

**AN EMPIRICAL ANALYSIS OF EXCHANGE RATE  
PASS-THROUGH TO PRICES IN SOUTH AFRICA  
(2002-2015).**

By

**Harris Maduku**

Student number: 201639654

A Dissertation Submitted to the Faculty of Commerce, Administration and Law in  
Fulfillment of the Requirement of the Master of Commerce (Economics) Degree

**University of Zululand**

**AN EMPIRICAL ANALYSIS OF EXCHANGE RATE  
PASS-THROUGH TO PRICES IN SOUTH AFRICA  
(2002-2015)**

By

**Harris Maduku**

Student number: 201639654

A Dissertation Submitted to the Faculty of Commerce, Administration and Law in  
Fullfilment of the Requirement of the Master of Commerce (Economics) Degree

**University of Zululand**

**January 2017**

Supervisor: Prof Contogiannis

Co-Supervisor: Prof Kaseeram

.....

.....

## **DECLARATION**

I, the undersigned do hereby declare that this document, besides the guidance from the supervisors is the product of my own hard work. To the best of my knowledge, I have acknowledged all the information as far as the academic expectations are concerned. This document has never been submitted anywhere before in order to attain a degree at any other University.

.....

Harris Maduku

Date: March 2017

## **Abstract**

The South African Reserve Bank (SARB) adopted an inflation targeting monetary policy with the effect from the 2000 in an attempt to curb inflation in the country. The band that was adopted was that of a minimum of 3% and a maximum of 6%. The main problem to the current monetary policy is the monthly inflation and other provincial inflation rates that are sometimes going outside the upper band of the target. Finding the duration taken by the price indices to respond to exchange rate fluctuations took a central interest to this research and also to find out the magnitude of the exchange rate fluctuations that are passed on to prices. This research did a comparative analysis from a SVAR and Recursive VAR to investigate exchange rate pass-through (ERPT) to tradable prices in South Africa for the period 2002-2015. Using monthly data, both estimations find the producer price index as the most contributing factor to inflation with an average of 22% of exchange rate fluctuations passed to prices. The argument behind the high pass-through in producer prices is mainly because of the high volumes of intermediate goods that are imported by the South African producers for local production. The results reveal that the impulse response functions are not very strong but the prices do not take long to respond to any exchange rate changes. We find that prices respond within 2 months to fluctuations in the exchange rate. It takes between 3 to 4 months for other price indices to respond to import prices. Also there is reverse causation on all the variables in the model but the magnitude differs from one variable to another. Large and persistent ERPT especially on import and producer prices accompanied by high wage demands and a depreciating currency are worrying factors for South Africa. Monetary policy makers are advised to put in place targeting measures on the exchange rate if inflation could be kept under control. Since inflation expectations play a pivotal role on inflation, it is wise for the upper band to be increased probably by 1% so that high inflation expectations that are influenced by inflation that is sometimes going outside the upper band can be held down.

## **ACKNOWLEDGEMENTS**

It is my privilege and honour to acknowledge the unwavering support, advice and assistance from the two Professors; Prof Contogiannis and Prof Kaseeram as they sometimes went outside schedules assisting me throughout my research.

My sincere gratitude is then extended to Mr Mutsau who played a very critical role in the early stages of this research before he left the University. Also the Economics department students and staff played a vital role in making this research a success through their support in different ways.

## **Dedication**

I dedicate this work to my late mother (Alice Madhuku), she was so happy to hear that I was starting this degree but it is so sad that she never saw me finishing it.

## **List of Acronyms**

ADF-Augmented Dickey Fuller

AIC-Akaike Information Criterion

ARDL-Autoregressive Distributed Lag

BIC-Bayesian Information Criteria

CCI-consumer confidence index

CPI-Consumer Price Index

DCC-dynamic conditional correlation

DF-Dickey-Fuller

ECB-European Central Bank

ER-exchange rate

ERPT-Exchange Rate Pass Through

EXP-export

FNB-First National Bank

GARCH-Generalized Autoregressive Conditional Heteroscedasticity

GDP-gross domestic price

HAIC-Hannan-Quinn Information Criteria

IMF-International Monetary Fund

IMP-import

IRF-impulse response functions

JB-Jarque-Bera

LCP-local currency pricing

LCPI-lagged consumer price index

LEXP01-lagged export price index

LIMP-lagged-import price index  
LNER-lagged-nominal exchange rate  
LOOP-law of one price  
LPPI-lagged producer price index  
LPTR-lagged petrol prices  
LRPT-long run pass-through  
MC-marginal cost  
MRP-monetary policy review  
MRPT-medium rate pass-through  
NEER-nominal effective exchange rate  
OLS-ordinary least squares  
PCP-producer currency pricing  
PPI-producer price index  
PPP-purchasing power parity  
RSVAR-recursive structural vector autoregressive  
SACCI-South African Chamber of Commerce and Industry  
SARB-South African Reserve Bank  
SIC-Schwarz Information Criteria  
SVAR-structural vector autoregressive  
VAR-vector autoregressive  
VECM-vector error correction mechanism



<b>List of Tables</b>	<b>Page number</b>
Table 2.1 Empirical literature review summary table.....	35
Table 4.1; popular estimation techniques in ERPT.....	65
Table 5.1- descriptive statistics results.....	108
Table 5.2- unit root table.....	110
Table 5.3-lag length selection.....	113
Table 5.4- Johansen cointegration test results.....	115
Table 5.5- the lower triangular (Cholesky identification).....	117
Table 5.6 –variance decompositions for the recursive VAR.....	118
Table 5.5.1 Variance Decompositions of Gap.....	118
Table 5.5.2 Variance Decompositions of Petr.....	119
Table 5.5.3 Variance Decompositions of Ner.....	120
Table 5.5.4 Variance Decompositions of Imp.....	122
Table 5.5.4 Variance Decompositions of Ppi.....	122
Table 5.5.6 Variance Decompositions of Exp.....	124
Table 5.5.7 Variance Decompositions of Cpi.....	126
Table 5.5.8: Comparative variance decompositions.....	136

## Table of Contents

Abstract.....	i
Acknowledgements.....	ii
Dedication.....	iii
List of Acronyms.....	iv
List of Tables.....	v
CHAPTER ONE.....	1
1.0 Introduction.....	1
1.1 Background of the Study.....	1
1.1 Problem statement.....	5
1.2 OBJECTIVES OF THE STUDY.....	6
1.3 Hypotheses.....	6
1.4 Organisation of the following section of the study.....	7
CHAPTER 2: A THEORETICAL AND EMPIRICAL REVIEW OF THE EXCHANGE RATE PASS-THROUGH.....	8
2.0 Introduction.....	8
2.1 Theoretical Literature.....	8
2.1.1 Exchange rate pass through (ERPT) defined.....	8
2.1.2 Modelling Exchange Rate Pass-Through (ERPT.....	22
2.2 Determinants of exchange rate pass through.....	10
2.2.1 Pricing to market strategy.....	10
2.2.2 Specific industry/market characteristic.....	11
2.2.3 Exchange rate pass-through channels.....	12
2.2.4 Monetary policy credibility and exchange rate pass-through.....	16
2.2.5 Inflation Targeting and Exchange rate pass through.....	18

2.2.6 Currency choice and Exchange rate pass through (ERPT).....	19
2.3 Exchange rate-pass through Asymmetry.....	20
2.4. EMPIRICAL LITERATURE REVIEW.....	21
2.4.1 Exchange rate pass through around the globe.....	23
2.4.2 ERPT IN SOUTH AFRICA.....	28
2.5 Conclusion.....	34
<b>CHAPTER 3: AN OVERVIEW OF THE WORLD, EMERGING MARKETS AND SOUTH AFRICAN ECONOMIIES.....</b>	<b>36</b>
3.0 Introduction.....	36
3.1 World Economy overview.....	36
3.2 Emerging Markets Economies Overview.....	38
3.3. Overview of the South African Economy.....	38
3.3.1 Exchange rate and inflation.....	49
3.3.2 Trade policies.....	51
3.3.3 Trade structure and ERPT.....	55
3.3.4 Market competitiveness in South Africa.....	58
3.4 Conclusion.....	59
<b>CHAPTER FOUR: METHODOLOGY AND EMPIRICAL ANALYSIS.....</b>	<b>61</b>
4.0 Introduction.....	61
4.1 Most Popular ERPT Estimations.....	61
4.1.1 Variables description and Data issues.....	63
4.2 Time Series Methodology.....	78
4.2.1 Stationary and Nonstationary in Time Series.....	68
4.2.2 Graphical analysis.....	71
4.2.3 Unit Root tests.....	72
4.2.4 Remedial Measures.....	73

4.3.0 Cointegration.....	74
4.3.1 Testing for Cointegration.....	76
4.3.2 The Johansen Test.....	82
4.4.0 Vector Autoregressions (VAR).....	84
4.4.1 Reduced form VAR.....	87
4.4.2 Recursive VAR Approach.....	90
4.4.3 Granger Causality.....	96
4.4.4 Structural VAR estimation.....	97
4.4.5 Conclusion.....	103
CHAPTER FIVE: EMPIRICAL ANALYSIS AND RESULTS.....	105
5.1 Introduction.....	105
5.2 Descriptive statistics.....	105
5.3 Graphical inspection.....	107
5.4 Stationarity tests.....	109
5.5 Lag length selection criteria.....	110
5.6 Cointegration results.....	112
5.7 VAR stability test.....	114
5.8 The VAR model Estimation.....	115
5.9 Impulse response functions.....	128
5.10 Structural VAR results analysis.....	132
5.10.1 Identification assumptions.....	132
5.11 Variance decompositions.....	135
CHAPTER SIX: SUMMARY, CONCLUSION AND POLICY RECOMENDATIONS.....	139
6.1 Summary of findings and conclusion.....	139
6.2 Policy Implication and Recommendations.....	140
6.3 Limitations to the study.....	141

## CHAPTER ONE

### 1.1 BACKGROUND OF THE STUDY

After the mid to late 1990s exchange rate crises, many emerging markets opted to change the focus of their policies to target inflation (Nogueira Junior, 2007). The monetary policy makers in South Africa made an announcement in 1999 the intention to target CPIX inflation directly beginning in 2000 (Mboweni, 2003). The CPIX inflation target was set as an (annual average) range of 3-5 percent in 2000 and 2001, and 3-6 percent onwards (SARB, 2004). Periods after the set of the policy saw large fluctuations and volatilities in the external value of the rand , especially from 2009-2015 made the South African Reserve Bank's (SARB) task of hitting the inflation target considerably more difficult. The South African rand lost value by an estimate of 23% in 2015 alone and inflation was sometimes outside the range (SARB, 2016). The rand depreciated by almost 40 percent in the last four months of 2001, CPIX inflation picked up significantly in 2002 (Bhundia ,2002). The lags in monetary policy showed that it was going to be difficult for the SARB to meet its inflation target in 2002 without making a significant increase in its policy interest rate, which would have brought unwanted consequences for output. The aim of the research was to analyse the link between the South African rand exchange rate behaviour and different types of inflation focusing more on tradables ; this is commonly known as Exchange Rate Pass-Through (ERPT).

In a small open economy such as South Africa, exchange rate movements have a material impact on prices from imports right up to the consumption goods prices (Kiptui *et al.*, 2005). This is particularly important in the current context with the changes in the South African rand vis-à-vis the United States dollar since the year 2000. Exchange rates have serious implications for the domestic economy, monetary policy and the adjustment of current and financial accounts. According to (Aron et al., 2014b), in their research about ERPT for developing countries, they found out that financial markets in these countries are heavily linked and as a result of aborting capital controls, policy makers are facing a hard time with inflationary pressures and exchange rate volatilities.

Volatilities in the exchange rate are commonly caused by the financial market prices that keep on changing and the world oil prices.

The volatility of exchange rates can induce instability and increase uncertainty in each of the trading areas affecting decision making for policy makers, firms and consumers (Parsley, 2012). SARB, (2007) cites that changes in exchange rates are more important in the determination of monetary policy because they might have a major impact on inflation especially when a country has a floating exchange rate policy as well as an open trade policy.

The transmission or consideration of the exchange rate changes to prices is what is called Exchange Rate Pass-through (ERPT) depending on the asymmetric behaviour of price adjustments (Choudhri and Hakura 2015). (Aron et al., 2014a) defined ERPT as the degree to which exchange rate variations influence trade prices and through them to other domestic prices. However, (Kabundi and Schaling, 2013) defined it alternatively as the link between nominal effective exchange rate and import prices (first stage) and finally as a link between exchange rate movements, producer price inflation and consumer inflation (second stage). This definition from Kabundi and Schaling is more inclusive and they capture a lot of things in their definition. Aron and Muellabauer, (2014) were also critical of the general definition of exchange rate pass through saying it only talks about the effects of exchange rate on imports and not on producer prices and export prices. Their argument is based on the fact that, there are other factors that wholly define EPRT until it reaches what they called overall ERPT. Aron and Muellabauer (2014), argue whether the changes in the exchange rates are passed all (complete) or part of them (incomplete) ERPT.

Arguably, exchange rate pass through has two effects on prices; they are namely indirect and direct (Lafleche, 1996). The direct effects of depreciation of the rand can lead to an increase in prices of imported finished goods into South Africa. Also, prices of inputs imported for local production can increase production costs and may finally push up producer prices. Savoie-Chabot and Khan, (2015), suggested that the magnitude of

the overall direct effects of ERPT on consumer prices are uncertain and depend on several factors like, the rate of pass-through on import prices and the share of imports in the consumer basket, demand conditions in the domestic economy and costs of adjusting prices and perceptions of the duration of the depreciation. Prices of services are typically immune to direct ERPT since they are largely domestically oriented and therefore less subject to pressures emanating from higher import costs. ERPT can also have indirect effects on prices through changes in the composition of demand and in the levels of aggregate demand and wages (Nell, 2000). A depreciation of the rand can cause the demand for South African goods to increase because imports from other foreign suppliers will be expensive. Also, the demand for South African goods can increase in the foreign markets because foreign customers will be using less of their money to buy more of the rand so assuming elastic demand, there will be an increase for domestic goods in foreign markets (Karoro et al., 2009). The demand for South African goods can lead to high labour demand and that may put pressure on production costs and then consumer goods prices go up (Parsley, 2012).

(Aron et al., 2014a) suggested that knowledge of exchange rate pass-through is very important for a number of reasons. Firstly, the level of ERPT is an approximation of international macroeconomic transmission and thus has implications for the timing of monetary policy intervention. Hence, the degree and speed of pass-through is important for forecasting inflation and formulating monetary policy responses to inflation shocks. In addition, the adoption of inflation targeting demands knowledge of the speed and size of ERPT on inflation. Also, understanding ERPT at the macro and microeconomic levels gives insights into the strength of the international market power of domestic industries vis-à-vis their international counterparts. Furthermore, a low ERPT level would make it possible for trade flows to remain relatively unchanged by exchange rate fluctuations, even with highly elastic demand. If prices respond sluggishly to changes in the exchange rate and if trade flows respond slowly to the relative price change, then the overall balance of payments adjustments could be severely held back (Kiptui et al., 2005).

In the case of South Africa and many other countries which adopted inflation targeting as a way of trying to monitor inflation, it is because of that inflation targeting monetary policy with its reliance on inflation forecasting, that huge interest in Exchange Rate Pass-Through (ERPT) has been generated. In addition, Aron et al., (2014a) argues volatility in the exchange rates and persistent trade imbalances worldwide as a galvanizing point increasing interest in the investigation of the role of ERPT in prices and monetary policies. On the other hand, the SARB, (2016) monetary policy review acknowledges that, although pass through seems to be going down, it is still contributing significant percentages to headline inflation and making it difficult for the bank to hit its target at the monthly, quarterly and yearly frequencies. To add, inflation expectations from the business community and the consumers is also playing a bigger role as they cause the second round effects stemming from exchange rate depreciations which in turn are passed on to consumers, which also leads to trade unions pushing for higher wages which then push up production costs.

