



Exchange rate pass-through and inflation targeting regime under energy price shocks

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ABSTRACT

The global surge in energy costs poses a significant obstacle for the attainment of price stability by the central banks across the world. This obstacle is further magnified for the economies that adopt an inflation-targeting framework and a flexible exchange rate regime. To overcome this challenge, our study attempts to answer whether inflation targeting can achieve price stability if an exchange rate pass-through exists, especially in the presence of energy price shocks. The study uses secondary data from twenty-one inflation-targeting economies for the period 1997–2020 and applies the non-linear autoregressive distributive lag (NARDL) model to test the hypotheses empirically, considering the possible asymmetries. The results confirm that exchange rate depreciation increases domestic price levels, while exchange rate appreciation reduces them in the long run. The study also finds that rising energy prices contribute to higher inflation in inflation-targeting economies. These findings suggest that inflation-targeting economies face a serious challenge in maintaining their core price stability goal due to exchange rate pass-through especially during energy price shocks. The results invite authorities of IT economies to re-evaluate their policy framework that conveniently ignores exchange rate pass-through by requiring a mandatory floating exchange rate regime.

1. Introduction

The history of the Inflation Targeting (IT) framework can be traced back to the 1990s when monetary authorities recognized price stability as their core objective [(Calvo, 1978; Kydland and Prescott, 1977). New Zealand was the first country to adopt this framework in 1990 and since then approximately half of the former socialist nations in Europe and Central Asia have embraced this framework (Arsić et al., 2022). Currently, 45 central banks worldwide follow this framework, and many others are gearing up to adopt the same. The popularity of the IT framework stems from the widespread acceptance of certain macro-economic beliefs; for example, there is no long-run trade-off between output and inflation, the monetary policy only affects prices in the long run, and low inflation fosters long-run economic growth and efficiency (Ball and Reyes, 2008; Barro et al., 1983; Bernanke and Mishkin, 1997; Kydland and Prescott, 1977; Calvo, 1978). These beliefs are also

supported by the evidence that if monetary authorities focus on price stability, other monetary objectives are achievable in the long run (Aron et al., 2014; Ha et al., 2020; Pham et al., 2022).

Nonetheless, researchers have raised the concern that “price stability” is difficult to achieve under the IT framework as it requires economies to follow a floating exchange rate regime (Rizvi et al., 2017). Floating rate choice is evoked by the idea of the Impossible Trinity, which postulates that monetary authorities can only achieve two of the three objectives: *independent monetary policy*, *exchange rate stability*, and *financial integration* (Fleming and Mundell, 1964). According to (Mishkin and Schmidt-Hebbel, 2007), if inflation targeting improves the credibility of monetary policy and keeps inflation expectations anchored, it is expected to reduce the responsiveness of domestic prices to exchange rate shocks. The evidence suggests, however, that the IT economies often experience high fluctuations in their exchange rates, which eventually get translated into their domestic prices (Berganza and Broto, 2012;

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Nasir and Vo, 2020). More importantly, if the IT economies are also dependent on imports, a minor decline in the exchange rate causes a substantial increase in import prices, leading to a rise in domestic price levels and consequent price instability (Simo-Kengne et al., 2020). Among several factors that may cause volatility in the exchange rate (e. g., credibility, monetary instability, foreign debts, trade deficit), energy price shocks stand out which exacerbate the challenge of price stability in the presence of the floating exchange rate regime and integrated financial system (Habib et al., 2016; Anjum, 2019; Fasanya et al., 2022; Hashmi et al., 2022; Volkov et al., 2016; Zhang et al., 2022).

Since the pandemic outbreak in 2019, the world has experienced high volatility in energy prices. In February 2020, the price per barrel of oil dropped from \$55.66 to \$32.01 and touched \$18.38 per barrel in April 2020 due to demand shocks (Sharif et al., 2020). However, as the global economy started recovering, the excessive stock of fuel accumulated in 2020 gradually wore out with the new normal, and prices shot up¹ (Longley and Blas, 2020). Moreover, the disruption in global supply chains caused by the pandemic resulted in a worsened imbalance between supply and demand, eventually leading to a sharp rise in oil prices when in June 2022, the price of oil per barrel touched \$122.7. Many economists argue that post-pandemic energy price shocks are already driving inflation up globally, and the monetary authorities are worried as their credibility of anchoring the inflation expectation and maintaining price stability could be jeopardized if energy prices keep fluctuating (Li and Guo, 2021; Nasir et al., 2019; Nasir et al., 2020a). This problem is especially precarious for the economies that adopted *price stability* as their core monetary objective under the Inflation Targeting (IT) framework and followed a floating exchange rate regime. As Ball and Reyes (2008) suggested if the monetary authorities are not intervening in the forex markets during the macro-economic instability period to control currency depreciation, the ultimate result would be a significant increase in price instability, coupled with high price variations or inflation volatility (Rizvi et al., 2014; Rizvi and Naqvi, 2008) and volatile exchange rates. We believe this is the dilemma of monetary authorities in IT economies to choose between price stability and floating exchange rate.

