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# UNRAVELING THE NEXUS: OIL PRICE DYNAMICS AND INFLATION IN MADAGASCAR

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## Abstract

*This work employs the Autoregressive Distributed Lag (ARDL) approach to investigate the nexus between macroeconomic variables and inflation in Madagascar. The findings reveal significant impacts of various factors, including imports, GDP, exchange rates, and oil prices, on inflation dynamics. Specifically, the study highlights the substantial influence of oil prices, with a one-unit increase leading to a 9.21 unit rise in inflation. These results underscore the importance of implementing targeted policy measures to address the inflationary pressures arising from volatile oil markets. Strategies such as diversification of imports, energy source diversification, and improvements in public transportation infrastructure are recommended to mitigate the adverse effects of oil price fluctuations and promote economic stability in Madagascar.*

**Keywords:** *Inflation, Madagascar, ARDL, Macroeconomic Variables, Oil Prices, Exchange rate, Imports.*

## 1 Introduction

In the realm of macroeconomic analysis, the intricate relationship between oil price fluctuations and inflation dynamics stands as a fundamental area of inquiry, wielding significant implications

for economic policymaking and financial stability on a global scale. Against the backdrop of an increasingly interconnected and interdependent global economy, the volatility in oil markets transcends national boundaries, permeating various sectors and exerting discernible effects on inflationary pressures. Within this context, elucidating the nuanced interplay between oil prices and inflation assumes paramount importance for policymakers, economists, and stakeholders alike, particularly in the context of emerging and developing economies striving to navigate the complex terrain of economic growth and stability.

Madagascar, situated at the confluence of economic transformation and energy market volatility, presents a compelling case study for examining the intricate nexus between oil price dynamics and inflationary trends. Endowed with abundant natural resources yet confronted with the imperatives of energy security and sustainable development, Madagascar serves as a fertile ground for probing the transmission mechanisms of oil price shocks and their ramifications on inflationary dynamics. Against this backdrop, this study embarks on a rigorous inquiry into the macroeconomic determinants of inflation in Madagascar, with a specific focus on the role of oil price fluctuations.

Employing rigorous econometric methodologies and drawing upon empirical evidence, this research endeavors to unravel the complex interactions between oil prices, inflation, and other pivotal macroeconomic variables, leveraging sophisticated analytical frameworks such as the Autoregressive Distributed Lag (ARDL) approach. By delineat-

ing the channels through which oil price fluctuations propagate to inflationary pressures, this study aims to furnish actionable insights for policymakers, guiding the formulation of targeted interventions to mitigate the adverse effects of energy market volatility and foster macroeconomic stability.

## 2 Literature Review

The interplay between oil prices and inflation has garnered considerable attention in macroeconomic research, with implications for economies worldwide. In the case of Madagascar, a country heavily reliant on imported petroleum products and susceptible to external shocks, understanding the dynamics of this relationship is paramount for policymakers and economists alike.

Hamilton [7] pioneered research on the macroeconomic effects of oil price changes, emphasizing the asymmetric nature of their impact. His work underscored that significant increases in oil prices tend to exert a more pronounced influence on the economy compared to decreases, highlighting the potential inflationary pressures associated with rising oil prices. This asymmetry has crucial implications for Madagascar, where elevated oil prices could lead to cost-push inflation, affecting consumer prices across various sectors.

Building on Hamilton's findings, Hooker [8] delved deeper into the link between oil prices and economic activity. His research suggested that substantial increases in oil prices have a discernible impact on GDP growth, with declines in oil prices having relatively limited effects. This observation underscores the significance of oil price movements as a driver of inflationary pressures in economies reliant on petroleum imports, such as Madagascar.

Lardic and Mignon [10] explored the transmission channels through which oil price fluctuations affect economic growth and inflation. They identified monetary policy as a critical factor influencing this transmission mechanism. In periods of rising oil prices, central banks often adopt contractionary monetary policies to counter inflation, potentially exacerbating the adverse effects on economic activity. Conversely, during periods of falling oil prices, central banks may not adjust monetary policy as aggressively, resulting in a less pronounced impact on inflation.

Empirical studies by Mork [11] and Hamilton [7] supported the notion that only increases in oil prices have a significant effect on GDP growth, while decreases do not. This asymmetry in the response of economic variables to oil price changes complicates the estimation of inflationary effects

and underscores the need for nuanced policy responses to oil price shocks in Madagascar.

