Nonlinear and Asymmetric Exchange Rate Pass-Through to Consumer Prices in South Africa

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DECLARATION

I declare that “Nonlinear and Asymmetric Exchange Rate Pass-Through to Consumer Prices in South Africa”, is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references and that this work has not been submitted before for any other degree at any other institution.

Vhulenda Patricia Lavhelani 09 May 2024

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ABSTRACT

After the breakdown of the Bretton Woods fixed exchange rate system, some economies, including South Africa, abandoned fixed exchange rate regimes in favour of floating exchange rate systems. When a country adopts a floating exchange rate and an open trade policy, it loses the ability to shield its economy from external economic shocks. One possible channel for the transmission of these shocks is the exchange rate. The extent to which exchange rate fluctuations are transmitted to import prices and subsequently, to final consumer prices is referred to as exchange rate pass-through. Recent literature suggests that exchange rate pass-through is asymmetric and nonlinear, particularly in emerging nations. Despite the relevance or prominence of these issues, there seems to be a dearth of studies analyzing nonlinear and asymmetric exchange rate pass-through (ERPT) to consumer prices in South Africa. The current study, therefore, aims to deepen the literature on this topic by examining the asymmetric and nonlinear exchange rate pass-through on consumer prices in South Africa using the nonlinear autoregressive distributed lag approach and quarterly data spanning from January 2015 to July 2023. The outcome of this study is that there is a nonlinear and asymmetric exchange rate pass-through in South Africa. The nonlinear autoregressive distributive lag (NARDL) model results reveal the nonexistence of a significant nonlinear asymmetric long-run correlation between exchange rate and consumer inflation. This is portrayed by the Wald test results, which suggest the absence of a nonlinear asymmetric correlation between inflation and exchange rate. This is supported by a significant p-value (0.0000), less than 0.05. The policy suggestion is that the South African monetary authorities should not duly worry about exchange rate depreciations as they don't have a significant impact on consumer prices

Keywords: *asymmetric exchange rate pass-through; nonlinear exchange rate pass-through; consumer prices, nonlinear autoregressive distributed lag approach, South Africa.*

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CHAPTER ONE
ORIENTATION TO THE STUDY

1.1 BACKGROUND OF THE STUDY

Following the demise of the Bretton Woods fixed exchange rate system, numerous economies (both advanced and emerging) shifted away from fixed exchange rate regimes and adopted the floating exchange rate system. In the early 1990s, South Africa, also embraced a flexible exchange rate system, aligning with other developing nations. The adoption of a floating exchange rate regime, coupled with the inflation targeting framework implemented in 2002, led to significant exchange rate volatility. As Chiparawasha (2015) notes, “When a country adopts a floating exchange rate and an open trade policy, it loses the power to insulate its economy from external economic shocks” (p.45). One potential conduit for the transmission of these shocks is the exchange rate.

The degree to which exchange rate fluctuations affect import prices and subsequently impact final consumer prices is termed “exchange rate pass-through” (Ander & Caporale, 2023; European Central Bank, 2020). It also denotes the extent to which exchange rate variations influence domestic prices (Aisen et al., 2021). Exchange rate pass-through also encompasses the responsiveness of domestic prices to such variations (Cao et al., 2015; Cunningham et al., 2017; Dilla et al., 2017).

Exchange rate fluctuations influence consumer prices through two primary channels: the direct channel and the indirect channel. Firstly, directly through their effect on imported consumer goods. For instance, following an exchange rate depreciation, imported final consumer goods become more expensive, ultimately increasing overall consumer price inflation. Secondly, indirectly, as some imported goods serve as inputs into production, an exchange rate depreciation leads to higher production costs, which cascade through different stages of domestic intermediate and final goods production, ultimately impacting domestic consumer prices (European Central Bank, 2020).

Historically, exchange rate pass-through to consumer prices has often been lower than to import prices in many economies. One possible explanation for incomplete exchange rate pass-through to inflation could be that firms with market power engage in pricing-to-market (PTM), resulting in the same product being sold at different prices in segmented markets (Krugman, 1986; Goldberg and Knetter, 1997). During the 1990s, most industrialized economies (such as the United States of America and the United Kingdom) experienced sustained low inflation rates despite expanding economies and increasing economic activity (Magwiro et al., 2019).

ERPT to consumer prices is significantly low in emerging market economies with single-digit inflation. Hence, when comparing direct and indirect exchange rate pass-through, ERPT is deemed effective when the impact of devaluation is fully reflected in import prices (complete pass-through). Conversely, if it only accounts for a fraction of the depreciation in import prices, it is considered inadequate or incomplete. Over the past 20 years, a significant body of empirical research has shown that the connection between fluctuations in consumer prices and changes in the nominal exchange rate has been quite low and diminishing for a large group of nations (Gwili, 2018).

Similarly, in South Africa, the exchange rate pass-through to consumer prices was reported to be low compared to the effect on import prices. Despite exchange rate volatilities, inflation has declined from 2000 to 2018. The adoption of the inflation targeting framework in 2000 saw the South African Reserve Bank allowing the rand to fluctuate with no interventions, indicating that the central bank did not have control over the impact of exchange rate changes on inflation outcomes. From 2002 to 2018, ERPT to consumer prices in South Africa ranged between 20 and 30 percent, meaning that prices did not fully respond to exchange rate changes during this period (Kabundi & Mlachila, 2018). One of the reasons for low ERPT-to-consumer prices could be the inflation-targeting policies adopted by the Reserve Bank of South Africa since 2002 (Magwiro, 2019).

According to the South African Reserve Bank (2018), the average dollar-rand exchange rates for January and August of 2018 were R12.2041/$ and R14.7797/$, respectively (a change of 2.58 percentage points or a 21.1 percent depreciation of the rand against the dollar). Core CPI for January and August was 4 percent and 4.4 percent, respectively, representing a 0.4 percentage point change, which is much less than the change in the exchange rate of 21.1 percent, indicating an incomplete exchange rate transmission to prices (Magwiro, 2019).

Kabundi and Mbelu (2018) find the exchange rate pass-through to headline inflation to be around 0.2 to 0.25 in the mid-2010s. They modeled ERPT for 1994 to 2014 using ECM and, instead of directly estimating overall pass-through, implemented a two-stage ERPT framework, distinguishing a first-stage pass-through (the impact of exchange rate movement on import prices) from a second-stage pass-through (the effects of import prices on overall consumer prices). They report that the behavior of ERPT over the business cycle is asymmetric, in that ERPT tends to rise during business cycle upturns relative to downturns. ERPT is complete in the first stage but incomplete in the second stage, implying that retailers do not pass all price changes to consumers (International Monetary Fund, 2019).

In their study, Magwiro et al. (2019) reveal the existence of exchange pass-through asymmetry to consumer prices and import prices in South Africa; however, the impact is higher on import prices than on consumer prices. There was also evidence of a significant asymmetric effect of appreciation and depreciation on consumer prices in South Africa. The results further indicate that when there is depreciation, consumer prices tend to increase (and vice versa). However, in this regard, the asymmetric effect is not significant.

According to Cheikh et al. (2018), the exchange rate transmission to inflation responds to economic activity in a non-linear manner, with the exchange rate pass-through being higher during expansion than during recession periods. Kabundi and Mbelu (2018) show that there is a degree of asymmetry in the level of pass-through depending on the phase of the business cycle in South Africa. Both the first- and

second-stage levels and speed of pass-through rise during a cyclical upturn of the economy and decline when the economy is weak (Kabundi & Mlachila, 2019).

1.2 PROBLEM STATEMENT

A prevailing assumption in the earlier empirical literature is that “exchange rate pass-through is both linear and symmetric”, suggesting that (a) large and small exchange rate changes and (b) appreciations and depreciations exert an effect of the same magnitude, proportionally (Bussière, 2013; Sverrisdóttir, 2015). However, there is a potential for directional asymmetries as well as nonlinearities. One of the primary sources of asymmetry in pass-through is the direction of the change in the exchange rate.

The source of nonlinearity is the size of the change in the exchange rate. Small changes in the exchange rate might not be mirrored in prices due to menu costs (Karaoğlu & Demirel, 2021). By accounting for an asymmetric and nonlinear ERPT to price levels in developed and emerging nations, researchers have been able to enhance their comprehension of the relationship between exchange rates and prices (Delatte & López-Villavicencio, 2012; Yanamandra 2015; Brun-Aguerre et al., 2016; Baharumshah et al., 2017; Kassi et al., 2018 among others).

Despite its significance or prominence in the context of South Africa, there is evidence of scarcity of studies that analyze nonlinear and asymmetric ERPT to consumer prices in South Africa. The literature reviewed indicates that the study by Gereziher and Nuru (2023) is the sole study examining the asymmetric effects of exchange rate shocks on inflation in South Africa. This highlights the necessity for conducting a study that embraces both nonlinearity and asymmetry for South Africa. Therefore, the present study may help address the gap in the literature by analyzing nonlinear and asymmetric ERPT to consumer prices in South Africa and also fill the periodical gap from 2021 to 2023 which the existing study did not cover.

1.3 RESEARCH OBJECTIVES

1.3.1 Major Objective of the Study

The current study aims to empirically investigate the nonlinear and asymmetric exchange rate pass-through to consumer prices in South Africa.

1.3.2 Specific Objectives

The study has the following interrelated specific objectives:

- To determine the existence of asymmetric exchange rate pass-through to consumer prices in South Africa.
- To establish if there is a nonlinear exchange rate pass-through to consumer prices in South Africa.
- To investigate the significance of exchange rate pass-through to consumer inflation in South Africa.

1.4 Research Questions

The study intends to address the following research questions:

- Is exchange rate pass-through to consumer prices in South Africa asymmetric?
- Is exchange rate pass-through to consumer prices in South Africa non-linear?
- Is exchange rate pass-through to consumer prices in South Africa significant?

1.5 SIGNIFICANCE OF THE STUDY

The exchange rate plays a pivotal role in shaping economic activity and prices within open economies. Movements such as depreciation or appreciation of the domestic currency directly influence the cost of imports, consequently impacting domestic prices. Additionally, such fluctuations may also affect net exports, either stimulating or depressing demand for domestic goods in foreign markets. These dynamics have profound implications for inflation and macroeconomic stability (Manguinhane & Simione, 2021).

Given the significant impact of exchange rate variations on inflation, quantifying the extent to which these variations are transmitted to domestic prices, known as exchange rate pass-through (ERPT), is of paramount importance to both researchers and policymakers. The magnitude and speed of ERPT plays a crucial role in guiding monetary policy decisions aimed at stabilizing inflation rates. However, estimating the size of ERPT remains an empirical challenge (Manguinhane & Simione, 2021).

There seem to be few studies conducted on nonlinearity and asymmetric ERPT to consumer prices in developed economies. In the case of developing economies, nonlinear and asymmetric exchange rate pass-through remains a debatable issue. There is little literature on this topic in South Africa. The literature shows only one study on nonlinear and asymmetric ERPT to consumer prices which exists in South Africa. The present study will therefore help contribute to the body of knowledge by making an empirical investigation on the nonlinear and asymmetric exchange rate pass-through to consumer prices in South Africa, by doing so, this will help deepen the literature on this topic, particularly for South Africa.

Monetary authorities closely monitor currency movements and their potential effects on consumer prices and inflation. This monitoring is particularly crucial in emerging market and developing economies (EMDEs), where currency movements are often large and central banks are more inclined to respond to them, posing risks of policy missteps (Calvo & Reinhart, 2002; Ball & Reyes, 2008; Ha et al., 2020).

Understanding ERPT is essential for policymakers as the success of monetary and fiscal policies hinges on the effective transmission of exchange rate movements to consumer prices. Inadequate ERPT can lead to exchange rate shocks, resulting in increased inflation and potential currency substitution. This study seeks to propose measures to mitigate inflationary pressures and address concerns regarding currency substitution, thus aiding policymakers in making informed decisions that support exchange rate stability, promote economic activity, and bolster GDP growth.

Furthermore, the study aims to provide insights that could guide policymakers in formulating strategies to maintain price stability, particularly within the framework of inflation-targeting regimes. ERPT is identified as one of the key factors influencing inflation in the existing literature (Campa & Goldberg, 2005; Cheikh & Rault, 2016; Anderl & Caporale, 2022).

1.6 DELIMITATIONS OF THE STUDY

This study is limited to the period from January 2015 to July 2023. This timeframe was chosen due to data availability, as consumer price data is only accessible from 2015 onwards. Furthermore, focusing on this timeframe adds relevance and significance to the study, as previous years have already been extensively researched

1.7 OPERATIONAL TERMINOLOGIES

To avoid dogmatic interpretations, this section expounds the operational terms underpinning the present study.

Exchange Rate Pass-Through: Salsa et al. (2017) define exchange rate pass-through as the change in local currency prices (domestic, import, or export) resulting from a one percentage change in the exchange rate. Moreover, it measures the degree to which fluctuations in exchange rates are transmitted to changes in domestic prices of goods and services. According to Janine et al. (2012), exchange rate pass-through is the degree to which a country's prices change in response to a change in its exchange rate.

Asymmetric Exchange Rate Pass-Through: Baharumshah et al. (2017) define asymmetric exchange rate pass-through as the value of a country's currency changes in relation to another country's currency. The exchange rate behaves asymmetrically when it responds differently to various economic or market conditions. Moreover, Kurtović et al. (2021) define asymmetric as a situation where the exchange rate between two currencies is not directly proportional or equal in both directions. Thus, the exchange rate behaves differently when converting from one currency to another compared to converting in the opposite direction.

Nonlinear Exchange Rate Pass-Through: According to Caselli and Roitman (2019), nonlinear exchange rate pass-through is a situation where the relationship between two exchange rates is not linear. However, changes in one currency's value in terms of another currency do not occur at a constant rate. Thus, Cheikh et al. (2018) define nonlinear exchange-rate pass-through as the degree to which international prices adjust in response to fluctuations in exchange rates. Specifically, it refers to the sensitivity of local-currency import prices to changes in the local-currency value of foreign currency.

The null hypothesis is that there is an asymmetric nonlinear long-run relationship between inflation and imports. If the Wald test results show a p-value greater than 0.05 at the 5% level of significance, we fail to reject the null hypothesis and conclude that the two variables have an asymmetric nonlinear long-run relationship.

Exchange Rate Transmission: Ndou et al. (2018) define exchange rate transmission as the process by which changes in exchange rates affect the prices at which one currency can be exchanged for another and impact various economic variables (for example, inflation, trade balances, interest rates, investment, and overall economic growth) within a country's economy. Nnaji and Ohuche (2008) define exchange rate transmission as one of the intermediate policy variables through which monetary policy is transmitted to the larger economy. This occurs through its impact on the value of domestic currency, domestic inflation (the pass-through effect), the external sector, macroeconomic credibility, capital flows, and financial stability.

