsilon_i^+, z_t^- = \sum_i^t \varepsilon_i^-, s_t^+ = \sum_i^t \eta_i^+, s_t^- = \sum_i^t \eta_i^- \quad (7)$$

Thus, we have:

$$z_t = z_0 + z_t^+ + z_t^- \qquad and \qquad s_t = s_0 + s_t^+ + s_t^- \quad (8)$$

Finally,

$$\Delta z_t^+ = \varepsilon_t^+, \Delta z_t^- = \varepsilon_t^-, \Delta s_t^+ = \eta_t^+, \Delta s_t^- = \eta_t^- \quad (9)$$

This method decomposes time series into positive and negative changes and calculates their cumulative sums. If these cumulative components are cointegrated, it indicates "hidden cointegration," a form of nonlinear cointegration. The Nonlinear ARDL (NARDL) model then uses these components to analyze the asymmetric effects of variables (like currency redenomination) on household energy consumption, testing for a long-run relationship.

4.2. Model Specification

This study uses a Nonlinear ARDL (NARDL) model to analyze the impact of removing four zeros from the national currency, along with macroeconomic factors (exchange rate, inflation, GDP, CPI, energy price, population), on household energy consumption in Iran from 1980-2024. A dummy variable represents the currency redesign policy, hypothetically starting in 2021, to assess its potential effects. This approach allows for the examination of long-run relationships, causality, and nonlinear interactions, similar to studies on CO_2 emissions and economic policies.

The modeling is expressed as follows:

$$z_t = z_{t-1} + \varepsilon_t = z_0 + \sum_{i=1}^{t} \varepsilon_i \quad (10)$$

Where the vector z_t consists of $hc_t, inf_t, gdp_t, cpi_t, ep_t, pop_t er_t$, and omz_t. hc is household energy consumption, inf is inflation, gdp is Gross Domestic Product, *cpi* is consumer price index, *ep* is energy price, *pop* is population, *er* is the exchange rate, and *omz* is the removal of four zeros from the national currency. *t* denotes the time period under review.

This study employs a Nonlinear Autoregressive Distributed Lag (NARDL) model to investigate household energy consumption in Iran. The model decomposes explanatory variables (excluding a dummy for currency redesign) into positive and negative shock components to capture asymmetric effects.

$$\ln(\mathrm{HC}_t) = \alpha_0 + \sum_{i=1}^{p} \lambda_i \ln(\mathrm{HC}_{t-i}) + \sum_{j=0}^{q} \beta_j^+ \ln(\mathrm{INF}_{t-j}^+) + \sum_{j=0}^{q} \beta_j^- \ln(\mathrm{INF}_{t-j}^-) + \sum_{j=0}^{q} \gamma_j^+ \ln(\mathrm{GDP}_{t-j}^+) + \sum_{j=0}^{q} \gamma_j^- \ln(\mathrm{GDP}_{t-j}^-) + \sum_{j=0}^{q} \delta_j^+ \ln(\mathrm{ER}_{t-j}^+) + \sum_{j=0}^{q} \delta_j^- \ln(\mathrm{ER}_{t-j}^-) + \sum_{j=0}^{q} \theta_j^+ \ln(\mathrm{POP}_{t-j}^+) + \sum_{j=0}^{q} \theta_j^- \ln(\mathrm{POP}_{t-j}^-) + \sum_{j=0}^{q} \vartheta_j^+ \ln(\mathrm{CPI}_{t-j}^+) + \sum_{j=0}^{q} \vartheta_j^- \ln(\mathrm{CPI}_{t-j}^-) + \sum_{j=0}^{q} \tau_j^+ \ln(\mathrm{EPI}_{t-j}^+) + \sum_{j=0}^{q} \tau_j^- \ln(\mathrm{EPI}_{t-j}^-) \emptyset \mathrm{D}_t + \varepsilon_t \quad (11)$$

Where:

