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Analyzing the Pump Diesel and Gasoline Prices on Inflation in Pakistan: A New Evidence from Non-Linear ARDL

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Abstract: Maintaining inflation is one of the prime goals of the macroeconomic policy executed through the country's central bank. The persistence of inflation is considered a serious problem in developing countries because it erodes the standard of living of the majority of people. Nowadays, researchers are showing interest in energy price shocks as one of the drivers of inflation. So, the present study examines the role of pump diesel and pump gasoline prices on inflation controlling real exchange depreciation and urbanization using NARDL from 1990 to 2020. The result shows that the pump domestic diesel prices and pump domestic gasoline prices have a positively asymmetric impact on inflation in Pakistan. In contrast, real exchange depreciation and urbanization positively affect inflation. This study recommended that the government decrease the dependence on imported energy and focus on cheaper and domestic energy resources to fulfil the growing energy demand.

Introduction

Inflation if persistent, is considered a threat to the economy's growth. It erodes the purchasing power of money and enhances the economic hardships of common people. Earlier inflation was always considered a monetary phenomenon (Friedman. 1963). Nowadays, non-monetary factors such as commodity shortages, oil price shocks, foreign exchange constraints, and crop failures are considered essential factors behind fueling the general price level (Onwiodukit, 2002). In reality, the study of inflation is complex, and many factors interplay in

determining inflation. In recent times, the energy price shocks have driven the attention of economists toward another powerful factor contributing to inflation. The international energy price shocks affect those economies dependent on foreign energy sources. A reasonable energy price increases economic growth (Ruhl *et al.*, 2012; Le & Nguyen, 2019). Energy price fluctuations have a substantial impact on a country's entire economy. (Nyga-Lukaszewska & Aruga, 2020). Oil and gas prices enhance energy inflation because few countries

control their supply. Pakistan fulfils its energy requirement by the imported oil and gas, but a slight disturbance in supply causes massive domestic inflation (Haider *et al.* 2013).

Pakistan does not have adequate energy resources, and a large quantity of crude oil and petroleum products are imported to meet more than 80% of its oil requirement (IAEC, 2014). The high energy dependency exposes Pakistan to international energy price shocks, domestic inflation, and the international competitiveness of exports. According to EIA (Energy information administration), data set 2021, Pakistan's total energy consumption was 3.68 (quad Btu) in 2018, in which oil share was 1.29 (quad Btu) and gas share was 1.45 (quad Btu).

This study inspects the causes of high inflation using domestic energy prices in Pakistan. Moreover, this study will attempt to answer the following questions. Does Pump Diesel Price (PDP) depict a linear relationship with inflation? Does Pump Gasoline Prices (PGP) depict a linear relationship with inflation? This study is the motivation of Abid *et al.* (2022) in which the researcher determined domestic inflation in Pakistan using international crude oil prices. Aside from this study, many studies evaluated energy prices as the global oil prices per barrel on inflation (Lily *et al.* 2021; Qasim *et al.* 2021; Olson, 2021). The study's uniqueness is that it uses the domestic Pump Diesel Prices (PDP) and Pump Gasoline Prices (PGP) to measure energy prices using NARDL to determine domestic inflation. International oil prices in barrels ignore the transportation cost, international organization profits, and government taxes. While the PDP and PGP include all profits of governments and international organizations. So, it is a good measure of reflecting energy prices.

Literature Review

Several empirical analyses have been undertaken to determine inflation. For example, In South Asian countries, Zakaria *et al.* (2021) explored the

causes of inflation using the non-linear Johnson co-integration and VAR model from 1980 to 2018. The study concluded that positive oil shocks significantly enhanced inflation in South Asian countries, while adverse oil shocks have an insignificant association with inflation. It also revealed that international oil prices (OP) on inflation have asymmetric behavior. In the same way, Lily *et al.* (2021) investigated the asymmetric inflationary impact of the exchange rate (EXR) and OP in ASEAN-5 countries. The non-linear ARDL econometric technique was applied to monthly data from 1979 to 2019. It was found that in the long run, ASEAN-5 countries had evidence of the asymmetric inflationary impact of OP. While on the other hand, Only Singapore had an asymmetrical long-run inflationary influence on the EXR.

Qasim *et al.* (2021) explored the nexus of EXR and OP on inflation in Pakistan. The co-integration econometric technique was applied to monthly data from 2004M1 to 2019M1. The result concluded that OP and the EXR had a robust significant impact on inflation. In the same way, Iqbal *et al.* (2021) scrutinized the energy inflation dynamics in Pakistan from 1991 to 2019. ARDL econometrics technique was applied to find the long-run association of the energy inflation index with many variables like OP, taxes, broad money supply (BMS), energy imports, and Economic growth (EG). The study found that energy demand increased energy inflation.

