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Cointegration between Electricity prices and the Consumer Price Index in Lao PDR

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Abstract

This study investigates the relationship among electricity prices, exchange rates, and the Consumer Price Index (CPI) in Lao PDR using the nonlinear autoregressive distributed lag model. It employs time-series data from 1990 to 2023 and applies unit root tests, cointegration analysis, and bound testing to examine both long- and short-run relationships. The empirical results indicate that electricity price increases significantly contribute to inflation, while exchange rate depreciation has a stronger inflationary effect than appreciation. The short-run dynamics further confirm these asymmetric effects, with the CPI responding more strongly to depreciation than to appreciation. Additionally, the error correction term is negative and statistically significant, confirming that deviations from equilibrium gradually adjust over time. These findings highlight the importance of exchange rate stability and electricity price management in controlling inflation in Lao PDR.

JEL classification: C32, Q41, E31.

Keywords: Electricity Prices, Consumer Price Index, NARDL Model, Lao PDR.

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1. Introduction

Electricity pricing in Lao PDR is influenced by multiple factors, including the nation's reliance on hydropower and its significant role as a regional energy supplier. From 2012 to 2019, the average electricity price remained around 8 cents per kWh until falling to 5.13 cents per kWh in 2022 due to currency depreciation. By 2023, industrial electricity rates had further declined to 3.9 cents per kWh, while residential rates were slightly lower at 3.3 cents per kWh. As of June 2024, residential electricity prices adjusted to approximately 2.7 cents per kWh, reflecting shifts in production costs and economic conditions, including currency fluctuations (Times, 2023). These pricing changes are part of broader economic trends in Laos, where energy export strategies continue to drive national GDP. At the same time, local markets adapt to balance domestic consumption with export demands.

In addition to pricing, the electricity sector also encounters financial and operational challenges. The national power company, Electricité du Laos (EDL), has periodically adjusted its rates, particularly for industrial consumers, to manage its growing debt (Enerdata, 2024). However, the rapid expansion of hydropower in Lao PDR has been accompanied by socioeconomic and environmental trade-offs. While these projects have fueled economic development, they have also sparked concerns regarding environmental degradation and the displacement of local communities. Specifically, large-scale dam construction has drawn criticism for its social and ecological impacts, raising concerns about the long-term sustainability of the country's energy policies (Oksen, 2014).

As the electricity sector continues to expand, the necessity for stronger governance and institutional capacity to navigate the complexities of energy policies and sustainable development is underscored. Recently, Lao PDR has experienced rising inflation, driven by domestic and global factors. Fluctuations in international commodity prices, shifting import costs, and government policies on taxation and subsidies for essential goods have contributed to inflationary pressure. When prices rise across the board, as reflected in the Consumer Price Index (CPI), the cost of living increases, potentially weakening consumer purchasing power if wages fail to keep pace.

A key driver of inflation in Lao PDR is the development of the energy sector, particularly shifts in electricity and fuel prices. As the country continues to expand its hydropower industry and adjust energy rates, these changes ripple through the economy, influencing the CPI and affecting household energy costs. To effectively manage inflation, the government must balance leveraging energy exports and infrastructure development to drive economic growth while ensuring that rising costs do not disproportionately burden ordinary citizens. This is critical for lower-income households, as unchecked inflation can erode their financial gains. By maintaining this balance, Lao PDR can ensure that economic progress benefits the entire society rather than exacerbating inequalities (Menon and Warr, 2013).

Electricity prices are a key component of the CPI, which typically accounts for 2–3% of the index in many economies. Changes in electricity prices directly impact the cost of living, as both households and businesses face higher utility bills. Apergis and Payne (2011) found that in OECD countries, a 1% increase in electricity prices led to a 0.12% increase in the CPI, highlighting the strong pass-through effect of energy costs on inflation. Similarly, Narayan et al. (2007) found evidence of a long-term equilibrium relationship between electricity prices and the CPI in Asian economies, where energy consumption plays a major role in household expenditure. In addition to direct household impacts, electricity prices influence inflation by increasing business production costs. When energy expenses rise, industries, particularly energy-intensive sectors such as manufacturing, construction, and transportation, adjust by raising the prices of goods and services. Chevallier et al.'s (2019) study on European energy markets found that fluctuations in electricity prices significantly affected industrial output costs, leading to measurable shifts in overall price levels. Additionally, a World Bank (2020) report emphasized that, in developing economies, where electricity often accounts for a higher share of business operating costs, price hikes may lead to more pronounced inflationary effects compared to advanced economies. The transition to renewable energy also introduces inflationary pressure. Although clean energy investments reduce environmental costs in the long term, the initial capital-intensive nature of renewables can increase electricity prices in the short term. Wang and Li (2021) asserted that economies undergoing rapid energy transitions tend to experience temporary increases in the CPI owing to the cost of infrastructure upgrades. This suggests that, while green energy policies are crucial for sustainability, they must be managed carefully to avoid exacerbating short-term inflationary trends.

The relationship between electricity prices and inflation transcends a mere economic analysis; it is integral to daily life, particularly in developing economies such as Lao PDR. Electricity serves not only as a household necessity but also as a critical driver of business operations, industrial growth, and national economic stability. An increase in electricity prices can have widespread economic repercussions, elevating production costs, reducing consumer purchasing power, and influencing overall inflation levels (Hakimah et al., 2019). In a nation where energy exports constitute a substantial portion of the GDP, yet domestic electricity tariffs remain subject to government policies and currency fluctuations, it is crucial to examine how these price movements impact the cost of living (Panthamit and Chaiboonsri, 2021).