However, majority of the previous studies is that a lot of them were multi-country studies and therefore ignored the fact that countries have heterogeneity that arises from different monetary policies, levels of development and trade regimes (Aron et al., 2014b). The vast differences in the ERPT estimates alone by different scholars using the same data is an issue as witnessed by a large chunk of contradicting pieces of information in the ERPT literature. It is still confusing since scholars are not singing from the same hymn book as others are seeing high ERPT in producer prices whilst others see high ERPT in consumer prices. The current also intends to add another variable which has been hardly used in the local research and that is the export indices data. Furthermore, most findings did not include the producer prices but only focussed on either CPI or import prices. However this research wants to add those variables to the already existing literature on ERPT. Also a lot of research papers published on ERPT were for developed nations leaving a huge gap of information between developed and developing nations and it is that gap this research intends to narrow by contributing to the body of knowledge for developing countries.



The purpose of this study is to give a robust analysis of the effects of the Exchange Rate Pass-Through on prices in South Africa from 2002-2015 using monthly data. This period also coincided with the inflation targeting regime which commenced in February 2000. The study seeks to explore the short-run and long-run impact of shocks on prices as a result of exchange rate changes using time series monthly data. The study used the Recursive Vector Auto-Regressive (VAR) whilst comparing its results with that from a Structural VAR model that includes import, producer, consumer and export prices. The VAR model will also take into account the gross domestic price output gap so that all the demand shocks will be identified and petrol prices to take care of supply shocks. The choice of the models is motivated by the fact that no comparative study of this kind has never been done in the South African context. To add, this research will help to expand the knowledge and understanding of the effects of ERPT in South Africa since changes in exchange rate are critical in anticipating inflation and determining monetary policy.

## **1.2 Problem statement**

Previous findings from South Africa such as Choudhri and Hakura, (2015), Akinboade et al.,(2002) , Edwards and Lawrence, (2006), Nogueira, (2007), Aron and Muellbauer, (2014), Bhundia, (2002), Nell, (2000), SARB, (2002), Aron et al., (2014a&b) and Bussiere and Peltonen, (2008) found exchange pass through to different price variables very high whilst Mihaljek and Klau, (2008), Rigobon, (2007), Jooste and Jhaveri, (2014) and Parsley, (2012) found exchange rate pass through low using different variables but sometimes the same methodologies. The conflicting findings of empirical studies on the size of ERPT warrants further research especially considering the recent depreciations of the rand against the dollar and currencies of other trading partners of South Africa.

Also, the exchange rate turbulence during this tenure of the inflation targeting regime and inflation rates out of range are causes of concern, hence the need to analyse the transmission mechanism as a contribution to the monetary policy debate. Most of the previous research used the Reduced form VAR, Johansen analysis, Structural VAR and VECM, but none has used a Recursive VAR. It is hoped that this research will be more

robust since, to the best of the researcher's knowledge, it is the first for South Africa to use a comparative analysis of a Recursive VAR and a Structural VAR both of which are multi equation methodologies. These VARs have been at the centre of macro-econometric analysis in research since the early 2000s. In addition this research combines all tradable variables affected by exchange rate changes unlike other research that only took one or two of the variables (imports, exports, PPI and CPI).

### **1.3 OBJECTIVES OF THE STUDY**

- To investigate pass through to import, export, producer and consumer prices and see the price index with the greatest pass through in South Africa.
- To check the duration taken by the import prices to respond to a shock in the exchange rate.
- To investigate if exchange rate and other price variables are cointegrated.
- To investigate whether exchange rate pass-through is complete or not.

### **1.4 Hypotheses**

- (1) Exchange rate pass through to import prices is greater than producer, consumer and export prices in South Africa.
- (2) There is cointegration between exchange rate and import, producer, consumer and export prices in South Africa.
- (3) Import prices respond with a lag to changes in the exchange rate in South Africa.
- (4) Exchange rate pass through is not complete in South Africa.

### **1.5 Organisation of the rest of the study**

Chapter two will have two parts, one part being a theoretical literature review and the other an empirical literature review. The theoretical literature view taken in this research will have underpinnings from the areas of general agreement in the literature including

the determinants of ERPT and the environments where ERPT will be high or low. The empirical literature review will mainly cover the studies and results found by different researchers across the globe. This part is divided into two parts as well. The first part will contain discussions of the findings on ERPT in other countries excluding South Africa. The remaining part will focus solely on the studies that were carried out in the Republic of South Africa.



## **CHAPTER 2**

# **A THEORETICAL AND EMPIRICAL REVIEW OF THE EXCHANGE RATE PASS-THROUGH**

### **2.0 Introduction**

This chapter is going to review the theoretical and empirical literature on ERPT from around the globe and the South African perspective as well. In this section issues like the magnitude and speed of pass through will be discussed. Exchange rate asymmetries to prices will also be reviewed although this is not one of the main objectives of the research.

### **2.1 Theoretical Literature**

#### **2.1.1 Exchange rate pass through (ERPT) defined**

Exchange rate pass through is basically regarded as the extent to which fluctuations or changes in the exchange rate are mirrored or reflected in the prices of goods and services (Ozkan and Erden, 2015). ERPT is generally divided into two stages, first from the exchange rate to imported goods prices and second from import prices to consumer and other goods.

The investigation of pass-through started with the study of the “law of one price” and the Purchasing Power Parity (PPP) literature (Dornbusch, 1987). In addition, the law of one price (LOOP) assumes, among other things that barriers to trade or transport costs do not exist (Aron et al., 2014a). The law of one price (LOOP) states that at equilibrium, the price of all the tradable goods in two international markets cannot differ when expressed in a uniform currency and if it happens we have a situation of a complete pass-through (Taylor, 2001).

### 2.1.2 Modelling Exchange Rate Pass-Through (ERPT)

The frequently used specification by many researchers on ERPT is normally on the pricing choices or behaviour of prices on imports especially from the microeconomic point of view. We start by taking a simple static profit maximisation problem an exporting firm faces.

Considering a foreign firm exporting its goods to our domestic market or country, the firm which is exporting solves the following profit maximisation problem:

$$\text{Max } \pi = e^{-1}pq - C(q) \dots \dots \dots (1)$$

$\Pi$ - represents profits in foreign currency,  $e$  – is the exchange rate in terms of units of domestic currency per unit of forex,  $p$ - price of goods in the domestic country,  $C$ - is the cost function and  $q$ - denotes quantity.

Then if we solve the equation (1) above we get the first order condition of the form:

$$P = eCq\mu \dots \dots \dots (2)$$

$Cq$ - represents the marginal costs, and  $\mu$ -mark-up of price over the marginal cost.

Equation (2) states that local currency pricing of the commodities can differ as a result of a change in the Nominal Effective Exchange Rate (NEER), changes in the additional costs (MC) and changes in the price (mark-up).

Most importantly, it must be noted that the firm's mark-up can change without any changes in the exchange rate. On another note Bailliu and Fujii (2004), observed that demand shocks from the importing country can change the mark-up of the exporter. A firm's mark-up can also be affected by things like oil prices since most of production processes use diesel or gas to run. Also proper care must be taken for changes of other determinants of prices so that when we want to estimate ERPT we isolate only the effects of the exchange rate change on the import prices and other price variables down the chain (Campa and Goldberg, 2005).

Below is a log reduced form equation showing the changes of ERPT as other things like marginal costs and demand conditions change.

$$P_t = \alpha + \lambda e_t + \beta p^* t + \Phi y_t + \varepsilon_t \dots \dots \dots (3)$$

$P^*$  and  $y$  are measurements of the MC of the exporter and the demand conditions of the importer, respectively whilst  $\lambda$  is a measure of ERPT itself.

## 2.2 Factors that influence exchange rate pass through

### 2.2.1 Pricing to market strategy

Kara and Nelson, (2003) explained pricing to market as a situation where price setters for imports are just to set prices which are equal to those in the domestic market they supplying irrespective of the exchange rate changes and world price. Their pricing just needs to make them competitive in the domestic market they will be supplying. Their model takes imports as only consumer goods and also does not consider inputs used in the production line or intermediate goods. Since prices are set in order to match those of domestic goods, this implies that there is no pass through (zero). Gaulier *et al.*, (2006), argue that there is low sensitivity of import prices to changes in exchange rate and this is linked to the fact that export firms would have adjusted their prices in a manner just to maintain their level of competitiveness in the destination market. The pricing to market does not hold for a market which is perfectly competitive since MR or prices have to be more than MC of production. When the margins of the exporting firms are positive then the model can be a sustainable strategy for exporting firms, in which case the pass through of the exchange rate changes to import and other local prices such as consumer and producer prices will be less than one. At the end of the day, the magnitude of the pass through will be affected by the ability of the exporting firms to absorb exchange rate change shocks into their profit margins. So for small firms they will be forced to pass some of the exchange rate costs on to the consumers but they will face the challenge of reduced demand. Multinational companies can afford to absorb

the costs of exchange rate changes because they have the muscle financially and operatively (economies of scale). With the recent growth of Chinese products on the world market, pass-through is not expected to be high or complete because China is offering cheap products in the market. Also the pricing to market will face a command not to pass anything to the domestic market for fear of losing business to the Chinese and other countries producing at a lower price and willing or able to absorb the exchange rate changes.

In addition, the period 2009-2015 saw the world commodity demand falling meaning that even if commodities were cheap, there was less demand in the global market. This factor is one of the contributions to low and incomplete pass through for many countries except for a few developing countries and highly inflationary economies.

### **2.2.2 Specific industry/market characteristics**

Different types of industries determine pass through because levels of competition differ from one industry to another also the market share between imports and local produce differs from one industry to another. Dornbusch, (1987), states that, the elasticity of import or export supply and demand, product substitutability and differentiation also play a major role in determining pass through. Industries with imperfect competition happen to have large shares of imports and as a result of not being perfectly competitive as well, they may experience a wide range of pricing responses subscribing to changes in the exchange rate leading to great pass through effects (Reyes, 2007). When imports control a bigger part of the domestic market, the scenario of exchange rate pass through will be very high since imports constitute a large portion of the consumption basket. This theory mostly affects net importers or economies that are failing to sustain their local demand. Another type of economy to be affected by this theory is an economy that has a growing manufacturing sector relying on imported inputs. A good example of this kind of economy is South Africa where industries like car manufacturing rely on imported inputs to assemble the cars for both the local market and the export



market. However, South Africa has a comparative advantage in this industry because it has a lot of sea ports and the steel industry is still functional, enabling it to provide cheap products for other African countries like Zimbabwe, Mozambique and Namibia. Furthermore, the South African economy is more oligopolistic in many sectors and that makes the pricing of a wide range of products to be sticky and as far as the exchange rate pass through is concerned it cannot be complete but maybe high for other products prone to easy adjustments.

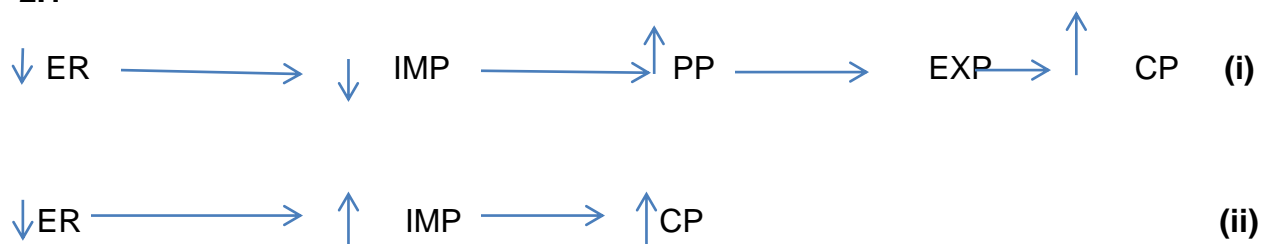
### **2.2.3 Exchange rate pass-through channels**

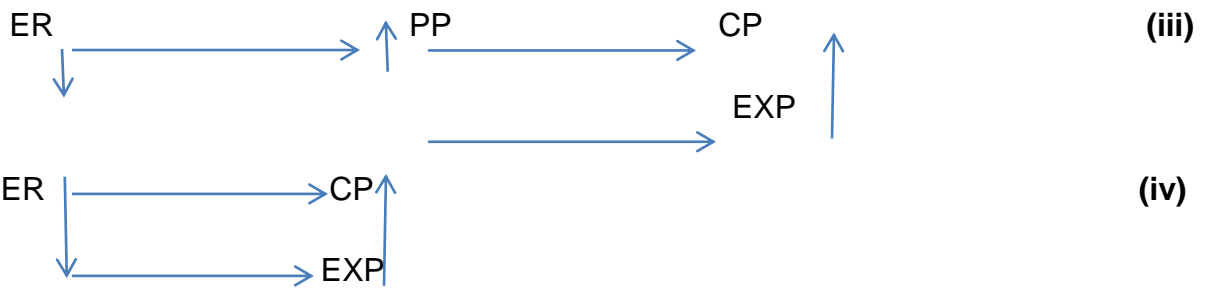
This section aims to discuss the possible channels of pass through to import, producer, consumer and export prices as a regime of a freely floating exchange rate in place as it is currently in South Africa. The theory states that exchange rate changes influence the prices of all the tradable goods which are exports and imports. In this case, the theory specifies that either a depreciation or an appreciation of the exchange rate will result in a rise or a fall in the local prices of imported goods and a decrease or increase in the foreign price of exports. However, it must be noted that in many business practices, it is much easier to adjust prices upwards than to push them downwards. The impact of exchange rate changes on local prices can be transmitted via direct and indirect channels (Hyder and Shah, 2004).

On another note Gomez et al., (2012), explains that, exchange rate movements are transmitted to consumer prices via three channels: (1) prices of imported consumption goods (2) domestically produced goods which are then priced in foreign currency and (3) prices of imported inputs or intermediate goods. With 1 and 2 the effects of the changes in the exchange rate are more direct since the shocks to import prices are recorded at the time docking. With the third one there is no direct contact since inputs have not yet been consumed but costs of production will be affected and then later on consumption goods. However, from the evidence observed from the existing empirical

literature, it is almost a unanimous agreement that exchange rate pass through is not complete (Gomez et al., 2012). There is also another general consensus which argues that direct pass through on import prices is higher than that indirect pass through. That is why scholars like Karoro et al., (2009) analysed pass through using two different methodologies, VAR and cointegration regression. They used the cointegration regression to capture the direct effects of exchange rate to import prices then analysed the shocks of both the exchange rate and import prices to other prices down the pricing chain. In their paper they also included producer costs to clearly isolate the effects of exchange rate changes to other prices like the producer and consumer ones. On the direction of causation, import prices do not make a significant contribution to exchange rate changes but the consumer prices and the export prices do have effects, especially the export prices. Export prices affect the money supply in the economy a thing that will affect the interest rate which in turn affects the financial markets causing the exchange rate to either depreciate or appreciate depending on the changes and magnitudes.

