Symmetric and asymmetric exchange rate pass-through in South Africa: The role of nominal rigidities and exchange rate volatility

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ABSTRACT

The goal of attaining low inflation levels and price stability has led many countries to adopt inflation-targeting policy frameworks. Through its monetary authorities, South Africa implemented an Inflation-Targeting policy in 2000 to monitor and, where necessary, influence the factors affecting inflation using short-term monetary policy tools. The aim of this study was to (1) measure the degree of exchange rate pass-through to both import and consumer prices, (2) examine the existence of asymmetric exchange rate pass-through to import and consumer prices between appreciation and depreciation episodes, and (3) examine the extend to which exchange rate volatility impact on inflation in South Africa. The study used a multi-model approach. The auto-regressive distributed lag (ARDL) approach was used to analyse the exchange rate pass-through (ERPT) to both import and consumer prices. The Vector Error Correction Model (VECM) was employed to analyse the short and long-run pass-through effects of exchange rate changes on domestic prices (import and consumer). Using Quarterly data from 1980Q1 to 2019Q4, the study concluded that ERPT was incomplete in South Africa. The ARDL results show a significant positive exchange rate pass-through to import prices of 42 percent and a positive but insignificant exchange rate pass-through to inflation of 31 percent. This implies that firms absorb some of the exchange rate changes to maintain market share. A Hybrid New Keynesian Phillips-Augmented Expectation (HNKPC) equation showed that Inflation Inertia as well as inflation expectations significantly impacted on current inflation. The study recommends continuation of the current policy of flexible exchange rate. However, there is need to take measures to dampen inflation-expectations by economic agents through Inflation-Targeting policy . The Asymmetry model showed that pass-through to import prices in South Africa was higher during appreciation (47percent) than during depreciation (41 percent), indicating the existence of asymmetric pass-through.

Generally, the incomplete and low exchange rate pass-through supported the Local Currency Pricing (LCP) strategy by firms that import rather than the Producer Currency Pricing (PCP) strategy. In a flexible exchange rate environment, the PCP strategy results in a complete exchange rate pass-through since prices would reflect any exchange rate changes one-on-one. In the inflation model, the Inflation-Targeting dummy revealed a low and insiginifcant exchange rate pass-through. This suggests that firms engaging in Pricing-to-Market behaviour undermined the monetary policy. The Regime-Switching model was used to evaluate how import price evolves as exchange rate regimes were increased using suitable thresholds. The result was that as exchange rate bands increase, other factors like local cost of production have a higher and more significant impact on import prices. This effectively means progressive significance of local cost of production in the determination of import prices. Policy recommendations include maintaining the current inflation-targeting policy as the econometric results show its efficiency in reducing inflation in a significant way as shown by the HNKPC results. The implementation of a managed float exchange rate regime with smaller bands to avoid large exchange rate swings that have asymmetrical effects on import and consumer prices is also recommended.

Key Words: *Exchange Rate Pass-Through, Regime-Switching, Asymmetric Pass-Through, Pricing-to-Market, Price-Rigidities.*

DECLARATION

I, the undersigned, **Amon Magwiro**, student number 31358462, hereby declare that the research work reported in this thesis is my own, except where otherwise indicated and acknowledged. The work is submitted for the degree of Doctor of Philosophy at the North-West University. This thesis has not been submitted, either in whole or in part, for a degree or diploma at any other university.

Date……21 June, 2023…….

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DECLARATION ON PLAGIARISM

I, Amon Magwiro, student number 31358462, hereby declare that I am fully aware of the North-West University's policy on plagiarism and I have taken every precaution to comply with these regulations.

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DECLARATION ON RESEARCH ETHICS

I, Amon Magwiro, student number 31358462, hereby declare that I am fully aware of the North West University's policy on Research Ethics and I have taken every precaution to comply with the regulations. I have obtained an ethical clearance certificate from the North West University's Research Ethics Committee and my reference number is NWU-00390-19-A4.

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I wish to state that all errors and omissions are mine.

DEDICATION

I dedicate this thesis work to my wife, Deizdaria Magwiro and my two daughters, Tsitsi and Anesu.

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ACRONYMS AND ABBREVIATIONS

AC	Autocorrelation
ADF	Augmented Dickey Fuller
AIC	Akaike Information Criteria
ANC	African National Council
ARDL	Autoregressive Distributed Lag (Model)
ARDL-MIDAS	Autoregressive Distributed Lag with Mixed Data Sampling (Model)
ARMA	Autoregressive Moving Average (Model)
BoP	Balance of Payment
BPM	Balanced-Portfolio Model
BQCT	Binding-Quantity-Constraint Theory
BRICS	Brazil, Russia, India, China & South Africa
BVAR	Bayesian Vector Autoregression
CA	Current Account
CES	Constant Elasticity of Substitution
CGE	Computable General Equilibrium
CF	Correction Factor
CIAM	Cash-in-Advance Model
CIS	Commonwealth of Independent States
CPI	Consumer Price Index
CUSUM	Cumulative Sum of Recursive Residuals
DCC	Decimal Coinage Commission
DCs	Developing Countries
DW	Durbin Watson
EC	Error Correction
ECM	Error Correction Model
EM	Emerging Markets
EME	Emerging Market Economies
ERPT	Exchange Rate Pass-Through
ERS	Elliot-Rothenberg-Stock
ESE	Expenditure-Switching Effect

FA	Financial Account
FDI	Foreign Direct Investment
FMLS	Fully Modified Least Squares
FOB	Free on Board
FOC	First Order Condition
GDP	Gross Domestic Product
GFC	Global Financial Crisis
GIR	Gross International Reserves
GLS	Generalised Least Squares
GMM	Generalised Methods of Moments
HPST	Hodrick-Prescot Smoothing Technique
HQC	Hannan-Quinn Criterion
ICV	International Currency Vehicle
IFC	International Financial Corporation
IFS	International Financial Statistics
IMF	International Monetary Fund
IRF	Impulse Response Function
ITD	Impossible Trinity Dilemma
KD	Kernel Density
KPSS	Kwiatkowski, Phillips, Schmidt & Shin
LCP	Local Currency Pricing
LOOP	Law of One Price
MCMC	Markov-Chain-Monte-Carlo
MCT	Menu Cost Theory
MPC	Monetary Policy Committee
NE	Nash Equilibrium
NEER	Nominal Effective Exchange Rate
NER	Nominal Exchange Rate
NKPC	New Keynesian Phillips-Curve
HNKPC	Hybrid New Keynesian Phillips-Curve
OECD	Organisation for Economic Co-operation and Development

OLS	Ordinary Least Squares
PCP	Producer Currency Pricing
PP	Phillips-Perron
PPI	Producer Price Index
PPP	Purchasing Power Parity
PT	Pass-Through
PTM	Pricing-to-Market
REER	Real Effective Exchange Rate
RESET	Regression Equation Specification Error Test
RSA	Republic of South Africa
RW	Random Walk
SA	South Africa
SADC	Southern African Development Community
SARB	South African Reserve Bank
SBIC	Schwartz Bayesian Information Criteria
SBVAR	Structural Bayesian Vector Autoregressive Model
SSA	Sub-Saharan Africa
TVC-VAR	Time-Varying Cointegrated Vector Autoregression
UAE	United Arab Emirates
UK	United Kingdom
UN	United Nations
USA	United States of America
VAR	Vector Auto Regression (Model)
VD	Variance Decomposition
VECM	Vector Error Correction Model
VIF	Variance Inflation Factor
WLOG	Without Loss of Generality
ZAR	Zuid Afrikaans Rand

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CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND TO THE STUDY

Exchange rate movements can have material impact on imports, consumer, and producer prices in the domestic market. The current and most recent exchange rate movements in South Africa make a compelling case to analyse the impact of exchange rate changes on domestic prices. One such recent study by Kabundi and Mlachila (2018) underscored the need to pay attention to the effects of exchange rate shocks on import and domestic prices. The other peripheral implication of the South African exchange rate volatility is the spill-over effects to the neighbouring countries and regions, such as the Southern African Development Community (SADC), and has the potential for macroeconomic crisis for all countries concerned (Qabhobho et al., 2020). According to the South African Reserve Bank (SARB) statistics of 2020, the average dollar-rand exchange rate for 2019 and 2020 were R14.45 and R16.47 to one dollar, respectively, showing about 13.97 percent depreciation in the value of the Rand. The question one would ask is whether the local consumer prices respond to the changes in the exchange rate and, if so, to what degree. The SARB statistics of 2019 recorded a Consumer Price Index change (core CPI) for January to be 4.1 percent, while the average for 2020 was 3.3 percent representing a 0.8 percentage point drop or a 19.5 percent downward change in CPI. The 19.5 percent downward change in CPI is far less than the upward change in the exchange rate (13.97 percent). This implies an incomplete and opposite effect of the exchange rate transmission to prices. By definition, exchange rate pass-through measures the elasticity of domestic currency import/consumer prices to changes in the exchange rate (Mirdala, 2015; Takhtamanova, 2010b). If the impact of the exchange rate change is not 100 percent, then it is partial[1] or incomplete. Such incomplete exchange rate pass-through (ERPT) has implications for economic policy. Typically a Central Bank whose mandate is to stabilise inflation uses tools such as interest rates, exchange rate, and reserve ratio. The monetary policy's success in stabilizing inflation would depend on how responsive inflation is to changes in the underlying tool. If, for example, the Central Bank decides to use the exchange rate (assuming it runs a managed float), inflation is expected to respond sufficiently to desired levels. If the ERPT is very low, the monetary policy becomes ineffective in controlling inflation. In the event of a shock in demand in the economy, the central bank may be forced to

[1] The problem with partial or incomplete ERPT is its implication for transmitting economic shocks (Betts & Devereux, 2000). On the contrary, though, low ERPT gives the authorities peace of mind in the knowledge that any exchange rate changes will not be inflationary (Ghosh and Rajan, 2007)

respond aggressively, resulting in a possible macroeconomic disturbance such as a sudden increase in import and consumer prices (André and Espidio, 2022).

To elaborate the concept of pass-through, Mann (1986) used an equation that links changes in the Import Prices with changes in foreign cost of production, changes in foreign profit margins, and changes in the exchange rate. If foreign costs are constant and foreign profit margins adjust to offset some exchange rate changes, then the exchange rate pass-through would be less than 100 percent. On the other hand, if foreign costs change, profit margins may change and buffer the final effect on the import price. It would be naïve, however, to conclude that the factors of the exchange rate pass-through are all included in the variables explained by Mann (1986). Many other critical factors also affect the pass-through's direction and speed.

It is essential that as the study discusses the South African background, there is also the need to briefly discuss the experiences of other economies for comparative purposes. In the 1990s, most industrialised economies, such as the United States of America (USA), and some European countries, such as the United Kingdom (UK), experienced sustained low inflation rates despite the expanding economies and rising economic activities. Historically, the pass-through (PT) to consumer prices has always been lower than the PT to import prices. Goldberg and Campa (2010) reported that Australia's ERPT to import prices was 0.67 (67 percent) versus ERPT to consumer prices of 0.09 (9 percent). For Canada, it was 0.65 versus -0.01, France was 0.98 versus 0.48, the UK was 0.46 versus -0.11, and the USA was 0.42 versus 0.01. Bussière et al. (2014) found the degree of pass-through to import prices for Brazil and Thailand was 0.84, for Venezuela, 0.20, and 0.65 for Mexico in the long run. The results of low PT to consumer prices in an environment of currency depreciation contradict the standard economic paradigm (Mccarthy, 2007). This phenomenon resulted in many economists, such as Campa and Goldberg (2003), studying the special factors influencing low inflation rates. In the undertaking, they discovered the special role of the exchange rate and import prices.

In the case of South Africa, a few studies the researcher is aware of have focused on exchange rate pass-through. Some of the few studies are by Parsley (2012), Karoro et al. (2009), and Kabundi and Mbelu (2016). The Rand in South Africa has not been stable for some time. There has been persistent depreciation of the Rand between 2011 to 2013, and during this period, there have not been significant increases in inflation (Jooste and Jhaveri, 2014). According to Jooste et al. (2014), the low pass-through in South Africa may have been caused by economic cycles, changing monetary policy objectives, and the composition of imports. The study also suggested that the price elasticity

of demand for imported goods is a factor to consider when analysing the degree of exchange rate pass-through. Aron et al. (2014) estimated the degree of exchange rate pass-through to imports for South Africa using a time-varying cointegration approach. The study criticises previous studies as the data lacks sufficient structural breaks showing pass-through degrees in the short, medium, and long term. Like the other studies, Aron et al. (2014) also found incomplete pass-through of about 30 percent for the short-term and 55 percent in the long-term. Using cross-country analysis, Bussière et al. (2014) found a long-run exchange rate elasticity to import prices for South Africa to be 0.5, thereby confirming other results by other scholars. A similar research outcome was obtained from a study by Ndou (2021), where the exchange rate pass-through to prices in South Africa was higher in the long-run than in the short-run.

An important study by Kabundi and Mbelu (2016) focused on indirect ERPT to consumer prices using a two-stage regression analysis. The first stage ERPT examined the effect of the exchange rate changes on Import Prices, and then the second stage ERPT to consumer prices. Their findings were that there was ERPT asymmetry to import and consumer prices. The paper cited that the magnitude of the pass-through was higher to import prices than consumer prices suggesting that traders were absorbing some of the exchange rate changes' effects on prices, perhaps due to pricing-to-market strategies.

Parsley (2012) estimated the ERPT for South Africa using samples of final goods and services and homogenous imports. The study found a 16 percent ERPT to consumer goods with a lag of two years. Parsley (2012) found a higher ERPT to import prices of about 60 percent, again showing that traders are unwilling to pass the 100 percent exchange rate transmission to consumer prices. The reasons for low ERPT to consumer prices may be diverse, and one such reason could be the inflation-targeting policies adopted by the South African Reserve Bank.

The extent to which exchange rate changes and import prices influence domestic inflation is a source of concern for monetary policy. As an example, if inflation rates in the 1990s among industrialised economies were due to lower import prices and stable exchange rates, then any reversal in the policies that gave rise to this economic state of affairs would result in higher inflation rates that would reduce the purchasing power of consumers as well as increasing cost of production for producers.

It is important to understand how nominal exchange rate (NER) changes affect domestic prices to draft effective monetary policies that stabilise inflation. Hara, Kazuhiro, and Yoshitaka (2015) explain that exchange rate fluctuations affect prices through their impact on production costs (for

example, via prices of materials) and transport costs. This implies that exchange rate pass-through affects not only price stability but the firms' profitability and households' real incomes. To this end, therefore, exchange rate pass-through has ripple effects on firms, consumers, and policymakers.

The real exchange rate is important as a measure of price competitiveness and is a key determinant of the adjustment pattern of the Balance of Payments. Empirical evidence from many studies like the ones mentioned above has indicated that nominal exchange rate changes still need to be fully passed through to goods prices (Devereux, 2002). This means that consumer prices are, to some extent, unresponsive to nominal exchange rate changes. The low pass-through implies that the "Expenditure-Switching Effect" (ESE) of the exchange rate would be small, meaning that a change in the nominal exchange rate might not lead to much substitution between domestically- and internationally-produced goods due to minor or no change in the relative prices of those goods for final users.

The weak exchange rate effect on prices may result in no change in the behaviour of the final purchasers of goods. This means that a considerable change in the exchange rate would be required to achieve equilibrium after some shocks to the economic fundamentals. For example, if a shock reduces the supply of foreign goods, a substantial home depreciation might be required to raise the relative price of foreign goods enough to reduce home demand sufficiently. To this end, low pass-through of exchange rates might imply high exchange rate volatility. The high volatility of real and nominal exchange rates may be caused by local currency pricing that eliminates the pass-through from changes in exchange rates to consumer prices (Devereux, 2002). Gopinath et al. (2010) found strong evidence that nominal price rigidities result in low pass-through and hence the need to adjust prices frequently to respond to changes in the exchange rate. Frequent local price adjustments will ensure quick adjustment of fundamentals towards equilibrium if any shocks happen to the economy.

A country whose exported products show a 100 percent exchange rate pass-through on the international market is defined as price-competitive and has market power over other countries. This improves the welfare of its citizens through distribution effect. Wang and Gou (2016) indicate that if there is an asymmetry in exchange rate pass-through, then this leads to asymmetric welfare effects. The welfare level of a country whose local prices show less pass-through degree than others experiences higher welfare levels in a world Nash Equilibrium (NE). Wang and Gou (2016) further argue that foreign monetary policy depends on the degree of home exchange rate pass-through. Another study that shows reduced credibility in the face of low ERPT is by Peer et al. (2023) when the results indicated a compromise of monetary policy in India. The conduct of monetary policy affects the frequency of price adjustment and hence the degree of exchange rate pass-through.

There are many reasons why incomplete exchange rate pass-through to inflation was found in many economies. One 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 & Knetter, 1997).

Takhtamanova (2010) states that exchange rate fluctuations affect the behaviour of inflation in an economy. This observation makes the exchange rate pass-through an important consideration with respect to monetary policy. An effective monetary policy demands that the monetary authorities understand the transmission mechanisms. Adolfson (2001) pointed out that the exchange rate provides an additional transmission channel for monetary policy, apart from the conventional aggregate demand channel. Adolfson (2001) argues that the Consumer price inflation (CPI) is directly linked to changes in the exchange rate through its effect on import prices. The evidence available for both large and small open economies is that there are systematic deviations from the law of one price because of incomplete exchange rate pass-through for both export and import prices (Alexius and Vredin, 1999).

Import prices are important determinants of the performance of small open economies. The first thing is that changes in the prices of imports affect the terms of trade and, therefore the trade balance (Naug and Nymoen, 1996). The next thing to happen is that domestic firms face foreign competition and relative prices between imported and domestically produced goods. Consequently, they are prime determinants of manufacturing output and import volumes. Price inflation in small open economies is, to a large extent, affected by the growth in prices of imported goods. Inflation targeting policies in some countries consider import prices and also assume a complete exchange rate pass-through environment (Mccallum and Nelson, 1999)[2]. Many other studies, such as that by Adolfson (2001) and Naug et al. (1996), found that the law of one price does not hold for many countries. This means that import prices do not move immediately and one-to-one with the exchange rate. Exchange rate movements have a minor immediate effect on consumer prices due to nominal rigidities.

According to Choudhri and Hakura (2015), there is an asymmetry in the exchange rate pass-through between import and export prices. While the study found an incomplete pass-through to both import and export prices, the pass-through to import prices was consistently higher than the pass-through to export prices in many countries. Economists, the world over, have traditionally assumed that tradable

[2] While this paper allows for complete exchange rate pass-through, others like (Batini, Haldane and Haldane, 1999) and (Leitemo, 2002) obtained a limited and gradual pass-through via an Error Correction Mechanism (ECM) for the import prices, making them adjust slowly to fluctuations of the exchange rate.

goods' prices are equal across countries when expressed in the same currency; this is the purchasing power parity condition (PPP) (Ca' Zorzi et al., 2007).

Campa and Goldberg (2003) cited that exchange rate pass-through has been declining in many countries across the globe in recent years, especially in the short-run. In the long run, however, there are microeconomic price adjustments in specific industries, where there would be reasonable degree of exchange rate transmission to local prices. Taylor (2000) attributes the low exchange rate pass-through to low and stable inflation rate in many countries. This is because many countries adopt inflation-targeting policies that keep general prices constant despite exchange rate changes. A study in India by Peer and Baig (2023) found a high ERPT to consumer prices and therefore, the exchange rate was an efficient tool to combat inflation in the country. Correa and Minella (2010) considered a non-linear pass-through due to the activity level in the economy. Their study found that business cycles play a role in determining the exchange rate pass-through. When there is a boom in economic activities, the pass-through effect is higher than when there is a slump.

Some studies have examined whether there were any symmetric or asymmetric exchange rate changes to import prices in South Africa. Karoro et al. (2009) examined the magnitude and speed of exchange rate pass-through to import prices in South Africa. They also strove to establish the presence of asymmetric ERPT during depreciation and appreciation episodes. Their findings were that ERPT in South Africa was high but incomplete and that there was an asymmetric transmission of the exchange rate changes to import prices between local currency depreciation and appreciation episodes.

1.2 STATEMENT OF THE PROBLEM

The problem in South Africa has been the exchange rate volatility and inflation that moved out of the band targeted by the South African Reserve Bank (SARB). The Monetary Policy Committee (MPC) in South Africa adopted an explicit inflation–targeting policy in 2000 that ensures that the inflation rate remains within the 3- 6 percent band. In 2002 the inflation rate averaged 9.5 percent, 10.1 percent in 2008, 6.6 percent in 2016, and 6.87 percent in 2022 (IMF, 2022). Efforts to contain inflation to a single digit within the 3-6 percent band did not always produce the intended results. Therefore there is a compelling reason why other channels, such as exchange rate controls, are crucial to examine for economic agents such as individuals and corporate firms, exchange rate volatility presents itself as a business risk. Unanticipated depreciation causes an increase in the cost of procuring foreign intermediate goods used in production, leading to imported inflation in South Africa (Miyajima, 2019).

Similarly, the unanticipated appreciation of the Rand reduced international competitiveness of South African exports. In so doing, exchange rate volatility negatively impacted trade, capital flows, economic growth, inflation, and interest rate (Miyajima, 2019; Mukalayi, 2021). According to Miyajima (2019), the Global Financial Crisis (GFC) of 2008 and the removal of the minister of finance in South Africa in 2015 caused exchange rate volatility, which led to capital flight of around 15 percent of Gross Domestic Product (GDP). Using the Bayesian Vector Autoregressive Model, Mukalayi (2021) showed that a one unit shock in the exchange rate volatility caused a temporary increase in inflation for a short period before reaching a steady-state level in South Africa. The increase in inflation was followed by a fall in consumption which ultimately led to a slight fall in Gross Domestic Product (GDP) growth rate. These stylised facts all point to the problem of exchange rate volatility in South Africa and, therefore, are worthy of investigation.

A secondary problem emerging from exchange rate volatility is an ineffective monetary policy. Monetary policies such as inflation-targeting may be compromised by exchange rate volatility. As represented by sudden shocks to the exchange rate, exchange rate volatility can influence other macroeconomic variables, such as inflation, by increasing the costs of imports necessary for domestic production. Kara and Dede (2023) study found a positive and significant relationship between exchange rate volatility and domestic prices in Turkey, showing a compromise of the Inflation-Targeting policy in the country. One of the macroeconomic objectives in South Africa is to achieve stable prices, which could be done using various instruments such as the exchange rate and the interest rate. When there is high inflation, the central bank can use sterilised foreign exchange intervention policy to smoothen the exchange rate and ultimately dampen inflationary pressures. This is only possible if prices respond to exchange rate changes. Devereux and Yetman (2014) suggest that if the exchange rate pass-through is too small, then stabilisation of prices through exchange rate sterilisation may not produce the intended results. The primary focus of this thesis is to measure and ascertain the impact of exchange rate changes on domestic prices, as high inflation levels have the potential to affect export earnings negatively

Literature suggests that exchange rate pass-through during low inflation period is subdued and therefore it would be interesting to assess the impact of exchange rate changes on domestic prices in South Africa before and after the adoption of the inflation targeting policy. A study on Emerging Economies (EE) by Lamia and Djelassi (2017) indicated that in those countries that adopted Inflation-Targeting policy the ERPT was found to be low. This confirms the assertion that ERPT is

usually low in economies with low inflation. The outcome of this research extends and deepens the available literature on exchange rate pass-through. It also contributes to interrogating whether inflation targeting policy is necessary for an environment with low exchange rate pass-through. Pursuant to this research agenda, the outcome of this study can be used to interrogate whether to maintain a current exchange rate regime or suggest another possible exchange rate regime that would also keep inflation levels down.

Aron et al. (2014) point out that South Africa undertook trade liberalisation measures in early 1995 and later adopted a unitary floating exchange rate regime under an inflation-targeting framework in 2000. The problem with a floating exchange rate and an open trade policy is that a country loses the power to insulate its own economy from external economic shocks. South Africa pursues a flexible exchange rate regime, and the result is that its exchange rate swings such as the one witnessed in 2008, which caused the inflation rate to rise from a single digit within the 3 to 6 percent band to 11.5 percent (Karoro et al. 2009). Exchange rate volatility creates uncertainty and increases the trading cost for firms (Palley, 2003). Exchange rate fluctuations affect an economy through various channels such as its impact on imports, exports and capital flows (Parsley, 2012).

The price stability objective is crucial for a country like South Africa (SA) that has adopted an inflation targeting policy. According to Mccarthy (2007), an exchange rate shock weakens the role of demand management policies by compromising the conduct of monetary policy and creating uncertainty regarding its impact on domestic prices.

In South Africa, there are difficulties in correcting macroeconomic disequilibria because of low ERPT to consumer prices compared to the effect on import prices. As advised by Adolfson (2001), low ERPT normally causes volatility in the exchange rate, especially when price stickiness is exogenous. If there is a need for price adjustment, a large change in the exchange rate would be needed. Consumer prices, fundamentally, should respond to changes in the exchange rate. The adoption of the inflation targeting framework in 2000 saw the South African Reserve Bank (SARB) allowing the Rand to fluctuate with no interventions, and this meant that the central bank did not have control over the impact of exchange rate changes on inflation outcomes (Kabundi and Mlachila, 2018). Therefore, it is essential to understand the exchange rate pass-through mechanism so that policymakers can make informed decisions regarding monetary policy and international competitiveness. Accordingly, the results of this thesis contribute, in addition to policy

recommendations, to the available knowledge on exchange rate dynamics in South Africa in two ways.

Firstly, previous studies such as Maduku et al. (2015), Sanusi (2010), and Karoro et al. (2009) used a Structural Vector Autoregressive model (SVAR) to study the ERPT in South Africa but neglected important variables such as the output and financial gap. Secondly, to the best of my knowledge, this is the first to use a threshold regression analysis that captures the response of prices at different exchange rate ranges for optimal policy purposes. This eclectic approach also serves as a robustness check besides broadening the scope of econometric analysis. Accordingly, the findings are more robust and better reflect the dynamics of exchange rate pass-through effects on import and consumer prices in South Africa.

1.3 RESEARCH QUESTIONS

The main research question addressed in this study is the extent to which ERPT affects some key macroeconomic fundamentals in South Africa. This broad question can be answered by addressing the following sub-questions:

1. What is the degree of exchange rate pass-through to import and consumer prices in South Africa?

2. Is there any asymmetry in the ERPT between periods of depreciation and appreciation of the South African Rand?

3. Is current inflation significantly driven by the inflation momentum and inflation expectations in South Africa?

1.4 RESEARCH AIM AND OBJECTIVES

The study aims to investigate the extent to which ERPT affects import prices and consumer prices in South Africa. The study also strives to establish whether there is asymmetry in the exchange rate pass-through between depreciation and appreciation episodes.

The specific objectives are designed to

1. Measure the degree of transmission of exchange rate changes to import and consumer prices and the speed of adjustment in the event of a system disequilibrium.
2. Examine the existence of asymmetric exchange rate pass-through to import and consumer prices between appreciation and depreciation episodes.
3. Measure the level of exchange rate volatility on inflation in South Africa.
4. To make policy recommendations

1.5 NULL HYPOTHESES OF THE STUDY

1. H_0 : The Exchange Rate Pass-Through to import and consumer prices is incomplete (i.e. less than 100 percent).

2. H_0 : There is symmetry of ERPT between episodes of depreciation and appreciation.

3. H_0: Current Inflation is significantly driven by inflation momentum and expectations.

1.6 SIGNIFICANCE OF THE STUDY

Before implementing the inflation targeting policy in South Africa, there have been inflation levels beyond one digit and unstable (Karoro et al., 2009). When the inflation targeting policy was adopted in 2000, the annual average inflation became 6 percent for the post-policy period compared to an annual average of about 9.4 percent before the policy (Ocran, 2010). There were some instances where the inflation rate reached 2-digits in the inflation-targeting period, suggesting that other factors had influenced the inflation rate (Maduku and Kaseeram, 2018). The need to unravel those other factors likely to include exchange rate changes motivated this study. Before the inflation targeting policy implementation, there was a steady decrease in the inflation rate, suggesting the effect of the exchange rate changes with inflation. The fact that exchange rate movements can influence inflation begs the question of whether there was a need for inflation targeting policy in the first place. Otherwise, managing exchange rates would be sufficient to stabilise prices. A study by Karoro et al. (2009), as well as Maduku and Kaseeram (2018), showed a low ERPT that accompanied low inflation levels in South Africa, and this shows that even though the inflation targeting policy could be credited with low inflation, there are other dynamics at play coming out of the exchange rate changes.

The study of ERPT is important for policymakers as the success of either monetary or fiscal policy depends on whether there is sufficient transmission of the exchange rate changes to consumer prices. When ERPT is incomplete, especially small, it eventually triggers an exchange rate shock that ultimately increases inflation in the economy, as cited by Adolfson (2001a). This study is designed to suggest policies that could be instituted to avoid inflationary outcomes and address the problems of agents substituting local currency for foreign money because of low pass-through.

The existence of asymmetric exchange rate pass-through would mean that economic agents in the country are affected differently, which has welfare implications (Amoah, 2017). This research focuses on identifying key household consumer goods affected by ERPT that are not symmetric. Knowing the degree to which exchange rate changes have on goods such as basic commodities like

sugar, maize meal, and cooking oil is crucial for policy that must be directed at cushioning the most vulnerable people in the country.

Having a clear understanding of the relationships between exchange rate changes and import and export prices is crucial for policy in South Africa. If there is low transmission of exchange rate changes to domestic prices, then volatility in the exchange rate may bring about a price change that results in an equilibrium between the goods and the money market. As McCarthy (2007) puts it, a shock in the exchange rate weakens the role of demand management policies as the conduct of monetary policy is compromised. This may result in price instability in the economy. Sound economic policies would then help prevent price instability in the country.

This research also discusses the possible consequences of both low and high ERPT to economic prices. It suggests possible policies to achieve equilibrium in the most important markets in the country and in the process, improve the livelihoods of the South African people. The kind of policies recommended should prevent a '*beggar-my-neighbour*' effect, as we know that our trading partners' worsening economic conditions may have a contagion effect on us.

The body of knowledge on the exchange rate pass-through cannot be said to be sufficient and exhaustive at the moment. Notable researchers in the area of ERPT in South Africa include Aron et al. (2014), Karoro et al. (2009), Jooste and Jhaveri (2014), Sanusi (2010), Maduku et al. (2015), Parsley and Farrell (2010) and Razafimahefa (2012) and a few others, showing that there is still room for further research and more contributions in the area of ERPT in the country. The fact is that it is a niche that is still being researched - meaning that there is room to improve both the methodology and estimation results. This study adds and extends the knowledge base in this niche area of exchange rate pass-through.

The reason for measuring ERPT is for economic planners to craft policies that would counter the adverse effects of low exchange rate transmission to domestic prices. Inaccurate measurement of the ERPT leads to implementing policies that may exacerbate the problems associated with low transmission of exchange rate change on prices. Previous researchers in the area have demonstrated significant strides. However, there is a need to keep looking for better ways to estimate the ERPT by identifying relevant factors and developing better forecasting models.

1.7 CONTRIBUTION OF THE STUDY

Previous researchers' models from South African data are good and relevant. However, more is needed to explain the exchange rate pass-through as potentially significant control variables were left out. Maduku et al. (2015), Sanusi (2010), and Karoro et al. (2009) used a SVAR to study the

ERPT in South Africa. The SVAR models did not include output and financial gap variables. Jooste and Jhaveri (2014) used time-varying VAR, which is an improvement on the Structural VAR, but it, too, did not include the financial gap which this study intends to include. The importance of the output gap is that when actual output is different from the projected level, it puts upward pressure on prices. Similarly, actual Foreign Direct Investment (FDI) may differ from the anticipated levels, which also affects prices.

One variable that has been overlooked in most studies is the Financial Gap. This study expects that including the financial gap would improve the ERPT results. The financial gap comes in different forms, and the definition needs to be more comprehensive. In the context of the pass-through studies, the term financial gap takes the form of the difference between the sum total of the domestic and Foreign Direct Investment (FDI) in South Africa and its long-run trend found by applying a Hodrick-Prescot Smoothening Technique[3] (HPST). The rationale behind using the financial gap variable is that in determining import prices we have several predictors, including the investment gap captured by the financial gap. Therefore, this study endeavours to use modified models and discuss other consequences of the misaligned or volatile exchange rates on prices (import and consumer) which tend to compromise the country's monetary policies. This study uses a multi-model approach that comprises ARDL, VECM, ARMA, Threshold Regression, and the HNKPC models in its analysis of the ERPT. Each model is intended for different econometric analyses, such as estimating the dynamic nature of relationships between the dependent variable and its regressors in the ARDL model and estimation of the short and long-run relationships using a VECM. The other approach, never before used in South Africa, is a threshold regression analysis that captures the response of prices at different exchange rate ranges for optimal policy purposes. This eclectic approach also serves as a robustness check besides broadening the scope of econometric analysis.

Reasons for incomplete exchange rate pass-through still need to be clarified. Hence there is a need to continue the search for more factors that affect the exchange rate change's transmission to prices. The vagueness comes from the fact that price-rigidities may be attributed to suppliers trying to maintain market share or to changing consumer tastes or expenditure-switching by consumers,

[3] **Hodrick-Prescott filter** The filter helps to separate the trend from the cyclical component of a scalar time series. The parameter λ is a positive number (quarterly data usually =1600) which penalizes variability in the growth component series, while the first part is the penalty to the cyclical component. The larger λ the smoother the trend component.

among other reasons. Some research papers attributed an incomplete ERPT degree to local pricing as well as mark-up adjustment in response to exchange rate changes. Choudhri and Hakura (2015) used the producer and local currency pricing as factors of exchange rate pass-through. This research adopts a strategy that decomposes the causes of the incomplete ERPT and focuses on inflation-targeting efforts by the South African Reserve Bank as a possible explanation for incomplete exchange rate pass-through.

The conduct of monetary policy affects the frequency of price adjustment and hence the degree of exchange rate pass-through (Devereux and Yetman, 2002). Inflation-targeting policies may be the source of price rigidities, and this has the effect of creating a *bubble* that falsely shields consumers. Many papers on exchange rate pass-through have yet to pay much attention to the role of nominal rigidities as a possible determinant of exchange rate pass-through but rather deal with hybrid models that explain ERPT such as a mix of producer currency and local currency pricing. Corsetti et al. (2008) and Goldberg and Tille (2008) advocated using a mix of PCP and LCP to explain ERPT. However, this recommendation was argued against by Bussiere and Peltonen (2008) who suggested the use of models of staggered prices as prices respond to a change in exchange rate with a lag. This research deals with such factors as price rigidities proxied by LCP and costs of price-adjustment as a vital and significant factor of ERPT. In doing so, the research further strengthens the focus on some of the undocumented but important factors that cause low ERPT.

1.8 ETHICAL CONSIDERATIONS

The study adheres to the ethical considerations (code of ethics) regarding research guidelines of North-West University. Data was obtained from secondary sources (specifically the SARB & IFS Databases) and as such no serious cases of unethical activities were expected. Notwithstanding the nature of data, the student applied for ethical clearance and was granted in 2019. However, extreme care is taken to avoid plagiarism and the study endeavours to acknowledge all sources.

1.9 STRUCTURE OF THE STUDY

Chapter 1 discussed the background to the study. Chapter 2 focuses on an overview of the exchange rate pass-through in South Africa. Chapter 3 surveys the theoretical and empirical literature relevant to this study before looking at Chapter 4, which discusses the methodology. Chapter 5 deals with the statistical and regression analyses before moving over to Chapter 6, which focuses on the discussion of results, summary of findings, policy recommendations and finally, conclusion.

CHAPTER TWO: OVERVIEW OF THE EXCHANGE RATE PASS-THROUGH IN SOUTH AFRICA

2.1 INTRODUCTION

South Africa is one of the BRICS countries whose currency, the Rand, is used as a currency of choice on international markets by the members in the group. It is traded in large volumes abroad by the Emerging Markets (EMs) and for this reason it is susceptible to both domestic and international financial shocks (Miyajima, 2019). The Rand plays the role of a shock absorber on financial markets and this is made possible as monetary authorities pursue a free-float exchange rate policy adopted by the South African Reserve Bank (SARB).

One of the central issues in international economics is the exchange rate pass-through that is crucial for optimal monetary policy. Sahminan (2005) outlines two major reasons for the growing interest in exchange rate pass-through. One is the implications that the ERPT has on optimal monetary policy and international macroeconomic transmission mechanism. The new open economy macroeconomic model acknowledges the welfare effects of monetary policy that depends on the degree of ERPT (Betts and Devereux, 2000; Pesenti and Cedric, 2000). The other reason for the interest in ERPT is that understanding the ERPT at industry level provides some insight on the international market power of that industry. This study, however, shall not concentrate on disaggregated ERPT in specific industries or sectors.

This chapter addresses objective number one (1) and presents an overview of the exchange rate changes on consumer and import prices in South Africa. The section gives a detailed overview of the ERPT to import and domestic prices in South Africa. The chapter also assesses the macroeconomic changes in terms of exchange rate regimes before and after democratic rule in South Africa. To this effect, therefore, there is a brief discussion of the genesis of exchange rate volatilities and its implications for Purchasing Power Parity and hence consumer prices in South Africa. This chapter, therefore, is important in terms of the stylised facts around ERPT to aggregate import and domestic prices in South Africa.

2.2 SOUTH AFRICAN EXCHANGE RATE REGIMES – PRE- DEMOCRACY AND POST-APARTHEID

South Africa has seen many exchange rate regimes since the 1960s and this is partly due to political instability and isolation during apartheid. These many changes bring with them a sense of political

and economic instability that cumulatively would affect the performance of macroeconomic policies (Mtonga, 2011). The exchange rate regimes in South Africa are summarized in Table 2.1.

Table 2. 1: Exchange rate regimes

Episode	Date	Exchange Rate regime
1	Feb 1961 –July 1971	Fixed Exchange Rate - rand pegged to British Pound
2	Aug 1971 – Nov 1971	Fixed Exchange Rate - rand pegged to US Dollar
3	Dec 1971 – Sept 1972	Fixed Exchange Rate - rand pegged to British Pound
4	Oct 1972 – May 1974	Fixed Exchange Rate - rand pegged to British Pound
5	Jun 1974 – May 1975	Crawling peg - rand fixed to a basket of currencies
6	Jun 1975 – May 1979	Fixed Exchange Rate - rand pegged to US Dollar
7	Jun 1979 – Jan 1983	Dual exchange rate : Crawling peg commercial rand & free floating financial Rand
8	Feb 1983 – Aug 1985	Unitary exchange rate: managed float rand
9	Sept 1985 – Feb 1995	Dual exchange rate : Crawling peg commercial rand & free floating financial Rand
10	Mar 1995 – Jan 2000	Unitary exchange rate: Managed float rand
11	Jan 2000 to present	Unitary exchange rate: Free floating Rand, with inflation-targeting framework

Source: Author's own compilation

Table 2.1 above shows that for the greater part of the 1960's through to 2000's the South African monetary authorities made use of many exchange rate regimes, presumably, in an attempt to respond and address the macroeconomic challenges of the time. It must be noted that during this period leading to the end of the 1990's South Africa was under sanctions and hence the kind of economic challenges it faced which were linked to Apartheid policies the Government pursued. It must be noticed, also, that the Rand was anchored on the United States dollar as well as on the British Pound and this makes the Rand more unstable. in the 1960s and 1970s the Rand was fixed at adjustable

parities with either the US Dollar or the British pound. The flip-flopping in the exchange rate regimes by the South African monetary authorities is of special interest for policy makers as exchange rate volatility is one of the determinants of inflation (Karoro, Aziakpono and Cattaneo, 2009).

2.3 TO PEG OR TO FLOAT ? – THE DILEMMA OF EXCHANGE RATE REGIME TRADE-OFFS

The consensus among scholars is that the choice of an exchange rate regime depends on the political and economic circumstances at the time (Edwards, 2006; Frankel, Parsley and Wei, 2012). Factors that lead to choice of regime include size and openness of a country to trade, financial flows, structure of exports, and the stage of financial development among others (Edwards, 2006). The final choice would depend on the weights assigned to these factors. Table 2.2 summarises the trade-offs that come with the various choices of exchange rate regimes.

Table 2. 2: Exchange Rate Regimes & Trade-offs

	Floating	**Intermediate**	**Soft Peg**	**Hard Peg**
Stability	Negative/Negative	Positive/Negative	Positive/Positive	Positive/ Positive
Misalignment	Positive/Negative	Positive/Positive	Positive/Negative	Positive / Positive
Vulnerability to currency crises	Positive/Positive	Positive/Positive	Negative/Negative	Negative/Negative
Vulnerability to shocks	Positive/Positive	Positive/Negative	Negative/Negative	Negative / Negative
Independence of Monetary Policy	Positive/ Positive	Positive/Negative	Negative/Negative	Negative/Negative

Negative = weakness of a regime & Positive = benefit of a regime

Source: Author's own compilation & Edwards, (2006).