Given the exogeneity of energy prices shocks putting pressure on domestic prices, along with the presence of floating exchange rate regime, we question the suitability of IT approach and exchange rate flexibility to achieve price stability. Specifically, we question “*does inflation targeting achieve price stability if there exists a high exchange rate pass-through owing to floating exchange rate regime especially in the presence of energy shocks*”. Our study makes important contributions. First, it provides fresh evidence on the inflation targeting economies and adds to the recent discussion on price stability as post-Covid price stability has emerged as the biggest global challenge (Nasir, 2020). Second, we measure the size and the magnitude of exchange rate pass-through to domestic prices (ERPT) while accounting for the recent episode of energy shocks as an independent exogenous variable. Third, we estimate ERPT considering possible asymmetries in order to get more promising insights into the effectiveness of the IT framework in achieving price stability targets.

Over the years, researchers have examined the ERPT to domestic prices under different monetary policy frameworks. However, the magnitude and the speed of ERPT to domestic prices (high or low) remains an unsolved paradox. The literature is divided as some researchers report low ERPT (Ball and Reyes, 2008; Devereux and Yetman, 2002; Edwards and Cabezas, 2022; Wu et al., 2017); while others report high ERPT (Ben Cheikh and Louhichi, 2016; Delatte and López-Villavicencio, 2012; Dilla et al., 2017; Engel, 2002; Pham et al., 2020; Simo-Kengne et al., 2020; Yeyati, 2006) in inflation targeting economies. However, we observe that most studies have employed standard

econometric techniques (i.e., VAR, VECM, GMM etc.) to calculate the size and speed of ERPT. The major drawback of these methods is their inability to capture possible asymmetries while estimating ERPT (Deluna et al., 2021). Based on the linear estimates, policymakers ignore how exchange rate shocks affect inflation because domestic prices respond asymmetrically to exchange rate fluctuations. Keeping this in view, we make a contribution to the literature and use non-linear autoregressive distributed lag (NARDL) approach to estimate the asymmetric ERPT.

The rest of the paper is organized as follows. Section 2 provides a review of relevant literature. Section 3 describes our methodology and econometric model. With the description of data in Section 4, Section 5 has the results of our model and the discussion of our results. We conclude the paper in Section 6 with policy recommendations while also acknowledging some of the limitations of our work.

2. Literature review

2.1. Inflation targeting (IT) and exchange rate pass-through to prices (ERPT)

Despite decades of research, the speed of ERPT to domestic prices (high or low) remains an unsolved paradox. The studies on ERPT are important because: 1) ERPT has far-reaching implications for monetary policies; 2) A high ERPT makes inflation forecasting difficult for monetary authorities (Taylor, 2000); 3) A high ERPT impacts domestic prices and affects the current account position (Woo and Hooper, 1984); 4) A high degree of ERPT is frequently a reason for a country to “Fear” floating exchange rates and hence justifies the intervention of foreign exchange markets (Ball and Reyes, 2008; Nogueira, 2006); and 5) ERPT limits the feasibility of independent monetary policy, and its understanding is a key to good monetary management.

This section reports recent and essential studies to understand how IT and ERPT are interlinked. We sub categorize the studies into two sections with reference to the findings to get a better understanding of ERPT.

2.1.1. Studies on IT and high ERPT

First-strand of researchers recognize IT's inept of achieving price stability. This strand reports that IT economies often experience high ERPT, which later translates into high domestic prices and hence creates hurdles in achieving the price stability target. For instance, Berganza and Broto (2012) conducted their research on IT and non-IT economies and found high ERPT for the economies that follow IT framework and low ERPT for the economies that follow the non-IT framework. Edwards and Cabezas (2022) performed their research on Iceland, which follows flexible inflation targeting regime. The study reported that the domestic prices of Iceland do not change much in response to exchange rate fluctuations. Hence, the author concluded low ERPT for the economies that follow non-IT frameworks. Nasir and Vo (2020) showed high ERPT and inflation patterns in nations that follow IT framework. The authors concluded that the IT framework is often aligned with high volatility in the exchange rates, which increases the overall domestic prices and reduces price stability. Karagöz et al. (2016) found High ERPT for the case of the Asia Pacific region, which also strives to achieve price stability as its core monetary policy objective. Kinda and Barry (2021) examined the impact of ERPT on import prices in West African economies, revealing that a 1% depreciation of the exchange rate resulted in a 0.25% increase in import prices. Their findings demonstrate that ERPT exerts a persistent and substantial influence on import prices, with a 1% increase in ERPT leading to a 0.83% increase in import prices. Ben Cheikh and Louhichi (2016) did similar research and revealed that countries with higher inflation rates experience high ERPT and volatile prices. Ben Cheikh and Ben Zaied (2020) assert that inflation regime serves as the primary driver of exchange rate pass-through (ERPT). The study finds that if inflation exceeds a threshold of 4.56%, the degree of