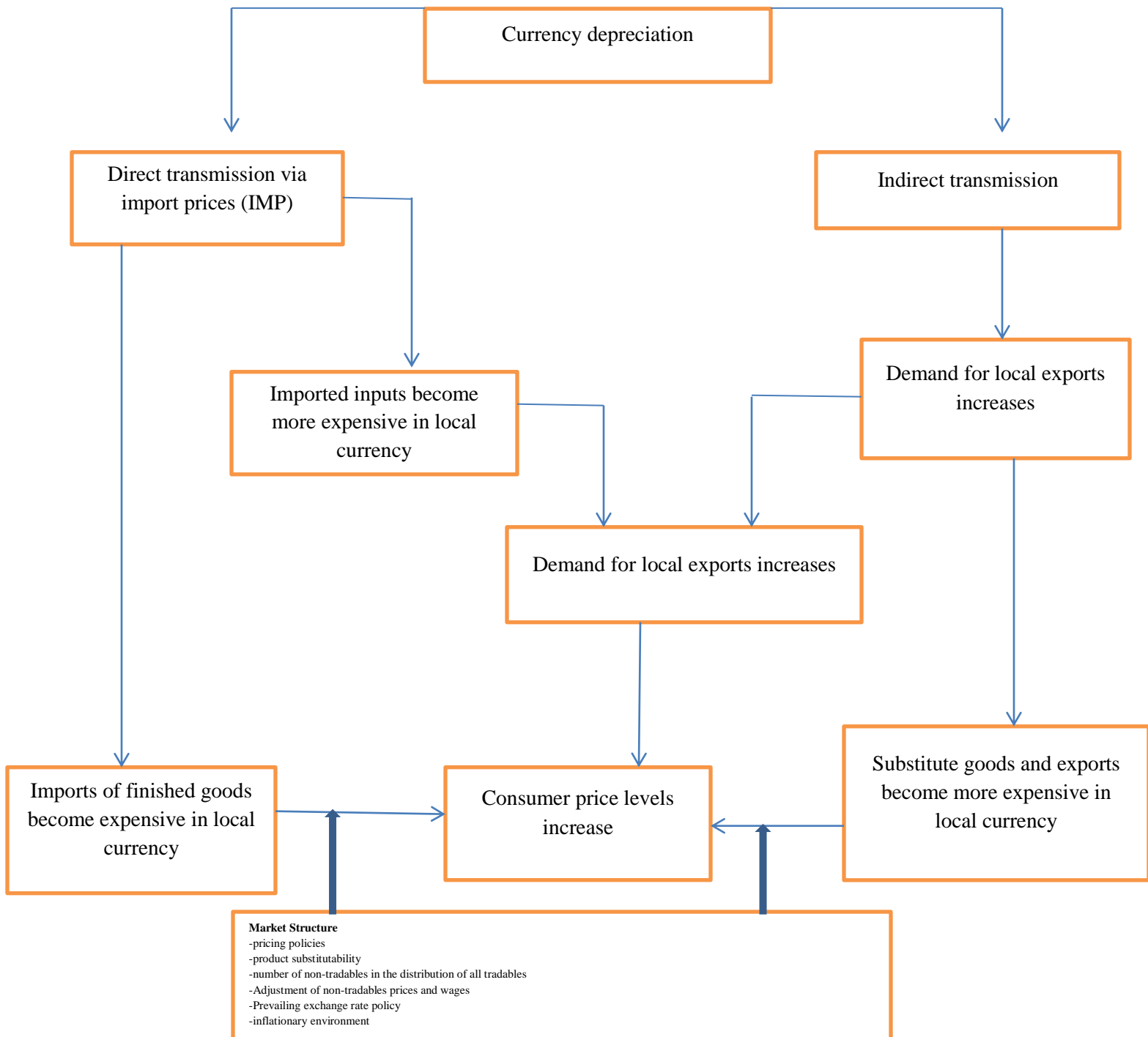
The direct and indirect channels of transmission of ERPT discussed above are illustrated in the diagram below. They are simplified to the last prices in the chain. **Fig 2.1**





Referring to the diagram the downward arrow on ER represents depreciation and an upward arrow represents increases in prices of producers, imports, consumer and exports. The above diagram illustrates the scenario of a depreciation alone, meaning that a depreciation will cause the import prices to be expensive and the expensiveness depending on the imported commodity will be passed through to other prices in the domestic economy as long as there is a link between the final product (consumer goods) and the exchange rate or the imported product.

**Fig 2.2: The transmission of ERPT to domestic prices**



Adapted from (Karoro et al., 2009)

#### **2.2.4 Reserve Bank credibility and exchange rate pass-through**

Mishkin, (2009) argued that, when an economy adopts inflation targeting and starts to monitor inflation levels from all angles it must then take action to implement the elements stated below. The central bank must be committed to price stability as the primary objective of its monetary policy. In a country where prices are stable, pass through will be low because of the low inflation environment. It is assumed that prices are easy to adjust in an inflationary environment as compared to a low inflation environment. The loss of value of the currency will force the importers and retailers to keep on adjusting prices so as to keep themselves in business. In the case of South Africa, inflation has sometimes gone outside the stipulated range of between 3-6 percent although it is in a low inflation environment compared to other African economies like Malawi, Zambia and Kenya (SARB, 2016). The low pass through estimates from other researchers confirm with this theory of low inflation environment especially a decade after the implementation of the Inflation targeting framework. The ability of the reserve bank to keep inflation within the desired range is an indication that the South African people believe in the Reserve Bank and they believe that it is possible for the Reserve Bank to keep prices down. Aron et al., (2014b) argue that the study of exchange rate pass-through is a way to measure the credibility of the Reserve bank to see whether it is credible enough to influence all the factors that can lead to high inflation and as a result high exchange rate pass-through.

Inflation targets should be announced to the public. The objective is to make stakeholders believe in and work with the central bank in keeping prices down. The target will be easy to achieve if all the agents in the economy believe that the target is feasible. Households, business people and everyone in the economy must agree with the target. This means that the central bank has to announce the targeted range to the people and be open to criticism and comments. This means that the target must not be too low or too high and it must look attainable. The Reserve Bank announces the target and other measures to make sure that the central bank is in control. Also, any

drawbacks the central bank is facing must be known by the economic agents especially the business community. This is because what the central bank does is to forecast using regressions and past data but there are certain shocks that cannot be predicted by the central bank and that can make the exchange rate very volatile. The 2016 drought might force the South African economy to import food from outside. Food prices are very volatile and very responsive to changes in the exchange rate hence the economy is prone to high exchange rate pass-through.

More engagements with the public about the plans and goals of the institution is what the central bank needs to aim for. The idea behind this is transparency. Economic agents do not want to see anything fishy as far as the central bank's mandate is concerned. The Monetary Policy Committee review document is presented at a provincial meeting and the business community, households and academics are invited there to have a better understanding and get an update from the reserve bank. This is a good platform to deal with questions especially from the business community because they are the ones who will be anticipating lengths and changes of the exchange rate and being able to absorb them when they see fit not to adjust prices upwards. When the business community is confident about the credibility of the Reserve Bank it means a lot in terms of their pricing decisions and the magnitude of their mark-up adjustments (Jooste and Jhaveri, 2014).

Accountability of the Reserve Bank is one of the instruments outlined in the literature especially Mishkin, (2009), Campa and Goldberg, (2005) and Karoro et al., (2009). In some countries, for example, Zimbabwe, the Reserve Bank is not independent of government interference. In this case accountability, and control of inflation, are issues of added complexity. In South Africa, the Reserve Bank still maintains its independence and the government respects the co-founding values of the Reserve Bank. This is observable since the central bank clearly executes its duties without the interference of the president or the finance minister. Independence of the Reserve Bank simply means that people can trust its actions. An accountable, credible and trustworthy central bank will be able to convince the economic agents not to have inflation expectations above

the set target because when people anticipate high inflation their mark-up adjustments will be high and that will push ERPT up and inflation will be high as well.

### **2.2.5 Inflation Targeting and Exchange rate pass through**

Empirical evidence has shown that pass through has been decreasing for the past decades especially in developed economies and, coincidentally, the inflation levels of these countries have been decreasing (Reginaldo, 2007). As a result of high inflation levels, most developing economies moved from controlling exchange rates to targeting inflation as a way to keep an eye on the prices of goods and services (Reginaldo, 2007). Inflation targeting comes into play when the primary objective of the central bank shifts to influencing the prices in a country. The literature assumes that there is a relationship between inflation and exchange rate changes. Campa and Goldberg, (2005) undertook an empirical analysis which showed the link between low inflation and low ERPT in developed economies. This implies that when average inflation is low or when inflation is kept low then ERPT can also be low. Choudhri and Hakura, (2015) also provided the same evidence but their analysis was for the developing countries that adopted inflation targeting like Brazil. However, credibility gains for the central bank play a vital role in keeping prices and inflation down.

South Africa informally targeted inflation in periods before the year 2000 but inflation started to be targeted formally by the South African Reserve Bank in the year 2000 (Mboweni, 2003). The target range for the starting period was a bit ambitious since the targeted range was between 3-5 percent in the first two years. From the year 2002 onwards the range was scaled up a bit to between 3 – 6 percent. This then means that any level of inflation within the targeted range is desirable for the South African economy. However, the inflation levels of South Africa are at the top of the range and sometimes with monthly inflation levels outside the range (SARB, 2016). Taking a look at provincial inflation levels, some provinces like Cape Town were ranging from 6.5% to

7.3% in some months especially on food price inflation. The average inflation is fluctuating in the upper range.

The bigger percentage of the inflation levels are being attributed to exchange rate volatilities. These volatilities are dangerous to the economy because they make planning difficult and it is easy to adjust prices upwards in such an environment. So it is because of the exchange rate volatilities and depreciation of the rand that the Reserve Bank is facing a hard time in keeping inflation within its targeted range.

The ultimate conclusion is that two things are needed for the monetary policy to successfully keep ERPT low namely: if the central Bank succeeds in keeping inflation down and when there are credibility gains.

#### **2.2.6 Currency choice and Exchange rate pass through (ERPT)**

Gopinath and Itskhoki (2010), in their multi-country study stated that in international trade, there are certain sectors of the economy that are dominated by dollar pricing and other sectors by non-dollar pricing. They gave examples of the animal, vegetable fats and oils as the markets that are mostly dominated by dollar pricing. This theory is mostly confirmed in an open economy with nominal rigidities where the currency used to price goods will have an impact on monetary policy, exchange rate policy and cause exchange rate pass through. In the United States it was seen that goods priced in foreign currency tend to have around 95% pass through as compared to a paltry 25% for local currency priced goods. Another segment of the economy where dollar pricing is dominant is online business trading. A person can actually buy things from abroad and the currency used in most cases is the dollar. Online business was boosted by and grew along with technological advancement in most countries including the developed countries. The use of debit and credit cards make it easy for someone in America to buy something in Europe and get it delivered to the door step. Most of these prices do not easily change but they tend to be expensive when the domestic currency depreciates as the rand has been doing for the past 3 years or so and that is inflationary as imports



become more expensive every time the dollar depreciates. In another paper, Gopinath and Itskhoki, (2010) saw the machinery and mechanic appliances as a market which is mostly denominated in non-dollar prices. The currency choices that are mostly made are either that of using the local currency (local currency pricing) when paying for imports or paying for the imports using the producer currency (producer currency pricing) (Atkeson and Burstein, 2008). Theoretically, exchange rate pass through is expected to be lower for those goods priced in local or destination market currency than for those priced using the producer currency; this is confirmed by (Gopinath and Itskhoki, 2010). Neiman, (2007) saw currency choice as something closely linked to medium run pass-through not long-run pass through. Also, he stated that when the frequency of adjusting prices is different between firms in the same sector, they will choose different currencies to price. In most instances, long-run pass through (LRPT) can be above 0.5 if the medium-run pass through (MRPT) is 0.5 the firm will choose Local Currency Pricing (LCP). Those firms that adjust their prices less frequently are most likely to set their prices using the producer currency. Gopinath and Itskhoki, (2010) concluded their work by saying that, in the case of firms with prices denominated in Producer Currency Pricing (PCP), those firms will have medium-run pass through (MRPT) as compared to firms in a sector denominated by local currency pricing (LCP), it must be noted that the LRPT for all firms in both sectors will be the same.

### **2.3 Exchange rate pass-through Asymmetry**

Studies by Pollard and Coughlin, (2003) and Knetter, (1994) argue that prices rise faster than they fall meaning that depreciations are mostly characterised by price increases as compared to appreciations which do not see much change in prices. Exchange rate pass through asymmetry is defined as differences or similarities in terms of price changes as a result of an exchange rate depreciation or appreciation. A case where a price changes by say 5 percent after a currency depreciated by 1 percent and by 3 percent when there is an appreciation confirm the theory of prices fast at increasing and low when decreasing. However, although theory says that prices move faster when

increasing than when decreasing, this was rejected by Peltzman, (2000) who argued for the opposite. His arguments were supported by a situation where an exporting firm is faced with a trade restriction policy and resorts to pricing to market. Pricing to market is a technique used by multinational companies to increase their market share or just to be able just to sell in foreign markets. When a company adopts that kind of practice it will reduce its prices in the foreign market just to be able to sell and that is when prices fall faster than they can increase.

Arguably it is this pricing to market technique that is leading to incomplete pass through (ERPT) in many economies. So this market share model of asymmetric pass-through as discussed by Pollard and Coughlin, (2003) argues that if a firm wishes to maintain its market share in the foreign market then it must keep its prices constant despite an exchange rate depreciation or appreciation. This means that the profits will fall under the periods of a depreciation and then recover the lost incomes when there is an appreciation. This then depends with the period taken by the currency to appreciate or if the currency just depreciates for a moment with an anticipation that it will then appreciate and the firm will recover the income it lost under depreciation. There is also another different view when it comes to the market share model of asymmetric pass through (ERPT) as (Marston, 1990). His arguments are that if a firm adjusts its markup to increase market share when the importing country's currency appreciates and it then maintains market share when the country's currency depreciates, ERPT will then be asymmetric as pass through to the home country's domestic prices will fall more at the time of currency appreciation than depreciation.

Also Marston, (1990) cites a wide range of influential factors leading to the issue of ERPT asymmetry especially at firm level or industrial level. Factors cited include menu costs, switching of products and binding quantity constraints. Menu costs are commonly understood as the costs of increasing prices especially in a market characterised by many sellers and where stiff competition prevails. Under such circumstances increasing prices can be detrimental to a business's market shares as others will take its business because they will be offering either constant or low prices. Product switching, is a

situation where a firm that is a price taker and supplies the local and foreign markets can buy its production inputs from the foreign or domestic markets it is operating in. Then in the event that of exchange rate changes, that firm can change or switch its sources of inputs and the kind of production technologies it applies. So if the company's domestic currency appreciates making it cheap to import inputs and expensive in the event of depreciation, the firm will switch to local inputs for production.

**Fig 2.3 Direction of the Asymmetry in ERPT summarised**

<b>Asymmetric ERPT Factor</b>	<b>Pass-Through</b>
Market share	Appreciation > Depreciation
Production switching	Appreciation > Depreciation
Quantity constraints	Appreciation < Depreciation
Menu costs(invoicing in exporter's currency)	ERPT is greater when ER changes are small

## **2.4 EMPIRICAL LITERATURE REVIEW**

### **2.4.1 Exchange rate pass through around the globe**

In validating the theoretical propositions by different authors on the degree and level of exchange rate pass through, there has been a wide range of empirical work employing various methodologies and data types in different countries. Most of the papers available are multi-country studies mainly from Europe and other developed countries although some data about South Africa and other developing countries is although on a smaller scale as compared to that of developed nations. Also in the research reviewed, not even one was sector or industry specific as all were analysing the effects of exchange rate changes on import and consumer prices.

The first category consists of the studies which looked at the effects of ERPT on consumer prices. Sanusi, (2008) and Mirdala, (2014) both studied the effects of a percentage change in the exchange rate on consumer prices holding other things like domestic labour and non-traded costs like transport constant. Sanusi, (2008) used quarterly observations of consumer prices in Ghana from 1983/Q3 to 2006/Q3 and as he used SVAR, found out that ERPT was very large but at the same time incomplete at 0.88 or 88%. On the other hand, research in the Euro Area, Mirdala, (2014) used monthly data from 2000 M1 to 2012 M12 using the Vector Auto-regression (VAR) and realised that there are different patterns of exchange rate pass through according to the baseline period as well as the exchange rate regime.

Another category is for the multi-country research mainly focusing on the developing and emerging markets. These papers employed different methodologies to estimate and analyse the effects of exchange rate pass through on different countries they looked on (Mihaljek and Klau, (2008), Shambaugh, (2008), Ibrahim and Erden, (2015), Aron *et al.*, (2014a), Ghardach, (2014), Barhoumi, (2008), Aleem, (2014), Choudhri and Hakura, (2015). In this multi-country research, there are three which used the Vector Auto-regression (VAR) in estimating the effects of ERPT on developing countries.