2.4 ISSUES IN SELECTING EXCHANGE RATE REGIME

2.4.1 Policy activism in lightly managed exchange rate regime

The real and nominal exchange rate are endogenous variables determined by demand and supply. Episodic and *ad hoc* interventions in lightly managed regimes are a case of '*leaning against the wind*' in order to dampen excessive fluctuations (Edwards, 2006). In this situation the government does not vigorously interfere in the determination of exchange rate but only plays the role of oversight to ensure stability in the country.

2.4.2 Discipline and Credibility: Time-inconsistency problem

The debate during the Fixed Peg in the 1960s and 1970s was around the benefits that come along with the peg. The Floating regime was seen as providing maximum discretion for monetary policy. According to Edwards (2006), discretion is normally associated with the problem of time-inconsistency, especially when the government decides to exercise its discretion. The discretion may reverse the policy that could have been pronounced earlier and may result in either currency depreciation or higher inflation. To this end then, most scholars regard inflation as associated with floating the currency. The policy reversal by authorities shows a lack of discipline that ultimately destroys the credibility of the government. The debate around fixed peg in the 1970s has since changed due to international capital flows and most countries have now adopted a free exchange rate system.

2.4.3 Volatility and misalignment due to floating

At times floating regimes exhibit high short- term exchange rate volatility that are weakly related to some economic fundamentals at the time (Duarte and Stockman, 2002). With the deepening of the capital markets we find transactions dominating changes in exchange rates and in the process creating a misalignment between the exchange rate and the macroeconomic fundamentals.

2.4.4 Soft peg argument

Edwards (2006) defines a soft peg as the type of exchange rate regime applied to a currency to make it stable against a basket of currencies. Currencies with a soft peg occupy the ***middle of the road*** status, as they are halfway between those with a fixed or hard pegged exchange rate and those with a floating exchange rate regime. The soft peg regime can maintain a stable currency if they are initially pegged at a sustainable level consistent with economic fundamentals. The soft peg, however, does not hold firm in an environment with high international capital flows. This could be the reason why South Africa does not rely much on the soft peg since there are reasonably high capital flows as compared to its neighbours (Maduku, Contogiannis and Kaseeram, 2015). The intermediate peg is very close to the fixed peg and is similar to soft peg in as far as the territory in which they exist is concerned. The intermediate peg stays close to the fixed peg with only minor adjustments.

2.4.5 Monetary policy autonomy

A floating policy allows an economy to use its monetary policy to guide the country to prosperity. A nominal anchor is chosen in order to guide the policy towards achievement of certain macroeconomic goals. In the case of South Africa, the anchor is around achieving a single digit inflation rate using the inflation-targeting policy instituted in the year 2000.

2.4.6 Vulnerability to shocks under floating regime

Under a floating system, an economy can deflect or absorb impacts of adverse external and domestic shocks such as capital reversals and Balance of Payments (BoP) deficit. In the case of BoP deficit, the exchange rate can change automatically in such a way as to eliminate the disequilibrium. The vulnerability to external shocks were seen during the Covid-19 pandemic in South Africa where, due to increased demand for goods and services, the Rand became volatile (van der Westhuizen et al., 2022). However, not all countries saw local currency volatility during Covid-19 pandemic. Results from a study by Farayibi and van de (2020) in Nigeria showed insignificant impact of the pandemic on macroeconomic variables such as GDP and inflation. Another study that produced mixed results on the effect of the pandemic was that by Peer et al. (2023) when disaggregated data was used for the case of India.

2.5 FIXED EXCHANGE RATE AND IMPOSSIBILITY TRINITY

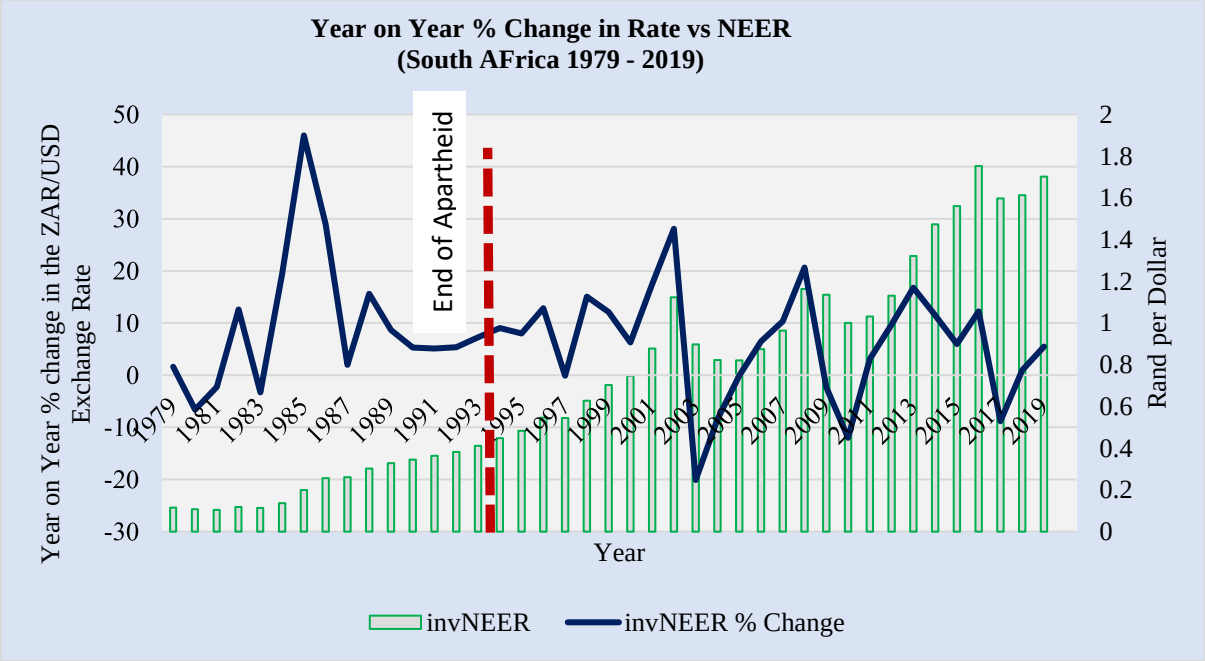
South Africa, like many other emerging markets ran a fixed exchange rate regime in the 1970s (Chiparawasha, 2015). The problem with fixed pegs is that countries with open trade policies get trapped in a monetary policy dilemma known as ***Impossibility Trinity*** (Edwards, 2006). The three objectives of exchange rate stability, free capital mobility and monetary policy autonomy cannot be achieved simultaneously (Yagci, 2001; Mtonga, 2011). South Africa adopted a floating exchange rate policy at the end of the 1970s and this meant loss of power to insulate the economy from external shocks. Failure to insulate against external and domestic shocks resulted in exchange rate volatility as well as increasing uncertainty in the economy and increasing trading costs for firms (Parsley and Farrell, 2010; Palley, 2003).

From 1983, quarter one, South Africa pursued a free-float exchange rate regime which allowed the Rand to be determined by market forces. Between 1985 and 1995 South Africa ran a dual exchange rate regime wherein the rand commercial rate was informed by the current account transactions and the rand financial rate was based on the capital account transactions (Eun et al., 2012). The empirical features, according to Eun and Lai (2012) were vastly different with the financial rate following a random walk (RW) process and the commercial rate was relatively stable. The experimental dual exchange rate allowed economists to answer some key exchange rate questions that include the origins of exchange rate volatilities and its effect on the Purchasing Power Parity as well as its implications on domestic prices of goods and services in South Africa.

The commercial exchange rate was linked to the macroeconomic fundamentals and the long-term PPP seemed to hold. The rising dominance of the international investments over trade worldwide

and South Africa in particular, gave birth to the flexible exchange rate, which is represented by a random walk process. The time-varying volatility of the financial rand exchange rate made it less predictable than its commercial rand exchange rate counterpart. This also led to failure of the PPP rule between South Africa and its major trading partner, the USA. The ARMA_GARCH model that was run by Eun and Lai (2012) showed that lagged values of the commercial exchange rate had more predictive power than the financial rate and therefore PPP would hold. Based on the discussion above, it can be concluded that the lessons from the dual exchange rate system in South Africa between 1985 to 1995 are that even in the absence of trade barriers, the long-run PPP fails if the investment flows dominate trade flows in currency transactions. It is the dominance of investment flows over trade flows that gives rise to the tenuous relationship between exchange rate and trade in South Africa. Figure 2.1 shows the exchange rate profile between South Africa and its major trading partner, the USA, from 1975 to 2015.

Figure 2. 1: Exchange Rate Profile



Source: Author's own computations using SARB data (2019)

As was alluded to earlier, the Rand traded at a rate of 1 rand to US$1.40 from 1961 to 1971 after which the South African Rand broke above parity with the dollar for the first time in March 1982. The Rand continued to trade between R 1 and R 1.30 to the dollar until June 1984, when depreciation of the currency gained momentum (Eun and Lai (2012). This downhill spiralling of the Rand against the US dollar forced the President of South Africa to make a Rubicon speech in 1985 and this helped the Rand to gain value as evident in Figure 2.1 (see the sharp fall in exchange rate change percentage

around 1985). The gain was, however, short-lived as the world realised that South Africa was not making the necessary political and economic reforms. The end of Apartheid did not stop the depreciation of the Rand immediately and this continued until around 2001 after which the Rand started to gain again.

Figure 2.1 above shows a precipitous slide of the Rand from 2003 until around 2008 and this could have been attributed to a number of factors. Some of the factors are South Africa's worsening Current Account (CA) at that time, a worsening Financial Account (FA) as well as global risk-aversion as investors took their investments to safer countries not associated with emerging-economies' risk profiles. Though there may have been brief moments of rand recovery, the depreciation momentum fired up by the problems faced by the electricity parastatal, Eskom, meant the Rand would continue to lose value against the *green back* all the way to 2015 and beyond. In short, therefore, the story of the South African Rand is characterised by volatilities from the 1970s to the present and therefore it is interesting to pursue studies on the effect of exchange rate volatilities on economic fundamentals in South Africa.

2.6 EXCHANGE RATE VOLATILITY IN SOUTH AFRICA

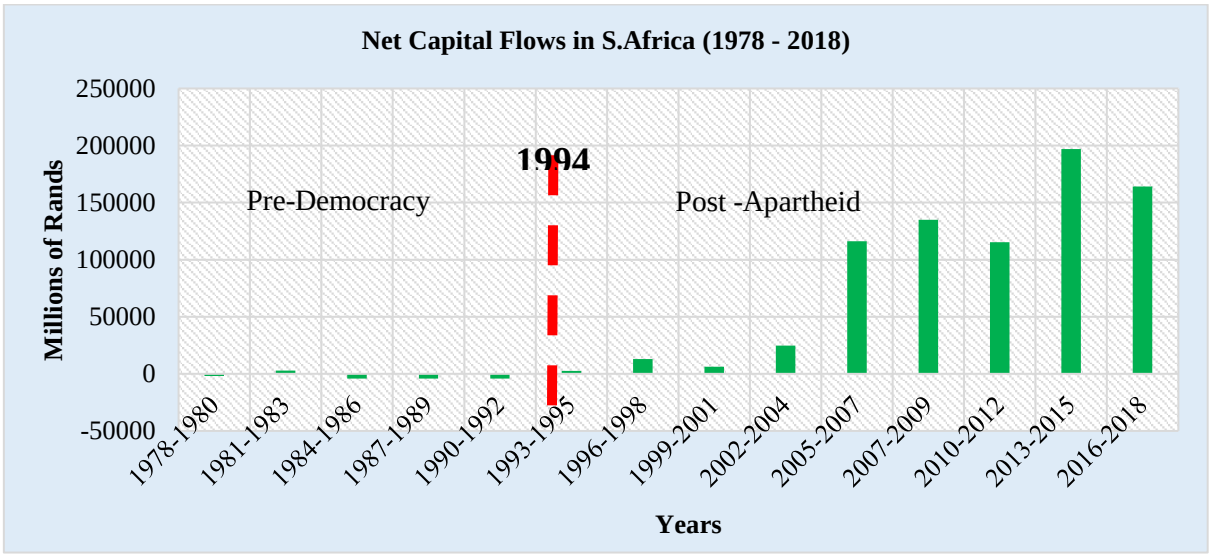
In recent times, the South African Rand has been volatile as it has been subjected to both domestic and external shocks (Miyajima, 2019). The volatility of the Rand happens because of the South African Reserve's free-float exchange rate regime. Furthermore, the role of the South African Rand is to act as a shock absorber as it is traded globally as a proxy for emerging market risks. In addition, there is a large volume of local assets in the hands of non-residents.

The volatility of the Rand may ultimately have implications for inflation in South Africa. Despite the volatility of the Rand, the pass-through of exchange rate depreciation or appreciation to inflation has been declining partly due to the increasing credibility of the central bank as well as its policies on targeting inflation (Miyajima, 2019).

2.7 STYLIZED FACTS ON RAND VOLATILITY

Capital flight in the mid-1980s resulted in large depreciation of the South African Rand and subsequent to that, a debt standstill. Capital flight, according to Mohamed et al. (2004), was estimated to have been worth between 15 to 20 percent of GDP in the early 1980s and up to 15 percent of GDP in the late 1990s. The debt-standstill (ceasing of debt repayment until restructuring agreement with creditors) in itself is an indicator of low business confidence and may result in further depreciation of the currency. Figure 2.2 shows the net capita flows in South Africa.

Figure 2. 2: Net Capital Flows in South Africa



Source: Author's own computations using SARB data (2019)

The period between 1981 and 1983 witnessed positive net capital inflows due to the high gold price on the international market and this is supported by the study by Karoro et al. (2009). The large capital inflows into South Africa in the early 1980s helped support the fixed exchange rate policy that South Africa adopted at the abandonment of the managed float policy in 1975. The price of gold on the international market fell and this significantly reduced the inflow of foreign currency into South Africa since gold was its main export product.

As mentioned by Karoro et al. (2009), there were other factors such as increased political instability, United Nations (UN) sanctions, immediate standstill of foreign debt repayment in 1985 as well as the fall in the price of gold that led to large capital flight from South Africa. This is shown by Figure 2.2 above with net negative capital inflows from 1984 to 1994. The graph above shows that capital flight halted in 1994 at the end of the apartheid system. The end of apartheid coincided with the policy of financial liberalisation in 1995. The same result was also observed by Mohamed et al., (2019) in their paper titled "Capital Flight from South Africa, 1980 -2000."

After the democratic election of 1994 there were large capital inflows spurred by the cessation of trade and financial sanctions as well as improvement in the creditworthiness of the new state (Elbadawi and Aron, 1999). Capital inflows were further improved because of the liberalisation of the capital account for foreigners. According to Elbadawi and Aron (1999), South Africa was included in key emerging markets indices such as the International Financial Corporation (IFC) emerging market index thereby increasing the investment inflows as shown in Figure 2.2.

Significant inflows started to be registered around the year 2002 as the graph above shows and this scenario continued throughout the period to 2018. This was made possible through the relief brought about by the multiracial democratic elections in South Africa accompanied by significant relaxation of the exchange controls (du Toit, 2009). The re-scheduling of the international debt repayments as well as removal of the financial Rand led to large capital inflows into South Africa.

Another reason for the shortage of foreign exchange for many developing countries (DCs), South Africa included, is that many export few primary goods that have low-income elasticities. On the other hand, these countries also import goods that have relatively high-income elasticities (Nell, 2000). The lack of foreign exchange reserves in many developing countries is one of the causes of the depreciation of their currencies. This subsequently causes a rise in import prices and inflation.

2.8 NOMINAL EFFECTIVE EXCHANGE RATE (NEER) VERSUS NOMINAL BILATERAL EXCHANGE RATE

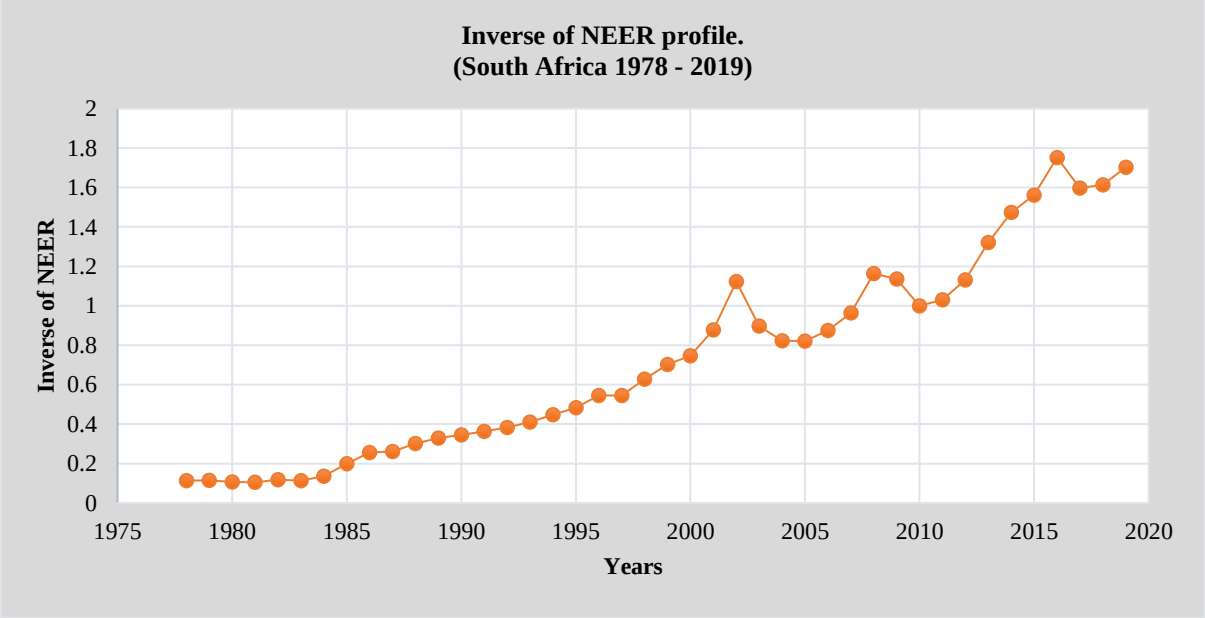
The Nominal Effective Exchange Rate in South Africa is an unadjusted weighted average rate at which a country's currency exchanges for a basket of multiple currencies (Sahminan, 2005; Maduku et al., 2015). The NEER usually represents a proxy for the bilateral exchange rate between a country's currency and the international vehicle currency (which is the US Dollar in this case). By way of calculation, the NEER is the geometric weighted average exchange rates of the main trading partners of South Africa which are the BRICS community, the USA, Germany, the UK and Japan (Maduku et al., 2015). According to Sahminan (2005), the choice between using the nominal currency unit per dollar (bilateral exchange rate with the US dollar) or the NEER depends on the invoicing of most of the international trade between the country and its trading partners. In this case, then, South Africa can either make use of NEER or the nominal bilateral exchange rate between the Rand and the dollar as its international trade is mostly invoiced in US dollars.

2.9 BILATERAL EXCHANGE RATE VERSUS THE NOMINAL EFFECTIVE EXCHANGE RATE (NEER)

The bilateral exchange rate between two currencies measures the strength of a local currency against the currency of another country. It (bilateral exchange rate) tells us the number of units of a local currency that are needed to buy one unit of another country's currency. If there is an increase in the number of local units required to purchase one unit of another currency, then that means depreciation of the local currency. The Nominal Effective Exchange Rate, on the other hand, gives us the unadjusted weighted average number of units of a currency basket required to purchase one unit of the local currency. It, therefore, means that when NEER increases, the local currency would have

appreciated against the basket of currencies of its trading partners. Following the approach by Karoro et al. (2009) and for ease of computation and avoidance of confusion between NEER and the nominal bilateral exchange rate (R/$ exchange rate), this study uses the inverse of NEER which can now be interpreted in the same way as the normal exchange rate. [4]The inverse NEER profile for South Africa is shown in Figure 2.3.

Figure 2. 3: Inverse NEER Profile for South Africa



Source: Author's own computations using SARB data (2019)

Note: *Inverse of NEER*[5] *was computed using figures from SARB (2019) meaning that an increase in inverse of NEER represents a depreciation of the Rand.*

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[4] The inverse of NEER is simply the reciprocal of NEER. The increase in the inverse of NEER means depreciation of the local currency.

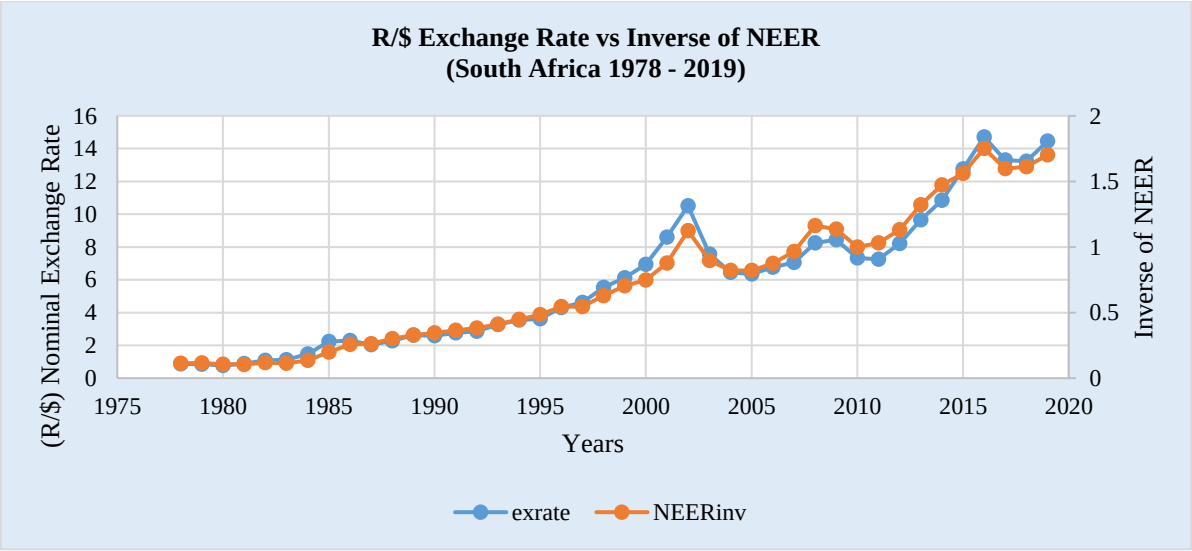
[5] By way of calculation $NEER = \prod_{i=1}^{n} \left(\frac{s_i}{s_i^*}\right)^{w_i}$ where;

n = number of countries (currencies) from a basket
s_i = exchange rate of the national currency against the currency of country i,
s_i^* = exchange rate of the national currency against the currency of a country i during the base period,
w_i = country's weight of the currency and that $\prod_{i=1}^{n} w_i = 1$

Nell (2000) states that exchange rate and rates of change remained stable due to the ability of the Reserve Bank of South Africa to maintain a fixed exchange rate system. The fixed peg in South Africa at the time was defended by the available foreign currency in the system as the price of gold was rising. This scenario is shown by the almost constant value of NEER from Figure 2.3 up to 1985 before the price of gold fell. The capital flight from South Africa between 1985 to about 2000 meant that there would be less foreign currency in the country and this resulted in the depreciation of the Rand as shown in the graph above. The depreciation coincided with capital outflows in South Africa. From around the year 2000 there has been a positive net inflow of capital into South Africa and this was accompanied by the appreciation of the Rand in South Africa as depicted in Figure 2.3. One would have expected an immediate appreciation of the Rand as positive net inflows actually stated just after the end of Apartheid in 1994. However, the depreciation of the Rand after 1994 in the face of rising capital inflows into the country could have been a case of a storm before calm as the Rand remained stable after 2002 to about 2011. The fact that there was a depreciation of the Rand after 2011 when the country continued to enjoy positive net capital inflows means that capital flow was not the only factor that influenced the behaviour and performance of the Rand. There were other factors as well. Apart from capital inflows into South Africa, the appreciation of the Rand around 2010 could be attributed to the large inflows of foreign currency into the country due to visitors who flocked in for the world soccer cup.

The Inverse NEER and the Rand - Dollar exchange rate profiles shown in Figure 2.4 behave as expected.

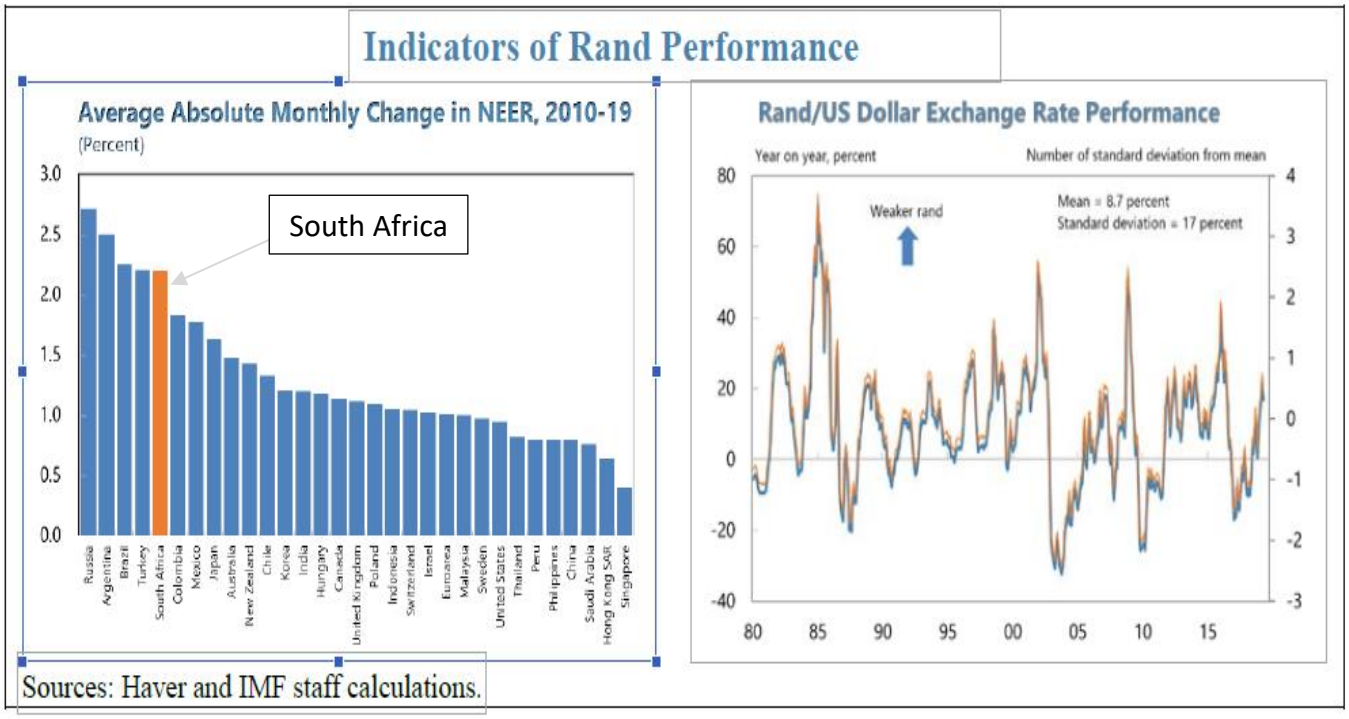
Figure 2. 4: Bilateral Exchange Rate vs Inverse NEER Profiles



Source: Author's own computations using SARB data (2019)

In a country such as South Africa where a free-float policy is in place as well as international trade invoicing in US dollars, it would be expected that the two exchange rates be closely related. In any case, the NEER rate is derived from the bilateral exchange rate between South Africa and the United States of America. As the Rand depreciates, it means that the value of the Rand against the weighted value of a currency basket falls. Indicators of the performance of the Rand are illustrated in Figure 2.5.

Figure 2. 5: Indicators of Rand Performance

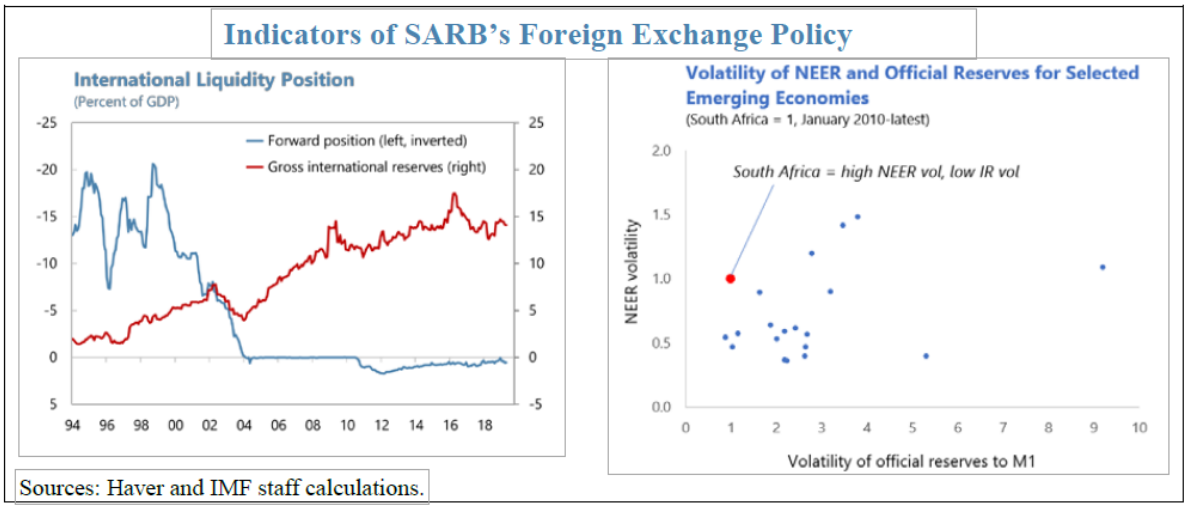


Source: Adapted from Haver and IMF staff calculations (January 2020, Country Report No. 20/34)

The exchange rate regime of maintaining some level of a fixed peg through a managed float means that one has to continuously defend it whenever it comes under attack. Figure 2.6 depicts what happens when the South African Reserve Bank (SARB) decides to defend the local currency by selling United States (US) dollars on the market. The Forward position (which can be described as the *short* position) is where the central bank depletes its stock of foreign currency by selling it in order to create an artificial demand for the local currency and in the 1990s up to about 20 percent of GDP was sold. Soon after the adoption of the inflation-targeting policy the selling of dollars declined and the reverse occurred. The central bank started to buy back the dollars in order to improve the international liquidity position as shown by a rising international reserve graph in Figure 2.5 on the left panel. The panel on the right hand side of Figure 2.5 compares South Africa with the rest of the selected emerging markets in terms of currency volatilities. The Rand is shown as being more volatile

in this case than other currencies of EMs. Again, in comparison to other EMs, South Africa has low International Reserves, which translates into short import-cover for the country. All these events mean that there would be either large depreciations or appreciations of the Rand and that has implications for the ERPT in the country.

Figure 2. 6: SARB Foreign Policy Indicators



Source: Adapted from Haver and IMF staff calculations (January 2020, Country Report No. 20/34)

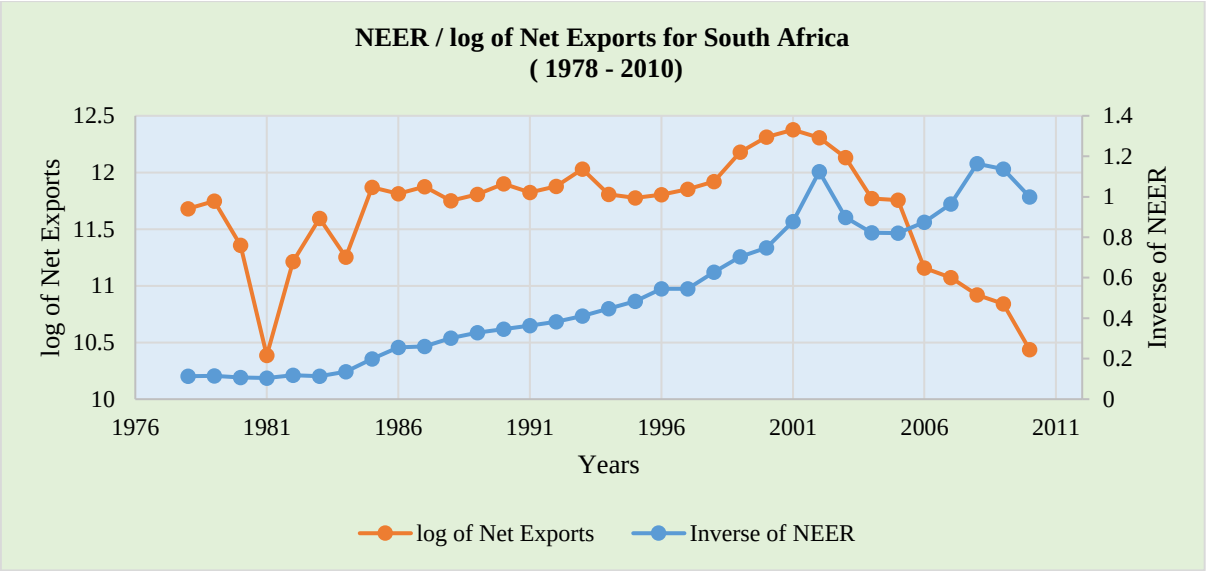
Figure 2.6 illustrates that the South African Gross International Reserves (GIR), as a percentage of GDP, have been increasing from 1994 to about 2016 before it slightly fell. The increase in International reserves bolstered the South African International liquidity position and therefore better prospects of importing essential imports. The right-hand side panel shows the relative position of South Africa in terms of the volatility of official reserves and Nominal Effective Exchange Rate (NEER). In comparison with other emerging economies South Africa's official reserves volatility was much lower and this was due to adequate international currencies in the country. The same, however, could not be said for the volatility of its NEER as it was relatively higher compared to a number of other emerging markets. This means that there were other factors that contributed to the volatility of the South African Rand despite the country having high levels of international reserves.

There are several factors that affect the volatility of the exchange rate. These factors include macroeconomic performance, political climate, economic status assigned by the rating agencies such as Moody's and Standard &Poor, fiscal policy and economic cycles (Jooste and Jhaveri, 2014).

2.10 NET EXPORTS AND RAND PERFORMANCE IN SOUTH AFRICA (1978 – 2010)

Having discussed the volatility of the Rand in the previous section, it is important and interesting to see the visual relationship between net exports of South Africa and the performance of the local currency. Figure 2.7 below illustrates the relationship.

Figure 2. 7: Exchange Rate & Net Exports Profiles



Source: Author's own computations using SARB data (2019)

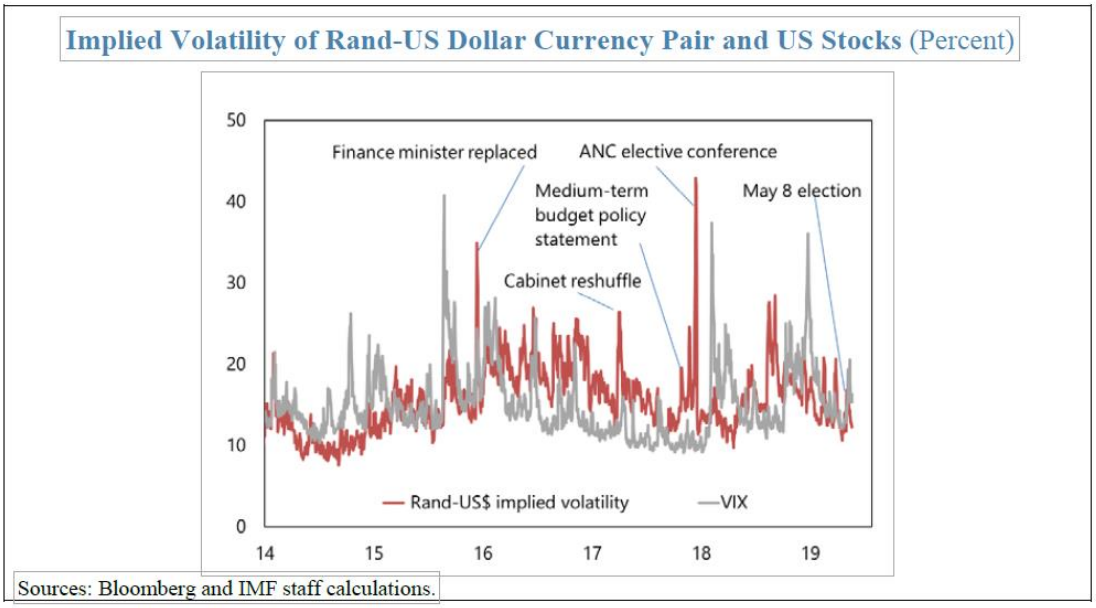
Note: *Inverse of NEER was computed using figures from SARB meaning that an increase in inverse of NEER represents a depreciation of the Rand.*

The log of net exports only existed up to 2010 as net exports beyond 2010 are negative and so their logarithms cannot be computed. The graph above tells a familiar story of the relationship between net exports and exchange rate. As the country's currency loses value against major currencies, exports tend to increase and imports fall resulting in positive net exports (Karoro, Aziakpono and Cattaneo, 2009). In the end, it is expected that the country will register an increase in foreign exchange inflows and ultimately improve the performance of the local currency.

2.11 POLITICAL FACTORS

Political uncertainty in South Africa may have played a part also in the volatility of the Rand. Figure 2.8 below illustrates the volatility of the Rand from 2014 to 2019.

Figure 2. 8: Bilateral Exchange Rate Volatility



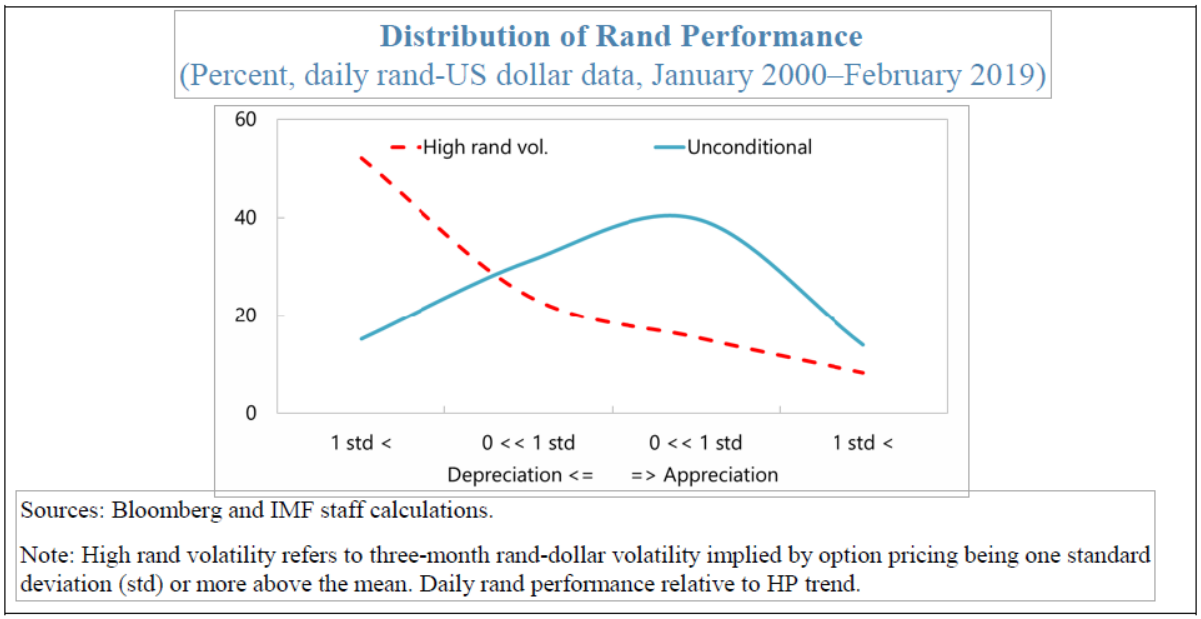
Source: Adapted from Bloomberg and IMF staff calculations (2020)

Figure 2.8 shows that political pronunciations have a huge and significant impact on the performance of the Rand against the USA dollar. The removal of the Minister of Finance and his replacement in 2015 caused serious uncertainty in the economy and this created a financial crisis in South Africa that resulted in the depreciation of the Rand. The medium-term budget statement, the cabinet reshuffle and the ANC elective conference including the May 8 elections of 2019 reinforced each other and the local currency took a negative knock against major international currency vehicles through the implied volatility.