Abid *et al.* (2022) also determined inflation in Pakistan using the crude oil prices and the non-linear quadratic ARDL econometric technique during 1990-2020. The study found that crude oil prices proposed a U-shaped relationship.

Al-Jafari and Altaee (2019) took money supply, EXR, and imports as factors influencing inflation in Iraq. They employed a bounds-testing approach for the data series from 1995 to 2015 and discovered that money supply (MS) and imports had a positive long-run impact on inflation. In contrast, EXR had a negative and significant impact on inflation in the case of Iraq.

Ghumro and Memon (2018) used the ARDL technique to analyze the different factors of inflation in Pakistan. This study found that BMS, EXR, lag inflation and GDP are significant inflation determinants.

Varghese (2016) investigated the relationship between OP shocks and inflation in India. According to the analysis, adverse OP shocks generated inflation in India. Aside from oil inflation, EXR is a significant driver of domestic inflation.

Abubakar *et al.* (2021) examined the EXR depreciation on inflation in Nigeria from 1981 to 2017 by using the ARDL model. It concluded that the depreciation in the EXR was the major contributor to inflation in the Nigerian economy.

Pham *et al.* (2020) studied in ASEAN-5 countries on EXR pass-through on inflation targeting by applying the NARDL framework from 2000Q1 to 2019Q4. The study found that EXR shocks led to inflation. Kahssay (2017) tested the impact of money supply and other determinants such as GDP, imports, and gross national expenditures for the Ethiopian economy. After using the augmented Engle-Granger cointegration test on the sample from 1975 to 2015, the study reported an accelerating role of money supply for inflation in Ethiopia.

Many studies are also available to consider the role of per capita energy use in determining inflation for Pakistan. The idea comes from Bassey and Ekong's (2019) study, which investigated the role of disaggregated energy

demand in the form of natural gas, oil, and coal in the Nigerian economy. This study applied a bounds test using a sample from 1980 to 2017 and found a negative and significant impact of disaggregated different energy consumption.

In another study, Iyke and Odhiambo (2014) investigated the causal relationships between inflation, energy consumption, and economic development in Ghana. They used a VECM-based causality test on a sample from 1971 to 2012. They discovered unidirectional causality going from energy use to inflation in the short run, but a bidirectional causal link between inflation and energy consumption in the long run. Such studies encourage us to include energy usage or demand as a predictor of inflation in our research.

Having reviewed the literature, it is found that many variables are held responsible for determining inflation, such as EXR, OP, BMS, etc. Not a single factor contributes to the persistent hike in the general price level of a country. This study will emphasize the role of domestic pump diesel and gasoline prices in determining inflation in Pakistan.

Methodology and Data

In this study, annual time series data during 1990–2020 is collected from the WDI; for detail see Table 1. To find the impact of energy prices on inflation, we used two proxies of energy prices pump diesel (PDP) and gasoline price (PGP) in domestic currency. Inflation is measured using the Consumer Price Index in the 2010 base year.

Table 1

Variables description

Symbol	Indicator	Units
CPI	Consumer Price Index	2010=100
PGP	Pump Gasoline prices	Pak Rupees per liter
PDP	Pump Diesel Prices	Pak Rupees per liter
REX	Real effective exchange rate index	2010 = 100
URPOP	Urban population	Total

Two models are built to find the empirical investigation of PDP and PGP on inflation, as discussed in Equations 1 and 2. Shin et al. (2014) explored that when a variable does not behave linearly, it is converted into a positive and negative partial sum. Apart from this study, many other studies (Zakaria et al. 2021; Jeribi et al. 2021) studied the asymmetric impact to find the non-linear association between explained and explanatory variables. So the stochastic form of the model can be written as

$$LCPI = \alpha_0 + \alpha_1(LPDP)_t + \alpha_2(LREX)_t + \alpha_3(LURPOP)_t + \epsilon_t \quad (1)$$

$$LCPI = \beta_0 + \beta_1(LPGP)_t + \beta_2(LREX)_t + \beta_3(LURPOP)_t + \epsilon_t \quad (2)$$