1.7 ORGANIZATION OF THE STUDY

This study is structured as follows:

Chapter 1: Introduction and Background: This chapter provides an introduction, outlining the dynamics of exchange rates and consumer prices. It discusses the problem statement and the purpose of the study. Research objectives and questions are articulated, followed by a justification of the study and its delimitations. Additionally,

operational concepts are defined, and the structure of the study is outlined. Finally, a summary of the chapter is provided.

Chapter 2: Literature Review: This chapter critically evaluates the theoretical and empirical literature relevant to the study's themes. It describes and assesses theoretical hypotheses concerning the relationships between exchange rates and consumer prices in South Africa.

Chapter 3: Research Methodology: This section presents the theoretical framework, model specification, and econometric methods employed in the study, along with addressing data issues.

Chapter 4: Presentation, Interpretation, and Discussion of Results: This chapter presents the results and findings of the study, providing interpretation and discussion.

Chapter 5: Summary, Conclusions, and Policy Recommendations: The final section of this chapter includes a summary of the study, a discussion of the key findings, and suggestions for possible interventions and avenues for future research. It summarises the research's results and outcomes and examines the empirical analysis considering fundamental theories and contemporary research.

1.8 CHAPTER SUMMARY

The section has explored the introduction and background, providing the researcher's initial context for the study. Subsequently, the problem statement was delineated, clearly outlining the issue at hand that necessitates investigation. The purpose of the study, encapsulating both major and specific objectives along with research questions, was outlined. Furthermore, the significance of the study was discussed, emphasizing its contribution and impact on the scientific field. Relevance was also addressed, highlighting the beneficiaries and implications of the study's conclusions. Finally, the chapter concluded with the delimitations and organisation of the study, providing a structured framework for further exploration.

CHAPTER TWO
LITERATURE REVIEW

2.1 INTRODUCTION

This chapter comprehensively reviews the theoretical and empirical literature concerning the asymmetric and non-linear responses of Exchange Rate Pass-Through (ERPT) to domestic prices. The chapter is structured as follows: Section 2.2 presents theoretical literature, discussing theories related to asymmetric and non-linear ERPT to domestic (import and consumer) prices. Section 2.3 presents empirical literature, examining studies that have explored these dynamics. Finally, Sections 2.4 and 2.5 critically assess the empirical literature and summarize the key findings of the chapter.

2.2 THEORETICAL LITERATURE REVIEW

This section presents a discussion on the theories regarding asymmetric and non-linear exchange rate pass-through (ERPT) to domestic prices. The theories reviewed include Pricing to Market Theory, the Binding Constraints Theory, and Purchasing Power Parity.

2.2.1 Pricing to Market Theory

The pricing-to-market theory is the foundational principle explaining the asymmetric and non-linear response of Exchange Rate Pass-Through (ERPT) to prices. According to this theory, foreign companies adjust their markups in response to changes in the exchange rate to stabilize prices in the importing country (Marston, 1990; Kassi et al., 2019). Marston (1990) employed a market share model to expound the pricing-to-market theory, suggesting that foreign exporters aim to preserve their market share in the export market. Consequently, they are inclined to absorb the depreciation of the importing country's currency while passing on the appreciation. As a result, ERPT is expected to be lower during currency depreciation and higher during appreciation.

2.1.2 The Binding Constraints Theory

Binding quantity constraints arise when exporters' capacity to increase sales in their export market is limited due to the appreciation of the local currency. According to Knetter (1994), various scenarios can lead to quantity constraints, such as trade restrictions like quotas or limitations on expanding marketing capacity. For instance, during the 1980s, the United States imposed restrictions on imports of Japanese-made automobiles. Consequently, Japanese automobile manufacturers encountered binding quantity constraints as the appreciation of the dollar hindered them from taking advantage of their increased price competitiveness by lowering their dollar price, given that the allowed quantity of Japanese automobiles sold in the U.S.A. had already been reached.

Furthermore, when unable to pass on the appreciation of the dollar to import prices, exporters chose to increase their mark-ups and charged the market clearing dollar price (Knetter, 1994). Quantity constraints are only binding during local currency appreciation. Therefore, the extent to which exchange rate pass-through to import prices occurs is higher during depreciation of the local currency compared to appreciation (Pollard and Coughlin, 2004).

The binding constraints theory posits that foreign firms faced with production constraints, such as full employment, are likely to pass through the depreciation of the importer's national currency and absorb appreciation (Kassi et al., 2019). This is because, at full capacity, foreign firms may not be able to meet the high demand when the importer's currency appreciates. Consequently, the pricing-to-market and production constraints models may produce contradictory results (Fandamu et al., 2023). Therefore, the pricing-to-market theory serves as the theoretical foundation of this study.

2.1.3 Theory of Purchasing Power Parity

The concept of exchange rate pass-through finds its theoretical underpinnings in the principle of purchasing power parity, which is rooted in the law of one price. The Theory of Purchasing Power Parity was first introduced during the sixteenth century at the University of Salamanca, but its modern formulation gained recognition in 1916 through the work of Swedish economist Gustav Cassel. According to this theory, it is posited that in a state of market equilibrium, the prices of tradable goods and services are equal across different countries, provided they are measured using a common monetary unit (Alola et al., 2023).

The Theory of Purchasing Power Parity is grounded in the principles of perfect and actual competitive arbitrage activities. These activities exert pressure on exchange rates to align with equilibrium levels, assuming the absence of transportation costs, tariffs, and imperfect competition. However, empirical research has shown evidence that the concept of purchasing power parity, in both its absolute and relative forms, is not always applicable due to the flexibility of nominal prices and the outcomes resulting from insufficiently robust competitive arbitrage actions (Balcilar et al., 2020). According to the PPP hypothesis, changes in exchange rates show that different countries' inflation rates are dissimilar. The theory assumes that when P_f(foreign price level) and/or P (local price level) fluctuate, the exchange rate (e) fluctuates in a way that keeps the provided terms of trade $\frac{ePf}{p}$ constant when P_f (foreign price level) and/or P (local price level) vary (Lado, 2015).

Therefore, according to the Theory of Purchasing Power Parity, differences in inflation rates between two countries may elucidate their respective exchange rates, and consequently, the equilibrium exchange rate should adjust to account for these differences (Dewing, 2015).

2.2 EMPIRICAL LITERATURE REVIEW

2.2.1 Introduction

Most studies examining the relationship between exchange rate changes and domestic prices initially presumed a symmetrical and diminishing exchange rate pass-through (ERPT) to prices over time, particularly in industrialized nations. However, research on this relationship has evolved, allowing for the consideration of asymmetric and nonlinear ERPT of price levels in both developed and emerging nations (Kassi et al., 2019).

One primary source of asymmetry and nonlinearity in pass-through is the direction of the change in the exchange rate, specifically, the appreciation and depreciation of the currency (Karaoğlu and Demirel, 2021). Exchange rate pass-throughs tend to be greater when the importer's currency appreciates compared to when it depreciates. When the importing country's currency appreciates, exporters typically reduce their prices in that currency to increase market share and import demand. Conversely, in the case of depreciation of the importing country's currency, exporters tend to compress their profit margins rather than raising prices to prevent loss of market share (Pollard and Coughlin, 2004). Another source of asymmetry is the magnitude of the change in the exchange rate. Small changes in the exchange rate may not be reflected in prices due to menu costs (Karaoğlu and Demirel, 2021).

Having elucidated the above, the empirical literature for developed, and developing economies, particularly, South Africa is presented below.

2.2.2. Empirical Literature Review on Developed Economies

Carrière-Swallow et al. (2023) document that ERPT to domestic prices is state-dependent. While pass-throughs are relatively low on average, they tend to be significantly larger during periods of high inflation and elevated uncertainty. They also find that the rate of pass-through triples when an exchange rate depreciation has been driven by U.S.A monetary policy tightening.

Anderl and Caporale (2023) investigate nonlinearities in the exchange rate pass-through (ERPT) to consumer and import prices by estimating a smooth transition regression model with different inflation expectations regimes for five inflation-targeting countries (the UK, Canada, Australia, New Zealand, and Sweden) and three non-targeters (the US, the Euro-Area and Switzerland) respectively over the period January 1993–August 2021.

The study incorporates both the market- and survey-based indicators of anticipated inflation as the transition factor, while also comparing the nonlinear model's outcomes to those of a standard linear model. The findings indicate a more robust exchange rate pass-through (ERPT) effect on both consumer and import prices within the nonlinear model, and in certain instances, the pass-through is almost total. Furthermore, the effect is particularly pronounced within the second regime, characterized by high inflation expectations among markets and consumers. This implies that stabilizing inflation expectations helps diminish the impact of ERPT. Lastly, the influence of inflation expectations on ERPT appears to be more significant in countries that follow inflation-targeting strategies.

Özyurt (2016) examines the extent and velocity at which the exchange rate pass-through (ERPT) affects additional import prices within the euro area aggregate and the five largest countries. The analysis encompasses the time frame between 1996Q1 and 2015Q2 utilizing quarterly frequency data. Two measures of the nominal exchange rate are employed: the NEER of the euro against 38 counterparts and the bilateral exchange rate of EUR/USD. The findings indicate that the pass-through within the euro area is merely "partial," most likely due to sluggish adjustments in nominal prices and the pricing-to-market behavior displayed by firms.

The author has discovered compelling evidence that there has been a decrease in the degree of pass-through over the last two decades. When examining the largest countries in the euro area, significant variations in both the degree and speed of the ERPT were observed. Germany has the lowest degree of pass-through for a change in NEER, while Italy has the highest. Furthermore, unlike the other major euro area countries, there is no evidence of a decline in the degree of pass-through over time for Italy.

In her study, Ji (2022) explores how exchange rate shocks impact various overall prices in China using vector autoregressive models that consider a pricing distribution chain. The research employs different adjustments for reliability. The findings indicate that when the local currency strengthens, it tends to have a dampening effect on domestic inflation during the initial production phases. However, this pass-through effect is only of moderate significance for consumer prices.

2.2.3. Empirical Literature Review on Developing Economies

Nan and Kiyotaka (2024) empirically investigate whether Japanese exporters have changed their exchange rate pass-through (ERPT) behavior in response to large fluctuations of the yen from January 2000 to December 2022 employing a nonlinear autoregressive distributed lag (NARDL) model with multiple thresholds. They found asymmetric ERPT between the periods of strong and weak yen in level. More intriguingly, Japanese exporters, especially in general machinery and transport equipment industries, strategically switch their pricing behavior from ERPT to pricing-to-market (PTM) and vice versa in response to unexpected yen appreciation and depreciation.

Aiyash (2023) investigates Asymmetries in Exchange Rate Pass-Through to Consumer Prices in Brazil and Mexico, using Autoregressive distributed lag (ARDL) and Nonlinear Autoregressive distributed lag (NARDL) from the period of 1996Q1 to 2018Q4 for Brazil and from 1994Q2 to 2018Q4 for Mexico. For Brazil, there is evidence of short-run asymmetric responses to exchange rate changes, where the estimates of ERPT are positive, statistically significant, and incomplete. However, there are no long-run asymmetries observed in Brazil, and the ERPT is negative, statistically significant, and incomplete. Conversely, no short-run asymmetries are detected for Mexico, where the estimates of ERPT are negative, statistically significant, and incomplete. Furthermore, there exists a long-run asymmetry for Mexico, with an ERPT estimate that is negative, statistically significant, and incomplete.

Appiah et al. (2023) examine the complex and intricate impacts of exchange rates, financial development, and oil prices on the economic growth of Ghana from the year 1990 to 2017, employing a nonlinear model. The empirical findings illustrate that the

global oil price exhibits asymmetric effects on both short-term and long-term growth, where positive changes in the price of oil yield distinct consequences compared to negative changes. Nevertheless, there is an absence of empirical evidence supporting the existence of asymmetric long-term effects of exchange rates and financial development on economic growth. Instead, only short-term asymmetries can be observed. The application of the nonlinear model allows for an evidence-based analysis of the intricate and complex asymmetric associations on growth of developing countries.

Fandamu et al. (2023) examine the asymmetric exchange rate pass-through (ERPT) to consumer price inflation in Zambia using a structural vector autoregressive model (VCM). Researchers examined ERPT to consumer price inflation arising from kwacha depreciation and appreciation for the period between the first quarter of 1985 to the fourth quarter of 2017. The results show that ERPT to consumer price inflation is incomplete and asymmetric. Consumer prices in Zambia are more responsive to kwacha depreciation than to appreciation. The depreciation of the kwacha has a greater significant impact on consumer prices than the appreciation of the kwacha.

Accordingly, the impulse response function analysis showed that the shock to kwacha depreciation is more persistent than that of kwacha appreciation. Finally, the forecast error variance decomposition showed that a depreciation shock explains a bigger portion of the variance in consumer price inflation than an appreciation shock. These findings show that kwacha depreciation and appreciation have different effects on consumer price inflation, thereby confirming the presence of asymmetries in the ERPT. The study also accounted for the effect of commodity price booms in influencing ERPT. However, the results of ERPT did not change much with the inclusion of commodity price booms.

Mendali and Das (2023) examine the exchange rate pass-through (ERPT) to domestic prices in India from 1993M4 to 2021M3 using a non-linear autoregressive distributed lag (NARDL) model by employing five variables (viz., exchange rate, consumer price, output gap, money supply, and oil prices). The structural break techniques are used to examine the differential effects of the pass-through. The study results show that exchange rate shocks do not lead to significant changes in consumer prices in the

long run, implying that the ERPT has insignificant consequences for monetary policy, and depreciation might pose a little threat to price stability.

Widarjono et al. (2023) explain the ERPT to inflation in Indonesia, Malaysia, and the Philippines, which adopted the floating exchange rate after the 1998 financial crisis. The empirical results show the existence of the long-run asymmetric ERPT to inflation such that there is no full transmission of depreciation to inflation in each country. The highest degree of ERPT to inflation occurred in Indonesia, while in Malaysia, and the Philippines depreciation (appreciation) is not completely transmitted in the short run. Overall, their study reveals that depreciation has a stronger impact on inflation than appreciation.