2.12 CURRENCY VOLATILITY AND DEPRECIATION

According to Miyajima (2019), a high rand volatility is accompanied by rand depreciation. In Figure 2.9 below, we have the x-axis standing for rand performance as measured by the number of standard deviations from the historical average for South Africa from January 2000 to February 2019.

Figure 2. 9: Daily Rand Performance (January 2000 - February 2019)



Source: Adapted from Bloomberg and IMF staff calculations (2020)

In Figure 2.9, the extreme left represents large rand depreciation (i.e. large differences of more than one standard deviation from the perceived average). To the extreme right we have large rand appreciation, and in the middle, we have moderate depreciation and appreciation. The y-axis on the graph represents the percent share of total observations. The bell-shaped curve shows the distribution of the rand performance without conditioning rand volatility and depicts moderate depreciation and appreciation. The downward-sloping convex line shows the distribution of the rand performance only during volatility episodes. One can decipher that most observations of currency volatilities were accompanied by large depreciation whereas most observations in the absence of volatility-conditioning, there was moderate depreciation and appreciation. Very few cases without volatility showed extreme currency appreciation and depreciation.

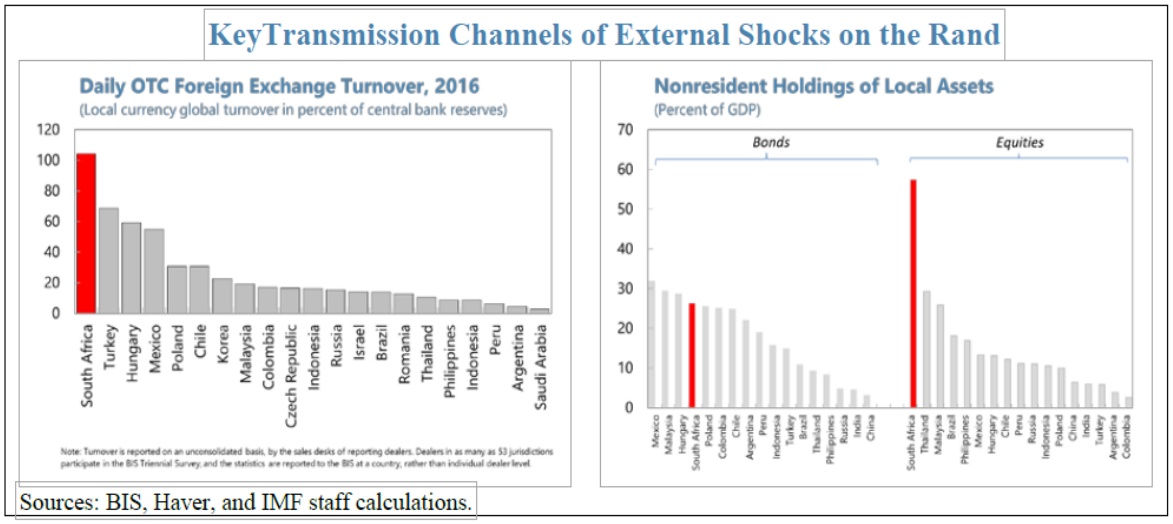
2.13 EXTERNAL FACTORS AND RAND PERFORMANCE

Externally, the Rand is affected through two channels. As alluded to earlier, the Rand is traded in large volumes globally because it is considered as a proxy currency by many EMs. This role makes the Rand susceptible to external shocks and must therefore act as some kind of financial shock absorber (Miyajima, 2019). Figure 2.10 below depicts that South Africa has the largest turnover of its local currency being traded globally as compared to other countries in the same league as itself. Among the 27 countries included in the International Financial Corporation Index, South Africa ranked highest in terms of stock exchange capitalisation in 1995. Its currency, therefore, was the most used for international settlements and this exposed the country to external shocks (Elbadawi

and Aron, 1999). This means that any shocks that affect markets globally would affect the South African Rand more than other currencies of the EMs countries.

Secondly, non-resident business people in South Africa hold local bonds and equities and these financial assets may be traded offshore resulting in the importation of external shocks that cause currency volatilities (see Figure 2.10).

Figure 2. 10: Key transmission channels of external shocks on Rand



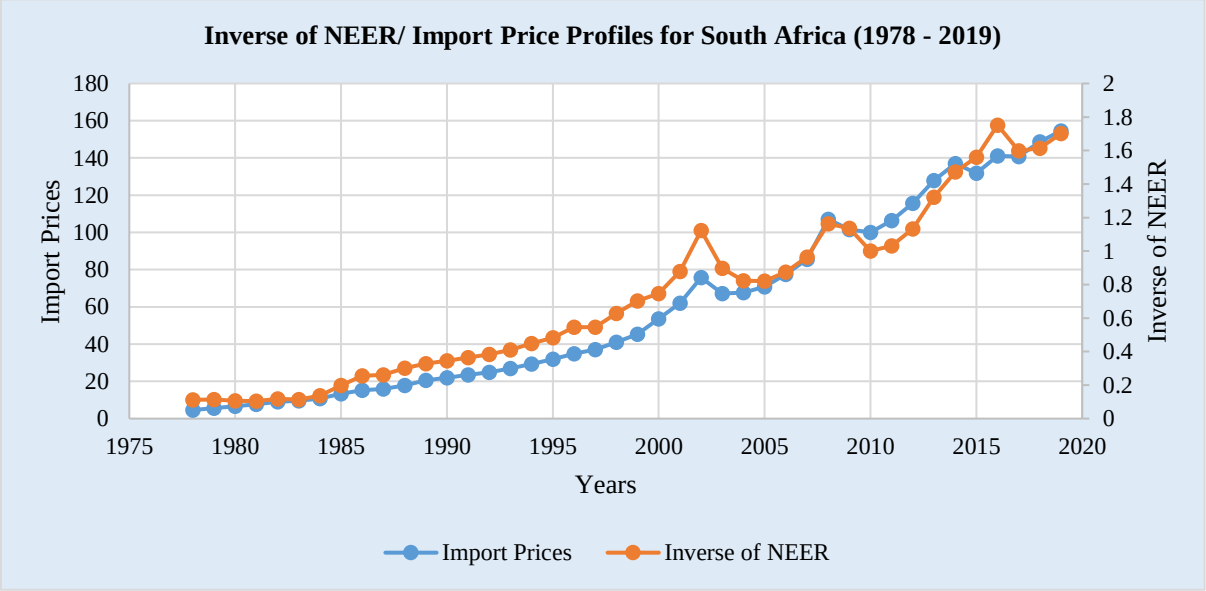
Source: Adapted from BIS, Haver and IMF staff calculations (2016)

The fact that many non-residents hold South African bonds and equities, which they later convert into foreign currency at a later stage, show the ease with which the South African Rand can be exchanged for other currencies. In addition to this, it might be that when the non-residents trade off the Rand on financial markets, it creates a situation where the Rand is seen to be weakening and therefore the possibility of economic agents substituting local currency for foreign currency as the Rand loses traction against major international currency vehicles that include the US dollar.

2.14 FIRST STAGE PASS-THROUGH (EXCHANGE RATE AND INFLATION IN SOUTH AFRICA: 1978 – 2019)

Maduku et al. (2015) points out that the measurement of the exchange rate pass-through normally proceeds in two stages. The first stage is the exchange rate pass-through to imports and the second one is the pass-through to consumer prices. Figure 2.11 below shows time profiles of the exchange rate and the import prices in South Africa over the period 1978 to 2019.

Figure 2. 11: Inverse NEER vs Import Price in South Africa



Source: Author's own computations using SARB data (2019)

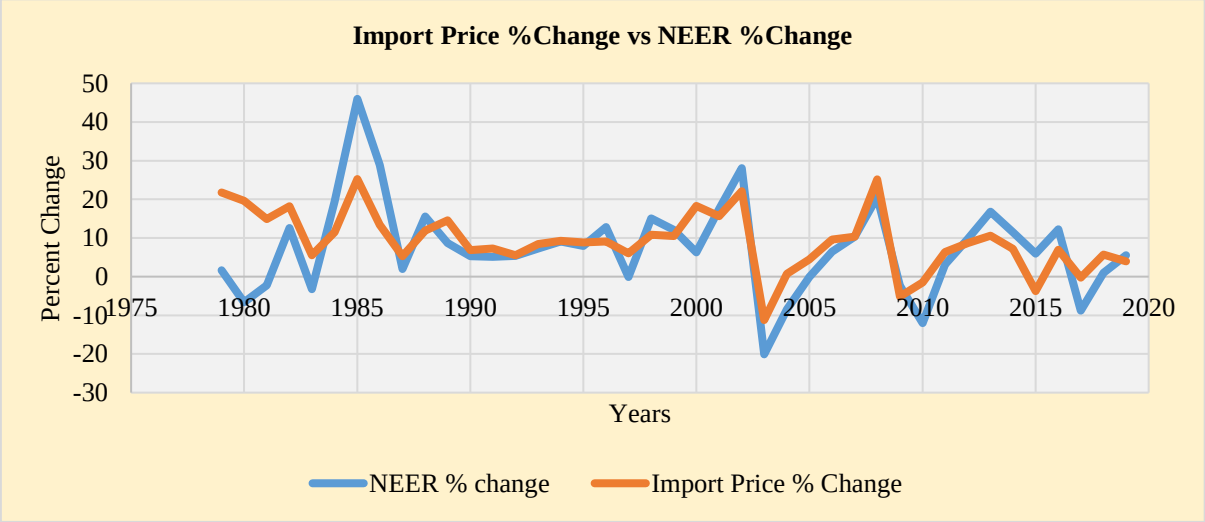
The policy of a free float in South Africa accompanied by the relaxation of the exchange controls exposed the Rand to both domestic and external shocks and in the process increased its loss of value against a basket of its major trading partners as shown in Figure 2.11. Figure 2.12 shows the time profiles of the nominal effective exchange rate (NEER) and import prices from 1978 to 2019.

Initially the Rand was stable between 1978 and 1985 partly due to a rise in net exports at the time. The rise is net exports meant that there would be an increase in the inflow of foreign currency into South Africa. Through the forces of demand and supply of foreign currency, it is noteworthy that the value of the Rand remains either stable, appreciates or depreciates. The profiles also show that there were episodes of exchange rate spikes around 2002 and 2008 when the Rand depreciated by a wide margin and subsequently import prices increased as well. The reason for a spike in 2008 was due to a global recession that affected South Africa negatively. The appreciation of the Rand in 2010 was evidently due to the influx of foreign currency into the country as many football visitors hit the South Africa shores.

Figure 2.11, however, shows that there was an upward trend in the movement of NEER implying that the Rand was depreciating. The implication of a rise in NEER was that there was also a rise in the import prices. This same scenario was shown in the paper by Karoro et al. (2009). One of the reasons for a concurrent increase of the import prices is that imports are invoiced using the international vehicle currency, in this case, the US Dollar. As the local currency loses value against the dollar it only means that imports become more expensive over time.

Figure 2.12 plots changes in NEER and import price inflation for South Africa. This graph illustrates the effect of exchange rate volatility on import price inflation. The graph clearly illustrates episodes of depreciation and appreciation of the South African Rand over time. It also shows that there are different magnitudes of depreciation and appreciation. In the graph most depreciations are followed by an increase in import price inflation and in the same vein, appreciations have been followed by a fall in the import price inflation. Easy to notice on the graph are the large changes in the value of the Rand in 1985, 2002 and 2008 and in all these years the country registered negative growth in some important macroeconomic fundamentals. Similar results are evident in the works of Maduku et al. (2015) and Karoro et al. (2009). The magnitude and extent of the ERPT to Imports Price Inflation cannot be ascertained by this graph but by further empirical investigation.

Figure 2. 12: Import Price percent Change vs NERR percent Change



Source: Author's own computations using SARB data (2019)

Figure 2.12 above and Figure 2.13 below show the response of import prices to changes in exchange rate. The graphs show that as the Rand appreciates (i.e. a fall in percent change) the import price change increases. This confirms the assertions by Delatte et al. (2014) that foreign exporters increased pass-through during appreciations and reduced it during depreciations in order to maintain market-share. This is the opposite of what price-setters in the domestic market do, as they are keen to pass depreciations more than appreciations to the final consumer prices if they have market power.

The reason why there may be asymmetry in ERPT between depreciation and appreciation could be that local traders do business in imported goods more than locally made goods and services and so would like to maintain their profit margins. A depreciation of the local currency reduces their (traders) profitability as they would face a higher importation bill to their merchandise. The opposite

is true when there has been an appreciation of the local currency. An appreciation of the local currency helps to reduce the import bill of the merchandise and this is expected to reduce consumer prices. However, in South Africa, this does not seem to be the case as traders, for some reason, do not pass a significant cost of import costs onto the consumer. This results in low ERPT.

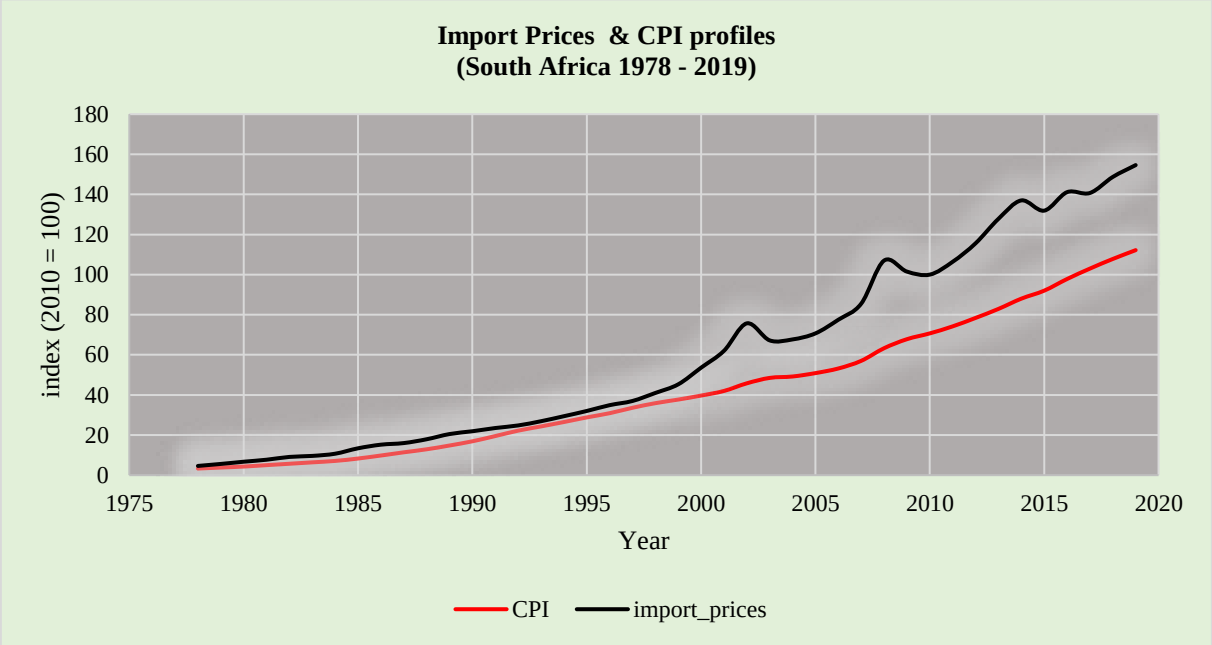
In conclusion, on import price and exchange rate the graph above also shows that the magnitudes of changes are not the same between exchange rate and import prices. Import prices respond less to changes in the exchange rate. According to Gaulier et al. (2006), the low response of import prices to changes in the exchange rate is attributable to the downward pre-adjustment of export prices so as to remain competitive in the destination market. The downward adjustment of export prices by exporters is only feasible when the price elasticity of demand of the exported products is high. This is akin to the Marshall-Lerner condition under which improvement in the Balance of Payments (BoP) for an economy can be improved. The Marshall-Lerner Condition of a currency devaluation is that a devaluation is the right decision for a country intending to improve its BoP only if the sum of elasticities of demand for exports and imports is greater than unity (Agenor, 2004; Hakan, 2014)

2.15 SECOND STAGE PASS-THROUGH (IMPORT PRICES AND CONSUMER PRICES IN SOUTH AFRICA: 1979 – 2019)

Having looked at the effect of the exchange rate on import prices, it is logical to follow this up with an analysis of a relationship between import and consumer prices. This follows the works of Campa et al. (2007; and Parsley (2012) who estimated both ERPT to imports as a first stage pass-through and then ERPT to consumer prices as a second stage pass-through. Figure 2.13 illustrates the time profiles of import prices and consumer prices from 1978 to 2019.

The graph above shows that generally, consumer prices have been lower than the import prices over the years. This shows reluctance of the importers to make a complete pass through to consumer prices. From 1978 to about 1997 the two price indices were very much closely related and only later in 2019 did the pass-through from import prices to consumer prices become much smaller. There are many theories to account for this behaviour. One of the theories stems from the desire by traders to maintain market share in the country as explained by the Pricing-to-Market theory in the paper by Bussiere (2013). Under this theory, traders find themselves unable to avoid reduction of prices during currency appreciation for the fear of losing market share.

Figure 2. 13: Import Prices vs CPI in South Africa



Source: Author's own computations using SARB data (2019)

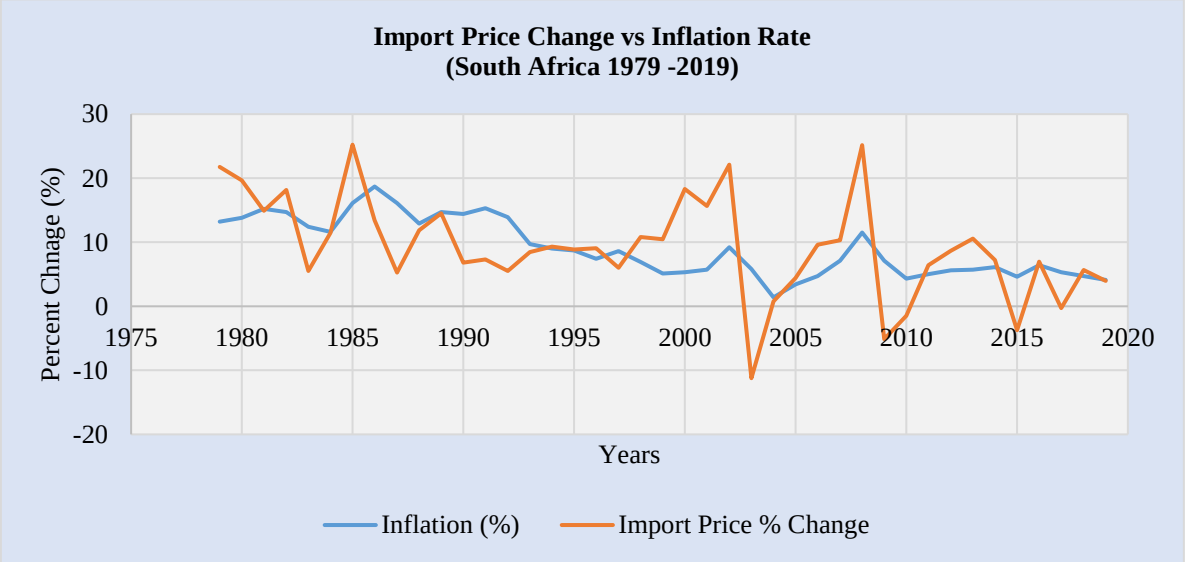
The other reason for low pass-through from import prices to consumer prices could be that there may be low "Expenditure-Switching" behaviour by consumers as mentioned by Devereux and Engel (2002). This means a change in the exchange rate might not result in consumers making a big substitution between locally made goods and imported goods due to small or no price-differentials between foreign and local goods.

2.16 IMPORT PRICE CHANGE AND INFLATION IN SOUTH AFRICA (1978 – 2019)

A better picture showing the relationship between Consumer Prices and Import Prices is shown through a visual inspection of the profiles of Import Price changes and CPI changes (inflations) in Figure 2.14 below. It is evident that when import price change falls the consumer inflation also falls. What is clear also is the fact that, in this graph, the consumer inflation responds with a lag each time there is a spike in the import price. The large changes in import prices in 1985, 2002-2003, 2008 and just before 2010 are all far greater than the size of the changes in the consumer price inflation. This

confirms the theories by Bussiere (2013) and Devereux and Engel (2002) that inflation does not change at the same degree as the exchange rate change though they have a tendency to move in sync.

Figure 2. 14: Import vs Inflation in South Africa



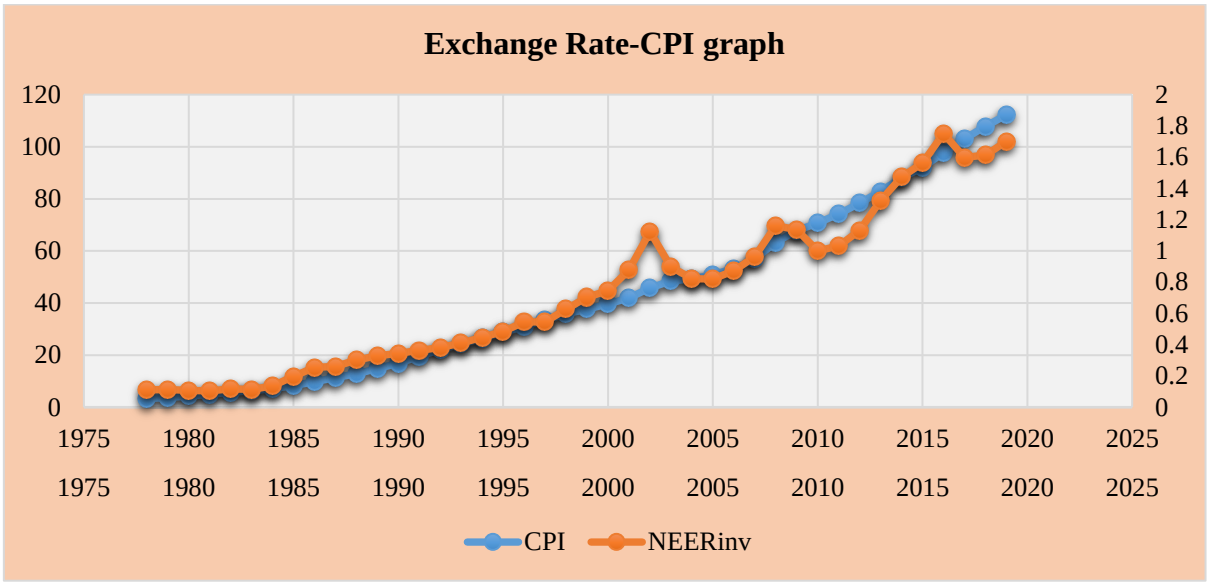
Source: Author's own computations using SARB data (2019)

Structural economists see inflation in developing countries as caused by the exchange rate depreciation. For them, the low export earnings in developing countries are not enough to purchase imported capital and intermediate goods (Nell, 2000). The lack of foreign exchange reserves and high demand for imports lead to exchange rate depreciation. The end result is the rise in import prices which then trigger the inflationary pressure that becomes self-perpetuating as the wage-price spiral sets into motion (Taylor, 2000).

2.17 DIRECT PASS-THROUGH (EXCHANGE RATE AND CONSUMER PRICES IN SOUTH AFRICA: 1978 - 2019)

This section shows the direct pass-through to consumer price in South Africa as illustrated in Figure 2.15.

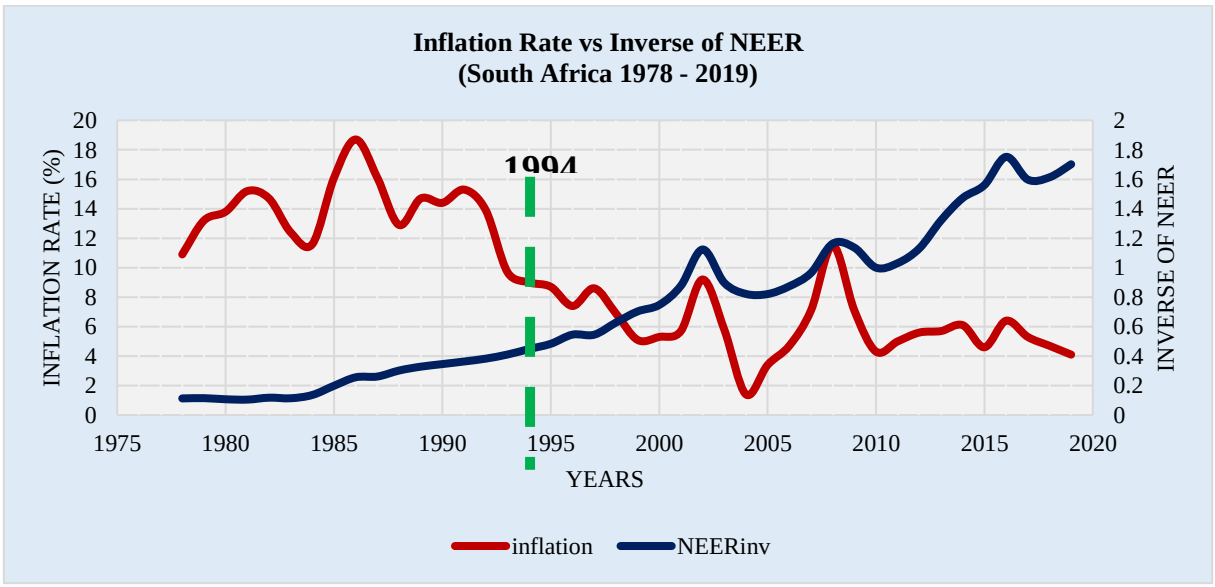
Figure 2. 15: Inverse NEER vs CPI in South Africa



Source: Author's own computations using SARB data (2019)

Figure 2.15 shows the direct effect that the exchange rate has on CPI. The relationship depicts almost a one-on-one relationship between the two variables. When the Rand depreciates, there is a rise in consumer prices as well. This happens because as the local currency loses value against currencies of its trading partners imports become expensive and so traders pass on part of importing costs to the consumers (Maduku, Contogiannis and Kaseeram, 2015). The relationship between inflation and inverse NEER is shown in Figure 2.16.

Figure 2. 16: Inflation Rate vs Inverse of NEER



Source: Author's own computations using SARB data (2019)

Inflation hovered in the double digit territory for the period from 1978 to 1993 and only changed to a single digit in 1994 after the apartheid system. In the year 2000 the South African Reserve Bank (SARB) adopted an inflation targeting policy with the objective of achieving a single digit target within a band between 3 percent and 6 percent. Due to the volatile nature of the Rand, there have been episodes in which the rate of inflation would go beyond the upper bound of 6 percent (Maduku, Contogiannis and Kaseeram, 2015). The goal of inflation targeting by South Africa, among other things, has been motivated by a desire to achieve inflation parity with its trading partners such as the United States of America (USA), the United Kingdom (UK), Germany and Japan (Akinboade and Niedemeier, 2005). The inflation parity is an important milestone since inflation differentials between South Africa and its trading partners can lower its trade competitiveness. The continued volatility of the Rand stands as the most important factor in achieving inflation rate parity.

Figure 2.16, shown above, illustrates the trends of exchange rate changes and consumer price changes from 2003 to 2017 for South Africa. Though there have been significant fluctuations of the exchange rate, the consumer prices did not follow suit thereby confirming that prices did not really respond well enough to changes in the exchange rate. There was only a slight dip of the prices in 2004 and a steady rise in prices from 2004 to about 2009 before there was a slight reduction in prices around 2010 when there was Football World Cup in South Africa. The local currency remained strong after the world cup perhaps due to the large inflows of foreign currency into South Africa as many visitors came into the country. Since 2010 prices remained subdued even in the face of a stronger rand when imported inflation was expected to be low. Figure 2.16 indicates that, even though South African prices would go up when there was a depreciation of the currency (increase in percent) or fall when there was an appreciation (decrease in percent) this was not significant; again corroborating that ERPT is incomplete in the economy.

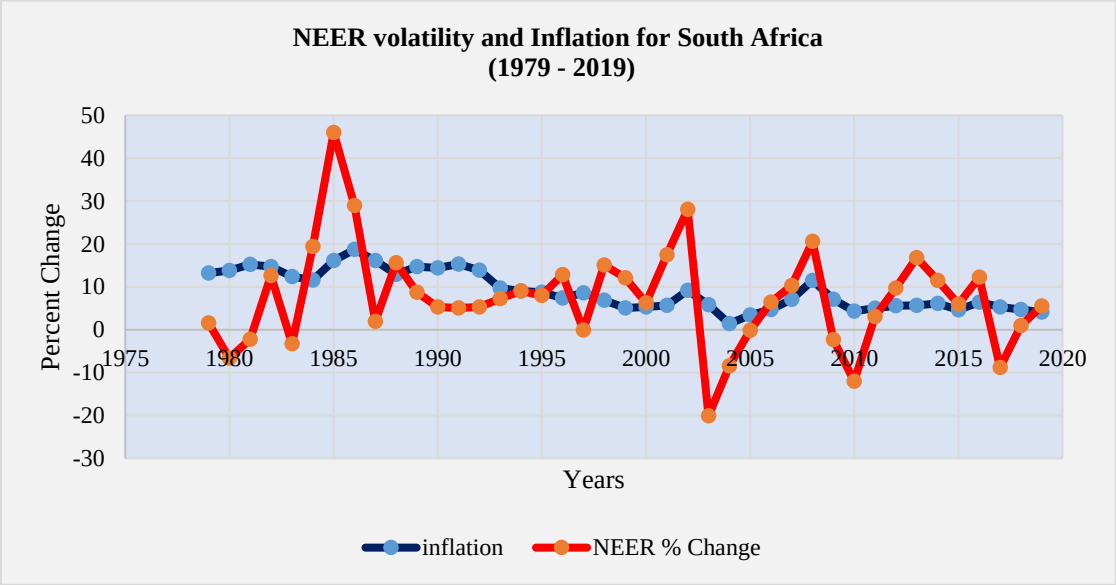
Another observation from the graph above is that after the inflation-targeting policy in South Africa, there were depreciation episodes in 2002, 2008 and 2016 as shown by the spikes in the inverse of NEER. These depreciations were instantly followed by increases in the price levels of domestic goods and services in the country. Similarly, the graph shows that there were episodes of appreciation of the Rand against a basket of currencies of the trading partners in the years 2004, 2010 and 2015. The inflation profile responded in unison and registered falls in price levels in the country. This relationship between exchange rate change and inflation has been well documented by scholars such as Froot and Klemperer (1989) using the data from the United States of America. Froot and Klemperer (1989) observed that consumer prices in the USA did not fall far enough when the dollar

appreciated and conversely, prices did not rise proportionately when the dollar depreciated against the currencies of its major trading partners in the 1980s.

2.18 EXCHANGE RATE VOLATILITY AND INFLATION IN SOUTH AFRICA (1979 – 2019)

Figure 2.17 shows the profiles of exchange rate volatility and inflation in South Africa.

Figure 2. 17: NEER Volatility vs Inflation in South Africa



Source: Author's own computations using SARB data (2019)

Figure 2.17 above shows an exchange rate profile that is characterised by some degree of volatility from 1979 to 2019 while the consumer price change (inflation) remained relatively constant over the period. This indicates that prices remained relatively sticky despite changes in the exchange rate.

2.19 CONTEMPORARY EXCHANGE RATE PASS-THROUGH IN SOUTH AFRICA

South Africa is classified as an EME and the evidence at hand is that the ERPT has been declining over time though still in the double-digit region (Aron et al., 2014; Jooste and Jhaveri, 2014; Karoro et al., 2009 and Parsley and Farrell, 2010). The reason for the declining ERPT in South Africa was the adoption of the Inflation-Targeting Policy (ITP) over time. Karoro et al. (2009) estimated the ERPT for South Africa to be between 75 percent and 81 percent. Parsley and Farrell (2010) recorded a lower ERPT around 60 percent and Aron et al. (2014) estimated the ERPT at between 44 percent and 50 percent. Parsley (2010) attributed the decline in ERPT over time to the stagnant composition of the CPI. A stagnant composition of CPI means that some other goods and services that are now worthy of being considered as basic needs of households are excluded. These excluded basic goods

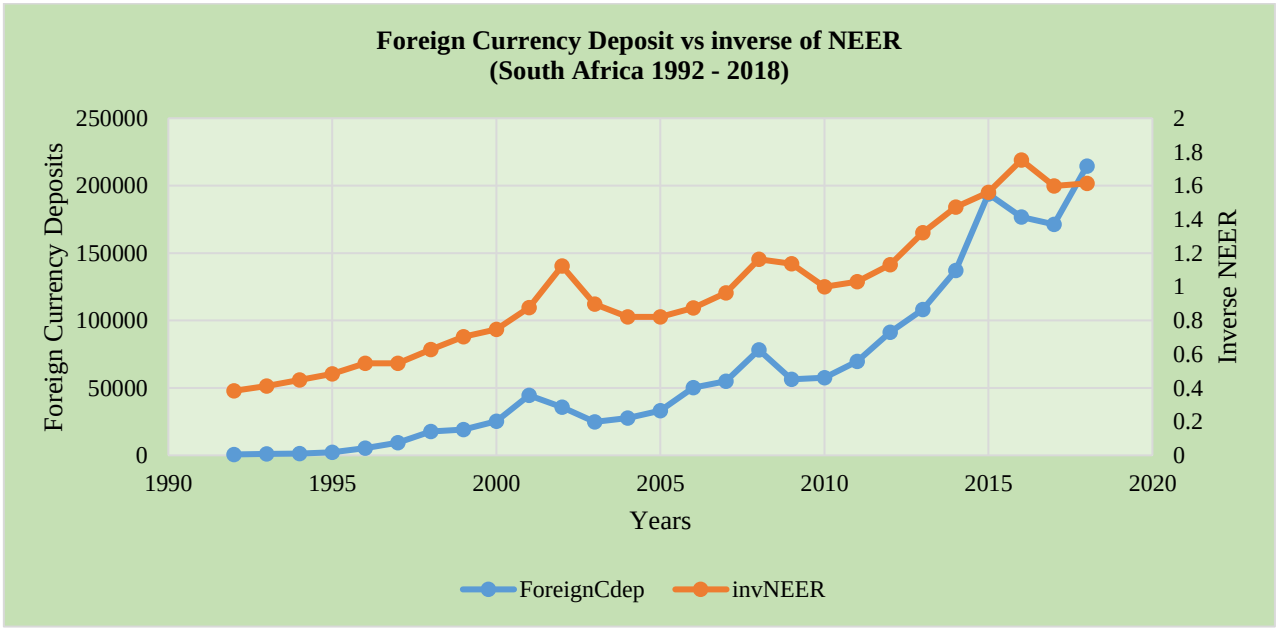
and services may be more modern and command a significant share of the budget of the consumer basket.

Aron et al. (2014) noted that the volatility of the exchange rate in South Africa, in its function as a shock-absorber, tends to reduce the PT in the short-term but not necessarily in the long-term. One could also attribute the falling ERPT to consumer goods in South Africa to the gradual changing economic status of the economy. As alluded to earlier, the more advanced the economy becomes the lower will be the ERPT.

2.20 EVIDENCE OF LOSS OF VALUE OF THE RAND IN SOUTH AFRICA (1995 – 2018)

One of the ways in which loss of a currency can be shown is through observing and quantifying foreign currency deposits as a fraction of the total deposits in the local banks by economic agents. The assumption behind this is that if people prefer to deposit more foreign exchange than local currencies, this would mean they have no confidence in the local currency. Depositing more of foreign currency is some kind of hedging against financial losses in the event of an exchange rate shock. Figure 2.18 illustrates the position with regards South Africa for the period 1995 to 2017.

Figure 2. 18: Exchange Rate vs Foreign Currency Deposits



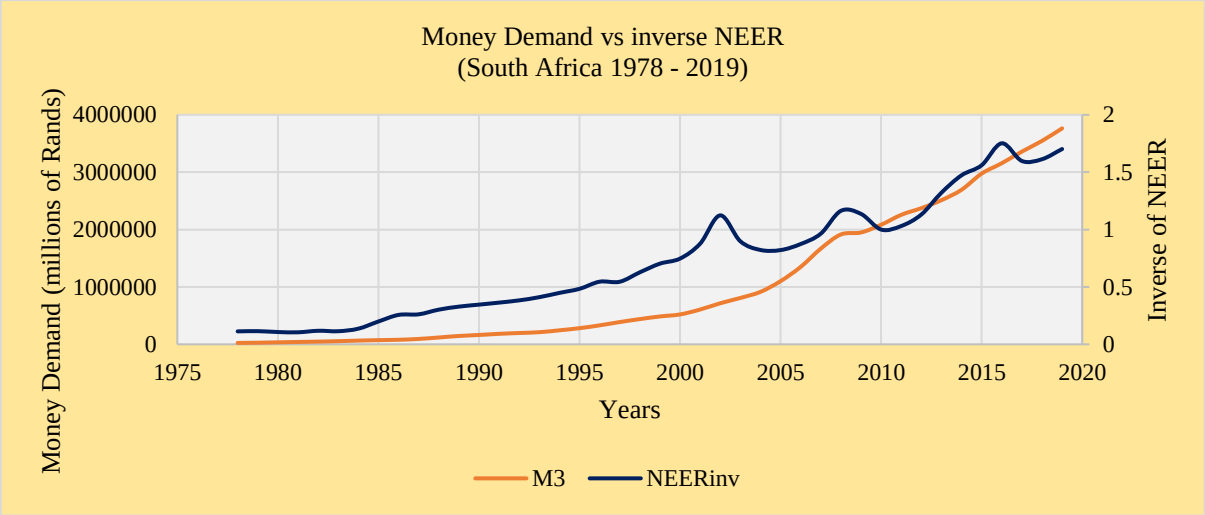
Source: Author's own computations using SARB data (2019)

In Figure 2.18 there is evidence of fluctuations of the Rand from 1995 to 2018 but showing an upward trend. That would mean that the Rand has been losing value against the US dollar, generally. There has been a steady increase in foreign currency deposits in the South African banks for the same period. This alone indicates the lack of confidence in the local currency due to loss of value in South

Africa. What remains to be analysed is the extent to which the loss of value of the Rand would impact on import and consumer prices that is dealt with in the econometric analysis chapter.

Figure 2.19 below triangulates the relationship between foreign currency deposits and the exchange rate in South Africa. The scatter plot between foreign currency deposits and exchange rate seems positive. This means that as the Rand depreciates further and further, more and more economic agents increase their foreign currency deposits because then they lack confidence in the Rand.

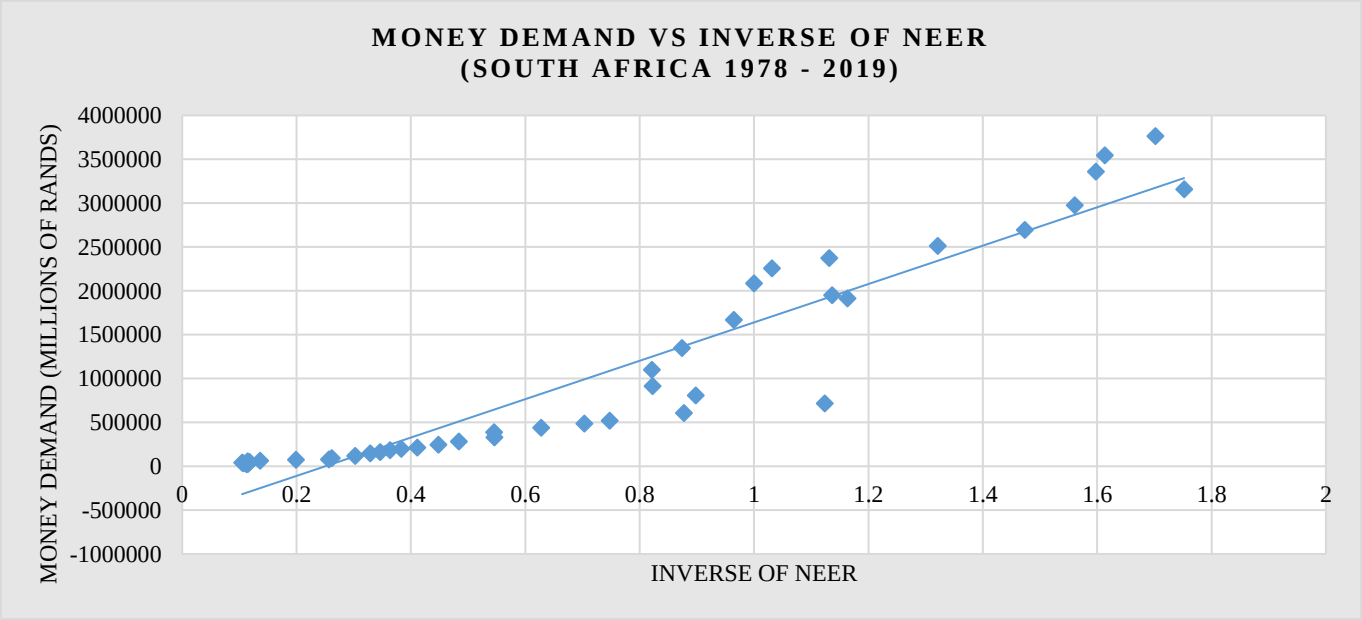
Figure 2. 19: Exchange Rate & Money Demand Profiles in South Africa



Source: Author's own computations using SARB data (2019)

The scatter plot in Figure 2.20 corroborates the trend already shown in Figure 2.19.

