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ANALYSIS OF SYMMETRIC AND ASYMMETRIC EFFECTS OF EXCHANGE RATE PASS-THROUGH IN INFLATION-TARGETING COUNTRIES

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ABSTRACT

The main purpose of this study is to analyze the effects of symmetry and asymmetry of the exchange rate pass-through in Middle-Income and High-Income countries that implement inflation-targeting policies. This study uses a sample of Middle-Income Countries (South Africa, Brazil, India, Indonesia, and Mexico) and High-Income Countries (Australia, Japan, Canada, Norway, and Sweden) in the form of time-series 2000:Q1- 2021:Q4 with the method of Autoregressive Distribution Lag (ARDL) and Nonlinear Autoregressive Distributed Lag (NARDL). The results showed that five countries have a significant positive effect on the real exchange rate on inflation in the short-run in the ARDL method. In addition, in the NARDL method, five countries significantly positively affect the depreciation of the real exchange rate on inflation in the short-run. Then, only one country has a significant negative effect between the appreciation of the real exchange rate on inflation in the short-run and eight countries in the long-run. Based on the estimation results, it can be concluded that the average quantity of real exchange rate effect on inflation (exchange rate pass-through) in Middle-Income Countries is greater than in High-Income Countries. Therefore, inflation-targeting policies are more flexible to be applied in high-income countries. In addition to the exchange rate, other variables such as oil prices, money supply, and real GDP also greatly affect inflation and have different effects in each country.

Keywords: *Exchange Rate Pass-through, Inflation Targeting, Middle-Income Countries, High-Income Countries, ARDL, and NARDL*

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ABSTRAK

Tujuan utama dari penelitian ini adalah menganalisis efek simetri dan asimetri exchange rate pass-through di middle income countries dan high income countries yang menerapkan kebijakan inflation targeting. Penelitian ini menggunakan sampel middle income countries (Afrika Selatan, Brazil, India, Indonesia, dan Meksiko) dan high income countries (Australia, Jepang, Kanada, Norwegia, dan Swedia) dalam bentuk data time-series 2000:Q1 – 2021:Q4 dengan metode Autoregressive Distributed-Lag (ARDL) dan Nonlinear Autoregressive Distributed-Lag (NARDL). Hasil penelitian menunjukkan bahwa terdapat lima negara yang memiliki pengaruh positif signifikan antara nilai tukar riil terhadap inflasi dalam jangka pendek pada metode ARDL. Selain itu, pada metode NARDL terdapat lima negara yang memiliki pengaruh positif signifikan antara depresiasi nilai tukar riil terhadap inflasi dalam jangka pendek. Kemudian, hanya satu negara yang memiliki pengaruh negatif signifikan antara apresiasi nilai tukar riil terhadap inflasi dalam

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jangka pendek dan delapan negara dalam jangka panjang. Berdasarkan hasil estimasi tersebut, dapat disimpulkan bahwa rata-rata besaran pengaruh nilai tukar riil terhadap inflasi (exchange rate pass-through) di middle income countries lebih besar daripada high income countries. Oleh karena itu, kebijakan inflation targeting memungkinkan lebih fleksibel untuk diterapkan di high income countries. Selain nilai tukar, variabel lain seperti harga minyak, jumlah uang yang beredar, dan PDB riil juga memiliki pengaruh yang besar terhadap inflasi dan memiliki besaran pengaruh yang berbeda di masing-masing negara.

Kata Kunci: *Perubahan nilai tukar, Target inflasi, Negara Berpenghasilan Menengah, Negara Berpenghasilan Tinggi, ARDL, dan NARDL*

JEL : E51; E52; F31; E31

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Introduction

Achieving and maintaining price stability by setting inflation at an efficient level is a major responsibility of the central bank and monetary authorities, especially after the high inflation occurred from 1970 to 1980 (Nasir et al., 2015). Efforts to maintain price stability have forced several countries to change their monetary policies within the monetary policy framework and the exchange rate regime used. Changes in the monetary policy framework that previously targeted the money supply (money targeting) or exchange rate targeting changed to inflation targeting (Bernanke et al., 2001; Nasir & Vo, 2020). Meanwhile, in the context of the exchange rate regime, there was a change that previously applied a fixed exchange rate to a free-floating exchange rate (Dilla, 2014).

Related to changes in the monetary policy framework, inflation targeting is a monetary policy strategy that focuses on indicators of the inflation rate that must be achieved in a certain period or directs the inflation rate to its target within a specified period, for example, the medium-long-run (Nasir & Vo, 2020). Mishkin & Hebbel (2001) state that the framework for inflation targeting policies is: (a) focus on the level of price stability so that it can be used as an 'anchor' of inflation expectations for the public; (b) make a forecast (forecasting) of the inflation rate in the next period; and (c) make adjustments to monetary policy to achieve the predetermined inflation target. Therefore, the inflation targeting policy is a forward-looking policy.

The implementation of inflation-targeting policies has a positive impact on a country, especially high-income countries. According to Creel & Hubert (2008), the application of inflation targeting in high-income countries causes inflation rates to tend to be low and controlled to improve economic performance. Meanwhile, according to Yetman (2017), inflation-targeting policies implemented in high-income countries have provided less uncertainty regarding future monetary policy actions. The successful implementation of inflation targeting in high-income countries has encouraged middle-income countries to adopt this policy. But the implementation of inflation targeting in middle-income countries does not always produce a positive impact. According to (Roger, 2009), the deviation of actual inflation from the inflation target in middle-income countries is relatively higher than in high-income countries. When there is volatility in the price of goods, the performance of high-income countries that apply inflation targeting is relatively better compared to middle-income countries. Therefore, inflation targeting is more suitable for high-income countries than middle-income countries.

The development of inflation-targeting implementation in a country can be evaluated by the actual inflation rate achieved by that country (Dilla, 2014). Figure 1 compares inflation rate and economic growth in middle- and high-income countries. Inflation rates in high-income countries tend to be lower than in middle-income countries, reinforcing that high-income countries can implement inflation-targeting policies well (Creel & Hubert, 2008). Also, technological advances that develop more rapidly in high-income countries make the production process faster and production costs lower. Therefore, the aggregate demand for goods can be fulfilled properly, and the price of an item can be well controlled (Draghi, 2016; Lowe, 2017; Yellen, 2017).

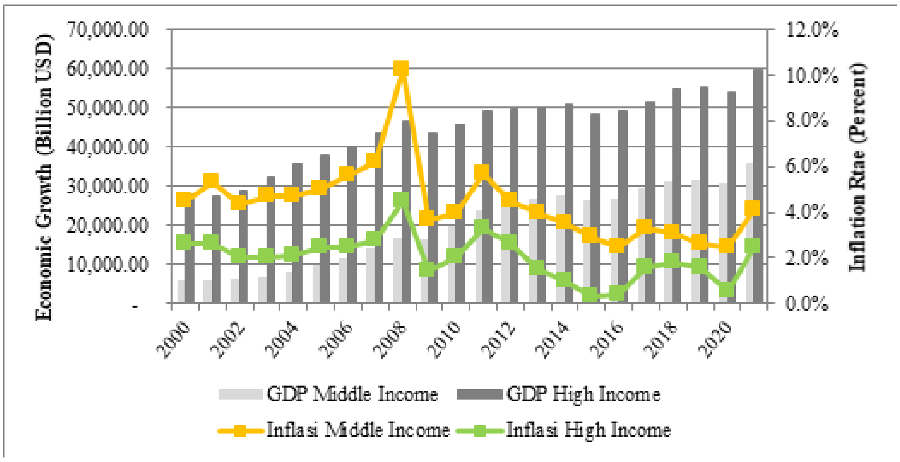

Figure 1: Inflation Rate and Economic Growth, 1990-2021

In general, forward-looking inflation targeting requires the ability of institutions (central banks) to predict future developments in inflation, so the ability to identify and analyze several indicators and variables that are dominant (the best indicators) affecting future inflation is required. According to Pham et al. (2020) and Agung (2002), exchange rate variables are 'the best indicators' of inflation and directly affect inflation. Therefore, exchange rate fluctuations are one of the main challenges for countries adopting inflation-targeting policies.

Figure 2 and Figure 3 shows exchange rate fluctuations in middle and high-income countries that adopt inflation-targeting policies. Fluctuations in the domestic exchange rate against foreign exchange (U.S. dollar) for high-income countries were relatively stable compared to middle-income countries, which experienced significant depreciation. According to Eichengreen (2001) and Mishkin & Savastano (2001), middle-income countries are still very vulnerable to shocks in both the goods market and the money market, which can disrupt the stability of foreign aggregate demand, ultimately impacting the exchange rate. The shock's magnitude, directly or indirectly, can endanger the predetermined inflation target. Therefore, the central bank can neutralize exchange rate changes by intervening in the foreign exchange market to stabilize exchange rates (fear of floating or dirty floating). The exchange rate shock that affected the inflation target was the Asian Financial Crisis (1998) and the Global Financial Crisis (2008), which could cause exchange rate depreciation in most countries, especially middle-income countries.