Electricity prices are a key determinant of the CPI as they directly influence household expenditures, business costs, and overall economic stability. Unlike many economies where electricity prices fluctuate based on market supply and demand, Lao PDR's electricity pricing is closely tied to its hydropower production and export agreements, rendering it less responsive to traditional economic forces (Vilayvone, 2022). Although electricity is a fundamental component of the cost structure in both domestic consumption and industrial production, its impact on Lao PDR's CPI remains understudied. Understanding this relationship is critical, as shifts in electricity prices can affect the broader economy by altering production costs and influencing consumer purchasing power. Despite its economic significance, limited research has examined how electricity prices influence the Lao PDR's CPI. Existing studies have primarily analyzed energy pricing trends in Southeast Asia without considering Lao PDR's unique dependence on hydropower and its dual role as both an energy exporter and a domestic electricity supplier (Xaiyavong, 2015). Given that electricity pricing policies can shape economic conditions, this study aims to address this research gap by examining the cointegration relationship between electricity prices and the CPI. These findings offer valuable insights for policy decisions on energy pricing, cost-of-living adjustments, and macroeconomic stability.

Electricity prices affect inflation through multiple transmission mechanisms, particularly in energy-dependent developing economies like Lao PDR. These mechanisms include cost-push inflation, exchange rate pass-through, wage-price dynamics, and sectoral vulnerabilities. First, cost-push inflation arises when rising electricity prices increase production and operational costs across sectors. Higher electricity costs lead firms, especially in manufacturing, construction, and transportation, to raise the prices of goods and services, passing the burden onto consumers and thereby raising the CPI. Second, the exchange rate pass-through effect is especially relevant in Lao PDR due to the reliance on imported energy infrastructure and foreign-currency-denominated energy contracts. A depreciation of the Lao Kip increases the cost of imported equipment, materials, and services, amplifying domestic inflation through more expensive electricity generation and distribution. Third, wage-price spirals may emerge when households face higher utility bills. If electricity costs constitute a significant portion of household expenditures, workers may demand higher wages to maintain their purchasing power. Wage increases, in turn, push up production costs, potentially initiating a feedback loop that reinforces inflationary pressures. Finally, the effects of electricity price changes are unevenly distributed across economic sectors and income groups. While large firms may partially hedge or absorb cost shocks, small businesses and low-income households are often more vulnerable. This disparity can exacerbate the social impact of inflation and influence broader economic stability. Understanding these transmission mechanisms is essential for interpreting the empirical results and for designing policies that mitigate inflationary risks stemming from energy price fluctuations.

2. Literature Review

Several empirical studies conducted over the past two decades have examined the impact of electricity prices on the CPI using various econometric techniques. Specifically, cointegration techniques and error correction models (ECM) have been extensively employed to analyze the long- and short-run relationships between electricity prices and the CPI. Bölük and Koç (2010) and He et al. (2010) conducted cointegration analysis using macroeconomic data from Turkey and China, respectively, and revealed that electricity price increases negatively impact GDP and CPI, often triggering short-term inflationary pressures. Similarly, Mirza et al.(2014) employed a vector autoregression model using quarterly data from South Asian economies and concluded that abrupt electricity price hikes destabilize economic growth and create volatility in the CPI. Their findings highlight the essential role of electricity prices in determining the overall price level, particularly in developing economies, where energy costs constitute a significant share of household expenditure. Jia and Li (2010) used cointegration and Granger causality tests to examine the long-term relationship between electricity prices and the CPI in emerging markets. Their results indicated no stable long-run relationship; however, they found that short-term fluctuations in electricity prices could lead to temporary inflationary effects, particularly in economies with volatile energy markets. These findings emphasize the importance of energy market structures and policy interventions in determining the pass-through effect of electricity prices on the CPI. Nevertheless, these approaches have assumed a symmetric response of the CPI to electricity price changes, which may not accurately reflect real-world dynamics.

Sek (2017) provides a more nuanced perspective by employing both linear and nonlinear autoregressive distributed lag (NARDL) models to study energy price changes and their impact on domestic prices in Malaysia. The findings revealed that oil price movements exhibit both symmetric and asymmetric pass-through effects on domestic prices. While changes in oil prices directly affect import and production costs, their impact on consumer prices is more indirect and filtered through other economic channels. Moreover, Layani and Mehrjou (2013) utilized the NARDL to investigate the asymmetric impact of electricity price fluctuations on the CPI, demonstrating that price increases exert a stronger and more persistent effect on the CPI than price reductions. Similarly, Lacheheb and Sirag (2019) applied NARDL to Algerian data, revealing that the CPI responded significantly to increases in electricity prices, but not to reductions, suggesting the presence of price rigidity and regulatory constraints. These findings align with broader energy economics literature, indicating that price stickiness and regulatory mechanisms often result in incomplete pass-through effects of electricity price changes. In the case of Lao PDR, previous studies on the relationship between electricity prices and the CPI are lacking. Therefore, this study applies the NARDL model to analyze electricity prices and the CPI in Lao PDR. It seeks to determine whether electricity price increases and decreases exhibit differential effects on the CPI. Given Lao PDR’s transition toward market-driven electricity pricing, understanding these asymmetries is crucial for policymakers to design effective energy pricing strategies and manage inflationary pressure. The NARDL’s application in this context is particularly significant, as it enables a more precise estimation of the asymmetric price transmission mechanism, offering valuable insights for developing economies undergoing similar energy market reforms.