Figure 2. 20: Money Demand /Inverse Exchange Rate Scatter Plot



Source: Author's own computations using SARB data (2019)

The study by Gupta and Ziramba, (2011) found that evidence of loss of local currency value is observable in the increase in money demand on the local money market as depreciation continues. The opportunity cost of keeping money in the financial institutions in the face of depreciation is evidence of the erosion of the value of the currency and so one would rather keep liquid cash rather than investing on the financial market.

2.21 FACTORS OF EXCHANGE RATE PASS-THROUGH IN SOUTH AFRICA

This section gives additional detail on the various factors of the ERPT in in South Africa as documented in literature. What must be noted is that if, at a microeconomic level, the exporting firm absorbs all the costs brought about by the depreciation of the currency of the importing country then the degree of exchange rate pass-through to import prices is zero (Maduku et al. 2015). A number of factors that would affect the degree of pass-through of exchange rate changes to import prices and to consumer prices is outlined below. The factors are not exhaustive but in some cases could be considered the most significant among others.

2.21.1 Inflation environment

The inflation environment alone can be a significant factor in the way changes in exchange rate affect import and consumer prices in a country. A low inflation environment may result in low ERPT (Takhtamanova, 2010). In this paper Takhtamanova (2010) attributed the low ERPT in the 1990s to the infrequent adjustment of those prices in a low inflation environment. Inflation-targeting policies often result in low inflation in the country which then causes low exchange rate pass-through. Taylor (2000) observed that the low ERPT cannot be permanent as expected future inflationary pressures gain momentum.

2.21.2 Degree of openness

Another important factor as captured by Nell (2000) and Kochovska (2015) is that the strength of CPI inflation's reaction to changes in the exchange rate depends on the degree of openness of the economy (i.e. the fraction of imported goods in the aggregate CPI). If, for example, the fraction of imports in the total goods traded in the country is small, then the ERPT may be low as there would be low demand for imported goods.

2.21.3 Central Bank's Monetary Policy Credibility

The credibility of a country's central bank is crucial for exchange rate pass-through. McCarthy (2007) pointed out that the more credible the central bank is, the lower would be the ERPT. Further to the lowering of the exchange rate pass-through, McCarthy (2007) noted that when the bank's

credibility is good, then whenever inflation surges for some reason, it would return to its long-run steady-state level faster than if the bank's credibility was low. A low credibility of the central bank affects the confidence that the outside world has about the country and this affects its future economic outlook and ultimately negatively affects the value of its currency.

2.21.4 Price elasticity of exported goods

Exchange Rate Pass-Through as Kochovska (2015) found, also depends on the elasticity of demand and cost functions faced by firms in the exporting country. When the importing country's currency depreciates, it is expected that the ERPT would increase. This may not be the case if the price elasticity of demand for imported goods is high. Any attempt to transmit consumer price increases through an increase in import prices is likely to be met with a highly reduced demand for imports and this reduces profitability. Similarly, we do not expect ERPT to increase when the costs faced by the exporting firms are low. There would be no incentive to increase export prices, especially when you want to grow your market.

2.21.5 Real Effective Exchange Rate (REER) Effect

The Real Effective Exchange Rate of a country's currency against a weighted composite basket of its trading partners' currencies is adjusted for inflation (Mackton et al., 2018). REER is an important determinant of the growth of cross-border trading and serves as a measure of a country's international competitiveness. The higher its value, the less competitive a country is, as its goods would be more expensive than its competitors would. The weights used in the calculation of REER[6] are determined by comparing the relative trade balance of a country's currency against each country within the index. The Real Effective Exchange Rate, as explained by Kemal and Qadir (2005), indicates the price a consumer pays for buying an imported product. This means that REER is correlated with imports in that as the local currency gets stronger (i.e. REER getting smaller and smaller) consumers tend to import more than they export and so in that case there is loss of international competitiveness). In

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[6] $REER = \frac{ER^* p^f}{p^d}$.
ER^* = Nominal Effective Exchange Rate (NEER) ;
p^f = Foreign price

p^d = domestic price

$\frac{p^f}{p^d}$ = foreign price deflated by the domestic prices to take into account price differentials.

the end then ERPT increases due to increase in import appetite. Takhtamanova (2010) states that REER is one of the drivers of ERPT. This claim was, however, challenged by Ito and Sato (2006) who pointed out that it is not worth our while to focus on REER as one of the factors of ERPT since it is itself a mirror image of NEER. They argue that REER is derived from NEER and so these two can be used interchangeably without loss of generality.

2.21.6 Quality of exported goods

A rather far-fetched approach to ERPT studies is the idea that ERPT depends on the quality of products being exported. In this case the exporter views quality as proxied by the Pricing-to-Market (PTM). The lower the PTM, the higher the quality, therefore the higher would be the ERPT (Ghosh and Rajan, 2007).

2.22 CONCLUSION

This chapter started with introducing its objectives. The discussion then progressed into the history of the Rand in South Africa, including the various other currencies used in South Africa. The bulk of the discussion focused on the effects that the exchange rate has on import prices as a 1^{st} stage pass-through and then the effect import prices have on consumer prices as a 2^{nd} stage pass-through. The effect of exchange rate changes on consumer price is not exactly direct but can be seen as a second stage exchange rate pass-through to prices via the pass-through to import prices. Due to the pricing-to-market behaviour of firms, as well as lack of expenditure-switching patterns by consumers, there is a tendency for incomplete exchange rate pass-through to domestic prices in South Africa. This disconnect between exchange rate dynamics and aggregate price levels was also attributed to the need to maintain market-share (Devereux, 2002; Malenbaum, 2015; Sahminan, 2005). The following Chapter 3 delves into the Literature Review (Empirical and Theoretical).

CHAPTER THREE:LITERATURE REVIEW

3.1 INTRODUCTION

Successful and non-spurious empirical analysis of the effect of exchange rate changes on imports and consequently on consumer prices is dependent on plausible and authentic theories of the Exchange Rate Pass-Through (Campa, Goldberg and González-Mínguez, 2007). This chapter discusses ERPT theories or models and how they can be applied to the South African data on exchange rate and prices. The bedrock for understanding the impact of exchange rate changes on import prices and consumer prices rests in discussing and adopting as well as adapting contemporary theories and models on ERPT. In essence, this chapter on literature review focuses on the genesis of key models and theories of exchange rate pass-through as well a review of the findings by other researchers in the area of ERPT.

The chapter is divided into three (3) sections which are Theoretical Literature, followed by Empirical Literature and finally a holistic reflection on this literature. The theoretical literature part has the following sections: section 3.2.1 focuses on the Law of one Price (LOOP) Theory and its limitations, section 3.2.2 deals with the Pricing-to-Market Theory and its limitations, section 3.2.3 focuses on the Expenditure-Switching Theory and its limitations and finally section 3.2.4 discusses the Mundell-Fleming Theory as it pertains to the possible causes of price-stickiness that ultimately results in low ERPT. Section 3.2.5 gives some conclusions on the theory explaining ERPT. A small section (section 3.3) briefly discusses ERPT asymmetry and the possible causes. The Empirical Literature under section 3.4 explores studies by other researchers in emerging markets, various countries and South Africa on ERPT. The same empirical section affords us the opportunity to analyse, explain models used and critique the approaches used by others. Ultimately, this part also compares these studies with the focus of this academic work.

3.2 THEORIES AND MODELS THAT EXPLAIN ERPT

This section presents theories and models that explain ERPT, amongst them the Law of one Price (LOOP), the Pricing-to-Market (PTM), The Mundell-Fleming Model of sticky prices and the Expenditure Switching Model.

3.2.1 The law of one price (LOOP)

The law of one price, alternatively known as the Purchasing Power Parity Rule, was developed by Cassel (1921) as a tool for estimating exchange rates using inflation differentials. The pass-through idea draws its theoretical underpinning from the purchasing power parity (PPP) theory that predicts

a full impact from changes in exchange rate on domestic prices. In essence, PPP theory argues that any change in exchange rates translates into proportional movements in domestic prices in a linear fashion. The PPP is taken as an anchor for long-run real exchange rates. According to Rogoff (1996) real exchange rates tend towards purchasing power parity in the very long run, meaning that the speed of adjustment in the long-run is very slow. The literature on exchange rate pass-through is closely related to the literature on Purchasing Power Parity in that there is a tendency to have less than full impact of the exchange rate changes on local prices but the full impact is realised in the long-term when full price-adjustment is complete and PPP is achieved (Maduku and Kaseeram, 2018). If PPP held for tradable goods, then pass-through would be complete. Also, in a perfect competition framework with frictionless markets, pass-through would be complete because the mark-up would always be equal to zero for the exporters (Bussiere, 2013). This LOOP theory is seminal in this research for understanding why ERPT tends to be incomplete in the short-run but more complete in the long-run.

The problem with PPP is that, in reality the idea of perfect competition is far-fetched. What is normally observed is the presence of imperfect markets and therefore prices can never be the same across countries with strong trading agreements. Again, markets across the world are not without friction and the mere fact that mostly one deals with countries in different geographical locations and therefore faced with logistical challenges such as transport costs and different labour laws all of which are factored into the prices. Trading partners with significant inflation-differentials have different prices for homogenous goods, hence the LOOP tends to fail.

Apart from transportation costs, Rogoff (1996) identified other reasons for the failure of PPP and these are presence of tariffs, non-tariff barriers and Pricing-to-Market behaviour. The Dornbusch (1976) Overshooting Model argues that nominal exchange rate volatility effect is neutralised by financial and monetary shocks, hence the tendency for stickiness in nominal prices. In relation to this study, the LOOP theory is indirectlty tested when we measure the degree of exchange rate transmision to import and consumer prices. If PPP (which is interchangeably referred as LOOP) holds between South Africa and the United States of America (USA), then one can expect almost a full transmission of the change in the exchange rate.

3.2.2 Pricing- to- Market (PTM) Theory

Krugman (1986) pioneered the Pricing-to-Market theory that explains why exchange rate pass-through in not complete in most cases. Export prices may be set in terms of the foreign currency

(which is called pricing-to-market), rather than in domestic currency. Sung et al. (2015) pointed out that exporters with market power implement PTM as a strategy to keep their share on the international market. To exercise non-competitive pricing strategies across markets means that markets should be separated in space, time and form to avoid opportunities for arbitrage. The firm must have sufficient power to influence prices. This strategy involves keeping foreign prices constant despite appreciation or depreciation of the domestic currency. When there is a depreciation of the exchange rate, the demand curve becomes more elastic and foreign competitors, in an attempt to secure the market-share, lower their price in foreign currency terms, implying that import prices increase by less than the magnitude of the exchange rate fall. When there is a depreciation, local consumers substitute foreign goods for local products and so the price elasticity of demand for foreign goods increases.

The model assumes that an incomplete ERPT is due to strategic interaction between firms in an imperfect competition environment where the demands of consumers are taken before setting prices (Dixit and Stiglitz, 1977). In addition, the theory assumes that the degree of substitutability between domestic and foreign goods determine the ERPT. The higher the degree of substitutability, the lower the ERPT (Taylor, 2000). Exporters move along demand curves and hence adjust prices and avoid price fluctuations leading to Pricing-To-Market tendencies (Corsetti and Pesenti, 2001). The PTM theory is expected to partly explain why ERPT is low in South Africa and therefore is one of the leading theories in this study.

The problem with this theory is that when there are many exporters or importers there is perfect competition and therefore firms cannot adjust prices unilaterally. The assumption of a monopolist falls away when there are many producers of homogenous or differentiated goods in the world. Markets are difficult to separate, especially given the information technology in the world and so markets cannot be separated in time and space. The Pricing-To-Market prediction in this regard becomes less reliable as an explanation of low ERPT. The other problem with the PTM theory is that it is not straightforward to capture quantitatively in a regression analysis and therefore it remains largely theoretical. Factors of ERPT need to be those that can be measured and scientifically put to test in a regression model

Exchange rate pass-through depends on several factors which are classified into microeconomic and macroeconomic factors (Campa and Goldberg, 2003).

The first category of factors relates to the industrial structure of the economy. As an example, in the Dornbusch, (1987) paper, pass-through depends on product substitutability, market structure and the number of foreign firms relative to local firms. The macroeconomic environment is highlighted in the second category of factors and in particular the role of monetary policy. In this regard, one can mention in particular the contributions of Betts and Devereux, (2000), who introduced pricing to market to the earlier model of Obstfeld and Rogoff, (1995). The main concepts in this literature are those of local currency pricing (LCP) and producer currency pricing (PCP) which refer to exporters pre-setting their prices in the currency of the importing country or in their own currency, respectively.

While the PTM theory seems plausible, it appears insufficient to explain fully the reason behind the less than 100 percent transmission of exchange rate changes to either import or consumer prices. A significant critique of the PTM theory is possible through exploring other possible and competing factors such as the econometric specification of the ERPT equation as was pointed out by Goldberg and Hellerstein (2008). Wrong specification may produce spurious conclusions. There is a need, therefore, to fully understand the structural determinants of the exchange rate pass-through for purposes of measuring the degree of transmission of the exchange rate changes to import and consumer prices as well as for future forecasting of the price paths in the economy as exchange rates vary (Marazzi et al., 2005). Having established the structural relationships among variables, it becomes easier to develop reduced-form econometric equations.

3.2.3 The Expenditure-Switching Theory (EST)

The Expenditure-Switching Theory originates from the works of Obstfeld and Rogoff, (1995) when they analysed the role of the exchange rate in the importation of intermediary goods to engage in import-substitution production. The indirect transmission of exchange rate on prices is through the composition of demand and in levels of aggregate demand and wages. When a depreciation takes place, the demand for local goods rises both at home and abroad. This has a tendency for inflation increasing, meaning a reasonably higher degree of ERPT. However, the assumption of a rise in the demand for locally produced goods internationally when depreciation occurs requires the fulfilment of the Marshal-Lerner Conditions. The marshal-Lerner conditions require that the absolute sum of the long-term export and import demand elasticities be greater than unity. This may not be the case when depreciation takes place resulting in local prices failing to rise. The level of the expenditure-switching effect depends upon the degree of price stickiness, the number of firms employing producer currency pricing versus local currency pricing and the elasticity of substitution between domestic and foreign goods (Dong, 2007).

The main model behind this study is the Mark-up Model (also known as the Pricing-to-Market model) that informs the behaviour of firms in pricing imported goods and services in the importing country. To this end, therefore, there is need for discussing both the microeconomic as well as the macroeconomic reasons for the low degree of transmission from exchange rate changes to import prices and domestic prices in many countries. The ideas of the Expenditure Switching Theory are good for the explanation of the low ERPT after controlling for other factors such as the Inflation-Targeting policy. For this reason, the theory of Expenditure- Switching is embraced in this study.

Betts and Devereux (2000) noted that a positive monetary policy, in the absence of pricing-to-market, tends to raise output in the economy as well as in those countries with which it trades. In other words, the international transmission effects of monetary policy on output are positive. This is because a positive monetary policy should increase output in the economy as well as causing a depreciation of the currency (Betts and Devereux, 2000). A currency depreciation should, *ceteris paribus,* cause an increase in exports to other countries but in a situation where exporters have to employ LCP, then there would be no expenditure switching effect as the prices of exported goods are matched by the prices of the importing nation. For Expenditure Switching-Effect to take place, the following factors should be considered, as argued by Swallow, Magud and Yepez (2018) as well as Gopinath, Itskhoki and Rigobon (2010):

- Degree of substitutability between local and foreign goods.
- Degree of price-stickiness.
- Fraction of firms engaged in Producer Currency Pricing and Local Currency Pricing.

Expenditure-Switching Effect takes place if agents in an economy can substitute foreign goods for locally made goods, especially when a depreciation takes place. However, in some cases, local goods are not substitutes for foreign goods and so a fall in import prices may not be due to Expenditure-Switching (Swallow, Magud and Yepez, 2018).

3.2.4 The Mundell-Fleming theory of price-stickiness

The Mundell-Fleming model (also known as the IS-LM-BoP model) assumes that prices of traded goods are sticky in the currency of the producer (Dornbusch, 1987). This suggests that producer currency pricing (PCP) plays no role in determining local prices. Adding to this theory, optimal monetary policy rules are inward looking in that they stabilize domestic prices and output, and do not react to international variables like the exchange rate (Corsetti and Pesenti, 2001). However, strict adherence to inward-looking policy objectives cannot be optimal in a situation where firms'

mark-ups are exposed to currency fluctuations since this leads to excessive volatility in exchange rates and therefore exporters' prices cannot be sticky.

An alternative view to PCP assumes that prices of traded goods are sticky in the currency of local consumers (Betts and Devereux, 2000). Local Currency Pricing (LCP) leads to very different prescriptions for monetary policy. Devereux and Engel (2002) showed that under LCP, there is no benefit to exchange rate flexibility and therefore fixed exchange rates are preferable.

The critique to these views becomes clear in that both PCP and LCP hypotheses have problems explaining the evidence on the exchange rate pass-through to import prices and ultimately to consumer prices. There is need, therefore for a hybrid price to be used in estimating the ERPT.
The perceived decline of the pass-through in industrial countries in the 1990s motivated a line of research that strove to explain this phenomenon. Taylor (2000) explains the decline in pass-through to a tightening and enhanced credibility of monetary policy.

Some of the strict assumptions of the Mundell-Fleming model make it unattractive to implement and use in empirical research. The model assumes that the spot and forward exchange rates are identical. It also assumes that the existing exchange rate would persist indefinitely. Further, it assumes fixed money wage as well as constant returns to scale for manufacturing industry. The spot and forward exchange rates are usually never the same unless the economy is running a fixed exchange rate regime. An economy with a flexible exchange rate is not likely to have the same exchange rate today and the following week or month because of the changing economic events in the country. With the changing structure of many economies, we do not expect to have constant returns to scale in the production process. Technology quickens the production process and increases productivity. Lastly, it is inconceivable to assume that wages would stay the same in the face of growing inflation in many countries. As the purchasing power of the local currency is eroded, workers are likely to engage firms in a bid to have wages adjusted upwards to mitigate the effects of inflation.

3.2.5 The Binding Quantity Constraints Theory

The Binding Quantity Constraint theory suggests that consumer prices rise more during depreciation than when the currency appreciates because of the legally binding constraints to the supply by an exporter. When supply is constrained, then the foreign firm may seek to make profit by increasing prices. This constraint disappears when the importers' currency appreciates (Pollard and Coughlin,

2003). The Pricing-to-Market share theory and the Expenditure-Switching Theories produce the opposite effect in that ERPT is higher during appreciation than during depreciation.

The assumption that prices may rise during depreciation is hard to imagine, especially in an environment where there are other factors at play. In South Africa, for example, prices may fail to rise even during depreciation due to monetary policies such as inflation-targeting efforts by the monetary policy committee. In some cases, the constraints may be overcome if there are other unofficial methods of increasing supply in the economy or if the authorities decide to implement an inward-looking strategy such as import substitution as pointed out by de Melo and Robinson (1980).

3.3 CONCLUSION ON THE THEORIES AND MODELS OF ERPT TO IMPORT AND CONSUMER PRICES

The theoretical section above dealt with challenges and possibilities around the determination of exchange rate and by extension, the determinants of exchange rate pass-through to import and consumer prices. Even though the theory of one price across trading partners did not seem a preferred alternative in the literature, there are some scholars such as Goodwin (1990) who found it holding provided researchers realise the importance of price expectations as commodity arbitrage across countries does not occur contemporaneously. The new Keynesian Model of a Small Economy posits that sticky prices in the currency of the producer and monetary policy regime are the prime reasons for low exchange rate pass-through in many countries. The widely accepted view is that of the Pricing-to-Market Model that sees imperfect competition among firms in an economy as responsible for keeping prices down resulting in low exchange rate –pass-through (Dixit and Stiglitz, 1977). The Expenditure-Switching model discussed the issue of elasticity of substitution between local goods and foreign goods as a determinant of exchange rate and ultimately exchange rate pass-through as propounded by Dong (2007). The Binding Quantity Constraints theory explains the asymmetric effect of the exchange rate changes on prices suggesting that prices rise more during depreciation due to supply constraints in the market. Finally, the section dealt with the Mundell-Fleming model of international trade that suggests that prices of traded goods are sticky in the currency of the producer and hence producer currency pricing has no role to play in the determination of domestic prices (Obstfeld and Rogoff, 1995).

3.4 ASYMMETRIC EXCHANGE RATE PASS-THROUGH AND STICKY PRICES

Asymmetric response of domestic prices (import and consumer) takes place when the degree of exchange rate pass-through is not the same for import and consumer prices. ERPT asymmetry comes

in various forms: there can be a different exchange rate pass-through to import prices during Rand appreciation and during Rand depreciation. Depending on the structure and nature of the economy, ERPT into consumer prices (import and consumer) may be higher during appreciation than during depreciation (Przystupa and Wróbel, 2014). On the other hand, holding exchange rate constant, asymmetric response of import and consumer prices to exchange rate changes may be due to strategies of both exporters and distributors in the importing country (Bacchetta and van Wincoop,2003).

3.4.1 Bacchetta-Wincoop approach to ERPT Asymmetry (Import & Consumer Prices)

Changes in the exchange rate has asymmetric effect on import and consumer prices. The work by Bacchetta and van Wincoop (2003) sought to explain the differences between pass-through to import and pass-through to consumer prices in an economy. They argue that the optimal pricing strategy by local firms is the reason behind the low pass-through to consumer prices.

Bacchetta and van Wincoop (2003) and Betts and Devereux (2000) view exporters as selling only intermediate products to the firms in the importing country. This views gives the impression that local importing firms only engage in assembling imported goods into finished products that are then sold to consumers. Bacchetta and van Wincoop (2003) submit that competition between domestic assembling firms and domestic firms producing non-traded goods is what causes importers to price the assembled finished products in domestic currency while exporters price their exports in the exporter's currency. This results in complete pass-through to import prices while pass-through to consumer prices is zero.

Burstein et al. (2003) showed that if tradable goods sold to consumers contain a significant share of local value added then consumer prices would be less sensitive to the changes in the exchange rate due to competition. In the absence of competition, one would expect higher pass-through to consumer prices as a result of domestic distribution costs (Burstein et al., 2003). Goldberg and Campa (2010) echoes the same view as that of Burstein et al. (2003) that border prices of traded goods are highly sensitive to exchange rate changes but the consumer price index (CPI) is more stable. Goldberg and Campa (2010) states that the reason for low sensitivity of CPI to exchange rate changes is that the distributors of goods in the country absorb some of the exchange rate fluctuations such that they maintain market share. Hellerstein (2011) adds that distributor profit margins provide partial insulation from internationally transmitted shocks.

3.4.1.1 Limitations of the Bacchetta-Wincoop Approach to ERPT Asymmetry

Firstly, the assumption that importers bring in intermediate products only is far-fetched as most imports, especially in less developed countries, consist of finished products. The reason for importing finished products could be that the importing countries have limited capacity to assemble the intermediate goods into finished products. Secondly, it is difficult to understand the notion that the exchange rate pass-through to imports is complete while that on consumer prices is zero. Evidence from many studies such as by Al Samara et al. (2013), Antoniades and Zaniboni (2016) and others have consistently shown that exchange rate pass-through to consumer prices is significantly different from zero even though it is lower than ERPT to import prices in many cases.

3.5 EMPIRICAL LITERATURE

This section interrogates the empirical findings by scholars in exchange rate pass-through in developed countries, emerging markets as well as developing countries and finally in South Africa. Furthermore, the empirical literature assesses the various models and relevant variables, including the nature of data used to do the analysis. This helps to inform the model, type of data and variables used in this research, albeit modifications may arise in the actual execution of the quantitative analysis. Besides being used as a guide for models, variables and data used, the other reason for categorising empirical findings is that the only way a country can judge whether it is faring well economically is when they have comparative studies so that international results are used as credible benchmarks for their own performance.

3.5.1 Evidence from developed countries

Gagnon, Mandel and Vigfusson (2014), as well as Nakamura and Steinsson (2016), argue that the actual long-run pass-through is substantially higher than the standard estimates because published price indexes miss the price changes associated with item replacement. Their argument is that if the prices of new products entering the index have already adjusted to exchange rate movements then the response of these prices to movements in exchange rates would be 'lost in transit.' They conclude that the measured pass-through is substantially underestimated; implying that exchange rate pass-through to US import prices is more complete in the long run than was previously assumed.

Gagnon, Mandel and Vigfusson (2014) used quarterly USA import prices to estimate the ERPT, taking into account the existence of missing prices as a result of item entry and exit into the index. After controlling for the selection bias, Gagnon, Mandel and Vigfusson (2014) reported an insignificant downward bias in the ERPT for USA and therefore concluded that the ERPT of about 0.4 that excluded oil, was stable. The study used OLS model and excluded oil prices as these tend to cause a spike in the price response and may result in spurious ERPT which compromises policy

implications. The use of simple OLS does not show any dynamics in the model and therefore does not capture the significance of past exchange rate changes on current prices. This weakness is addressed by the Autoregressive Distributed Lag model used in this study.

3.5.1.1 Evidence of Exchange Rate Pass-Through to import and consumer prices in Developed Countries

Chabot and Khan (2015), relying on Canadian quarterly data from 1995 to 2013, used reduced form equations to estimate ERPT to Canadian consumer prices. They found that ERPT played a significant role in the inflation dynamics. ERPT for various sectors were estimated and the result was that the long-run ERPT was higher than the short-run ERPT and that the highest elasticity was in the energy sector with ERPT elasticity of 0.5 while the overall elasticity for CPI was 0.025 in the short-run and 0.075 in the long-run. While the Canadian study used various sectors to estimate sector-specific ERPT, this study only estimates the overall ERPT in South Africa, keeping in mind that sector-specific ERPT is important for sector-specific policies.

In earlier studies, Campa and Goldberg (2003) used cross-country data from the Euro area and the cointegration model showed that the short-run ERPT was smaller than in the long-run. They established that the long-run ERPT elasticity across countries was about 0.8. The study also found out that both LCP and PCP did not have any significant effect on ERPT. The study, however, noted that microeconomic factors related to composition of imports play a significant role in determining exchange rate pass-through. Another earlier study by Hakura and Choudhri (2001) verified that import price pass-through is attributable to behaviour of foreign firms and may not have anything to do with home inflationary environment. Choudhri and Hakura (2015), using a combination of simple regression, VAR-based and dynamic general equilibrium model and quarterly data from 1979 to 2010 for advanced economies as well as for emerging markets estimated the ERPT to import prices and concluded that the average ERPT for advanced and emerging markets were 0.60 and 0.54 respectively. The findings were that the nominal rigidities (incomplete ERPT) in local prices were due to prices that were sticky in the countries of origin of the imported goods. This thesis also uses a mixed approach to estimate the effect of the ERPT, extending this to offering robustness checks. The models used in this research are similar to a large extent, except the use of the general equilibrium model approach. The findings of Choudhri and Hakura (2015) confirm the PCP theory of ERPT.

Using Polish data and short-run dynamic equations, Przystupa and Wróbel (2014) found that the exchange rate pass-through was incomplete in the economy, even in the long run. The study also found the existence of pricing to market behaviour in both the long and short run. The research did not find any strong evidence of nonlinearity in import prices' reaction to the exchange rate. The study rejected the hypothesis of an asymmetric response to appreciations and depreciations in Poland. The hypothesis of an asymmetric reaction of prices in a high- and low inflation environment was rejected as well. Przystupa and Wróbel (2014) used single equation regressions to capture short-term ERPT and included output gap as one of their key determinants of ERPT. The single equation regressions were appropriate in the context of the study as they gave sharper results than VARs in some cases. However, the non-use of the distributed lag model means the results did not capture the dynamic nature of the model. This research uses both single (Autoregressive Distributed Lag Model) and the VAR approach which enables the study to capture the dynamic relationships among the variables.

In a study by Devereux and Yetman (2014) and using a VAR model, the Asia-Pacific countries generally had ERPT to import prices as well as inflation of between 0.7 percent to 1.3 percent when there was a depreciation of about 10 percent in their currencies. The study used quarterly data from 1982 to 2012 and the conclusion was that there was generally a failure of the policy of sterilizing the foreign exchange intervention due to low ERPT. Sterilisation of Exchange Rate Intervention works well where there is reasonable response of the domestic prices to changes in the exchange rate. The study by Devereux and Yetman illustrates the effect of very low ERPT when it comes to monetary policy implementation. In another earlier study by Devereux and Yetman (2002), ERPT for 122 countries using industry level data and applying OLS method on dynamic equations was estimated. The results of the study were that prices responded to changes in exchange rate changes but there was no clear direction of asymmetry for most countries. The study also found a non-linear relationship between ERPT and inflation. According to Devereux and Yetman (2002), as inflation increases, pass-through increases as well but at a declining rate. It is possible then to conclude that the results offer *prima facie* evidence of the crucial role of price rigidities in the determination of the ERPT.

Nguyen (2013) estimated ERPT using only one industry - the motor vehicle industry. The study relied on Norway quarterly data from 1991 (2^{nd} quarter) to 2012 (4^{th} quarter) and used both the OLS and Error Correction model. The study found that only 27 percent of the exchange rate shock was passed on to the prices of vehicles for the period. The problem with using only one industry is that

there is a lot of information lost from the other industries and therefore results cannot be used for policy purposes.

An earlier study that also used industry-specific data was by Goldberg and Knetter (1997). They used industry specific data to investigate the degree of ERPT to prices of goods in specific industries in the United States of America. The study used the Fixed-Effects model for data in specific industries across the country and the results showed that ERPT for the truck industry was 63 percent and 100 percent for motorcycles. The differences in the ERPT between the truck and the motorcycles could have been due to industry-specific factors. After aggregating the panel data, the estimation produced an ERPT of 60 percent for the USA. In another study, Goldberg (1995) used aggregate data on USA import prices and found industry specific evidence of incomplete exchange rate pass-through and that the pass-through rates were different for episodes of depreciation and appreciation thereby suggesting the presence of ERPT asymmetry. The two results from the same authors for the different periods were not so different, especially when the data was aggregated and not based on industry-specific data. Just like the Nguyen (2013) study, the Goldberg and Knetter (1997) also used industry-specific data and the results are not as good as when one uses aggregate data which gives more accurate information.

Poghosyan (2020) used a Panel-VAR with monthly data (Jan 1995 – May 2020) from Caucasus & Central Asia (CCA) countries to estimate ERPT to import and consumer prices as well as investigating presence of any ERPT asymmetry. The results were that there was a 10 percent effect on impact and 25 percent after 12 months. The study found no evidence of ERPT asymmetry with respect to size and direction of change of the exchange rate. A panel-VAR has the advantage of having a large sample size but results may be misleading due to country specific factors. This research does not adopt this methodology but rather uses data from one country and the normal ARD-lag model and simple VARs and an Error-Correction model.

A study of the ERPT to prices in Norway using time-series data and cointegrated VAR by Boug,(2020) indicated that ERPT was higher in import prices than in consumer prices. This confirmed both the Pricing-to-Market and Local Currency Pricing (LCP) hypotheses. Naug and Nymoen (1996) investigated the determinants of import prices for the period covering 1970 (1^{st} quarter) to 1991 (4^{th} quarter) using a multivariate cointegration methodology. The study showed a long-run exchange rate elasticity of import price of 0.63 and a long-run exchange rate elasticity of consumer price of 0.37. This showed that import prices react more to changes in exchange rate than

consumer prices. The estimated parameters were stable over the sample period. This study also estimates the cointegration model to measure the ERPT in the short-term and long-term.

Pollard and Coughlin (2003) analysed the ERPT using data from manufacturing industries in USA for the period 1978.Q1 to 2000.Q4. The study used simple OLS equations for each industry and the findings indicated that there was asymmetric response of import prices to exchange rate changes in USA as well as in the 32 Eastern European Economies. For most industries ERPT was greater than 50 percent while the ERPT was 100 percent for petroleum industries.

Bussière et al. (2014) using data from the G7 countries found that ERPT was incomplete and that non-linearities and asymmetries occurred across the countries. The standard assumption in the literature is that exchange rate pass-through is both linear and symmetric. In Japan, Wickremasinghe and Silvapulle (2004) found that import prices of manufacturing displayed a statistically significant difference in their adjustment to appreciations and depreciations and that the reaction to the former is larger than to the latter. This supports the pricing-to-market theory that states that ERPT to imports is low due to reluctance by firms to increase prices in an effort to maintain the market-share.

López-Villavicencio and Delatte (2010) used data from 1970 to 2009 for G7 countries to estimate the degree of response of consumer price index (CPI) to exchange rate changes. The paper used a mark-up model using the asymmetric Autoregressive Distributed Lag (ARDL) model and confirmed that prices reacted differently to appreciations and depreciations in the long-run. In the USA and Germany, the pass-through was lower during appreciation than during depreciation. The effect was different in France, the UK, Japan and Canada. In Japan, exporters increased pass-through during appreciation of the Japanese Yen and decreased it during depreciation in order to maintain market share in a country with strong barriers and this confirms the Pricing-to-Market theory.

A study of ERPT in the Commonwealth of Independent States (CIS) countries was carried out by Comunale and Simola (2016) using members states' data from 1999.Q1 to 2014.Q4. This period of study was appropriate as member states had stabilised after the organisation was formed in 1991 when the USSR was dissolved. Member states are former Soviet Republics that include Kazakhstan, Azerbaijan, Armenia, Georgia and Russia among others. The study applied the IV-GMM (Instrumental Variable- Generalised Methods of Moments) model as well as a Dynamic Factor model also known as the Dynamic (MG)- GMM model that can overcome and smoothen the results of IV-GMM. As mentioned by Chesher and Rosen (2020), IV-GMM is a suitable model when dealing with pooled data from a number of countries characterised by heterogeneity. The short-run ERPT

using bilateral exchange rate with the USA dollar was between 12 to 13 percent in the region and increased to above 50 percent when using the Nominal Effective Exchange Rate (NEER). With respect to exchange rate pass-through asymmetry, the Comunale and Simola (2016) study used dummy variables for appreciation and depreciation interacted with the different exchange rates and found no evidence of asymmetry.

Hájek and Horváth (2016) investigated how consumer prices responded to exchange rate shocks in the Czech Republic for the period 1998 to 2013. The study employed the Time-Varying Cointegrated- VAR (TVC-VAR) models using aggregate prices and its subcomponents and found that the response in prices happened with a lag of about nine and thirteen months after the initial shock. The average ERPT in the Czech Republic for the study period was around 20 percent at aggregate level, but was even higher for the food prices.

Using Time-Series Panel Regression and VAR estimations and quarterly Euro data spanning from 1991 to 2002 , Goldberg and Campa (2010) studied the sensitivity of consumer prices to changes in the exchange rate for the twenty-one OECD[7] countries using Panel Data Analysis. The average exchange rate pass-through for the OECD countries was found to be 0.17. The low ERPT for the region actually conceals the large cross-country differences in CPI sensitivity. This means that individual country studies are superior to panel studies, especially if individual countries are concerned more about domestic monetary policies rather than policies for the entire region. Similar results were also found by Comunale and Simola (2016) when they studied ERPT for the CIS countries.

3.5.1.2 Evidence of Exchange Rate Pass-Through to import and consumer prices in Emerging Economies

Emerging markets have generally registered low pass-through rates over the years. A study by Álvarez, Jaramillo and Selaive (2008) used monthly time-series data from 1996 to 2007 and a simple ECM model to report weak asymmetry between the reactions of import prices to appreciations and depreciations in Chile.

The study used monthly disaggregated import prices from mining, agriculture and industry and recorded the short-run ERPT of 0.52 and a long-run ERPT of 0.82 which can be said to be almost

[7] OECD is short for Organisation for Economic Co-operation and Development and is a group of countries with mutually beneficial trade agreements.

complete. The results are in line with the Producer Currency Pricing theory in which the low ERPT was due to sticky prices in the producer which translated to low ERPT to Chilean import prices.

Correa and Minella (2010) investigated nonlinearities in pass-through to consumer prices in Brazil. Quarterly data from 1995:Q1 to 2005:Q4 was applied to a Self-Exciting Threshold Autoregressive Model (SETAR) within a Phillips-Curve setting where the threshold is given by the lagged term of the dependent variable. The estimated Phillips curve with a threshold for the pass-through showed that the magnitude of a short run pass-through was higher when the economy was growing faster, when the exchange rate appreciates above a certain threshold and when exchange rate volatility was lower. This result is in line with the Pricing-to-Market theory (PTM) which states that ERPT increases when the local currency appreciates. A similar study employing the same Augmented Phillips Curve model by Kara and Dede (2023) found an incomplete pass-through in Turkey import and consumer prices despite the exchange rate volatility of the local currency known as the Turkish lira. Even though the exchange rate volatility was significant in explaining inflation it still could not fully transmit 100 percent of the exchange rate changes and instead it was the inflation inertia itself that drove the current inflation to the tune of 33 percent.

Shioji (2012) studied the exchange rate pass-through for China using a time-series sample from January 1980 to January 2010. The study applied a Time-Varying Parameter VAR (TVP-VAR) model without stochastic volatility and concluded that exchange rate pass-through to both import and consumer prices fell over time. This method gives results that are different from what theory suggests. Theory suggests that ERPT tends to increase in the long-run and consequently this approach to analysis may not be the best. A study of by Li and Zhang (2018) acknowledged the existence of a widely known exchange rate disconnect in the case of China. This research is rather unique in the sense that, while the majority of studies look at ERPT to import and consumer prices, this one focuses on ERPT to export prices. The study employs both the Instrumental Variable (IV) and Ordinary Least Squares (OLS) regression models to capture the degree of ERPT to export prices. The results showed that using the IV method there was a 67 percent ERPT into Free-on-Board (FOB) export prices of Chinese exports and a 100 percent ERPT when OLS method was used. Though this can be viewed as a flipside study of the ERPT on Imports or Consumer prices, it does shed light on the fact that using different methodologies leads to different solutions to an econometric problem. The results of Li and Zhang (2018) cannot be compared to those of Shioji (2012) in the sense that they focused on different ERPTs- one focused on ERPT to import and the other ERPT to export prices.

Using a Pooled (Panel) Regression analysis for monthly times series data from 2006 to 2010, Antoniades and Zaniboni (2016b) studied the relationship between retail prices and exchange rate across the Emirates that included Abu Dhabi, Dubai and Sharjah. The overall pass-through in the United Arab Emirates (UAE) rose from close to zero percent to about 25 percent in the long run. This, again, confirms the widely reported exchange rate disconnect in most economies around the world.

Nogueira and Junior (2006) used a structural VAR for a pool of countries (developed and emerging markets) prior to and following the adoption of the inflation targeting policy. The study by Nogueira and Junior (2006) found an exchange rate pass-through averaging 0.12 before the inflation-targetting policy and 0.09 after the adoption. This showed that the ERPT fell in an environment of low inflation rate as what has been reported in the literature. The study also found that ERPT was higher in both developed and emerging markets during depreciation.

3.5.1.3 Evidence of Exchange Rate Pass-Through to import and consumer prices in Developing Countries

It is of paramount importance to review literature from developing countries in order to understand how exchange rate changes have been affecting prices as well as the models and data used. This will support the approach to be used in the analysis in this research work.

Using the ARDL model Manguinhane and Simione (2021) carried a study on ERPT in Mozambique with quarterly data from 2001 to 2019. They found that there was asymmetric response of import and consumer prices to exchange rate changes and that the ERPT was higher during depreciation than during appreciation. In addition, the ERPT to consumer prices was incomplete at 50 percent. In Zimbabwe (Kavila and Le Roux,(2019) analysed monthly data from 2009:1 to 2012:12 using the ARDL model and the Rand/Dollar exchange rate and the results showed that a 1 percent appreciation of the Rand led to 0.098 percent increase in Zimbabwean prices. Since the Zimbabwe economy was using the US Dollar as the currency at the time, it meant that a depreciation of the US dollar against the Rand would cause prices to increase. A study of ERPT in Zambia by Roger, Smith and Morrissey (2017) using a Structural VAR model and quarterly data spanning from 1995 to 2014 verified that ERPT was incomplete and a shock from copper price resulted in a pass-through of 7 percent while monetary shocks produced an ERPT of 25 percent.