Shambaugh (2008), used VAR and quarterly data for 1973 to 1994 and found out that supply and nominal shocks are larger in developing nations while the effect of demand shock is weaker in well-established industrialised economies. Also using VAR, Wang (2011) employed monthly producer prices (PPI), consumer prices (CPI) and import prices (IMP) to estimate ERPT. His findings indicate that, ERPT is much higher for IMP than PPI and CPI. The estimates he made were 88% (IMP), 27% (PPI) and 10% (CPI). Incomplete ERPT also seem to be common in developing countries as far as his findings are concerned. On the other side, Choudhri and Hakura, (2015) also analysing exchange rate pass through, used quarterly data from 1979 to 2012 using the VAR and OLS models to estimate the effects of ERPT in developing nations. Their findings were that, ERPT is high for small economies. They also concurred with a lot of other researchs when they found that IMP is higher than EXP. They found the average pass-through for developing countries to be between 35% and 70%.

Analysing the multi-country and developing nations is Aleem's, (2014) work which checked the effects of exchange rate changes on prices using the semi-structural VARX model and quarterly inflation data from 1995 to 2009. The reason for using inflation data was to check the effects of an inflationary environment on prices in emerging markets like Latin America and East Asia. He discovered that in the different inflationary environments, there is a higher ERPT in Latin America than in East Asia meaning that those inflationary pressures in East Asia were lower during the time he conducted the research. Using the single equation per country to estimate the short-run effects of exchange rate on prices from 1994-2006 was the work by Mihaljek and Klau, (2008). Using yearly data they found that ERPT had declined in those nations that had seen a significant decrease in inflation in the 2000s compared to the 1990s.

Ghardach, (2014) analysed the link between exchange rate changes and import prices in a multi-country analysis. In his research he estimated the pass through for different countries, also checking the elasticity of import prices to exchange rate changes. Using monthly import data from 1983 to 2013 and the Johansen cointegration approach, the results showed that pass through for developing countries reflects a heterogeneous

character that is normally caused by different monetary policies adopted by different countries and also the existence of menu costs or costs of changing prices. On the topic of multi-country analysis as well, there is a paper by Ozkand and Erden, (2015). Using a unique methodology called dynamic conditional correlation (DCC) and generalized autoregressive conditional heteroskedasticity (GARCH). These models were used as a combination (DCC-GARCH). Using monthly data on nominal exchange rate and consumer price indices from 1980 to 2013, they discovered that ERPT is very low for developed nations, while for developing nations it is low but still higher than the developed nations.

Bussiere and Peltonen, (2008) adopted an OLS equation approach to measuring both short run and long run pass through. It is not clear whether they introduced any lags in their analysis but they used quarterly data on import prices from 1980/Q1- 2006/Q6. It was also a multi-country analysis and they were analysing the effects of exchange rate changes on both export and import prices. Their analysis on estimating pass-through brought fair results which were in line with the general expectations of pass-through because pass-through for developing nations like South Africa were within the range since they discovered that effects of pass-through on PPI were somewhat higher as compared to developed nations.

A study by Guillermo Peón and Rodríguez Brindis, (2014) analysed the impact on exchange rate pass through (ERPT) in Mexico using the Recursive Structural VAR (RSVAR). The analysis was done in the period before and after the inflation targeting monetary policy regime. The investigation aimed at analysing the effects of nominal exchange rate depreciation on domestic prices and trying to understand the transmission mechanism in the Mexican economy. The recursive methodology was supported by the theory in relation to pass-through, the ordering of the variables were ordered in such a way that the least endogenous variable was ordered last so that it could be affected by all other variables without it affecting any of them. The paper used impulse response functions to interpret the effect of the exchange rate shocks on prices in the Mexican economy. Also the variance decompositions were used to establish the

importance of a nominal exchange rate shock explaining inflation fluctuations. The variance decompositions quantify the impact of a shock on a certain price variable in the model and it also tells the researcher the speed of adjustment of prices and the time it takes for pass through to slow down or decrease. The findings from the research show that consumer prices pass through is small and fast. In the Mexican economy exchange rate shocks are not significant enough to explain price changes. Their results confirm the notion that if the central bank adopts an inflation targeting monetary policy then economic agents' inflation expectations can be lowered and as a result low pass through can be experienced. If people's expectations are high and there can be high inflation in the country stemming from the high ERPT. Also the high inflation expectations can make it easy for business people to adjust prices compared to a low inflation expectations situation. Also we have seen in the literature that prices are sticky going downwards and easier to go up something which applies most in an inflationary environment.

In another paper by Bandit and Razafindrabe, (2014) reflects that there is incomplete pass-through in all the Euro dollar countries for both short-run and long-run. They also found out that multilateral ERPT is incomplete in the short-run but complete in the long-run. To achieve those results the researchers used monthly import data for the countries analysed and also employed the VAR model. In the Euro area again there was a study by Mirdala, (2015) who investigated ERPT in an effort to bring a better understanding of it. In doing that he used a wide range of variables for the Euro area countries. Oil, money supply, industrial production, nominal exchange rate, import and export data were used to investigate the effects of exchange rate changes on prices. Using a VAR model as well, the findings were that the first stage in the pass through revealed absorption capabilities of nominal effective exchange rate (NEER) in the large economies like Germany, Spain, France and Italy.

As a comparative study between Mexico and Canada, Donayre and Panovska, (2016) investigated the exchange rate pass through and economic activity causality. They checked how the exchange rate fluctuations affected economic indicators in Canada

and Mexico. Using annual data they adopted a threshold vector autoregression technique to analyse the relationship. In their analysis they used the impulse response functions and concluded that there is no linearity in both economies. Making a conclusion they found out that ERPT is country or economy dependent, meaning to say that the factors of pass-through differ as we move from one country to another.

Gosh and Rajan, (2006) investigated exchange rate-pass through (ERPT) for Korea and Thailand. They used quarterly data for two decades up to 2009 on the nominal effective exchange rate (NEER). The results showed that exchange rate pass-through was high for Thailand as compared to that of Korea. Also they investigated pass through for the period the period before 1997- 1998 and the period just after. The period mentioned above was characterised by a currency crisis in these two countries and they faced slow to no economic growth and inflation pressures. Also the countries analysed as at 2009 had just changed their monetary policies in order to allow their currencies to float freely with any other currencies in the global market.

In a case concerning the Euro area, Hufner and Schroder, (2002) did an analysis of the effects of exchange rate changes on consumer prices alone. Using the Vector Error Correction Mechanism (VECM) for Italy, Germany, Spain, France and the Netherlands, the harmonised consumer price index was used to investigate ERPT. To interpret their results they used the impulse response functions like any other VAR. In response to a 10 % depreciation of the Nominal Effective Exchange Rate (NEER), the pass through in the Euro area was 0.4% after a period of 12 months and slowed down to only 0.8% after a period of 36 months or 3 years.

Ito *et al.*, (2005) and Gosh and Rajan, (2008) investigated the exchange rate pass-through (ERPT) in Thailand and Korea in different years using different models. Ito *et al.*, (2005) used a first differenced model with a lag of effective exchange rate up to 4 periods whilst Gosh and Rajan, (2008) used an OLS model adopted from Stock and Watson (1993). The research by Ito *et al.*, (2005) used import and consumer prices to



estimate ERPT in Korea and they found out that CPI pass through was 26% for Thailand and 13% for Korea.

There is also other research on Canada and New Zealand done by Choudhri and Hakura (2015) and Jacob (2015) for those two countries respectively. Regarding Canada, it was found that short-run import pass-through had a greater elasticity after a 10 % change in the exchange rate as it was seen to be somewhere around 60.5%. This means that in the short-run without the interference of other factors, the shock will lead to great responses by import prices. The short-run export pass through of Canada as well was found to be at 28.8% meaning that import prices respond more as compared to export prices. However, they discovered that pass through in Canada was incomplete in both the short-run and the long-run. As for New Zealand, it was found that US import mark-up had a pass through of 20% on persistent habit shocks and 30 % on non-persistent shocks. Gomez *et al.*, (2012) looked at ERPT in dollarised countries checking on the level of completeness of pass through in those countries. Using an error correction model (VECM) and monthly import data, the findings were that, pass through is incomplete and low for dollarized countries.

Within the African context Oyinlola and Babatunde, (2009) checked the effects of pass through in Nigeria using aggregate data of import prices. Using the UECM-Bound tests by Pesaran *et al.*, (2001) they found that short-run ERPT is lower than long-run pass through. The short-run ERPT was two times smaller than the long-run pass through which was at 24%. Boamah, (2012) looked at the West African Monetary Zone using monthly import data and concluded that there are varying degrees of ERPT between countries mainly because of different monetary policies adopted by those different countries.

#### **2.4.2 ERPT IN SOUTH AFRICA**

In the case of South Africa, there are a number of studies worth considering although they used different methodologies and variables. The studies in question are by Aron *at*

*al.*, (2014a), Edwards and Garlick, (2008), Karoro et al., (2009), Jooste and Jhaveri (2014), Razafimahefa, (2012) and (Parsley, 2012). Aron *et al.*, (2014b) analysed the inflationary effects of inflation targeting and currency invoicing on import prices in South Africa. Using single equation models and systems to check the pass-through of import price, they discovered that depreciations and volatilities of the exchange rates can increase the options of hedging and foreign currency invoicing because of uncertainties. The moment exporters price their commodities in producer currency (foreign currency) there is going to be an increase in the level of pass-through to prices in South Africa, considering the volatilities and depreciations of the exchange rate. The paper argues the openness of trade and that of the current account to be culprits in increasing the pass through.

Aron *et al.*, (2012) estimated a Johansen Cointegration model and single equations for short-run Exchange Rate Pass-Through (ERPT) using monthly data on import price indices for 1980:1 to 2009:12. They reported an average pass through of 50% within a year and 30 % in 6 months. They also found the long-run pass through to be 55%. The results concur with the general agreement that pass through on import prices is high but depending on the type of goods included in the import basket. If the bundle has tradable goods that have less pass through elasticity then the average estimation will be low.

Edwards and Lawrence, (2006) singled out an analysis of trade flows and exchange rate pass-through in South Africa based on the relationship between the nominal effective exchange rate (NEER) and trade flows; they also used a Johansen cointegration approach. Their empirical evidence supports the positive relationship between the balance of trade and a real depreciation of the rand. This means that import or trade prices respond to changes in the exchange rate. After they used quarterly data from 1980 to 2005, they found that pass through to export prices had an estimation of 0.85 (85%) and that of import prices was at 0.89 (89%).

Karoro *et al.*, (2009) investigated the long-run pass-through in South Africa, employing the VECM. They checked equilibrium pass through using the Johansen technique it was based on a VAR including two lags but they seemed very short of monthly data. They used various proxies for the exporter's costs of production and that resulted in long-run pass-through measurements that varied in the range of 0.75(75%) to 0.82(82%). Their findings about the equilibrium pass-through to import prices appeared to be higher for depreciations, 0.72 (72%) than that of appreciations 0.64 (64%). They also found no significant asymmetry in the ERPT of large or small changes in the exchange rate.

One of the recent studies was done by Jooste and Jhaveri, (2014) using a time varying VAR as they investigated the effects of time varying ERPT in South Africa. The methodological approach adopted in the study made use of the monthly import, export and consumer prices in South Africa from 1980 to 2011. Their results showed that, pass through is higher in the first period of the year than later but the long term pass through is always higher than the short term. Export pass-through in the first period was 6% and 7 % in the 12<sup>th</sup> period, while the import pass-through was 3% in the first period and 7% in the 12<sup>th</sup> period. This concurs with research by Parsley, (2012) who also concluded that long-run pass-through is higher than the short-run one. Parsley, (2012) estimated the effects of exchange rate changes to import prices and services in South Africa using panel data of goods and services at the dock and using disaggregated homogenous import units. This study found low pass through to the final consumer goods prices of between 14%-27% in two years after an exchange rate change. There was an unusual phenomenon as it was found from this research that pass through of services is higher than that of goods. Under normal circumstances, services are domestic-oriented and hence are not much affected by exchange rate changes. This study attributed the decline in pass through to changes in the consumption baskets of people, including more goods which are not affected by the exchange rate changes, and therefore with low ERPT; the researcher saw the decrease as not linked to changes in the monetary environment or pricing behaviour of the firms.

A study by Korap, (2007), found the composition of industries in a country's basket to be a kingpin in determining the ERPT. He adopted the unrestricted VAR model as he was examining the effects of exchange rate changes on domestic inflation. The study concurred with idea that, exchange rate shocks affect domestic inflation in a specific manner and one which is estimated to be from the manufacturer's price down to the level of the consumer. He also concluded that countries with fixed exchange rate and lower tariffs realise higher long-run ERPT to import prices than domestic prices as compared to those countries with high tariffs and floating exchange rates like South Africa.

Razafimahefa, (2012) checked on the asymmetries of the pass through in South Africa using exchange rate data. He investigated the effects of the rand depreciation for 4 quarters and 8 quarters. Using the sign restricted VAR, he found that, pass through is less asymmetric after 4 quarters (13%) than after 8 quarters (16%). This means that prices respond more to a depreciation than an appreciation but the level of response also depends on the size of the depreciation. If it is high then exporters may choose to put mark ups on their prices but if it is small they may choose to just absorb the change so that they will protect their market share. It also depends on the level of completion and availability menu costs or costs of changing prices.

**Table 2.1 Empirical literature review summary table**

<b>Authors and years</b>	<b>Country of study</b>	<b>Data used and methodology</b>	<b>Findings</b>
Aron et al., (2012)	South Africa	Monthly data on a Johansen framework	ERPT after one year was found to be 50% and 30% after six months.
Abdul Aleem, (2014)	Multi-country study for emerging market countries	Monthly data on a semi-structural VAR model	Higher pass through in Latin America than in East Asian Countries
Bandit and Razafindrabe, (2014)	Multi-country study in the Euro dollar countries	Monthly import price data was used in a VAR system	ERPT was found to be

			incomplete in the short-run and complete in the long-run
Barhoumi, (2008)	Multi-country study for developing countries	Quarterly data for import prices on a non-stationary panel approach	Found ERPT to be lower for countries with Inflation targeting and high for those without.
Boamah, (2012)	West African monetary zone	Monthly data was used in a VAR	Results showed varying degrees of ERPT across countries. ERPT was highest for Ghana and Nigeria
Bussiere and Peltonen, (2008)	Multi-country study for the global economy	Quarterly data for import and export prices on OLS	Producer price pass-through for SA was found to be 42% and consumer price pass through at 18%
Donayre and Panovska, (2016)	Mexico and Canada	Annual data was used in a Threshold VAR	Their results concluded that there is no ERPT linearity between the 2 countries
Edwards and Garlick, (2008)	South Africa	Quarterly data on a Johansen Cointegration	Pass through on exports 85% and 89% on imports
Gomez et al., (2012)	Multi-country study for dollarised countries	Monthly data on a VECM	ERPT was found to be incomplete and low for dollarised countries
Gosh and Rajan, (2006)	Korea and Thailand	Quarterly data on a Stock and Watson, (1993) OLS	14% ERPT for Korea and 29% for Thailand (Consumer prices)
Guillermo and Rodriguez, (2014)	Mexico	Monthly data was used in the Recursive SVAR	The results show that ERPT to consumer prices is small and fast.
Hufner and Schroder, (2002)	Multi-country approach Euro zone	Using monthly data in a VAR	After a euro depreciation ERPT for consumer price will be 0.4% after 12 months and 0.8% after 36 months
Ito et al., (2005)	Thailand and Korea	Yearly data for import and consumer prices on an First	ERPT for Thailand was found to be 26% and that of Korea at

		differenced model with a lag of effective exchange rate up to 4 periods	13% (consumer prices)
Jimborrean, (2012)	New EU member states	A panel approach using quarterly data on the General Moment methods (GMM)	The study found that ERPT is high for import dependent nations and those with inflation and exchange rate volatility
Jooste and Jhaveri, (2014)	South Africa	Monthly data on a VAR	6% pass through on exports and 3% on imports
Karoro et al., (2009)	South Africa	Monthly data was used is a VAR and Johansen Cointegration approach	Equilibrium ERPT to import prices was 72% for depreciations and 64% for appreciations
Korap, (2007)	South Africa	Yearly data was used in an Unrestricted VAR	High long-run pass through under the periods of fixed exchange rates and low pass through under flexible exchange rates
Mihaljek and Khan, (2008)	ERPT for emerging markets	Yearly data on an OLS	ERPT was found to be declining for countries with declining inflation
Mirdala, (2014)	ERPT for consumer prices in the European transitory economies	Monthly data on an unrestricted VAR	Results suggested that there are different patterns of ERPT to domestic prices according to the baseline period as well as the exchange rate regime
Mirdala, (2015)	Multi-country study in the Euro Area	Monthly data on a VAR	Results of the first stage in the ERPT revealed reduced Absorption capacity of Nominal Effective Exchange rate (NEER) in large economies like Germany, Spain, France and Italy
Nyamazama, (2006)	Zimbabwe	The study used quarterly data in a Johansen cointegration approach	It is shown that a 100% depreciation of the zim dollar could cause 5% change in

			inflation in the short run and 51% in the long run
Oyinlola and Babatunde, (2009)	Nigeria	Monthly data on UECM-Bounds testing by Pesaran et al., (2001)	Short-run pass through was found to be 12% and long-run 24%
Sanusi, (2008)	Ghana	Quarterly data on a SVAR	ERPT was found to be 88% for consumer prices
Takhtamanova, (2008)	The USA, San Francisco	Quarterly data in a VAR	The findings reveal that ERPT was decreasing due to low inflation environment
Wang, (2011)	Multi-country study	Monthly data for consumer prices was used in a VAR	As for SA found ERPT much higher for import prices than producer prices. 88% import prices pass through and 27% producer price pass through and 10% for cpi. For all countries checked ERPT is incomplete
Yanamandra, (2015)	India	Monthly data for import prices was used in the VECM	The results show that ERPT is more than complete in the short run and even more in the long run. The results also show non-linearity.