As energy prices have a non-linear association with inflation, we use a non-linear ARDL model instead of the usual ARDL model. Before applying NARDL, first, we discuss the ARDL model tested by Pesaran et al. (1997) as follows;

$$Y_t = \alpha_0 + \alpha_1 t + \sum_{i=1}^p \theta_i Y_{t-i} + \beta X_t + \sum_{i=1}^{q-1} \beta^* \Delta X_{t-i} + u_t \quad (3)$$

In this study, LNPDP and LNPGP have asymmetric relationships with LNCPI while LNREX and LNURPOP have a symmetric relationship with LNCPI in the case of Pakistan. The asymmetric co-integration equation was used to explore asymmetric behavior. The formula is as follows:

$$a_t = \rho^+ b_t^+ + \rho^- b_t^- + U_t(4)$$

In Equation 4, ρ^+ and ρ^- are the long-run coefficients and b_t^+ and b_t^- are the coefficient of asymmetric independent variables.

The following equations (5 to 8) show the positive and negative changes in LNPDP and LNPGP.

$$LPDP^+ = \sum_{i=1}^t \Delta(LPDP)^+ = \sum_{i=1}^t \max(\Delta LPDP, 0) \quad (5)$$

$$LPDP^- = \sum_{i=1}^t \Delta(LPDP)^- = \sum_{i=1}^t \min(\Delta LPDP, 0) \quad (6)$$

$$LPGP^+ = \sum_{i=1}^t \Delta(LPGP)^+ = \sum_{i=1}^t \max(\Delta LPGP, 0) \quad (7)$$

$$LPGP^- = \sum_{i=1}^t \Delta(LPGP)^- = \sum_{i=1}^t \min(\Delta LPGP, 0) \quad (8)$$

In this next step, we will replace LPDP and LPGP in Equations 1 and 2 with LPDP⁺, LPDP⁻, LPGP⁺, and LPGP⁻. It can be written as:

$$LCPI = \alpha_0 + \alpha_1(LPDP)^+ + \alpha_2(LPDP)^- + \alpha_3(LREX) + \alpha_4(LURPOP) + \epsilon_t \quad (9)$$

$$LCPI = \beta_0 + \beta_1(LPGP)^+ + \beta_2(LPGP)^- + \beta_3(LREX) + \beta_4(LURPOP) + \epsilon_t \quad (10)$$

In this study, Equations 9 and 10 present the long-run results of the NARDL model. Here α_1 and α_2 are the long-term coefficient parameters of the asymmetric effect of LPDP incorporated the positive changes in LPDP⁺ and negative changes in LPDP⁻. While β_1 and β_2 are long-run asymmetric coefficients of LPGP. Here α_0 and β_0 are the intercept terms, and ϵ_t are the error terms in both models.

The short-run coefficient of the NARDL equation can be written as:

$$LCPI = \alpha_0 + \sum_{k=1}^m \alpha_1 \Delta(LCPI)_{t-k} + \sum_{k=1}^m \alpha_{2k} \Delta(LPDP)_{t-k}^+ + \sum_{k=1}^m \alpha_{3k} \Delta(LPDP)_{t-k}^- + \sum_{k=1}^m \alpha_{4k} \Delta(LREX)_{t-k} + \sum_{k=1}^m \alpha_{5k} \Delta(LURPOP)_{t-k} + \lambda_1(LCPI)_{t-1} + \lambda_2(LPDP)_{t-1}^+ + \lambda_3(LPDP)_{t-1}^- + \lambda_4(LREX)_{t-1} + \lambda_5(LURPOP)_{t-1} + \epsilon_t \quad (11)$$

$$\Delta LCPI = \beta_0 + \sum_{k=1}^m \beta_1 \Delta(LCPI)_{t-k} + \sum_{k=1}^m \beta_{2k} \Delta(LPGP)_{t-k}^+ + \sum_{k=1}^m \beta_{3k} \Delta(LPGP)_{t-k}^- + \sum_{k=1}^m \beta_{4k} \Delta(LREX)_{t-k} + \sum_{k=1}^m \beta_{5k} \Delta(LURPOP)_{t-k} + \lambda_1(LCPI)_{t-1} + \lambda_2(LPGP)_{t-1}^+ + \lambda_3(LPGP)_{t-1}^- + \lambda_4(LREX)_{t-1} + \lambda_5(LURPOP)_{t-1} + \epsilon_t \quad (12)$$

Equations 11 and 12 are error correction terms (ECT) that show short-run coefficients by Δ and long-run coefficients as λ_i . However, this study's main concern is finding the asymmetric impact of LPDP and LPGP with LCPI in Pakistan. Equations 13 and 14 are the Shin et al. (2014) equation derived from the bounds testing approach, derived by the original finding of (Shin & Smith, 2001; Pesaran et al. 2001) bound testing approach applies to the equations 13 and 14. Linear ARDL Equations 1 and 2 decompose negative and positive series of LPDP and LPGP making the NARDL.