Studies from East and West Africa produced similar results as those in Southern Africa. In Kenya a study by Mhjama, (2011) used a Johansen Cointegration as well as the VAR approach and quarterly data from 1993Q1 to 2008Q1and found only a 36 percent transmission of exchange rate changes to domestic prices in the long run. The study also established that ERPT was higher during depreciation and lower during appreciation of the Kenya Shilling. In Ghana Amoah, (2017) a VAR analysis produced evidence of asymmetric effect with respect to direction and size of exchange rate changes. ERPT was found to be greater during depreciation than during appreciation and o that ERPT was higher during large changes in the exchange rate. A VECM was used by Bada (2016) to analyse quarterly data from Nigeria from 1995Q1 to 2015Q1 and the report established that the long-run ERPT was about 30 percent. The report also showed that there was an asymmetric response of import and consumer prices to the exchange rate changes with ERPT being higher in import prices than with consumer prices. Razafimahefa (2012) conducted a study for Sub-Saharan Africa (SSA) to estimate the exchange rate pass-through to domestic prices using a VAR. The study found that the ERPT was lower in those countries with flexible exchange rate regimes, sustainable fiscal policies, low inflation environment and credible monetary policies. On the ERPT asymmetry, the study showed that during appreciation the ERPT was lower than during depreciation and that the average exchange rate elasticity of consumer prices was about 0.4. Generally, the ERPT in SSA declined since the mid-1990s as a result of improved macroeconomic management (Razafimahefa, 2012). The study also estimated the exchange rate pass-through for South Africa for one and two years ahead to be between 0.13 and 0.16 respectively. When there is a very low ERPT in the economy then this situation may cause prices to rise by a large margin as the monetary authorities may overreact as they vigorously try to correct the macroeconomic disequilibria that may be caused by a shock in the demand for goods and services in the country. The evidence for this was seen through a study by André and Espidio (2022) in Mexico where authorities had to aggressively respond to the demand shocks and as a result caused inflation to rise and at the same time causing the local curreny volatility.

3.5.1.4 Empirical evidence from South Africa

Jooste and Jhaveri (2014), using a time-varying parameter VAR and quarterly data decomposed pass-through over time and across different monetary policy regimes. Results showed that exchange rate pass-through has been declining over time but volatile exchange rate leads to higher ERPT. The paper pointed out that persistent depreciation of the rand did not result in large increases in consumer prices for the period 2011 to 2013. Jooste and Jhaveri (2014) also found out that there was asymmetric pass-through during appreciation and depreciation. The study shows that the Binding-

Quantity Constraint Theory was confirmed from the studies undertaken even though it was not strong in this case.

A study on South Africa using monthly data from 1980 to 2009 by Aron et al. (2014) sought to investigate the link between exchange rate and import prices. The study used the single equation as well as systems Johansen model to capture the long-term ERPT. Aron et al., (2014) study found the short-horizon (6 months) ERPT to be 30 percent and the long-horizon (1 year) ERPT to be 50 percent. The study also found that the exchange rate pass-through was declining since the implementation of the inflation-targeting policy in South Africa. Lastly, the study also registered an increase whenever there was a small appreciation thereby confirming ERPT asymmetry in South Africa for the study period. This study goes beyond the analysis done by Aron et al. (2014) by also examining the historical decompositions to ascertain the causes of deviations in the behaviour of prices by looking at Baseline as well as post-shock movements of prices.

Karoro et al. (2009) used quarterly data from 1980 to 2005 on CPI time-series data and applied an Error-Correction model to measure the degree of ERPT in South Africa. The results were that the ERPT was not complete and that there was ERPT asymmetry, which increased during depreciation and decreased during appreciation thereby confirming the binding quantity constraint theory. The results confirmed the Binding-Quantity Constraints Theory.

Fedderke and Schaling (2005) applied an expectations-Augmented Phillips Curve model to investigate the relationship between exchange rate and inflation and inflation expectations in South Africa. The time-series analysis showed that the exchange rate pass-through to the general price level (measured by the gross domestic product (GDP) deflator) was 0.23 in the long run, implying that ERPT in South Africa was incomplete and closer to zero than unity. This study also examines the ERPT to prices in South Africa using the Augmented Phillips-Curve model to compare results.

Another study that focused on measuring ERPT before and after inflation-targeting policy was carried out by Rigobon (2007). The study also measured ERPT using time-series individual and aggregate prices. The study did not find any significant differences in the ERPT coefficients when applied to individual commodity prices and when applied to aggregate prices. Furthermore, Rigobon (2007) reported that the ERPT declined after the implementation of the inflation-targeting policy in South Africa. Table 3.1 below summarises the major findings and helps inform the methodology that this study adopts.

Panel data and individual product price data from Johannesburg area was used to estimate exchange rate pass-through to consumer prices by Parsley (2012). Employing the Error Correction Model (ECM) the study found the ERPT of between 0.14 percent and 0.27 percent depending on which model has been employed. The study also found that the ECM coefficient was insignificant, showing that there was a small increase in pass-through over the 20-year sample that covered 1990 to 2009 period.

3.5.2 Summary of empirical evidence of the ERPT to prices in developed and emerging markets

The summary is given in Table 3.1.

Table 3. 1: Empirical Evidence of ERPT to prices in Developed & Emerging Markets

Author(s)	Country	Data & Methodology	Results
Gagnon et al. (2014)	USA	Time series on Import prices. OLS model with Correction Factor (CF)	ERPT = 0.4 (Excluding oil prices). ERPT not affected by entry & exit of items in the consumer basket.
Comunale & Simola (2016)	Commonwealth of Independent States (CIS) or Former Soviet Republics	Panel Data (1991.q1 – 2014.q4). IV- GMM modelling	ERPT: 12 -13% without NEER. ERPT > 50% with NEER. No evidence of asymmetry in ERPT.
Przystupa & Wrobel (2014)	Poland	Systems Equations	ERPT incomplete both in the short-run and long-run.
Wickremasinghe & Silvapulle (2008)	Japan	Import prices	ERPT asymmetry confirmed. ERPT (appreciation) > ERPT (Depreciation) ∴PTM Theory holds
Alvarez et al. (2008)	Chile	Monthly disaggregated import data Jan 1996-May 2007. ECM modelling.	ERPT complete in the long-run. ERPT = 0.52 in short-run. Weak evidence of ERPT asymmetry.
Shioji (2012)	China	Monthly consumer time-series data (1980 – 2010). Time-Varying Parameter VAR model	ERPT incomplete both in short- and long-run.
Naug & Nymoen (1996)	Norway	Multivariate cointegration model 1970(1) – 1991(4)	High ERPT = 0.6 (import prices) & Low ERPT = 0.37 (consumer prices)
Goldberg (1995)	USA	Time-series on Import prices	ERPT incomplete

			Presence of ERPT asymmetry
Goldberg & Knetter (1997)	USA	Panel Data (industry specific data) Fixed-Effects modelling	63% ERPT (Trucks) 100% ERPT (Motorcycles) 60% ERPT for aggregated Panel Data
Pollard & Coughlin (2003)	USA	Cross-sectional data (1978.q1 – 2000.q4) Single OLS industry equation model	ERPT > 50% for most industries & ERPT = 100% for petroleum products
Devereux & Yetman (2002)	122 countries covered	Single non-linear models	No clear ERPT asymmetry . Existence of Price-Rigidities confirmed
Hájek and Horváth (2016)	The Czech Republic	Consumer Time series data. Aggregate data & Disaggregated Data. Time-Varying Cointegrated VAR.	ERPT = 20 (Aggregate data) ERPT higher for disaggregated data such as food prices.
Herzberg et al. (2003)	UK	Import price deflator. Linear ECM model & non-linear models	ERPT low even when £ appreciated. ERPT low due to price rigidities & Pricing-to-Market
Goldberg & Campa (2010)	OECD countries	Cross-country data. Panel regression.	ERPT = 0.17 for OECD.
Delatte et al. (2010)	G7 countries	Time-series data 1970 – 2009 ARDL model	ERPT asymmetry present for all G7 economies

Source: Author's own compilation, 2020

3.5.3 Summary of empirical evidence of the ERPT to prices in developing countries

The empirical evidence is summarised in Table 3.2.

Table 3. 2: Empirical Evidence of ERPT to prices in Developing Economies

Author(s)	Country	Data & Methodology	Results
Manguinhane and Simione (2021)	Mozambique	ARDL model applied on quarterly data (2001-2019)	Incomplete ERPT at 50% . Asymmetric response with ERPT higher during Depreciation
Kavila and Le Roux,(2019)	Zimbabwe	ARDL model used on monthly data from 2009 to 2012	Incomplete ERPT: ERPT higher during appreciation of the Rand (i.e. Depreciation of the US dollar used in Zimbabwe)
Roger et al, (2017)	Zambia	Structural VAR used on quarterly data from 1995 to 2014.	ERPT of about 7% due to copper prices & 25% due to Monetary shocks

Mhjama,(2011	Kenya	Johansen Cointegration & VAR models used on quarterly data from 1993Q1 to 2008Q1	ERPT asymmetry confirmed. ERPT (appreciation) > ERPT (Depreciation) ∴PTM Theory holds
Amoah,(2017)	Ghana	VECM & VAR models applied	ERPT higher during depreciation as well as during large exchange rate changes
Bada (2016)	Nigeria	VECM model used on 1995Q1 – 2015Q1 data	ERPT = 30%. ERPT higher in imports than in consumer prices. PTM Theory upheld

Source: Author's own compilation

3.5.4 Summary of empirical evidence of the ERPT to prices in South Africa

Summarised evidence on the empirical evidence of the ERPT to prices in South Africa is given in Table 3.3.

Table 3. 3: Empirical Evidence of ERPT in South Africa

Author(s)	Nature of data & Methodology	Results
Joost & Jhaveri (2014)	Time-varying parameter VAR model on time-series CPI data	0.35 in 1st quarter (2011-2013 contemporaneously) & 0.36 in 4th quarter (2011 -2013 contemporaneously)
Karoro et al. (2009)	Error Correction Modelling on CPI time-series data	Very high ERPT coefficient > 0.8
Akinboade et al. (2002)	VAR applied to CPI time series data	0.86 (long run)
Fedderke & Schaling (2005)	Multivariate cointegration & Johansen VECM on CPI data	0.23 (long-run)
Rigobon (2007)	Rolling regressions in a mark-up model on CPI data	0.12 (long-run)
Maduku & Contogiannis (2015)	Used Structural VAR and Recursive VAR , Monthly data from Jan 2002 to Dec 2015	5.49% (six months) to 11.55% (1 year)
Aron et al. (2014)	Single equation models & Johansen VECM model on Import Prices	0.3 (Short-run) 0.5 (long-run)
Parsley (2012)	Pooled Panel Data on CPI time-series data (1990 – 2009)	0.25 (for two years)
Nogueira (2006)	Structural VAR on CPI time-series data	0.2 (before Inflation targeting) & 0.1 (after Inflation Targeting)
Razafimahefa (2012)	Single country equations using VAR and ECM models	0.4 (for SSA) & 0.13 – 0.16 (for South Africa)

Source: Author's own compilation

3.6 GENERAL ASSESSMENT AND CONCLUSION ON EMPIRICAL LITERATURE

The overarching objective of the empirical evidence was to shed light on methodologies used to analyse data as well as the results obtained by various scholars around the world. This helps to inform

other researchers on the kind of models to adopt and adapt in a bid to analyse data for studies in the same niche area. The other advantage of empirical review is for robustness checks in similar studies. The ERPT to developed countries were generally a little lower than in developing countries as was found by Nogueira and Junior (2006). However, what the developed and emerging, developing countries share in common is that all the studies reviewed registered incomplete ERPT. Most of the studies showed that ERPT into import prices were higher than ERPT into consumer prices. This is an affirmation of the Pricing-to-Market behaviour by firms in an attempt to maintain their markets.

Most studies found asymmetric response of prices to changes in the exchange rate. The results were mixed with some reporting ERPT increase during depreciation than during appreciation and then others found the opposite to be true. The asymmetric[8] results depend on the behaviour of firms with some increasing the pass-through during appreciation and then reducing the pass-through during depreciation in an effort to maintain the customer base, assuming absence of Binding-Quantity Constraints in the economy. The majority of the studies, however, showed that ERPT was higher during depreciation than it was during appreciation, supporting therefore the Binding-Quantity Constraints Theory. On the methodology front, the models used most were the Time-Varying Parameter VAR (TVP-VAR), simple OLS, VAR and the Error-Correction Model (ECM). The most suitable models to use from the literature are the ARDL, Johansen Cointegration and the Structural VAR models. This research shall uses these models to analyse the ERPT to import and consumer prices. The rationale behind using these models is that the ARDL shall give the impact (regression) parameters linking prices to exchange rate changes and other control variables while the ECM gives the long-run ERPT to prices.

[8] Literature suggests two major causes of ERPT asymmetry. The first one is the exchange rate changes (depreciation and appreciation) and the other one, according to Miyajima (2019), is the Business Cycle. The Business Cycle effect posits that ERPT increases during the upturn and falls during the downturn in economic activities.

CHAPTER FOUR:RESEARCH METHODOLOGY

4.1 INTRODUTION

This chapter seeks to develop the appropriate research methods that address the stated objectives. The research basically focuses on estimating four baseline models and their alternative specifications. The four models are: model for estimating exchange rate pass-through into import prices as 1st stage pass-through analysis, followed by a model to estimate exchange rate pass-through into consumer prices as 2nd stage pass-through analysis, then a model for investigating the direction and size of the pass-through asymmetry with regards appreciation and depreciation. Studies that followed this approach include those of Kabundi and Mbelu (2016), Pollard and Coughlin (2003) and others.

This chapter is very much linked to the chapter on the theoretical and empirical literature. The theoretical literature part serves to give the broad theoretical model(s) used such as the Pricing-to-Market and the Expenditure Switching Model when examining the incidence of ERPT or the Cash-in-Advance and the Portfolio-Balance model in the detrmination of loss of value in the local currency. The empirical section now gives us the opportunity to dovetail on the actual estimation model used such as Error-Correction model, Time-Varying Parameter model, Panel Data or simply Ordinary Least Squares, among others. The empirical literature is crucial for understanding the nature of variables used in specific studies and this informs the approach this research takes. In an nutshell, then, the section on literature review set out the agenda for the research methodology. The rest of this chapter is organised as follows: 4.2 discusses the research philosophy, section 4.3 deals with the emperical model specificationl for estimating ERPT into consumer and import prices as well as specifying the model for asymmetric ERPT and finally the model for inflation momentum and expectations, section 4.4 gives the the definition of variables, data sources and predicted signs of regression parameters on the variables.

Section 4.5 explains the estimation techniques and diagnostic tests. The section also discusses the descriptive tests, graphical visualisation of trends on the key variables and the issue of stationarity tests. Section 4.6 explains the ADF and the Phillips-Perron tests for testing the presence of unit root in variables. The lag-length criterion test is discussed under section 4.7 and the cointegration tests are discussed in section 4.8. The VECM stability test is given under section 4.9. The Ramsey's Reset test and the Recursive Least Squares estimates and testing are explained under sections 4.10 and 4.11

respectively. Section 4.12 and 4.13 discuss the problem of autocorrelation and chapter conclusion respectively.

4.2 RESEARCH PHILOSOPHY

4.2.1 Introduction

According to Ormstom et al. (2014), different methodological approaches are underpinned by particular philosophical assumptions and it is crucial to maintain consistency between the philosophical orientation and the methods adopted. The two branches of metaphysics which are ontology and epistemology guide the research agenda. In brief, ontology deals with establishing the truth from a world of ideas and epistemology deals with the methodologies of figuring out those truths. The research methods, as indicated by Guba and Lincoln (1994), are linked to questions relating to ontology (form and nature of reality in the social world) and epistemology (knowledge extraction from those realities in the social world). According to Guba and Lincoln (1994) the ontological question in research seeks to lay bare the assumptions around abstract ideas and then extract reality out of them while epistemology influences the research framework in the quest to discover knowledge. The ideas in ontology and epistemology are used in this research as we make assumptions about relationships among variables and then apply these ideas to models that are useful in extracting reality about such linkages through econometrics and statistics.

4.2.2 Pragmatic Research Philosophy

A pragmatic discipline is one with a prominent focus on practical research and theory as well as addressing the practical implications. Goles (2000) states that pragmatism has its roots in the work of late 19th and early 20th century scholars and philosophers such as William James, C. S. Pierce, John Dewey and others. Goles (2000) goes on to explain pragmatism as a welcome opportunity to improve the rigour and relevance of research methodology. Pragmatism recognizes the importance of theory as a means of explaining and predicting phenomena, while at the same time subjecting it to the test of practice and time in order to determine its usefulness. This study adopts and adapts existing analytical tools so that the analysis fits the purpose of the current research. This study interrogates in a practical way the scientific approach of making use of the theoretical frameworks such as the Pricing-to-Market and the Binding Quantity Constraint in assessing the degree of the Exchange Rate Pass-Through in South Africa. The New Keynesian Phillips-Augmented model is practically deployed to test the pass-through to consumer prices . These models are meant to address the main research questions of the study.

4.3 EMPERICAL MODEL SPECIFICATION

This section specifies the model which was built to achieve objective one, restated below:

Objective 1: **To measure the degree of transmission of exchange rate changes to import and consumer prices as well as the speed of adjustment in the event of a system disequilibrium.**

4.3.1 The Autoregressive Distributed Lag (ARDL) Model

The Autoregressive Distributed Lag (ARDL) model is a single-equation model that is used to analyse dynamic relationships within time series data and is an ordinary least squares (OLS) based. The model can be applied for both series with mixed order of integration as well as non-stationary series, unlike the pure OLS model. The general-to-specific modelling approach is employed to decide the optimal number of lags to be used in order to capture the data generating process.

The general ARDL specification takes the following form:

$$Y_t = \beta + \emptyset_1 Y_{t-1} + \emptyset_2 Y_{t-2} + \cdots + \delta_1 \Delta X_{1t-1} + \delta_2 X_{1t-2} + \cdots + \vartheta_1 \Delta X_{2t-1} + \vartheta_2 \Delta X_{2t-2} + \cdots + \varepsilon_t \quad \text{.....(4.1)}$$

Which, for brevit purposes, can be written as:

$$Y_t = \beta + \sum_{i=1}^{K} \varphi_i Z_{it-i} + \varepsilon_t, \quad where\ i = 1, 2, 3 \ldots, K \quad \text{.....(4.2)}$$

Where **Y** is the dependent variable, **Z** represents an exogenous variable that includes lagged values of the dependent variable and **φ** is the corresponding parameter.

To estimate the degree of transmission of exchange rate changes to import and consumer prices the study used the ARDL model since it is a robust method especially when variables are non-stationary. The other advantage of the ARDL method is that one can capture the dynamic nature of the variables themselves over time. For robustness, the VECM was used to capture the speed of adjustment from long-run disequilibrium.

The variables used to estimate the exchange rate pass-through to import and consumer prices, the exchange rate pass-through asymmetry and the inflation model are based on both theoretical and empirical literature. The model for estimating the exchange rate pass-through to import price is the modified version of the one used by Nogueira (2007) and is given below:

$$lnImport_{Price_t} =$$

$$f\left(lnImport_{Price_{t-i}}, lnNER_{t-i}, lnProdc_{RSA_{t-i}}, lnProdc_{USA_{t-i}}, lnCPI_{RSA_{t-i}}, lnCPI_{USA_{t-i}}, IncGap_{t-i}, FinGap_{t-i}\right)$$

……..….(4.3)

Where lnImport_Price is the log of Import Price, lnNER is the log of Nominal Exchange Rate, lnProdc_RSA represents the log of Production cost in South Africa, lnProdc_USA stands for log of production cost in the USA (largest trading partner of South Africa), lnCPI_RSA is the log of South African Consumer Price, lnCPI_USA stands for the USA Consumer Price, IncGap and FinGap represent Income Gap and Financial Gap respectively.

The import equation represents the first stage ERPT. It is envisaged that the second stage pass-through is when import prices influence the consumer prices and so the study also estimates the consumer price model where consumer price as a dependent variable is proxied by inflation. The consumer price model is shown in (4.4).

$$Infl_t = f\left(infl_{t-i},\right.$$

$$\left.lnImport_{Price_{t-i}}, lnNER_{t-i}, lnProdc_{RSA_{t-i}}, lnProdc_{USA_{t-i}}, lnCPI_{RSA_{t-i}}, lnCPI_{USA_{t-i}}, IncGap_{t-i}, FinGap_{t-i}\right)$$

……(4.4)

The Autoregressive Distributed Lag model in this section is used to measure the impact of exchange rate changes on import and inflation in South Africa. Prices in an economy respond to shocks in other variables with a lag. It is therefore imperative to consider a model that allows the dynamic process and takes into account price inertia as prices do not adjust in one period, especially quarters (Bussiere, 2013). To strengthen the case for the ARDL model, Campa, Goldberg and González-Mínguez (2007) used one lag in both the prices and exchange rate as they realised that prices react after about 3 months (1 period) to changes in the exchange rate.

Most studies on ERPT have looked at the short-run dynamic asymmetries only. Researchers like Wickremasinghe and Silvapulle (2004) and López-Villavicencio and Mignon (2017) have dealt with the long-run asymmetry using ARDL framework. This thesis addresses the shortcomings of the short-run dynamic model by estimating an ARDL model as well. This allows us to examine the long-run asymmetries together with the short-run asymmetry in pass-through. According to Banerjee, Dolado and Mestre (1998), the long-run asymmetry is the static equilibrium solution. The other advantage of the ARDL model is that the estimates are consistent and efficient in the presence of endogenous explanatory variables. Pesaran (2008) argues that the ARDL model yields consistent coefficients irrespective of whether the variables are I(1) or I(0) since unit root tests normally produce misleading results. In log-linearized form, the relationship is expressed as in (4.5):

$$lnimp\_price_t = \phi_0 + \phi_1 lnNER_t + \phi_2 lnProdc\_usa_t + \phi_3 cons\_price_t + \phi_4 incgap_t + \phi_5 fin\_gap_t + \varepsilon_t. \quad \text{(4.5)}$$

In this equation *lnimp_price* is the log of import price, *lnNER* is the log of nominal exchange rate, *lnProdc_usa* is the log of production cost in the USA, *cons_price* is the South African consumer price and incgap is the income gap in South Africa, and *lnfin_gap* is the log of financial gap To consider the possibility of non-stationary processes in the exchange rate as well as other exogenous variables, in line with Nogueira (2007), variables in (4.2) are expressed in 1st differences to give:

$$\Delta cons\_price_t = \beta + \gamma cons\_price_{t-1} + \delta \Delta lnNER_{t-1} + \tau \Delta lnProdc\_usa_{t-1} + \eta \Delta inc\_gap_{t-1} + \varphi \Delta fin\_gap_{t-1} + \alpha lnimp\_price_{t-1} + \varepsilon_t \quad \text{(4.6)}$$

The above model has an additional variable *fin_gap,* known as the financial gap, capturing the quality of the financial market. The variable *inc_gap* captures the income gap in real terms and *cons_price* is the consumer price. In situations characterised by longer business cycles and market volatilities, a variable called financial gap must be included in estimating import price and inflation (Gilchrist et al., 2015). The argument is that financial distortions create incentives for firms to raise prices.

The final model then takes the form given below:

$$\Delta\, lnimp\_price_t = \beta + \sum_{k=1}^{n} \gamma \Delta\, lnimp\_price_{t-k} + \sum_{k=0}^{n} \delta \Delta lnNER_{t-k} + \sum_{k=0}^{n} \tau \Delta lnProdc\_usa_{t-k} + \sum_{k=0}^{n} \eta \Delta \text{inc\_gap}_{t-k} + \sum_{k=0}^{n} \alpha \Delta \text{cons\_price}_{t-k} + \varepsilon_t \quad \text{(4.7)}$$

where Δ is the change operator and a simple OLS is applied to estimate the model. A general-to-specific approach using the Lag-length Criteria test is used to determine the optimal number of lags required (more discussion on number of lags comes under regression diagnostics). The ERPT is captured by the coefficient of the lagged exchange rate change. The short-run effect is the coefficient of the exchange rate change in one lag following a depreciation. The long-run effect or static solution is captured by the expected value after all the dynamic adjustments have been factored in or simply the coefficients after one lag.

4.3.2 The Vector Error Correction Model (VECM)

To estimate the short-run and the long-run ERPT the study will use the Vector Error Correction (VECM) model as shown below.

$$\Delta y_t = \Gamma_0 D_t + \Pi Y_{t-1} + \sum_{j=1}^{p-1} \Gamma_j \Delta y_{t-j} + \varepsilon_t \text{ , j = 1, 2, …, p-1} \quad \text{(4.8)}$$

Where $\Delta y_t = \begin{bmatrix} \Delta lnImport\_price_t \\ \Delta lnNER_t \\ \Delta lnProdc\_RSA_t \\ \Delta lnProdc\_USD_t \\ \Delta infl\_RSA_t \\ \Delta incGap_t \\ \Delta finGap_t \end{bmatrix}$ ……..

Where D_t is a vector of deterministic variables (constant, trends, and /or seasonal dummies) and ε_t is the independent p-dimensional Gaussian variables with mean of zero and variance matrix Λ.

$\boldsymbol{\Gamma_j = -I + \phi_1 + \ldots + \phi_j}$**, j = 1, …, p -1** are ***m***x***m*** matrices and the coefficients in the matrix represent the short-run impacts of independent variables in the model. The term shown as Π is a matrix of rank r and showing the number of cointegrating vectors and gives the long-run impact of the independent on the endogenous variables.

The VECM model is intended to achieve Objective 1 by estimating the short and the long-run relationship between prices and exchange rate as well as the speed of adjustment whenever a disequilibrium occurs in the system.

Having established the unit-root statuses of the variables it is important to also capture the short-term and the long term-term relationships that exist among the variables. This is done through the use of the VECM. Vector Error Correction Model (VECM) captures the dynamic relationship between the dependent and the independent variables over time as well as capturing the degree and speed of exchange rate pass-through to import prices.

In terms of the variables this research, in addition to the usual output gap, brings on an important variable called the financial gap as an extra control factor to explain exchange rate pass-through. This variable is informed by the fact that any large difference between the actual and the expected financial resource has implications for the cost of production and subsequently the consumer prices. Following the model used by Choudhri and Hakura (2015), Frankel, Parsley and Wei (2012) as well as Fedderke and Schaling (2005) and others, this study estimates a simple regression model as well as a VECM model in order to understand the dynamics among variables over a period of time.

Traditionally, exchange rate pass-through is measured by regressing changes in published import price indexes on changes in trade-weighted exchange rate indexes along with other explanatory variables (Gagnon, Mandel and Vigfusson, 2014). Many studies of the pass-through effect are based on short-run dynamic equations; such estimates have been made for Poland by Przystupa and Wróbel, (2014). This paper estimates a long-run reaction of import prices to the exchange rate. If variables are cointegrated, then limiting the analysis to the short run reduces the information content. On the

other hand, cointegration analysis requires a data span sufficient for inferences on equilibrium levels of the variables. Our analysis covers a forty-year period - the first quarter of 1980 to the last quarter of 2019 - which makes our conclusions more credible.

The speed and direction of exchange rate pass-through to import prices is captured in this study by use of a VECM and one such equation of the VECM is shown below:

$$\Delta lnimp\_price_t = \beta_0 + \beta_1 EC_{t-1} + \sum_{i=0}^{4} \beta_{2,i} \Delta lnNER_{t-i} + \sum_{i=0}^{4} \beta_{3,i}\, \Delta lnprodc\_usa_{t-i} + \sum_{i=0}^{4} \beta_{4,i}\, \Delta lnprodc\_rsa_{t-i} + \sum_{i=0}^{4} \beta_{5,i}\, \Delta lnimp\_price_{t-i} + \sum_{i=0}^{4} \beta_{6,i}\, \Delta inc\_gap_{t-i} + \sum_{i=0}^{4} \beta_{7,i}\, \Delta fin\_gap_{t-i} + e_t \quad \text{(4.9)}$$

EC is the Error Correction Term (ECM). (i =0, 1…, 4 and representing quarters), *imp_price* is import price, *NER* is nominal exchange rate, *prodc_usa* is production cost in the USA, *prodc_rsa* is production cost in South Africa, *inc_gap* is income gap and *fin_gap* is financial gap. The advantage of the VECM is that it captures both the short-term relationships among the variables as well as their long-term relationships through the error-correction term. The VECM results are important for policy purposes especially in a situation where both the short-term and the long- term effects of a policy are important to estimate.

Objective number 2 Model: To examine the existence of asymmetric exchange rate pass-through to import and consumer prices between appreciation and depreciation episodes.

4.3.3 The Autoregressive Moving Average (ARMA) model

This section re-estimates the import-price model using ARMA but this time including some pass-through asymmetry dummies. The addition of these dummies also helps to us to check for the relevance of such variables through the variable redundancy test. Objective two in the initial chapter of this thesis was about examining the existence of an asymmetric exchange rate pass-through between appreciation and depreciation as well as the differential impact exchange rate has on import and consumer prices (inflation) in South Africa. This section is about the construction of dummies that would represent appreciation and depreciation of the Rand against the US dollar.

A forecasting model in which the methods of autoregression (AR) and moving average (MA) are both applied to well-behaving time series is known as the ARIMA presentation. The

assumption of the ARIMA model is that the time series is stationary and fluctuates uniformly around a particular trend. The ARIMA forecasts are basically the past values of the dependent variable times a scalling factor plus the past residuals. The ARIMA is a parsimonious presentation of a weakly stationary stochastic process in terms of two polynomials which are the AR and the MA processes. In essence, the multivariate ARIMA model describes the dynamics of an individual time series based on its own history up to time t-1 as well as its past residuals that form part of the uncertainty component (Gomes and Castro, 2012)**.**

This research uses a mixed pth order AR process and a qth order MA process, which is formally written as ARIMA (p, q) and is represented by an equation below.

$$\boldsymbol{Y_t = \alpha + \sum_{i=1}^{p} \theta_i Y_{t-i} + \sum_{j=1}^{q} \psi_j \varepsilon_{t-j} \quad where \begin{cases} i = 1, 2, 3, \dots, p \\ j = 1, 2, 3, \dots, q \end{cases}} \quad \textbf{(4.10)}$$

In the equation, Y is the dependent variable of interest, ε is the error term in the system whose past values would form the moving average series and α, θ and ψ are regression parameters. In fact θ1, θ2, θ3 ,…, θp are the AR parameters and ψ1, ψ2, ψ3, …, ψq are the MA process parameters while ε_i is the white noise process.

The import equation is once again shown as $\Delta lnimp\_price_t = \beta_1 \Delta lnNER_t + \beta_2 \Delta lnprodc\_rsa_t + \beta_3 \Delta lnprodc\_usa_t + \varepsilon_t$. In order to investigate the asymmetric effect of the exchange rate changes to import prices, we introduce and construct dummies shown below:

$$A_t = \begin{cases} 1 \; if \; \Delta lnNER_t < 0 \\ 0 \; otherwise \end{cases}, \; D_t = \begin{cases} 1 \; if \; \Delta lnNER_t > 0 \\ 0 \; otherwise \end{cases} \quad (4.11)$$

A and *D* are dummies standing for appreciation and depreciation (of the rand respectively). If $\Delta lne < 0$ then it means local residents now pay less South African Rands to get a unit of the US dollar, and the opposite is true. The component $\beta_1 \Delta lns_t$ in the import equation is replaced by $\beta_{1A} A_t \Delta lns_t + \beta_{1D} D_t \Delta lns_t$ to result in an equation suggested by Pollard and Coughlin (2003) that is shown below:

$$\Delta infl_t = \beta_{1A} A_t \, \Delta lnNER_t + \beta_{1D} D_t \Delta lnNER_t + \beta_2 \Delta lnprodc\_rsa_t + \beta_3 \Delta lnprod\_usa_t + \varepsilon_t \quad (4.12)$$

where the interactive parameters β_{1A} and β_{1D} represent appreciation and depreciation coefficients respectively. The signs and significance of these coefficients tell us if there exists differential impact of exchange rate change on import prices and therefore confirms exchange rate pass-through asymmetry of depreciation and appreciation to import prices.

This study also focuses on analysing the behaviour of the import prices when there are episodes of high and low exchange rate changes that are akin to volatility. To do this, we introduce a threshold for exchange rate changes below which we declare a low change (L) and above which we declare a high change (H). In their study, Pollard and Coughlin (2003) did a sector specific study and used an exchange rate threshold of three percent. In this study, due to the volatility nature of the Rand, we use a threshold of 4 percent and as a result we get the following dummies:

$$L_t = \begin{cases} 1\ if \mid \Delta NER_t \mid < 4\% \\ 0\ otherwise \end{cases},\ H_t = \begin{cases} 1\ if\ \mid \Delta NER \mid \geq 4\% \\ 0\ otherwise \end{cases} \ldots\ldots\ldots\ldots \text{(4.13)}$$

As we did with the appreciation and depreciation dummies, we replace $\beta_1 \Delta lnNER_t$ with $\beta_{1L} L_t \Delta lnNER_t + \beta_{1H} H_t \Delta lnNER_t$ and final estimating model is as follows:

$$\Delta lnimp\_price_t = \beta_{1L} L_t\ \Delta lnNER_t + \beta_{1H} H_t \Delta lnNER_t + \beta_2 \Delta lnprodc\_rsa_t + \beta_3 \Delta lnprod\_usa_t + \varepsilon_t \ldots\ldots\ldots\ldots \text{(4.14)}$$

In equation 4.14 the interactive parameters β_{1L} and β_{1H} respectively indicate the differential impact of the low and high exchange rate changes on import prices. This is also a form of exchange rate pass-through asymmetry from high and low changes in the exchange rate.

4.3.4 Autoregressive Moving Average (ARMA) for Threshold Regime-Switching Model

To extend the asymmetric analysis (objective 2) the threshold regime-switching model was estimated. The idea of estimating a threshold or regime-switching model is to assess the differential impact of some exogenous variables of interest (in this case production costs) to domestic prices such as Import Price, as one moves from lower exchange rate band to higher exchange rate band. In simple terms the question being answered is whether there is asymmetric effects of exchange rate on domestic prices through some exogenous variables.

Threshold regression models are models in which predictors are associated with the outcome in a threshold-dependent fashion. In this regard, the research's interest is to assess the threshold-dependent association between Import Prices and Production Costs (local and foreign). As indicated by Fong *et al.* (2017), a threshold regression is a non-regular or non-linear equation model that depends on change points or thresholds. The break-points are, in essence, regimes created using a threshold variable. Typically, time-series data are divided into regiments in which the threshold variable (Exchange Rate, in this case) and the exogenous (costs) variables are simultaneously

thresholded. The outcome and predictor relationships are allowed to differ across regiments.in the model. In this research, the leading threshold variable is the exchange rate and the other exogenous variables are the two production costs which are local and foreign. The exogenous variables are also thresholded in tandem with the leading threshold variable so that only data points of the exogenous variables that fall within the thresholds are used in the piece-meal regressions for that exchange rate band. The idea is to see if different results are obtained for the regression of Import Price on Production Costs as we move from one exchange rate band (regiment) to another. This has important implications for monetary policy especially when one wants to see the dynamic impact of production costs on Import Prices when we operating within a particular exchange rate band.

The analysis uses a regression model with T observations and ***m*** potential thresholds resulting in ***m*** **+1** regimes (bands). The regime-switching model, inspired by Klutse et al. (2022), can be written as shown below:

$$y_t = \acute{X}_t\beta + \sum_{j=0}^{m} 1_j(q_t, \tau) * \acute{Z}_t\delta_j + \varepsilon_t \text{ , j = 0, 2, 3,..., m} \quad \text{.....(4.15)}$$

In the equation y is the dependent variable and in the case of this study, it is the Import Price. The variable $\mathbf{q_t}$ is the value of the threshold and $\boldsymbol{\tau}$ is the threshold limit, **Z** is a vector of the exogenous variables and in our case they are Production Cost in South Africa and Production Cost in the USA. The parameter δ is the coefficient of thresholded variable and these are the production costs. The term 1_j is an indicator function taking a value of one (1) if $-\infty < \boldsymbol{q_t} < \boldsymbol{\tau}$ and if $-\tau < \boldsymbol{q_t} < \infty$ and zero (0) otherwise in the case of two thresholds. This study uses multiple thresholds and therefore the regimes can be written as $-\infty < \boldsymbol{q_1} < \boldsymbol{q_2} < \boldsymbol{q_3} < \ldots < \infty$.

In the model the parameters of the X variables remain unchanged across regimes but the parameters of Z are regime-specific. The non-linear least squares associated with the threshold equation is:

$$S(\delta, \beta, \tau) = \sum_{t=1}^{T}\left(y_t - \acute{X}\beta - \sum_{j=0}^{m}\acute{Z}\delta_j\right)^2 \quad \text{.....(4.16)}$$

The threshold regression estimates are obtained by minimising $S(\delta, \beta, \tau)$ with respect to parameters. The diagnostic tests for threshold regressions are not well developed but the usual t-statistics can be used to comment on the significance of the threshold parameters. Lastly, it must be noted that the threshold regression can be compared to the estimation of two or more time series data with a structural break after performing a Chow-Breakpoint test in a given time series.

4.3.5 Hybrid New Keynesian Phillips-Curve (HNKPC) Model

The HNKPC model was estimated to adresss objective 3**: To measure the level of of exchange rate volatility on, inflation in South Africa.**

To estimate the model that elicits answers on the role of inflation expectations as well as inflation momentum on current inflation the study runs a Hybrid New Keynesian Phillips-Augmented Expectation NKPC equation shown below:

$$\pi_t = \alpha_0 + \alpha_1 E(\pi_{t+1}) + \alpha_2 \pi_{t-1} + \alpha_{3A} A\Delta NER_{t-1} + \alpha_{3D} D\Delta NER_{t-1} + \alpha_4 inc\_gap_t + \alpha_5 \text{fin\_gap}_t + \alpha_6 Dum_t + \varepsilon_t \quad \text{.....(4.17)}$$

Equation (4.17) is a modified version of the HNKPC model suggested by Calvo (1983). It incorporates both the backward-looking (π_{t-1}) and forward-looking $E(\pi_{t+1})$ components. The former measures the lagged values of inflation and represents inflation momentum while the latter captures expected inflation..The variable *Dum* is the inflation targeting policy dummy, taking value of 1 when adopted and 0 otherwise. ΔNER_{t-1} stands for the change in the exchange rate and is used as a proxy for exchange rate volatility, inc_gap_t is the income gap and fin_gap_t represents the financial gap. The model aslo shows coefficients that include α_{3A} and α_{3D} and they represent parameters for exchange rate appreciation and depreciation respectively.

4.4 DEFINITION OF VARIABLES

The variables used in the estimation of the ERPT and other various statistical analysis are listed and described in Table 4.1.

Table 4. 1: Definition of variables

Variable	Source	Description	Role of the variable	Expected sign in the regression equation
imp_price	SARB statistics	Import Prices (Border Import Price Index)	Endogenous variable	Mostly it is an endogenous variables
cons_price	SARB statistics	Composite figure from weighted specific price indices of a consumer basket with 2010 as a base year.	Endogenous variable	Mostly it is an endogenous variables
Prodcost_rsa	SARB statistics	Local Marginal Cost (domestic PPI) = This is the	Exogenous	Expected to have a positive coefficient in

		local cost of production index (base year = 2010)		both import and inflation equation
Prodcost_usa	International Financial Statistics (IFS-IMF) data	Exporter's marginal cost which is, in effect, the foreign producer price index (base year = 2010)	Exogenous	Expected to have a positive coefficient in both import and inflation equation
Financial_gap	Calculated	Financial gap measured as the difference between the actual foreign direct investment (FDI) and the Hodrick-Prescott filtered real FDI. (FDI inflows = % of GDP)	Exogenous	Expected to have a positive coefficient in both import and inflation equation
Gdpnom_rsa	SARB statistics	Nominal GDP in South Africa (millions of Rands)	Exogenous	A negative sign on coefficient expected in inflation and import equations
Gdpreal_rsa	SARB statistics	Real GDP of South Africa (2010 = Base year) (millions of Rands)	Exogenous	A negative sign on coefficient expected in inflation and import equations
Incgap_real	Calculated	Real GDP gap measured as the difference between the real GDP, its potential GDP calculated as the long-term trend. The long-term trend is basically the Hodrick-Prescott (HP) filtered real GDP using a lambda (smoothening coefficient) value of 1600.	Exogenous	A positive sign on coefficient expected in inflation and import equations
NER	SARB statistics	Bilateral exchange rate (ZAR with the US$)	Exogenous	A positive sign on coefficient expected in inflation and import equations

NEER	SARB statistics	Unadjusted weighted average rate at which one country's currency exchanges for a basket of multiple foreign currencies	Exogenous	A positive sign on coefficient expected in inflation and import equations
infl_rsa	IFS-IMF data	South African Inflation rate (CPI Based)	Endogenous variable	Endogenous variable
infl_usa	IFS-IMF data	USA Inflation rate (CPI Based)	Exogenous variable	A positive sign on coefficient expected in inflation and import equations
Cpi_rsa	IFS-IMF data	Consumer price index (2010 = base year)	Endogenous variable	Endogenous variable
Cpi_usa	IFS-IMF data	Consumer price index (20101 = base year)	Exogenous variable	A positive sign on coefficient expected in inflation and import equations
ERV	Calculated	Exchange rate volatility captured through the Generalised Autoregressive Conditional Heteroscedasticity (GARCH) process	Exogenous in the inflation model	A positive sign on coefficient expected in inflation and import equations
Quarterly Data from 1980:Q1 to 2019:Q4 shall be used for both South Africa and the USA.				