Obeng et al. (2022) analyse the US dollar exchange rate pass-through to consumer prices in Ghana from January 1990 to January 2020 using the empirical mode decomposition-based nonlinear autoregressive distributed lags model (EMD-NARDL). This model eliminates the noise component of the underlying data and captures the short- and long-run nonlinearities. Evidence of cointegration between denoised series of consumer prices and exchange rate and asymmetric pass-through in both the short and long run was found. Specifically, exchange rate pass-through was found to be in the long run incomplete in the period of depreciation and statistically zero pass-through in the period of appreciation. In the short run, the exchange rate pass-through in periods of depreciation is near complete; that is, 81% against 74% in periods of appreciation.

Karaoğlu and Demirel (2021) investigate the Asymmetric Exchange Rate Pass-Through into Inflation in Turkey using the NARDL model, from 2004: Q1–2019: Q4. Their findings show that the exchange rate pass-through to inflation is asymmetric in the long run. A 1% increase in the exchange rate increases the annual inflation by 0.11% in the long run, whereas a 1% decrease in the exchange rate decreases inflation by 0.28%. Besides, a decrease in the exchange rate has no statistically significant effect on inflation, but an increase also increases inflation in the short run.

Kayamo (2021) investigate the asymmetric impact of the real exchange rate on inflation in Ethiopia, using a non-linear ARDL approach for the period of 1982 to 2019. Long- and short-run estimations were done based on the non-linear ARDL error correction methodology. Kayamo's study reveals that the real exchange rate has asymmetric effects on inflation in the short and long run.

Furthermore, Usman (2021) examines the asymmetric pass-through of exchange rate to CPI in Nigeria from 1986M01 to 2015M12. By utilizing the NARDL model, the study reports that the pass-through of the exchange rate is asymmetric, and the study shows depreciation results in a higher pass-through compared to appreciation. It is also stated that the pass-through is higher in the long run compared to the pass-through in the short run.

Ho and Hafrad (2020) examine asymmetric exchange rate pass-through in Vietnam using Nonlinear Autoregressive Dynamic Lag from 2000Q4 to 2018Q2. Their findings show the existence of an asymmetric effect of exchange rate on domestic price in both the short run and long run; the exchange rate pass-through is high, the impact of exchange rate depreciation on domestic price is stronger than appreciation, and the exchange rate pass-through is higher in the long run than in the short run, and foreign competitor price plays an important role for domestic price movement.

Teferra (2020) examine exchange rate pass-through and inflation dynamics in 14 Selected Sub-Saharan African Countries with a special focus on the asymmetrical relationship between exchange rates and consumer prices. The study estimates exchange rate pass-through (ERPT) including the macroeconomic determinants of consumer prices by using the nonlinear autoregressive distributed lag (NARDL) framework of both time series, and panel fixed effect model considering cross-sectional dependence. The study findings suggest world oil price and output gap have significant effects in the long run, whereas the effect exchange rate depends on the direction and size of exchange rate changes.

The study also reveals significant adjustment speed which converges to equilibrium slowly. The study also found an asymmetrical ERPT in the entire sampled SSA and fixed exchange rate regime subgroups during the long term, whereas a symmetrical effect was observed during the short term across subgroups. The results suggest complete and significant ERPT to consumer prices in the entire SSA region, which is higher during the appreciation of the local currency than after depreciation in the long term, especially in the fixed exchange rate regime subgroups. Further, the result confirms the non-zero incomplete ERPT over the short term and the nonlinear ERPT concerning the size of the exchange rate change.

Zhang et al. (2020) examine the phenomenon of testing for the complete pass-through of exchange rates without trade barriers in China through the utilization of a quasi-experimental case. Their findings indicate that exchange rate pass-through is not fully achieved due to the existence of an imperfect market, specifically characterized by the presence of transaction costs and imperfect competition. Furthermore, it is observed that the complete pass-through continues to persist even after accounting for the impact of asymmetry and volatility.

Caselli and Roitman (2019) explore non-linearities and asymmetries in the transmission of exchange rate fluctuations to prices in a panel of 27 emerging markets from 1990 to 2013. Utilizing local projection techniques, they find asymmetry in ERPT for the period of appreciation rather than depreciation. A non-linear pass-through was found when the exchange rate depreciates by more than 24%.

Musti (2019) examines the nonlinearities and asymmetries in the exchange rate pass-through (ERPT) to consumer prices in Nigeria using quarterly time-series data from 1986 to 2013 and the nonlinear smooth transition autoregressive (STAR) method. The standard literature assumes linearity and symmetry in the ERPT to consumer prices in developing countries, despite the importance and presence of potential asymmetries and nonlinearities generated by the presence of various factors such as menu costs, capacity constraints, market share objectives and production switching.

Employing the Johansen maximum likelihood approach, Amoah and Aziakpono (2018) examine the long-run symmetric and asymmetric ERPT in Ghana from 1990Q1 to 2015Q. There is evidence of an important asymmetry regarding the direction and size of exchange rate changes. ERPT is found to be incomplete but moderately higher during depreciation than in periods of appreciation.

Also, Patra and John (2018) investigated non-linearities, asymmetric, and time variations in ERPT to consumer prices in India by using a DSGE model from April 2005 to March 2016. ERPT was discovered to be asymmetric, with modest depreciation passthrough being the strongest. In a low-inflation climate with falling trade openness, the ERPT to consumer inflation has fallen in recent years. ERPT is important because around 15% of exchange rate fluctuations are cumulatively carried through to CPI inflation over 5 months, with time-varying parameter estimation boosting it to above 15% by 2013–2014 and dropping since then.

Baharumshah et al. (2017) examine the asymmetric effect of exchange rate changes on consumer prices in Sudan, an extremely inflationary country by applying Shin et al. (2011) NARDL model from 1992Q1 to 2015Q2. The findings from this study show an asymmetric relationship between the exchange rate and domestic inflation in the short and long run. A 10% depreciation in the Sudanese pound leads to roughly an 8-percentage point rise in consumer price levels.

Caselli and Roitman (2016) estimate exchange rate pass-through to consumer prices in emerging markets focusing on non-linearities and asymmetries. They document non-linearities and asymmetries in the transmission of exchange rate fluctuations to prices using local projection techniques to obtain state-dependent impulse responses in a panel of 28 emerging markets. They find significant evidence of non-linearities during episodes of depreciation greater than 10 and 20 percent. More specifically, researchers find that, after one month, the exchange rate pass-through coefficient is equal to 18 and 25 percent respectively, compared to a coefficient of 6 percent in the linear case.

The pass-through is found to be higher in countries with fixed exchange rate regimes in a high inflationary environment than in countries with floating exchange rate regimes and low inflation levels which supports Taylor's hypothesis. Pass-through is greater during small exchange rate changes than after large changes. Finally, the result of time series analysis suggests mixed results which demand country-specific policy implications are inevitable. Therefore, the policy implication of both panel and time series analysis is to consider various asymmetries of exchange rate on consumer prices when formulating exchange rate and monetary policy rules.

Pérez and Vega (2015) examine the reaction of prices to exchange rate shocks for the Peruvian economy in a non-linear framework using a Structural Vector Autoregressions model (SVARs) from 1993: M1 to 2014: M12. The results show a significant asymmetry in the response of consumer prices and wholesale import goods prices. The result of a depreciation shock on the consumer price index after one year is about twice the size of that corresponding to an appreciation shock. Approximately, the 1 year pass-through to prices is 20% under depreciation and only 10% after appreciation.

Muhammed et al. (2019) investigate the asymmetric exchange rate pass-through and sectorial stock price indices: Evidence from Turkey using the NARDL model. They find empirical results of an incomplete pass-through effect of exchange rate on stock prices in both the long and short run.

2.3 EMPIRICAL LITERATURE REVIEW FOR SOUTH AFRICA

The literature reviewed reveals the evidence of a scarcity of studies that analyze nonlinear and asymmetric ERPT to consumer prices in South Africa.

The study by Gereziher and Nuru (2023) is among the few. These authors examine the asymmetric effects of exchange rate shocks on inflation for South Africa, over the period 1970Q1–2020Q1 with the aid of a Threshold Vector Autoregressive model. Whilst the generalized impulse responses are used to study the effects of exchange rate shocks on inflation depending on their size, sign, and timing to the inflation cycle,

a Cholesky decomposition is used to identify exchange rate shocks in the non-linear model.

The findings of the study show that there is a non-linear effect of the exchange rate shock on inflation. In particular, the effects of 1 or 2 standard deviations of positive (appreciation) or negative (depreciation) exchange rate shock on inflation are small in the long run but a bit larger in the high inflation regime than in the low inflation regime.

The study by Kassi et al. (2019) is among those that examine asymmetric ERPT to consumer prices. It does, however, focus on a group of countries. Using the Nonlinear Autoregressive Distributed Lag (NARDL) framework and dynamic panel techniques robust to cross-sectional dependence, they examined the asymmetrical relationship between exchange rates and consumer prices in 40 Sub-Saharan African (SSA) countries (South Africa is one of these countries), from 1990Q1 to 2017Q4, they estimated the exchange rate pass-through (ERPT) to consumer prices for each country.

The findings of their study suggest an asymmetrical ERPT in the SSA region during the short term, whereas there are mixed results across subregions in the long term. Second, the results of the panel analysis suggest incomplete and significant ERPT to consumer prices in the entire SSA region, which is higher during depreciation of the local currency than after appreciation in the short term, especially in the CFA Franc zone. Third, they find nonlinear ERPT concerning the size of the exchange rate. Finally, it is vital to note that pass-through is higher in countries with fixed exchange rate regimes (CFA franc zone) in a low inflationary environment than in countries with floating exchange rate regimes and high inflation levels.

Teferra (2020) also examines exchange rate pass-through and inflation dynamics in 14 Selected Sub-Saharan African Countries, including South Africa, with a special focus on the asymmetrical relationship between exchange rates and consumer prices. The study estimates ERPT including the macroeconomic determinants of consumer prices by using NARDL framework of both time series, and panel fixed effect model taking into consideration cross-sectional dependence. The study findings suggest world oil price and output gap have a significant effect in the long run whereas the

effect exchange rate depends on the direction and size of exchange rate changes. There is, hence, a need to conduct a study on nonlinear and asymmetric exchange rate pass-through to consumer prices in South Africa. The present study will help contribute to the body of knowledge by filling the periodical gap in the literature on this topic from 2021 to 2023, which the previous studies failed to fill.

2.4 ASSESSMENT OF EMPIRICAL LITERATURE REVIEWED

The literature review suggests a scantness of studies conducted on nonlinearity and asymmetric ERPT to consumer prices in developed economies. This may be attributed to the shifting focus of researchers in advanced economies towards ERPT to imports rather than consumer prices.

In the case of developing economies, the results are inconclusive. The issue of nonlinear and asymmetric exchange rate pass-through remains a topic of debate in these economies. Therefore, this study contributes to this ongoing debate.

Besides, very few studies were conducted in South Africa on this topic. The reviewed literature indicates that there is only one study by Gereziher and Nuru (2023), which focuses solely on nonlinearity and asymmetric ERPT to consumer prices. However, the study covers up to 2020, without covering the period from 2021 till present. The current study will contribute by covering the period from 2021 to 2023.

2.5 CHAPTER SUMMARY

This section presented a discussion of the theoretical and empirical literature review. Initially, it discusses three selected theories underlying nonlinear and asymmetric ERPT, namely, Pricing to Market Theory, Binding Constraint Theory, and Purchasing Power Parity. It then presents empirical literature for developed and developing economies and those that focus on South Africa. Finally, it offers an assessment of the empirical literature.

Literature review results reveal conflicting results for developing economies. There are also very few studies conducted in South Africa on this topic. From those few, the period 2021 to 20 3 was not covered. The current study will contribute to the literature by covering this period.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1. INTRODUCTION

This chapter provides a discussion on research methodology. The chapter is structured as follows: Section 3.2 presents the theoretical framework, outlining the theoretical model that underpins the study. In section 3.3, the empirical model is presented. Sections 3.4 and 3.5 discuss the econometric tools employed to estimate the model and data issues. Finally, section 3.6 presents a summary of the chapter.

3.2. THEORETICAL FRAMEWORK

The Pricing to Market Theory forms the foundational principle that underlies the asymmetric and nonlinear responsiveness of Exchange Rate Pass-Through (ERPT) to prices. According to this hypothesis, foreign businesses are inclined to adjust their markups in response to exchange rate fluctuations to uphold pricing stability in the country from the exporting country (Kassi et al., 2019; Marston, 1990). Hence, the Pricing to Market Theory serves as the theoretical basis for the empirical model employed in this study.

3.3 THE EMPIRICAL MODEL

The study follows Karaoğlu and Demirel (2021) by employing the nonlinear autoregressive distributed lag (NARDL) model developed by Shin et al. (2014), an extension of the method introduced by Pesaran et al. (2001). Unlike the linear ARDL model, which does not account for the possibility of positive and negative shocks affecting the inflation rate differently and thus overlooks any asymmetries in the short- and long-run transmission of uncertainty shocks, the NARDL framework considers hidden cointegration (i.e., between the positive and negative components of individual time series), thereby allowing for potential nonlinearities (Liang et al. 2020; Anderl & Caporale, 2023).

Moreover, it offers advantages over other nonlinear frameworks. Firstly, it distinguishes between short- and long-run asymmetries. Secondly, it separately estimates the impact of positive and negative shocks under non-stationarity. Thirdly, it provides a flexible approach to establishing long-run relationships between variables with mixed integration orders. Consequently, the model offers an opportunity to test asymmetry in shocks, assessing whether the positive shocks of the independent variables have the same effect as their negative shocks on the dependent variables (Menegaki, 2019; Anderl & Caporale, 2023). The NARDL long-run model is stated as follows:

$NARDL\ (p, q_1, q_2, q_3, q_4)$

$$inf_t = \mu + \sum_{i=1}^{p} \phi\ inf_{t-i} + \sum_{i-0}^{q_1} \theta_i^+\ ex_{t-i}^+ + \sum_{i-0}^{q_2} \theta_i^-\ ex_{t-i}^- + \sum_{i-0}^{q_3} a_i\ imp_{t-1} + \sum_{i-0}^{q_4} \delta_i\ igrowth_{t-1} + \varepsilon_t \quad \text{.....(3.1)}$$

$$ex_t^+ = \sum_{j-1}^{t} \Delta ex_j^t = \sum_{jj-}^{t} max\left(\Delta ex_j, 0\right),\ \ ex_t^+ = \sum_{j-1}^{t} \Delta ex_j^- = \sum_{jj-}^{t} m\left(\Delta ex_j, 0\right) \ \ldots \quad (3.2)$$

Where inf is the consumer price indices. ex is the nominal exchange rate between the South African rand US dollar. It is decomposed into, ex_t^+ and ex_t^-around a threshold zero. ex_t^+ and $ex_t^-$are partial sum processes of positive and negative changes in the exchange rate, respectively. imp is the price indices of imports of goods and services expressed in Rands millions. $growth$ is the quarterly growth rate of the real GDP.