The magnitude of the influence of the exchange rate on inflation or the formation of domestic prices projected in the customer price index can be referred to as the Exchange Rate Pass-Through (ERPT) concept, which is becoming one of the central issues in the international economy. ERPT is the percentage change in prices (exports and imports) due to a one percent change in the exchange rate or the rate of variation in exchange rates that transmits to domestic prices (Dilla, 2014; Pham et al., 2020). Changes in the exchange rate can affect both directly (direct exchange rate pass-through) and indirectly (indirect exchange rate pass-through) developments in the price of goods and services in the country. The direct effect occurs because changes in the exchange rate affect the pattern of price formation by companies and inflation expectations by the public, especially for imported goods.

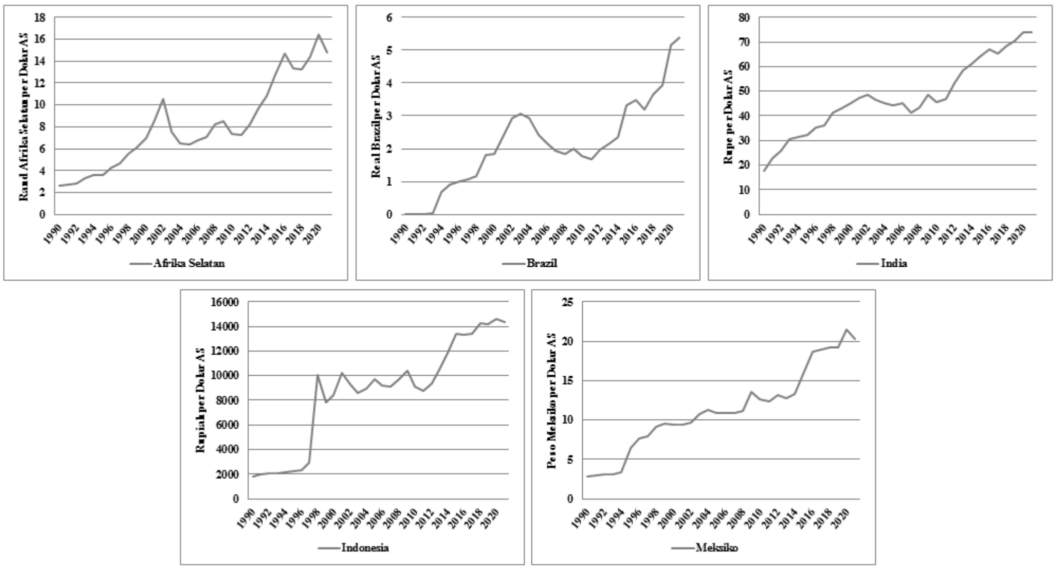

Figure 2: Middle Income Countries Exchange Rate Fluctuations, 1990-2021

Furthermore, indirect effects occur because changes in exchange rates affect export and import activities, which in turn impact output and developments in the prices of goods and services. Figure 1.4 shows that monetary policy affects the exchange rate and then influences output and inflation through the interest rate differential, capital flows, and risk premium.

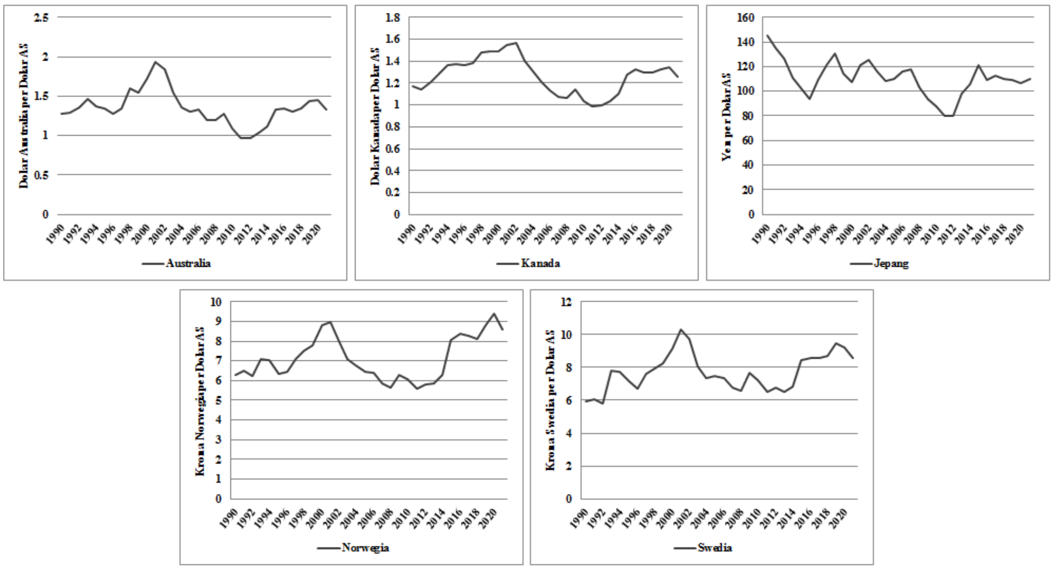

Figure 3: High-Income Countries Exchange Rate Fluctuations, 1990-2021

The effect of changes in exchange rates, directly and indirectly, on inflation can be measured symmetrically and asymmetrically. The effect of symmetry shows that there is no difference between positive exchange rates (depreciation) and negative exchange rates (appreciation) in influencing inflation, while the effect of asymmetry shows this difference (Shin et al., 2013). The effect of asymmetry is considered more effective because it influences inflation positively and negatively (Pham et al., 2020; Nasir et al., 2020; Schorderet, 2003; Lee, 2000; and Viren, 2001). The results of the effect of asymmetry between the exchange rate on inflation can be explained as price changes. If the exchange rate changes do not affect the price level, then it can be called a zero exchange rate pass-through.

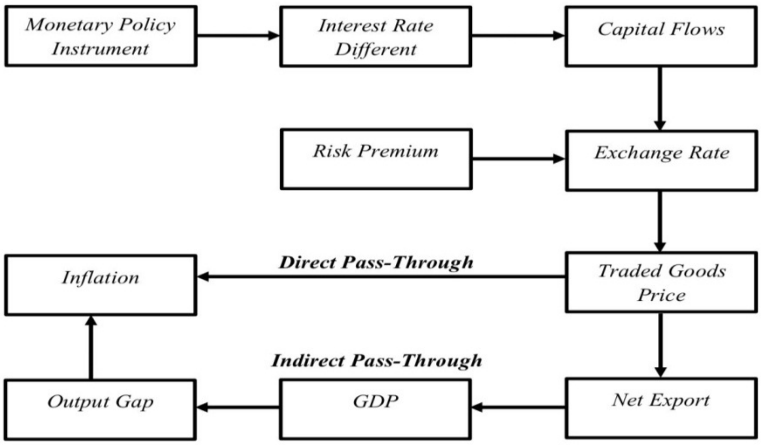

Figure 4: Transmission of Exchange Rate Influence on Inflation

Source: Krugman & Obstfeld (2000)

Based on the problems above, this study aims to analyze the effects of symmetry and asymmetry of exchange rate pass-through in countries that implement inflation-targeting policies in the short and long-run and to analyze differences in the magnitude of exchange rate pass-through in middle and high-income countries. This study incorporates the assumptions of the Dornbusch-Overshooting Model, which explains an adjustment process in exchange rates and prices that do not move at the same rate. The Dornbusch-Overshooting Model explains that differences between short-run and long-run exchange rates and price deviations from the equilibrium point in the short-run cause changes in the inflation rate. The research that found differences in the amount of exchange rate pass-through in countries that adopted inflation-targeting policies was Odria et al. (2012); Shintani et al. (2013); Dilla (2014); Anh et al. (2018);Pham et al. (2020); Nasir & Vo (2020). This study uses data from middle-income countries (South Africa, Brazil, India, Indonesia, and Mexico) and high-income countries (Australia, Canada, Japan, Norway, and Sweden).

This study uses a quantitative approach using time-series data for the quarterly observation period 2000Q1-2021Q4. Then, using the Autoregressive Distributed-Lag (ARDL) analysis technique to analyze the effect of the exchange rate on inflation symmetrically in the short and long-run, and the Nonlinear Autoregressive Distributed-Lag (NARDL) analysis technique to analyze the effect of the exchange rate on inflation asymmetry in the short-run and long-run. In the NARDL method, exchange rate variables are broken down into two new variables: positive exchange rates (depreciation) and negative exchange rates (appreciation).

Based on the estimates that have been made, the significant positive effect of the real exchange rate on inflation in the short-run in the ARDL method results in four countries: Indonesia, Japan, Norway, and Sweden. In addition, in the NARDL method, five countries significantly positively affect real exchange rate depreciation on inflation, namely South Africa, Indonesia, Mexico, Norway, and Sweden. Then, only one country has a significant negative effect between real exchange rate appreciation and inflation in the short-run, namely Brazil, and there are eight countries in the long-run, namely South Africa, Brazil, Indonesia, Mexico, Australia, Japan, Canada, and Sweden. Based on the results of the effect of the exchange rate on inflation, it can be called a complete pass-through because changes in the exchange rate have a more significant influence on changes in inflation.