Krugman [9] and Bénassy-Quéré et al. [3] investigated the relationship between oil prices and exchange rates, highlighting its relevance to economies like Madagascar. Higher oil prices often lead to appreciations in the currencies of oil-exporting nations, influencing import prices and contributing to inflationary pressures in importing countries. This dynamic underscores the vulnerability of import-dependent economies to fluctuations in global oil markets.

Moreover, the indirect effects of oil price fluctuations on various sectors of the economy cannot be overlooked. Studies by Balke et al. [2] and Haltiwanger [6] emphasized the challenges faced by industries in adapting to oil price changes, which can exacerbate inflationary pressures. These findings underscore the importance of holistic macroeconomic analysis in understanding the implications of oil price fluctuations on inflation and economic stability in Madagascar.

## 3 Methodology

In this section, we outline the methodology employed for the regression analysis to investigate the relationship between the Consumer Price Index (IPC) and its potential determinants. The ARDL approach allows us to model both short-term and long-term dynamics, capturing the lagged effects of variables on the IPC.

### 3.1 Data

The data used in this analysis was sourced from the World Bank database (see table 1). The dataset covers the period from 1991 to 2020, with adjustments made for missing or incomplete observations.

### 3.2 Model Specification

The model is specified as follows:

**Base Model:**

$$\begin{aligned} CPI_t = & \beta_0 + \beta_1 CPI_{t-1} + \beta_2 IMP_t + \beta_3 GDP_t \\ & + \beta_4 GDP_{t-1} + \beta_5 OIL_t + \beta_6 EXCH_t \\ & + \beta_7 EXCH_{t-1} + \epsilon_t \end{aligned} \tag{1}$$

Where:

★  $CPI_t$  represents the Consumer Price Index at time  $t$ .

Variable	Source	Definition
CPI	World Bank ( <a href="https://data.worldbank.org/">https://data.worldbank.org/</a> )	<i>Consumer Price Index</i> : A measure of the average change over time in the prices paid by urban consumers for a basket of consumer goods and services. It serves as a key indicator of inflation.
IMP	World Bank ( <a href="https://data.worldbank.org/">https://data.worldbank.org/</a> )	<i>Imports</i> : The total value of goods and services purchased by a country from foreign sources. It can reflect a country's reliance on imported petroleum products.
GDP	World Bank ( <a href="https://data.worldbank.org/">https://data.worldbank.org/</a> )	<i>Gross Domestic Product (GDP)</i> : The total monetary value of all finished goods and services produced within a country's borders in a specific time period. It is an indicator of the economic health of a country.
OIL	World Bank ( <a href="https://data.worldbank.org/">https://data.worldbank.org/</a> )	<i>Oil Prices</i> : The price of crude oil on the global market. Changes in oil prices can have significant effects on economies dependent on fossil fuels.
EXCH	World Bank ( <a href="https://data.worldbank.org/">https://data.worldbank.org/</a> )	<i>Exchange Rate</i> : The value of one currency relative to another. It can impact the cost of importing petroleum and domestic prices.

Table 1: Data Sources and Definitions

★  $CPI_{t-1}$  is the lagged value of the Consumer Price Index.

★  $IMP_t$ ,  $GDP_t$ ,  $OIL_t$ , and  $EXCH_t$  denote the current values of the dynamic regressors: Imports, GDP, Oil Prices, and Exchange Rate, respectively.

★  $GDP_{t-1}$  and  $EXCH_{t-1}$  represent the lagged values of GDP and Exchange Rate, respectively.

★  $\epsilon_t$  is the error term.

**ARDL Model:**

$$\begin{aligned}
CPI_t = & \gamma_0 + \gamma_1 CPI_{t-1} + \gamma_2 IMP_t + \gamma_3 GDP_t \\
& + \gamma_4 GDP_{t-1} + \gamma_5 OIL_t + \gamma_6 EXCH_t \\
& + \gamma_7 EXCH_{t-1} + \sum_{i=1}^p \delta_i \Delta CPI_{t-i} + \epsilon_t
\end{aligned} \tag{2}$$

Where:

★  $\gamma_0, \gamma_1, \dots, \gamma_7$  are coefficients of the ARDL model.

★  $\Delta CPI_{t-i}$  represents the differenced Consumer Price Index at lag  $i$ .

★  $p$  is the order of the ARDL model.