Results and Interpretation

We employed descriptive statistics in Table 2. The p-values of the JB test are greater than 10%, proving that this model is normally distributed (Sial et al. 2022; Wang et al., 2022).

Table 2

Descriptive Statistics

	LCPI	LPDP	LPGP	LREX	LURPOP
$\bar{X}$	4.143	3.182	3.677	4.684	17.796
$\bar{X}$	4.021	3.173	3.882	4.674	17.813
SD	0.723	1.077	0.767	0.088	0.274
Kurtosis	1.778	1.590	1.649	1.533	1.854
Jarque-Bera	1.928	2.619	2.951	3.102	1.829
P-value	0.381	0.270	0.229	0.212	0.401

Table 3 reported the unit root test of the ADF and PP tests. It is reported that all variables become stationary at mixed order 1(0) and I(1).

Table 3

ADF and PP results

	PP		ADF	
	I(0)	I(1)	I(0)	I(1)
LCPI	-2.025	-3.362*	-0.262	-3.672**
LPGP	2.193	-2.684*	1.281	-2.772*
LPDP	-0.087	1.666**	-1.973**	0.794
LREX	-1.058	-4.009*	-1.072	-4.140*
LURPOP	-8.688*	-1.394	-2.741***	-1.344

Note. ***, **, *demonstrate level of significance at 1%, 5% and 10% respectively

In the next step, we found the variance inflation factor (VIF). Table 3 demonstrated the results of VIF and found that all observations are less than

10, so there is no multicollinearity issue in the model (Amjad et al., 2022; Shahzad et al., 2022).

Table 4

VIF Results

Model 1			Model 2		
	LPGP	LREX		LPDP	LURPOP
LPGP			LPDP		
LREX	1.445		LREX	1.445	
LURPOP	3.655	1.450	LURPOP	3.930	1.387

In Table 5, the NARDL bound test is used to determine whether the models have long-run co-integration. It demonstrated that long-term

co-integration exists in both models since F-statistic values are bigger than the upper critical constraint.

Table 5

Bounds testing of NARDL

	F-statistic	Lower Bound I(0) 90%	Upper Bound I(1) 90%	Decision
Model 1	10.578	1.9	3.01	Exist long run co-integration
Model 2	22.392	1.9	3.01	Exist long run co-integration

Table 6 shows the coefficients of NARDL models. In models 1 and 2, the ECT_{t-1} is negative and significant, proving that our models can recover. In model 1, LPDP is decomposed into LPDP+ and LPDP- series. It shows that a 1% increase in LNPDP+ significantly increases LCPI by an average of 0.918% while a 1% decline in LPDP significantly enhances LCPI by an average of 0.191%. In simple words, the positive and negative shocks in LPDP increase LCPI in Pakistan. These results have supported the finding of (Zakaria et al., 2021; Lily et al., 2021). To check the asymmetric effect of LPDP on LCPI wald test is applied in Table 7. The P-value of LPDP is statistically significant, proving the evidence of the asymmetric effect of LPDP on LCPI. So, we reject the null hypothesis that PDP

has a linear relationship with inflation. In model 2, a one percent increase in LPGP+ significantly increases LCPI by an average of 1.013% while a one percent decline in LPGP- significantly increases LCPI by an average of 0.633%. To test the validity of the asymmetric relationship Wald test is applied in table 7. The P-value of LPGP is statistically significant shows that we reject our null hypothesis that PGP has a linear relationship with inflation.

Figure 1 shows the dynamic multiplier graph of LNPDP and LNPGP sufficiently flexible to accommodate asymmetries. It allows tracing the asymmetric adjustment patterns following negative and positive shocks to the LNPDP and LNPGP in models 1 and 2.