¹ <https://www.worldoil.com/news/2020/12/11/oil-prices-find-new-strengthen-as-financial-markets-prepare-for-a-2021-recovery>

ERPT in transition economies will be significantly high. Nasir et al. (2020b) directed their attention to exploring the connection between inflation expectations and ERPT and identified a significant relationship between these two variables. Valogo et al. (2023) investigated the influence of ERPT on inflation and found a high ERPT. The study revealed that the depreciation in the exchange rate beyond the monthly threshold of 0.70% can lead to a potential rise in inflation. The study advises monetary authorities to closely monitor the exchange rate levels to regulate policy rates and control ERPT-induced inflation. Anderl and Caporale (2023) analyzed the ERPT to consumer and import prices in both IT and non-IT countries and found a high ERPT. The impact was significant in both types of economies, but more pronounced in inflation-targeting economies. Some other researchers (Ben Cheikh and Louhichi, 2016; Delatte and López-Villavicencio, 2012; Dilla et al., 2017; Engel, 2002; Pham et al., 2020; Simo-Kengne et al., 2020; Yeyati, 2006) also reported high ERPT for the economies that follow the IT framework. Nasir and Simpson (2018) also provided strong evidence of a high ERPT, despite the implementation of inflation targeting policies. An analysis of this strand identifies some critical reasons “*why IT economies often experience high ERPT*”. Some important reasons include:

1. The economies that follow the IT framework must leave their exchange rates freely floating, which often results in high exchange rate volatility. This volatility is translated into import prices and domestic prices (Pham et al., 2022). Related to this argument of import prices, is the idea that imports are mostly intermediary products priced in foreign currency. While retail prices are set in the domestic currency but intermittently adjusted for increased costs (Engel, 2002). Therefore exchange rate variations through hikes in import prices translate into retail pricing (Simo-Kengne et al., 2020).
2. IT economies frequently experience high ERPT due to the monetary authorities' lack of credibility (Dilla et al., 2017).
3. High ERPT is often a result of the nonintervention of the central bank in the forex market. For instance, if central banks are not controlling currency depreciation, the ultimate result will be high price fluctuations.
4. Economies experience high ERPT during their macroeconomic instability period (i.e., during economic recessions and financial crises). The possible justification is that when nations are in bad macroeconomic conditions, foreign enterprises may seek to transmit greater exchange rate movements due to the possibility of importer's default risk. Under this condition, since exporters set pricing in their own currency (e.g., producer currency pricing strategy), ERPT would be higher (Wu et al., 2017).
5. IT economies often experience higher ERPT if they are highly dollarized. This is so because dollarization causes instability in money demand, increasing the likelihood of banking crises due to the devaluation of the home currency. Hence, economies face high ERPT (Yeyati, 2006).

2.1.2. Studies on IT and low ERPT

The second strand of researchers, however, recognize IT as a conduit to achieving the core objective of “price stability”. This strand argues that IT economies often experience lower ERPT because exchange rate variations in IT economies are less compatible with their price variations (López-Villavicencio and Pourroy, 2022). For instance, Aron et al. (2014) conducted their research and found slower ERPT to import prices for South Africa under the IT framework. This implies that the import prices of the nations that follow the inflation targeting framework are less sensitive to exchange rate fluctuations. Peer and Baig (2021) also found a significant decline in ERPT under an inflation-targeting regime. Poghosyan (2021) performed their analysis on seven Caucasus and Central Asian (CCA) economies to estimate the degree and speed of ERPT. The study showed CCA nations faced a decline in ERPT after the global financial crises as these economies entered a relatively low inflationary environment. López-Villavicencio and Pourroy (2019)

identified the significant association between ERPT and inflation and concluded that the countries with IT regimes tend to experience lower ERPT. Ha et al., (2020) also provided empirical evidence of low ERPT in economies adhering to the IT. Ndou (2022) documented the same for the case of South Africa, where a slow ERPT was observed within the targeted inflation rate of 3–6%. Some other researchers (Ball and Reyes, 2008; Devereux and Yetman, 2002; Edwards and Cabezas, 2022; Wu et al., 2017) also reported low ERPT for the economies that follow price stability as their core monetary objective. An analysis of this strand highlights some rationale behind “*why IT economies often experience low ERPT*”. Some important reasons include:

1. ERPT is sensitive to the choice of monetary policy; and the phenomenon of delayed price adjustment (sticky pricing) gives a plausible explanation for the slower ERPT to domestic prices (Devereux and Yetman, 2002)
2. Central banks typically raise interest rates to protect the currency value and to prevent exchange rate fluctuations from translating into domestic prices. These actions of the central banks impede the exchange rate volatility transmission to the domestic price volatility, leading to lower ERPT (Ball and Reyes, 2008).
3. IT economies often experience low ERPT because the central banks use exchange rate as a shield against external shocks to stabilize inflation (Ha et al., 2020).
4. Establishing a low inflationary environment (Taylor, 2000) and a strong monetary policy credibility (Edwards and Cabezas, 2022) under IT regime is another reason of declining ERPT.
5. Economies experience low ERPT during stable macroeconomic periods. A possible justification for this is that when macroeconomic conditions are favorable, exporting countries can pass on price changes due to currency volatility within a certain acceptable limit. This is achieved by setting prices in the currency of the more stable importing country, a practice known as local currency pricing (Wu et al., 2017).