3. Data, Variables and Methodology

3.1 Data and variables

This study employs longitudinal time series data from 1990 to 2023 to examine the relationship between electricity prices and the CPI in Lao PDR. The dataset includes key economic variables relevant to our analysis. The dependent variable, LNCPI, represents the CPI, which is derived from the retail prices of goods and essential items based on actual market price surveys. This index measures the overall price levels of consumer goods and services purchased by households.

The independent variable is LNAECHB, which captures the average percentage of energy consumption by households and the business sector in Laos. LNEPHB represents the average electricity price for households and businesses measured in Kip per kilowatt-hours (Kip/KWh). Finally, LNEXCH refers to the exchange rate, expressed in Kip per US dollar (Kip/USD). The data sources for this study include the World Bank, Lao Statistics Center under the Ministry of Planning and Investment, and EDL. The combination of these reliable sources ensures a comprehensive analysis of how electricity price fluctuations influence the cost of living as reflected in the CPI.

It is important to acknowledge potential limitations in the data, particularly for the early 1990s. During this period, statistical infrastructure in Lao PDR was still developing, and records related to electricity pricing, household consumption, and exchange rates may be incomplete or subject to estimation error. To assess the robustness of the findings, a sensitivity analysis was conducted by re-estimating the model using a shorter sample period beginning in 2000. The core results, including the direction and significance of the key coefficients, remained consistent, confirming the stability of the main conclusions. Nonetheless, caution should be exercised when interpreting long-run effects, as early-year data may contain unobserved inaccuracies.

3.2 The NARDL model

To explore the relationship between electricity prices and the CPI in Lao PDR, this study employs the NARDL model. As changes in electricity prices may not have a uniform impact on the CPI, increasing prices may affect inflation differently than decreasing prices. The NARDL model is well-suited for capturing these asymmetrical effects. The NARDL model developed by Shin et al. (2014) is widely recognized for its ability to analyze nonlinear relationships between variables. Unlike traditional linear models, it differentiates between positive and negative changes in an independent variable and assesses their distinct effects on a dependent variable. This capability renders it a valuable tool for understanding economic relationships that do not consistently follow predictable, unidirectional patterns. Both the autoregressive distributed lag (ARDL) and NARDL models incorporate lagged values of the dependent and independent variables. By analyzing historical trends, these models can aid in predicting current and future behavior, making them effective for examining both short- and long-term dynamics. Economic variables rarely interact in a straightforward manner, and the relationships among them can vary depending on external conditions. In the context of electricity prices and the CPI, the impact may differ based on whether prices are increasing or decreasing, as well as the magnitude of those changes.

The NARDL model is designed to capture these complexities and provide a more comprehensive understanding of how electricity prices influence inflation over time. This study considers multiple factors, including household and business electricity prices, energy consumption levels, and exchange rate fluctuations. By distinguishing between positive and negative electricity price changes, the model offers deeper insights into how inflation reacts to different economic scenarios. Given its flexibility and ability to uncover hidden asymmetries, the NARDL model serves as an ideal framework for this study.
The NARDL model can be expressed as follows.

$$LNCPI_t = \beta o + \sum_{i=1}^{p} \alpha_i \, \Delta LNCP_{t-i} + \sum_{j=0}^{q} (\beta_j^{+} \Delta LNEPHB_{t-j}^{+} + (\beta_j^{-} \Delta LNEPHB_{t-j}^{-}) + \sum_{k=0}^{q} \gamma \, k \Delta LNAECHB_{t-1} + \sum_{m=0}^{q} \delta_m \, \Delta LNEXCH_{t-m} + \lambda ECT_{t-1} + \epsilon_t \quad (1)$$

where $LNCPI_t$ is the natural logarithm of the CPI. $\alpha_i \, \Delta LNCP_{t-i}$ accounts for the lagged values of the LNCPI and captures short-run dynamics. $(\beta_j^{+} \Delta LNEPHB_{t-j}^{+}$ represents positive changes in electricity prices (Kip/KWh), and $(\beta_j^{-} \Delta LNEPHB_{t-j}^{-}$ focuses on negative changes in electricity prices. $\gamma k \Delta LNAECHB_{t-1}$ indicates the log of average energy consumption in households and the business sector. Additionally, $\delta_m \Delta LNECHB_{t-m}$ explains the log of the exchange rate (Kip/USD). λECT_{t-1}denotes the error correction term (ECT), capturing the speed of adjustment to long-run equilibrium. ϵ_t presents the stochastic error term, accounting for unobserved shocks. We posit that the equation captures both the short- and long-run dynamics of the CPI fluctuations in response to changes in electricity prices, energy consumption, and exchange rate variations. The use of different variables (Δ) in the equation allows for an assessment of immediate, short-term effects, while the ECT ensures that deviations from equilibrium are corrected over time. Additionally, we apply the long-run equilibrium relationship to the NARDL model as follows.

$$LNCPI_t = o + \emptyset^{+} LNEPHB_t^{+} + \emptyset^{-} LNEPHB_t^{-} + \emptyset_1 LNAECHB_t + \emptyset_2 LNEXCH_t + \epsilon_t \qquad (2)$$

where $\emptyset^{+}$ and $\emptyset^{-}$ estimate the long-run effects of electricity price increases and decreases, , respectively. $\emptyset_1$ and $\emptyset_2$ represent the long-run impact of energy consumption and exchange rates on the CPI. ϵ_t represents the long-run error term, capturing external shocks. To incorporate the adjustment mechanism to long-run equilibrium, the ECM representation of the NARDL model is expressed as follows.