Table 6

Coefficients of NARDL

Long run coefficients		
Variable	Model 1:ARDL(1, 1, 0, 0, 1)	Model 2: ARDL(1, 2, 2, 1, 1)
LPDP+	0.918* (0.076)	
LPDP-	-0.191* (0.044)	
LPGP+		1.013* (0.041)
LPGP-		-0.633* (0.079)
LREX	-0.626*** (0.343)	-0.396*** (0.215)
LURPOP	0.078 (0.072)	0.123** (0.043)
Short run Coefficients		
D(LPGP)+	0.171** (0.065)	
D(LPGP)-	-0.053* (0.017)	
D(LPGP)+		0.085*** (0.047)
D(LPGP(-1))+		-0.324* (0.055)
D(LPGP)-		0.603* (0.181)
D(LPGP(-1))-		0.472* (0.183)
D(LREX)	-0.174** (0.085)	0.167*** (0.088)

D(LURPOP)	38.415* (6.119)	32.416* (4.316)
CointEq(-1)	-0.278* (0.050)	-0.380* (0.036)

Note. ***, **, * demonstrate significance level at 1%, 5% and 10%, respectively while standard error in ().

In both models, the depreciation in the real exchange increases domestic inflation. In model 1, a 1 percent increase in the LREX causes to decline in LCPI by 0.626 percent, while in model 2 decline in inflation by 0.396 percent (Similar findings were Abubakar et al. 2021; Pham et al. 2020). Urbanization shows a positive relationship

with inflation. In Model 1, this relationship is statistically insignificant; in Model 2 this relationship is statistically significant. In Model 2, a 1% increase in urbanization causes inflation to increase by 0.123%. These results are similar to the famous Phillips curve.

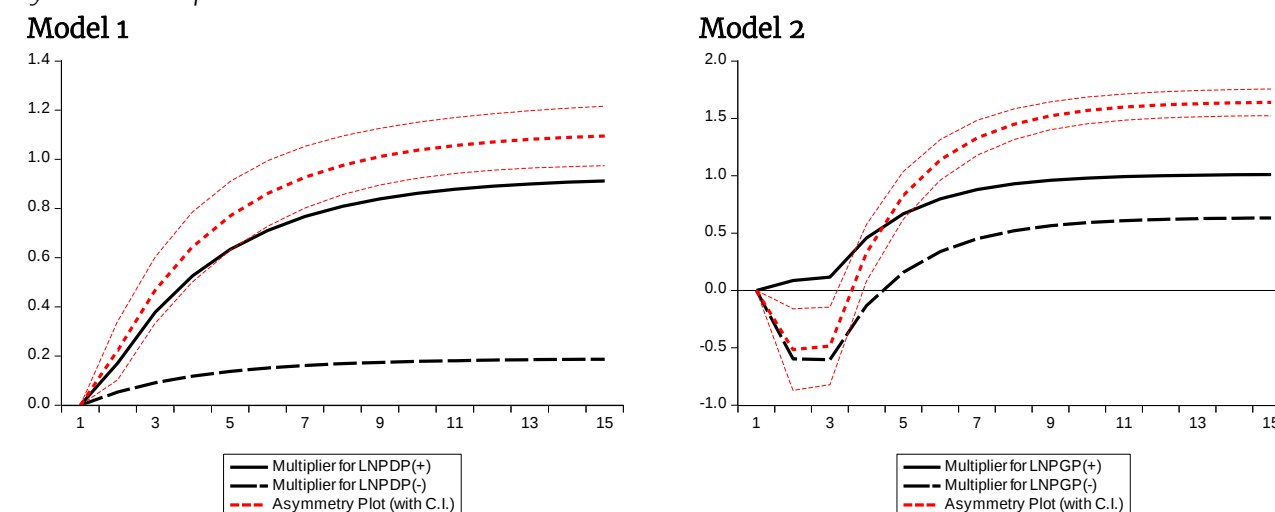
Table 7

Results of the Wald Test

Variables	t-statistic(Prob.)	Decisions
LPDP	6.368(0.000)	Existence of an asymmetric relationship
LPGP	7.825(0.000)	Existence of an asymmetric relationship

Figure 1

Dynamic multiplier



After analysis of NARDL models, we applied the necessary diagnostic tests in Table 8. The probability values of all diagnostic tests are

statistically insignificant. So, we accept the null hypothesis of all diagnostic tests.