In sum, it is evident that the findings on the IT-ERPT nexus are mixed. Two schools of thought have compelling reasons and there is no consensus regarding the speed of ERPT, even in inflation-targeting economies. However, researchers agree that ERPT, whether high or low if it exists, significantly affects prices. Moreover, the asymmetries of exchange rate fluctuations may also affect the findings, especially in the recent context of surging energy prices. Therefore, the present study contributes to the ongoing debate on the IT-ERPT nexus after considering possible asymmetries in exchange rate movements and also includes energy price shocks as an exogenous variable to provide fresh evidence on the resilience of IT framework and floating exchange rate regime in achieving the objective of price stability. Specifically, we test the following hypotheses:

H₁. There is a significant high exchange rate pass-through in inflation targeting economies following the floating exchange rate regime.

H₂. There exist possible asymmetries in the pass-through in inflation targeting economies following the floating exchange rate regime.

3. Methodology

The objective is to estimate exchange rate pass-through while considering possible asymmetries in the relationship between exchange rate and inflation to avoid misleading estimates. To achieve this purpose, we primarily rely on Non-Linear Autoregressive distributed Lags (NARDL) and analyze the impact of Exchange Rate Movements on Inflation, while controlling for economic variables that could affect inflation too. These variables include Policy Rate, Output, Monetary base, International Reserves, Foreign Interest Rate, and Oil Prices. The exchange rate and domestic price index are the key variables of interest. Oil prices and foreign interest rates are included to capture supply

shocks whereas the other variables are included to control their potential influence on exchange rate pass-through.

Before estimations, we convert all variables into standardized forms to avoid biases in the results.

The standard form of the model is presented in eq. (1).

$$INF_{it} = \beta_0 + \beta_{INF} INF_{i,t-k} + \beta_{ER} ER_{i,t-k} + \beta_{PR} PR_{i,t-k} + \beta_{GDP} GDP_{i,t-k} + \beta_{MB} MB_{i,t-k} + \beta_{IR} IR_{i,t-k} + \beta_{FI} FI_{i,t-k} + \beta_{OP} OP_{i,t-k} + u_{it} \quad (1)$$

Referring to eq. (1), β_0 is the intercept; β_i are the slope coefficients, INF is the inflation rate, which is significantly predicted by its lagged values (INF_{t-k}), exchange rate (ER), policy rate (PR), Output (GDP), monetary base (MB), international reserves (IR), foreign interest rate (FI) and oil prices (OP), u is the error term, i is the cross section and t denotes time period.

The underlying assumption of eq. (1) is that all the regressors are affecting the regressand symmetrically. However, our purpose is to test the asymmetric impact of exchange rate movements on the domestic price volatility. Accordingly, we decompose exchange rate into its negative and positive components to check the isolated impact of exchange rate appreciation and depreciation on price movements. Thus, eq. (1) is modified as:

$$INF_{it} = \alpha_0 + \alpha_1 INF_{i,t-k} + \alpha_2 ER^+_{i,t-k} + \alpha_3 ER^-_{i,t-k} + \alpha_4 PR_{i,t-k} + \alpha_5 GDP_{i,t-k} + \alpha_6 MB_{i,t-k} + \alpha_7 IR_{i,t-k} + \alpha_8 FI_{i,t-k} + \alpha_9 OP_{i,t-k} + u_{it} \quad (2)$$

Referring to eq. (2), α_i are the cointegrating vectors having the long run parameters. ER^+ and ER^- are the partial sum of positive and negative movements in the exchange rate, which is specified as follow:

$$ER^+_{it} = \sum_{k=1}^t \Delta ER^+_{it} = \sum_{k=1}^t \max(\Delta ER^+_{it}, 0) \quad (2.1)$$

$$ER^-_{it} = \sum_{k=1}^t \Delta ER^-_{it} = \sum_{k=1}^t \max(\Delta ER^-_{it}, 0) \quad (2.2)$$

After formulating eq. (2), we expect the different impacts of exchange rate appreciation and depreciation on domestic prices, which can also be justified with the help of empirical and theoretical support. For instance, theoretically, exchange rate appreciation tends to reduce Inflation while exchange rate depreciation tends to increase it. However, the extent to which the effect of exchange rate appreciation and depreciation is being translated into the prices might differ. For instance, the impact of exchange rate depreciation on prices might be stronger than exchange rate appreciation (i.e., $\alpha_2 > \alpha_3$) in our case. At this point, we can transform eq. (2) into a NARDL setup.