The average magnitude of the effect of the exchange rate on inflation (exchange rate pass-through) in middle-income countries is greater than in high-income countries. Therefore, inflation-targeting policies allow more flexibility to be implemented in high-income countries. This condition is in line with research conducted by Choudhri & Hakura (2006), which explains that when the effect of the real exchange rate on inflation (exchange rate pass-through) is low, it will enable a country to implement monetary policies that are more independent and flexible in which policies Inflation targeting can be implemented more efficiently.

This study uses writing systematics which consists of five parts, namely (1) introduction; (2) theoretical studies; (3) research methods and data analysis; (4) results and discussion; and (5) closing.

Literature Review

Dornbusch Overshooting Model

The effect of exchange rate changes on inflation (exchange rate pass-through) can be explained by the Dornbusch Overshooting Model, in which there is an adjustment process in exchange rates and prices that do not move at the same speed. This influence can be initiated by analyzing the behavior of nominal exchange rates in the short-run in the monetary sector, which is expressed by the following equation:

$$m = p + \emptyset y - \lambda r^* - \lambda\theta(\bar{s} - s) \quad (1)$$

where m, y, p, and r^* are the logarithm of the money supply, price level, output, and international interest rate, respectively. In the long-run, the conditions $\bar{s} - s$ and $p^* - p$ apply so that the equilibrium price level is:

$$p^* = m + \emptyset y - \lambda r^* \quad (2)$$

When there is an increase in the money supply, it will only impact the long-term exchange rate $(\partial\bar{s}/\partial m = 1)$ and $(\partial p/\partial m = 1)$ the price level . Therefore, in the short-run, the behavior of the exchange rate is as follows:

$$s = \bar{s} + \frac{(m - p - \varnothing y)}{\lambda\theta} + \frac{r^*}{\theta} \quad (3)$$

Based on equation (3), an increase in the money supply will cause the exchange rate *to overshoot* in the short-run, i.e. move beyond the equilibrium level in the long-run. Therefore, the following equation is obtained:

$$(\partial s/\partial m)^{ST} = \frac{\partial\bar{s}}{\partial m} + \frac{1}{\lambda\theta} = (1 + \frac{1}{\lambda\theta}) > 1 = (\partial s/\partial m)^{LT} \quad (4)$$

Since the price level is *sticky* in the short-run, the magnitude of *the* misalignment (the difference between short and long-run exchange rates) is:

$$s - \bar{s} = \frac{(m - \varnothing y - \lambda r^*) - p}{\lambda\theta} = \frac{p^* - p}{\lambda\theta} \quad (5)$$

The economy will move to long-run equilibrium after the exchange rate has experienced *overshooting*. The price adjustment behavior ($p^* - p$) is determined in the goods market equilibrium as shown by the following *Philips curve equation*:

$$\pi = \alpha(y^d - y) = \alpha(\delta(s - p) - (1 - \gamma)y + g) \quad (6)$$

Where π shows inflation, y^d shows aggregate demand, y shows output levels, and g shows government spending. Aggregate demand is obtained from the equation $y^d = \delta(\bar{s} - p) + \gamma y + g$. If the long-run equilibrium holds condition $(1 - \gamma)y - g = \delta(\bar{s} - p)$, then:

$$\pi = \alpha\delta((s - \bar{s}) - (p - p^*)) \quad (7)$$

The equation above shows that exchange rate pass-through to the price level can occur for two reasons. First, because of the difference between short-term and long-term exchange rates that have a direct effect. Second, due to the effect of price deviation from the equilibrium point in the short-run.

In the floating exchange rate regime, the exchange rate pass-through is determined by the difference between the long-term and short-term exchange rates $(s-\bar{s})$. The greater the exchange rate fluctuation, the greater the exchange rate pass-through to the price level. Therefore, the exchange rate pass-through to the price level is quite large in a floating exchange rate regime because exchange rates that move according to market mechanisms without government intervention significantly contribute to short-term and long-term exchange rate differences.

Furthermore, under a fixed exchange rate regime, the short-term exchange rate will always equal the long-term exchange rate $s=\bar{s}$. In this condition, the exchange rate pass-through to the inflation rate can occur through the demand for money. If the government can control the demand for money, it can produce $s=\bar{s}$. Therefore, the exchange rate pass-through to the inflation rate will be smaller. However, if the government cannot control the demand for money, where $m-øy-\lambda r*>p^*$, then it is certain that the short-term exchange rate is greater than the long-term exchange rate $(s>\bar{s})$. This will put pressure on the devaluation of the currency, which will impact the exchange rate pass-through to the inflation rate. The greater the devaluation, the greater the exchange rate pass-through to the inflation rate.

Inflation Targeting

According to Taylor (1995), inflation targeting is a framework for the rules of monetary policy as opposed to discretionary policies. According to Eichengreen (2001), inflation targeting is a monetary policy strategy consisting of four elements, namely: (a) commitment from institutions (Central banks) to achieve price stability as the main goal of monetary policy; (b) the mechanism implemented must be transparent and accountable; (c) the inflation target is announced to the public; and (d) the information provided by the central bank to the public and the market is rational.

Mishkin (2000) tries to formulate the limits of inflation targeting which consists of five elements, namely: (a) announcement of the target medium-term inflation rate to the public; (b) an institutional commitment to price stability as the main objective of monetary policy, while other objectives are subordinate; (c) an information strategy that is inclusive in which many variables, not only monetary aggregates or exchange rate variables, are used in the preparation of policy instruments; (d) increasing the transparency of the monetary policy strategy through communicating the plans, objectives, and decisions of the monetary authority to the public and the market; and (e) increasing central bank accountability in achieving its medium-term inflation objective.

According to Taylor (1995), monetary policy has a rule that can be seen from two sides. First, the rule can be seen as a guiding tool in making monetary policy. Then, rules can also be seen as ‘benchmarks’ for making policies. As a rule in monetary policy, inflation targeting can be classified into two parts: instruments and targets (Svensson, 2000).

Inflation targeting can be classified as an instrument when inflation targeting is expressed as an instrument in monetary policy, defined as an observed macro variable. One of the basic characteristics of inflation targeting as an instrument is when only inflation is used as an argument in determining the interest rate. Meanwhile, inflation targeting can be classified as a target when inflation targeting is a solution to the optimization problem the central bank faces. The optimization problem is defined in two ways: a loss function that describes the cost of deviations from the target variable and a model of the economic structure. The minimization of the loss function against its constraints is determined by an economic structure (model), defined as an optimization model (interest rate reaction function). The model can determine the interest rate as a function of the relevant variables. Therefore, inflation targeting is classified as a loss function focusing on inflation deviations from a certain target.

Research Paradigm

Research on exchange rate pass-through, or the rate of variation in exchange rates that transmits to domestic prices, has attracted great attention from academics, practitioners, and policymakers to provide recommendations for effective monetary policy (Forbes et al., 2015; Forbes, 2016; Nasir & Vo, 2020). Based on several empirical studies analyzing exchange rate pass-through transmission, various pieces of evidence are provided (Nasir & Vo, 2020; Prasertnukul et al., 2010). The amount of exchange rate pass-through in a country is still widely debated depending on the data or econometric techniques used and differences in monetary policy, both the exchange rate regime and inflation targeting in each country (Balcilar et al., 2021). Based on research by Taguchi & Sohn (2010), it is explained that countries that adopt inflation-targeting policies will experience a decrease in the exchange rate pass-through. The results of this study support the study of Minella et al. (2003), which stated that the amount of exchange rate pass-through decreased under the inflation targeting policy, especially in Brazil.

Campa & Goldberg (2005) explained that pass-through exchange rates tend to be lower in countries with low inflation rates and exchange rate volatility. The countries sampled from the research were 23 Organization for Economic Co-operation and Development (OECD) countries. The results of this study support a study from Bailliu (2004), which explains that countries with low and stable inflation rates will experience a decrease in exchange rate pass-through. According to Taylor (2000), countries with low inflation rates, especially the United States, experience a decrease in the exchange rate pass-through.

Data and Research Methods

Data Analysis

The type of data used to describe the relationship between the dependent variable (inflation) and the independent variable (real exchange rate, oil price, money supply, and real GDP) is secondary data in the form of time series data for quarterly periods from 2000:Q1 to 2021:Q4. In detail, the analysis of data and variables used in this study are as follows:

Table 1: Data, Notation, and Variable

Variable	Notation	Explanation
Inflation	π	quarterly data from the Consumer Price Index (CPI) as a proxy for inflation (data in percent).
Real Exchange Rate	REX	quarterly data from the Effective Real Exchange Rate (REER) in points (index).
Oil Price	OIL	quarterly data on crude oil prices (West Texas Intermediate, WTI) in US Dollars per Barrel.
Money Supply	MS	quarterly data from broad money (M2), which is the broadest measure of the money supply in terms of Local Currency Units (LCU).
Gross Domestic Product	GDP	quarterly data on real GDP growth as a proxy for economic growth in middle and high-income countries (in billions of USD).