Source: Own compilation

4.5 ESTIMATION TECHNIQUES AND DIAGNOSTIC TESTS

4.5.1 Descriptive Statistics

A good medical doctor checks vital signs such as temperature, pulse rate and other basic signs before treatment is prescribed to the patient. Likewise, in statistical and regression analysis, the study needs to work with data whose basic characteristics are known such as normality, mean versus median, standard deviation and extreme values such as maximum and minimum. Working with data that is highly skewed and not normally distributed may result in spurious inferences. Furthermore, the relevance of normality is for the fulfilment of the central limit theory (Kirkwood and Steme, 2003). The available normality tests are the Jarque-Bera, Anderson-Darling and the Kolmorogov-Smirnov

tests. Each is suitable for use under certain circumstances. The most commonly used test is the Jarque-Bera test and is given below:

$$JB = n\left[\frac{S^2}{6} + \frac{(K-3)^2}{24}\right]$$

where n = sample size, S is the coefficient of skewness and K is the kurtosis term. The null hypothesis is H_0 : S = 0 and K = 3 The null is rejected if the JB is greater than the critical value of the Chi-square with 2 degrees of freedom.

4.5.2 Partial and Bivariate Correlation Coefficients

In statistics, it is important to have a feel of how two variables are linearly related to each other with or without the influence of other variables. The partial correlation coefficient measures the linear association and strength net effect of all the influences of all the other variables. Correlations can be viewed as some kind of a pre-cursor to regression analysis.If the independent variable is highly correlated with one or more of the other independent variables in a multiple regression model, then multi-collinearity exists. Multicollinearity undermines the statistical significance in the independent variable(s). When this econometric problem appears, it inflates the variance and the standard error, resulting in downward-bias of the t-statistics and ultimately committing type-II error of accepting a null hypothesis that is not true.To augment the standard correlation analysis, the Variance Inflation Factor (VIF) test was conducted to detect multicollinearity. The variance inflation factor (VIF) identifies correlation between independent variables and the strength of that correlation. The rule of thumb is that a VIF value equal or less than five is ideal.

4.5.3 Graphical visualisation of trends

It is important to visualise the trend of the variables over time for reporting purposes as well as for evaluating the success of implemented policies. In addition, the graphs give signs of whether the series are stationary or not though these graphs are not conclusive as authentic unit-root tests.Formal Unit Root Tests still need to be done.

4.5.4 Stationarity Tests (ADF, PP)

This section discusses the two leading methods of testing for stationarity in variables and these are the ADF and the PP. The rationale behind discussing the two of them is that each has some weaknesses, justifying the need to use both of them as a robustness check exercise. Stationarity of variables is crucial in obtaining non-spurious statistical results. A variable is stationary when it exhibits a constant variance and mean over time. All variables (excluding dummies) are to be tested for stationarity to establish order of integration using the Augmented Dickey-Fuller (ADF) and the

Phillips-Peron (PP) tests where the sample is large enough. The Phillips-Peron test, though asymptotically more efficient, tends to work better in the presence of heteroscedasticity and autocorrelation. Generally, the PP test is more robust in situations where there is deviation from the *gentleman's* set of properties before testing for unit root.

Before testing for stationarity we establish the optimal number of lags to be used through the lag-length criteria determined by Akaike Information Criteria (AIC) or Schwartz Bayesian Criterion (SBC).

4.6 THE ADF & PHILLIPS-PERRON TEST

The starting point in the discussion of the ADF testing is to first consider the simple model in which the unit root testing uses the Dickey-Fuller Test. The DF-test is a test of non-stationarity of the time series in question. The simple model is an AR (1) process shown below:

$$Y_t = \alpha + \beta Y_{t-1} + \varepsilon_t$$

……..(4.18)

The null hypothesis is H_0 : $\beta = 1$ (meaning that Y is a Random-walk model). Normally the equation is transformed by using the 1st difference version given by:

$$\Delta Y_t = \alpha + \rho \Delta Y_{t-1} + \varepsilon_t$$

…….(4.19)

In this equation the null hypothesis for unit root testing is $\rho = 0$ (since $\rho = \beta - 1$). The problem with the DF-Test is that it lacks power and size due to possible presence of autocorrelated residuals (Kwiatkowski et al., 1992). This has necessitated the development of a test statistic that generates more thoroughness in the stationarity test by adding more and more lags of the dependent variable.

The ADF statistic does not follow a traditional distribution and so the critical values at specified significance level were worked out by Dickey and Fuller (1979). The statistic is heavily tailed on the left and is asymmetrical implying that the more negative the statistic, the greater is the likelihood of rejecting the null hypothesis.

The general ADF unit-root testing model is given by:

$$\Delta y_t = \varphi_0 + \pi y_{t-1} + \varphi_2 t + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \varepsilon_t$$

……(4.20)

where φ_0 is a drift value, and φ_2 is the trend-coefficient and $\varepsilon_t \xrightarrow{d} N(0, \sigma^2)$. One can test for stationarity in which the drift and trend occur or one in which none occur or in which one of the two occurs. The null hypothesis in this case is that $\Delta y_t \sim I(0)$ meaning the first difference of the series is

stationary. The presence of unit root is rejected if the absolute ADF statistic is greater than the MacKinnon (2010) critical values. Because of the low performance of the ADF in the presence of autocorrelation, Phillips and Perron (1988) developed a modified test from the ADF known as PP test and has the same distribution as the ADF test statistic, hence the same critical ADF values can be used. The PP Test is asymptotically valid in the presence of autocorrelation.

4.7 DETERMINATION OF NUMBER OF LAGS IN AND VECM (LAG-LENGTH CRITERION TEST)

The use of optimal number of lags in VAR and VECM estimations ensures the production of credible econometric results. In some cases, one could arrive at a conclusion that the variable under investigation displays unit root when it is actually stationary and this may be caused by using the wrong number of lags. We make use of the Lag-Length Criterion tests to determine the number of lags suitable for any given data and method. Ivanov and Kilian (2005) argue that in the case of quarterly data with a sample size greater than 120, the Hannan-Quinn Criterion (HQC) is more accurate. In literature, however, more researchers have used the Schwarz's Bayesian Information Criterion (SBIC) as this works better for quarterly data. For expository and intuition purposes, a brief description of the different criteria are shown below:

We shall take $\boldsymbol{n}$ to be the number of observations in model M, $\boldsymbol{k}$ is the number of parameters, $\boldsymbol{p}$ is the number of lags, $\boldsymbol{L_{max}}$ is the log likelihood of M and $\hat{\boldsymbol{L}}$ is the maximised value of the likelihood function of the model, $\boldsymbol{x}$ is the observed data, $\widehat{\boldsymbol{\theta}}$ is the parameter value that maximises the likelihood function and $\widehat{\boldsymbol{\Sigma}}$ is the variance of the residuals in the model.

4.7.1 Akaike Information Criterion (AIC)

$AIC = ln|\hat{\Sigma}| + 2k/(T-p)$. The formula shows that a lower AIC is due to a smaller variance of the residuals as well as having more number of observations used in the estimation (T-p)

4.7.2 Hannan_Quinn Criterion (HQC)

$HQC = -2L_{max} + 2kln(ln(k))$. A larger log-likelihood value gives a better value of the HQC test.

4.7.3 Bayesian Information Criterion (BIC)

$BIC = kln(n) - 2\ln(\hat{L})$. Where $\hat{L} = p(x|\hat{\theta}, M)$ with $\hat{\theta}$ described as shown above. With a maximised value of the likelihood one gets a better value of the test. A higher value of $\hat{L}$ means a smaller value of BIC. These tests will be carried out in this study especially when estimating a VECM or a Hybrid New Keynesian Phillips Curve model of inflation or using the ARDL equation. Only

those models with the correct number of lags will bear credible results free of serial correlation issues and heteroschedasticity problems.

4.8 COINTEGRATION TESTS

It is natural that in the event of finding the variables being cointegrated there is need totest if they have a long-term association in terms of direction of movement. It is important to test if the variables are cointegrated so that one can, in the end, estimate a model that explains the short-term and the long-term relationships and simultaneously get the speed of adjustment towards the long-term equilibrium. Cointegration relationships is tested using the celebrated Johansen Procedure using the trace and the maximum eigenvalue statistics.

The Johansen test is a procedure for testing cointegration of several k series that are I(1). The advantage of the Johansen test over the Engle-Granger test is that it allows for more than one cointegration relationship, unlike the other which is a test of a single cointegrating relationship based on the residuals of the Augmented Dickey-Fuller equation. There are two types of the Johansen test which are the trace and eigenvalue test statistics. This research shall make use of the cointegration tests so as to derive the long-run and short-run impact of the exchange rate on domestic prices.

4.8.1 The Johansen Test

The following discussion around testing for cointegration using either the Trace or Maximum Eigenvalue approach are well narrated by Dwyer (2015).

We first consider a simple VAR(p) of the form:

$$Y_t = \delta D_t + \varphi_t Y_{t-1} + \cdots + \varphi_p Y_{t-p} + \varepsilon_t \quad \text{.....(4.21)}$$

where Y_t is a time series mx1 vector of I(1) variables.

The VAR (p) model is deemed stable only if

Det($\mathbf{I_n} - \phi_1 z - \ldots - \phi p\, z_p$) = 0 has all roots outside the complex unit circle.

If there are roots on the circle, then some or all the variables in Yt are I(1) and may also be cointegrated rendering a VAR(p) not very unsuitable for estimation. In such a case, a VAR(p) is then transformed into a VECM and estimated after testing for cointegration using either the Trace or Maximum eigenvalue algorithm.

4.8.2 The Trace test (Based on Brownian Motion Matrix)

We consider a VECM of the form below:

$\Delta Y_t = \Gamma_0 D_t + \Pi Y_{t-1} + \sum_{j=1}^{p-1} \Gamma_j \Delta Y_{t-j} + \varepsilon_t$, t = 1, 2, …, T ……(4.22)

where D_t is a vector of deterministic variables (constant, trends, and /or seasonal dummies) and ε_t is the independent p-dimensional Gaussian variables with mean of zero and variance matrix Λ. $\boldsymbol{\Gamma_j = -I + \phi_1 + \ldots + \phi_j}$ **, j = 1, …, p -1** are ***m***x***m*** matrices. The matrix $\boldsymbol{\Pi}$ can be written as a vector or matrix of adjustment parameters $\boldsymbol{\gamma}$ and the vector or matrix of cointegrating vectors A as:

$\boldsymbol{\Pi = \gamma A'}$ is the long-run impact *;* ***A*** *and* $\boldsymbol{\gamma}$ are ***m***x***k*** matrices and

ε_t are i.i.d. $N_m(\mathbf{0}, \sum)$ and det ($\mathbf{I_n} - \sum_{j=1}^{p-1} \Gamma_j B^j$) = 0 has its roots outside a unit circle.

where $\mathbf{I_n}$ is the nth order identity matrix. Cointegration takes place when $\boldsymbol{\Pi}$ has reduced rank and this is the basis for the Trace test. With all the restrictions on the likelihood function (i.e. trend, drift or no drift), the likelihood is given by $L_{max}(k)$ = function of the Cointegrating rank *k.* The null hypothesis of this test is that the number of cointegrating vectors is rank ($\boldsymbol{\Pi}$) = r_0 (i.e. r = r* < k) with the alternative being r_0 < rank ($\boldsymbol{\Pi}$) ≤ n, where n is the maximum number of possible cointegrating vectors. If the null is rejected, the next null would be rank ($\boldsymbol{\Pi}$) = r_0 +1 and its alternative is r_0 +1 < rank ($\boldsymbol{\Pi}$) ≤ n and the test proceeds sequentially for r =1,2, … until the first non-rejection of the null hypothesis is taken, r_0 +n is the estimated number of cointegrating vectors.

The Trace statistic motivated by the works of Johansen (1989) is given by:

$LR(r_0, n) = -T \sum_{i=r_0+1}^{n} \ln (1 - \lambda_i)$……..(4.23)

The trace is the sum of the diagonal elements in a diagonal matrix of the generalised eigenvalues.

4.8.3 The Maximum Eigenvalue test

The set of eigenvalues for the *n*x*n* matrix **A** are given by the *n* solutions to the polynomial equation:

Det ($\mathbf{A} - \lambda \mathbf{I_n}$) = 0 ……..(4.24)

Det (.) denotes the determinant of the matrix $\mathbf{A} - \lambda \mathbf{I_n}$ and $\lambda = \lambda_1, \lambda_2, \lambda_3, \ldots \lambda_n$ and $\lambda_i \geq 0$, $\forall i$. if $\lambda_1 = 0$ then rank($\boldsymbol{\Pi}$) = 0 and therefore no cointegration. If $\lambda_1 \neq 0$ then move on to $\lambda_2 \leq \lambda_1$ and if $\lambda_2 = 0$ then rank($\boldsymbol{\Pi}$) = 1 and one cointegrating vector. In general if $\lambda_{n-1} \neq 0$ then test whether $\lambda_n = 0$ and if this is confirmed, then the system has *n* – 1 cointegrating vectors.

The Null hypothesis for the Maximum Eigenvalue test is that rank($\boldsymbol{\Pi}$) = 0 (i.e. r = r_0 + 1) against that rank($\boldsymbol{\Pi}$) = 1 and the sequential testing proceeds until the null hypothesis of an eigenvalue being equal to zero cannot be rejected.

Maximum Eigenvalue statistic is shown below:

$LR(r_0, r_0+1) = \lambda_{max} = -T\ln(1 - \lambda_{r_0+1})$ ……..(4.25)

where λ, again, is the estimated eigenvalues of reduced rank of the matrix π. The sequential tests starts with r = 0 until it cannot be rejected.

Where $LR(r_0, r_0+1)$ is the likelihood ratio statistic for testing whether rank(Π) = r_0 against the alternative that rank(Π) = r_0 +1 and the statistic, like the Dickey-Fuller statistic, does not follow any known standard distribution (Johansen, 1989).

4.9 ADDITIONAL POST REGRESSION DIAGNOSTICS & ESTIMATIONS

1. VECM stability tests

   The stability tests are important for both policy and forecasting purposes. A model that does not pass the stability tests would be difficult to make use of as parameters may change over time and would not confer the same econometric information as the one that is stable.

4.10 RAMSEY'S RESET TEST

We are going to perform a test to confirm linearity of the variables in regression equations. The test to apply is the Ramsey's RESET test with a Taylor expansion for non-linear function. The Taylor expansion ensures that we include possible higher powers of exogenous variables as well as cross products of these independent variables. In statistics, the Ramsey Regression Equation Specification Error Test (RESET) test is a general specification test for the linear regression model. More specifically, it tests whether non-linear combinations of the fitted values help explain the response variable. The Ramsey's RESET test will be made use of in this study specifically to find out if the model should be liner or non-linear in determining the exchange rate pass-through. Ramsey (1969) proposed a restricted general specification of the form:

$$Y = \beta_0 + \beta_1 X_1 + \cdots + \beta_k X_k + u \quad \text{.....(4.26)}$$

The procedure assumes that the correct specification may have been:

$$Y = \beta_0 + \beta_1 X_1 + \cdots + \beta_k X_k + \eta_1 X_1^2 + \cdots + \eta_m X_m^2 + \phi_1 X_1 X_2 + \cdots + \phi_1 X_n X_m + \varepsilon \quad \text{.....(4.27)}$$

The first step is to get $\hat{y} = \widehat{\beta_0} + \widehat{\beta_1} X_1 + \cdots + \widehat{\beta_k} X_k$ and then estimate:

$\hat{u} = \beta_0 + \beta_1 X_1 + \ldots + \beta_k X_k + \tau_1 \hat{y}^2 + \tau_2 \hat{y}^3 \ldots +$ cross products + ε ……(4.28)

Take note that $\hat{y}^2$ includes all the squared exogenous variables in the proposed restricted model.

The null hypothesis is H_0: $\tau_1 = \tau_2 = \ldots = \tau_m = 0$ (i.e model has no nonlinear exogenous variables)

Against the alternative H_A: τ_1 and /or $\tau_2 \neq 0$ (meaning original model not correctly specified)

The test statistic is given by $nR^2 \sim \chi^2$ with 2 degrees of freedom (if $\hat{u}$ is used) or and F-test with numerator degrees of freedom of 2 and denominator degrees of freedom n - k -3 (if $\hat{y}$ is used instead).

If the Ramsey's RESET test returns a verdict of presence of nonlinearities in the system, then we must investigate if this is not due to autocorrelation or heteroscedasticity or it is pure misspecification that rules out quadratic or cubic or even cross products of exogenous variables.

Generally, when performing the RESET procedure, we write the modified equation as:

$$\mathbf{Y} = \mathbf{X}\,\beta + \mathbf{Z}\delta + \epsilon \qquad (4.29)$$

where **Z** is a matrix of omitted variables (that includes higher powers and cross-products), **Y** is a vector of dependent variables and **X** is a matrix of exogenous factors. In this case, the null hypothesis is alternatively written as:

H_0: $\epsilon \sim N(0, \sigma^2 I)$

H_0: $\epsilon \sim N(\mu, \sigma^2 I)$

The output, as before, reports the F-statistics and the log likelihood ratio for testing the hypothesis that the restrictions $\delta = 0$ holds. Rejection of H_0 leads to the conclusion that the original model was not correctly specified.

4.11 RECURSIVE LEAST SQUARES ESTIMATION AND TESTING

The Recursive Least Squares approach is a crucial one for time-series analysis. The method estimates the model $\mathbf{Y} = \mathbf{X}\,\beta + \epsilon$ repeatedly using the ever larger subsets of the sample data. The 1st estimation uses k observations and the next estimation uses k + 1 observations and the process is repeated until all observations are used to produce T – k +1 estimates of the β vector. The forecast for the dependent variable is given by $X'_t\,\beta$ and forecast error of $Y_t - X'_t\,\beta$ and a forecast variance of $\sigma 2(1 + X'_t (X'_{t-1} X_{t-1})^{-1} X_t)$. The recursive residual w_t is given by:

$$w_t = \frac{(y_t - X'_t\,\beta)}{[1 + X'_t (X'_{t-1}\,X_{t-1})^{-1}\,X_t]^{1/2}} \qquad (4.30)$$

t = k +1, …, T. If the model is valid, the recursive residuals are independently and normally distributed with zero mean and constant variance σ2 (i.e. $w_t \xrightarrow{d} N(0, \sigma^2)$).

A plot of recursive residuals about the zero line with plus or minus 2-standard errors show stability or lack of the same by residuals inside and outside the standard error bands respectively. This test will be used in this study when we estimate the multivariate ARDL model to determine the degree of exchange rate pass-through. The following are the auxiliary tests to Recursive Least Squares:

Table 4. 2: List of model Tests

Recursive Test	Function	Interpretation of results
Cumulative Sum of Recursive Residuals (CUSUM)	Test of Stability of Parameters over time	Parameters are jointly stable if residual plots are within the ±2-standard error band.
CUSUM Of Squares Test	Test of constant variance in the error term over time	The variance is constant if plots stay within the 5% critical lines.
One-Step-Ahead Forecast	Helps to locate periods when equation was least successful	Shows points that lie less than 5% probability of coming from model. Periods of stability are seen by plots beyond 5% to 15%.
Recursive Coefficient Estimates	Enables one to trace the evolution of a specific parameter as more data is added. Plots residuals that come from the fitted model with a given probability.	Significant variation of a specific parameter shows a possible change and therefore suggests structural break.

Source: Own compilation

4.12 TESTING FOR AUTOCORRELATION IN THE RESIDUAL TERMS

The starting point is the model given by:

$$\boldsymbol{Y} = \boldsymbol{X}\beta + u \quad \text{.....(4.31)}$$

We also assume that the residual term exhibits a Random-Walk model of the form:

$u_t = \rho u_{t-1} + \varepsilon_t$ and if there is no autocorrelation then $\rho = 0$.

The usual assumption in time series is that there is no pairwise correlation between residuals as shown below:

$$E(u_t, u_{t-1}) = \begin{cases} \sigma_u^2, & s = 0 \\ 0, & s \neq 0 \end{cases} \quad \text{.....(4.32)}$$

When $E(u_t, u_{t-1}) \neq 0$ for $\forall\ s \neq 0$, then we have a violation of serial independence among the residuals or constant variance across all residuals. In a way, if this takes place then we have Heteroscedastic error terms.

4.13 CONCLUSION

Chapter 4 concentrated on reviewing the estimation methods and the kind of diagnostic tests performed in order to get robust results that are fit for policy recommendations. The chapter discussed the genesis of the estimation models (analytic framework) with regards estimation of import prices and CPI inflation as a result of the exchange rate instability in South Africa. A multi-model approach was used. Firsty, the ARDL technique was used to estimate the ERPT to import prices and consumer prices. Secondly, the VECM approach was employed to capture the short-term and long term impact of variables on the import prices and consumer prices. In addition, VECM was used to augment the analysis of the speed of adjustment to equilibrium in the event of a shock in the sytem.Thirdly, the ARMA model was applied to estimate the ERPT exchange rate pass through asymmetry between appreciation and depreciation periods. Furthermore, the HNKPC model was estimated to account for the influence of inflation momentum and inflation expectations to current inflation. Along the way, diagnostic tests such as multicollinearity, Ramsey reset test, unit root tests, Johansen cointegration tests were done to ensure robustness of results. In the next Chapter, results from these estimations and tests are presented and reported.

CHAPTER FIVE: PRESENTATION AND INTERPRETATION OF RESULTS

5.0 INTRODUCTION

Exchange Rate Pass-Through is one of the crucial econometrics niche areas and certainly so because of its implications for monetary policy. Exchange rate changes have macroeconomic implications for monetary policy, as any attempt to influence inflation through exchange rate management would not yield expected changes since the transmission would be weak. This chapter focuses on measuring the degree of exchange rate transmission to import as well as consumer prices as first stage exchange rate pass-through and second-stage pass-through, respectively. As a secondary aim, the analysis interrogates the existence of ERPT asymmetry between depreciation and appreciation phases and the degree of pass-through in the short and long run. The chapter has the following sub-sections:

Section 5.1 presents the descriptive statistics of the key variables of interest; Section 5.2 shows the visual appearances of the key variables through their Box-Plots with a trend; section 5.3 illustrates variables in differenced form; while Section 5.4 gives the bi-variate correlation coefficients of key variables. Section 5.5 presents unit root test results. The presentation, interpretation, and discussion of results from the ARDL, VECM, ARMA, and HNKPC are coverd in section 5.6 to 5.11.. Finally, section 5.12 concludes the chapter.

5.1 DESCRIPTIVE STATISTICS FOR KEY STUDY VARIABLES

The descriptive statics of key variables are shown in Table 5.1.

Table 5. 1: Descriptive Statistics of Key Variables

	IMPORT PRICE	CPI	INFLATION	EXCHANGE RATE	EXCHANGE RATE VOLATILITY	INTEREST RATE
Mean	61.46090	62.55517	8.859695	5.987009	2.066695	11.38330
Median	47.20000	56.82294	7.731882	6.113233	1.863486	11.00000
Maximum	156.6000	155.0112	19.25042	15.85730	27.37499	21.85000
Minimum	6.700000	6.311441	-1.761430	0.751000	-18.48792	5.000000
Std. Dev.	45.86309	42.60028	4.786403	3.869636	6.866383	4.585476
Skewness	0.527517	0.475325	0.210256	0.584798	0.522001	0.355565
Kurtosis	1.896096	2.158335	2.183856	2.453026	4.731033	2.009950
Jarque-Bera	15.15607	10.47888	5.478991	10.83639	26.56170	9.658376
Probability	0.000512	0.005303	0.064603	0.004435	0.000002	0.007993
Observations	156	156	156	156	156	156

Source: Own construction using SARB & World Bank Data using Eviews

All the variables, except the exchange rate volatility proxy, show that the standard deviation is less than the mean of the series. This shows how volatile the change in the exchange rate is. Normally distributed series must have skewness that is zero (0) or very close to it as well as having peakedness (kurtosis) of three (3). The main purpose of the above descriptive statistics is to find out if the variables are normally distributed – which is a requirement in many statistical analysis for optimal results. The usual Null Hypothesis in testing for normality is that the variable is normally distributed and therefore Gaussian. We reject the Null Hypothesis whenever the probability value of the Jarque-Bera (JB) statistic is less than 5 percent. The JB statistic is constructed from the skewness and kurtosis coefficients. For a purely normally distributed variable, the skewness and kurtosis coefficients should be zero (0) and three (3) respectively.

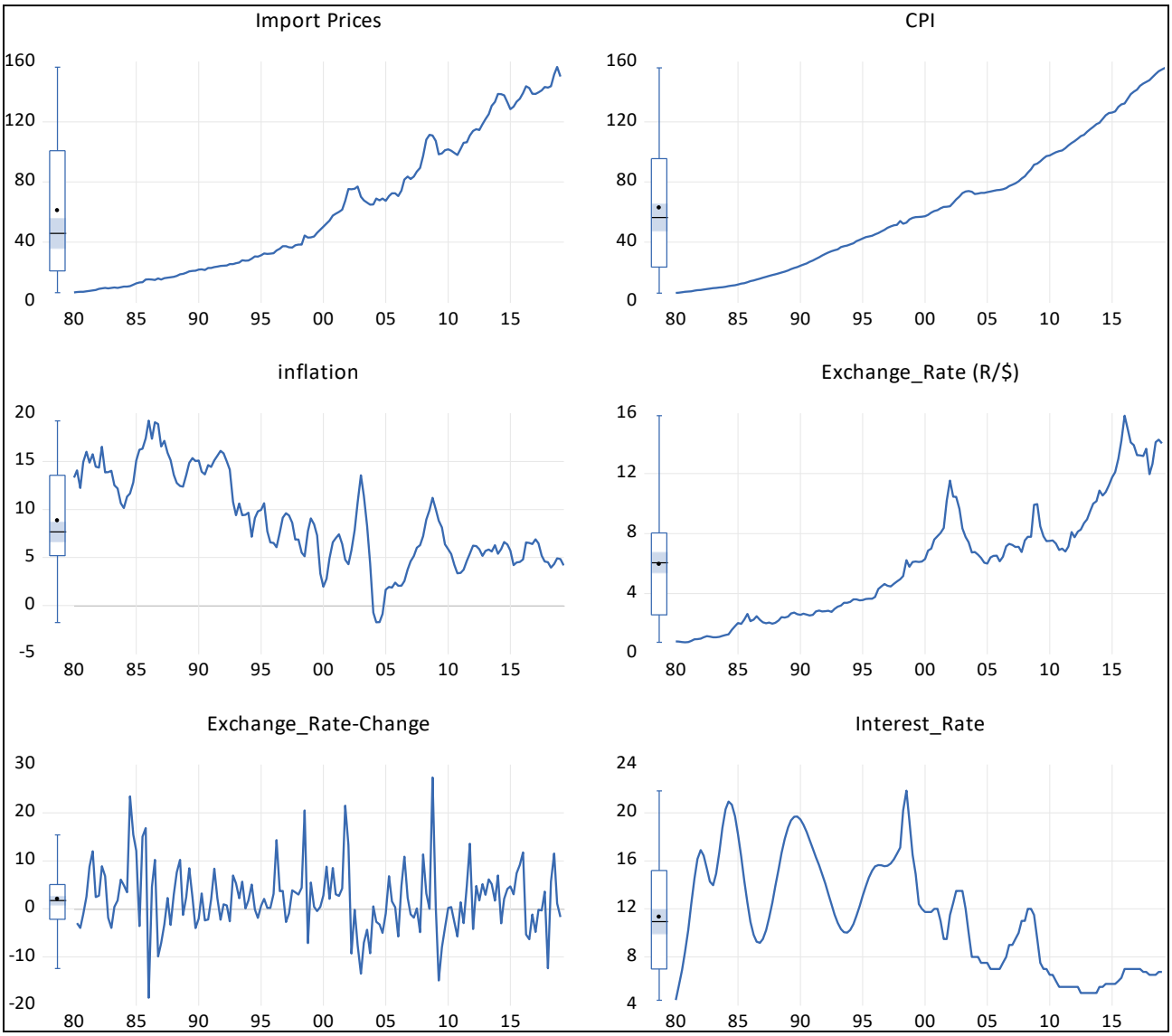
For the Import Price variable, it can be seen that the mean differs significantly from the median which is a sign of non-normality. The Jarque-Bera statistic has a p-value of 0.0005 (less than 5%) indicating rejection of a null hypothesis of normality in the variable. The skewness coefficient is 0.5275 and the kurtosis value is 1.8961 making the distribution platykurtic (less kurtosis than normally distributed series) and therefore not normal. The CPI variable is not normally distributed as the p-value of the JB statistic is less than 5 percent at 0.00530. Inflation rate is normally distributed as shown by its p-value of the JB statistic of 0.06460 that is greater than the 5 percent decision critical level. Interest rate variable has a JB p-value of 0.00799 that is less than the critical 5 percent and therefore is not normally distributed. The exchange rate and its volatility have p-values of their JB statistics that are less than 5 percent and therefore not normally distributed. The exchange rate variable, however, is normally distributed when 10 percent significance level is used. The results of the JB normality tests should be followed by the robustness checks using the Box-Plots diagrams. The Box-Plot diagrams will tell whether the non-normality for some variables is a serious issue or can just be ignored, especially when we don't have sufficient outliers to declare non-normality.

5.2 NORMALITY TESTS USING BOX-PLOTS OF KEY VARIABLES

Box-plots with trend lines are combo-graphs designed to show two things: normality and the trend in the series over time. The interpretation of the Box-Plot is via its median and the outliers far from the mean or median. Data may be found to be non-stationary simply because of outliers. If a few outliers are very close to the median, then we can, *with a pinch of salt*, declare the series fit for analysis without further managing it. The other role played by a Box-Plot with a trend is that the graphs help us make an informal interpretation of whether the variables are stationary. Estimating econometric relationships among unit root variables may result in spurious inferences. A stationary

variable is one with a variance that is not time-dependent, and the series is mean-reverting. When one uses stationary series, conventional statistical measures such as the t-statistic and the coefficient of determination (R^2) with the *a priori* knowledge from economic theory can be trusted in assessing the performance of the model being considered.The box plots are shown in Figure 5.1.

Figure 5.1: Box-Plots of Key Variables

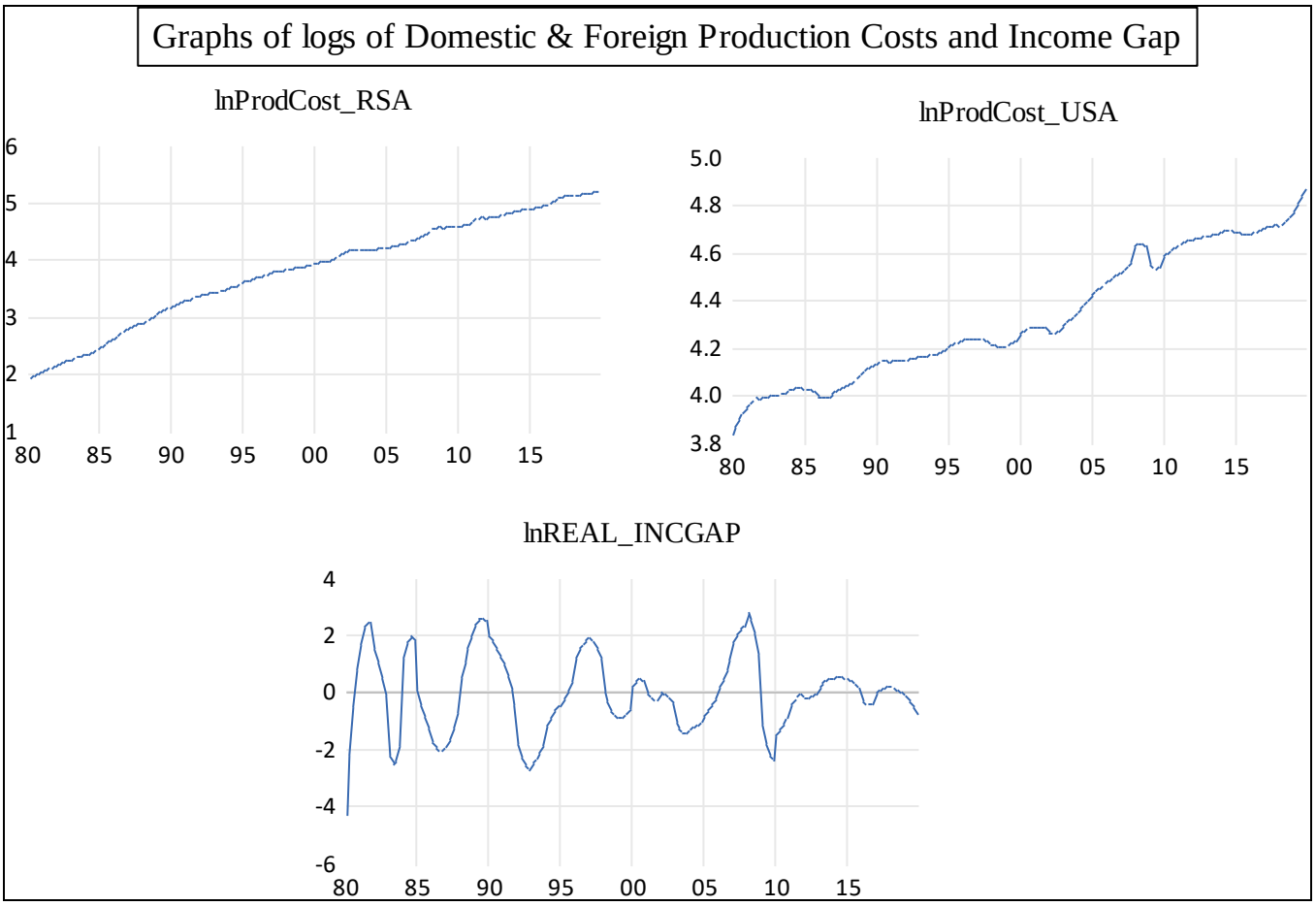


Source: Own construction using SARB & World Bank Data using Eviews

The Box-Plots in Fig 5.1 are those shown on the vertical axes and the dot (.) shows the outlier(s) in each series. The horizontal stroke indicates the median of the series. From the diagram it is evident that all the variables show Box-Plots whose series distributions do not exhibit extreme cases of outliers as measured from each series's median. One can then override some of the Jarque-Bera tests, whose results had shown non-normality in the series' distributions. This means one can proceed with the analysis using unaltered data The results will not be deemed spurious and therefore are credible.

The variables also show an upward trend over time, except the inflation rate, interest rate, and exchange rate change variables that trended downwards or were mean-reverting. Variables may be trend-stationary or simply non-stationary, and therefore the only way to verify the trend is through performing unit-root tests,as shown in Table 5.3. The graphs visually show that most variables are non-stationary except that of the exchange rate change. The visuals show that inflation has been falling while both nominal exchange rate and import price increase. The fall of inflation in the face of increasing depreciation of the Rand could be as a result of the inflation targeting policy adopted in the year 2000 and, perhaps, partly due to firms absorbing some of the depreciation pressures to maintain the market, which is symptomatic of presence of Pricing-to-Market behaviour by firms. Similarly, there has been an inverse relationship in general between import prices and inflation, as shown in Figure 5.1. The visuals of the variables are extended in Figure 5.2 to explain the likely relations between variables as a precursor to both statistical and econometric analysis.

Figure 5. 2: Line profiles of key variables



Source: Own construction using SARB & World Bank Data using Eveiews

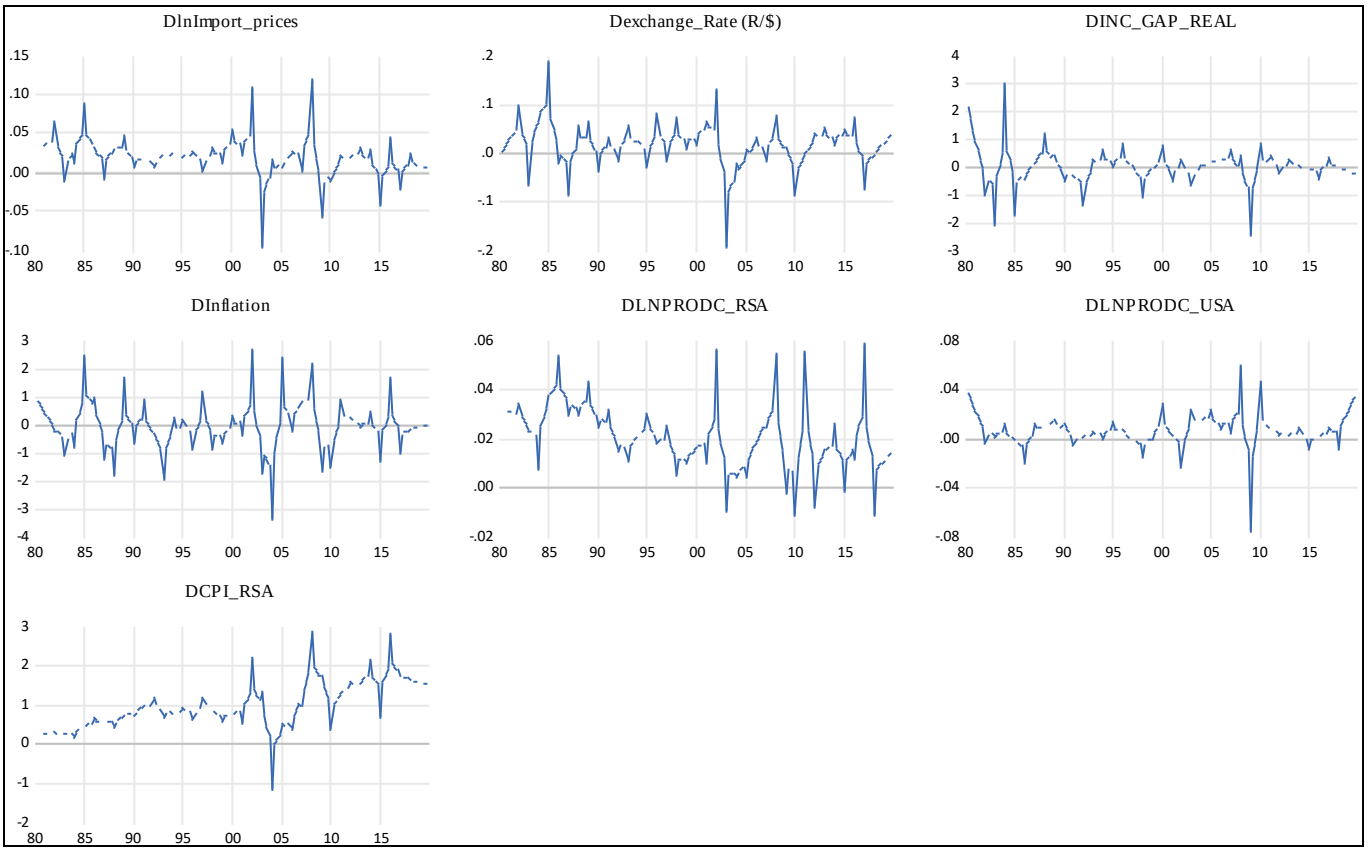
Both local costs and foreign costs, as represented by log of South African production cost and the log of USA production costs increased during the period. However, inflation (as shown in Figure

5.1) continued to decline which is further proof that both foreign and domestic costs are not fully transmitted to the consumers. This, therefore, calls for further investigation as to what extent do inflation-targeting policy and exchange rate affect both import and consumer prices. The Income Gap variable is mean-reverting around zero showing that the Income Gap may not be a significant in influencing either inflation or Import Price.