- HC_t: Household energy consumption in Iran at time *t*.
- INF_t: Inflation rate; decomposed into two components: INF_{t-j}^+ (positive changes/inflationary pressure) and INF_{t-j}^- (negative changes/disinflation).
- GDP_t: Gross Domestic Product; decomposed into two components: GDP_{t-j}^+ (production expansion cycles) and GDP_{t-j}^- (production contraction cycles).
- ER_t: Exchange rate; decomposed into two components: ER_{t-j}^+ (exchange rate increase/Rial depreciation) and ER_{t-j}^- (exchange rate decrease).
- POP_t: Population; decomposed into positive and negative components.
- CPI: the Consumer Price Index; decomposed into two components: CPI_{t-j}^+ (increase in CPI/inflation) and CPI_{t-j}^- (decrease in CPI/deflation).
- EP: the Energy Price Index; decomposed into two components: EPI_{t-j}^+ (increase in EPI) and EPI_{t-j}^- (decrease in EPI).
- D_t: Dummy variable related to the policy of removing four zeros from the national currency (assumed to be 1 from the year 2021).
- α_0: Intercept.
- λ_i: Coefficients of the lags of the dependent variable (autoregressive part).
- $\beta, \gamma, \delta, \theta, \vartheta, \tau$: Short-run coefficients for positive and negative shocks of explanatory variables.
- ε_t: Error term.

The NARDL model is chosen for its ability to handle variables with different integration orders (I(0) and I(1)) and, crucially, to model asymmetric adjustments in both the short and long run. This is particularly relevant because economic policies like currency redesign can trigger nonlinear behavioral responses, such as differing impacts from policy implementation or asymmetric reactions to macroeconomic changes. The NARDL framework, therefore, offers a more accurate representation of these complex dynamics compared to linear models. The study incorporates a dummy variable for the zero-elimination policy to capture its overall discrete structural shift on household energy consumption, assuming a unified policy effect rather than disaggregated positive and negative impacts.

4.3. Modeling and Empirical Analysis

The estimation results are presented after conducting unit root tests on all variables. Table 1 shows that most variables become stationary after first differencing, indicating no I(2) variables and thus reliable results.

Table 1. Results of the Augmented Dickey-Fuller (ADF) unit root test.

Variables	Variables definition	Statistic	Significance Level	Order of Integration
hc_t	Household Energy Consumption	-3.05	0.03	I(1)
inf_t	Inflation Rate	-6.73	0.0000	I(1)
gdp_t	Gross Domestic Product (GDP)	-5.70	0.0000	I(1)
pop_t	Population	-5.65	0.0003	I(0)
er_t	Exchange Rate	-3.65	0.0085	I(1)
cpi_t	Consumer price index	-6.95	0.01	I(1)
epi_t	Energy price	-6.67	0.0000	I(1)

Source: Research Findings

The study examines the impact of variables in two separate models to avoid multicollinearity. Table 2 summarizes the results of the first model, where the logarithm of household energy consumption is the dependent variable. The independent variables include shocks from the removal of four zeros from the national currency, the exchange rate, inflation rate, GDP, and population.

Table 2. Nonlinear ARDL Model Results (first model)

Variables	Coefficients	Statistic	Probability
LHC(-1)	0.232407	1.7683	0.086
LINF_POS	-0.0136	-1.339	0.1901
LINF_NEG	-0.0319	-2.340	0.0259
LGDP_POS	0.0158	0.0931	0.9264
LGDP_NEG	0.0551	0.167	0.868
LPOP	4.1108	3.989	0.0004
LER	0.0331	4.146	0.0002
OMZ	-0.067	-1.758	0.08
C (constant)	-27.7899	-2.9201	0.006

Source: Research Findings

The Nonlinear Autoregressive Distributed Lag (NARDL) model reveals that Iranian household energy consumption exhibits asymmetric responses to economic shocks. A decrease in inflation (coefficient: -0.0319) significantly increases energy consumption, while an increase in inflation lacks statistical significance. Short-term fluctuations in economic growth (GDP) do not substantially impact energy consumption. An appreciating exchange rate (coefficient: 0.0331) is associated with higher energy consumption. Population (coefficient: 4.1108) stands out as the most robust determinant of energy consumption. The policy of removing zeros from the national currency (coefficient: -0.067) is linked to a reduction in energy consumption, and the consumption in the current period is strongly influenced by the previous period (coefficient: 0.232407), indicating habit persistence.