Table 8

Diagnostic test

	P-values of Model 1	P-values of Model 2
Serial Correlation	0.434	0.128
Functional Form	0.958	0.906
Normality	0.602	0.541

Heteroscedasticity

0.232

0.379

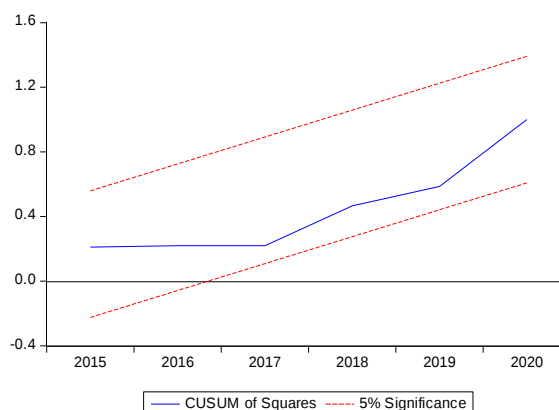
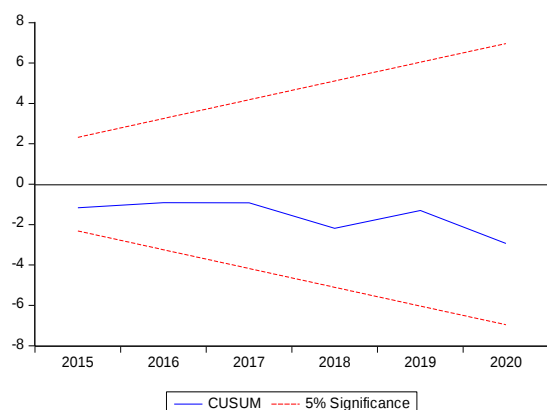
CUSUM and CUSUMQ tests are presented in Figure 2 to check the stability of the models. These models are stable because CUSUM

residuals graphs are within the limits of 5 percent significance.

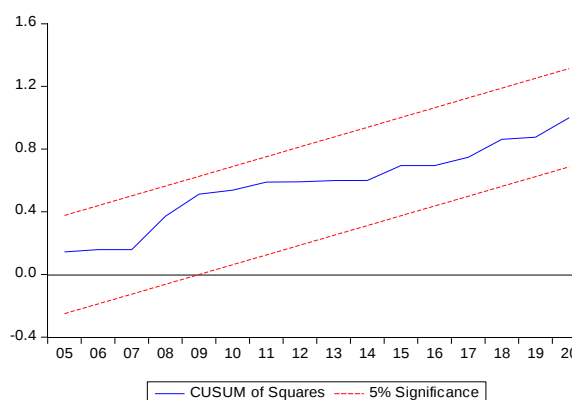
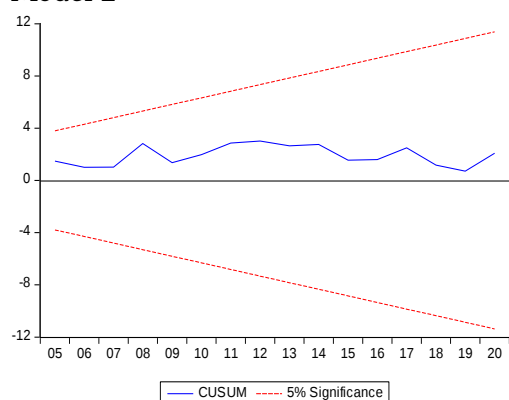
Figure 2

Stability of the Model

Model 1



Model 2



Conclusion and Policy Recommendations

This study has explored the causes of higher inflation based on energy prices by using the NARDL from 1990 to 2020 in Pakistan. Here inflation is measured by using the proxy of the Consumer Price Index (CPI) as the dependent variable; on the other hand, energy prices are calculated by Pump Diesel Prices (PDP) and Pump Gasoline Prices (PGP). Two models are constructed to determine inflation, in Model 1, PDP, while in Model 2, PGP is used as the leading independent variables, while real effective exchange rate (REX) and urbanization (URPOP)

are used as the control variables in both models. To check the stationarity of the data set ADF) test and PP test are applied. All series become stationary at mixed order at $I(0)$ and $I(1)$ so, it fulfils the precondition of the NARDL. F-statistic values are greater than the upper critical bound, which shows co-integration exists in the long run. The NARDL coefficient demonstrated that both PDP and PGP have a positive asymmetric relationship with inflation in Pakistan. On the other hand, the depreciation in REX and URPOP raises inflation in Pakistan. The diagnostic test argued that the model is well-fitted and stable.

Pakistan does not have enough domestic energy output to meet domestic needs. As a result, it imports straight from the worldwide market. Oil and petrol prices in the worldwide market are not steady and change regularly. These changes always have a negative impact on the domestic economy and produce inflation. Increases in oil and petrol prices typically raise production costs since they directly impact the industrial sector. According to the findings of this study, the Pakistani government should work to reduce its reliance on foreign energy resources. As a result, the government of Pakistan should prioritise cheaper, renewable, and local energy supplies to meet the economy's energy needs.

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