$\theta_t^+$and $\theta_t^-$are the coefficients of the asymmetric exchange rate pass-through and $0 \leq |\theta_t^+|, |\theta_t^-| \leq 1$. If the pass-through coefficient is 0, the exchange rate changes do not affect prices. If the pass-through coefficient is equal to 1, the changes in the exchange rate affect the prices by 100%.

If the coefficient is between 0 and 1, the exchange rate changes partially affect the prices. The exchange rate is decomposed into positive and negative partial sums, according to Shin et al. (2014), as follows:

$$ex_t^+ = \sum_{j=1}^{t} \Delta ex_t^+ = \sum_{j=1}^{t} max(\Delta ex_{j,} 0) \qquad ex_t^- = \sum_{j=1}^{t} \Delta ex_t^- = \sum_{j=1}^{t} min(\Delta ex_{j,} 0)$$

A Priori Assumption

- **Exchange rate and consumer inflation**

When the exchange rate falls (that is, when the domestic currency appreciates), the prices are expected to fall at the general level (decrease in inflation) (Monfared and Akin, 2017).

- **Imports and consumer inflation**

The anticipated relationship between inflation and import prices is typically positive (Corrigan, 2005). Theoretically, imports of goods and services exert inflationary pressure through both the exchange rate and purchasing power parity channels. According to Houck's (1979) explanation, inflation can be mitigated by maintaining the yearly exchange rate at a lower level, which results in an overvaluation of the country's currency. This overvaluation increases imports while discouraging exports. Conversely, domestic prices can be influenced by adjustments to the purchasing power parity of the country's currency. Policymakers may either overvalue their country's currency by utilizing foreign exchange assets to purchase the domestic currency or devalue it by buying foreign exchange, thereby reducing the price of the domestic currency. Therefore, the relationship between imports and the Consumer Price Index (CPI), often used as a proxy for inflation (Tolasa et al., 2022), is interconnected.

The inclusion of import prices in the model is quite important as imports represent the channel through which exchange rate movements are transmitted to other variables of the distribution chain (Awad, 2019).

- **Economic growth and inflation**

An increase in economic growth means more goods for money to “chase”, which puts downward pressure on the inflation rate. Therefore, the relationship between growth and inflation is negative.

3.4 ESTIMATION TECHNIQUES

3.4.1 Introduction

This study employed the nonlinear autoregressive distributed lag (NARDL) bounds cointegration technique to ascertain the long-run relationships and short-run dynamics between nonlinear and asymmetric exchange rate pass-through to consumer prices. Before discussing the different tests, a discussion on the descriptive statistics is given.

3.4.2 Descriptive Statistics

Descriptive statistics summarizes the sample being studied without drawing any inferences based on probability theory. Even if the primary aim of a study involves inferential statistics, descriptive statistics are still used to give a general summary. When describing the population using tools such as frequency distribution tables, percentages, and other measures of central tendency, like the mean, we are talking about descriptive statistics.

Descriptive statistics can help in summarizing data in the form of simple quantitative measures, such as percentages or means, or the form of visual summaries such as histograms and box plots. They can be used to describe a single variable (univariate analysis) or more than one variable (bivariate/multivariate analysis). In the case of more than one variable, descriptive statistics can help summarize relationships between variables using tools such as scatter plots (Kaliyadan & Kulkarni, 2019).

3.4.3 Stationarity) testing

The initial step in conducting a cointegration analysis entails evaluating each time series to determine their degree of integration through stationarity testing. The rationale behind autoregressive moving average (ARMA) estimation relies on time series that demonstrate stationarity. Stationarity is defined as a condition where the

average and auto-covariance of the series remain constant over time (Kwiatkowski et al., 1992). An instance of a non-stationary series is exemplified by the random walk equation:

$\beta_t = \beta_{t-1} + \mu_t$ ..... (3.3)

Where, μ_t is a stationary random disturbance term. The series β has a constant forecast value, conditional on t, and the variance increases over time. The random walk is a differenced stationary series since the first difference of y is stationary.

β_t-β_{t-1}=$(1 = L)_{yt}$=μ_t .....(3.4)

A series that remains the same over time is referred to as an integrated series and is represented by (d). The value of indicates the level of integration. Integration level refers to the number of original elements present in the series, or the number of operations required to make the series stable. As an example, in the given random walk, there is one original element, making it a series *I* (1). Similarly, a series that is stable is considered stationary *I* (0).

When conducting regressions with a dependent variable or regressors that are integrated, standard inference procedures cannot be applied. Therefore, it is crucial to determine the stationarity of a series before using it in a regression. The unit root test is a formal method used to test the stationarity of a series.

Various tests are employed to assess the presence of a unit root. These examinations include the Augmented Dickey-Fuller (1979) and Phillips-Perron (1988) tests, the GLS-detrended Dickey-Fuller (Elliot, Rothenberg, and Stock, 1996) test, Kwiatkowski, Phillips, Schmidt, and Shin (KPSS, 1992) test, Elliott, Rothenberg, and Stock Point Optimal (1996) test, and Ng and Perron (NP, 2001) test for unit root. In this research, the Augmented Dickey-Fuller (ADF) and Phillips-Perron tests are utilised. The ADF test is widely employed for evaluating the null hypothesis of a unit root (Guney and Komba, 2016).

3.4.3.1 The Augmented Dickey-Fuller (ADF) Test

The ADF technique was formulated by David Dickey and Wayne Fuller in 1979. This technique entails a regression analysis that involves examining the first difference of a variable on its lagged level, along with additional lags of the first difference (Gujarati and Porter, 2009). When employing the ADF technique, the null hypothesis suggests that the time series possesses a unit root, thus requiring further differentiation to attain stationarity. Conversely, the alternative hypothesis suggests that the series is stationary. Thus, eliminating the necessity for additional differentiation.

According to Gujarati and Porter (2009), the ADF unit root test is used to check the stationarity of the variables. Suppose one determines that Y and X are not stationary in level forms following the random walks but become stationary at first difference$\Delta\Upsilon t$ and ΔXt respectively.

$\beta_t = \beta_t - 1 + t + ut$ .....(3.5)

Serial correlation presents a problem. To account for this, the augmented Dickey-Fuller tests of the model include lags of the first differences of β_t. The present research employs the ADF model to conduct the unit root test, wherein the equation utilized is as follows:

$\Delta Y_{t=\mu+\beta t+eY_{t-1}} + \sum_{t-1}^{N} p_t \Delta Y_{t-1} + e_t$.....(3.6)

Where:

Y_t = time-series tested

t = time trend variable

Δ =the first difference operator

N = Number of lags which are added to the model to ensure that there are residuals

e_t= white noise disturbance

Therefore, The ADF test focuses on estimating the parameter in equation (3.1). To ascertain the degree of integration in non-stationary time series data, the unit root test is employed. The hypotheses for the unit root test are presented as follows:

H_0 = All variables are not stationarity

H_1 = All variables are stationarity

Hence, If the t-statistic exceeds the critical value, the null hypothesis (H0) is rejected, indicating that the time series is stationary, and there is no presence of a unit root. Conversely, if the t-statistic is below the critical value, the null hypothesis (H0) is not rejected, signifying that the time series is non-stationary, and a unit root is present.

3.4.3.2 Phillip- Perron Test

As per Gujarati and Porter (2009), the Phillips–Perron (PP) test (1988) assesses whether a variable possesses a unit root. The null hypothesis suggests that the variable contains a unit root, while the alternative hypothesis suggests that the variable is stationary. PP employs Newey–West (1987) standard errors to adjust for serial correlation. PP's test statistics can be considered as Dickey–Fuller statistics made robust to serial correlation by utilizing the Newey–West (1987) heteroscedasticity- and autocorrelation-consistent covariance matrix estimator.

3.4.3.3 Zivot-Andrews Structural Breaks test

Zivot and Andrews's (dates) endogenous structural break test is a sequential procedure that utilizes the entire sample and employs distinct dummy variables for each potential break date. The break date is determined where the t-statistic (for α) from the ADF test of unit root attains a minimum (most negative or significant). This break date indicates strong evidence against the null hypothesis of a unit root (Nilsson, 2009). The critical values of Zivot and Andrews (1992) differ from those of Perron (1989) due to the selection of the break time being treated as the outcome of an estimation procedure, rather than predetermined exogenously (Glynn et al., 2007).

In the Zivot and Andrews test, if the null hypothesis of the unit root cannot be rejected, the results may not be entirely reliable. Testing the unit root hypothesis while allowing for structural breaks offers the advantage of preventing the test outcomes from being biased towards the unit root and identifies the occurrence of any potential breaks (Nilsson, 2009).

The Zivot-Andrews's approach offers a higher level of generality as it permits shifts in the level of the series (Fahmi et al., 2019). Within this framework, the choice of the breakpoint (TB) is selected to minimise the one-tailed t-statistic. The Zivot-Andrews model can detect and accommodate one endogenous structural break within a series, as detailed below. Model A allows a one-time change in the intercept of the series:

y_t =μ +ey_{t-1}+β_t +θƉU_t+$\sum_{p-1}^{n} c - p$+y_{t-p}+e_t.....(3.7)

where: DU_trepresents the intercept dummy DU_t = 1, if (t > TB) breakpoint and zero otherwise.

Model B allows a one-time change in the slope of the series:

y_t =μ +ey_{t-1}+β_t +yDT_t+$\sum_{p-1}^{n} c - p$+y_{t-p}+e_t..... (3.8)

DT represents the slope dummy DT_t = t – TB, when t > TB (breakpoint) and zero otherwise.

Model C allows a one-time change in both slope and intercept of the trend function of the series:

y_t =μ +ey_{t-1}+β_t +θDU_ty+DT_t+$\sum_{p-1}^{n} c - p$+y_{t-p}+e_t..... (3.9)

Therefore, the present study employs the Zivot and Andrews (1992) test, to check for unit roots allowing for one endogenously determined structural break.

3.4.4 CO-INTEGRATION TESTING

The Johansen test approaches the testing for cointegration by examining the number of independent linear combinations (k) for an m time series variables set that yields a stationary process. In principle, testing for Cointegration is like testing the linear regression residuals (ε_t) for stationarity. Moreover, the Johansen test statistical method is used to assess the presence of cointegration in a group of time series variables. It determines the number of independent linear combinations (k) that result

in a stationary process among a set of variables. The process of testing for cointegration might be compared to the process of verifying the stationarity of linear regression residuals should first be conducted. So, to establish a cointegration relationship, an OLS regression model for the variables and test the residuals for stationarity. Cointegration means that, while many developments can cause permanent changes in the individual variable ($X_{i,t}$), there is some long-run equilibrium relation tying the individual variables together, represented by some linear combination of them for your variables and test the residuals for stationarity (Gujarati and Porter, 2009).

3.4.5 THE WALD TEST

The Wald test is a useful statistical instrument for analyzing short-run asymmetries in ERPT, which can aid in gaining a better understanding of how exchange rate changes influence prices and inform policy decisions (Tang & Lean, 2007).

The Wald test is a statistical test used to determine the significance of individual regression model coefficients. It can also be used to test hypotheses regarding the relevant parameters. In the context of short-run asymmetry in a regression model, the Wald test can be used to determine if certain coefficients are substantially different from zero, thereby indicating the presence of short-run asymmetry.

3.4.6 DIAGNOSTIC TESTS

For this study, the diagnostic tests that will be employed are:

3 4.6.2 Breusch-Pagan Tests

In a linear regression model, a test of a null hypothesis of homoscedasticity is tested against the alternative hypothesis. The test statistic is $\mathfrak{y}=NR^2$, where N is the sample size and R^2 is the coefficient of determination from the second regression. Under the null hypothesis $H_{0,}$ $\mathfrak{y}$ is asymptoticallyχ^2 $(s-1)$; this result does not depend on the function of h. (Black, Hashimzade & Myles, 2009).

3.4. 6.2 ARCH Test (with cross terms and no cross terms)

This model is used to describe volatility clustering, that is, a pattern observed in many financial data where large and small forest errors appear to occur in clusters. It is a test of the hypothesis of homoscedasticity against the alternative of homoscedasticity, since under heteroscedasticity the ordinary least squares estimator of the covariance matrix is inconsistent. The test is performed by regressing squared OLS residuals from the main regression on all explanatory variables, their squares and cross-products, and a constant. The test statistic is given by $\mathrm{N}R^2$, where *N* is the sample size and R^2 is the coefficient of determination from the test regression. Under the null it has an asymptotic Chi-square distribution with the degrees of freedom equal to the number of regressors in the regression, excluding the constant, (Black *et al,* 2009).

3.4.6.3 Normality Test

Jarque-Bera Test was tested. According to Gujarati and Porter (2009) the JB test is applied to the test of normality. This test first computes the skewness and kurtosis measures of the OLS residuals.

3.5. DATA

This study utilizes monthly data series covering the period from January 2015 to July 2023 to estimate the non-linear and asymmetric exchange rate pass-through to consumer prices in South Africa. The data is sourced from the South African Reserve Bank. The analysis of the data was conducted using EViews software.

3.6 CHAPTER SUMMARY

This chapter introduces the methods employed to achieve the study's objectives. Before introducing the methods, the theoretical model underlying the model to be used and the empirical model were presented. Various methods were discussed, including stationarity and cointegration tests. This study utilized the NARDL model to determine the long-run relationships and short-run dynamics between nonlinear and asymmetric exchange rate pass-through to consumer prices. Before conducting the NARDL tests, stationarity tests were performed to examine the presence of unit roots in the series. The results of the techniques discussed above are presented in the following chapter.

CHAPTER FOUR

EMPIRICAL RESULTS AND DISCUSSION

4.1. INTRODUCTION

The study aims to analyze the nonlinear and asymmetric exchange rate pass-through to consumer prices in South Africa. To achieve this aim, the researcher employed various econometric techniques, as stipulated in Chapter Three. Therefore, this chapter presents the results of all the procedures undertaken. It provides both the analysis and discussions of the findings. Section 4.2 presents the results for unit root test results. Sections 4.3 and 4.4 show the results for Nonlinear ARDL and diagnostic tests, respectively. Section 4.5 gives the summary of the study.