Auto-Regressive Distributed Lag Method

According to Pesaran & Shin (1995), the Auto-Regressive Distributed Lag (ARDL) model is a method used to analyze long-term relationships involving cointegration between time series variables. The procedure in ARDL is believed to estimate long-term parameters accurately and estimate t-statistics validly. The following is the long-term ARDL model used in this study:

$$\pi_t = \alpha_0 + \alpha_1 Ln(REX_t - \overline{REX}_t) + \alpha_2 Ln(OIL_t - \overline{OIL}_t) \\ \alpha_3 Ln(MS_t - \overline{MS}_t) + \alpha_4 Ln(GDP_t - \overline{GDP}_t) + e_t \quad (8)$$

Where π_t is the inflation rate at time t, α_0 is the constant, $\alpha_1, \alpha_2, \alpha_3, \alpha_4$ is the speed of adjustment, $Ln(REX_t - \overline{REX_t})$ is the adjustment between the logarithm of the actual and long-term real exchange rates at time t, $Ln(OIL_t - \overline{OIL_t})$ is the adjustment between the logarithm of the actual and long-term oil price logarithm at time t, $Ln(MS_t - \overline{MS_t})$ is the adjustment between the logarithm of the actual and long-term money supply at time t, $Ln(GDP_t - \overline{GDP_t})$ is the adjustment between the logarithm of the actual and long-term real GDP at time t, and e_t is the error term at time t.

The above model includes assumptions from the Dornbusch-Overshooting Model, which explains that there is an adjustment process in exchange rates and prices that do not move at the same speed. According to Anh et al. (2018), adjustments to all independent variables must be made due to changes in the amount of money in circulation, exchange rates, and prices. Meanwhile, the independent variable in the form of natural logarithms because it can be interpreted as elasticity, can minimize one of the Ordinary Least Square (OLS) deviations, namely heteroscedasticity, and can reduce excessive data fluctuations (Gujarati, 2012). Based on the ARDL model above, an Error-Correction Model (ECM) can be made as follows:

$$\Delta\pi_t = \beta_0 + \beta_1(\pi_{t-1}) + \beta_2 Ln(REX_{t-1} - \overline{REX}_{t-1}) + \beta_3 Ln(OIL_{t-1} - \overline{OIL}_{t-1}) \\ \beta_4 Ln(MS_{t-1} - \overline{MS}_{t-1}) + \beta_5 Ln(GDP_{t-1} - \overline{GDP}_{t-1}) + \\ \sum_{i=1}^{n1} \lambda_0 \Delta(\pi_{t-1}) + \sum_{i=0}^{n2} \lambda_{1,i} \Delta Ln(REX_{t-i} - \overline{REX}_{t-i}) + \\ \sum_{i=0}^{n3} \lambda_{2,i} \Delta Ln(OIL_{t-i} - \overline{OIL}_{t-i}) + \sum_{i=0}^{n4} \lambda_{3,i} \Delta Ln(MS_{t-i} - \overline{MS}_{t-i}) + \\ \sum_{i=0}^{n5} \lambda_{4,i} \Delta Ln(GDP_{t-i} - \overline{GDP}_{t-i}) + e_t \quad (9)$$

The main assumption in models (8) and (9) is that changes in exchange rates are considered the same for depreciation and appreciation, so an asymmetric cointegration method, which divides changes in exchange rates into positive and negative changes, is needed.

Nonlinear Auto-Regressive Distributed Lag Method

This study also uses Nonlinear Auto-Regressive Distributed Lag (NARDL) to estimate and analyze the determinant impact of real exchange rate variables, oil prices, money supply, and real GDP on inflation. The NARDL framework is used to analyze asymmetric effects in both the short and long-run without assuming a constant speed of adjustment over time (Shin et al., 2014). In addition, NARDL is also able to track asymmetric adjustment patterns after positive and negative shocks to the independent variable by reducing the effect of Asymmetric Dynamic Multipliers.

Exchange rate variables include positive changes (depreciation) and negative changes (appreciation). Therefore, the two changes produce two new variables as follows:

$$LnREX_t^{+} = \sum_{i=1}^{t} \Delta LnREX_t^{+} = \sum_{i=1}^{t} \max\left(REX_t, 0\right)$$
$$LnREX_t^{-} = \sum_{i=1}^{t} \Delta LnREX_t^{-} = \sum_{i=1}^{t} \min\left(REX_t, 0\right)$$
$$Ln\overline{REX}_t^{+} = \sum_{i=1}^{t} \Delta Ln\overline{REX}_t^{+} = \sum_{i=1}^{t} \max\left(\overline{REX}_t, 0\right) \quad (10)$$
$$Ln\overline{REX}_t^{-} = \sum_{i=1}^{t} \Delta Ln\overline{REX}_t^{-} = \sum_{i=1}^{t} \min\left(\overline{REX}_t, 0\right)$$

Model (10) shows the variable and is the partial sum of the positive changes and (represents the actual and long-term exchange rate depreciation), while the variable and is the partial sum of the negative changes and (represents the appreciation of the actual and long-term exchange rate). After generating exchange rate variables in positive and negative forms, the next step is to enter these variables into the model (9). Therefore, the NARDL model is obtained as follows:

$$\begin{aligned}\Delta\pi_t = {} & \beta_0 + \beta_1(\pi_{t-1}) + \beta_2 Ln(REX_{t-1}^{+} - \overline{REX}_{t-1}^{+}) + \beta_3 Ln(REX_{t-1}^{-} - \overline{REX}_{t-1}^{-}) \\ & + \beta_4 Ln(OIL_{t-1} - \overline{OIL}_{t-1}) + \beta_5 Ln(MS_{t-1} - \overline{MS}_{t-1}) + \beta_6 Ln(GDP_{t-1} - \overline{GDP}_{t-1}) \\ & + \sum_{i=1}^{n1} \lambda_0 \Delta(\pi_{t-i}) + \sum_{i=0}^{n2} \lambda_{1,i} \Delta Ln(REX_{t-i}^{+} - \overline{REX}_{t-i}^{+}) \\ & + \sum_{i=0}^{n3} \lambda_{2,i} \Delta Ln(REX_{t-i}^{-} - \overline{REX}_{t-i}^{-}) + \sum_{i=0}^{n4} \lambda_{3,i} \Delta Ln(OIL_{t-i} - \overline{OIL}_{t-i}) \\ & + \sum_{i=0}^{n5} \lambda_{4,i} \Delta Ln(MS_{t-i} - \overline{MS}_{t-i}) + \sum_{i=0}^{n6} \lambda_{5,i} \Delta Ln(GDP_{t-i} - \overline{GDP}_{t-i}) + e_t\end{aligned} \quad (9)$$

Finding and Discussion

Stationary Test

This study used the Augmented Dickey-Fuller (ADF) stationary test. The results of the stationarity test show that on the dependent variable (inflation), two countries show stationary at level I (1) or first difference, namely South Africa and Brazil, while eight other countries show stationary at level (0). Then, the independent variables (real exchange rates, world oil prices, and real GDP) show stationary at level (0). Meanwhile, on the independent variable (the amount of money in circulation), there is one country that shows stationary at level I(1) or first difference, namely South Africa, while nine other countries show stationary at level (0).

ARDL Bound Test

Short-run ARDL Bound Test

Table 2 and Table 3 show the short-term ARDL estimation results. The estimation results show that four countries significantly positively affect the real exchange rate on inflation, namely Indonesia, Japan, Norway, and Sweden. At the same time, one country has a significant negative effect, namely South Africa. The oil price variable significantly affects inflation in three countries, namely Japan, Canada, and Sweden. Then, there is no significant positive effect between the money supply on inflation in the short-run. Finally, the real GDP variable significantly positively affects inflation in five countries, namely India, Mexico, Australia, Canada, and Sweden.