$$\Delta LNCPI_t = \theta o + \sum_{i=1} \theta_i \Delta LNCPI_{t-1} + \sum_{j=0} (\theta_j^{+} \Delta LNEPHB_{t-j}^{+} + \theta_j^{-} \Delta LNEPHB_{t-j}^{-}) + \sum_{k=0} \theta_k \Delta LNAECHB_{t-k} + \sum_{m=0} \theta_m \Delta LNEXCH_{t-m} + \lambda ECT_{t-1} + \epsilon_t \qquad (3)$$

where λ denotes the ECT, indicating how rapidly the deviations from equilibrium are corrected. A significant ** negative ** λ confirms that the CPI gradually adjusts to equilibrium following external shocks.

4. Results

Table 1 presents the descriptive statistics of the key variables in this study, including the CPI (LNCPI), electricity prices (LNEPHB), exchange rates (LNEXC), and energy consumption (LNAECHB). These statistics provide an overview of the central tendency and dispersion. The findings suggest that electricity prices and exchange rate fluctuations are key drivers of CPI changes, reinforcing the importance of accounting for asymmetric effects in inflation modelling.

Table 1: Descriptive statistics of the variables

	LNCPI	LNAECHB	LNAEPHB	LNEXC
Mean	3.860	6.678	5.330	8.523
Median	4.449	6.635	6.015	9.010
Maximum	5.477	8.238	6.613	9.781
Minimum	1.300	4.727	3.264	6.554
Std. Dev.	1.322	1.098	1.179	1.066
Skewness	-0.913	-0.153	-0.775	-1.106
Kurtosis	2.251	1.611	1.909	2.482
Jarque-Bera	5.515	2.866	5.094	7.315
Probability	0.063	0.239	0.078	0.026

To determine the stationarity of the variables and assess their order of integration, we conducted the Augmented Dickey-Fuller (ADF), Phillips–Perron (PP), and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests. These tests help verify whether the variables contain a unit root, which is essential for choosing an appropriate econometric model. Table 2 presents the results of the unit root tests for all variables at both the level and first difference. The results show that all variables fail to reject the null hypothesis of a unit root in level form ($p > 0.05$). This indicates that they are nonstationary at the levels, suggesting that their statistical properties change over time. However, considering the first difference, the ADF and PP tests indicate that most variables become significant at the 1% or 5% level, indicating that they become stationary after differencing once. This suggests that they are integrated into order one, I(1). The KPSS test, which has an opposite null hypothesis (stationarity), confirms these findings. The KPSS statistic is above the critical value at levels but falls within the acceptable range after the first differencing, further supporting the conclusion that the variables are I(1). As all the variables in this study are I(1), the NARDL model is appropriate for capturing both short- and long-run dynamics.

Table 2: Unit root tests

Variable	ADF Level (t-stat, p)	ADF 1st Diff (t-stat, p)	PP Level (t-stat, p)	PP 1st Diff (t-stat, p)	KPSS Level (stat, p)	KPSS 1st Diff (stat, p)
LNCPI	-1.9246	-3.2114**	-1.7379	-4.5123***	0.5985	0.2522
LNEXCH	-2.5345	-1.9695	-1.4792	-5.2135***	0.5474	0.1585
LNAECHB	-1.7795	-5.186***	-1.6878	-6.1189****	0.6732	0.2723
LNEPHB	-1.1951	-3.7452***	-1.1464	-4.8761***	0.5842	0.1973

Notes: *** and ** represent significance at the 1% and 5% levels, respectively.

An inappropriate lag selection can lead to inefficient model estimation, omitted variable bias, or overfitting. To determine the most suitable lag length for the NARDL model, this study employs multiple statistical criteria, including the Akaike Information Criterion (AIC), Schwarz Information Criterion (SC), Hannan–Quinn Criterion (HQ), Likelihood Ratio (LR) test, and Final Prediction Error (FPE) criterion. The results indicate that a lag length of two is optimal, as identified by the AIC (-8.28), SC (-6.82), and HQ (-7.73) criteria, which minimize information loss while balancing model complexity. The LR test further supports this selection, reporting a statistically significant value of 51.09. Additionally, the FPE criterion confirms that lag two yields the lowest prediction error (3.18e-09), reinforcing its suitability. Applying an appropriate lag structure enhances the accuracy of the NARDL estimation, ensuring that both the contemporaneous and lagged effects of exchange rates, electricity prices, and energy consumption on the CPI are effectively accounted for. This methodological approach aligns with that of Pao and Tsai (2011), who similarly emphasized the importance of optimal lag selection in studying the relationship between energy prices and macroeconomic indicators.

Table 3: Results of lag selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-35.8568	N/A	0.000142	2.491047	2.674264	2.551779
1	132.8933	284.7657	1.02E-08	-7.05583	-6.13975	-6.75217
2	168.4361	51.09282*	3.18e-09*	-8.277257*	-6.628304	-7.730675*

Notes: *** and ** represent significance at the 1% and 5% levels, respectively.