### 3.3 Justification of ARDL Model Selection

The Autoregressive Distributed Lag (ARDL) model is chosen for several reasons:

★ **Flexibility:** The ARDL model allows for the inclusion of both lagged and contemporaneous variables, providing flexibility in capturing short and long-term dynamics in the relationship between the dependent and independent variables.

★ **Endogeneity:** By incorporating lagged values of the dependent variable and differenced terms, the ARDL model addresses potential endogeneity issues, especially when dealing with non-stationary time series data.

★ **Model Parsimony:** The ARDL model avoids over-parameterization by including only lagged terms that are theoretically justified and statistically significant, leading to a more parsimonious model compared to unrestricted VAR models.

★ **Inference:** The ARDL model allows for straightforward inference using standard techniques such as hypothesis testing, estimation of long-run and short-run coefficients, and diagnostic tests for model adequacy.

## 4 Results

### 4.1 Interpretation of Coefficients

Table 2 presents the results of the ARDL regression analysis, providing coefficients, standard errors, t-statistics, and associated probabilities for each variable.

The coefficients of the model provide insights into the impact of each variable on the CPI in Madagascar. The model exhibits an explanatory power of approximately 78% (R-squared: 0.787123), indicating a robust fit to the data.

#### 4.1.1 CPI(-1)

The coefficient value of 0.3921 suggests that a one-unit increase in the lagged Consumer Price Index (CPI) leads to a 0.3921 unit increase in the current CPI, holding other variables constant. This coefficient is statistically significant at the 0.01 level ( $p = 0.0064$ ), indicating a strong short-term relationship between the lagged CPI and the current CPI.

#### 4.1.2 LIMP

The coefficient value of 8.8834 implies that a one-unit increase in imports (LIMP) leads to an 8.8834 unit increase in the CPI, but this relationship is not statistically significant at the conventional levels ( $p = 0.0540$ ). Therefore, the short-term impact of imports on CPI is weak.

#### 4.1.3 GDP

With a coefficient of 37.3774, a one-unit increase in GDP leads to a 37.3774 unit increase in CPI. This relationship is statistically significant at the 0.05 level ( $p = 0.0376$ ), suggesting a moderate impact of GDP on CPI in the short term.

#### 4.1.4 GDP(-1)

The negative coefficient value (-60.5713) indicates that a one-unit increase in lagged GDP leads to a decrease of 60.5713 units in CPI. This relationship is statistically significant at the 0.01 level ( $p = 0.0004$ ), implying a strong inverse relationship between lagged GDP and current CPI in the short term.

#### 4.1.5 OIL

The coefficient value of 9.2094 suggests that a one-unit increase in oil prices leads to a 9.2094 unit increase in CPI. This relationship is statistically significant at the 0.05 level ( $p = 0.0430$ ), indicating a

moderate impact of oil prices on CPI in the short term.

#### 4.1.6 LEXCH

The coefficient value of 75.2845 indicates that a one-unit increase in the exchange rate (LEXCH) leads to a 75.2845 unit increase in CPI. This relationship is highly statistically significant at the 0.01 level ( $p < 0.001$ ), suggesting a strong short-term impact of exchange rate fluctuations on CPI.

### 4.2 Normality test

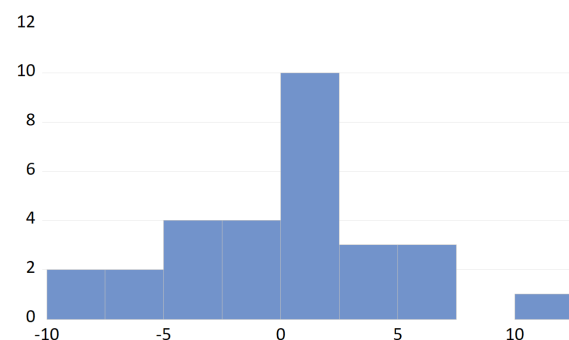


Figure 1: Normality test

Since the p-value is greater than the conventional significance level of 0.05, we fail to reject the null hypothesis that the data follows a normal distribution.

Therefore, based on the Jarque-Bera test (see table 3 and figure 1), we can conclude that the residuals appear to be normally distributed.

### 4.3 Stability of the Model

To assess the stability of the ARDL model over time, we conducted the CUSUM and squared CUSUM tests. These tests examine whether the coefficients of the model remain stable over the sample period.