Table 2: Middle-Income Countries Short-Run ARDL Estimation

Variable	Middle-Income Countries				
	S. Africa	**Brazil**	**India**	**Indonesia**	**Mexico**
Constant	-0.01 (-0.13)	0.02 (0.23)	-0.04 (-0.32)	0.06 (0.44)	-0.02 (-0.31)
$\Delta\pi_{(t-1)}$	0.47** (6.44)	0.58** (7.26)	0.17 (1.52)	0.31** (3.70)	0.25** (2.83)
$\Delta\pi_{(t-2)}$	0.24** (2.89)	-	0.22* (1.99)	0.32** (3.58)	0.28** (3.13)
$\Delta\pi_{(t-3)}$	0.22** (2.63)	-	0.29** (2.82)	0.37** (4.07)	0.47** (5.07)
$\Delta\pi_{(t-4)}$	-	-	-	-	-
$\Delta LN(REX_t - \overline{REX}_t)$	-0.03* (-1.97)	-0.03 (-1.29)	-	0.18** (3.28)	0.01 (0.65)
$\Delta LN(REX_{t-1} - \overline{REX}_{t-1})$	0.04** (2.12)	-	-	0.11** (2.07)	-
$\Delta LN(REX_{t-2} - \overline{REX}_{t-2})$	0.05** (2.65)	-	-	0.18** (3.47)	-
$\Delta LN(REX_{t-3} - \overline{REX}_{t-3})$	-	-	-	-	-
$\Delta LN(REX_{t-4} - \overline{REX}_{t-4})$	-	-	-	-	-
$\Delta LN(OIL_t - \overline{OIL}_t)$	-	-	-	0.02 (1.50)	0.01 (0.23)
$\Delta LN(OIL_{t-1} - \overline{OIL}_{t-1})$	-	-	-	-	-0.01 (-1.35)
$\Delta LN(OIL_{t-2} - \overline{OIL}_{t-2})$	-	-	-	-	-
$\Delta LN(OIL_{t-3} - \overline{OIL}_{t-3})$	-	-	-	-	-
$\Delta LN(OIL_{t-4} - \overline{OIL}_{t-4})$	-	-	-	-	-
$\Delta LN(MS_t - \overline{MS}_t)$	-	-	-0.19 (-0.64)	-	-
$\Delta LN(MS_{t-1} - \overline{MS}_{t-1})$	-	-	-	-	-
$\Delta LN(MS_{t-2} - \overline{MS}_{t-2})$	-	-	-	-	-
$\Delta LN(MS_{t-3} - \overline{MS}_{t-3})$	-	-	-	-	-
$\Delta LN(MS_{t-4} - \overline{MS}_{t-4})$	-	-	-	-	-
$\Delta LN(GDP_t - \overline{GDP}_t)$	-	-	0.01 (0.14)	-	0.01 (0.66)
$\Delta LN(GDP_{t-1} - \overline{GDP}_{t-1})$	-	-	0.15** (2.28)	-	0.02 (1.29)
$\Delta LN(GDP_{t-2} - \overline{GDP}_{t-2})$	-	-	0.12* (1.82)	-	0.08** (3.59)
$\Delta LN(GDP_{t-3} - \overline{GDP}_{t-3})$	-	-	-	-	0.04 (1.55)

Note : (**) significant at 5%; (*) significant at 10%
Signs in brackets indicate the value of the t-statistic
T-table value 5% (1.98); 10% (1.66)

Table 3: High-Income Countries Short-Run ARDL Estimation

Variable	Australia	Japan	Canada	Norway	Sweden
Constant	-0.02 (-0.39)	0.01 (0.26)	0.02 (0.49)	0.01 (0.01)	0.03 (1.01)
$\Delta\pi_{(t-1)}$	0.44** (4.87)	0.03 (0.30)	0.42** (3.46)	0.33** (2.87)	0.17* (1.77)
$\Delta\pi_{(t-2)}$	0.40** (4.90)	0.10 (1.08)	0.19* (1.73)	0.35** (3.06)	0.08 (0.86)
$\Delta\pi_{(t-3)}$	0.39** (4.81)	0.41** (5.04)	0.28** (2.82)	0.48**(4.79)	0.28** (2.71)
$\Delta\pi_{(t-4)}$	-	-	-	-	-
$\Delta LN(REX_t - \overline{REX}_t)$	-	0.01 (0.05)	-0.02 (-0.78)	0.07* (1.81)	-0.01 (-0.14)
$\Delta LN(REX_{t-1} - \overline{REX}_{t-1})$	-	0.04** (3.10)	-	0.06 (1.51)	0.03 (1.43)
$\Delta LN(REX_{t-2} - \overline{REX}_{t-2})$	-	-	-	0.09** (2.24)	0.05** (2.17)
$\Delta LN(REX_{t-3} - \overline{REX}_{t-3})$	-	-	-	-	-
$\Delta LN(REX_{t-4} - \overline{REX}_{t-4})$	-	-	-	-	-
$\Delta LN(OIL_t - \overline{OIL}_t)$	-	0.02** (3.34)	0.02**(2.99)	-	0.02** (3.12)
$\Delta LN(OIL_{t-1} - \overline{OIL}_{t-1})$	-	-	0.01 (1.62)	-	0.02** (2.34)
$\Delta LN(OIL_{t-2} - \overline{OIL}_{t-2})$	-	-	0.02** (2.65)	-	0.01** (2.43)
$\Delta LN(OIL_{t-3} - \overline{OIL}_{t-3})$	-	-	0.01** (2.06)	-	0.02** (3.19)
$\Delta LN(OIL_{t-4} - \overline{OIL}_{t-4})$	-	-	-	-	-
$\Delta LN(MS_t - \overline{MS}_t)$	-	0.21 (1.51)	-	-0.04 (-0.51)	0.03 (0.63)
$\Delta LN(MS_{t-1} - \overline{MS}_{t-1})$	-	-	-	-0.09 (-1.12)	-0.08 (-1.48)
$\Delta LN(MS_{t-2} - \overline{MS}_{t-2})$	-	-	-	-	-
$\Delta LN(MS_{t-3} - \overline{MS}_{t-3})$	-	-	-	-	-
$\Delta LN(MS_{t-4} - \overline{MS}_{t-4})$	-	-	-	-	-
$\Delta LN(GDP_t - \overline{GDP}_t)$	0.15** (3.87)	-0.02 (-0.87)	0.15** (4.56)	-	0.07** (2.10)
$\Delta LN(GDP_{t-1} - \overline{GDP}_{t-1})$	-	-	-0.19** (-3.90)	-	-0.13** (-4.47)
$\Delta LN(GDP_{t-2} - \overline{GDP}_{t-2})$	-	-	-0.15** (-3.44)	-	-0.09** (-2.71)
$\Delta LN(GDP_{t-3} - \overline{GDP}_{t-3})$	-	-	-0.12** (-2.87)	-	-0.12** (-3.40)
$\Delta LN(GDP_{t-4} - \overline{GDP}_{t-4})$	-	-	-	-	-

Note : (**) significant at 5%; (*) significant at 10%
Signs in brackets indicate the value of the t-statistic
T-table value 5% (1.98); 10% (1.66)

Long-run ARDL Bound Test

Table 4 shows the long-term ARDL estimation results. The estimation results show that seven countries show a significant negative effect of the real exchange rate on inflation: South Africa, Brazil, Mexico, Australia, Japan, Canada, and Sweden. The oil price variable significantly affects inflation in five countries, namely South Africa, Indonesia, Mexico, Australia, and Japan. Then, the money supply variable significantly positively affects inflation in six countries, namely South Africa, India, Indonesia, Canada, Norway, and Sweden. Finally, the real GDP variable has a significant positive effect on inflation in four countries, namely South Africa, Brazil, Canada, and Sweden, while two countries have a significant negative effect, namely India and Indonesia.

Table 4: Long-Run ARDL Estimation

Country	Long-Run Estimation				
	Constant	$LN = REX - \overline{REX}$	$LN = OIL - \overline{OIL}$	$LN = MS - \overline{MS}$	$LN = GDP - \overline{GDP}$
MiddleIncome					
South Africa	-0.01	-0.21**	0.03**	0.18**	0.14**
	(-0.13)	(-8.18)	(3.99)	(1.99)	(2.94)
Brazil	0.02	-0.29**	0.02	-0.29	0.44**
	(0.23)	(-3.58)	(0.57)	(-0.69)	(2.58)
India	-0.04	-0.04	0.02	0.61**	-0.24*
	(-0.32)	(-0.69)	(1.02)	(2.05)	(-1.72)
Indonesia	0.06	-0.08	0.07**	0.83**	-0.23*
	(0.44)	(-1.29)	(3.64)	(3.24)	(-1.83)
Mexico	-0.02	-0.07**	0.04**	0.01	-0.08
	(-0.31)	(-2.97)	(3.82)	(0.01)	(-1.49)
HighIncome					
Australia	-0.02	-0.03**	0.02**	0.01	0.05
	(-0.39)	(-2.51)	(5.23)	(0.47)	(1.28)
Japan	0.01	-0.04**	0.04**	-0.02	0.03
	(0.26)	(-4.08)	(5.03)	(-0.22)	(0.76)
Canada	0.02	-0.08**	0.01	0.07*	0.38**
	(0.49)	(-3.29)	(0.54)	(1.89)	(5.88)
Norway	0.01	-0.04	0.01	0.13**	-0.02
	(0.01)	(-0.82)	(0.28)	(2.20)	(-0.37)
Sweden	0.03	-0.10**	0.01	0.17**	0.32**
	(1.01)	(-2.96)	(1.04)	(3.98)	(4.20)

Note : (**) significant at 5%; (*) significant at 10%
Signs in brackets indicate the value of the t-statistic
T-table value 5% (1.98); 10% (1.66)

ARDL Cointegration Test

The cointegration test determines whether there is a long-term relationship between the variables in the model. In this study, the cointegration test used the bound test introduced by Pesaran et al. (1996). The cointegration test estimation results in Table 5 show that all countries are cointegrated at the 5% level in the long-run.