5.3 GRAPHS OF DIFFERENCED KEY VARIABLES

Prior to the unit root tests, visualisation of time profiles were generated. These are illustrated in Figure 5.3.

Figure 5. 3: Time Profiles of Differenced Variables



Source: Own construction using SARB & World Bank Data Using Eviews

The graphs of variables in Figure 5.3 above are in differenced form and only serve as precursors to the formal tests of unit roots shown in Table 5.3. All variables seem to revert to the long term average except for ΔCPI_RSA and Production Cost, meaning that the CPI-RSA and the Production Cost variables are not stationary even after differencing once. A differenced variable X_t is actually a variable ΔX_t which is basically $X_t - X_{t-1}$. The assumption in regression analysis is that the variables are stationary and devoid of any other variations that produce non-constant variances. The reason is

that if the variances of the variables are time varying then one fails to disaggregate the impact that variables have on others. The impact that one variable has on another, when both dependent and independent variables have constant variances, would be non-spurious. The time profiles of differenced variables can be taken as a visual test of stationarity in variables when differenced once. It must be noted, however, that even though a variable may be deemed non-stationary based on its differenced graph, it can still be found to be stationary along a trend when formal unit-root tests are carried out.

5.4 BI-VARIATE CORRELATION COEFFICIENTS OF KEY VARIABLES

In this section, the Bi-viriate correlation results are presented in Table 5.2.

Table 5. 2: Correlation Table

Correlation Coefficients & Probability	**lnImp_Price**	**lnNER**	**lnProdc_rsa**	**lnProdc_usa**	**Incgap_real**
lnImp_Price	1				
lnNER	0.978811 (0.0000)**	1			
lnProdc_rsa	0.995080 (0.0000)**	0.974403 (0.0000)**	1		
lnProdc_usa	0.956919 (0.0000)**	0.895965 (0.0000)**	0.956620 (0.0000)**	1	
Incgap_real	0.015466 (0.8461)	-0.000973 (0.9903)	0.012260 (0.8777)	0.075637 (0.3418)	1

*Key: Figures in parenthesis are probability values, ** means the correlation coefficient is significant at the 5% level of significance.*

Source: Own calculation, using Eviews

Correlation coefficients as well as their probability values are important in showing which variables are correlated with each other. The results show that import prices are significantly and positively correlated with NER, Production cost in South Africa, the Nominal Exchange Rate and production cost in the trading partner, the USA. The other results are that NER is positively and significantly correlated with Production cost in both South Africa and the USA. The Output Gap was not correlated with any of the variables. Bussiere (2013) pointed out that the coefficient of the output gap was insignificant because the information contained in the demand conditions was also contained in the local prices. Even though the correlation between Income Gap and Import prices was not strong but it is included in the Import equation as was suggested in the study by Przystupa and Wróbel (2014).

The significance of the coefficient of production in South Africa is evidence of presence of Pricing-to-Market behaviour in the economy. The production cost in South Africa is a good instrument for local consumer prices as suggested by the positive and significant partial correlation coefficient of 0.9951. This means that if import prices react significantly to changes in the domestic prices then foreign suppliers would allow prices to adjust according to the changes in local prices.

Including variables that are highly and significantly correlated with each other often results in a problem of multicollinearity that has a tendency of inflating the variances of the estimated parameters which, in turn, gives inaccurate inferences. Moderate multicollinearity that is not severe is not a problem in econometrics. The importance of the correlation analysis is to help us decide which model to use. This study is going to use models that produce robust parameters as well as correcting for the presence of severe multicollinearity. The methods to be used in this study make use of the Cochrane-Orcutt procedure which is usually embedded in them thereby correcting for multicollinearity. The Cochrane-Orcutt method makes use of re-scaled variables that produced standardised predictors that are now proxies to the original variables and, without loss-of-generality (WLOG), return results that are reliable for forecasting or for policy use.

5.5 TESTING FOR STATIONARITY (ADF & PHILLIPS – PERRON TESTS)

In addition to visual unit root screening, formal unit root tests were conducted using the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron tests. The results are shown in Table 5.3.

Table 5. 3: Unit Root Testing

Variables	**Augmented Dickey-Fuller (ADF)**				**Phillips –Perron (PP)**			
	Level		**1st Diff**		**Level**		**1st Difference**	
	Intercept	Intercept & Trend	Intercept	Intercept & Trend	Intercept	Intercept & Trend	Intercept	Intercept & Trend
Lnimport_price	-2.827	-1.102	-2.848**	-3.952***	-2.831	-1.449	-5.854***	-5.69***
lnNEER	-2.225	-2.499	-3.386**	-3.769***	-1.632	-1.652	-5.729***	-5.67***
NER	0.408	-2.006	-3.86***	-3.997***	0.217	-2.105	-5.534***	-5.59***
lnNER	-1.805	-3.145	-2.835*	-2.100	-1.893	-2.377	-5.76***	-5.84***
Lncpi_rsa	-2.766	-2.310	-1.556	-2.509	-7.13***	-2.294	-2.334	-3.58
Lngdp_r	-0.114	-2.031	-3.098**	-3.073	-0.175	-1.473	-5.643***	-5.60
Lnprodcost_rsa	-2.504	-2.242	-2.410	-3.215	-4.194***	-1.974	-5.227***	-5.76**
Lnprodcost_usa	1.100	-2.191	-3.200**	-3.347	-0.015	-2.097	-5.754***	-5.65***
Infl_rsa	-1.448	-2.398	-4.621***	-4.612***	-1.675	-2.923	-5.838***	-5.81***
Infl_usa	-3.683***	-4.97***	-4.285***	-4.115***	-5.196***	-5.037***	-5.826***	-5.86***
rir_rsa	-2.905**	-2.958	-3.307**	-3.246	-6.316***	-6.083	-8.448	-8.68***
rir_usa	-2.193	-2.909	-3.849**	-3.938**	-1.872	-3.523**	-5.789***	-5.64***
Inc_gap	-5.85***	-5.82***	-5.265***	-5.246***	-4.791***	-4.775***	-6.413***	-6.32***
Fin_gap	-4.780***	-4.78***	-5.115***	-5.096***	-2.55	-2.529	-13.35***	-13.3***

, **, and * shows stationarity at the 10%, 5%, and 1% level of significance, respectively.*

Source: Own table form Unit Root Analysis using Eviews.

Table 5.3 shows that after differencing variables once and having tested for unit-root using ADF and PP only log of CPI and log of South African production cost were non-stationary even after differencing once. This, indeed, confirms the picture that was seen in Fig 5.3 where the differenced profiles of CPI and Production Cost showed no reversion to the long-term path. The variables are all integrated of order 1 (i.e. all are *I(1)*) except log of CPI and log of South African production cost. The variables lnCPI and lnprodcost were found to be integrated of order 2 (i.e. *I(2)*) and this means the log of CPI and log of production cost should be used with caution. The implication of presence of unit root is that we cannot use OLS regression in levels. The OLS approach can only be used in situations where the variables (dependent and independent) rea in 1st difference form.

5.6 ARDL ESTIMATION RESULTS FOR IMPORT PRICE

This section presents the ARDL estimation results on the degree of transimission of exchange rate changes to import and consumer prices as well as the speed of adjustment in the event of a system disequilibrium. Table 5.4 shows findings from the import price equation.

Table 5. 4: ARDL Estimation Results (Import Price)

Dependent Variable: LNIMPORT_PRICE				
Method: ARDL				
Sample (adjusted): 1980Q3 2019Q4				
Included observations: 158 after adjustments				
Maximum dependent lags: 4 (Automatic selection)				
Model selection method: Akaike info criterion (AIC)				
Dynamic regressors (4 lags, automatic): LNNER LNPRODCOST_RSA LNPRODCOST_USA LNCPI_RSA LNCPI_USA INCGAP_REAL FINANCIAL_GAP				
Fixed regressors: C				
Number of models evalulated: 312500				
Selected Model: ARDL(2, 2, 2, 2, 2, 1, 0, 2)				
Note: final equation sample is larger than selection sample				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LNIMPORT_PRICE(-1)	1.493530	0.074086	20.15947	0.0000
LNIMPORT_PRICE(-2)	-0.525960	0.072493	-7.255357	0.0000
LNNER	0.417945	0.024080	17.35656	0.0000
LNNER(-1)	-0.655935	0.053563	-12.24609	0.0000
LNNER(-2)	0.248764	0.042239	5.889367	0.0000
LNPRODCOST_RSA	0.472815	0.098523	4.799056	0.0000
LNPRODCOST_RSA(-1)	-0.650295	0.160984	-4.039499	0.0001
LNPRODCOST_RSA(-2)	0.189049	0.099685	1.896451	0.0600
LNPRODCOST_USA	0.400914	0.088513	4.529445	0.0000
LNPRODCOST_USA(-1)	-0.859315	0.140129	-6.132312	0.0000
LNPRODCOST_USA(-2)	0.352534	0.098156	3.591575	0.0005
LNCPI_RSA	0.703393	0.196005	3.588648	0.0005
LNCPI_RSA(-1)	-1.247558	0.355235	-3.511921	0.0006
LNCPI_RSA(-2)	0.481104	0.196117	2.453156	0.0154
LNCPI_USA	1.196965	0.332406	3.600911	0.0004
LNCPI_USA(-1)	-0.880429	0.313909	-2.804725	0.0058
INCGAP_REAL	-0.000738	0.000623	-1.184567	0.2382
FINANCIAL_GAP	-0.003937	0.001447	-2.721048	0.0074
FINANCIAL_GAP(-1)	0.006519	0.002224	2.931169	0.0040
FINANCIAL_GAP(-2)	-0.002984	0.001524	-1.957926	0.0523
C	-0.618109	0.184767	-3.345341	0.0011
R-squared	0.999938	Mean dependent var		3.795776
Adjusted R-squared	0.999929	S.D. dependent var		0.922920
S.E. of regression	0.007768	Akaike info criterion		-6.754273
Sum squared resid	0.008268	Schwarz criterion		-6.347219
Log likelihood	554.5876	Hannan-Quinn criter.		-6.588963
F-statistic	110789.1	Durbin-Watson stat		2.088261
Prob(F-statistic)	0.000000			
*Note: p-values and any subsequent tests do not account for model selection.				

Source: Own econometric analysis using Eviews

As shown in Table 5.4, the parameter for LNNER is 0.4179 implying that a 1 percent increase in the nominal exchange rate (NER) would lead to a 0.4179 percent increase in import prices. Accordingly, this translates to an exchange rate pass-through to import prices of 42 percent. The parameter is signifcant at 1 percent level suggesting that nominal exchange rate is an important determinant of

import price. The parameter of 1.49 on the log of past Import Price is positive with a p-value of less than 5 percent and a t-statistic (20.16) of more than a *Rule-of-Thumb* value of 2 implies that there is a strong Import Price momentum. The coefficient of the log of Production Cost in South Africa of 0.4728 with a t-statistic of 4.799 and a p-value of less than 5 percent imply that local costs impact import costs positively and probably this is due to higher importation of goods from other countries with lower costs of production. Foreign cost of production with a parameter of 0.400 is significant at 1 percent This suggests that the USA production cost is positively and significantly related to the South African Imports Prices. This is not surprising given that a rise in the production cost in the USA means that exporters would pass on some of the costs to the importer .

The interpretation of the parameter of the Production Cost in the USA is that a 1 percent rise in the cost of production in the USA results in only a 0.4 percent rise in the cost of imports into South Africa. The results conveys a message that even though there may have been rising production cost in exporting firms, they cannot pass it on 100 percent to importing firms for fear of losing some degree of market share. The economic implication of the significant production cost coefficient in the USA is that some of those costs are passed on to the importing country and that causes import prices to rise and this situation can be exacerbated by the depreciation of the local currency. On the CPI varaibles, both local and foreign, one can see that they have a positive influence on the Import Prices in South Africa. The income gap variable did not show the expected sign and was also not significant in the determination of the Import Prices in South Africa. A positive sign was expected on the income gap since one can hypothesise that a large disparity between the actual output and the expected output trend would drive prices upwards. Similary, the financial gap variable showed a negative sign but was a significant factor of Import Price.

The fact that Income-Gap did not explain import price significantly implies that, during the period of analysis, deviation of actual output from expected level did not have significant impact on import prices. This might not be surprising for an open econmy like South Africa. Even if output deviations occur, the effect is neutralised as trade responds to offset the shock (Juvenal, Petrella and Di-Pace, 2020). Also, increased financial integration reduces the impact of domestic shocks in the financial sector. In addition, the impact of shocks on import prices is muted in economies adopting inflation targeting policy (Carrière-Swallow *et al.*, 2022) as is the case with South Africa.

Similar results of incomplete pass-through to import prices were found by Karoro, Aziakpono and Cattaneo (2009), Parsley and Farrell (2010) and Parsley (2012a). The result also echoes the findings

of a study in Turkey by Kara and Dede (2023) but the impact of exchange rate on prices was found not to be significant.

5.6.1 Post Regresssion Diagnostic Tests for import price ARDL Model

The post estimation diagnostic tests for the import price model are shown in Table 5.5.

Table 5. 5: Diagnostics for the ARDL Import Model

Diagnostic Test	Description of Test	Test Statistic & p-value	Decision
Homoscedasticity	Testing for equality of variances in the residuals	F-statistic = 2.082 p-value = 0.0857	Accept H_0 of Homoschedasticity in residual terms
Ramsey Test	Testing for the absence of non-linear independent variables	Likelihood Ratio (LR test) p-value = 0.7164	Accept H_0 of absence of non-linearity in the model
Variance Inflation Factor (VIF)	Testing for Multicollinearity among exogenous variables	Average Uncentered VIF Rule of Thumb: VIF < 10 Recorded Average = 2.104	Since average VIF < 10 we conclude there is no problem of multicollinearity
Breusch-Godfrey LM test	Test for serial correlation in the residual terms	F-statistic = 0.8799 p-value = 0.4172	Accept H_0 of absence of serial correlation in the residual terms

Source: Own compilation from estimation results using Eviews.

From Table 5.5 above and using the 5 percent level of significance the hypothesis of equal variances in the residuals (Homoskedasticity) is not rejected in this estimation. As a result of this, the regression results do not suffer the problem of biased standard errors that ultimately affect the statistical inferences. The Null Hypothesis in the Ramsey RESET test is that there are no omitted variables in the pass-through equation. From the Ramsey's RESET Test, it can be seen that the p-values of all the test statistics are greater than 5 percent or 10 percent and therefore we fail to reject the Null Hypothesis. This tells us that there are no important variables, especially non-linear, that have been omitted from the model, hence the more model is correctly specified.

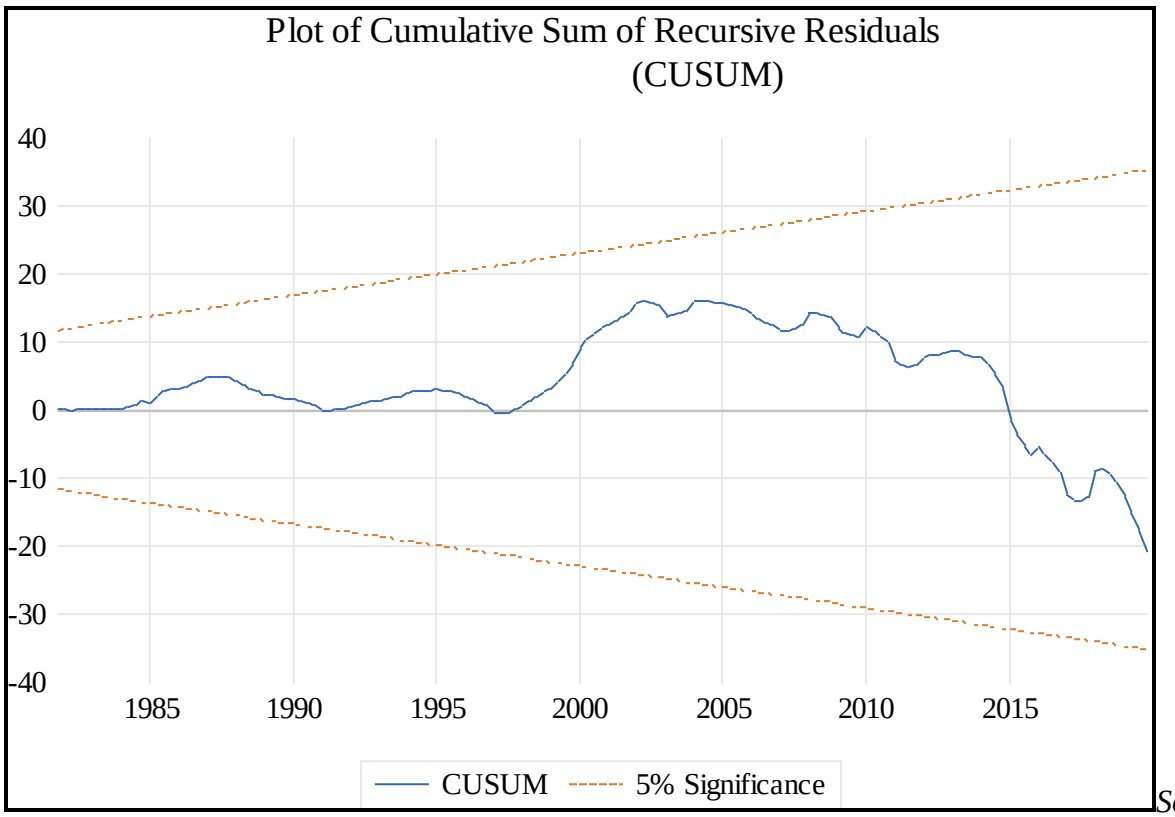
Multicollinearity, if severe, can cause the standard errors to be inflated as well as switching of signs in the coefficients. Most researchers use a Variance Inflation Factor (VIF) larger than 10 to be an indicator of multicollinearity while others use a more conservative value of 5 or even 2.5 (Menard, 2000). Using a threshold of 5 as an indicator for causing multicollinearity, we see that most of the variables have Variance Inflation Factors between 1 and 3 and this shows that each of these variables do not have coefficients whose variances suggest multicorrelation among regressors. The average VIF is 2.104 and is way below the thereshold of 5. The analysis concludes that multicollinearity does not exist in the regression results. The absence of multicollinearity suggests that the standard errors of estimated coefficients are not inflated and hence the statistical power of p-values get increased.

The Breusch-Godfrey LM test for autocorrelation test has shown the absence of serial correlation in the residuals of the regression. This means we can rule out the possibility of spurious outcomes. This was just a routine exercise to do but the E-Views software had already given us the Durbin-Watson (DW) statistic of 2.088 in Table 5.4. To check on the stability of the imprt model results, the CUSUM CUSUM-SQ tests were conducted and results are illustrated in Figures 5 and ….

5.6.2 CUSUM Test results for the import price ARDL model

The CUSUM test was run to test for parameter stability of the multivariate ARDL Model.The Null Hypothesis is that parameters are stable across time [H_0: Parameters are stable (desirable)]. Alternative Hypothesis is that parameters significantly change [H_A: Parameters are unstable (undesirable)]. Decision Rule is to Reject H_0 if the decision graph lies outside the 5 percent critical lines or bounds. The results are shown in Figure 5.4.

Figure 5. 4: Cumulative Sum of Recursive Residuals (CUSUM)



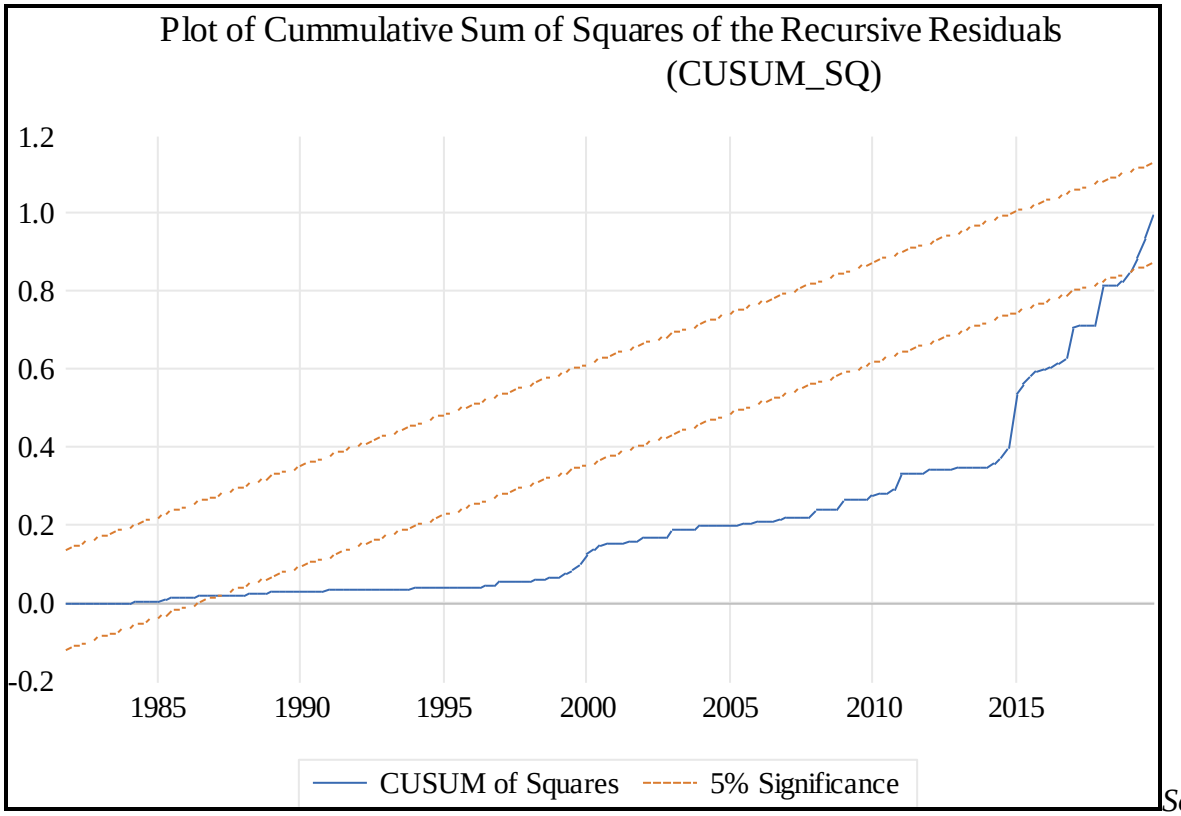
Source: Own econometric analysis using Eviews.

Based on the CUSUM graph shown above, we fail to reject the Null Hypothesis and conclude that the estimated parameters of the Multivariate ARDL model are stable across time. This means the results are far from being spurious and can be used for both forecasting and policy recommendation.

5.6.3 CUSUM-SQ test results for the import price ARDL model

The CUSUM-SQ test was conducted to test for sudden change is parameters of the multivariate ardl model. The Null Hypothesis is that variances of residuals are constant across time [H_0: variances are unchanging]. Alternative Hypothesis is that residual variances change [H_A: Variances of residuals are not constant]. Decision Rule: Reject H_0 if the decision graph lies outside the 5 percent critical lines or bounds. The test output is illustrated in Figure 5.5.

Figure 5. 5: Cumulative Sum of Squares of Recursive Residuals (CUSUM-SQ)



Source: Own econometric analysis using Eviews.

Figure 5.5 shows that the variance of the residuals are not constant across time and this means that at some point some parameters may suddenly change but overall, due to joint stability of the parameters we cannot view the CUSUM-SQ results as implying that the model results cannot be relied upon.

5.6.4 Bivariate ARMA model for Import Price (For Robustness Checks to the ARDL Model)

For robustness checks on the stability of the Import Price we estimate a pure AR(2) process with log of NER as the input variable. The results will not only show the stability of the variable but also to check if the dynamics of the variable vis-a-vis its return to equilibrium in the long run. To do this, we estimate a univariate time series model for Import Prices and in its level as shown below.The

Bivariate model has only the dependent variable (import price) and the independent variable (exchange rate). This is designed to establish if there would be any significant change in the impact of exchange rate on import price in the absence of the other variables. The estimation of this model continues to address objective 1 and results are shown in Table 5.6.

Table 5. 6: Bivariate ARMA Model (Import Price)

Dependent Variable: LNIMP_PRICE				
Method: ARMA Maximum Likelihood (OPG - BHHH)				
Sample: 1980Q1 2019Q4				
Included observations: 160				
Convergence achieved after 42 iterations				
Coefficient covariance computed using outer product of gradients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNNER	0.463607	0.027131	17.08795	0.0000
AR(1)	1.741555	0.000651	2676.053	0.0000
AR(2)	-0.741591	0.000128	-5801.382	0.0000
SIGMASQ	0.000166	9.39E-06	17.68942	0.0000
R-squared	0.999811	Mean dependent var		3.771725
Adjusted R-squared	0.999808	S.D. dependent var		0.941835
S.E. of regression	0.013055	Akaike info criterion		-5.741501
Sum squared resid	0.026589	Schwarz criterion		-5.664622
Log likelihood	463.3201	Hannan-Quinn criter.		-5.710283
Durbin-Watson stat	2.235177			
Inverted AR Roots	1.00	.74		

Source: Own econometric analysis using Eviews.

The terms AR(1) and AR(2) are lagged terms of the dependent variable which is the Import Price in this case. The term SIGMASQ ($\hat{\sigma}^2$) is actually the sum of squares of the residual terms and is also taken as the variance of the dependent variable. This variance of the dependent variable is regarded as volatility in the variable. One can model variance as an uncertainty variable.

The estimated model is shown below:

LnImp_price = 0.463607087192*lnner + [AR(1)=1.74155486467,AR(2)= -0.741590927045] + 0.000166*σ^2 and if we let $\emptyset_1 = 1.74155486467$ and $\emptyset_2 = -0.741590927045$ we have $\phi_1^2 + 4\phi_2 = 1.74155486467^{\,2} + 4 * (-0.741590927045) = 0.066649$ and $0 < 0.066649 < 1$ meaning that there is absence of pseudo-periodic cycles in the variable and does not show exploding tendencies when subjected to a one standard deviation shock. This corroborates the results obtained from the multivariate regression estimate before. Also, the result shows us that a 100 percent increase in the nominal exchange rate (depreciation) leads to about 46 percent increase in Import Prices and this again illustrates that there is an incomplete exchange rate pass-through of exchange rate change

to import prices in South Africa. Table 5.6 also shows that the lagged values of Import Price are significant and appear to influence current Import Price cyclicaly. The uncertainty variable, as represented by the variance (SIGMASQ) of the dependent variable is a significant factor in future import prices.

Literature has not indicated what level of exchange rate pass-through is deemed acceptable in the economy. A very high ERPT is equally undesirable just like the very low ERPT as these have the potential to cause future exchange rate volatility in the event there is need to adopt a harsh monetary policy when responding to sudden macroeconomic changes such as an unplanned shock in the aggregate demand. The view of the author is that an ERPT of between 50% and 60% would cause macroeconomic shockwaves. By way of policy therefore, a gentle, but not harsh intervention in the management of macroeconomic tools such as the exchange rate and interest rate can be pursued or experimented with.

5.7 VECTOR ERROR CORRECTION MODEL (VECM) (FOR INVESTIGATING THE EXISTENCE OF LONG-RUN AND SHORT-RUN ASSOCIATIONS AMONG VARIABLES)

This section presents findings from the VECM estimates on the long-term and short-term impact of exogenous variables on endogenous variables as outlined in objective 1. These are as shown in Table 5.7.

Table 5. 7: Vector Error Correction Estimates

MODEL 1				**Error Correction = -0.0211**
Dep Variable: Δ lnIMP_PRICEt				
Independent Variables	Coefficient	t-statistic	p-value	
Δ lnIMP_PRICEt-1	0.7750	3.9161	0.0001	t-statistic = -1.7810
Δ lnNERt-1	- 0.0700	-0.7407	0.4592	P-value = 0.0755
Δ lnPRODC_RSAt-1	- 0.0096	-0.0352	0.9719	
ΔlnPRODC_USAt-1	- 0.1377	-0.7363	0.4619	
Constant	0.0082	2.1300	0.0336	
MODEL 2				**Error Correction = -0.0706**
Dep Variable: Δ lnNERt				
Independent Variables	Coefficient	t-statistic	p-value	
Δ lnIMP_PRICEt-1	0.2189	0.6636	0.5073	t-statistic = -3.5641
Δ lnNERt-1	0.5003	3.1564	0.0017	P-value = 0.0004
Δ lnPRODC_RSAt-1	0.0409	0.0897	0.9286	
ΔlnPRODC_USAt-1	-0.2328	-0.7465	0.4557	
Constant	0.0113	1.7717	0.0771	

Long-Run Equation:

$$lnImp\_price_{t-1} = -4.6290 - 0.0303 * lnNER_{t-1} + 0.588 * lnprodc\_rsa_{t-1} + 1.437 * lnprodc\_usa_{t-1}$$

$$t\text{-}statistic = [-0.1403] \quad [1.9940] \quad [2.8100]$$

Short-Run Equations:

$$\begin{cases} \Delta lnimp_{price_t} = 0.7750 * \Delta lnimp_{price_{t-1}} - 0.0700 \Delta lnNER_{t-1} - 0.0096 \Delta lnprodc_{rsa_{t-1}} \\ \qquad\qquad - 0.1377 \Delta lnprodc_{usa_{t-1}} + 0.0082 \\ \Delta lnNER_t = 0.2189 * \Delta lnimp_{price_{t-1}} + 0.5003 \Delta lnNER_{t-1} + 0.0409 \Delta lnprodc_{rsa_{t-1}} \\ \qquad\qquad - 0.2328 \Delta lnprodc_{usa_{t-1}} + 0.0113 \end{cases}$$

Source: Own econometric analysis using Eviews.

The long-run equation shows that when the nominal exchange rate increases (depreciation) then import prices fall. This is expected in an environment where foreign firms absorb some of the exchange rate changes to keep the market share. The impact of exchange rate on import prices, however, is not significant as the t-statistic is far below the '*Rule-of-Thumb'* value of 2. Domestic and foreign costs of production impact positively on import prices. When domestic costs increase, this has the effect of increasing consumer prices and so economic agents turn to imported goods and services but this puts an upward pressure on import prices. Similarly, when foreign costs increase, the exporters pass-on some of the costs to the importers and so we can expect import prices to rise.

The short-term impact of exchange rate changes to import price is the same as in the long-run, at least in terms of the sign but different in terms of degree. The short-term impact of exchange rate changes on import prices is greater than in the long-run as can be seen when we compare their coefficients which are -0.0700 and -0.0303 respectively.

Error Correction term for the 1st model is -0.0211 and only significant at 10 percent and not at 5 percent level of significance. One can state that the cointegration parameter for the model is weakly significant. The system for model 1 returns to historical equilibrium very slowly after a disequilibrium at a rate of 2 percent per quarter. This means import prices do not get back to equilibrium level soon enough after any deviation caused by changes in the independent variables. On the other hand, the speed of adjustment for the 2nd model is about 7 percent and is significant. The implication of this is that exchange rate adjusts sluggishly after a deviation from equilibrium but faster than the adjustment in import prices. These results mirror those found by Sanusi (2010) and Frimpong and Adam (2010) in which they found no evidence of a significant long-run pass-through using data from Ghana.

5.8 EXCHANGE RATE PASS-THROUGH TO CONSUMER PRICE

The estimation of the pass-through to inflation still addresses objective 1 that endeavours to measure the degree of exchange rate pass-through to consumer prices (inflation). The results are shown in Table 5.8.

The model used is the ARDL model as it allows us to see the dynamics in the system over time. The importance of persistence of some variables on future values of themselves cannot be overemphasized. Policy prescriptions require knowledge of the relationships among variables and their evolution over time.

Table 5. 8: ARDL Estimation Results (Inflation equation)

Dependent Variable: infl_rsa **Estimation Method: ARDL**			
Dynamic Regressors	Coefficient	t-statistic	p-value
INFL_RSA(-1)	1.338037	17.54960	0.0000
INFL_RSA(-2)	-0.329837	-2.855285	0.0050
INFL_RSA(-3)	-0.091040	-1.440083	0.1521
LNIMP_PRICE	14.76330	5.760495	0.0000
LNIMP_PRICE(-1)	-24.36002	-5.638659	0.0000
LNIMP_PRICE(-2)	9.019846	3.428783	0.0008
LNNER	0.309115	0.935881	0.3509
INCGAP_REAL	-0.152442	-1.963035	0.0516
INCGAP_REAL(-1)	0.200610	2.546955	0.0119
LNPRODC_RSA	18.48230	3.942738	0.0001
LNPRODC_RSA(-1)	-18.49330	-3.960870	0.0001
LNPRODC_USA	0.783492	1.114235	0.2671
FIN_GAP	0.219515	2.635897	0.0093
FIN_GAP(-1)	-0.336478	-2.597476	0.0104
FIN_GAP(-2)	0.181152	2.089882	0.0384
INTEREST_DIFFERENTIAL	0.020213	1.096794	0.2746
Diagnostics: 1. $R^2 = 0.9915$, $\overline{R^2} = 0.9906$ 2. F- Statistic = 1025.209, Prob(F-statistic) = 0.0000 3. Durbin-Watson statistic = 1.988 ≈ 2 Selected Model using AIC from 312 500 models: ARDL(3, 2, 0, 1, 1, 0, 2, 0)			

Source: Own econometric analysis using Eviews.

Immediate past inflation levels have a positive and significant impact on the current inflation. The 1st lag of the inflation variable is shown to be significant in explaining future inflation rates in South Africa for the period of study. The parameter of 1.33 coupled with a t-statistic of 17.54 and a p-value of 0.0000 means that the emmediate past inflation positively influences current inflation and this is in keeping with the literature that suggests that one of the causes of inflation is inflation itself. This means that the momentum that has been built by previous inflation rates cause future inflation levels to rise. Import prices, as shown by the regression output, have a significant relationship with the inflation rate in South Africa. From the results in Table 5.8, the coefficient of log of Import Price is 14.76 meaning that when import price increases by 1 percent then the increase in inflation would be 0.1476 percentage points. This result shows that importers do not pass the full impact of the exchange rate change to the consumers and this confirms the PTM theory. The analysis also shows that even though the sign of the exchange rate is the predicted one, it is not significant. This means then that for the period of study exchange rate pass-through to prices was small.

The current Income Gap was found not to significantly affect Inflation but its lagged counterpart is strongly significant in explaining inflation and with a lag. Production cost (p-value = 0.0001) in South Africa and the financial gap (p-value = 0.0093) were both found to be strong factors of inflation and this was expected. Increasing costs of production and widening Financial Gap as represented by less sophisticated financial system can cause increase in inflation. Interest rate differential and Production Cost in the USA were found not to impact inflation significantly. All the econometric results indicate the need to have policies that stabilise macroeconomic variables such as real income, good financial system in the country and a policy that protect importers from high import costs that ultimately are borne by the consumer.

From the results, it is evident that the ERPT to consumer prices in South Africa for the period was about 31 percent, which is smaller than the 46 percent and 48 percent transmission to Import Prices found in the Bivariate and ARMA model earlier. The result of the ERPT to consumer prices is a demonstration of the existence of a Pricing-to-Market strategy by exporters exporting to South Africa. Since this one was a Lin-log ARDL model it shows that a 1 percent depreciation of the exchange rate results in inflation increasing by 0.00309 percentage points.[9] Also a 1 percent increase in import prices in South Africa resulted in a 0.148 percentage increase in inflation, meaning that local distributors have less *appetite* to increase consumer prices even in the face of rising import prices.

The inflation rate differential coefficient is positive, meaning that a lower interest rate in South Africa causes consumers to borrow more from the financial markets and increase demand of goods and services and ultimately causes inflation to go up. Higher USA interest rates compared to South Africa may also result in arbitrage conditions in which people can borrow cheap money in South Africa and then invest it at a higher interest rate in the USA. To check on the efficiency of the estimations above, diagnostic tests were carried out and results are shown in Table 5.9.

[9] In a lin-log model of the form $y = \beta_0 + \beta_1 lnx$, $\frac{dy}{dx} = \frac{\beta_1}{x} \Rightarrow\ dy * 100 = \frac{dx}{x} * 100(\beta_1)$ & $if\ \frac{dx}{x} * 100 = 1\ \ then\ \Delta y = \frac{\beta_1}{100}$. The interpretation is that a 1% change in x results in $\frac{\beta_1}{100}$. Units change in y.

Table 5. 9: Post Regression Diagnostics (Inflation Model)

Diagnostic Test	Description of Test	Test Statistic & p-value	Decision
Ramsey Test	Testing for the absence of non-linear independent variables	Likelihood Ratio (LR test) p-value = 0.0689	Accept H_0 of absence of non-linearity in the model
Breusch-Godfrey LM test for serial Correlation	Test for serial correlation in the residual terms	F-statistic = 0.4581 p-value = 0.6334	Accept H_0 of absence of serial correlation in the residual terms

Source: Own econometric analysis using Eviews.

Our model does not suffer from serial correlation of residuals as evidenced by the LM tests of serial correlation results. The Ramsey RESET test shows that no important variables that are non-linear and independent have been omitted. We can declare the model a reasonable one for estimation and forecasting purposes.

5.9 VECM FOR INFLATION IN SOUTH AFRICA

This section responds to Objective 1 that interrogates the speed of adjustment in the inflation model in the event of a disequilibrium in the model. The objective also looks at the short-run and long-run relationship among the variables in the Inflation model. In econometric estimations using time series data, it is always scholarly to examine how variables of interest would regain historical equilibrium after a disequilibrium has occurred. This is crucial information for policy. We present the results of the cointegration test as well as the VECM results. After performing the lag-selection criteria procedure it has been found that using 6 lags would deliver optimal results.

5.9.1 Johansen Cointegration Test (Inflation Model)

The Johansen cointegration test results are illustrated in Table 5.10.

Table 5. 10: Johansen Cointegration Test (Inflation Model)

Johansen Cointegration Test: Linear deterministic trend assumed. Variables: **inflation, lnNER, lnImp_price, inc_gap, fin_gap, lnProdc_rsa, lnProdc_usa**								
Null Hypothesis	TRACE TEST				MAXIMUM EIGENVALUE TEST			
H_0	H_A	Λ_{trace} Test	Critical value (95%)	p-value	Λ_{max} Test	Critical value (95%)	p-value	Decision
r = 0	r > 0	188.65*	125.61	0.0000	75.23	46.23	0.0000	Reject H_0
r ≤ 1	r > 1	113.42*	95.75	0.0197	43.52	40.08	0.0197	Reject H_0
r ≤ 2	r > 2	69.901*	69.82	0.0401	34.68	33.88	0.0401	Reject H_0
r ≤ 3	r > 3	35.221	47.86	0.5896	16.87	27.58	0.5896	Accept H_0
Both Trace and Maximum Eigenvalue tests indicate that there are 3 Cointegrating Equations at the 5% level of significance.								

Source: Own calculations using Eviews.

The results in Table 5.10 show that for ranks 0 to 2, the trace statistics are all greater than the 5 percent critical values. This means that the null hypotheses of zero, one, and two cointegrating equations are rejected. However, for rank three, the trace statistic of 35.221 is less than the 5 percent critical value of 47.86. As such, the null hypothesis of at least three cointegrating equations could not be rejected. This confirms the existence of 3 cointegrating relationships and justifies the estimation of the VECM. The VECM was estimated and results are presented in Table 5.11.

5.9.2 Vector Error Correction (VECM) Results (Inflation model)

Table 5. 11: VECM results (Inflation Model) long-run results

Variable	Coint Eq1	Coint Eq2	Coint Eq3
Long-run terms			
Inflation(-1)	1	0	0
lnNER(-1)	0	1	0
lnImp_price(-1)	0	0	1
inc_gap(-1)	-1.564 [-2.475]	0.309 [3.929]	0.048 [1.448]
lnProdc_rsa(-1)	-0.526 [-0.204]	-1.066 [-3.319]	-0.559 [-4.132]
lnProdc_usa(-1)	1.712 [0.204]	1.492 [1.429]	-1.146 [-2.607]
constant	-13.997	-3.943	3.304
ECM t-statistics of ECM	**-0.0726** [-2.539]	**-0.228** [-0.858]	**-0.601** [-1.122]
Diagnostics: $R^2 = 0.9915$, $\overline{R^2} = 0.9906$	Figures in [ ] are t-statistics.		

Source: Own compilations from estimation results using Eviews.

Expressed in model form, the three cointegrating equations are given below. The cointegrating equations show the long-term relationships among the variables. Short-term results are not presented here because the focus is on capturing the long-term relationships. In particular, how soon inflation gets back to its long tem path following shocks in the independent variables.