The CUSUM (Cumulative Sum) test checks for structural stability by plotting cumulative sums of recursive residuals against time. If the CUSUM plot remains within critical bounds, it suggests that the coefficients are stable over time.

Similarly, the squared CUSUM test examines the squared cumulative sums of recursive residuals. A stable model should produce squared CUSUM plots that remain within critical bounds, indicating that the model's coefficients are not subject to structural change.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CPI(-1)	0.392067	0.130146	3.012511	0.0064
LIMP	8.883400	4.363503	2.035841	0.0540
LGDP	37.37735	16.89158	2.212780	0.0376
LGDP(-1)	-60.57134	14.44767	-4.192465	0.0004
LOIL	9.209408	4.286694	2.148370	0.0430
LEXCH	75.28454	14.28413	5.270501	0.0000
LEXCH(-1)	-82.57940	13.15570	-6.277080	0.0000
R-squared	0.787123	Mean dependent var: 11.67176		
Adjusted R-squared	0.729065	S.D. dependent var: 10.06505		

Table 2: ARDL Regression Results

Statistic	Value
Mean	-0.005870
Std. Dev.	4.643874
Jarque-Bera	0.205192
Probability	0.902491

Table 3: Summary Statistics and Jarque-Bera Test Results

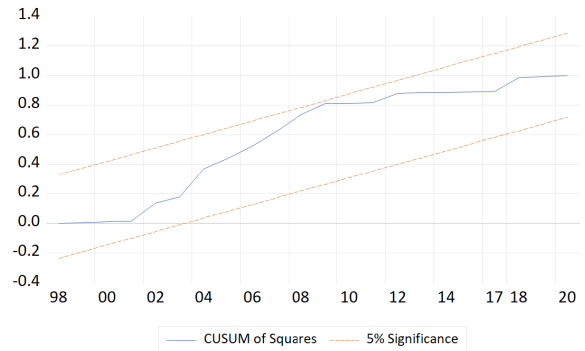


Figure 3: Squared CUSUM Plot

Figures 3 and 2 depict the CUSUM and squared CUSUM plots, respectively. Both plots indicate that the model coefficients remain stable over the sample period, providing evidence of the model's stability.

These stability tests support the robustness of the ARDL model and provide confidence in its reliability for analyzing the relationship between the variables over time.

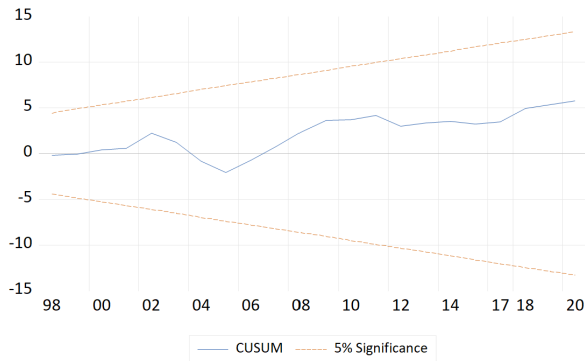


Figure 2: CUSUM Plot

## 5 Discussion

The results of the ARDL regression analysis provide insights into the macroeconomic factors influencing inflation, as measured by the Consumer Price Index (IPC) in Madagascar. The coefficients of the model reveal the magnitude and direction of the impact of each variable on inflation. Here, we discuss the macroeconomic influences identified in the analysis:

### 5.1 Determinants of Inflation in case of Madagascar

Based on the results presented in Table 2, several variables exhibit significant coefficients indicating their influence on inflation in Madagascar. The coefficients represent the estimated impact of each variable on inflation, while the t-statistic and probability values indicate the statistical significance of these estimates.

★ **Consumer Price Index (CPI):** The lagged CPI variable (CPI(-1)) shows a positive coefficient of 0.392067, indicating that past inflation positively affects current inflation. This suggests a persistence or momentum effect in inflation dynamics, where previous price increases continue to influence current price levels. Madagascar’s economy may exhibit sticky prices or wages, causing inflation to persist over time.

★ **Imports (IMP):** The coefficient of imports (IMP) is 8.883400, though not statistically significant at the conventional level ( $p = 0.0540$ ). Nonetheless, the positive coefficient suggests that an increase in imports may contribute to higher inflation, possibly due to the pass-through of import costs to domestic prices. Madagascar’s reliance on imports, particularly for essential goods and energy, can amplify the impact of global price fluctuations on domestic inflation.