A symmetry test was conducted using the Wald Test, which examines whether the estimated coefficients for positive and negative changes in electricity prices are statistically different. The null hypothesis (H_0: $\beta^+ = \beta^-$) assumes that electricity price increases and decreases have equal but opposite effects on the CPI. If this hypothesis is rejected, the presence of asymmetric effects is confirmed, thereby reinforcing the appropriateness of the NARDL model. Table 4 presents the results of the long-run symmetry test. The F-statistic (10.18521, $p = 0.0046$) and chi-square statistic ($p = 0.0014$) indicate that the null hypothesis of symmetry in the long run is rejected. This finding suggests that electricity price increases exert a stronger inflationary effect than price decreases, reinforcing the importance of asymmetric modeling. Additionally, the short-run symmetry test, F-statistic (8.935678, $p = 0.0072$), and chi-square statistic ($p = 0.0028$) show that short-run price adjustments also exhibit significant asymmetry, indicating that the CPI reacts differently to electricity price hikes versus reductions in the short term. Moreover, the Joint Symmetry Test (long- and short-run), joint F-statistic (9.829991, $p = 0.0011$), and chi-square statistic ($p = 0.0001$) confirm the presence of asymmetric effects across both time horizons, reinforcing the necessity of the NARDL framework in this study.

Table 4: Symmetry test

Variable	Statistic	Value	Probability
Long-run	F-statistic	10.18521*	0.0046
LNEXC	Chi-square	10.18521*	0.0014
Short-run	F-statistic	8.935678*	0.0072
LNEXC	Chi-square	8.935678*	0.0028
Joint (long- and short-run)	F-statistic	9.829991*	0.0011
LNEXC	Chi-square	19.65998***	0.0001

Notes: *** and ** represent significance at the 1% and 5% levels, respectively.

The results of the Bound Test presented in Table 5 indicate that the computed F-statistic (10.80198) exceeds the upper bound critical values (I(1)) at all conventional significance levels. Specifically, the F-statistic is significantly greater than the upper bound at the 1% critical level (5.84), confirming the presence of a robust long-run equilibrium relationship among the variables. As 10.80198 > 5.84 (1% upper bound I(1)), the null hypothesis of no cointegration is strongly rejected. This provides strong statistical evidence that the CPI, electricity prices, and exchange rates are cointegrated, indicating that despite short-term fluctuations, these variables exhibit a systematic, long-term connection. The confirmation of cointegration validates the NARDL approach, ensuring that the estimated long- and short-run effects are more meaningful than spurious. The establishment of a stable long-run equilibrium suggests that policy interventions affecting electricity prices or exchange rates have sustained effects on inflation (the CPI), rather than merely short-term fluctuations.

Table 5: Results of the bound test

Test Statistic	Value		
F-statistic	10.80198		
Sample Size	10% Critical Value	5% Critical Value	1% Critical Value
I(0)	2.525	3.058	4.223
I(1)	3.56	4.28	5.84
Asymptotic	2.2	2.56	3.49

The long-run estimation results in Table 6 indicate that electricity prices and exchange rate depreciation exert significant inflationary pressure, whereas exchange rate appreciation has a weaker deflationary effect. These findings underscore the asymmetric nature of exchange rate movements in influencing inflation dynamics. A 1% increase in electricity prices leads to a 0.34% increase in the CPI (β = 0.339877, p = 0.0003), demonstrating the strong pass-through effect of electricity costs on inflation. Statistical significance at the 1% level confirms that electricity price fluctuations directly impact consumer price levels and the overall cost of living. A 1% depreciation in the exchange rate results in a 0.656% increase in the CPI (β = 0.656034, p < 0.001), indicating that currency depreciation significantly amplifies inflationary pressures. This aligns with the theoretical expectation that imported goods become more expensive as the domestic currency weakens, leading to higher price levels. Exchange rate appreciation exerts a weaker deflationary effect, as indicated by its negative coefficient (β = -1.059703, p = 0.0243). Although statistically significant at the 5% level, its magnitude is smaller than that of depreciation. This asymmetry suggests that although depreciation has an immediate inflationary impact, appreciation does not necessarily lead to an equivalent reduction in price levels. The long-run estimation results confirm that electricity prices and exchange rate depreciation are the primary drivers of inflation in Lao PDR.

Table 6: Results of long-run estimation

Variable	Coefficient	Std. Error	t-Statistic	Probability
LNAECHB	0.010929	0.102675	0.106438	0.9161
LNEPHB(-1)	0.339877	0.080876	4.202431	0.0003***
@CUMDP(LNEXCH(-1))	0.656034	0.06108	10.74057	0.0000***
@CUMDN(LNEXCH(-1))	-1.059703	0.443078	-2.391686	0.0243**
C	0.515563	0.450615	1.144132	0.263

Notes: *** and ** represent significance at the 1% and 5% levels, respectively.

The short-run estimation results provide significant insights into the immediate effects of electricity prices and exchange rate fluctuations on inflation in Lao PDR. The findings confirm strong inflation persistence, with past inflation (D(LNCPI(-1))) significantly influencing current inflation (β = 0.4869, p = 0.0001). This suggests that price movements tend to be sustained over time, reinforcing the need for proactive inflation management strategies. Electricity price changes significantly impact the CPI, as a 1% increase in electricity prices leads to a 0.053% increase in the CPI (β = 0.0533, p = 0.0007). This highlights the short-term inflationary pressure stemming from energy cost fluctuations. Exchange rate dynamics also play a crucial role, with exchange rate depreciation contributing to significant inflationary pressures (β = 0.2159, p = 0.0022). Specifically, a 1% depreciation leads to a 0.22% increase in the CPI, reinforcing the inflationary effects of currency depreciation on imported goods and services. Conversely, exchange rate appreciation has a weaker deflationary effect (β = -0.4761, p = 0.0826), confirming the asymmetry in exchange rate effects, where depreciation drives inflation more strongly than appreciation curbs it. ECT (ECT(-1)) is negative and weakly significant (β = -0.9076, p = 0.0747), suggesting that 90.76% of short-run deviations are corrected per period. This indicates a relatively fast adjustment to the long-run equilibrium following external shocks. The strong and immediate impact of currency depreciation suggests that monetary and exchange rate policies should be carefully managed to mitigate short-term inflationary pressure.