## 2.5 Conclusion

The literature on the exchange rate pass-through in South Africa does not agree on the magnitude, completeness and asymmetry of exchange rate pass through to prices as can be observed by the different estimations found by different researchers in various years. The observed trend of pass through estimations is that pass through was very high in periods when the economy was using the exchange rate as an anchor. When the South African economy adopted an inflation targeting monetary policy, some estimates of pass through were still high but not as high compared to the period before

that monetary policy. The South African Reserve Bank (SARB) when it noticed that targeting exchange rate was not working because of high inflation pressure mainly from import prices, it targeted inflation directly though not officially before 2000. However, despite observable success on keeping inflation down, some authors still do not see targeting inflation as a sufficient strategy the bank can use to stabilize the economy. This came after the economy has been continuously rocked with unstable exchange rates and this continued to keep pressure to the bank because of exchange rate pass through (ERPT).

Despite some disagreements about the correct estimates about the size of inflation that can be attributed to the exchange rate changes, there is an agreement between theory and empirical literature in the sense that import prices still pass through the bigger chunk compared to other price variables. The pass-through magnitudes are big at the dock and as we go down the pricing chain (import, producer and consumer prices) the amount of exchange rate costs passed on to prices will be decreasing up to around zero for consumer prices in some cases. One aspect the researcher discovered from the literature is the growing chunk of the Chinese products in the global market and that is causing most business people to be reluctant of pass through the costs in fear of losing business to the cheap Chinese produce and that has contributed much to the low ERPT levels in most countries with South Africa not spared.



## **CHAPTER 3**

### **AN OVERVIEW OF THE WORLD, EMERGING MARKETS AND SOUTH AFRICAN ECONOMY**

#### **3.0 Introduction**

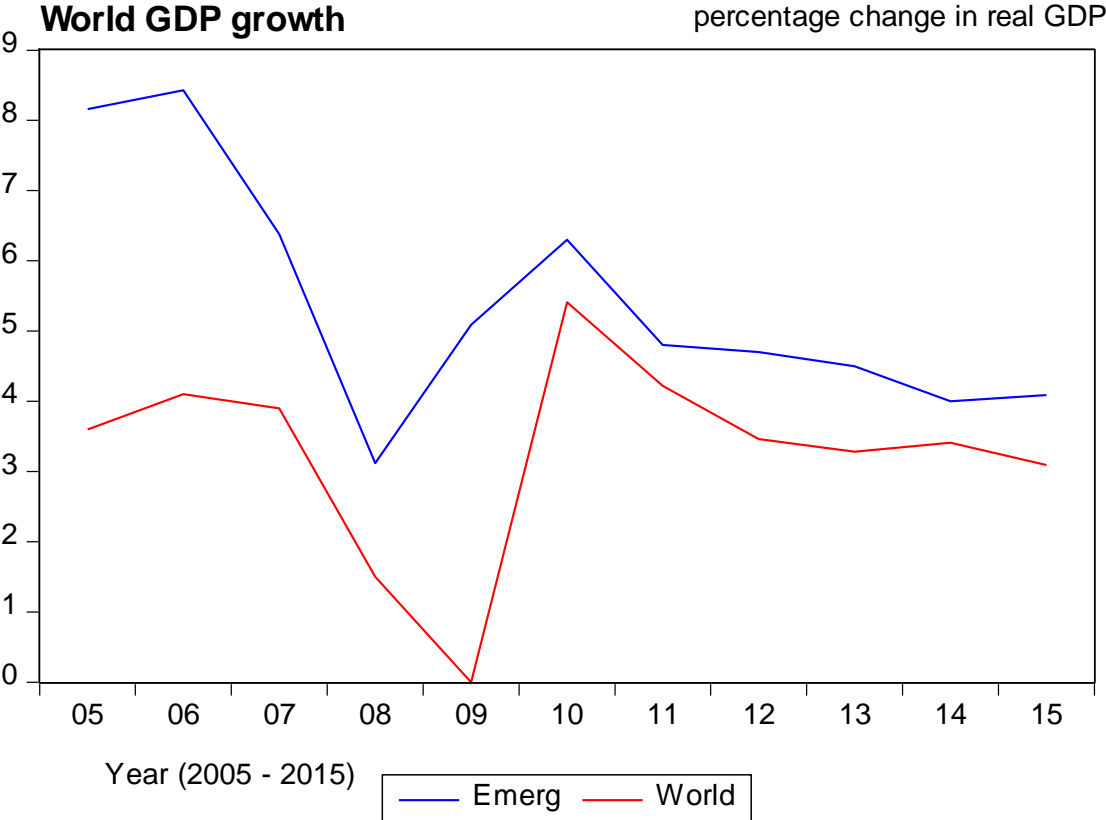
In this chapter, the general overview of the South African economy is discussed so as to understand its implications for the Exchange Rate Pass-Through (ERPT). Inflation trends for both South Africa and the world economy are given so as to motivate the reason for ERPT investigation in South Africa. The competitiveness of the South Africa market, its structure and the composition of trade are other aspects to be included in this section. For the establishment of the channels of ERPT in South Africa, the exchange rate and trade policies are going to be reviewed in this research.

#### **3.1 World Economy overview**

By the end of 2015, the leading two economies in trade China and the United States (US) and their low economic growth reflected the reason why global growth was at an all-time slow since the great recession (SARB, 2016). These two giant economies control the biggest chunk as far as world output is concerned. There were also decelerations in the middle income countries because of the low growth spell resulting from low world commodity prices (World Bank 2016). The most contributing factor to the whole story was the financial market volatility from the end of 2015 into January 2016 which led to a growth in pessimism as agents believed that the world economy has lost its momentum and its vulnerability to external shock was increasing (SARB, 2016).

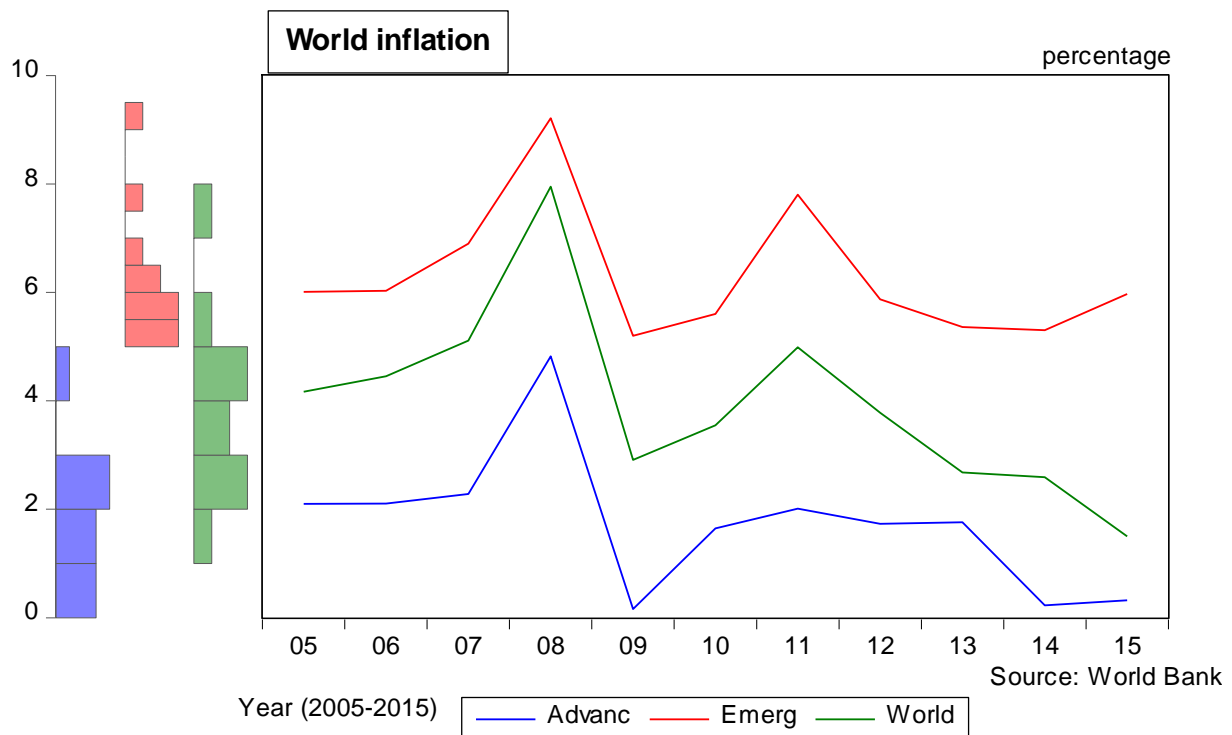
For the past 4 or 5 years the global economy has shrunk in contrast to the recovery witnessed in some advanced economies especially the US, stagnation in the Europe zone and a serious slowdown in the emerging markets where South Africa is a resident (SARB 2016). The outstanding feature of the world economy was shaped by a lot of issues ranging from the appreciating dollar, to the negative interest rates adopted by

some countries. The appreciation of the dollar in relation to other currencies simply means that it will be cheap for America to import goods in the form of inputs which means cheap production costs and those costs will lead to low prices holding other things constant. Since the USA is one of the leading exporters, the low commodity prices prevailing in the USA simply mean that the world commodity prices will be too low and that can stifle economic growth for economies that rely on export led growth. The strong dollar is contributing to lower commodity prices spearheading very strong shifts in the commodity market supply and demand dynamics (SARB, 2016). Below is a diagram showing the trend of world economic growth compared with the growth trend of emerging market economies. **Fig 2.4**



Source: International Monetary Fund

**Fig 2.5**



The diagram above shows the inflation trends of the different integrated economies namely world economy, emerging markets and advanced economies.

A series of policy divergences that took place in some advanced economies contributed to the slow-down in world growth coupled with commodity price collapse. World trade slowed since the year 2010 and that led to slow growth in emerging market economies (SARB, 2016). On the other hand the negative interest rates adopted in Japan by the Bank of Japan and the European Central Bank (ECB) contributed to negative growth in the financial market and as a result led low growth. According to the SARB April 2016 monetary policy review (MPR), world supply has been exceeding demand and this is assumed to be mainly motivated by the nose-diving world oil prices. The lowest oil prices of all time were caused by increased if not excess capacity utilisation by the suppliers as a result the previous booms. Theoretically the excess supply of commodity can only be restrained if the oil producers responsible bring to a halt their production so that they will clear the buffer stocks and then produce according to what is being

demand. However, the world demand is very low and consumption is low despite falling prices linked to low world oil prices. This is observed from the low commodity importing growth in the world (SARB, 2016).

The low commodity prices that rocked the world economy led to downward pressure on inflation in some countries and this contributed to reduced world inflation as well. However, most of the economies that are witnessing depreciations of their currencies can experience sky-rocketing inflation rates that are exchange rate motivated. When a currency depreciates, for an importing country, it will be expensive to import and on the other hand cheap to export. The countries with depreciated currencies did not and are not benefiting enough since the demand is very weak as compared to what was assumed to should have happened under the normal assumption of depreciated currency in international trade. So the bigger chunk of the inflation for depreciating currency countries is coming from import prices and is most popularly known as the exchange rate pass-through (ERPT) effect. If the effect is high, the headline inflation can respond by increasing but if the effect is small, inflation will be low (Aron et al, 2014b).

### **3.2 An overview of emerging market economies**

China is a major player in international trade both as an exporter because of its rapid growth and as a final destination for goods and services (importer) from across the globe (Savoie-Chabot and Khan, 2015). However, the Chinese economic growth rate has slowed after a long period of continuous growth from the 1990s. One of the main reasons for the slowdown is its graduation to middle-income status. Policy makers in China in the past five years aimed to balance the composition of the GDP from investment and exports then focus more on domestic demand and consumption (SARB, 2016). The market has also been liberalised giving more chance to supply and demand conditions in the allocation of resources.

The economic reform agenda adopted by the Chinese government had a lot of adverse effects for the Chinese economy and the emerging market economies at large. This

kind of development especially from the exchange rate and equity market had serious effects to the financial market in China and across the world. Economic agents around the globe lost hope and believed that the weakening of the Chinese economy was going to continue (Choudhri and Hakura, 2015). China in recent years announced a new basket to be referenced when calculating exchange rate and this basket includes the currencies of China's biggest trading partners like the yen, euro and dollar. It is argued that if China had announced this basket way before, its currency could have been twenty times cheaper than the dollar (SARB, 2016). On another note, the volatilities in the Chinese currency (renminbi) are due to the influence of China on international trade. Consequently, China devalued its currency by 2% in August 2010 and a further 1.2 % in January 2016 (IMF, 2016). The devalued renminbi caused a stir in the financial markets across the globe with Chinese people who had borrowed from abroad in dollar rates paying their debts quickly. This was so because the Chinese currency was now far cheaper as compared to the period when Chinese residents had invested in the United States dollar conditions and that only meant that they were going to suffer in repaying the interest rates back. This panic saw a huge percentage of capital outflow as investors lost confidence in the Chinese economy (IMF, 2016).

The Shanghai stock exchange index gained value very fast in the early months of 2015 but it did not go far as it started to fall rapidly. The authorities responded quickly by shutting the stock exchange and putting restrictions on the selling of shares within a period of 6 months of purchase. Also, the GDP growth rate reduced its pace sitting below the 7% target of 2015 and this was its lowest since 1990 (STATS SA, 2016). This nose diving of the Chinese economy as far as an emerging market economy is concerned was a major blow since it is one of the biggest output contributors in the emerging market economies. As a consequence, the integrated economy also nosedived. China later adopted a 5 year plan pegging growth at 6.5% up until 2020 and if that was archived their GDP was going to double more than they had achieved in 2010. Public and private borrowing was expanding rapidly and it exceeded 250% of the GDP of 2015. That level is far too high for an emerging market and is more in line with

to that of developed countries. This debt accumulation has been large in the corporate sector and government parastatals are particularly exposed. The leverage made a huge contribution to exceeding capacity especially in industries like manufacturing (World Bank 2016). The excess capacity forced prices to go down and China will not receive much from the global market considering weaker demand and high competition. So the stifled growth of the Chinese economy is a huge blow to world growth and output since it is a major player in international trade (SARB, 2016).

The deceleration of the Chinese economy is an important development in the emerging market slowdown but its growth pattern still looks much better and faster compared to other emerging markets. The performance of the emerging markets does not look good without China (SARB, 2016). Brazil and Russia are in recession and it is assumed that their recession is worse than was assumed. The Russian economy declined by an average of 4% in the year 2015 and for 2017 there is no much of good news as it is expected to continue to go down (World Bank 2016). The GDP of Brazil contracted by 3.8% a figure which is almost that of Russia. According to the IMF, (2016), the estimated shrinking of the Brazilian economy of -3.5% if realised will be the lowest and deepest ever even including the time of the great depression.