Table 5: ARDL Cointegration Test Results

Country	F-Statistics	Information	Country	F-Statistics	Information
Middle Income			**High Income**		
South Africa	23.71**	Cointegration	Australia	22.59**	Cointegration
Brazil	13.44**	Cointegration	Japan	22.56**	Cointegration
India	8.05**	Cointegration	Canada	12.64**	Cointegration
Indonesia	18.54**	Cointegration	Norway	10.72**	Cointegration
Mexico	13.22**	Cointegration	Sweden	13.45**	Cointegration

Remarks :(**) significant at 5%; (*) significant at 10%
5% = upper limit (4.01); lower bound (2.86)
10% = upper bound (3.52); lower bound (2.45)

ARDL Diagnostic Test

Table 6 shows the results of the ARDL diagnostic test. The test results show that all models are significantly negative at the 5% level. The largest coefficient is in Canada, which is -0.97, which means that the speed of adjustment between the long and short-run is 97%. The Lagrange Multiplier test shows that only two models have autocorrelation (reject the null hypothesis), namely Australia and Canada. The results of the Ramsey RESET test show that three models are unsuitable (rejecting the null hypothesis), namely India, Indonesia, and Japan, while seven other countries have correct models.

In the Adjusted test, the model with the highest goodness of fit was found in the South African model of 0.75. This explains that in the South African model, variations in the independent variables (real exchange rates, oil prices, money supply, and real GDP) can explain 75% of the variation in the dependent variable (inflation), while the rest are influenced by other variables that are not present in models.

Table 6: ARDL Diagnostic Test Results

Country	ECM_{t-1}	LM	RESET	Adj.R^2
MiddleIncome				
South Africa	-0.63** (-11.19)	2.81	1.82	0.75
Brazil	-0.28** (-8.40)	0.11	1.52	0.58
India	-0.59** (-6.52)	1.94	5.70**	0.33
Indonesia	-0.76** (-9.90)	0.61	4.36**	0.56
Mexico	-0.56** (-8.36)	1.21	2.35	0.57
HighIncome				
Australia	-1.06** (-10.91)	3.68**	0.23	0.66
Japan	-0.66** (-10.92)	0.87	4.69**	0.65
Canada	-0.97** (-8.19)	3.72**	3.27	0.69
Norway	-0.82** (-7.53)	0.96	1.22	0.51
Sweden	-0.57** (-8.46)	0.64	0.09	0.69

Note : (**) significant at 5%; (*) significant at 10%
Specifically for ECMt-1, the sign in brackets represents the t-statistic value
T-table value 5% (1.9 8); 10% (1.6 6)
For LM and RESET, it is significant if Prob <0.05

NARDL Bound Test

Short-run NARDL Bound Test

Table 7: Estimates of Short-Run NARDL Middle-Income Countries

Variable	Middle-Income Countries				
	S. Africa	Brazil	India	Indonesia	Mexico
Constant	-1.62** (-5.07)	-0.66** (-2.59)	0.11 (0.44)	-0.53 (-0.91)	0.04 (0.29)
$\Delta\pi_{(t-1)}$	0.47** (6.44)	0.60** (7.68)	0.17 (1.50)	0.16* (1.78)	0.26** (3.04)
$\Delta\pi_{(t-2)}$	0.25** (2.99)	-	0.21* (1.97)	0.24** (2.70)	0.27** (3.04)
$\Delta\pi_{(t-3)}$	0.22** (2.61)	-	0.29** (2.79)	0.40** (4.71)	0.47** (5.07)
$\Delta\pi_{(t-4)}$	-	-	-	-	-
$\Delta LN(REX_t^+ - \overline{REX}_t^+)$	-0.02 (-0.56)	-0.01 (-0.09)	-	0.38** (4.17)	0.06** (2.44)
$\Delta LN(REX_{t-1}^+ - \overline{REX}_{t-1}^+)$	0.06* (1.79)	0.07 (1.55)	-	0.17* (1.84)	-
$\Delta LN(REX_{t-2}^+ - \overline{REX}_{t-2}^+)$	0.09** (2.89)	-	-	0.22** (2.73)	-
$\Delta LN(REX_{t-3}^+ - \overline{REX}_{t-3}^+)$	-	-	-	-0.15* (-1.80)	-
$\Delta LN(REX_{t-4}^+ - \overline{REX}_{t-4}^+)$	-	-	-	-	-
$\Delta LN(REX_t^- - \overline{REX}_t^-)$	-0.05 (-1.65)	-0.05 (-1.55)	-	-0.12 (-1.23)	-
$\Delta LN(REX_{t-1}^- - \overline{REX}_{t-1}^-)$	-	-0.09** (-2.63)	-	0.23** (2.16)	-
$\Delta LN(REX_{t-2}^- - \overline{REX}_{t-2}^-)$	-	-0.07* (-1.94)	-	0.26** (2.48)	-
$\Delta LN(REX_{t-3}^- - \overline{REX}_{t-3}^-)$	-	-	-	0.32** (2.94)	-
$\Delta LN(REX_{t-4}^- - \overline{REX}_{t-4}^-)$	-	-	-	-	-
$\Delta LN(OIL_t - \overline{OIL}_t)$	-	-	-	-	0.01 (0.35)
$\Delta LN(OIL_{t-1} - \overline{OIL}_{t-1})$	-	-	-	-	-
$\Delta LN(OIL_{t-2} - \overline{OIL}_{t-2})$	-	-	-	-	-
$\Delta LN(OIL_{t-3} - \overline{OIL}_{t-3})$	-	-	-	-	-
$\Delta LN(OIL_{t-4} - \overline{OIL}_{t-4})$	-	-	-	-	-
$\Delta LN(MS_t - \overline{MS_t})$	-	-	-0.19 (-0.62)	-	-
$\Delta LN(MS_{t-1} - \overline{MS_{t-1}})$	-	-	-	-	-
$\Delta LN(MS_{t-2} - \overline{MS_{t-2}})$	-	-	-	-	-
$\Delta LN(MS_{t-3} - \overline{MS_{t-3}})$	-	-	-	-	-
$\Delta LN(MS_{t-4} - \overline{MS_{t-4}})$	-	-	-	-	-
$\Delta LN(GDP_t - \overline{GDP_t})$	-	-	0.01 (0.11)	-	0.03* (1.82)
$\Delta LN(GDP_{t-1} - \overline{GDP}_{t-1})$	-	-	0.15** (2.31)	-	0.01 (0.05)
$\Delta LN(GDP_{t-2} - \overline{GDP}_{t-2})$	-	-	0.13* (1.86)	-	0.06** (3.04)
$\Delta LN(GDP_{t-3} - \overline{GDP}_{t-3})$	-	-	-	-	-
$\Delta LN(GDP_{t-4} - \overline{GDP}_{t-4})$	-	-	-	-	-

Note : (**) significant at 5%; (*) significant at 10%
Signs in brackets indicate the value of the t-statistic
T-table value 5% (1.98); 10% (1.66)

Table 8: Estimates of Short-Run NARDL High-Income Countries

Variable	High-Income Countries				
	Australia	Japan	Canada	Norway	Sweden
Constant	-0.22 (-1.61)	0.15 (1.59)	-0.24* (-1.79)	-0.43** (-2.18)	-0.28* (-1.74)
$\Delta\pi_{(t-1)}$	0.45** (4.83)	0.11 (1.21)	0.42** (3.52)	0.28** (2.48)	0.17* (1.76)
$\Delta\pi_{(t-2)}$	0.40** (4.86)	0.20** (2.48)	0.19* (1.75)	0.36** (3.44)	0.02 (0.18)
$\Delta\pi_{(t-3)}$	0.39** (4.78)	0.43** (5.44)	0.27** (2.74)	0.49** (5.11)	0.27** (2.66)
$\Delta\pi_{(t-4)}$	-	-	-	-	-
$\Delta LN(REX_t^+ - \overline{REX}_t^+)$	-	-	-	0.04 (0.59)	-0.02 (-0.41)
$\Delta LN(REX_{t-1}^+ - \overline{REX}_{t-1}^+)$	-	-	-	0.16** (2.52)	0.04 (0.10)
$\Delta LN(REX_{t-2}^+ - \overline{REX}_{t-2}^+)$	-	-	-	0.24** (3.44)	0.12** (3.40)
$\Delta LN(REX_{t-3}^+ - \overline{REX}_{t-3}^+)$	-	-	-	-	-
$\Delta LN(REX_{t-4}^+ - \overline{REX}_{t-4}^+)$	-	-	-	-	-
$\Delta LN(REX_t^- - \overline{REX}_t^-)$	-	0.04* (1.93)	0.03 (0.68)	0.08 (1.39)	-0.01 (-0.22)
$\Delta LN(REX_{t-1}^- - \overline{REX}_{t-1}^-)$	-	0.06** (3.16)	-	-	0.07 (1.55)
$\Delta LN(REX_{t-2}^- - \overline{REX}_{t-2}^-)$	-	0.03 (1.36)	-	-	-
$\Delta LN(REX_{t-3}^- - \overline{REX}_{t-3}^-)$	-	-	-	-	-
$\Delta LN(REX_{t-4}^- - \overline{REX}_{t-4}^-)$	-	-	-	-	-
$\Delta LN(OILt - \overline{OIL}t)$	-	0.01** (2.57)	0.02** (2.55)	-	0.02** (3.39)
$\Delta LN(OIL_{t-1} - \overline{OIL}_{t-1})$	-	-	0.01 (1.40)	-	0.01 (1.52)
$\Delta LN(OIL_{t-1} - \overline{OIL}_{t-1})$	-	-	0.02** (2.43)	-	0.02** (3.26)
$\Delta LN(OIL_{t-3} - \overline{OIL}_{t-3})$	-	-	0.01* (1.71)	-	0.02** (3.31)
$\Delta LN(OIL_{t-4} - \overline{OIL}_{t-4})$	-	-	-	-	-
$\Delta LN(MS_t - \overline{MS_t})$	-	-	-	-0.01 (-0.01)	-
$\Delta LN(MS_{t-1} - \overline{MS_{t-1}})$	-	-	-	-0.10 (-1.27)	-
$\Delta LN(MS_{t-2} - \overline{MS_{t-2}})$	-	-	-	-0.23 (-2.83)	-
$\Delta LN(MS_{t-3} - \overline{MS_{t-3}})$	-	-	-	-0.15 (-1.51)	-
$\Delta LN(MS_{t-4} - \overline{MS_{t-4}})$	-	-	-	-	-
$\Delta LN(GDP_t - \overline{GDP_t})$	0.15** (3.85)	-	0.16** (4.79)	-	0.04 (1.42)
$\Delta LN(GDP_{t-1} - \overline{GDP}_{t-1})$	-	-	-0.18** (-3.82)	-	-0.12** (-4.33)
$\Delta LN(GDP_{t-2} - \overline{GDP}_{t-2})$	-	-	-0.15** (-3.43)	-	-0.07** (-2.31)
$\Delta LN(GDP_{t-3} - \overline{GDP}_{t-3})$	-	-	-0.12** (-2.90)	-	-0.09** (-2.83)
$\Delta LN(GDP_{t-4} - \overline{GDP}_{t-4})$	-	-	-	-	-