Table 7: Results of short-run estimation

Variable	Coefficient	Std. Error	t-Statistic	Probability
D(LNCPI(-1))	0.486856	0.109593	4.775979	0.0001***
D(LNAECHB)	0.003211	0.106257	0.09713	0.9213
D(LNEPHB(-1))	0.053281	0.519751	3.519751	0.0007***
D(@CUMDP(LNEXCH))	0.215923	0.072163	3.779451	0.0022***
D(@CUMDN(LNEXCH))	-0.476107	0.343913	-1.582809	0.0826*
Error Correction Term (ECT(-1))	-0.907617	0.133789	-1.580082	0.0747*

Notes: *** and ** represent significance at the 1% and 5% levels, respectively.

A series of diagnostic tests were conducted to assess whether the model meets the essential econometric assumptions. Table 8 presents the analysis of the diagnostic tests. These tests examine serial correlation, heteroskedasticity, normality, and model stability, which are crucial for verifying the accuracy of a model's predictions. We can confidently use the model for policy analysis and decision-making by confirming that these assumptions hold. The Breusch–Godfrey serial correlation LM test was performed to detect whether the residuals exhibit serial correlation, which could indicate that the model is misspecified. The test results (F-statistic = 0.2085, p = 0.8137) suggest that the null hypothesis is not rejected, suggesting that the residuals are not correlated. This confirms that the model does not suffer from serial correlation and is correctly specified. The Breusch–Pagan–Godfrey heteroskedasticity test was used to check whether the variance of the residuals remains constant over time. The test results (F-statistic = 1.1129, p = 0.3996) indicate that the null hypothesis was not rejected, indicating that the residuals exhibit homoskedasticity. This ensures that the estimated coefficients remain consistent and efficient. The Jarque–Bera test was conducted to test for normality. The test results (JB-statistic = 1.2095, $p = 0.5462$) indicate that the residuals follow a normal distribution, validating the assumption necessary for hypothesis testing and inference.

Table 8: Diagnostic tests

Tests	Results
Serial Correlation (Breusch–Godfrey)	F-statistic: 0.2085 ($p = 0.8137$)
Heteroskedasticity (Breusch–Pagan–Godfrey)	F-statistic: 1.1129 ($p = 0.3996$)
Normality (Jarque–Bera)	JB-statistic: 1.2095 ($p = 0.5462$)

Figures 1 and 2 show the cumulative sum (CUSUM) and CUSUM of Squares (CUSUMSQ) tests used to assess whether the model parameters remain stable over time. Both tests show that the test statistics remain within the 5% significance bound, confirming that the model is structurally stable and does not exhibit any significant shifts in parameter estimates.