Table 3. Nonlinear ARDL model results (second model)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LHC(-1)	0.209426	0.197225	1.061864	0.2962
LGDP	0.203298	0.092875	2.188936	0.0360
LPOP	1.790981	0.512189	3.496717	0.0014
LER	0.028018	0.011522	2.431620	0.0208
OMZ	-0.048446	0.013373	-3.622585	0.0010
LCPI_NEG	0.033201	0.071183	0.466408	0.6441
LCPI_POS	0.002704	0.027761	0.097384	0.9230
LEP_NEG	-0.041758	0.021464	-1.945490	0.0605
LEP_POS	0.028941	0.025492	1.135320	0.2647
C	-31.87625	9.052603	-3.521225	0.0013

Source: Research Findings

The NARDL model (Table 3) identifies population (LPOP: 1.7910) and exchange rates (LER: 0.0280) as key drivers of Iranian household energy consumption, with economic growth (LGDP: 0.2033) also having a positive short-run effect. Consumption exhibits persistence (LHC (-1)), and the OMZ policy has a restraining impact (-0.0484). Short-term price elasticities (CPI and LEP) are generally low and often insignificant, with a decrease in energy prices showing a marginally significant negative impact (-0.0418). Diagnostic tests (Table 4) confirm that both models adhere to classical linear regression assumptions, with no serial autocorrelation or heteroscedasticity at the 95% confidence level, validating their robustness.

Table 4. Results of diagnostic Tests for classical assumptions

First Model			
Serial Correlation Test			
F-Statistic	0.28	Probability	**0.75**
Heteroskedasticity Test			
F-Statistic	1.47	Probability	**0.19**
Normality Test			
Jarque-Bera Statistic	2.60	Probability	**0.27**
Second Model			
Serial Correlation Test			
F-Statistic	0.301	Probability	**0.74**
Heteroskedasticity Test			
F-Statistic	1.24	Probability	**0.30**
Normality Test			
Jarque-Bera Statistic	2.25	Probability	**0.32**

Source: Research Findings

Subsequently, to ensure the stability of the estimated regression coefficients and the reliability of the results obtained in two models, the Cumulative Sum of Recursive Residuals (CUSUM) and the Cumulative Sum of Squares of Recursive Residuals (CUSUMQ) tests were conducted.



Figure 3. Model Stability Test (first model)
Source: Research Findings

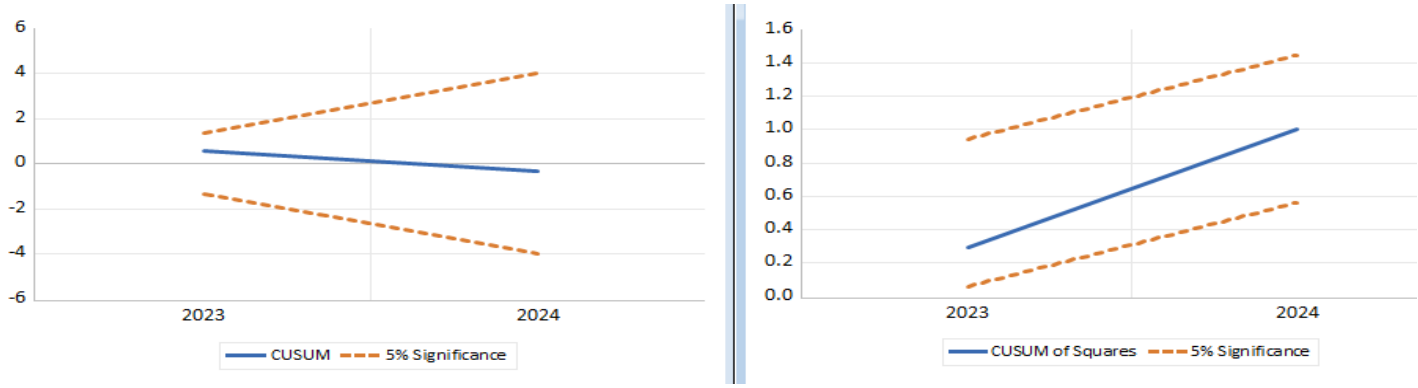


Figure 4. Model Stability Test (second model)
Source: Research Findings

Stability tests (Figures 1 & 2) confirm the NARDL model's robustness. Test statistics for recursive residuals (CUSUM and CUSUMSQ) remain within critical 95% bounds, indicating stable coefficients and no structural breaks throughout the estimation period. This validates the reliability of the long-run inferences.