Taking a look at the emerging economies in Europe and Asia, economic output slowed and contracted in these two regions up to the year 2015. In Latin America things worsened as the economic situation and growth prospects were hindered because of very low commodity prices (SARB, 2016). As for Argentina and Venezuela there were economic downturns and massive protests rocked these countries leading to opposition parties starting to govern in those countries. Quoting the IMF, (2016), Argentina witnessed a 30% inflation whilst there was too much money chasing too few goods in Venezuela and inflation hiked to 100%. It is expected to be just below the Zimbabwe record as it expected to reach 720% by the end of 2016 (SARB, 2016).

As for Peru, Chile and Mexico growth is expected to be slow as well whilst inflation is accelerating although central banks in these countries adopted the monetary policies of

targeting inflation (World Bank, 2016). None of these economies are shrinking and inflation is high but still in single figures. As for emerging markets in Asia, commodity importing countries fall into the same problem of currency depreciation and inflation coming mostly from the effects of exchange rate changes being passed through to domestic prices. The commodity importing countries in Asia are witnessing low inflation levels just like the advanced economies. This is said to be motivated by industries that are over capacitated leading to low commodity prices. Countries like Vietnam experienced deflation in 2015 whilst the Philippines, Vietnam and Malaysia had low inflation figures but their economic growth rates were also low. Although the growth rate of the emerging market countries has been cooling off in recent years, reflecting the exposure to demand from China, the region continues to be the fastest growing region in the world (SARB, 2016).

### **3.3. Overview of the South African Economy**

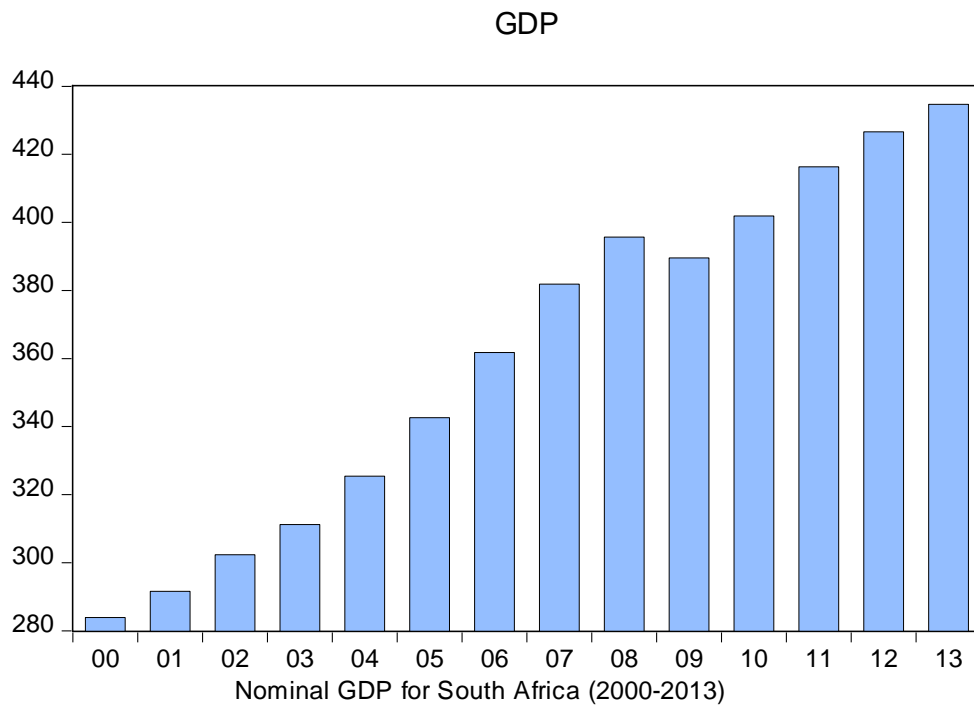
Slow growth, out of range (target) inflation and a series of macroeconomic imbalances is what characterises the South Africa economy at the moment. Growth output has been slow for the past five years and the projection for 2016 growth had to be reviewed from 1.6% to 0.8% (SARB, 2016). From the inception of the first democratically elected government in South Africa until 2008 the growth rate averaged 3% every year, but since the global crisis the growth rate has never reached 4%. **Fig 2.6**

Economic Growth for SA (Percentage) Growth



Fig 2.7





Source: SARB

There is a wide range of different reasons given by different research houses in and outside South Africa investigating why growth has been slowing. There is disagreement with regard to the assumptions in economics theory when it comes to South Africa. When a currency depreciates, it is assumed that the commodity prices of that country will be cheap on the world market and having adopted an export led growth policy, growth was supposed to be high for the past 5 years, but it was in fact in a low spell (SARB, 2016). The graduation of China into the middle income country bracket, and over production of oil and a wide range of commodities around the world have put downward pressure on commodity prices, hence reducing the profits realised by exporting countries. Also, world demand is assumed to be low because the low commodity prices that are prevailing in the world market are not boosting the export basket for South Africa and other countries around the globe.

According to Choudhri and Hakura, (2015) slow growth in South Africa to some extent could have been caused by high levels of household debt. The citizens who acquired

debt before the crisis have been selling their assets to quickly pay back because now it is expensive for them to pay them especially those in dollar terms and this is the same scenario as in China. Also the debt repayment is making households to be left with less disposable income to spend hence reducing domestic consumption. South Africa relies heavily on domestic consumption and it constitutes around 60% of GDP (World Bank, 2016). Also rising inflation in South Africa has eroded the buying power. Net savings have also been reduced since people are having high debt levels and household spending has exceeded their incomes by an estimated 3% as at December 2016 (SARB, 2016).

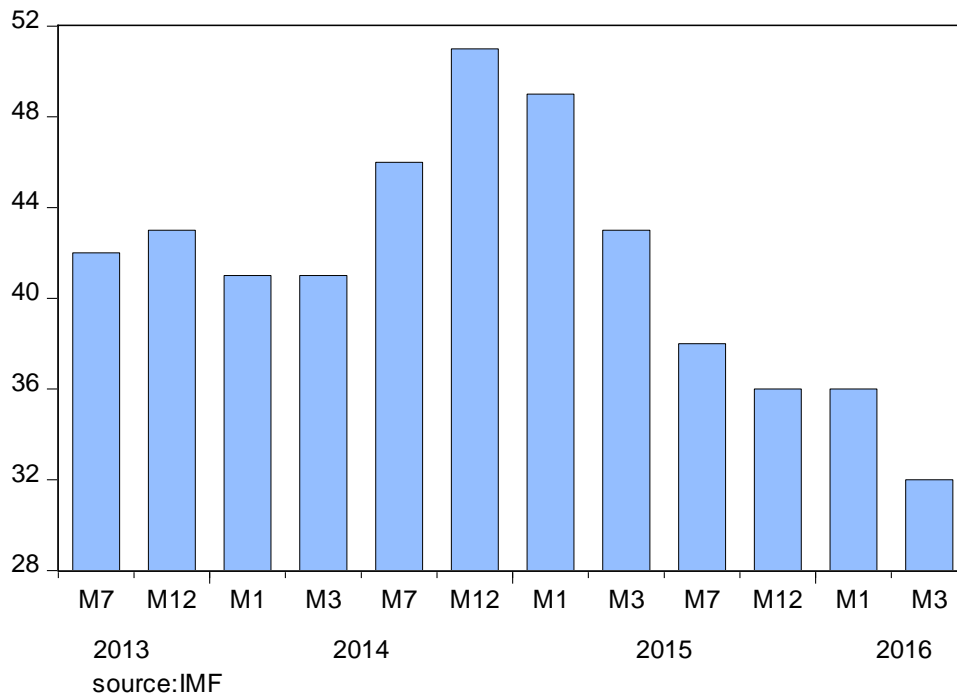
Demand for electricity has increased in the past five years but there is a mismatch between the amount of demanded electricity and what is being supplied and this has been named as one factor contributing to stifled growth patterns. The country has been rocked by a series of strikes in different sectors and others have been prolonged enough to disturb output like the motor car manufacturing strike in 2013. Also labour disruption in the platinum mines (2014) was long enough to affect the output for that calendar year (SARB, 2016). The 2015/2016 farming season was hit by a drought. The agriculture sector contributes a significant percentage to GDP but it shrank by around 8.4 % which is a huge blow to output. However, the drought shocks are transitory to the economy and are very hard to forecast and prepare for. Their effects can be felt in the long run if they continue hitting the economy and since food imports are inflationary under a depreciating currency, it will take time to reduce inflation. The effects of these short lived shocks to the South African economy and their slow growth narrative for the country can damage private agents' confidence and this can affect the monetary policy's inflation targeting and private investment.

The forecast of the output gap (realised minus potential output) has been lowered again by the authorities as they cite that it is now difficult judge at what rate the economy will grow. The output gap has been deteriorating since 2010 and growth has shrunk to a forecast of 0.8% for 2016, when it was originally set at 1.6%. In addition, the employment growth rate has been on a slow move since the 2008 world crisis. The

pattern is expected to worsen since the government is about to implement the freezing of any hiring and the mining sector which plays a big role when it comes to employment in South Africa, has been retrenching workers as well (SARB, 2016).

Citing from the First National Bank (FNB) bureau for economic research, the consumer confidence index (CCI) had hit a low rate for 2015 into 2016, a figure seen 15 years ago around 1993. The South Africa Chamber of Commerce and Industry (SACCI) also concur with the findings from the FNB that the CCI will be low and this is one of the factors affecting local demand and consumption despite the country running high levels of inflation and high household debts. Investment by the private sector which constitutes around 75% of the total investment only increased by a paltry 2% since the global crisis. The same sector of investment used to grow by an average of 9% to 10% per annum before the world recession (STATS SA, 2016). Consequently the contribution of investment to GDP for South Africa has dwindled contributing only 20% compared to the 23% contribution before 2008. The 20% is far below the South Africa's National Development Plan (NDP) which pegged the contribution of investment to GDP at 30%. Political uncertainty and militant trade unions are other factors that have made investors not to prefer South Africa as a better investment destination and that has contributed to low and stunted growth of the economy. All of this has contributed to a low growth potential and that has created an environment of foreign investors are wary of the associated risks thus leading to capital outflows when sentiment turns against emerging markets which then leads to exchange rate volatilities.

Business Confidence Index BCI

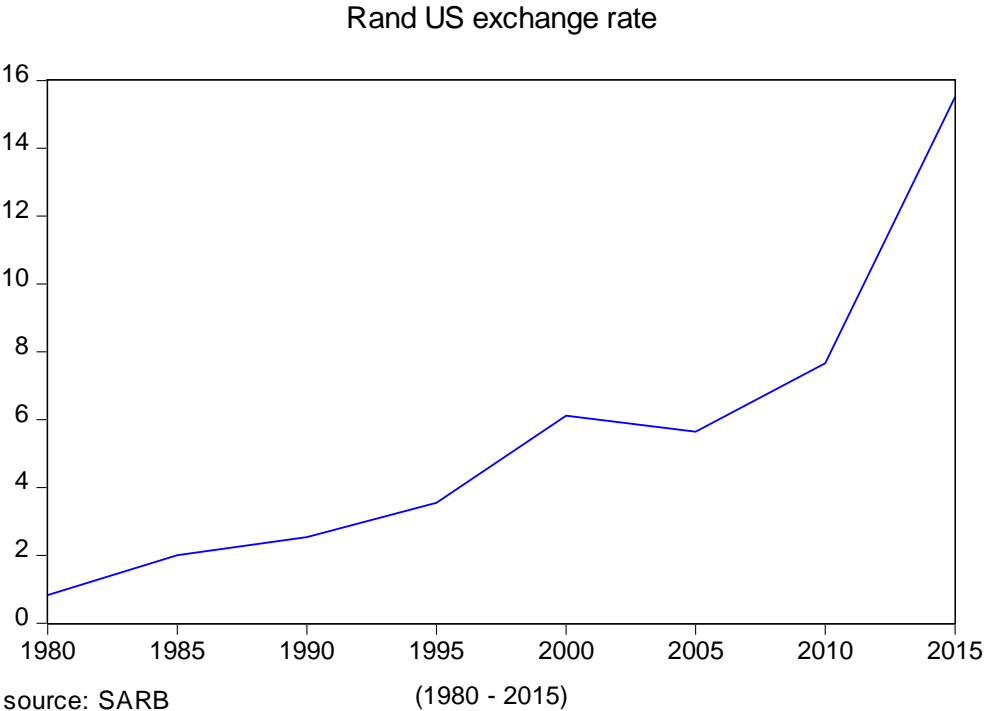


Net exports have been contributing quite positively to the national output growth for the past 5 years. SARB forecast a weaker contribution of net exports to growth for 2016 and they are expected not to contribute anything in 2017 but are then expected to contribute positively in the following years. There is also a negative current account which is widening and it is expected to be more than 5% of GDP for 2016. The terms of trade have also worsened hitting an all-time low of 8% although they are expected to improve with time. According to Marks and Trapido, (2014) the current account deficit of South Africa is happening at a time when there is a prevalence of cheap oil prices and improved export prices but the export values are not increasing, possibly because of the China effect (cheap commodity prices as a result of over production and cheap production costs). However, the SARB because of the lower world prices and improved export prices reviewed the forecasts of the terms of the trade at 4.6% for 2016 and 4.7% for 2017.

On another note, the depreciation of the rand has reduced the effects of recent declines in the world oil prices on domestic prices in South Africa. However, the depreciation is

making the importation of food items expensive yet the country is in a drought period. These high import costs will have an adverse effect on prices and will continue to make it hard to keep inflation within its targeted range of 3-6%. Also the fact that the country is in a drought means that import values are going to balloon and this puts pressure on the terms of trade. The SARB argues that the persistent current account deficits which have been rocking the country for a couple of years back can best be explained by depreciations of the currency against its major trading partners.

**Fig 2.9**



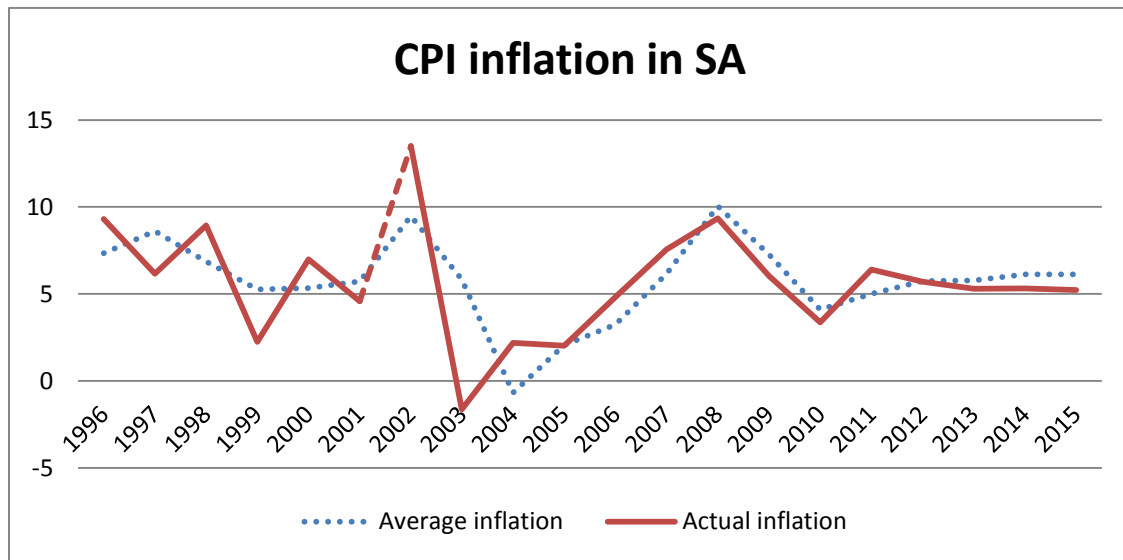
The rand against the US dollar has depreciated by almost 53% since the year 2000, by close to 95% since 1980 and by 51% for the period 2010 to 2015. This depreciation has not made a big impact on the tourism sector although it is cheap to visit South Africa at the moment. However, it is argued that the visa regulations into South Africa have not been favourable and easy and if these could be revised the country could see an increase in the number of people coming to visit the republic of South Africa.