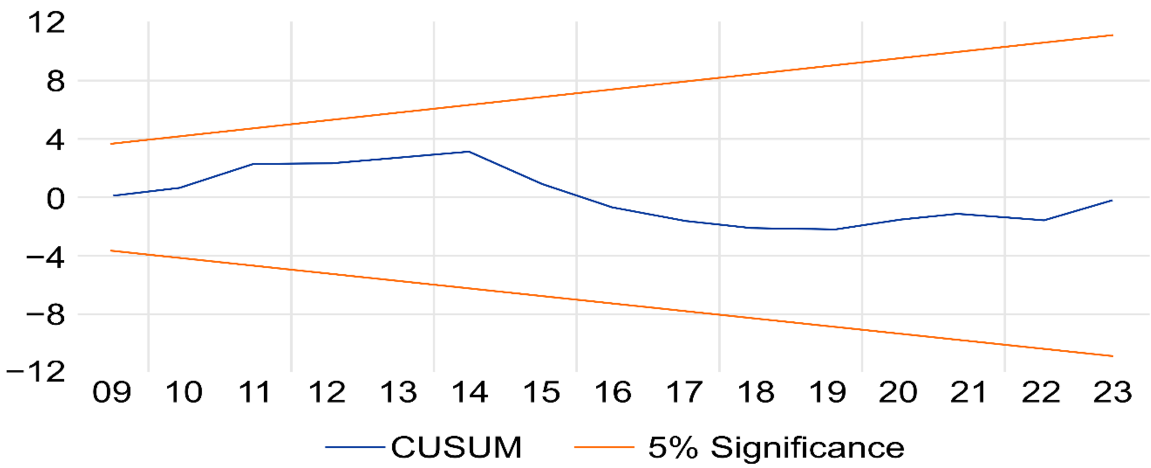

Figure 1: CUSUM test

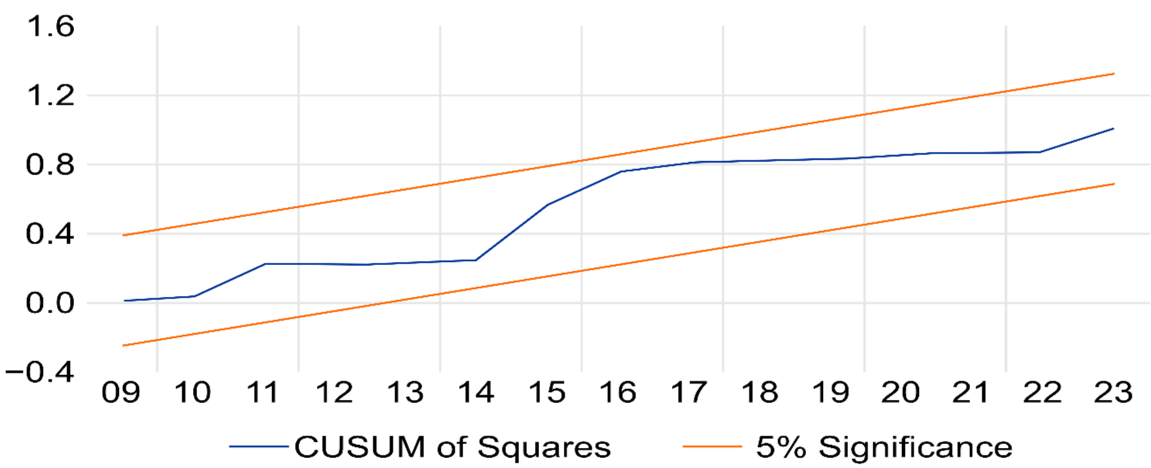

Figure 2: CUSUMSQ test

5. Conclusion and Discussion

This study employed the NARDL model to investigate the relationship among electricity prices, exchange rates, and the CPI in Laos. The unit root test results confirmed that all variables were integrated of order one, I(1). These findings align with those of prior studies, including Narayan and Smyth (2005) and Shahbaz et al. (2022), who demonstrated that inflation-related macroeconomic variables often exhibit non-stationary behavior at the level but become stationary after first differencing. These results justify the application of the bound test for cointegration, which established the presence of a long-run relationship among the variables. The long-run estimation results indicate that electricity prices significantly and positively impact the CPI, reinforcing the strong pass-through effect of energy costs on inflation. Furthermore, exchange rate depreciation exerts a stronger inflationary effect than appreciation, confirming the asymmetric influence of exchange rate fluctuations on price levels. These findings highlight the vulnerability of inflation in the Lao PDR to external shocks, particularly in the energy and foreign exchange markets. The short-run dynamics further confirm asymmetric inflationary responses, with the CPI reacting more strongly to currency depreciation than to appreciation. This suggests that price levels in Lao PDR are more sensitive to external inflationary pressures than to deflationary adjustments from exchange rate appreciation. The ECT is significant and negative, indicating that 90.76% of the deviations from the long-run equilibrium are corrected annually, signifying a relatively fast adjustment to equilibrium. These findings align with those of previous research, such as Narayan and Smyth (2005), who demonstrated that energy prices significantly influence inflation. Similarly, Pao and Tsai (2011) found that electricity price fluctuations contribute to inflationary pressure, supporting our results. More recent studies, including those by Lenhart (2019) and Shahbaz et al. (2022), emphasize the critical role of exchange rate volatility in driving inflationary trends in emerging economies. The empirical validation of these relationships confirms the robustness of the NARDL model in capturing both short- and long-run inflationary dynamics.

Our results underscore the necessity for targeted macroeconomic policies to mitigate inflationary pressures arising from electricity price volatility and exchange rate fluctuations. Policymakers should focus on stabilizing exchange rates to limit imported inflation while ensuring a sustainable energy pricing framework to prevent excessive inflationary shocks linked to electricity costs. The presence of asymmetric inflationary responses suggests that traditional monetary policies may not be sufficient for counteracting price instability. Therefore, a combination of exchange rate interventions, energy price stabilization policies, and inflation-targeting frameworks is recommended to achieve long-term price stability and economic resilience in Lao PDR. This study contributes to the growing literature on energy inflation dynamics by providing empirical evidence on the role of electricity prices and exchange rate fluctuations in shaping inflationary trends. Future research could explore sector-specific inflation responses to energy price shocks and examine the effectiveness of monetary and fiscal policies in mitigating inflationary pressure in Lao PDR.

Future research could benefit from comparative analysis with other developing, hydropower-reliant economies such as Nepal, Ethiopia, or Bhutan. These countries share structural similarities with Lao PDR, including dependence on electricity exports, regulated pricing, and exposure to external shocks via currency and fuel markets. Benchmarking Lao PDR's inflationary response against these economies could help identify whether the observed cointegration patterns and asymmetric inflation dynamics are unique to Laos or reflect broader regional trends. Such comparisons would enhance the generalizability of findings and provide valuable insights for policymakers in similar contexts.