5. Discussion and Interpretation of Results

The estimation results for the Iranian household sector reveal that energy consumption is primarily influenced by structural variables like GDP, exchange rate, and demographics, rather than short-term policies. Inflation plays a key role through the purchasing-power channel, leading households to reduce energy use as real income erodes. The low short-term price elasticity of energy demand is evident from the asymmetric CPI coefficients, where price level fluctuations have minimal impact on consumption. Population growth and exchange rate depreciation notably increase energy use.

The currency reform (removal of four zeros) had a statistically significant but nominal and temporary influence, likely affecting consumer expectations and prompting precautionary adjustments. However, its impact is overshadowed by the persistent effects of GDP, population, and exchange rates. The weak response to energy price changes (EPI) further supports that nominal policies and short-term price shifts are not dominant factors.

Given the household sector's significance and policy sensitivity, the study recommends focusing on real economic levers rather than nominal monetary reforms for energy demand management. Controlling exchange rate volatility and fostering sustainable economic growth are crucial. Integrating demographic planning with energy efficiency policies is also advised, acknowledging that growth alone, without considering distributional factors and consumption behavior, is insufficient for improving household energy efficiency.

These findings align with international research [40, 17, 68](Žídek & Chribik, [40], Astrini et al. [17], Bawuah, [68]), which also highlight the structural and persistent impact of macroeconomic variables and monetary policies on household energy consumption. The study's conclusions regarding the influence of exchange rates, inflation, and nominal policies on Iranian households are consistent with theoretical literature and global empirical evidence, reinforcing the model's validity.

6. Conclusions

This study, utilizing the Nardl method, examined the asymmetric and dynamic effects of removing four zeros from Iran's national currency on household energy consumption between 1980 and 2024. The findings strongly suggest that household energy consumption is predominantly shaped by fundamental

macroeconomic forces—specifically exchange rate dynamics, demographic trends, and production activities—rather than nominal or administrative reforms like the Redenomination policy. Although the dummy variable for the Redenomination policy exhibited a statistically significant negative impact, this effect appears to be largely short-term and psychological, operating mainly through shifts in inflation expectations rather than through real economic channels.

This conclusion is supported by the weak short-term responsiveness to variations in the Consumer Price Index (CPI) and the Energy Price Index (EPI), indicating that neither inflationary pressures nor energy price adjustments fundamentally alter consumption behavior in the short run. Consequently, the Redenomination policy alone lacks the capacity to induce sustainable or structural modifications in energy demand, remaining largely a nominal and symbolic adjustment. The overall results underscore that in an economy marked by chronic inflation, budgetary imbalances, and pronounced exchange rate volatility, this policy is insufficient to meaningfully transform household energy consumption. Instead, structural variables such as population growth and exchange rate movements exert far more decisive and enduring influences, highlighting the need for deep structural reforms over purely monetary interpretations of energy challenges.

7. Policy Recommendations

This study's empirical findings, demonstrating the limited and transient impact of Iran's currency redesign on household energy consumption, alongside the sector's high sensitivity to core macroeconomic variables, necessitate a multi-pronged policy approach. Firstly, the currency reform should not be treated as an isolated administrative measure but integrated into a comprehensive economic reform package. This necessitates stabilizing the exchange rate, achieving sustainable inflation control, bolstering central bank independence, and fundamentally revising credit and monetary policies. Without this macroeconomic stability, the initial psychological boost from the reform will dissipate, failing to yield improvements in real economic indicators.

Secondly, to translate the policy's indirect effects on consumption behavior into tangible, lasting changes, coordinated monetary policies with structural energy market reforms are crucial. This includes readjusting energy prices to reflect real and social costs, phasing out hidden subsidies, and redirecting support towards energy-efficient technologies. Furthermore, strengthening public trust through transparent budgeting, deficit reduction, and prudent public debt management is vital to reinforce the policy's psychological impact and mitigate potential monetary shocks from destabilizing the energy market. Future research using micro-level data and advanced econometric models is recommended for more precise analysis.

Credit Authorship Contribution Statement

Mahboobeh Khadem Nematollahy: Investigation and perform calculations, Mojtaba Bahmani: Supervision, Project administration, and Manuscript writing and editing results.

Conflicts of Interest

The authors declare that they do not have any personal or financial conflicts of interest.

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