★ **Gross Domestic Product (GDP):** Both GDP and lagged GDP variables exhibit significant coefficients. The positive coefficient for GDP (37.37735) implies that higher economic growth is associated with increased inflation. This aligns with the concept of demand-pull inflation, where robust economic activity leads to higher aggregate demand and upward pressure on prices. Madagascar’s expanding economy, driven by sectors like agriculture and mining, may fuel demand and contribute to inflationary pressures.

★ **Oil Prices (OIL):** The coefficient for oil prices (OIL) is 9.209408, indicating a positive relationship between oil price fluctuations and inflation. Higher oil prices can lead to increased production costs, particularly in sectors reliant on petroleum products, thereby contributing to inflationary pressures. Madagascar’s dependence on imported petroleum products for energy generation and transportation exacerbates the inflationary impact of global oil price changes.

★ **Exchange Rate (EXCH):** The exchange rate variable (EXCH) and its lagged value (EXCH(-1)) both exhibit significant coefficients. The positive coefficient for EXCH (75.28454) suggests that a depreciation of the local currency relative to foreign currencies is associated with higher inflation. Exchange rate movements can affect the cost of imported goods and services, influencing domestic price levels. Madagascar’s vulnerability to

exchange rate fluctuations, coupled with its import-heavy economy, magnifies the inflationary effects of currency depreciation.

## 5.2 Impact of Oil Prices on Inflation in Madagascar

The relationship between oil prices and inflation in Madagascar is intricate, driven by the country’s heavy dependence on imported petroleum products, notably in electricity generation and transportation.

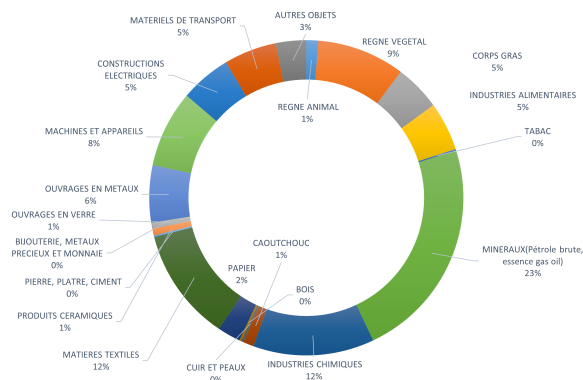


Figure 4: Imports from Madagascar over the past four years (2020 to 2023)

### 5.2.1 Electricity Generation

Madagascar relies predominantly on imported diesel and heavy fuel oil (23% from the overall imports see Figure 4) to power its electricity generation plants. When global oil prices surge, such as during the Ukraine war in 2022, the cost of importing these fuels escalates, directly impacting the cost of electricity production. For instance, the sharp increase in oil prices during the war led to higher fuel costs for power plants in Madagascar, resulting in a subsequent rise in electricity tariffs. This translated into increased operational costs for businesses across sectors, which passed on the higher costs to consumers through elevated prices, thereby contributing to inflation.

### 5.2.2 Transportation

The transportation sector plays a pivotal role in Madagascar’s economy, with diesel fuel being the primary fuel for trucks, buses, and other vehicles. The impact of oil price fluctuations, such as those observed during the Ukraine war, is felt keenly in this sector. For example, the surge in oil prices led to a sharp increase in transportation costs in Madagascar in 2022, as evidenced by higher bus

fares and freight rates. Consequently, the prices of goods transported by road also rose, contributing to inflationary pressures across the economy.

### 5.2.3 Indirect Effects

Beyond direct consumption in electricity generation and transportation, oil price fluctuations have indirect effects across various sectors. Industries reliant on diesel generators for backup power or primary electricity supply face higher production costs when oil prices rise due to geopolitical tensions like the Ukraine war. For instance, during this period, businesses in Madagascar experienced increased costs of operating diesel generators, leading to higher prices for goods and services. Additionally, the transportation sector's role in the supply chain is crucial, as illustrated by the 2022 oil price surge, resulting in higher transportation costs and subsequently elevated prices for both imported and domestically produced goods, amplifying inflationary pressures.