4.2. STATIONARITY) TEST RESULTS

Before presenting the unit root tests, the descriptive test results are portrayed in Table 4.1. below:

Table 4.1 Descriptive statistics

	Excrate	GDP_Growth	Imports	Inflation
Mean	13.2993	4.5989	25.4030	4.5001
Median	13.2523	4.6053	25.3408	4.5078
Maximum	13.8559	4.6139	25.9114	4.6746
Minimum	12.7731	4.4527	24.9923	4.2986
Std Dev	0.3213	0.0238	0.2133	0.0909
Skewness	0.1328	-4.0941	0.9654	-0.1665
Kurtosis	1.7393	21.4074	2.9196	2.3620
Jarque Bera	7.1232	1741.91	16.0277	2.2229
Probability	0.0283	0.0000	0.0003	0.3290
Observations	103	103	103	103

The descriptive statistics show that only one variable was normally distributed. This was the inflation variable. The Jarque Bera (JB) statistic for the inflation variable was insignificant. This shows that it was normally distributed. All other variables were not normally distributed.

The test results for all variables at both levels and after the first differencing are represented in Table 4.1 below. The results of the ADF and the PP test for unit roots confirm that all variables are stationarity at first difference except the Gross domestic

product, which is stationary at level. Hence, the hypothesis of inflation, exchange rate, imports, and gross domestic product contain a unit root can be rejected at 1st difference. can be concluded that variables are integrated at different orders giving the go-ahead for the engagement of ARDL methodology.

Table 4.2 The Augmented Dickey-Fuller (ADF) Test

Series	Level or 1st Differencing	Critical value at 5% significance level	ADF Statistics	Probability	Decision	Conclusion
Inflation	At level	-2.890037	-1,830101	0,3641	We fail to reject H_0.	Inflation has a unit root
	After 1st differencing	-2.890327	-8,403266**	0,0000	We reject H_0.	Inflation is stationary
Exchange rate	At level	-2.890037	0,308887	0,97777	We fail to reject H_0	Exchange rate has a unit root
	After 1st differencing	-2.890327	-8.997065**	0,0000	We reject H_0.	Exchange rate series is stationary
Imports	At level	-2.890037	-1,277697	0,6377	We fail to reject H_0.	Imports series has a unit root
	After 1st differencing	-2.890327	-12.58257**	0,00001	We reject H_0.	Imports series is stationary
GDP	At Level	-2.891234	-3.393606**	0.0135	We reject H_0.	GDP series is stationar

* denotes the rejection of the null hypothesis at the 10% level of significance** denotes the rejection of the null hypothesis at the 5% level of significance
*** denotes the rejection of the null hypothesis at the 1% level of significance
Source: Author compilation using EViews 12

TABLE 4.3 Philip- Perron (PP) test

Series	At level or After 1st Differencing	Critical value at 5% significance level	ADF Statistics	Probability	Decision	Conclusion
Inflation	At level	-1,944006	9,287969	1.0000	We fail to reject H_0	Inflation has a unit root.
	After 1st differencing	-1,944039	-6,265132	0,0000	We reject H_0	Inflation is stationary
Exchange rate	At level	-1,944006	-1,132999	0,2327	We fail to reject H_0	Exchange rate has a unit root.
	After 1st differencing	-1,944039	-8.347133	0,0000	We reject H_0	Exchange rate series is stationary
Imports	At level	-1,944006	1,112193	0,9303	We fail to reject H_0	Imports series has a unit root.
	After 1st differencing	-13,34430	-1,944039	0,0000	We reject H_0	Imports series is stationary
GDP	At Level	-1,944006	-0,063748	0.06592	We reject H_0	GDP series is stationary.

* denotes the rejection of the null hypothesis at the 10% level of significance ** denotes the rejection of the null hypothesis at the 5% level of significance
*** denotes the rejection of the null hypothesis at the 1% level of significance
Source: Author compilation using EViews 12

Table 4.4 Zivot-Andrews Structural Breaks test for one Break

At level

Variable	Inflation	Exchange Rate	Imports	GDP_Growth
Number of lags	12	12	12	12
Minimum t-statistic	0.084744	-3.524824	-4.357664*	-3.544522
1% critical value	-4.949133	-4.949133	-4.949133	-4.949133
5% critical value	-4.443649	-4.443649	-4.443649	-4.443649
10% critical value	-4.193627	-4.193627	-4.193627	-4.193627

Source: Author's compilation and EViews 12

1st difference

Variable	Inflation	Exchange Rate	Imports	GDP_Growth
Number of lags	12	12	12	12
Minimum t-statistic	-13.18690	-9.148739	-13.25039	-7.357037
1% critical value	-4.949133	-4.949133	-4.949133	-4.949133
5% critical value	-4.4436490	-4.443649	-4.443649	-4.443649
10% critical value	-4.193627	-4.193627	-4.193627	-4.193627

Source: Author's compilation and EViews

The null hypothesis for Zivot-Andrews's (1992) unit root test is that the series has a unit root with a structural break in constant, trend, or constant and trend stationary process. The hypothesis can only be rejected when the Zivot-Andrew test statistic value (minimum statistic) is less than the critical values at the 1%, 5% & 10% levels of significance or when the absolute value of this t-statistic is greater than critical values.

If the minimum t-statistic is greater (or its absolute value is less) than the critical value at the 1% or 5% significance level, we reject the null hypothesis that the series has a unit root with a structural break. We thus, conclude that the series is stationary. Alternatively, If the minimum t-statistic is less (or its absolute value is greater) than the critical value at the 1% or 5% significance level, we fail to reject the null hypothesis that the series has a unit root with structural break and is the series is therefore non-stationary.

The following are the results for each variable:

Exchange rate

Since the absolute value of the minimum t-statistic (-3.5248) of the exchange rate variable (excrate) at the level is less than the critical values (-4.443649), we conclude that the variable is non-stationary. So, we can take the 1st difference.

The absolute value of the calculated t-statistic of the exchange rate variable (excrate) after 1st differencing (-9.148739) is greater than the critical value (-4.443649). We thus conclude that the variable is stationary. January 2016 period (2016M01) is selected as the break date in this instance.

The exchange rate break date coincides with the South African rand plummeting to an all-time low of R17.9169 to the US dollar on January 9, 2016, before rebounding to R16.57, following Zuma's surprise *sacking of* Nhlanhla *Nene* as finance minister in December 9, 2015, which harmed international confidence in the rand, and the exchange rate was volatile throughout much of January 2016.

Inflation

The absolute value of the minimum t-statistic (0.084744) of inflation at the level is less than the critical value (-4.443649), implying that the variable is non-stationary. We can thus take the 1st difference.

The absolute value of the minimum t-statistic of inflation after 1st differencing (-13.18690) is greater than the critical value (-4.443649). We therefore conclude that the variable is stationary. January 2022 period (2022M01) is selected as the break date in this instance.

The break date for the exchange rate corresponds with the considerable hike in inflation during this month. Inflation rose to 6.9% in 2022 from 4.5% in 2021, driven by higher food and fuel prices (South Africa Economic Outlook, 2023).

Imports

The absolute value of the minimum t-statistic (-4.357664) of imports at the 5% and 1% level is less than the critical value (-4.443649), except for the 10% level. As we are only focusing on the 5%, we therefore conclude that the variable is non-stationary. As a result, we can take the 1st difference.

The absolute value of the minimum t-statistic of imports after 1st differencing (-4.949133) is greater than the critical value (-4.443649). We therefore conclude that the variable is stationary. January 2023 period (2023M01) was selected as the break date in this instance.

The break date tallies South Africa's swings into a R23 billion trade deficit in January 2023 due to exports of R139.36 billion and imports of R162.41 billion, as recorded by the South African Revenue Service in March 2023.

Gross Domestic Product

The absolute value of the minimum t-statistic (-7.357037) of GDP growth at the level is less than the critical value (-4.443649), implying that the variable is non-stationary. As a result, we can take the 1st difference.

The absolute value of the minimum t-statistic (-4.949133) of GDP growth after 1st differencing is greater than the critical value (-4.443649). We therefore conclude that the variable is stationary.

April 2020 period (2020M04) was selected as the break date in this instance. The GDP's break date matches the decline in real gross domestic product (measured by production) by a record 51,0% in the second quarter of 2020 owing to the impact of the COVID-19 lockdown restrictions since the end of March 2020.

The following are the graphs for the Z-A structural break test for the four variables at the level and after 1st differencing:

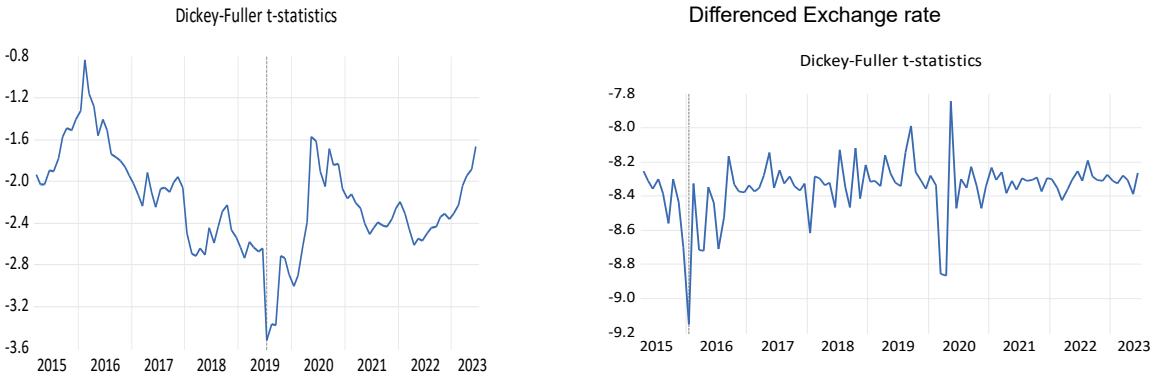

Figure 4.1 Exchange rate at level and After 1st differencing

The exchange rate is nonstationary at levels because is not moving along the mean and hence, is not stationary. The exchange rate seems to be stationary at 1st difference as it is hovering over the mean.

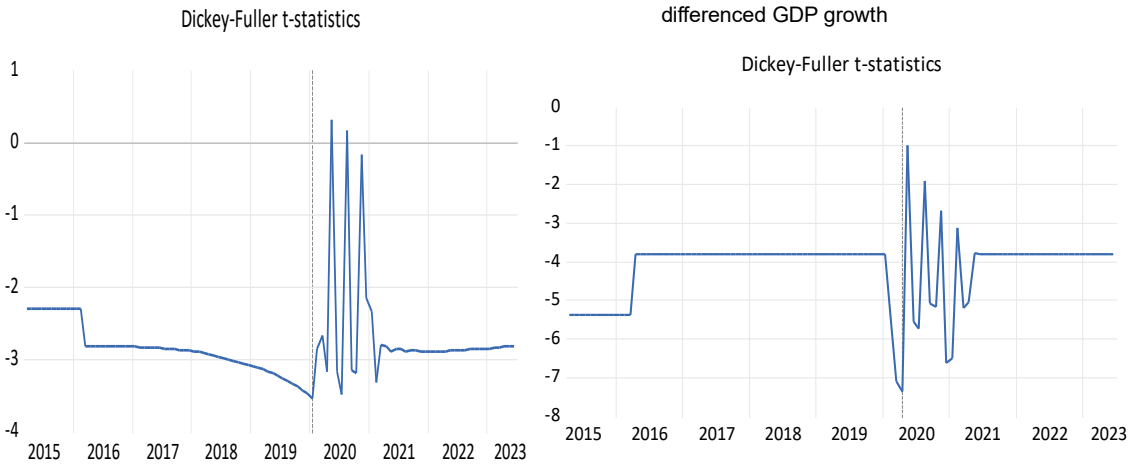

Figure 4.2 GDP_ growth at level and After 1st differencing

GDP_ growth appears to be non-stationary at levels because is not moving along the mean and hence, is not stationary. GDP_ growth seems to be stationary at 1st difference as it is hovering over the mean.

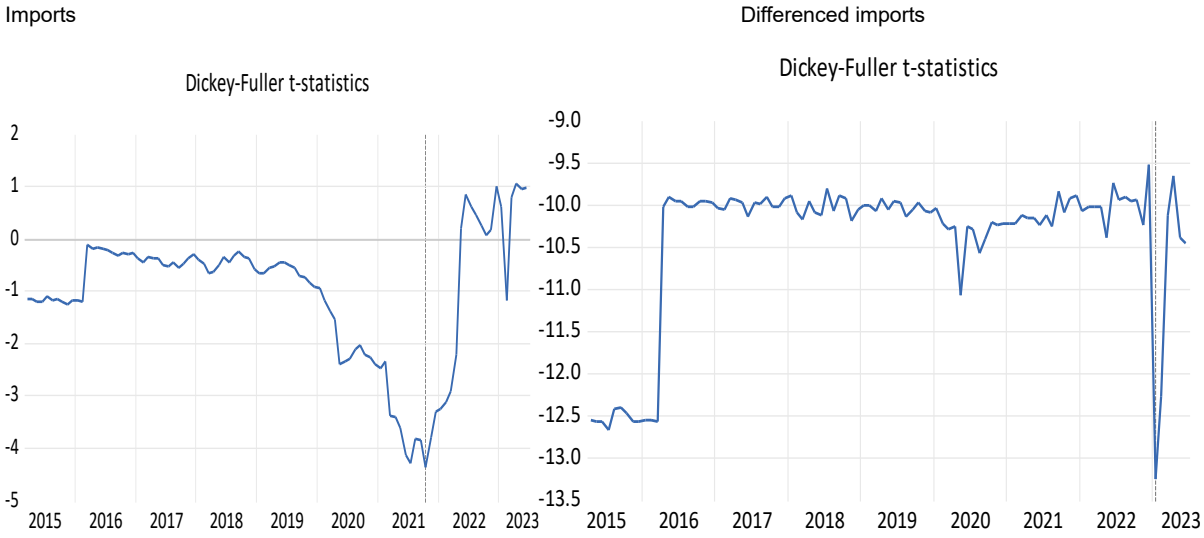

Figure 4.3 Imports at level and After 1st differencing

Imports series is nonstationary at levels because is not moving along the mean and hence, is not stationary. Imports series seemingly is stationary at 1st difference as it is hovering the mean.