Accordingly, eq. (2) is modified as follows:

$$\begin{aligned} \Delta INF_{it} = & \beta_0 + \beta_1 INF_{i,t-k} + \beta_2 ER^+_{i,t-k} + \beta_3 ER^-_{i,t-k} + \beta_4 PR_{i,t-k} + \beta_5 GDP_{i,t-k} \\ & + \beta_6 MB_{i,t-k} + \beta_7 IR_{i,t-k} + \beta_8 FI_{i,t-k} + \beta_9 OP_{i,t-k} + \sum_{k=1}^p \alpha_i \Delta INF_{i,t-k} \\ & + \sum_{k=0}^q \left(\delta_i^+ \Delta ER^+_{i,t-k} + \delta_i^- \Delta ER^-_{i,t-k} \right) + \sum_{k=0}^q \gamma_i \Delta PR_{i,t-k} \\ & + \sum_{k=0}^q \theta_i \Delta GDP_{i,t-k} + \sum_{k=0}^q \vartheta_i \Delta MB_{i,t-k} + \sum_{k=0}^q \eta_i \Delta IR_{i,t-k} \\ & + \sum_{k=0}^q \rho_i \Delta FI_{i,t-k} + \sum_{k=0}^q \varphi_i \Delta OP_{i,t-k} + e_{it} \end{aligned} \quad (3)$$

Referring to the above equation, p and q is the lag order which might differ for the dependent and independent variables; $\alpha_1 = \frac{-\beta_2}{\beta_1}$; $\alpha_2 = \frac{-\beta_3}{\beta_1}$ are the abovementioned LR impacts of positive and negative movements in the ER on π (see Eq. 2). $\sum_{k=0}^q \delta_i^+$ signifies the SR impact of exchange rate appreciation on domestic prices while $\sum_{k=0}^q \delta_i^-$ Signifies the SR impact of exchange rate depreciation on domestic prices.

Before applying NARDL, the study undergoes some precautionary tests to ensure that data is free from possible econometric errors. One advantage of NARDL is that it can be employed if variables are I (0), I (1), or both [I (0), I (1)]. So, whatever the integrated order of variables will be, we can move forward with NARDL (Shin et al., 2014). NARDL produce efficient estimates even for the case of small data sets. (Adabor, 2022; Shin et al., 2014). This approach is also robust against the issue of endogeneity, as it allows for lagged values of the independent variables and includes an error correction term. In addition, NARDL model allows capturing both short-term and long-term dynamics between the variables. The appealing feature of NARDL is its non reliance on any separate cointegration test to examine the long-run association among variables. Its build-in bound testing approach immediately reveals whether or not the chosen study variables move together in the long run (Shin et al., 2014). After estimating the NARDL model, the bounds cointegration test is employed to evidence the cointegration among modeled variables. This step allows us to test the null hypothesis $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = 0$. Rejection of null hypothesis implies that modeled variables move together in the LR. Finally, Wald test is employed to check if exchange rate movements have some asymmetric impact on domestic prices or not. Significant test statistics of the wald test indicate asymmetric association among variables. Contrarily, insignificant test statistics of the wald test show the symmetric association among variables. However, concerning price increases, we also calculated the cumulative asymmetric effects of a 1% shift in exchange rate via dynamic multiplier; viz.,

$$m_h^+ = \sum_{j=0}^g \frac{\partial y_{t+j}}{\partial ER_{t-1}^+}, m_h^- = \sum_{j=0}^g \frac{\partial y_{t+j}}{\partial ER_{t-1}^-}, g = 0, 1, 2 \quad (4)$$

Referring to eq. (4), as $g \rightarrow \infty$, $m_h^+ \rightarrow \alpha_1$ and $m_h^- \rightarrow \alpha_2$.

It is important to highlight that the NARDL approach has several advantages over other linear methods. First, NARDL remains one of the most versatile techniques to capture the non-linear and asymmetric relationship among variables (Pham, 2019). Second, there is no need to formulate complex systems of equations to calculate the ERPT. Third, the results of NARDL are also not sensitive to the order of variables, and last but not the least, NARDL provides a more insightful understanding of the interaction between exchange rate shocks and price volatility (Goh et al., 2022).

4. Data

Table 1 shows the classifications of exchange rate regimes of the nations that follow IT as their monetary policy framework. The table indicates that, out of 45 inflation targeting economies, 36 (or 80%) follow the floating exchange, 8 (or 18%) follow the soft pegged exchange rate regime, and 1 (or 2%) are those that follow other than floating and pegged exchange rate regimes.

We collected the annual data of 21 out of 36 Inflation targeting economies over the period of 1997–2020 to analyze the results. These countries include Albania, Armenia, Australia, Brazil, Chile, Colombia, Czech Republic, Hungary, Iceland, India, Indonesia, Jamaica, Japan, Mexico, Moldova, Paraguay, Peru, Seychelles, South Africa, Uruguay, and Ukraine. Total of 15 IT economies have been excluded from the sample due to insufficient data availability. We choose data from 1997 to 2020 due to the consistent availability of data during these years.

Table 1

Inflation targeting economies and their exchange rate regime.