## 6 Recommendations

Given the profound impact of oil price fluctuations on inflation in Madagascar, policymakers must enact targeted measures to mitigate these effects and ensure macroeconomic stability. The following recommendations are proposed:

### 6.1 Diversification of Imports

The recent geopolitical tensions between Russia and Ukraine have highlighted the vulnerability of relying on a limited number of import sources for essential goods and commodities, such as energy and foodstuffs. To enhance resilience against supply shocks and minimize vulnerability to price volatility, Madagascar should prioritize diversifying its import sources. This diversification strategy should encompass exploring opportunities to bolster intra-African trade, particularly through initiatives like the African Continental Free Trade Area (AfCFTA) [16]. By diversifying trade relationships, Madagascar can reduce its dependence on a single supplier and ensure a stable supply of goods, especially less volatile agricultural products and value-added manufactured goods.

### 6.2 Diversification of Energy Sources

Despite facing challenges in providing reliable electricity, Madagascar boasts significant untapped potential in renewable energy resources. With approximately 2,800 hours of sunlight per year [14]

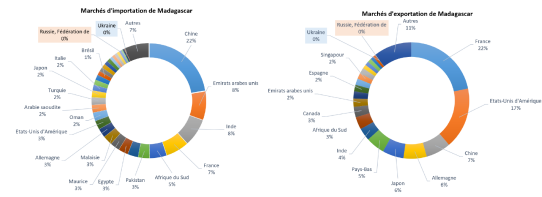


Figure 5: Overview of Major Trade Partners of Madagascar

and numerous rivers and streams suitable for hydroelectric dam projects [1], the country stands at a pivotal moment in its energy sector development. Transitioning to renewable energy sources such as solar, wind, and hydroelectric power is crucial for reducing dependency on imported petroleum products and mitigating the inflationary impact of oil price fluctuations. Moreover, promoting energy efficiency measures and adopting cleaner technologies can foster sustainable energy consumption practices while alleviating production costs.

### 6.3 Improvement of Public Transportation Infrastructure

Investing in public transportation infrastructure offers a pragmatic approach to reducing the economy's vulnerability to oil price shocks. Enhancing public transportation networks, including railways and bus systems, can incentivize a shift towards more fuel-efficient modes of transportation. This shift not only reduces overall fuel consumption but also mitigates the impact of oil price fluctuations on transportation costs. Additionally, integrating alternative fuels such as compressed natural gas (CNG) or biodiesel into public transportation fleets presents an opportunity to further diminish reliance on volatile oil markets and promote environmentally sustainable transportation practices.

### 6.4 Monetary Policy Considerations

In addition to structural reforms and diversification efforts, prudent monetary policy measures can play a crucial role in mitigating the impact of oil price fluctuations on inflation. The Central Bank of Madagascar should adopt a vigilant stance, closely monitoring inflationary pressures and adjusting monetary policy instruments accordingly. Targeted interventions, such as interest rate adjustments and liquidity management operations, can help stabilize prices and maintain overall macroeconomic stability.



Moreover, transparent communication of monetary policy decisions and objectives is essential to anchor inflation expectations and enhance the effectiveness of policy measures. By fostering confidence in the central bank's commitment to price stability, policymakers can mitigate the pass-through effects of oil price shocks on inflation, thereby promoting sustainable economic growth and resilience against external shocks.

## 7 Conclusion

In conclusion, the application of the Autoregressive Distributed Lag (ARDL) approach has provided valuable insights into the intricate relationship between various macroeconomic factors and inflation dynamics in Madagascar. Through rigorous econometric analysis, we have discerned the nuanced impact of variables such as imports, GDP, exchange rates, and oil prices on inflation.

The ARDL regression results underscore the significance of these variables as drivers of inflationary pressures in Madagascar. For instance, the positive coefficients associated with imports and GDP suggest that increases in these variables are associated with higher inflation, reflecting the country's vulnerability to external economic shocks and internal demand pressures.

Moreover, the positive coefficient for exchange rates indicates that a depreciation of the local currency relative to foreign currencies is associated with higher inflation. This underscores the importance of exchange rate stability in managing inflationary pressures and promoting economic stability.

While oil prices play a significant role in driving inflation in Madagascar, as evidenced by the positive coefficient in the ARDL model, it is essential to recognize the broader macroeconomic context within which inflation dynamics operate. Therefore, we should consider a comprehensive approach that addresses not only oil price fluctuations but also other macroeconomic variables to effectively manage inflation and promote sustainable economic growth.

In light of the ARDL findings, the recommendations outlined - including diversification of imports, energy source diversification, and improvements in public transportation infrastructure emerge as crucial policy imperatives. These strategies offer pragmatic pathways to mitigate the adverse effects of various macroeconomic factors on inflation, enhance economic resilience, and promote sustainable development in Madagascar.

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