The country in the past years has been rocked by a series of trade union (COSATU) demonstrations in demand for higher wages and better working conditions. The increase of wages by others in the country after the demands increased the costs of production and this put pressure on prices as producers passed on the burden to the consumers. The firing of finance ministers by the South African President reduced investor confidence in the Rand as it was witnessed by a drastic fall in value of the rand after the announcement of the last minister. The announcement made the rand to be very unstable and it did not recover by December 2016. A volatile and depreciating rand put pressure on inflation through the exchange rate pass-through.

### **3.3.1 Exchange rate and inflation**

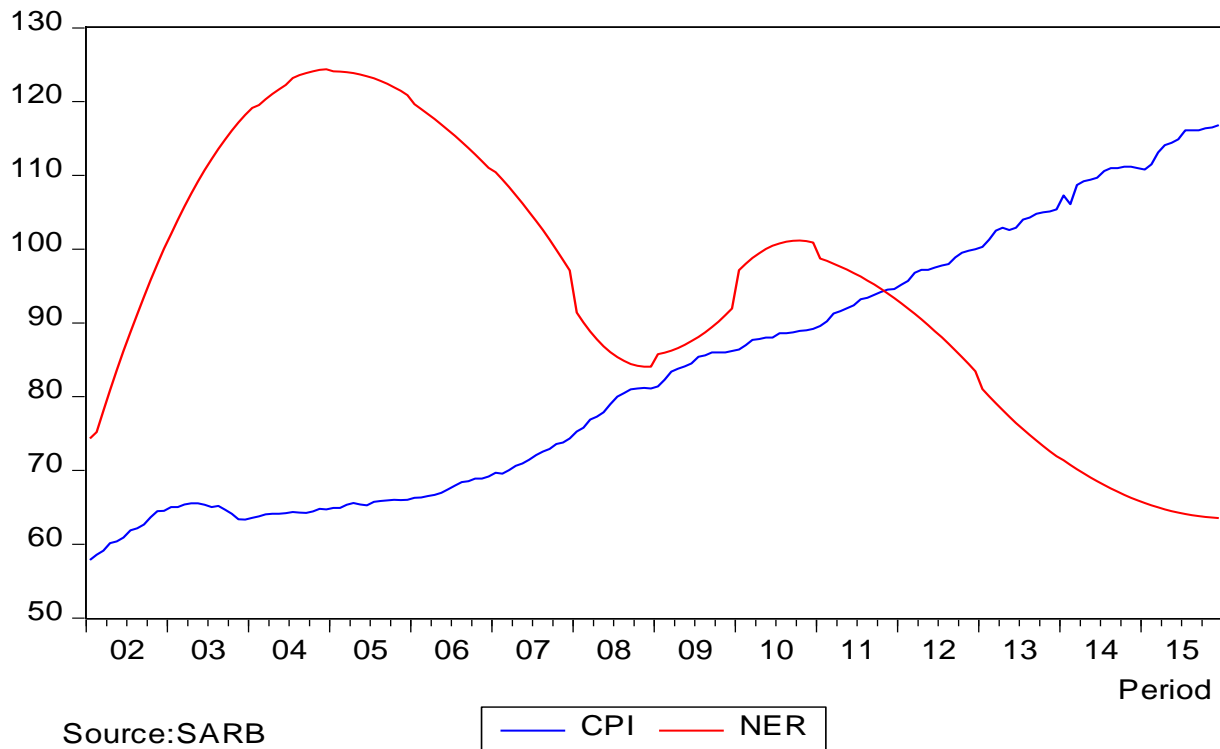
The exchange rate depreciation has been persistent over the past few years in South Africa. According to the SARB, (2016) the depreciation is mainly caused by commodity demand shocks and portfolio shock as the Fed is argued to have been tightening its instruments and the panic sell and return of US investments from abroad. This is happening because the US dollar is appreciating so all the investments in the US dollar terms in a depreciating currency country like South Africa will be disposed. Also the market volatilities in China shocked the whole world economy when China intentionally devalued its currency by a 2% in 2015 and this also contributed to the depreciation of the rand.

**Fig 2.10**



Source: SARB

**Fig 2.11; Cpi and Nominal exchange rate relationship for South Africa**



Source: SARB

The continued depreciation of the rand against its trading partners has been said to be contributing to inflation in South Africa. The inflation aspect comes in because it will be expensive for South African importers to get goods from countries like the United States, Germany, Canada and other countries with strong and appreciating currencies. The effects of exchange rate change to inflation depend on the exchange rate pass through (ERPT) magnitudes in the country. However, Aron et al., (2014a) argued that the low levels of pass through are being caused by the weakening demand conditions in the country basically as a result of high debt levels and low consumer confidence and inflation eroding the purchasing power.

Domestic firms are reluctant to adjust and pass on exchange rate changes costs to the customers or fear of losing business (SARB, 2016). Another argument is that the country adopted an Inflation targeting (IT) monetary policy and there is an agreement in the exchange rate pass through literature that the adoption of IT will help to instill confidence in the economy and that will have an effect on the levels of inflation. However, if the economic agents give credit to the reserve bank, as far as the ability to keep inflation within its range is concerned then inflation will be low no matter how volatile the exchange rate remains. Another argument under IT is that the monetary policy will work as an anchor for inflation expectations. So no matter how the exchange rate changes if the agents believe that inflation will be stable price setters and wage negotiators will not demand too high increments.

### **3.3.2 Trade policies**

In South Africa industrialisation started when the import substitution procedure was in place and the focus was about producing previously imported manufactured goods to cater for domestic consumption (Bell, 1993). The government implemented policies that were put in place and gave support to import substitution including restricting quantities on imports in the form of quotas, licenses and duties on imports as a way to discourage imports and support local industry which was rising. In response, by around 1972, there was an emergence of some signs of trade liberalisation as policies shifted from the historical import substitution to export oriented industrial growth. In the same period



there was a commission of enquiry into the Export trade of South Africa called the Reynders Commission and that is where most of the initiatives to change the policy came from. However, according to Bell, (1993) the report produced by the Commission did not suggest that liberalising imports was a condition necessary to speed up the expansion of growth. Although the commission saw import liberalization as something important in overcoming the anti-export bias which was within the trade policy at that time, the commission channeled its focus more on export growth promotion than liberalising imports.

When South African trade liberalization came into place, the economy moved from quantity restrictions on imports to the use of tariffs. Although the tariffs were high, it is argued that they were better as compared to the monetary value of the quantity restrictions on imports (Bell and Farrell, 1997). The bringing in of the tariff idea reduced the protectionism by a large fraction in South Africa. To promote the growth of exports into the world market the government put in place some export incentives so that the exporters would be motivated or find it a bit cheaper to continue doing business abroad. Tax allowances were put in place as a way to make exporters use that money to promote and market their products abroad and as a result the country was going to witness growth in the export sector. However, the trade liberalisation that was put in place (1972 to 1976) faced a challenge from the appreciation of the rand as a result of the 1973 to 1994 gold-led boom. When the currency appreciates it means that the South African goods prices will be dearer compared to the period before the appreciation. The rand kept appreciating for that period and that affected the growth of the exports because South Africa is a small country with no market power of any sort in the world market.

The idea of trade liberalisation was later renewed in 1980 after the mid-late 1970s setbacks as a result of the appreciating rand and making prices expensive abroad (Karoro et al., 2009). In 1985, the value of the imports as result of quantity restrictions had decreased by 23 % from 77% in 1983 (Bell and Farrell, 1997). In the same period South Africa moved from having a positive list of allowed and licensed imports into the

country to having a negative list of prohibited imports which covered 23% of imports and imported goods that were exempted from licensing amounted to 77% of the total imports. This meant that the liberalisation gap widened as a result of the reduction of licensed imports into the country moving towards total liberalisation of trade. Karoro et al., (2009) also argued that another contributing factor to trade liberalisation was the depreciation of the rand towards the end of 1983 up to the end of 1985. As a result of all these initiatives, there was an observable reduction in the magnitudes of protection of the manufacturing sector goods during the same period and it was a major step up in the whole process of trying to liberalising trade (Bell and Farrell, 1997).

According to Karoro et al., (2009), up to the period of 1990, further relaxations on the quantity restrictions were effected. The percentage of tariff items subject to the quantity restrictions decreased from 28% in 1985 to less than 15% by the end of 1992. Unfortunately again the progress of the trade liberalisation agenda was stifled by the imposition of sanctions on South Africa and the debt payment issues in 1985. In the same period there was an import surcharge of 10% which was put in place in 1985 and which then rose to 60% for a wide range of selected items in 1988 (Bell, 1993). By 1990 there were various rates for the so called surcharge on goods that were not in the trade agreement by General Agreement on Tariffs and Trade (GATT). The different rates imposed or put in place included 10%, 15% and 40% for different goods.

In order to incentivise exports in the country, the government introduced structural adjustment programs for specific industries namely clothing, textile and motor vehicle. Also duty free goods for all the companies that were importing for export were put in place so as to try to suppress the costs of production and increase competitiveness of local companies in the world market (Karoro et al., 2009). In the mid-1990s all the separate programmes were bonded together to form one strong system of export subsidies named the General Export Incentives Scheme (GEIS). This scheme brought home tax free subsidies for exporters relative to the value of exports, the processing of the exported goods, the quantity of locally made content put into the goods to be exported and the magnitude of the overvaluation or misalignment of the exchange rate

(Jonsson and Subramanian, 2001). Despite having the zeal to liberate trade in the 1980s, South Africa still had a heavy tariff regime. In 1980, South Africa had the highest and widest range of tariffs and one of the highest as well when it came to the degree of dispersion in tariff rates among the developing countries across the globe (Karoro *et al.*, 2009).

In 1990, after the Uruguay round of trading negotiations, South Africa adopted two trade liberalisation approaches, the unilateral trade liberalization and multilateral trade liberation. The period 1990-1994 was characterised by the main emphasis of the government as far as liberalisation is concerned to totally eliminate the remaining import controls (those licensed) and reduction of the tariffs. The average tariffs decreased from 28% to 16% and the surcharge was totally eliminated. In 2000 the average import weighted tariff was below the level committed to by the country to the World Trade Organisation (WTO) by more than 5 percentage points (Jonsson and Subramanian, 2001).

According to Bell and Farrell, (1997), in 1994 South Africa agreed at the Uruguay round to reduce tariff through implementation of a 5 year rationalisation programme. In the agreement South Africa had to reduce the number of tariff categories from over 100 to 6 and average weighted import duties had to be reduced. Moreover, a reduction of industrial protection over a 5 year period was negotiated and recommended at the round of negotiations moving down from an average of 12% in 1994 to 5% in 2001. The average import weighted tariff rates were to be slashed from 34-17% a 100% decrease in the tariff on consumer goods. As for the intermediate goods a 8-4% decrease was implemented and 11-5% for capital goods. (Cassim *et al.*, 2004). Karoro *et al.*, (2009) reported that the average import weighted tariff, declined from 28-10% from the date of implementation of the offer but by the year 2000 tariffs had fallen by a paltry percentage from 11.4 % to 8.6% as for the industrialised products.

The commitment and offer to the WTO demonstrated the South Africa's willingness and efforts to open the economy to the international economy (Karoro *et al.*, 2009). In

another development, regional trade agreements were signed between South Africa and other African countries especially SADC namely the SADC trade protocol of 1996. Opening the economy to the rest of the world to accept imports of finished goods and intermediate goods to be used in the production line is one of the achievements the South African government did as this can expose the local industries to competition and that competition can force producers to improve quality and offer better prices to the market. It was also agreed that 69% of the SADC imports into South Africa should not be charged any rates to fully complete the protocol and South Africa completed liberalisation by 2012 (Aron et al., 2014a). It is evident enough to see now that the trade regime of South Africa is now open and the economy can be affected by shocks from across the globe causing volatilities in the exchange rate and later affecting the inflation targeting regime which was formally employed in 2000 (Choudhri and Hakura, 2015). All the quantity restrictions were eliminated and the number of tariff-based bands went down from above 200 to 35 and the lines of the tariff went down from over 13000 in 1990 to 7831 in 2001. By 2002 the country's trade regime was relatively simplified as the quantity of lines that were facing specified tariffs were reduced down to 277 from 500 (Cassim *et al.*, 2004). After that period, trade volumes increased significantly. The period 2000 to 2005 saw imports growing very fast in real terms showing average figures of 7.6% there was double growth of national output (GDP) comparing same periods (Cassim *et al.*, 2004).

In the ERPT literature openness of a country (economy) to international trade and the liberalisation of trade is one contribution to high estimates of pass through to prices especially the import prices. The South African policies pushed for trade liberalisation mainly because the productive industries in the country rely heavily on imported inputs or intermediate goods. The continuous depreciation of the rand against mainly its trading partner's currencies is likely to cause an inflationary environment mainly from second stage pass through (from import prices to other prices down the chain). Also the country is susceptible to short term capital inflows which can be very destabilizing when sentiments turn against the country causing exchange rates to become volatile.

### **3.3.3 Trade structure and ERPT**

The magnitude of trade in relation to the economy or its output is important in the assessment of the existence and importance of studying ERPT in the economy. If the international business of a country (imports and exports) is small it means that either their exports or imports constitute a smaller percentage when compared to the GDP. When a country is not very involved in world trade, ERPT will be expected to have no or a very insignificant contribution to inflation in a country, hence it would be less important. The exchange rate will have a higher impact on local prices if the local consumption or production relies heavily on imports meaning that countries with a higher fraction of imports or exports to the GDP have higher pass through as compared to those with less. In the case of South Africa, the local industries rely on imported inputs for production either for domestic consumption or exports. Also South Africa is a country with a leading role in Africa in terms of technological progress in Africa meaning that there is a hype of activity in the technological business with South Africa playing an importing role. In the manufacturing industry taking the machinery and car manufacturing, a lot of inputs in these industries are imported from other countries and considering that import prices respond much to exchange rates, South Africa is exposed to high pass through.

According to statistics from the South African Reserve Bank (2015), South Africa comes in as the 36th largest export country in the world and takes 46th position in the list of most complex economies. In 2014 the country exported goods to the value of \$106 Billion and imported goods worth \$102 billion meaning that it had a trade surplus of \$3.39Billion. This meant that the country was managing to grow and produce goods and services to cater for local and international demand. In the last couple of years the exporting industry of South Africa has increased, expanding by an average annual growth rate of 6.6% with values stretching from \$77.3 billion in 2009 to \$106Billion in the year 2014 (SARB, 2015). In the export sectors the leading contributor was gold bringing in 9.6% contribution to the total exports.

The leading destinations for the South African exports are mostly where the bigger proportion of its imports also come from. The Republic of China imports goods and services worth \$9.8 billion from South Africa followed by the United States of America who take goods worth \$8.95 billion from South Africa. India cannot be excluded since it also take goods worth \$7.07 billion from South Africa. The United Kingdom and Hong-Kong named last in the top 5 taking \$6.8 billion and \$6.08 billion, respectively (SARB, 2015).

On the importing side, South Africa is ranked as the 33rd largest importer of goods and services in the world for both consumption and those that are imported as inputs for producing industries. In 2014 alone South Africa imported goods and services worth \$102 billion and a figure which grew from \$70.2 billion in 2009. The major contributors in the ballooning import basket are crude oil (constituting 15%), refined oil (contributing 5%) and food imports taking another bigger share in the basket (STATS SA, 2015). On another note due to the continuous depreciation of the rand against other currencies, imports of vegetables into South Africa declined by 34% as at December 2015, optical photographic imported goods decreased by 10% whilst plastics and rubber items decreased by around 6% and minerals falling by 3% by the end of 2015( SARB, 2016). However, machinery and electronics are defying all odds since they are increasing by 3 % while some goods and services are decreasing because of the depreciating rand.