Exchange rate arrangements	Floating exchange rate	Soft pegged	Residual	Total
Number of countries	36	8	1	45
Percentage	80%	18%	2%	100%

Source: “Annual Report of IMF on exchange arrangements and exchange restrictions (2021)”.

Table 2
Key variables.

Variable	Description/ proxy	Unit of measurement	Data source	Abbreviation
Inflation	Consumer price index (2010 = 100)	Index	WDI	INF
Exchange rate	Official exchange rate (LCU per US \$, period average)	US\$	WDI	ER
Policy rate	Lending interest rate (%)	%	WDI	PR
Output	GDP (constant 2015 US\$)	US\$	WDI	GDP
Monetary base	Broad money (current LCU)	US\$	WDI	MB
International reserves	Total reserves (includes gold, current US\$)	US\$	WDI	IR
Foreign interest rate	US interest rate	%	WDI	FI
Oil prices	Global crude oil prices, current US \$ per cubic meter	US\$ per cubic meter	Our World in data	OP

Moreover, after the Asian Financial Crisis of 1997, the idea became a very popular belief that it is impossible to have a stable exchange rate and consequently, all central banks should move towards a flexible exchange rate regime. This is how they will be able to have monetary policy independence in an increasingly financially open environment. The data was retrieved from two secondary sources, WDI and our World in Data. The details of our key variables are shown in Table 2.

5. Results and discussions

5.1. Descriptive statistics

We begin our analysis by reporting the descriptive statistics of our standardized variables (See Table 3). The table shows the “zero mean” and “one standard deviation” for all the relevant variables, which is the property of such transformation. The idea behind the standardized transformation of variables is to convert all the relevant variables into an equally weighted scale to avoid biases in the results.

5.2. Multicollinearity results

Detection of multicollinearity is of utmost importance to obtain unbiased and consistent estimates. The present study relies on the correlation matrix to detect this problem. Results are presented in Table 4, which are quite satisfactory. Outcomes reveal that the problem of multicollinearity does not exist in the data, as the coefficient of correlation between most pairs of two explanatory variables is less than 0.7.

5.3. Stationarity results

The choice of estimation technique is based on the order of

integration/stationary properties of variables. To this end, the test of stationarity is important. We employed two different unit root tests [i.e., LLC and IPS] to confirm the stationarity properties of the variables. Both tests detect the unit root problem under the null hypothesis of “non-stationary series.” The tests are applied to the chosen variables in their level form and by taking their first difference under two conditions, i.e., (without trend and with trend). Results are reported in Table 5, which reveals that all the variables suffer from the problem of unit root at level except PR and FI. However, when we take their first difference, all the variables become stationary by rejecting the null hypotheses at a 1% significance level. Results elucidate that chosen studied variables are integrated into mix order.

5.4. NARDL results

Based on the inferences drawn from the results of unit root tests, we move forward with NARDL approach to test the hypothesized relationship among modeled variables. Results of NARDL are presented in Table 6, consisting of two panels. Panel A reports the results of LR estimations”, while “panel B report the results of SR estimations.

5.4.1. Exchange rate movements (ER)

The coefficient of exchange rate depreciation [ER (POS)] and exchange rate appreciation [ER (NEG)] are significant at the level of 1% in long run while insignificant in short run. At first glance we observe that exchange rate depreciation positively, while exchange rate appreciation negatively impacts the domestic prices of inflation-targeting economies in the long run. After that we observe that the effect of depreciation is stronger than appreciation. For instance, exchange rate depreciation tends to increase domestic prices by 2.868 units, while exchange rate appreciation tends to reduce it by 2.846 units. The results indicate a noticeable asymmetric impact of the exchange rate on inflation, which aligns with those studies that conclude that the exchange rate movements are generally translated into domestic prices and creating a high *ERPT* for *IT* economies. (Berganza and Broto, 2012; Karagöz et al., 2016; Delatte and López-Villavicencio, 2012). The findings are also consistent with those of (Baharumshah et al., 2017; Bhat and Bhat, 2021; Pham et al., 2020), who conclude that the impact of exchange rate appreciation and depreciation might differ on domestic prices in terms of its magnitude, and also with (Baharumshah et al., 2017), who calculate the asymmetric *ERPT* for the *IT* economies and find High *ERPT* in case of exchange rate depreciation. Asymmetric *ERPT* occurs because the effect of exchange rate appreciation and depreciation differently translates into domestic prices. We take the support of the following argument to justify the asymmetric *ERPT*. Imports are normally priced in foreign currency and when the exchange rate depreciates, imports become expensive. The retail price of the imports are set in domestic currency which is intermittently adjusted for increased costs (Engel, 2002), and therefore, the effect of exchange rate depreciation quickly translates into the retail pricing (Simo-Kengne et al., 2020). The opposite is true when the exchange rate appreciates. Therefore, *IT* economies, particularly those that are developing, often fear from the exchange rate depreciation as it makes the issue of price stability more difficult to achieve (Rizvi et al., 2012).