Note : (**) significant at 5%; (*) significant at 10%
Signs in brackets indicate the value of the t-statistic
T-table value 5% (1.98); 10% (1.66)

Table 7 and Table 8 show the short-term NARDL estimation results. The estimation results show that five countries significantly affect real exchange rate depreciation and inflation: South Africa, Indonesia, Mexico, Norway, and Sweden. Then, there is one country that has a significant negative effect between real exchange rate appreciation and inflation, namely Brazil, while there are two countries that have a significant positive effect, namely Indonesia and Japan. The oil price variable significantly affects inflation in three countries, namely Japan, Canada, and Sweden. Then, there is no significant positive effect between the money supply and inflation in the short-run. Finally, the real GDP variable has a significant positive effect on inflation in four countries, namely India, Mexico, Australia, and Canada, while there is one country that has a significant negative effect, namely Sweden.

Long-run NARDL Bound Test

Table 9: Long-Run NARDL Estimation

Country	Long-run Estimation					
	Constant	$LN(REX^{+}-\overline{REX}^{+})$	$LN(REX^{-}-\overline{REX}^{-})$	$LN(OIL-\overline{OIL})$	$LN(MS-\overline{MS})$	$LN(GDP-\overline{GDP})$
MiddleIncome						
South Africa	-1.62**	-0.18**	-0.18**	0.04**	0.19**	0.15**
	(-5.07)	(-7.38)	(-7.30)	(3.98)	(2.04)	(3.05)
Brazil	-0.66**	-0.18**	-0.18**	0.03	-0.43	0.62**
	(-2.59)	(-2.10)	(-2.10)	(0.81)	(-0.93)	(2.90)
India	0.11	-0.04	-0.03	0.02	0.64**	-0.25*
	(0.44)	(-0.70)	(-0.64)	(1.05)	(2.08)	(-1.74)
Indonesia	-0.53	-0.16*	-0.15*	0.09**	0.64**	-0.29**
	(-0.91)	(-1.77)	(-1.76)	(4.21)	(2.41)	(-2.22)
Mexico	0.04	-0.06**	-0.06**	0.03**	0.04	-0.01
	(0.29)	(-2.51)	(-2.58)	(3.25)	(0.50)	(-0.03)
HighIncome						
Australia	-0.22	-0.03**	-0.03**	0.02**	0.01	0.05
	(-1.61)	(-2.51)	(-2.48)	(5.20)	(0.48)	(1.26)
Japan	0.15	-0.04**	-0.04**	0.03**	0.05	-0.05**
	(1.59)	(-4.65)	(-4.62)	(5.56)	(0.65)	(-2.17)
Kanada	-0.24*	-0.08**	-0.08**	0.01	0.09**	0.39**
	(-1.79)	(-3.30)	(-3.28)	(0.56)	(2.23)	(5.87)
Norwegia	-0.42**	-0.05	-0.05	0.01	0.16**	-0.03
	(-2.18)	(-1.22)	(-1.31)	(1.47)	(2.62)	(-0.56)
Sweden	-0.28*	-0.12**	-0.12**	0.02	0.14**	0.27**
	(-1.74)	(-3.33)	(-3.23)	(1.66)	(3.55)	(3.81)

Note : (**) significant at 5%; (*) significant at 10%
Signs in brackets indicate the value of the t-statistic
T-table value 5% (1.98); 10% (1.66)

Table 9 shows the long-term NARDL estimation results. The estimation results show that eight countries show a significant negative effect of real exchange rate depreciation on inflation: South Africa, Brazil, Indonesia, Mexico, Australia, Japan, Canada, and Sweden. Then, eight countries showed a significant negative effect of real exchange rate appreciation on inflation: South Africa, Brazil, Indonesia, Mexico, Australia, Japan, Canada, and Sweden. The oil price variable significantly affects inflation in five countries: South Africa, Indonesia, Mexico, Australia, and Japan. Then, the money supply variable significantly positively affects inflation in six countries: South Africa, India, Indonesia, Canada, Norway, and Sweden. Finally, the real GDP variable has a significant positive effect on inflation in four countries: South Africa, Brazil, Canada, and Sweden, while three countries have a significant negative effect, namely India, Indonesia, and Japan.

NARDL Cointegration Test

Table 10 shows the cointegration test in the long-run in each country. Based on the table, it can be concluded that all countries are cointegrated in the long-run at the 5% level.

Table 10: NARDL Cointegration Test Results

Country	F-Statistics	Information	Country	F-Statistics	Information
MiddleIncome			***HighIncome***		
South Africa	20.89**	Cointegration	Australia	18.58**	Cointegration
Brazil	11.25**	Cointegration	Japan	19.65**	Cointegration
India	6.68**	Cointegration	Canada	10.82**	Cointegration
Indonesia	14.48**	Cointegration	Norway	10.33**	Cointegration
Mexico	10.43**	Cointegration	Sweden	12.15**	Cointegration

Note :(**) significant at 5%; (*) significant at 10%
5% = *upper limit* (3.79); *lower bound* (2.62)
10% = *upper bound* (3.35); *lower bound* (2.26)

NARDL Diagnostic Test

Table 11: NARDL Diagnostic Test Results

Country	ECM_{t-1}	LM	RESET	Adj.R^2	Wald-SR	Wald-LR
Middle-Income						
South Africa	-0.62** (-11.59)	1.13	3.35	0.75	6.50**	0.01
Brazil	-0.26** (-8.50)	0.12	1.80	0.65	4.10**	0.16
India	-0.59** (-6.55)	1.85	6.35**	0.33	0.00	0.02
Indonesia	-0.69** (-9.67)	0.58	0.53	0.65	3.53*	0.01
Mexico	-0.54** (-8.19)	0.16	1.33	0.58	6.61**	0.27
High-Income						
Australia	-1.06** (-10.91)	3.57**	0.23	0.66	0.00	0.03
Japan	-0.77** (-11.24)	1.73	2.10	0.67	11.87**	0.12
Canada	-0.95** (-8.36)	2.23	3.22	0.69	0.00	0.04
Norway	-0.84** (-8.17)	2.00	1.54	0.57	22.56**	0.21
Sweden	-0.55** (-8.88)	1.01	0.05	0.71	0.24	0.95

Note : (**) significant at 5%; (*) significant at 10%
Specifically for ECMt-1, the sign in brackets represents the t-statistic value
T-table value 5% (1.98); 10% (1.66)
For LM, RESET, Wald - SR, and Wald - LR are significant if Prob <0.05

Table 11 shows the results of the NARDL diagnostic test. The test results show that all models are significantly negative at the 5% level. The largest coefficient is in Canada, which is -0.95, which means that the speed of adjustment between the long and short-run is 95%. The Lagrange Multiplier test shows that only one model has autocorrelation (rejects the null hypothesis): Australia. The results of the Ramsey RESET test show that one model is not suitable (rejects the null hypothesis), namely India, while nine other countries have correct models.

In the adjusted R^2 test, the model with the highest goodness of fit was found in the South African model, which was 0.75. This explains that in the South African model, variations in the independent variables (real exchange rates, oil prices, money supply, and real GDP) can explain 75% of the variation in the dependent variable (inflation), while the rest are influenced by other variables that are not present in models.

The Wald-SR test shows that five models are significant at 5% (South Africa, Brazil, Mexico, Japan, and Norway) and 10% (Indonesia). This proves an asymmetric effect of the real exchange rate on inflation (exchange rate pass-through) in the short-run. Meanwhile, the Wald-LR test shows that all countries are insignificant at 5% or 10%. Therefore, it can be concluded that the exchange rate has no effect on inflation (exchange rate pass-through) asymmetrically in the long-run.