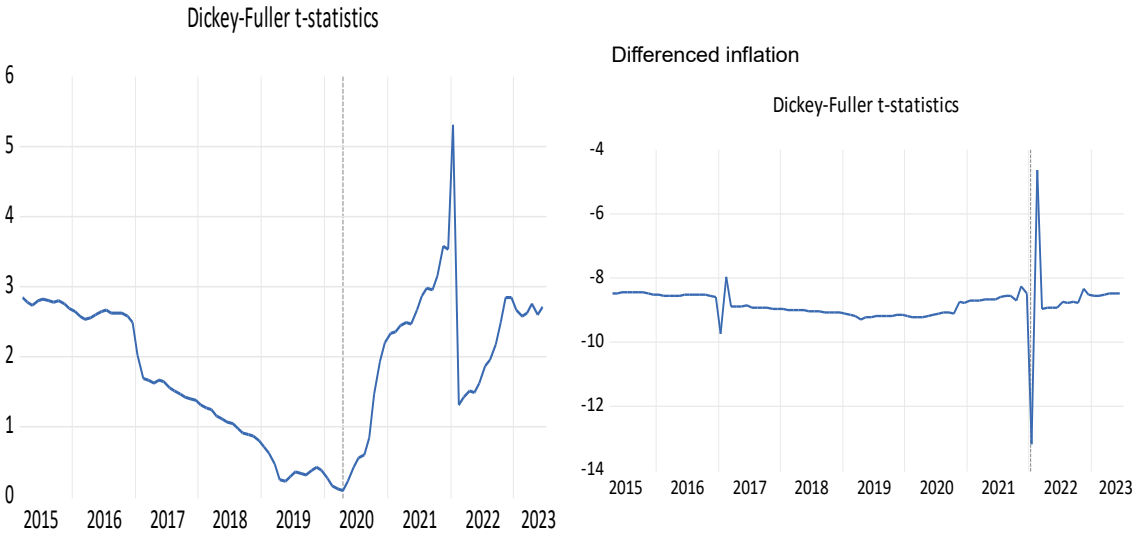

Figure 4.4 Inflation at level and After 1st differencing

Inflation is nonstationary at levels because is not moving along the mean and hence, is not stationary. Inflation appears to be stationary at 1st difference as it is hovering over the mean.

4.2 Long-run relationship between Consumer Inflation and Exchange Rate

Table 4.5 ARDL Bounds Test.

Test statistic	Value	Signif	I(0)	I(1)
F-Statistic	8.1721	10%	2.53	3.59
	6	5%	2.87	4
		2.5%	3.19	4.38
		1%	3.6	4.9

The results for ARDL show that the F- statistic value (8.1721) is greater than the lower bound *I* (0) and the upper bound *I*(1) bound tabulated values, hence the null hypothesis of no long-run relationship is rejected and we conclude that there is a long run relationship between the dependent and explanatory variables. The next step was to estimate the NARDL.

4.3 NONLINEAR ARDL (NARDL) TEST RESULTS

Table 4.6: NARDL – Long Run

Variable	**Coefficient**	**Std. Error**	**t-statistic**	**Prob**
Inflation (-1)	0.7629	0.0486	15.6746	0.0000
Imports_Pos	-0.2237	0.04155	-5.3833	0.0000
Imports_Neg	-0.0905	0.0698	-1.2969	0.1978
GDP-Growth_Pos	1.1561	0.2284	5.0602	0.0000
GDP-Growth_Neg	-0.9554	0.1555	-6.1406	0.0000
Excrate_Pos	0.0072	0.3145	0.0229	0.9818
Excreate_Neg	-0.3036	0.1889	-1.6071	0.1114

Note: POS implies a positive or direct relationship between the independent and dependent variables, whilst NEG implies a negative or indirect relationship between the independent and dependent variables).

In the case of asymmetry, if the response of the dependent variable to the positive (negative) changes in the independent variable is larger than that of a negative (positive) change, we say there is an asymmetric relationship between the two variables. However, if it is the same, we conclude that the relationship is symmetric.

The positive change in imports has a significant effect as denoted by the p-value of 0.0000, whilst its negative effect has an insignificant effect as portrayed by the p-value of 0.1978.

The negative sign of the coefficient of IMPORTS_POS (-0.2237) implies that, if there is an increase in imports by R1 million, consumer inflation will decrease by 0.2 %. On the contrary, the negative sign of IMPORTS_NEG (-0.0905) implies that, if imports decrease by R1 million, consumer inflation will increase by 0.09 (or about 0.1) %.

In the case of GDP_GROWTH, the positive sign of GDP_GROWTH_POS (1.1561) implies that, if there is an increase in GDP growth by R1 million, consumer inflation will also increase by 1.15% (or 1.6%) units. Conversely, the positive sign of GDP_GROWTH_NEG (-0.9554) implies that, if GDP growth decreases by R1 million, consumer inflation will decrease by 0.95 (or about 0.1) %.

The positive sign of EXCRATE_POS (0.0072) implies that, if the exchange rate appreciates by 1%, consumer inflation will also increase by 0.01%. On the other hand, the negative sign of EXCRATE-NEG implies that if the exchange rate depreciates by 1%, consumer inflation will increase by 0.30 units (or about 0.3) %.

The results reveal that there is an asymmetric nonlinear relationship between the dependent variable (consumer prices) and each independent variable.

A negative change in the dependent variable results in response to a change in imports, as denoted by the coefficient -0.2237, which is greater than the relatively smaller change in asymmetry,

The long-run results indicate that inflation is affected by positive changes in imports in the long -run. Results show that when imports increase, inflation goes down.

The effect of negative changes in imports was seen to be having no effect on inflation.

Results show that inflation is affected by both negative and positive changes in GDP in the long run. The results show that inflation is affected positively by positive changes in GDP. This implies that when GDP increases, inflation also increases.

Results also reveal that negative changes in GDP result in a decrease in inflation. This implies that when GDP decreases, inflation also decreases.

The effect of excrate on inflation was seen to be insignificant. This implies both positive (0.0072) and negative changes (-0.3036) in exchangrate do not have a significant effect on inflation.

Table 4.7 Short-run NARDL results

Imports POS	-0.943649	0.216459	-4.359486	0.0000
Imports NEG	-0.382077	0.325516	-1.173761	0.2435
GDP Growth POS	4.876977	1.117737	4.363259	0.0000
GDP Growth NEG	4.030248	0.883975	4.559234	0.0000
EXCRATE POS	0.030426	1.328364	0.022905	0.9818
EXCRATE_NEG	-1.280761	0.802469	-1.596026	0.1139

ECM Regression

Variable	Coefficient	Std.Error	T-statistic	Probability
C	1.072213	0.137927	7.773774	0.0000
@Trend	0.003290	0.000429	7.664575	0.0000
CoinEq(-1)*	-0237061	0.030379	-7.803588	0.0000

The speed-of-adjustment coefficient, also referred to as the error correction term (ECT) tells us how fast the process for the dependent variable reverts to its long-run relationship when this equilibrium is distorted If it is closer to 1, this would imply that—in the absence of any other short-run fluctuations—any deviation from the equilibrium is corrected within a short period after the distortion occurs. In contrast, if it is closer to 0, this would imply that the process returns to its equilibrium path after a long period (Kripfganz & Schneider,2023). The error correction term has a coefficient (-0.237061) with a correct negative sign which is less than 1 and is perfectly significant with a p-value of 0.000.

The ECT coefficient (-0.237061) implies that if there is any disturbance in this system it takes an average speed of about 24% on this non-linear ARDL model to adjust back from the short run to the long run (Chirwa, 2017).

The positive change in imports has a significant effect as denoted by the p-value of 0.0000, whilst its negative effect has an insignificant effect as portrayed by the p-value of 0.2435.

The negative sign of IMPORTS_POS implies that, if there is an increase in imports by R1 million, consumer inflation will decrease by 0.9 %. On the contrary, the negative sign of IMPORTS_NEG implies that, if imports decrease by R1 million, consumer inflation will increase by 0.38 (or about 0.4)%.

In the case of GDP_GROWTH, the positive sign of GDP_GROWTH_POS implies that, if imports increase by RI million, consumer inflation will also increase by 4.87 (or 4.9) %. Conversely, the positive sign of GDP_GROWTH_NEG implies that, if imports decrease by 1 unit, consumer inflation will decrease by 0.38 (or about 0.4) %.

The positive sign of EXCRATE_POS (0.0072) implies that, if the exchange rate appreciates by 1%, consumer inflation will also increase by 0.03 %. On the other hand, the negative sign of EXCRATE-NEG (-. implies that, if the exchange rate depreciates by 1%, consumer inflation will increase by 1.28 units (or about 1.3) %.

4.4 WALD TEST

As stated earlier, the Wald test is a statistical tool used to assess the significance of regression model coefficients and hypotheses, particularly in detecting short-run asymmetry in regression models. Tables 4,81, 4.8.2, and 4.83 present the Wald tests for exchange rate-Inflation, imports-Inflation, and GDP_GROWTH-Inflation nexuses, respectively.

The null hypothesis is that there is an asymmetric nonlinear long-run relationship between the dependent variable and the explanatory variable, against the alternative one that there is a symmetric nonlinear long-run relationship between the dependent variable and the explanatory variable.

Table 4.8 Wald tests

Table 4.8.1: Equation: NARDL

Test Statistic	Value	Df	Probability
t-statistics	-1.594704	93	0.1142
F-statistic	2.543081	(1, 93)	0.1142
Chi-square	1.594704	1	0.1108

C (2)*IMPORTS_POS + C (3)*IMPORTS_NEG

From Table 4.8.1, the null hypothesis is that there is an asymmetric nonlinear long-run relationship between inflation and imports. As the p-value (0.1142) is greater than 0.05 at the 5% level of significance and therefore insignificant, we fail to reject the null hypothesis and conclude that the two variables have an asymmetric nonlinear short-run relationship.

Table 4.8.2: Equation: NARDL

Test Statistic	Value	Df	Probability
t-statistic	1.192675	93	0.2360
F-statistic	1.422473	(1, 93)	0.2360
Chi-square	1.422473	1	0.2330

C (4)*GDP_GROWTH_POS + C (5)*GDP_GROWTH_NEG

The p-value on the relationship between inflation and GDP_GROWTH (0.2360) from Table 4.8.2, is insignificant as it is greater than 0,05 at the 5% level of significance. We can also conclude that inflation and GDP_GROWTH have an asymmetric nonlinear short-run relationship.

Table 4.8.3: Equation: NARDL

Test Statistic	Value	Df	Probability
t-statistic	-4.397058	93	0.0000
F-statistic	19.33412	(1, 93)	0.0000
Chi-square	19.33412	1	0.0000

EXCRATE_POS + C(7)*EXCRATE_NEG + C(8)

From Table 4.8.3, in the case of exchange rates, there is a nonexistence of an asymmetric correlation between inflation and exchange rate. This is portrayed by a significant p-value (0.0000) of less than 0.05.

4.5. DIAGNOSTIC TESTS

Diagnostic tests were conducted to determine any possible violation of the classical assumptions. Since non-violation produces more efficient estimates. The following tests were used: the Breush –Godfrey serial correlation LM test, the Breusch-Pagan Heteroscedasticity test, the normality test, and the Ramsey test.

Table 4.9: Serial Correlation Test

F-statistic	0.1596	Prob. F	0.8527
Obs*R-Squared	0.3565	Prob. Chi-Square	0.8367

In the serial correlation test, the null hypothesis of no serial correlation against the alternative positive or negative serial correlation hypothesis is tested. Results show that there was no serial correlation in the model. The Probability of the F-statistic turned out to be 0.852 and this was above 0.05. This shows that there was no serial correlation.

Table 4.10: Breusch-Pagan-Godfrey Heteroscedasticity Test

F-statistic	1.1109	Prob.F	0.3632
Obs*R-Squared	8.8971	Prob-Chi Square	0.3510
Scale Explained SS	8.9522	Prob-Chi-Square	0.3463

Heteroscedasticity tests suggest two hypotheses: H_0 (null hypothesis) indicates homoscedastic data (covariance), and H_a (alternative hypothesis) suggests heteroscedastic data (no covariance). Results show that there is homoscedasticity in the model. The Probability of the F-statistic turned out to be 0.3632 and this was above 0.05. This shows that there was no heteroscedasticity.

Table 4.11 Jarcque Bera Normality Test

Jarcque Bera	4.663720
Prob	0.097115

The null hypothesis for the Jarcque Bera normality test is that the data is normally distributed, against the alternate hypothesis that the data does not come from a normal distribution. The results show that the residuals are normality distributed. This is shown by the p-value associated with the JB8: statistic. It was above 0.05.

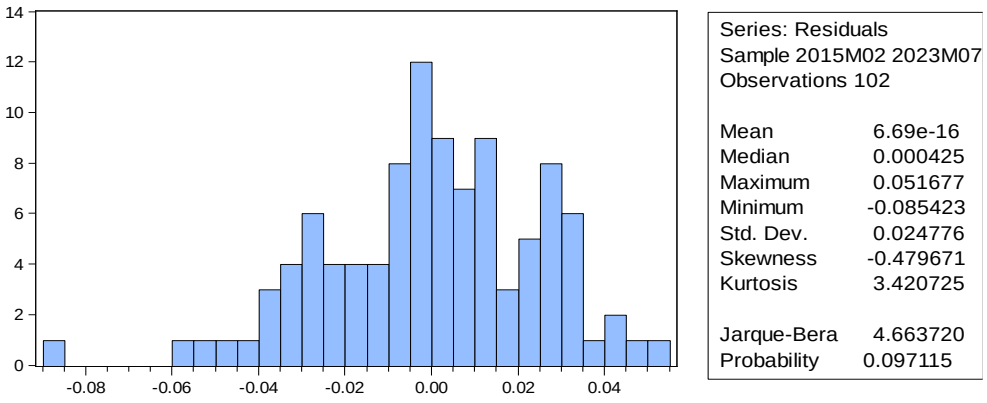

Figure 4.5: Normality Test

The Jarque-Bera test is based on the notion that the skewness should be 0 and Kurtosis have a value of 3 (Kallner,2017)

Note: When testing for normality using the histogram of residuals, the researcher superimposes the bell-shaped normal distribution curve on the histogram in Figure 4.5. This implies that normal approximation is inappropriate (Gujarati & Porter, 2009). It is evident from Figure 4.5 that the residuals are normally distributed given the probability value of 0.097115. Although the skewness is not exactly zero however it is almost close to zero and the kurtosis is 3.420725, the value is still accepted.

4.6 CHAPTER SUMMARY

This chapter presented the empirical results and discussion where the tests carried out utilizing the Zivot-Andrews unit root test unveiled that, initially, the variables - exchange rate, inflation, imports, and GDP growth - exhibited non-stationary behaviour at their respective levels. After this, the NARDL model investigation offered more

profound insights into the interrelations among these variables, with a particular emphasis on inflation as the endogenous variable and imports, GDP growth, and exchange rates as exogenous variables. The outcomes revealed an asymmetric nonlinear long-run nexus between inflation and imports, as well as inflation and GDP growth. These connections entailed dissimilar reactions to positive and negative variations in the explanatory variables. However, no long-run asymmetric nonlinear relationship exists between exchange rate and inflation.