Table 3
Descriptive statistics.

Variables	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
INF	0.000	0.007	5.276	−2.058	1.000	0.971	5.929
ER	0.000	−0.348	5.701	−0.366	1.000	3.427	14.852
IR	0.000	−0.336	5.576	−0.411	1.000	4.324	23.009
MB	0.000	−0.266	9.120	−0.268	1.000	5.830	41.258
OP	0.000	−0.102	1.766	−1.469	1.000	0.355	1.977
PR	0.000	−0.241	7.498	−1.112	1.000	2.556	12.684
FI	0.000	−0.387	2.070	−1.166	1.000	0.864	2.404
GDP	0.000	−0.429	4.213	−0.559	1.000	2.774	10.821

Table 4
Test of multicollinearity.

	INF	ER	IR	MB	OP	PR	FI	GDP
INF	1.000							
ER	0.034	1.000						
IR	0.162***	−0.050	1.000					
MB	0.141***	0.762***	0.272***	1.000				
OP	0.435***	0.008	0.147***	0.057	1.000			
PR	−0.335***	0.036	−0.186***	−0.129***	−0.300***	1.000		
FI	−0.550***	−0.043	−0.149***	−0.079*	−0.536***	0.333***	1.000	
GDP	0.133***	−0.033	0.293***	0.306***	0.055	−0.152***	−0.055	1.000

Note: *, and *** show the significance of results at the level of 10% and 1%, respectively.

Table 5
Test of stationarity.

		INF	ER	IR	MB	OP	PR	FI	GDP
<i>Panel A: Common Unit Root Test (Levin, Lin & Chu) [LLC]</i>									
Level	Without Trend	2.900	1.567	1.325	13.457	2.7885	−11.492***	−7.719***	3.693
	With Trend	−0.297	1.398	0.348	4.51519	1.88454	−12.975***	−3.382***	2.413
First difference	Without Trend	−5.315***	−8.749***	−7.114***	−5.248**	−11.5009***	−15.515***	−6.772***	5.776
	With Trend	−6.187***	−8.279***	−5.771***	−2.663***	−12.7982***	−12.884***	−3.756***	−8.831***
<i>Panel B: Individual Unit Root Test (Im, Pesaran and Shin) [IPS]</i>									
Level	Without Trend	8.882	2.271	5.510	17.895	2.028	−7.653***	−6.196***	0.661
	With Trend	1.210	1.248	0.627	10.756	4.181	−10.240***	−4.456***	0.998
First difference	Without Trend	−7.051***	−8.017***	−7.751***	−3.374**	−9.248***	−13.973***	−7.280***	−3.017***
	With Trend	−5.833***	−5.337***	−5.338***	−2.019**	−7.949***	−11.464***	−4.485***	−4.269***

Note: **, *, and *** show the significance of results at the level of 10%, 5%, and 1%, respectively.

Table 6
NARDL estimations.

Variables	Coeff.	P-Value
<i>Panel A: Long Run Results</i>		
constant	−0.127**	0.035
ER (POS)	2.868***	0.000
ER (NEG)	−2.846***	0.000
IR	−0.032**	0.003
MB	0.163***	0.000
FI	0.008	0.247
OP	0.016***	0.010
PR	0.841***	0.000
GDP	0.407***	0.000
<i>Panel B: Short Run Results</i>		
D(S_ER_POS)	32.740	0.189
D(S_ER_NEG)	16.738	0.518
D(S_IR_GOLD)	18.062	0.256
D(S_MB_\$)	−10.652	0.188
D(S_FI)	−0.016**	0.026
D(S_OP)	0.023***	0.016
D(S_PR)	−0.135	0.471
D(S_GDP)	−15.003	0.369
COINTEQ	−0.180***	0.003
S.E. of regression	0.045169	
Sum squared residual	0.481499	
Log likelihood	1060.265	

Note: **, and *** shows the significance of results at the level of 5% and 1% respectively.

5.4.2. International reserves (IR)

The coefficient of international reserves [IR] is significant at the level of 1% and is negative in the long run, posits that international reserves may be helpful in controlling domestic prices. Results are interesting and aligned with the findings of (Chițu, 2021; Padhan et al., 2021), who also concluded international reserves as a remedy for inflation. International reserves increase the value of home currency in terms of foreign currency (Padhan et al., 2021), which eventually translates into domestic

price stability. To this end, it is reasonable to conclude that international reserves also play a vital role in reducing the exchange rate variations to be translated into the domestic prices and achieve price stability. This happens because international reserves help the economies to achieve macroeconomic stability, and economies usually experience low ERPT during their stable macro-economic period (Wu et al., 2017). This is so because when the macroeconomic conditions are favorable, exporting countries can absorb the price changes within their acceptable thresholds. This can be done by basing their prices on the currency of the more stable importing country (i.e., the local currency pricing). The result does not confirm any significant relationship between these variables in the short run which is again justifiable because the impact of international reserves cannot be immediately translated into price stability.