ARDL and NARDL Robustness Test

The resilience test, by confirming the ARDL and NARDL methods, shows that the effect of the exchange rate on inflation is explained more by the NARDL method, namely that five countries have a significant positive effect between real exchange rate depreciation and inflation in the short-run. There is one country that has a significant negative effect between real exchange rate appreciation with inflation in the short-run and eight countries in the long-run while using the ARDL method; four countries have a significant positive relationship between the real exchange rate and inflation.

Table 12: ARDL and NARDL Resistance Test Results

Country	ARDL Method		NARDL Method	
	CUSUM	CUSUMSQ	CUSUM	CUSUMSQ
MiddleIncome				
South Africa	S	S	S	S
Brazil	US	US	S	S
India	S	S	S	US
Indonesia	S	US	US	US
Meksiko	S	US	S	US
High-Income				
Australia	S	US	US	US
Jepang	S	US	S	US
Kanada	S	S	S	S
Norway	S	US	US	US
Sweden	S	S	S	S

Furthermore, each method carried out the robustness test using the CUSUM and CUSUMSQ stability tests. Based on Table 12, the results of the CUSUM stability test on the ARDL method show that one country has an unstable model, namely Brazil, while nine other countries have stable models. Then, the CUSUMSQ test on the ARDL method shows six countries with unstable models, namely Brazil, Indonesia, Mexico, Australia, Japan, and Norway, while four other countries have stable models.

The results of the CUSUM stability test on the NARDL model show three countries with unstable models, namely Indonesia, Australia, and Norway, while seven other countries have stable models. Then, the CUSUMSQ test on the NARDL method shows six countries with unstable models, namely India, Indonesia, Mexico, Australia, Japan, and Norway, while four other countries have stable models.

Discussion of Research

Effect of the Real Exchange Rate on Inflation

Depreciation can usually increase inflation because the price of imported goods becomes higher than that of domestic goods. However, if the level of interdependence between countries is low, the effect of depreciation on import prices will be lower. Therefore, it allows the price of domestic goods to be low and local companies usually continue to cut costs and increase productivity to remain competitive (Engel, 2006; Gopinath et al., 2010; Shintani et al., 2013). Then, appreciation can usually reduce inflation because the price of imported goods becomes lower than that of domestic goods. However, if the level of interdependence between countries is low or implementing import restriction policies so that importing companies decide to cooperate, the price of domestic goods may tend to be high (Engel, 2006; Gopinath et al., 2010; Shintani et al., 2013).

Differences in the short-run and long-run exchange rate's effect on inflation can be found in the J-Curve phenomenon. Real depreciation causes exports to increase and imports to decrease, but this does not happen in a short period (Blanchard, 2017). At the beginning of the period, depreciation has more effect on price than quantity. The price of imported goods increases so that exports decrease. However, the quantities of exports and imports adjust slowly because consumers do not quickly notice changes in relative prices. So, at the beginning of the period, the real depreciation causes a decrease in the trade balance. This description is contained in the research of Adiningsih et al. (2013); Ari et al. (2019); Bahmani-Oskooee et al. (2016); Bahmani-Oskooee et al. (2017), and Bahmani-Oskooee & Karamelikli (2018).

Based on the estimation results using the ARDL and NARDL methods above, it can be concluded that the average magnitude of the effect of the exchange rate on inflation (exchange rate pass-through) in middle-income countries is greater than in high-income countries. Therefore, inflation-targeting policies allow more flexibility to be implemented in high-income countries. This condition is in line with research conducted by Choudhri & Hakura (2006), which explains that when the effect of the real exchange rate on inflation (exchange rate pass-through) is low, it will enable a country to implement a more independent and flexible monetary policy in which policies Inflation targeting can be implemented more easily. Not only that, the effect of the exchange rate on inflation can be called a complete pass-through because changes in the exchange rate have a greater influence on changes in inflation.

Effect of the Oil Price on Inflation

Based on the estimation results using the ARDL and NARDL methods above, it can be concluded that world oil prices have a major influence on inflation, especially in South Africa, Indonesia, Mexico, Australia, Japan, Canada, and Sweden. That is, if there is an increase in oil prices, it will cause inflation in the country. These results are consistent with research from Pham at al. (2020); Nasir at al. (2020); Choi et al. (2018), and Anh et al. (2018), which explains that world oil price shocks have a major influence on increasing the cost of production or industrial fuel which will eventually lead to an increase in prices.

Furthermore, estimation results stated that world oil prices did not have an important role in determining inflation. These results were found in Brazil, India, Canada, Norway, and

Sweden. According to Anh et al. (2018), there are two possibilities that oil prices do not significantly affect inflation, namely that there is a role in determining oil prices because it has abundant natural resources and industrial activities use little oil because it already has other alternatives. For example, Brazil, India, and Canada are starting to implement *energy security* and have an alternative as a substitute for oil, namely Ethanol.

Effect of the Money Supply on Inflation

Money supply can positively affect inflation because it can increase people's purchasing power, while the stock of goods and services grows more slowly. As a result, the price of goods and services will increase. When these prices increase continuously, it will cause inflation (Mankiw, 2006). The results of this study also strengthen the results of previous studies, which explain that there is a high correlation between the growth rate of the money supply and the inflation rate in the long-run (McCandless & Weber, 1995).

According to Walsh (2003), the high correlation between inflation and the growth rate of the money supply supports the quantity theory argument that growth in the money supply causes a similar increase in the price level. This opinion is consistent with research by Oomes and Ohnsorge (2005), who analyzed the impact of money demand on inflation for monthly data in Russia from April 1996 to January 2004 using an error correction model. The results of this study indicate that the excess supply of money in circulation has the strongest influence on inflation and can last both in the short and long-run.

Furthermore, estimation results stated that the money supply does not have an important role in determining inflation. These results were found in Brazil, Mexico, Australia, and Japan. According to Pham et al. (2020), if the increase in the money supply equals real output, the price of goods will remain the same, not to cause inflation.

Effect of the Gross Domestic Product on Inflation

Real GDP has a varying effect on inflation, both positive and negative (Pham et al., 2020; Nasir et al., 2020; Nasir & Vo, 2020). Real GDP positively affects inflation when an increase in real GDP causes an increase in aggregate demand while supply cannot offset it. Therefore, a shortage of goods increases prices (Pham et al., 2020; Nasir et al., 2020; Munyeka, 2014). The results of this study support the theory of Krugman & Obstfeld (2000), which states that if economic growth increases, it will increase the positive output gap or the difference between actual output and potential output so that there is a potential for inflation.

Furthermore, real GDP can also have a negative effect, which if real GDP increases will reduce inflation. The results of this study are consistent with the research of Hodge (2006); Gillman et al. (2004), and Jackman et al. (2004), which explains that real GDP harms inflation when economic growth can meet higher levels of aggregate demand without putting upward pressure on the general price level.

Conclusion

This study aims to analyze the effects of symmetry and asymmetry of exchange rate pass-through in countries that implement inflation-targeting policies in the short and long-run and to analyze differences in the magnitude of exchange rate pass-through in middle and high-income countries. Based on the estimates made using the ARDL method, four countries have a significant positive effect on the real exchange rate on inflation in the short-run: Indonesia, Japan, Norway, and Sweden.

In the NARDL method, five countries have a significant positive effect between real exchange rate depreciation and inflation in the short-run: South Africa, Indonesia, Mexico, Norway, and Sweden. In addition, only one country has a significant negative effect between real exchange rate appreciation and inflation in the short-run, namely Brazil, and there are eight countries in the long-run, South Africa, Brazil, Indonesia, Mexico, Australia, Japan, Canada, and Sweden. This explains that when the real exchange rate is decomposed into depreciation and appreciation it will produce more significant short-term effects. Based on the estimation results, it can be concluded that the average magnitude of the effect of the exchange rate on inflation (exchange rate pass-through) in middle-income countries is greater than in high-income countries. Therefore, inflation-targeting policies allow more flexibility to be implemented in high-income countries. Not only that, the effect of the exchange rate on inflation can be called a complete pass-through because changes in the exchange rate have a greater influence on changes in inflation.

Apart from the real exchange rate, other variables such as oil prices, the money supply, and real GDP greatly influence inflation. In the ARDL and NARDL methods, three countries have a significant positive effect between world oil prices and inflation in the short-run, namely Japan, Canada, and Sweden, while in the long-term, there are five countries, namely South Africa, Indonesia, Mexico, Australia, and Japan.

Furthermore, in the ARDL and NARDL methods, six countries significantly positively affect the money supply on inflation that lasts in the long-run, namely South Africa, India, Indonesia, Canada, Norway, and Sweden. Then, in the ARDL method, five countries have a significant positive effect between real GDP and inflation in the short-run, namely India, Mexico, Australia, Canada, and Sweden, while in the NARDL method, there are four countries, namely, India, Mexico, Australia, and Canada. Then, in the ARDL and NARDL methods, four countries have a significant positive effect between real GDP and inflation in the long-run, namely South Africa, Brazil, Canada, and Sweden.

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