The presence of an error correction term implied a relatively slow adjustment mechanism for any deviations from the long-term equilibrium, as depicted by 24%, which is relatively low. Additionally, the analysis exposed a symmetric association between inflation and exchange rates, suggesting that fluctuations in exchange rates consistently impacted inflation, irrespective of the direction of the change. Nevertheless, the influence of exchange rates on inflation was considered negligible over the long term.

CHAPTER FIVE

SUMMARY, CONCLUSION, AND POLICY IMPLICATIONS

5.1 INTRODUCTION

This study analyzed the nonlinear and asymmetric exchange rate pass-through to consumer prices in South Africa for the period spanning from January 2015 to July 2023. The current chapter, thus, summarizes the study, as it provides the conclusion, and policy implications on the nonlinear and asymmetric exchange rate pass-through to consumer prices in South Africa. The chapter is divided into seven sections: Section 5.2 presents the problem statement, objectives, and contribution of the study. Theories and brief empirical studies are presented in section 5.3. The gap in the literature is also highlighted in this section. Section 5.4 presents the estimation methods and the data used in the study. In sections 5.5 and 5.6 key findings and policy implications are provided, respectively. Finally, delimitations and areas of further research are presented in sections 5.7 and 5.8, respectively.

5.2 PROBLEM STATEMENT, OBJECTIVES, AND RATIONALE OF THE STUDY

Earlier empirical literature has commonly assumed that the exchange rate- consumer prices nexus follows a linear and symmetric pattern. This suggests that both large and small changes in exchange rates, as well as appreciations and depreciations, have a proportional effect on consumer prices. However, recent studies have challenged this assumption, suggesting that exchange rate pass-through to consumer prices is nonlinear and asymmetric. The question whether ERPT is symmetric or linear remains a topic of debate. Hence, this study aims to contribute to this ongoing debate.

Literature reviewed reveals that current research is deficient concerning the examination of how changes in exchange rates affect consumer prices in South Africa. This necessitates the need to conduct a study on this topic as it will help to deepen the literature on this issue. The intended research endeavours to fill this gap in the context of South Africa.

Studying exchange rate pass-through is essential for policymakers because the effectiveness of monetary or fiscal policies relies on how exchange rate changes affect consumer prices. When ERPT is inadequate, it can trigger an exchange rate shock, resulting in heightened inflation and potentially prompting people to switch to foreign currency. This study seeks to suggest actions that can be taken to reduce inflationary effects and tackle the problem of individuals opting for foreign currencies due to limited pass-through.

5.3 KEY THEORIES AND EMPIRICAL FINDINGS

The theory and the empirics concerning asymmetric and nonlinear exchange rate pass-through were presented. Regarding the review of theoretical literature, three theories relating to asymmetric and nonlinear exchange rate pass-through to domestic prices were discussed: pricing-to-market theory, binding constraints theory, and Purchasing Power Parity.
On the empirical side, literature on developed, developing, and, in particular, South Africa, was presented.

The review results reveal that in recent times, there has been asymmetry as well as nonlinearity exchange rate pass-through to domestic prices, mainly to consumer prices in both the advanced and emerging economies. In the case of South Africa, despite its relevance, few studies focus on asymmetry, and the results are unclear on non-linearity. The study aims to fill a gap in the literature by analysing nonlinearities and asymmetric ERPT to consumer prices in South Africa.

5.4 THE KEY METHODS AND DATA USED

This study employed the nonlinear autoregressive distributed lag (NARDL)and monthly data to estimate the non-linear and asymmetric exchange rate pass-through to consumer prices in South Africa, and the complete data set consists of 103 observations. Secondary time series data were collected from the South African Reserve Bank. EViews 12 software package was employed to conduct stationarity (unit root) tests, tests for choosing the optimal lag length criterion, NARDL, the Zivot-Andrew's test, and diagnostic tests.

5.5 KEY FINDINGS

Consistent with Hossain et al. (2021), the study findings reveal a nonlinear asymmetric correlation between GDP growth and consumer inflation. The implication is that positive and negative changes in GDP growth do not have the same effect on consumer prices in South Africa.

The results of the study show that there is a nonlinear asymmetric correlation between imports and consumer inflation. This is In line with the study by Alsamara et al. (2020). This suggests that positive and negative shocks from imports do not impact consumer inflation with the same magnitude. This infers that the negative changes in import prices are passed on more strongly than positive changes in South Africa

The results on the nexus between exchange rates and consumer inflation which show an insignificant relationship, imply that exchange rate shocks have no effect on consumer price changes. These results are inconsistent with the recent study by Mashao & Choga (2023), whose results indicate that the exchange rate has significantly influenced consumer prices negatively in the SACU region in the long run. The results are also not in line with those of Karaoğlu & Demirel (2021), which reveal that exchange rate pass-through into inflation is asymmetric in Turkey. However, the results support the findings of Mendali & Das (2023), who showed that exchange rate shocks do not lead to significant changes in consumer prices in the long run in India.

5.6 POLICY IMPLICATIONS

The policy implication is that the ERPT has insignificant consequences for monetary policy, and depreciation might pose a little threat to price stability. Hence, the South African monetary authorities (in this instance, the South African Reserve Bank) should not appropriately worry about such depreciations.

5.7 LIMITATIONS OF THE STUDY

The study covered a period from January 2015 to July 2023. The variables used are inflation, exchange rate, imports, and GDP growth. It also provides relevance and

significance, since the previous years have been thoroughly dealt with, by other researchers.

5.8 AREAS OF FURTHER RESEARCH

The current study aimed to enhance exploration by analysing macroeconomic variables rather than focusing solely on microeconomic factors. Variables such as market structure and pricing behaviour have the potential to impact exchange rate pass-through. Subsequent studies may utilise microeconomic frameworks to delve into how businesses adjust pricing strategies in response to exchange rate fluctuations and the consequent impact on consumer prices.

While the present study suggests that exchange rate shocks do not significantly affect monetary policy in South Africa, further investigation could delve into the potential effects of non-linearities in exchange rate pass-through on policy development. This could involve examining alternative policy measures in response to exchange rate fluctuations and their effectiveness in maintaining price stability.

Refining the topic to concentrate on “Exchange Rate Pass-Through and its Implications” could provide a more focused direction. Moreover, exploring these research avenues can deepen scholars’ understanding of the complex relationship between exchange rates and consumer prices in South Africa, offering valuable insights for policymakers and practitioners.

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APPENDICES

Appendix 1A: Descriptive statistics

Sample: 2015M01 2023M07

	INFLATION	IMPORTS	GDP_GR...	EXCRATE
Mean	4.500150	25.40305	4.598965	13.29932
Median	4.507888	25.34089	4.605361	13.25234
Maximum	4.674603	25.91147	4.613917	13.85593
Minimum	4.298645	24.99230	4.452745	12.77311
Std. Dev.	0.090912	0.213343	0.023829	0.321386
Skewness	-0.166558	0.965422	-4.094165	0.132870
Kurtosis	2.362030	2.919691	21.40748	1.739374
Jarque-Bera	2.222967	16.02770	1741.919	7.123285
Probability	0.329070	0.000331	0.000000	0.028392
Sum	463.5154	2616.514	473.6934	1369.830
Sum Sq. Dev.	0.843023	4.642547	0.057918	10.53550
Observations	103	103	103	103

Appendix 1B : Augmented Dickey Fuller unit root test -EXCRATE

Null Hypothesis: EXCRATE has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.308887	0.9777
Test critical values:	1% level	-3.495677	
	5% level	-2.890037	
	10% level	-2.582041	

*MacKinnon (1996) one-sided p-values.

Appendix 1C: Augmented Dickey Fuller unit root test -Imports

Null Hypothesis: IMPORTS has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.277697	0.6377
Test critical values:	1% level	-3.495677	
	5% level	-2.890037	
	10% level	-2.582041	

*MacKinnon (1996) one-sided p-values.

Appendix 1C: Augmented Dickey-Fuller unit root test -Inflation

Null Hypothesis: INFLATION has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.830101	0.3641
Test critical values:	1% level	-3.495677	
	5% level	-2.890037	
	10% level	-2.582041	

*MacKinnon (1996) one-sided p-values.

Appendix 1D: Augmented Dickey-Fuller unit root test -GDP-Growth

Null Hypothesis: GDP GROWTH has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.393606	0.0135
Test critical values:	1% level	-3.498439	
	5% level	-2.891234	
	10% level	-2.582678	

Appendix 2A: Augmented Dickey- Fuller unit root test -D(EXCRATE)

Null Hypothesis: D(EXCRATE) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.997065	0.0000
Test critical values:	1% level	-3.496346	
	5% level	-2.890327	
	10% level	-2.582196	

*MacKinnon (1996) one-sided p-values.

Appendix 2B: Augmented Dickey- Fuller unit root test- D(Imports)

Null Hypothesis: D(IMPORTS) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-12.58257	0.0001
Test critical values:	1% level	-3.496346	
	5% level	-2.890327	
	10% level	-2.582196	

*MacKinnon (1996) one-sided p-values.

Appendix 2C: Augmented Dickey -Fuller unit root test- D(Inflation)

Null Hypothesis: D(INFLATION) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.403266	0.0000
Test critical values:	1% level	-3.496346	
	5% level	-2.890327	
	10% level	-2.582196	

*MacKinnon (1996) one-sided p-values.

Appendix 3A: Philips Perron unit root test- Excrate

Null Hypothesis: EXCRATE has a unit root
Exogenous: None
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.132999	0.2327
Test critical values:	1% level	-2.587831	
	5% level	-1.944006	
	10% level	-1.614656	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(EXCRATE) has a unit root
Exogenous: None
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-8.347133	0.0000
Test critical values:	1% level	-2.588059	
	5% level	-1.944039	
	10% level	-1.614637	

*MacKinnon (1996) one-sided p-values.

Appendix 3B: Philips perron unit root test- Imports

Null Hypothesis: IMPORTS has a unit root
Exogenous: None
Bandwidth: 10 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		1.112193	0.9303
Test critical values:	1% level	-2.587831	
	5% level	-1.944006	
	10% level	-1.614656	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(IMPORTS) has a unit root
Exogenous: None
Bandwidth: 5 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-13.34430	0.0000
Test critical values:	1% level	-2.588059	
	5% level	-1.944039	
	10% level	-1.614637	

*MacKinnon (1996) one-sided p-values.

Appendix 3C: Philips perron unit root- Inflation

Null Hypothesis: INFLATION has a unit root
Exogenous: None
Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		9.287967	1.0000
Test critical values:	1% level	-2.587831	
	5% level	-1.944006	
	10% level	-1.614656	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(INFLATION) has a unit root
Exogenous: None
Bandwidth: 7 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-6.265132	0.0000
Test critical values:	1% level	-2.588059	
	5% level	-1.944039	
	10% level	-1.614637	

*MacKinnon (1996) one-sided p-values.

Appendix 3D: Philips perron unit root- GDP-Growth

Null Hypothesis: GDP_GROWTH has a unit root
Exogenous: None
Bandwidth: 12 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-0.063748	0.6592
Test critical values:	1% level	-2.587831	
	5% level	-1.944006	
	10% level	-1.614656	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(GDP_GROWTH) has a unit root
Exogenous: None
Bandwidth: 48 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-5.314211	0.0000
Test critical values:	1% level	-2.588059	
	5% level	-1.944039	
	10% level	-1.614637	

*MacKinnon (1996) one-sided p-values.

Appendix 4A: Ziviot- Andrews Test: Structural breaks_ Excrate

Null Hypothesis: EXCRATE has a unit root
Trend Specification: Intercept only
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 2019M07
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 1 (Automatic - based on Schwarz information criterion, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.524824	0.3733
Test critical values:	1% level	-4.949133	
	5% level	-4.443649	
	10% level	-4.193627	

*Vogelsang (1993) asymptotic one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: EXCRATE
Method: Least Squares
Date: 04/23/24 Time: 20:23
Sample (adjusted): 2015M03 2023M07
Included observations: 101 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EXCRATE(-1)	0.837686	0.046049	18.19119	0.0000
D(EXCRATE(-1))	0.248060	0.096442	2.572119	0.0116
C	15.27014	4.422996	3.452442	0.0008
INCPTBREAK	-1.799451	0.724601	-2.483368	0.0147
BREAKDUM	4.981294	2.664293	1.869649	0.0646

R-squared	0.894758	Mean dependent var	90.07594
Adjusted R-squared	0.890373	S.D. dependent var	7.907628
S.E. of regression	2.618213	Akaike info criterion	4.811099
Sum squared resid	658.0840	Schwarz criterion	4.940560
Log likelihood	-237.9605	Hannan-Quinn criter.	4.863509
F-statistic	204.0459	Durbin-Watson stat	1.951034
Prob(F-statistic)	0.000000		

Appendix 4B: Ziviot- Andrews Test: Structural breaks_ Imports

Null Hypothesis: IMPORTS has a unit root
Trend Specification: Intercept only
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 2021M10
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 0 (Automatic - based on Schwarz information criterion, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.357664	0.0638
Test critical values:	1% level	-4.949133	
	5% level	-4.443649	
	10% level	-4.193627	

*Vogelsang (1993) asymptotic one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: IMPORTS
Method: Least Squares
Date: 04/23/24 Time: 20:21
Sample (adjusted): 2015M02 2023M07
Included observations: 102 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IMPORTS(-1)	0.720341	0.064176	11.22438	0.0000
C	2.78E+10	6.34E+09	4.379117	0.0000
INCPTBREAK	1.74E+10	4.07E+09	4.261773	0.0000
BREAKDUM	-1.32E+10	7.77E+09	-1.699055	0.0925

R-squared	0.924792	Mean dependent var	1.11E+11
Adjusted R-squared	0.922490	S.D. dependent var	2.61E+10
S.E. of regression	7.26E+09	Akaike info criterion	48.28830
Sum squared resid	5.17E+21	Schwarz criterion	48.39124
Log likelihood	-2458.703	Hannan-Quinn criter.	48.32999
F-statistic	401.6861	Durbin-Watson stat	2.166711
Prob(F-statistic)	0.000000		

Appendix 4C: Ziviot- Andrews Test: Structural breaks_ Inflation

Null Hypothesis: INFLATION has a unit root
Trend Specification: Intercept only
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 2020M04
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 0 (Automatic - based on Schwarz information criterion, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.084744	> 0.99
Test critical values:	1% level	-4.949133	
	5% level	-4.443649	
	10% level	-4.193627	