5.4.3. Oil price (OP)

Results indicate that oil price tends to increase domestic prices. This effect was observed in the long as well as in the short run. Specifically, an increase in oil prices by one unit can lead to a corresponding increase of 0.016 and 0.023 units in the long and short run, respectively, for inflation-targeting economies. These findings align with previous studies that have identified oil prices as a potential barrier to achieving price stability targets (Deluna et al., 2021; Husaini and Lean, 2021; Kilian and Zhou, 2022; Nasir et al., 2020; Zakaria et al., 2021). Oil is an important raw material for producing goods and services. When oil prices experience a positive shock, production cost rises, resulting in an increase in prices of related goods. This price increase ultimately results in domestic inflation (Wen et al., 2021). Moreover, when oil price rises, it can have a negative impact on output and productivity, creating an energy demand and supply gap. This, in turn, raises the costs of production and results in an increase in domestic inflation (Bhat and Bhat, 2021). Moreover, most developing economies rely on imported oil to fulfill their demand requirements. Therefore, any oil price variations trigger the gales of inflationary pressures (Nasir et al., 2018). To this end, it is reasonable to conclude that oil price is a critical factor in affecting domestic prices.

In addition to oil prices, other control variables i.e., monetary base,

and output, are also significant in the long run but insignificant in the short run. The positive signs of the coefficients reflect their augmenting effects on domestic prices and these results are supported by the (Chîțu, 2021; Sinclair et al., 2008; Winkelried, 2014)).

6. Conclusion and policy recommendations

Energy prices have always been challenging for the monetary authorities struggling to fight price instability. Energy price shock is indeed the biggest artiste in pushing the inflation rates up and making the exchange rates volatile. A number of economists argue that post-pandemic energy price shocks are already driving inflation up globally, and the monetary authorities are worried as their credibility of anchoring the inflation expectation and maintaining price stability could be jeopardized if energy prices keep fluctuating. This problem is especially precarious for the economies that adopted price stability as their “core monetary objective” under the Inflation Targeting (IT) framework because, coupled with energy price shocks, these economies have their exchange rates floating which exposes them to additional vulnerabilities.

Our study reveals that exchange rate movements significantly impact domestic prices in inflation-targeting economies, posing a challenge to maintaining price stability. Our results also indicate that exchange rate depreciation has a stronger impact on domestic prices than exchange rate appreciation. It is essential to highlight that this strong exchange rate pass-through exists in addition to the impact of oil prices on domestic prices. The literature has frequently reported that exchange rate pass-through exists through the transmission channel of energy prices and our results completely support this idea that oil price shock affects domestic prices. However, this is not the whole story and the fact is when oil price enters as an exogenous variable, we can observe that the volatility in the exchange rate and the exchange rate depreciation create a larger impact on domestic prices.

Our results provide insightful implications for the monetary authorities of the IT economies. From a policy point of view, we suggest monetary authorities screen the exchange rate movements to formulate the appropriate policy action to counteract the inflationary pressures. The monetary authorities must gauge the factors leading to disruptive exchange rate movements and high price variations. As the pass-through from oil prices to domestic prices has been captured separately, monetary authorities must identify other factors causing exchange rate fluctuation that are translated into domestic prices. Our findings point towards what Mishkin said “a stable monetary policy - supported by an institutional framework that allows the central bank to pursue a policy independent of fiscal considerations and political pressures - effectively removes an important potential source of high pass-through of exchange rate changes to consumer prices. Moreover, with expectations of inflation anchored, real shocks arising from various channels - whether from aggregate demand, energy prices, or the foreign exchange rate - will also have a smaller effect on expected inflation and hence on trend inflation” (Mishkin, 2008).

We further suggest that IT economies should adopt their exchange rate policy, considering their reliance on oil imports to reduce the unwarranted inflationary pressures on the economy. The findings also suggest that international reserves play a positive role in achieving price stability, and exchange rate pass-through could be mitigated by effectively building large foreign exchange reserves. The long-run relationship between interest rates and domestic prices also requires the attention of monetary authorities due to the non-desirable and ineffective outcome of interest rate on inflation.

Although our study makes a substantial effort to add to the current understanding of asymmetric pass-through, it is subject to certain limitations that require attention from future researchers. For instance, first, the study used annual time-series data. Future researchers could replicate the study using monthly or quarterly data to provide a more granular understanding of the phenomenon. Second, the study discussed the potential role of exchange rate fluctuations and energy price shocks

separately to test their impact on domestic prices. Upcoming research can investigate the combined impact of these two variables by creating an interaction term for the oil prices and exchange rate.

CRedit authorship contribution statement

Nawazish Mirza: Software, Validation, Project administration, Supervision, Visualization, Writing – original draft. **Bushra Naqvi:** Conceptualization, Formal analysis, Investigation, Validation, Writing – original draft. **Syed Kumail Abbas Rizvi:** Methodology, Validation, Formal analysis, Writing – original draft. **Sabri Boubaker:** Supervision, Project administration, Writing – review & editing.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.eneco.2023.106761>.

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