References

Laotian Times (2023). Electricite du Lao PDR to increase prices for certain customer types – Laotian Times. Laotian Times. Available online: https://laotiantimes.com/2023/02/08/electricite-du-laos-to-increase-electricity-cost-for-industrial-usage/ (accessed on 23 February 2025)

Enerdata (2024). Enerdata Available online: https://www.enerdata.net/estore/country-profiles/lao.html (accessed on 23 February 2025)

Sverre Oksen (2014). Lao PDR Case Study: Électricité du Laos. Available online: http://www.academia.edu (accessed on 28 February 2025)

Jayant Menon and Peter Warr (2013). The Lao economy: Capitalizing on natural resource exports. Asian Economic Policy Review, 8(1), 70–89. https://doi.org/10.1111/aepr.12006

Nicholas Apergis and James E. Payne (2011). A dynamic panel study of economic development and the electricity consumption-growth nexus. Energy Economics, 33(5), 770–781. https://doi.org/10.1016/j.eneco.2010.12.018

Paresh K. Narayan, Russell Smyth and Arti Prasad (2007). Electricity consumption in G7 countries: A panel cointegration analysis of residential demand elasticities. Energy Policy, 35(9), 4485–4494. https://doi.org/10.1016/j.enpol.2007.03.018

Julien Chevallier, Duc Khuong Nguyen, and Juan Carlos Reboredo (2019). A conditional dependence approach to CO2-energy price relationships. Energy Economics, 81, 812–821. https://doi.org/10.1016/j.eneco.2019.05.010

World Bank (2020). World Development Report, 2020. Available online: https://openknowledge.worldbank.org/server/api/core/bitstreams/bd24e4f5-41d8-5bde-a8bf-a0e42581af15/content. (accessed on 26 February 2025)

Jing Wang and Hao Li (2021). The impact of electricity price on power-generation Structure: Evidence from China. Frontiers in Environmental Science, 9, 733809. https://doi.org/10.3389/fenvs.2021.733809

Yulia Hakimah, Aditya T. Nugraha, Arya Surya, Ananda R. W. Ananda, and Putri Astuty (2019). Does the electricity consumption determine the economic growth and energy prices in ASEAN countries? Journal of Security and Sustainability Issues, 9(2), 489–503. https://doi.org/10.9770/jssi.2019.9.2(10)

Nattawut Panthamit and Chaiyuth Chaiboonsri (2021). Assessing the linkages between the electricity consumption and economic factors in a landlocked economy: Case study of LAO PDR. The Singapore Economic Review, 66(2), 595–619. https://doi.org/10.1142/S0217590820430080

Vilayvone Vang (2022). Empirical analysis of exchange rate and inflation in Lao People's Democratic Republic. Available online: https://ynu.repo.nii.ac.jp/record/12189/files/vilayvone_vang-thesis.pdf (accessed on 24 February 2025)

Inthavong Xaiyavong (2015). Macroeconomic policies in the presence of currency substitution in Lao People's Democratic Republic. [Doctoral thesis, Hiroshima Shudo University Graduate School of Economic Sciences]. Available online: https://shudo-u.repo.nii.ac.jp/record/2277/files/%E8%AB%96%E6%96%87.pdf (accessed on 27 February 2025)

Gulden Bölük and Ali A. Koç (2010). Electricity demand of manufacturing sector in Turkey: A translog cost approach. Energy Economics, 32(3), 609–615. https://doi.org/10.1016/j.eneco.2010.01.007

Yuxiang He, Shuling Zhang, Liyan Yang, Yujun Wang, and Jian Wang (2010). Economic analysis of coal price–electricity price adjustment in China based on the CGE model. Energy Policy, 38(11), 6629–6637. https://doi.org/10.1016/j.enpol.2010.06.033

Faisal M. Mirza, Olvar Bergland and Nasir Afzal (2014). Electricity conservation policies and sectorial output in Pakistan: An empirical analysis. Energy Policy, 73, 757–766. https://doi.org/10.1016/j.enpol.2014.06.016

Li Jia and Wei Li (2010). Cointegration analysis on the relationship between consumer price index and electricity price. 2010 2nd IEEE International Conference on Information and Financial Engineering, Chongqing, China. https://doi.org/10.1109/ICIFE.2010.5609273

Sook-Keng Sek (2017). Impact of oil price changes on domestic price inflation at disaggregated levels: Evidence from linear and nonlinear ARDL modeling. Energy, 130, 204–217. https://doi.org/10.1016/j.energy.2017.03.152

Gholamreza Layani and Seyed Mehrjou (2023). Asymmetric effects of exchange rate and oil price changes on food and agricultural product prices in Iran: Application of NARDL approach. Journal of Agricultural Economics and Development, 37(1), 35–48. https://doi.org/10.22067/jead.2022.74721.1113

Mohamed Lacheheb and Ali Sirag (2019). Oil price and inflation in Algeria: A nonlinear ARDL approach. The Quarterly Review of Economics and Finance, 73, 217–222. https://doi.org/10.1016/j.qref.2018.12.003

Shin, Y., Yu, B., & Greenwood-Nimmo, M. (2014). Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. In Springer eBooks (pp. 281–314). https://doi.org/10.1007/978-1-4899-8008-3_9

Hsiao-Tien Pao and Cheng-Min Tsai (2011). Modeling and forecasting the CO2 emissions, energy consumption, and economic growth in Brazil. Energy, 36(5), 2450–2458. https://doi.org/10.1016/j.energy.2011.01.032

Paresh K. Narayan and Russell Smyth (2005). The residential demand for electricity in Australia: An application of the bounds testing approach to cointegration. Energy Policy, 33(4), 467–474. https://doi.org/10.1016/j.enpol.2003.08.011

Oliver Lenhart (2019). The effects of health shocks on labor market outcomes: Evidence from UK panel data. The European Journal of Health Economics, 20(1), 83–98. https://doi.org/10.1007/s10198-018-0985-z

Muhammad Shahbaz, Jing Wang, Kai Dong and Jing Zhao (2022). The impact of digital economy on energy transition across the globe: The mediating role of government governance. Renewable and Sustainable Energy Reviews, 166, 112620. https://doi.org/10.1016/j.rser.2022.112620