*Vogelsang (1993) asymptotic one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: INFLATION
Method: Least Squares
Date: 04/23/24 Time: 20:19
Sample (adjusted): 2015M02 2023M07
Included observations: 102 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INFLATION(-1)	1.000700	0.008255	121.2243	0.0000
C	4462.799	4095.993	1.089552	0.2786
INCPTBREAK	4767.142	3396.267	1.403642	0.1636
BREAKDUM	-1786.810	7822.795	-0.228411	0.8198

R-squared	0.998652	Mean dependent var	630907.5
Adjusted R-squared	0.998611	S.D. dependent var	202671.4
S.E. of regression	7552.791	Akaike info criterion	20.73565
Sum squared resid	5.59E+09	Schwarz criterion	20.83859
Log likelihood	-1053.518	Hannan-Quinn criter.	20.77733
F-statistic	24209.42	Durbin-Watson stat	1.871848
Prob(F-statistic)	0.000000		

Appendix 4D: Ziviot- Andrews Test: Structural breaks_ GDP-growth

Null Hypothesis: GDP_GROWTH has a unit root
Trend Specification: Intercept only
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 2020M01
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 7 (Automatic - based on Schwarz information criterion, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.544522	0.3631
Test critical values:	1% level	-4.949133	
	5% level	-4.443649	
	10% level	-4.193627	

*Vogelsang (1993) asymptotic one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: GDP_GROWTH
Method: Least Squares
Date: 04/23/24 Time: 20:22
Sample (adjusted): 2015M09 2023M07
Included observations: 95 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP_GROWTH(-1)	0.824084	0.049631	16.60437	0.0000
D(GDP_GROWTH(-1))	0.867385	0.100826	8.602750	0.0000
D(GDP_GROWTH(-2))	0.124471	0.122282	1.017903	0.3116
D(GDP_GROWTH(-3))	-0.777083	0.122335	-6.352110	0.0000
D(GDP_GROWTH(-4))	0.725248	0.136071	5.329942	0.0000
D(GDP_GROWTH(-5))	0.056002	0.118437	0.472840	0.6376
D(GDP_GROWTH(-6))	-0.418023	0.118458	-3.528853	0.0007
D(GDP_GROWTH(-7))	0.351343	0.101851	3.449584	0.0009
C	17.62518	4.971557	3.545203	0.0006
INCPTBREAK	-0.337109	0.164109	-2.054181	0.0431
BREAKDUM	0.422931	0.670287	0.630970	0.5298

R-squared	0.930303	Mean dependent var	99.34420
Adjusted R-squared	0.922005	S.D. dependent var	2.340346
S.E. of regression	0.653601	Akaike info criterion	2.095879
Sum squared resid	35.88431	Schwarz criterion	2.391591
Log likelihood	-88.55427	Hannan-Quinn criter.	2.215369
F-statistic	112.1210	Durbin-Watson stat	1.850436
Prob(F-statistic)	0.000000		

Appendix 5A: Ziviot- Andrews Test: Structural breaks_ D(EXCRATE)

Null Hypothesis: D(EXCRATE) has a unit root
Trend Specification: Intercept only
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 2016M01
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 0 (Automatic - based on Schwarz information criterion, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.148739	< 0.01
Test critical values:	1% level	-4.949133	
	5% level	-4.443649	
	10% level	-4.193627	

*Vogelsang (1993) asymptotic one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(EXCRATE)
Method: Least Squares
Date: 04/23/24 Time: 21:12
Sample (adjusted): 2015M03 2023M07
Included observations: 101 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(EXCRATE(-1))	0.103202	0.098024	1.052821	0.2950
C	-1.806916	0.854794	-2.113861	0.0371
INCPTBREAK	1.781978	0.898108	1.984147	0.0501
BREAKDUM	-6.590084	2.727683	-2.416000	0.0176

R-squared	0.112518	Mean dependent var	-0.298020
Adjusted R-squared	0.085070	S.D. dependent var	2.792507
S.E. of regression	2.671088	Akaike info criterion	4.841647
Sum squared resid	692.0670	Schwarz criterion	4.945216
Log likelihood	-240.5032	Hannan-Quinn criter.	4.883575
F-statistic	4.099337	Durbin-Watson stat	1.914208
Prob(F-statistic)	0.008734		

Appendix 5B: Ziviot- Andrews Test: Structural breaks_ D(Imports)

Null Hypothesis: IMPORTS has a unit root
Trend Specification: Intercept only
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 2021M10
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 0 (Automatic - based on Schwarz information criterion, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.357664	0.0638
Test critical values:	1% level	-4.949133	
	5% level	-4.443649	
	10% level	-4.193627	

*Vogelsang (1993) asymptotic one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: IMPORTS
Method: Least Squares
Date: 04/23/24 Time: 20:21
Sample (adjusted): 2015M02 2023M07
Included observations: 102 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IMPORTS(-1)	0.720341	0.064176	11.22438	0.0000
C	2.78E+10	6.34E+09	4.379117	0.0000
INCPTBREAK	1.74E+10	4.07E+09	4.261773	0.0000
BREAKDUM	-1.32E+10	7.77E+09	-1.699055	0.0925

R-squared	0.924792	Mean dependent var	1.11E+11
Adjusted R-squared	0.922490	S.D. dependent var	2.61E+10
S.E. of regression	7.26E+09	Akaike info criterion	48.28830
Sum squared resid	5.17E+21	Schwarz criterion	48.39124
Log likelihood	-2458.703	Hannan-Quinn criter.	48.32999
F-statistic	401.6861	Durbin-Watson stat	2.166711
Prob(F-statistic)	0.000000		

Appendix 5C: Ziviot- Andrews Test: Structural breaks_ D(Inflation)

Null Hypothesis: D(INFLATION) has a unit root
Trend Specification: Intercept only
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 2022M01
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 0 (Automatic - based on Schwarz information criterion, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-13.18690	< 0.01
Test critical values:	1% level	-4.949133	
	5% level	-4.443649	
	10% level	-4.193627	

*Vogelsang (1993) asymptotic one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(INFLATION)
Method: Least Squares
Date: 04/23/24 Time: 20:04
Sample (adjusted): 2015M03 2023M07
Included observations: 101 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(INFLATION(-1))	0.157494	0.063890	2.465086	0.0155
C	5480.867	688.6204	7.959199	0.0000
INCPTBREAK	4557.575	1307.115	3.486745	0.0007
BREAKDUM	-61448.24	5145.674	-11.94173	0.0000

R-squared	0.606519	Mean dependent var	6787.446
Adjusted R-squared	0.594350	S.D. dependent var	7863.124
S.E. of regression	5008.078	Akaike info criterion	19.91429
Sum squared resid	2.43E+09	Schwarz criterion	20.01786
Log likelihood	-1001.672	Hannan-Quinn criter.	19.95622
F-statistic	49.83922	Durbin-Watson stat	1.603935
Prob(F-statistic)	0.000000		

Appendix 5D: Ziviot- Andrews Test: Structural breaks_ D(GDP-Growth)

Null Hypothesis: D(GDP_GROWTH) has a unit root
Trend Specification: Intercept only
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 2020M04
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 5 (Automatic - based on Schwarz information criterion, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.357037	< 0.01
Test critical values:	1% level	-4.949133	
	5% level	-4.443649	
	10% level	-4.193627	

*Vogelsang (1993) asymptotic one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(GDP_GROWTH)
Method: Least Squares
Date: 04/23/24 Time: 20:01
Sample (adjusted): 2015M08 2023M07
Included observations: 96 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GDP_GROWTH(-1))	-0.174814	0.159686	-1.094738	0.2767
D(GDP_GROWTH(-1),2)	0.781541	0.137343	5.690415	0.0000
D(GDP_GROWTH(-2),2)	0.552858	0.132204	4.181863	0.0001
D(GDP_GROWTH(-3),2)	-0.020588	0.103802	-0.198343	0.8432
D(GDP_GROWTH(-4),2)	0.350273	0.096900	3.614795	0.0005
D(GDP_GROWTH(-5),2)	0.210871	0.097762	2.156984	0.0338
C	-0.113219	0.088154	-1.284327	0.2024
INCPTBREAK	0.359946	0.140206	2.567256	0.0120
BREAKDUM	-3.276896	0.959339	-3.415786	0.0010

R-squared	0.648321	Mean dependent var	0.003981
Adjusted R-squared	0.615983	S.D. dependent var	1.060126
S.E. of regression	0.656951	Akaike info criterion	2.086644
Sum squared resid	37.54782	Schwarz criterion	2.327052
Log likelihood	-91.15892	Hannan-Quinn criter.	2.183821
F-statistic	20.04811	Durbin-Watson stat	1.565084
Prob(F-statistic)	0.000000		

Appendix 7: NARDL

Sample (adjusted): 2015M02 2023M07
Included observations: 102 after adjustments
Maximum dependent lags: 1 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (0 lag, automatic): IMPORTS_POS IMPORTS_NEG GDP_GROWTH_POS GDP_GROWTH_NEG EXCRATE_POS EXCRATE_NEG
Fixed regressors: C @TREND

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
INFLATION(-1)	0.762939	0.048673	15.67464	0.0000
IMPORTS_POS	-0.223703	0.041555	-5.383340	0.0000
IMPORTS_NEG	-0.090576	0.069836	-1.296983	0.1978
GDP_GROWTH_POS	1.156143	0.228475	5.060264	0.0000
GDP_GROWTH_NEG	0.955416	0.155588	6.140667	0.0000
EXCRATE_POS	0.007213	0.314558	0.022930	0.9818
EXCRATE_NEG	-0.303619	0.188922	-1.607115	0.1114
C	1.072213	0.221965	4.830550	0.0000
@TREND	0.003290	0.004957	0.663704	0.5085

R-squared	0.923999	Mean dependent var	4.498538
Adjusted R-squared	0.917461	S.D. dependent var	0.089871
S.E. of regression	0.025820	Akaike info criterion	-4.391275
Sum squared resid	0.061998	Schwarz criterion	-4.159660
Log likelihood	232.9550	Hannan-Quinn criter.	-4.297486
F-statistic	141.3335	Durbin-Watson stat	1.872356
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection.

Appendix 8: ECM Regression & Short run

ECM Regression
Case 5: Unrestricted Constant and Unrestricted Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.072213	0.137927	7.773774	0.0000
@TREND	0.003290	0.000429	7.664575	0.0000
CointEq(-1)*	-0.237061	0.030379	-7.803588	0.0000

Short run

IMPORTS_POS	-0.943649	0.216459	-4.359486	0.0000
IMPORTS_NEG	-0.382077	0.325516	-1.173761	0.2435
GDP_GROWTH_POS	4.876977	1.117737	4.363259	0.0000
GDP_GROWTH_NEG	4.030248	0.883975	4.559234	0.0000
EXCRATE_POS	0.030426	1.328364	0.022905	0.9818
EXCRATE_NEG	-1.280761	0.802469	-1.596026	0.1139

Appendix 9: Wald Test

Wald Test:
Equation: NARDL

Test Statistic	Value	df	Probability
t-statistic	-1.594704	93	0.1142
F-statistic	2.543081	(1, 93)	0.1142
Chi-square	2.543081	1	0.1108

Null Hypothesis: C(2)=C(3)
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(2) - C(3)	-0.133127	0.083481

Restrictions are linear in coefficients.

C (2) *IMPORTS_POS + C (3) *IMPORTS_NEG

Wald Test:
Equation: NARDL

Test Statistic	Value	df	Probability
t-statistic	1.192675	93	0.2360
F-statistic	1.422473	(1, 93)	0.2360
Chi-square	1.422473	1	0.2330

Null Hypothesis: C(4)=C(5)
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(4) - C(5)	0.200727	0.168300

Restrictions are linear in coefficients.

C (4) *GDP_GROWTH_POS + C (5) *GDP_GROWTH_NEG

Wald Test:
Equation: NARDL

Test Statistic	Value	df	Probability
t-statistic	-4.397058	93	0.0000
F-statistic	19.33412	(1, 93)	0.0000
Chi-square	19.33412	1	0.0000

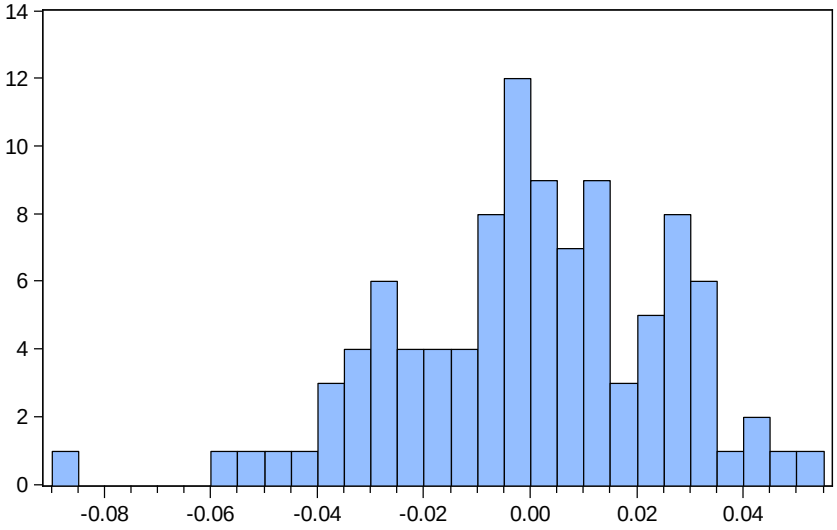
Null Hypothesis: C(7)=C(8)
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(7) - C(8)	-1.375832	0.312898

Restrictions are linear in coefficients.

EXCRATE_POS + C (7) *EXCRATE_NEG + C (8)

Appendixes 10: Normality test



Series: Residuals	
Sample 2015M02 2023M07	
Observations 102	
Mean	6.69e-16
Median	0.000425
Maximum	0.051677
Minimum	-0.085423
Std. Dev.	0.024776
Skewness	-0.479671
Kurtosis	3.420725
Jarque-Bera	4.663720
Probability	0.097115

Appendix 11: Serial Correlation

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.159610	Prob. F(2,91)	0.8527
Obs*R-squared	0.356557	Prob. Chi-Square(2)	0.8367

Appendix 12: Heteroscedasticity

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.110912	Prob. F(8,93)	0.3632
Obs*R-squared	8.897125	Prob. Chi-Square(8)	0.3510
Scaled explained SS	8.952221	Prob. Chi-Square(8)	0.3463