(Notice that the signs are reversed when writing out the long-run equations)

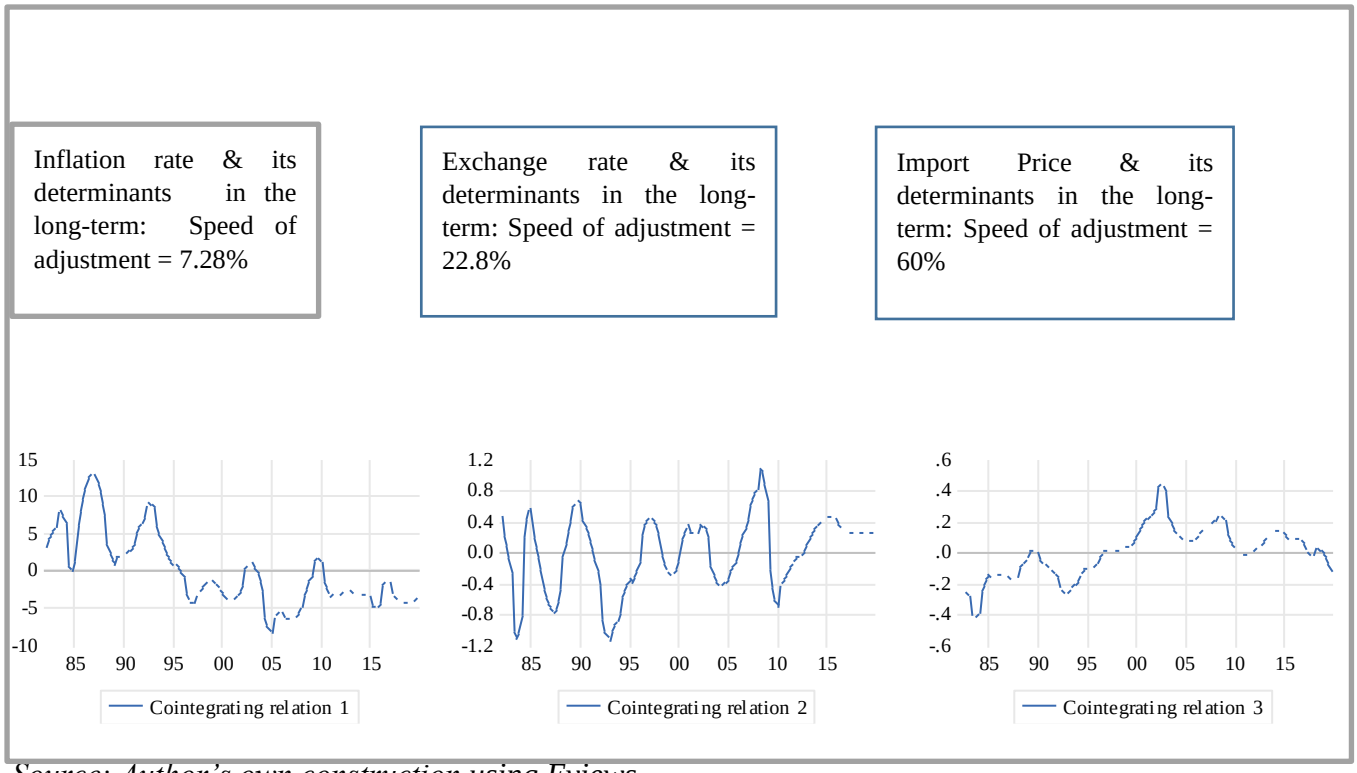
Coint Eq1: $\boldsymbol{infl_{t-1} = 1.564inc\_gap_{t-1} + 0.526lnProdc\_rsa_{t-1} - 1.712lnProdc\_usa_{t-1} + 14.00}$

Coint Eq2: $\boldsymbol{lnNER_{t-1} = -0.309inc\_gap_{t-1} + 1.066lnProdc\_rsa_{t-1} - 1.492lnProdc\_usa_{t-1} + 3.94}$

Coint Eq3: $\boldsymbol{lnimp\_price_{t-1} = -0.048inc\_gap_{t-1} + 0.559lnProdc\_rsa_{t-1} + 1,146lnProdc\_usa_{t-1} - 3.30}$

As can be seen from Table 5.11, only the error correction term (ECT) for cointegating equation 1 (inflation equation) is statistically significant. The other two ECTs (exchange rate and imports) are insiginificant, though they have higher speeds of adjustment. As a result, analysis is based on the first error correction term ECM. The ECT for inflation is -0.0726, suggesting that any disequilibrium in the inflation equation is corrected at the rate of 7.2 percent per quarter. This is a slow return towards historical equilibrium, though the model is siginficant. For the inflation equation only the income gap variable is significant to explain inflation in South Africa. This means a large income gap may result in unstable supply of goods in the economy, leading to increase in prices. Cost of production in South Africa has the correct sign for inflation but is not significant. The behaviour of the three cointegarting equations are illustrated in Figure 5.6.

Figure 5. 6: Cointegration Graphs



Source: Author's own construction using Eviews.

Figure 5.6 illustrates the adjustment process for the observed paths of the leading variable and its determinants. The zero line illustrates the long-run equilibrium among the variables after the shock has subsided in the system. The curves represent the deviations from the long-run. Linear combinations return to long-run equilibrium in each case but the speed of adjustment differs. The inflation variable and its determinants have been above equilibrium for most of the 1990s until about 1995 after which it mostly remained below equilibrium with very low speed of adjustment towards equilibrium of about 7 percent. This means inflation adjusts slowly after a shock in South Africa during the period. The exchange rate, on the other hand, adjusts to shocks at a speed of 22.8 percent and does not have serious implications for policy. The import price adjusts well in the long run at a speed of 60 percent. From the cointegration graphs it appears that both the exchange rate and import prices quickly adjust to long-term equilibrium path than inflation. This calls for a monetary policy that ensures the shocks that cause inflation to deviate from its long-term path be given attention- a policy such as stronger managed float system that allows for a free-market exchange rate determination with temporary intervention from time to time.

5.10 INVESTIGATING ASYMMETRIC IMPACT OF EXCHANGE RATE ON PRICES

This section addresses Objective number 2 which is: **To examine the existence of asymmetric exchange rate pass-through to import and consumer prices between appreciation and depreciation episodes**

One of the reasons for incomplete and even small ERPT to prices is that firms try to absorb some of the effect of the exchange rate and this is in accordance with the Pricing-to-Market Theory (PTM). The PTM theory states that exchange rate pass-through to prices is smaller during depreciation of the currency of the importer and is high during appreciation. If, on the other hand, there is a constraint as to the quantity that an importer can bring in then a pass-through would be higher during deprecation and this is known as the Binding Quantity Constraint Theory. We therefore need to test these theories and see which 'stick' for the South African data. The asymmetric analysis require us to disintegrate exchange rate into depreciation and appreciation before including them in a regression model. The results of the exchange rate pass-through asymmetry regression are shown in Table 5.12.

Table 5. 12: Asymmetric Model Results (Binding Quantity Constraint and PTM Theories Test)

Dependent Variable: lnImp_price Sample: 1980Q2 – 2019Q4 Number of observations = 159 Estimation Method: ARMA Maximum Likelihood			
Variable	Coefficient	t-statistic	p-value
Appreciation term	0.4736	16.4199	0.0000
Depreciation term	0.4101	16.1740	0.0000
lnProdc_rsa	0.6056	12.3244	0.0000
lnProdc_usa	0.5841	12.9566	0.0000
AR(1)	0.6057	10.3490	0.0000
AR(2)	0.1278	1.4222	0.1570
$\hat{\sigma}^2$	7.71E-05	13.1568	0.0000
Diagnostics	$R^2 = 0.9915,\ \overline{R^2} = 0.9906$ Durbin-Watson Statistic: 1.960		

Source: Own econometric analysis using Eviews.

The above is a regression of lnimp_price on appreciation and depreciation controlling for both domestic and foreign costs of production. The appreciation and depreciation parameters of 0.4736 and 0.410 respectively imply that there is an asymmetric impact of exchange rate on import prices

as the degree of pass-through during appreciation is greater than during depreciation. This confirms the Pricing-to-Market Theory in which the pricing mechanism is designed to keep prices low for market share purposes. Higher pass-through during appreciation than depreciation is not consistent with the Binding Quantity Constraint Theory that hypothesizes that pass-through during depreciation is higher due to quantity restrictions in the importing country and hence increasing profits by exporters means raising prices of exports. The coefficients for local costs (0.6056) and foreign costs (0.5841) have the expected positive signs. This indicates that the production costs have important influence on import prices in South Africa.

The variables shown as AR(1) and AR(2) are basically lagged terms of the dependent variable lnImp_Price (i.e log of Import Price). Only the immediate momentum of the Import Price (t-statistic of 10.35 and p-value of 0.0000) in the form of AR(1) was significant to influence import prices. The uncertainty term, represented by $\hat{\sigma}^2$ is very significant in explaining Import Price as indicated by the large t-statistic of 13.15 and a probability value of 0.0000. Both local and foreign costs of production are significant in explaining Import Prices and the t-statistics of 12.32 and 12.96 respectively, confirm that assertion. The results show that, even though an appreciation of the Rand is desirable for some economics agents such as importers and others, higher levels of appreciation may result in higher import prices. Moderate exchange rate management is encouraged in South Africa. However, since there is no material difference in terms of the coefficients between appreciation and depreciation, harsh or aggressive exchange rate policy is not desirable. Uncertainty has been seen to cause an increase in import prices and so it is important to stabilise the economy in terms of the variables that influence the exchange rate and ultimately affect import prices.

These results are similar to those obtained by Qabhobho et al. (2020) and Parsley and Farrell (2010) for South Africa. Parsley and Farrell (2010) used monthly data and found ERPT to import prices being higher during appreciations and lower during depreciation. While the degree of pass-through for appreciation differs from that of depreciation, it would be interesting to actually find out if the degree of ERPT during appreciation is significantly different from that of depreciation. To do this we subject our results to a formal Wald-Test of equality of coefficients as shown below.

5.10.1 Wald Test of equality of coefficients of Appreciation & Depreciation

To check on the equlity of parameters of appreciation and depreciation in the asymmetric model, the Wald test was carried out and estimates are as in Table 5.13.

Table 5. 13: Test of equality of coefficients

Wald Test:			
Equation: Appreciation_Depreciation_REGRESSION			
Test Statistic	Value	df	Probability
t-statistic	1.596023	152	0.1126
F-statistic	2.547289	(1, 152)	0.1126
Chi-square	2.547289	1	0.1105
Null Hypothesis: $\beta_{1A} = \beta_{1D}$			
Null Hypothesis Summary:			
Normalized Restriction (= 0)		Value	Std. Err.
$\beta_{1A} - \beta_{1D}$		0.063448	0.039754
Restrictions are linear in coefficients.			

Source: Own econometric analysis using Eviews.

The null hypothesis that there is ERPT Symmetry between appreciation and depreciation is not rejected at the 5 percent level of significance (i.e. H_0: $\beta_{1A} = \beta_{1D}$ is accepted), implying that during the study period in South Africa exchange rate changes did not have significant differential impact on import prices between appreciation and depreciation. The only slight trace of PTM existence is that the coefficient of appreciation (0.4736) is slightly larger than that of depreciation (0.4101). These results mirror those by Pollard and Coughlin (2003) who found no significant evidence of any ERPT asymmetry using the USA industry-specific data. The results also show that the ERPT to import prices is higher at 47 percent than during depreciation at 41 percent. This is an example of Pricing to Market Strategy by firms when they decrease mark-up during depreciation and increase during appreciation thereby offsetting losses made when trying to maintain market share. The reason why studying the asymmetric effect of the ERPT to prices is for policy purposes. In this case a policy that keeps the Rand stable without extreme cases of appreciation or depreciation is encouraged. Both episodes of exchange rate have significant and positive impact on prices but more so for appreciation. Stable macroeconomic environment without high unemployment, high inflation and low economic growth will help stabilise the local currency in South Africa. The Null Hypothesis of symmetry of ERPT between appreciation and depreciation is rejected in this case.

5.10.2 Direction of Asymmetry and Explanatory Theories

For guidance purposes Table 5.14 shows the direction of pass-through and the possible reasons for the ERPT Asymmetry as adopted from Pollard and Coughlin (2003).

Table 5. 14: Direction of Asymmetric Pass-Through & Theories

Direction of Asymmetry in Exchange Rate Pass-Through	
Explanation (Theory)	Pass-Through
Market Share	Appreciation > Depreciation
Production Switching	Appreciation > Depreciation
Quantity Constraints	Depreciation > Appreciation
Menu Costs	Large changes in NER > small change in NER

Source: Own calculation using Eviews.

When the currency of the importing country depreciates, exporters may choose to maintain or even reduce prices to keep the market and in the process absorb some of the losses (Goldberg and Knetter, 1997). These losses are offset during times of appreciation of the currency of the importing country. Production-Switching occurs when a foreign firm chooses to use its own domestically produced inputs in manufacturing when there has been a depreciation in its own currency or when there has been an appreciation in the currency of the importing country. This causes the firm to adjust its mark-up upwards when selling to the importing country whose currency has appreciated. On the other hand, depreciation of currency for the importing country would cause the exporting firm to use inputs of the country that is importing and therefore Exchange Rate Pass-Through tends to be close to zero

5.10.3 Multicollinearity Test in the Asymmetric Model

In addition to the correlation matrix, the variance inflation factor for each variable and for all were computed and the output is as shown in Table 5.15.

Table 5. 15: Test of multicollinearity in the Asymmetric Model

Variance Inflation Factors
Sample: 1980Q1 2019Q4
Included observations: 159

Variable	Coefficient Variance	Uncentered VIF
APPR_TERM	0.000832	1.049841
DEPR_TERM	0.000643	1.479997
DLNPRODC_RSA	0.002414	1.413704
DLNPRODC_USA	0.002032	1.132411
AR(1)	0.003426	2.245019
AR(2)	0.008078	2.483248
SIGMASQ	3.43E-11	1.297611

Source: Own econometric analysis using Eviews.

Results in Table 5.15 shows that the uncentered variance inflation factor (VIF) for all the variables are less than three. Conventionally, a VIF of less than 10 shows absence of multicollinearity. The results, therefore, are robust. Some authors use a maximum value of 5 on the VIF to declare absence of multicollinearity among exogenous variables. In this test, the average VIF for each variable is far below the maximum value of 5 thereby confirming that the model does not suffer a problem of multicollinearity.

5.10.4 High and Low Exchange Rate Change Asymmetry

The results of the impact of the size of the change in the exchange rate on import prices are shown in Table 5.16.

Table 5. 16: Large & Small NER Change Regression (Menu Cost Theory Testing)

Dependent Variable = lnImp_Price

Sample (adjusted): 1981Q3 2019Q4
Included observations: 154 after adjustments
Maximum dependent lags: 6 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (4 lags, automatic): LOW_XRATE HIGH_XRATE
Fixed regressors: C
Number of models evalulated: 150
Selected Model: ARDL(6, 0, 0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LNIMP_PRICE(-1)	1.613865	0.077594	20.79886	0.0000
LNIMP_PRICE(-2)	-0.450739	0.131562	-3.426056	0.0008
LNIMP_PRICE(-3)	-0.100825	0.124390	-0.810551	0.4190
LNIMP_PRICE(-4)	-0.708567	0.125505	-5.645732	0.0000
LNIMP_PRICE(-5)	0.987603	0.131657	7.501323	0.0000
LNIMP_PRICE(-6)	-0.344675	0.076737	-4.491638	0.0000
LOW_XRATE	0.000681	0.000996	0.683420	0.4954
HIGH_XRATE	0.000587	0.000431	1.363211	0.1749
C	0.019400	0.007211	2.690417	0.0080

R-squared	0.999718	Mean dependent var	3.843294
Adjusted R-squared	0.999703	S.D. dependent var	0.885572
S.E. of regression	0.015269	Akaike info criterion	-5.469363
Sum squared resid	0.033804	Schwarz criterion	-5.291878
Log likelihood	430.1409	Hannan-Quinn criter.	-5.397269
F-statistic	64316.80	Durbin-Watson stat	1.997206
Prob(F-statistic)	0.000000		

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

Source: Own econometric analysis using Eviews

The above model is simply showing the import price dynamics with low and high exchange rate as the variables of interest and other control variables are laaged terms of the dependent variable. The idea behind the estimation is to capture the autoregressive effect of import price as price momentum can fuel future prices. The study also measured the relative impact of high and low exchange rate on import prices. The wisdom in estimating relative impacts is understand the nature of the impact of exchange rate on import prices. It has been shown that even though moderate exchange rate changes may have no significant impact on import prices, we assume that an increase or decrease of the exchange rate above or below the established threshold would produce different results. In this estimation the low (t-statistic of 0.6834) and high (t-statistic of 1.3632) exchange rate variables have been created using exchange rate tthreshold and the results show that large changes above or below the exchange rate threshold have no significant effect on the import prices even though they carry the expected sign.

What we can conclude is that exchange rate change, large or small, has no significant effect on import price. This effectively mean that other factors of import prices may be of interest to researchers rather

than the exchange rate. What we, however, notice is that past import prices significantly cause future prices. The results do not mirror those found for Nigeria by Amoah (2017) where ERPT was higher during periods of large exchange rate changes. Parsley and Farrell (2010) used South African data and obtained results that showed that ERPT was higher during periods of large changes in the exchange rate. Our results show otherwise, but again they are not significant. This essentially means that practically large and small changes in the exchange rate have the same impact on import prices. To ensure robust estimation, the Breusch-Godfrey and the Wald tests were carried out.

The Breusch-Godfrey and and Wald tests were carried out to check for serial dependence among residuals and to check if parameters for High and Low exchange rate are equal. The test resuts are summarised in Table 5.17.

Table 5. 17: Postestimation diagnostics for High and Low Exchange Rate Change Asymmetry Model.

Null Hypothesis (H_o)	Diagnostic Test	Description of Test	Test Statistic & p-value	Decision
Residuals are independent of each other .	Breusch-Godfrey Serial Correlation Test	Testing for serial correlation in the residual terms	F-statistic = 1.026114 p-value = 0.3610	Accept H_0 .
Parameters for High and Low exchange rate are equal.	Wald Test	Testing for equality of regression parameters	Chi-Square =0.011759 p-value = 0.9136	Accept H_0 .

Source: Own calculation using Eviews.

As shown in Table 5.17, the probability values of the F (0.3610) and Chi-square (0.9136) statistics for the Breusch-Godfrey test and the Wald are all greater than 0.05. This means that there is no sufficient evidence to reject the specified null hypotheses. It can be concluded that the results are not spurious. The Wald Test of equality of coefficients between large and small changes returned a verdict of no significant differences meaning that even though there is asymmetric effect of exchange rate on import price it is not that significant. The results of the size-effect of exchange rate on import price is not consistent with the Menu-Cost Theory explained in chapter 4 but consistent with the Pricing-to-Market scenario.

5.10.5 Regime Switching Models/Threshold Regression Analysis

To support objective 2, the regime swiching model/threshod regression was carried. This shows the asymmetric effect of changing from low to higher exchange rate bands. The results are presented in Table 5.18.

Table 5. 18: Regime Switching Model Results

Dependent Variable: ΔlnImp_Price

Method: Discrete Threshold Regression

Threshold variable: NER_PERCENT_ABSOLUTE
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 5.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
NER_PERCENT_ABSOLUTE < -2.101809 -- 15 obs				
DLNPRODC_RSA	0.488242	0.619489	0.788137	0.4319
DLNPRODC_USA	-0.007178	0.432235	-0.016606	0.9868
C	-0.017830	0.013937	-1.279374	0.2028
-2.101809 <= NER_PERCENT_ABSOLUTE < 1.457318 -- 48 obs				
DLNPRODC_RSA	0.426944	0.211088	2.022587	0.0449
DLNPRODC_USA	0.566046	0.148613	3.808846	0.0002
C	0.001192	0.005082	0.234492	0.8149
1.457318 <= NER_PERCENT_ABSOLUTE < 4.419648 -- 71 obs				
DLNPRODC_RSA	0.678185	0.226411	2.995375	0.0032
DLNPRODC_USA	0.195597	0.298583	0.655086	0.5134
C	0.008290	0.005592	1.482499	0.1403
NER_PERCENT_ABSOLUTE=> 4.419648 -- 25 obs				
DLNPRODC_RSA	1.825590	0.261233	6.988360	0.0000
DLNPRODC_USA	0.085006	0.254050	0.334602	0.7384
C	-0.002827	0.008149	-0.346934	0.7291

R-squared	0.705792	Mean dependent var	0.020087
Adjusted R-squared	0.683777	S.D. dependent var	0.022793
S.E. of regression	0.012817	Akaike info criterion	-5.803601
Sum squared resid	0.024149	Schwarz criterion	-5.571985
Log likelihood	473.3862	Hannan-Quinn criter.	-5.709544
F-statistic	32.05880	Durbin-Watson stat	1.296047
Prob(F-statistic)	0.000000		

Source: Own econometric analysis

It can be observed from Table 5.18 that both local and foreign costs of production are not significant to explain import prices at the lowest exchange rate band (exchange less than -0.201809). As the bands increase, the impact and significance of local production costs increases. At the lowest band, local cost has a non-signficant parameter of 0.488 while at the highest band (NER≥ 4.419648) the parameter is higher (1.8255) and becomes significant. It can be deduced that local production costs have a higher and more significant impact on exchange rate pass-through to import prices as the exchange rate depreciates (Ji, 2022). This has direct implication for welfare of consumers as well as firms in the economy as higher import prices will be passed on to consumers. For foreign production costs, save for the band where 2.101809 ≤ NER≤ 1.457318, the parameter is insignificant. This suggests that foreign costs do not significantly cause import prices as the South African Rand

depreciates . The policy implication of the threshold model results is that government should provide subsdies to producers to cushion consumers from rising imported inflation. In addition to the subsidies policy it is important that, even though the country runs a flexible exchange rate regime, there is need to find a balance where there Rand does not tend to gain value beyond certain regime bands so that this does not influence an upward movement of import prices that, in the end, translate to higher consumer prices and hence inflation in South Africa.

5.11 EXAMINING THE HYBRID NEW KEYNESIAN PHILLIPS CURVE (HNKPC) MODEL IN SHAPING INFLATION EXPECTATIONS.

This section addresses objective number 3 which is: **To measure the level of exchange rate volatility on inflation in South Africa .**

Now that the study has established the magnitude of the ERPT to import prices as well as ERPT to consumer prices, the effort now is the need to focus on the role of inflation momentum and inflation expectations in determining current inflation and this is motivated by studies by Kabundi and Mbelu (2016). The model this study uses is the one inspired by the New Keynesian Phillips Curve (NKPC), especially the Hybrid NKPC (HNKPC) developed by Gali and Mark (1998) as well as Lacker and Weinberg (2007). The NKPC model was first developed by Calvo (1983) but the first version lacked some important determinants of inflation which then led to the development of a Hybrid type. The NKPC is consistent with the demands of modern macroeconomic theories as well as some key statistical properties of inflation.

The estimation equation is a modified Hybrid NKPC Model given by:

$$\pi_t = \alpha_0 + \alpha_1 E(\pi_{t+1}) + \alpha_2 \pi_{t-1} + \alpha_{3A} A\Delta NER_{t-1} + \alpha_{3D} D\Delta NER_{t-1} + \alpha_4 inc\_gap_t + \alpha_5 \text{fin\_gap}_t + \alpha_6 Dum_t + \varepsilon_t$$

The model is a modified version of the original model by Calvo (1983) as it incorporates both the forward and backward-looking components such as the future expected inflation $E(\pi_{t+1})$ (due t rising costs and exchange rate changes) as well as the history represented by lagged values of inflation π_{t-1}.The variables inc_gap_t *and* fin_gap_t are for the income gap and financial gap accordingly and ΔNER_{t-1} is the proxy for exchange rate volatility in the past period.

5.11.1 The New Keynesian Phillips-Augmented Expectation Regression

In measuring the role of inflation momentum and inflation exectectation on the current inflation, the NKPC was estimated and produced the results in Table 5.19.

Table 5. 19: Hybrid New Keynesian Phillips-Augmented Expectation Results

Dependent Variable: INFL_RSA
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 02/23/21 Time: 16:20
Sample: 1980Q3 2019Q3
Included observations: 157
Convergence achieved after 19 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INFL_EXPECTATION	0.497322	0.017202	28.91124	0.0000
INFL_1	0.516773	0.016052	32.19344	0.0000
APPR_TERM(-1)	1.919992	1.052399	1.824395	0.0701
DEPR_TERM(-1)	-0.870688	0.880679	-0.988656	0.3244
INCGAP_REAL(-1)	0.011647	0.017307	0.672991	0.5020
FIN_GAP	-0.008797	0.020011	-0.439599	0.6609
INFL_TARGET_POLICY	-0.137707	0.068903	-1.998580	0.0475
AR(1)	-0.313742	0.067903	-4.620471	0.0000
$\hat{\sigma}^2$ (Volatility)	0.105872	0.010591	9.996087	0.0000

R-squared	0.995052	Mean dependent var	8.747465
Adjusted R-squared	0.994785	S.D. dependent var	4.640542
S.E. of regression	0.335127	Akaike info criterion	0.707659
Sum squared resid	16.62185	Schwarz criterion	0.882858
Log likelihood	-46.55125	Hannan-Quinn criter.	0.778814
Durbin-Watson stat	2.045361		

Source: Own calculation using Eviews.

The substituted equation for the above estimation is given by:

$$\hat{\pi}_t = 0.4973 * E(\pi_{t+1}) + 0.5168 * \pi_{t-1} + 1.9200 * A\Delta NER_{t-1} - 0.8707 * D\Delta NER_{t-1} + 0.0116 * inc_{gap} - 0.0088 * fin_{gap} - 0.1377 * Dum_t$$

The sign of the inflation expectation variable π_{t+1}, ($\alpha_1 > 0$) is the expected one as hypothesized. The forward expectations of future inflation dynamics by economic players cause current inflation to rise. Also the parameter for back-ward looking inflation, as hypothesized ($\alpha_2 > 0$), returned an expected sign. The backward-looking inflation parameter confirms the theory that inflation actually causes itself through built-in momentum (Nason and Smith, 2008). By way of policy it is recommended that measures be put in place to control inflation now so that there is no knock-on effect in the next period because of built-in momentum. Similarly, there is need to dampen the future expectations in the behaviour of inflation so that the self-fulfilling prophesy by economic agents does not come to pass.

The *a priori* expected signs on the changes in exchange rate (ΔNER_{t-1}) were positive for depreciation episodes (i.e. $\alpha_{3D} > 0$) and negative for appreciation (i.e. $\alpha_{3A} < 0$) but the regression estimations produced opposite results. This is because we expected that as the local currency loses value against the US dollar, then imports for South Africa become expensive and therefore results in

imported inflation. Appreciation (t-statistic of 1.82 and p-value < 5%) produced the opposite effect but was not significant at the 5 percent level of significance. The results of the exchange rate movements agree with the Pricing-to-Market theory which postulates that importers tend to cushion their markets from the real effects of a depreciation of the local curreny. Since firms help control inflation through their deliberate move to internalise the exchange rate effect it would be recommended that the policy makers subsidise those firms which play the role of monetary policy implementors.

A rise in inflation when there has been appreciation of the Rand against the USA dollar is contrary to the theory that when domestic currency appreciates then import prices fall, leading to a subsequent fall of local prices. In this case, however, we witness a rise in inflation when the currency appreciates, perhaps due to the presence of Pricing-to-Market behaviour by firms. Pricing-to-Market behaviour sometimes works to undermine monetary policy. The regression results further show that during depreciation of the local currency firms reduce their prices, perhaps to maintain market share and this is PTM behaviour.

The coefficient of the output gap (p-value > 5%) is positive ($\alpha_4 > 0$), meaning that labour costs would increase in response to increased demand, leading to a rise in prices. This translates into greater consumers' expectations which become more forward-looking. The coefficient α5 on the financial gap (p-value of 0.6609 and t-statistic of -0.4395) was expected to be positive but results show a negative sign that is, nonetheless, insignificant. We expected a positive coefficient since a large difference between nominal and real Foreign Direct Investment (FDI) leads to higher inflation due to lack of foreign currency needed for the importation of goods and services. The pre- and post-inflation targeting dummy produced an expected sign on the coefficient but was found to be insignificant. This shows that there were other factors that interfered with the policy and partially undermined the efforts to maintain inflation within a 3- 6 percent band. The dummy variable is a relevant variable as it indicates shifts in the inflation dynamics in the 1990s and 2000s and as such we expected that α_6 would be negative for a period where inflation-targeting policy was implemented. Shifting attention to inflation volatility (represented by $\hat{\sigma}^2$), the results show that the expected sign was realised and that the t-statistic of the regression parameter (t-statistic of 9.996 & p-value of 0.0000) was high and well beyond the value of 2, used as a rule-of-thumb and this means that volatility (or uncertainty) results in higher inflation in South Africa.

Overally, the estimation using the Hybrid NKPC, has shown that both the forward-looking and backward-looking variables are significant in explaining current inflation and this confirms the Null

Hypothesis where the study predicted the siginificance of inflation momentum and inflation expectations in the determination of inflation in South Africa. To ensure efficient and unbiased estimates, diagnostic tests were conducted on the HNKPC model. The results are summarised in Table 5.20.

5.11.2 Diagnostic tests for the HNKPC model

Table 5. 20: Diagnostic tests for the HNKPC model

Null Hypothesis	Diagnostic Test	Description of Test	Test Statistic & p-value	Decision
The error terms are homoschedastic	Breusch-Pagan-Godfrey Test	Testing for equality of variances in the residuals	F-statistic = 1.5902 p-value = 0.1425	Accept H_0
There are no omitted important variables	Ramsey Test	Testing for the omittion of important variables	Likelihood Ratio =1.1381 p-value = 0.2860	Accept H_0
There is equality in the coeffients of the forward and backward looking inflation	Wald Chi-Square Test	Testing for equality in the coeffients of the forward and backward looking inflation	Chi-Square = 0.3529 p-value = 0.5525	Accept H_0
There is equality in the appreciation and depreciation coeffients	Wald Chi-Square Test	Testing for equality in the equality in the appreciation and depreciation coeffients	Chi-Square = 1.41176 p-value = 0.2348	Accept H_0
There is no serial correlation of the residuals	Durbin-Watson Test	Testing for serial correlation of the residuals	2.04	Accept H0

Source: Own calculations using Eviews.

For all the diagnostic tests in Table 5.20, the null hypotheses are accepted, meaning that the HNKPC model is robust.

5.12 CONCLUSION

Having carried out a number of regressions, the study concludes that using the ARMA model the Exchange Rate Pass-Through (ERPT) to Import-Prices was about 48 percent with all other control variables included. A bivariate ARMA model (Import Price and NER only) produced an ERPT of about 46 percent. The Error Correction model indicated that any change in the exchange rate causes the whole system to sluggishly return to equilibrium, meaning that there is some level of permanence in the Import Prices following an exchange rate change. Using the ARDL model the ERPT to Import Prices was about 42 percent. All the models point to an incomplete ERPT to Import Prices. The ARMA model for consumer price shows that ERPT to inflation was only 31 percent, which is lower than the ERPT to Import Prices. This confirms the Pricing-to-Market theory where importers absorb

some of the exchange rate impacts. Looking at the structural Impulse Response Functions, the analysis showed that the response of inflation to a shock in NER is minimal and returns to equilibrium quickly. Lastly, the analysis also indicated that the ERPT is higher during appreciation (47%) and lower during depreciation (41%), thereby confirming the presence of ERPT asymmetry. For objective 2, results have shown that appreciation has a higher impact on the exchange rate pass-through to import and consumer prices than depreciation. Also, the threshold model revealed that the impact of local production costs becomes higher and more significant with increasing echange rate bands. Lastly, results for objective 3 depicts that both inflation momentum and expectations have positive and significant impact on current inflation. Also, it was deduced that exchange rate volatility had a positive and significant impact on currenct inflation. The next chapter concludes the study.

CHAPTER SIX: SUMMARY, CONCLUSIONS AND POLICY RECOMMENDATIONS

6.1 INTRODUCTION

This study aimed at conducting an investigation into the degree of exchange rate pass-through to both South African Import Prices as well as Consumer Prices (proxied by inflation since Consumer Price variable was integrated of order two). The study also disintegrated exchange rate into appreciation and depreciation as well as high and low exchange rate movements so as to achieve a deeper understanding of the different aspects of exchange rate impact on prices. The asymmetric effects of the exchange rate has implications for both household welfare as well as the economy at large (Amoah, 2017). The study also estimated models that attempt to understand the role that exchange rate volatility, past inflation and inflation expectations have on current inflation.

6.2 CONCLUSION ON STUDY CHAPTERS

Chapter 1 discussed the introduction and background of the study on exchange rate Pass-through in South Africa. Research questions, objectives, research hypotheses and problem statement were discussed as well in this chapter. The chapter also was important as it set the tone of the study and gave direction.

Chapter 2 gave the outline to the study detailing the previous and status quo regarding the exchange rate pass-through in South Africa. It also looked at the evolution of the exchange rate regimes as well as monetary policies in South Africa especially the Inflation-Targeting policy and how it is related to the exchange rate pass-through. Stylised facts on exchange rate volatility was also discussed in Chapter 2.

Chapter 3 looked at the Theoretical as well as the Empirical Literature review for Developed, Emerging as well as Developing countries. The two sections are important in that they provide the researcher with some information on what theories exist about the subject matter and to what extend they have been used. Literature survey also gives the researcher the opportunity to view models that have been used by others in the same study and how they can be modified to suit the analysis that the study would carry out.

Chapter 4 discussed the methodology of the study. It dealt with the research Philosophy as well as the Analytical Framework including the variables and models the research would use. The econometric models as well as techniques to be used were discussed in this chapter.

Chapter 5 focused on the estimations of the relevant models that would give answers to the research questions as well as interpretations of the results. The ARDL model showed that the exchange rate pass through to Import Prices was 42 percent while the pass-through to inflation was 31 percent. This confirms the research Null Hypothesis number 1 of an incomplete ERPT. The ARMA model produced results that indicate that there is ERPT asymmetry between appreciation and depreciation. The results do confirm the Null Hypothesis number 2 of the existence of unequal effect of appreciation and depreciation on import prices in Soouth Africa. The ERPT was higher during appreciation than during depreciation. The ARDL inflation model showed that exchange rate increase (depreciation) causes inflation to increase but the impact was not significant. Similarly, the Hybrid New Keynesian Phillips-Augmented Expectation Model (HNKPC) showed that there was asymmetric effect of depreciation and appreciation on inflation but with appreciation having a larger impact. This means that the ARDL and the HNKPC results imply that the current policy of floating the Rand is recommended in order to stabilise prices. In addition, the HNKPC showed that both inflation momentum and inflation expectations positively influenced current inflation. This result validates the Null Hypothesis of a significant influence of inflation momentum and inflation expectations on current inflation. In a nutshell, then all the research questions have been answered positively in that the ERPT in South Africa is incomplete, there exists the ERPT asymmetry between depreciation and appreciation of the Rand and lastly the exchange rate volatility has a positive knock-on effect on inflation together with inflation momentum as well as expectations.

Chapter 6 discussed the policy recommendations based on research findings as well as the research conclusions and suggestions for further work in the area of exchange rate pass-through.

6.3 POLICY RECOMMENDATIONS

Exchange rate response to its own shock was persistent and this causes a semi-permanent deviation from its historical average. Efforts to keep exchange stable are crucial even in a flexible exchange rate environment. Both the VECM and the Bayesian VAR indicated that a shock to the exchange rate produces a persistent response of the inflation rate in South Africa. Again, avoiding exchange rate volatility is paramount through appropriate monetary policy measures. A credible monetary policy that is always time-consistent with predictable results is important so that there is no room for economic agents to behave in a manner that puts pressure on the Rand against International Currency Vehicles (ICVs) such as the US dollar or the British Pound and the Euro. The monetary policy can also be complemended by government implementing fiscal discipline in the economy.

The Asymmetric models to estimate the import prices as well as the inflation in South Africa found that ERPT to both import prices and inflation was greater during appreciation phase. The appropriate policy recommendation would be to stabilize the Rand in such a way as to prevent it from appreciating beyond its true value. The current regime is recommended to maintain the current policy, meaning a managed floating exchange rate regime. A discreet approach to monetary policy is recommended since a conspicuous handling of policy would raise suspicion and therefore economic agents might act to undermine the efforts.

The slow return to equilibrium of import prices after a disequilibrium caused by changes in the exchange rate and other determinants of import prices has implications for policy. A speed of adjustment of only 2 percent per quarter indicates a very slow return to equilibrium after a deviation from historical long-term mean of import price. This means that policies implemented should not cause a long-term shift in the import prices. Similarly, the speed of adjustment for the exchange rate long-run equation was 7 percent, meaning only 7 percent of the disequilibrium is corrected in the next quarter. Factors that affect exchange rate produce a semi-permanent shift and so monetary authorities should endeavour to stabilize such factors. These factors include income gap and domestic cost of production. Recommended policies to minimize income gap could be devised through the introduction of the quasi-fiscal policies whose aim is to fund productive activities in the country and in the process minimize demand for foreign goods that ultimately affect exchange rate. The inflation speed of adjustment was equally small at only 7.3 percent and was significant. Policies that address factors of inflation need immediate attention as deviation from equilibrium tends to disenfranchise the poor and vulnerable members of the communities and country at large.

Even though the Inflation-Targetting Dummy was not significant to explain inflation but the fact that it had the correct sign means that the Monetary Policy of targeting inflation with a single digit around six percent is encouraged and should be maintained. The recommendation is for the monetary authorities to tighten the use of monetary policy tools (such as Repurchase Rate (REPO)) to strengthen the Inflation_Targetting policy. Government, through its relevant organs such as the Central Bank and the Competition Commission of South Africa, can strengthen existing policies regarding pricing- strategies so as to prevent PTM scenarios. The presence of ERPT Asymmetry has implications for the general welfare of South African households as well as firms and ultimately the real sector. A higher pass-through during appreciation negatively impacts the purchasing power of the domestic currency as well as increasing costs for firms. Monitoring of exchange rate movements is imperative for Monetary Policy authorities to ensure stability of the currency. The Structural Impulse Response Functions showed that a one-standard deviation shock to the exchange rate

initially leads to a fall ininflation before it begins to rise and only reaches its steady-state after a long time of 10 periods after the shock. This shows some kind of a long-term effect of exchange rate volatility on inflation in South Africa. A policy that helps to avoid unanticipated depreciation and appreciation is recommended and this may be through both fiscal and monetary policies that do not undermine business confidence in the economy.

6.4 LIMITATIONS OF THE STUDY

The study faced challenges with some missing quarterly data for some variables. Both the South African Reserve Bank (SARB) as well as the International Financial Statistics (IFS) databases could not provide quarterly data for all variables of interest and subsequently yearly data was transformed into quarterly data using the Cubic Spline Algorithm (embedded in E-Views version 12). The cubic spline-algorithm is a third order numerical method used to obtain unknown values of series by interpolating between two known points (Ahmad, 2017).

The other interpolation method is the Lisman-Sandee (1964) method explained in Lisman et al. (2009) but is based on four stringent conditions that sometimes are unrealistic and so could not be used here. Also the degree of arbitrariness in the Lisman-Sandee method is greater than in the Cubic Spline approach.

Due to the unit-root statuses of some key variables such Consumer Price Indices for both South Africa and its trading partner, the USA, it was not plausible to include them in some cases of econometric analysis as they were found to be integrated to the order two while the rest of the variables were either I(0) or I(1). The study had to use proxies instead.

The study used a bilateral exchange rate between the USA and South Africa. This exchange rate may not adequately explain movements in the import prices as these are attributed not only to South African imports from the USA but also from the rest of the world. What gave the author the green light to proceed with the bilateral instead of the trade weighted exchange rate is that the greater percentage of imports are from the USA as the strongest trading partner.

The other limitation in this study is that of aggregation of the data. This study used aggregate data that has a tendency to obscure any asymmetric effect that may exist in different industries. To have a clearer picture, one has to use industry-based data that is likely to produce varying degrees of exchange rate pass-through as well as varying directions of pass-through, thereby exposing ERPT asymmetry. Due to time and data constraints, this study could not pursue the robust logic of working with firm-level data.

6.5 SUGGESTIONS FOR FUTURE STUDIES

Due to time-constraints this study could not work with firm-level and sector-level data. It could have been more interesting to examine the impact the exchange rate volatility would have on different sectors so as to design policies that would mitigate such impacts on those most affected. Regarding firm-level data it is equally important to analyse the imapact any exchange rate changes would have on specific firms in the economy. Large firms that rely on inputs from foreign markets are negatively impacted by unanticipated shocks in theexchnage rate and a policy that help such companies is very crucial in South Africa.

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