Although the trade policies in the country were export growth centered, because of the openness of the country to trade and competition in the international market, most of the times the imports out weighted the exports except for 2014 where a significant trade surplus was realised (Chabot and Khan, 2015). The behaviour of trade compared with GDP for South Africa can help to paint a picture of the behavior of ERPT since the currency has suffered persistent depreciation and the exchange rate volatilities are assumed to have contributed to the decrease in demand for some of the tradable goods and it can help to explain why the Inflation Targeting regime adopted by the South African Reserve Bank is struggling to keep inflation within its expected range.

Analysis of the South African trade structure is done by checking the percentage of imports to the GDP and the contribution of exports to GDP growth or its ratio to the GDP. In the period that is being analysed by this research (the inflation targeting (IT) period), the economy has been growing at a slower rate in the early periods of the IT before achieving negative growth in 2009 then went back to positive figures again but has never exceeded 2% since then and as for 2016, the forecast is that the growth rate will not exceed 1%. The sectors contributing most to both export and import are manufacturing, agriculture, tourism and mining. The manufacturing sector is being fed mostly by imported inputs since some of them cannot be found locally or they are cheaper to import as compared to those locally produced. However, the country's major imports are food items, petroleum and technological items since the country is fast moving in adopting and embracing technology. As said earlier the majority of this trading is done in Europe and Asia since the biggest trading partners for South Africa for both imports and exports are not from Africa (Cassim *et al.*, 2004).

Theoretically, the growth observed in the imports of South Africa only meant that the country is prone to the effects of Exchange Rate Pass-Through (ERPT). If it is assumed that a country's import shares can be used as a measure of the penetration of imports faced by firms in the country then countries with high import penetration should have a higher ERPT than those with low penetration (Nusrate *et al.*, 2013).

It is evident that South Africa relies to a large extent on imported goods and services for both consumption and industrial production especially food items and the manufacturing sector. Thus the exchange rate pass through to prices in South Africa is expected to be higher in second stage and that is the causation from the import prices down in the pricing chain to the consumer prices.

### **3.3.4 Market competitiveness in South Africa**

During the apartheid era, the white government would not allow black business to take part or participate in doing business and only white people were allowed to do business (Karoro *et al.*, 2009). Also some companies were not allowed to take part in the

international business and some companies, for example De Beers and Sasol were not allowed to venture into multi-national businesses. Consequently those companies resorted to enlarging their territories in South Africa. This kind of arrangement created oligopolistic market structures in the economy (Jooste and Jhaveri, 2014). When the companies in an economy are involved in international trade, the exchange rate pass-through is expected to be very low if not zero because all the intermediate goods that are needed for production will be provided from within the economy.

The situation in the country loosened when the country got independence, when the black government came into power. After independence the government encouraged competitiveness in all the market, to the extent of making laws that made sure that competitiveness was not hampered by anyone. The country also went through a lot of structural changes in terms of monetary policies and trade policies. Checking from the 1980s different policies have been adopted and have brought different export and import incentives with them. In sectors like the telecommunications, energy, mining and banking, the level of competition improved but the oligopolistic nature of the sectors like banking sector warrants more to be done since there are a few giant banks controlling the market. The big four banks in 2013 controlled 83% of South Africa's deposits (SARB, 2014). This then means that they control the major shares in the banking sector and that is not healthy because quality of service and growth of the economy require the banking sector to be very big and competitive (Karoro *et al.*, 2009).

On the question of ease of doing business, South Africa is ranked 73rd out of 189 countries considered as at April 2016 having been ranked 69th out of 155 countries in 2015 (world bank, 2016). These statistics are quite disturbing considering the openness of the economy and the efforts being made by the government to make sure that there is growth coming from investment boosting employment and competition in all sectors of the economy. In another survey on the global competitiveness, South Africa was ranked the 42nd out of 177 countries considered while in 2015 the ranking had deteriorated but was still better than other Southern Africa Countries since it was pegged at 54th out of 189 countries considered (World economic forum, 2016). The fact that the country is



competing with the international market makes it prone to the changes in exchange rate. Unfortunately the size of the country and its bargaining power is small meaning it have low exchange rate pass through(ERPT) when it comes to export and import prices. In addition, the country has made important moves in installing industrial support measures to promote the competitiveness in the industry. Those measures include placing more energy and emphasis on supply-side policies than demand-side; examples to such policies put in place are lower tariffs and big budgets for export support programmes (Karoro *et al.*, 2009).

### **3.4 Conclusion**

There have been vast changes in the South African economy since the 1980s, with efforts to open up the economy to the rest of the world. This opening up has seen a huge inflow of imports from the rest of the world but the situation is likely to cause more harm than good to the economy considering the volatile and depreciating exchange rate. Also, the monetary policy has changed over the period with exchange rates moving from being fixed to managed and, lately to being left floating. On the other hand the SARB used to informally target inflation in the period before 2000 and now it is formally targeting inflation. The position that the Reserve bank took can be seen as a promulgator of the study of ERPT.

In addition, as a result of the increased competitiveness of the local business both locally and internationally, there is a wide range of factors that are likely to influence the size and speed of ERPT in the country. The recent activities in the country like the Marikana killings and trade unions continuous demands of high wages are other things that managed to influence the exchange rate and inflation for the past years in the country hence making it difficult for the inflation targeting monetary policy to perform better.

## CHAPTER 4

### METHODOLOGY AND EMPIRICAL ANALYSIS

#### 4.0 Introduction

This chapter will focus more on the model estimation techniques to be used in the research, the issues of data stationarity, measures to deal with non-stationarity of data, Cointegration technique and the estimation of ERPT.

Referring to the discussions in the literature, the transmission mechanism for the South African case is assumed to be direct ERPT. Direct ERPT is the effect of exchange rate on import prices and later on producer prices, export prices and consumer prices. In the direct pass through, there are two stages in how the exchange rate changes affect prices. The first stage exchange rate changes will affect import prices while in the second stage the import prices will affect the other prices variables. The indirect pass through can be available but it is not expected to have more significant effects on inflation. The indirect pass through is when the changes in the demand will put pressure on producer prices and consumer prices. Basically when import prices are very high, demand for local produce will increase and that will put pressure on local producer to demand more labour to produce more and that is how the producer and the consumer prices are affected because the local producers will just pass on the costs to the consumers.

So this chapter will be modelling the direct transmission mechanism as it is the one expected to be significant and practical for the South African case. The variables to be used in the research are output gap, petrol prices (oil prices), nominal effective exchange rate (NEER), import price index ((IMP), Producer Price Index (PPI), export price index (EXP) and The Consumer Price Index (CPI).

#### 4.1 Most Popular ERPT Estimations

Exchange rate pass through (ERPT) has been defined by various scholars as the response of domestic prices in relation to exchange rate changes. If ERPT is estimated in the same period using different methodologies, the results obtained will be different. Some of the wide range of differences in estimations are attributable to different researchers failing to correctly specify the model they are using to get proper estimates. The ERPT estimation in some of the past papers used non-stationary data. When a model is estimated using non-stationary data without economic assumptions in place the researcher might run a spurious regression.

As noted in the literature different techniques have been used to investigate ERPT. These techniques include the OLS which is very popular in the initial stages of pass through studies. The Vector autoregressive (VAR) models have also been used for example the reduced form VAR, Structural VAR, Threshold VAR and, more rarely the Recursive VAR (Cholesky decomposition). The VAR models will be interpreted using the impulse response functions (IRF) and the Variance decompositions (VD). The variance decompositions quantify the change of a certain variable as a result of a shock in another variable whilst the IRF show the effect of a shock graphically on a certain variable. Lastly, another methodology that has been widely used in the literature is the Johansen (1988) Cointegration technique together with the Vector error correction model for a VAR. Briefly below, there is a summary of these techniques and the reasons why they were favoured and the reasons why some are no longer being favoured now (given their flaws).

**Table 4.1; popular estimation techniques in ERPT**

<b>OLS</b>	<b>VAR</b>	<b>Johansen</b>
Hakura (2015)	Mwase, (2006)	Nyamazana, (2006)
Gosh and Rajan, (2008)	Jacob and Uuskula, (2015)	Waldyr and Marta, (2012)
Bussiere and Peltonen, (2008)	Jooste and Jhaveri, (2014)	Edwards and Garlick, (2008)

Mihaljek and Klan, (2008)	Hakura, (2015)	Aron et al., (2012)
	Sanusi, (2006)	
	Razafimahefa, (2012)	
	Mirdala, (2014)	
	Wang, (2011)	
	Nogueira (2008),	

#### 4.1.1 Variables description and Data issues

The empirical work will use monthly data for both the Structural VAR and the Recursive VAR as outlined by Ouliaris et al., (2016) as they argued that SVAR is better specified using disaggregated data than yearly data. The period captured in this research is motivated by the need to check the contribution of exchange rate changes within the period of the inflation targeting regime and by so doing it will cover the year 2002 January up to 2015 December. The primary source of the data is Quantec, a data house that gathers data from all over the world and makes it available to researchers at a cost. This makes the data more reliable since it comes from a recognised source. Below is a list of variables to be used in the model.

**Output gap**-The output gap is the difference between potential output of South Africa and the actual output produced in a given year. The out gap can either be positive or negative depending on the value of the actual output. The potential output is more like the full employment output and if the actual output is greater than the potential output then that can be inflationary to the economy. When the potential output is greater than actual then it is deflationary to the economy. So the positive value of output gap is when the actual is greater than the potential and is negative when the actual output is lower than the potential output. This variable will enter into the model representing the demand shocks in the economy.

**Petrol prices**-Petrol prices will be entered into the model representing the world oil price shocks. The oil prices represent the supply shocks in the model. The petrol prices used are those of South Africa and they fluctuate in their pricing depending on the world

oil prices. South Africa is a net importer of oil so the increase of oil prices is expected to be inflationary to the economy whilst their decreases are welcome as the objective of the reserve bank is to keep prices down.

**NEER**- Is the nominal effective exchange rate which is a proxy for the exchange rate. This is the geometric weighted average exchange rates of the main trading partners of South Africa, the BRICS community and also the Euro area. The base year index of the nominal exchange rate used is 2012=100. The nominal effective exchange rate is measured in foreign currency terms. By so doing the increase of the absolute figure reflects a depreciation of the rand and the reduction in the absolute value show that the rand has appreciated. If the index moves from 130.35 to 125.25 then we say that the rand has appreciated in value; the opposite reflects a depreciation of the currency. According to the International Monetary Fund (IMF) international financial statistics, the NEER is calculated by accounting for every nation's tradable goods in both the manufacturing production and input markets or the primary products.

**IMP**-the import price index is used as a proxy to represent the prices of the goods and services imported by the country. The import price index is found from Quantec who get the data from the reserve bank of South Africa. The index is also seasonally adjusted and the base is 2012=100.

**PPI**- is the producer price index of South Africa, (also offered by the reserve bank of South Africa with a base of 2012=100). It is the average weighted value of index of the goods and services produced for domestic use or international market consumption excluding the imports. According to Karoro et al., (2009), the producer price index goes in line with the line 63 of the International Monetary Fund (IMF) financial statics.

**Expo**- is the export price index of South Africa for goods and services produced in South Africa and sold in the other countries. The export index data is also downloaded from the Quantec data providers with the producer being the South Africa Reserve Bank (SARB). The index has a base of 2012=100 and falls under line 65 of the IMF financial statistics.

**CPI-** is the consumer price index of South Africa representing a basket of goods and services sold to the consumers in South Africa. This Index takes care of the food prices, mortgage interest and other items that are volatile to cost structure changes in the economy with exchange rate change not spared. This index goes in line with line 64 in the financial statistics of the IMF. The CPI index has a 2012=100 base as well.

All the variables explained above will be transformed into natural logs because the interpretations will be done in percentages.

## **4.2 Time Series Methodology**

Time series unlike others other data that are collected at a fixed point in time, it is so much dependent on time and periods. This then means that we can get different values of different variables at different times (Koop, 2013). According to Enders, (2010) there are certain fundamental facts of economic time series data and it is assumed that most of the time series data have a clear trend, some series seem to wander, some series does co-move with other series. Also, the volatility of many series is not constant overtime. Gujarati, (2004), states that some these properties of the time series data display a number of challenges to statistical analysis namely spurious regressions and autocorrelation. However, before we do statistical analysis of any research, statistical properties within the data generating process will be explored.

### **4.2.1 Stationary and Nonstationary in Time Series**

In theory, a definition of a time series is a group of random variables ordered in time called a stochastic process (Gujarati, 2004; Maddala and Lahiri, 2009). If we have a stochastic process that has a mean, variance and auto-covariance that are constant over time then we say it is weakly stationary. Taking a normal generating process, assuming that the current value of  $Y$  depends on its previous period value  $Y_{t-1}$  and an

error term (random shock)  $\mu_t$  that is normally distributed with zero mean and variance  $\sigma^2$ , thus we show:

$$Y_t = \rho Y_{t-1} + \mu_t$$

(4.0)

From the above equation, a condition of weak stationarity exists when:

Mean:  $E(Y_t) = \mu$

(4.1)

Variance:  $\text{var}(Y_t) = E(Y_t - \mu)^2 = \sigma^2$

(4.2)

Auto-covariance:  $\gamma_k = E[(Y_t - \mu)(Y_{t+k} - \mu)]$  (4.3)

where  $E(Y_t)$ , and  $\text{var}(Y_t)$  are constant and  $(Y_t, Y_{t+k})$  which is finite are constant for all  $t$  and all  $k \neq 0$ . There is also another technique to describe a stochastic process and this is by specifying the coalition distribution of the variables of interest. One stochastic process that is characterised by joint probability distribution that does not change when changed in time is known to be strictly stationary. In this kind of stationarity, the parameters such as the mean and variance, if available, these do not change over a period of time or follow any trend. The above mentioned conditions are best described as below:

Mean:  $E(Y_t) = \mu$  (4.4)

Variance: 
$$\text{var}(Y_t) = E(Y_t - \mu)^2 = \sigma^2$$
  
(4.5)

Auto-covariance: 
$$\gamma(t_1, t_{1+k}) = \text{cov}(Y_{t_1}, Y_{t_{1+k}})$$
  
(4.6)

when  $k = 0$ , our auto-covariance will be  $\sigma^2$ . This then means that, a time series is said to be strictly stationary when its joint distribution of  $r$  observations  $Y(t_1), Y(t_2), \dots, Y(t_r)$  is the same as the joint distribution of  $Y(t_1 + k), Y(t_2 + k), \dots, Y(t_r + k)$  for all  $r$  and  $k$ .

With reference to Gujarati (2004), the definition of weak stationarity seems to hold in practice; hence it is the definition adopted in this research. A time series that is stationary will make it possible for the researcher to get meaningful and trustworthy sample statistics that are important as far as forecasting and extrapolation are concerned. A time series that is stationary is trusted not to give spurious regressions. Almost every researcher desire to work with stationary time series data but in practical econometrics it is not alien to see that data is nonstationary. It is argued that most macroeconomic data is nonstationary. A stochastic process is regarded as nonstationary only and if it fails to live within those conditions iterated above. A time series that is stationary will always reverts back to its mean and it will be fluctuating around the mean in a reasonably constant manner. On the other hand a nonstationary series will give us different means in different time slots and also its variance is so time-dependent meaning that it goes to infinity as time approaches infinity (Engle and Granger, 1987).

Undesirably, the variance of this variable will become very big as time gets close to infinity. In addition, the error terms or the disturbances of this time series will be correlated perfectly giving a reflection of autocorrelation over time. The situation will then lead to differences of time series means across the time and the length of the time period from the time the series will be returning to some of its initial or normal mean



figures. More to that, if the series is discovered to be not stationary; the normal and standard techniques in estimation will no longer be applicable to the series data. The deterministic trend process and the random walk model are two techniques of a nonstationary time series. However, the random walk has its two types namely, random walk with a drift and random walk without a drift.

Random walk without Drift,

$$Y_t = Y_{t-1} + u_t \quad (4.7)$$

Therefore, the current value of  $Y$  is depending on its previous period value  $Y_{t-1}$  and random shock (error term)  $u_t$  with a mean which is zero and variance  $\sigma^2$ . If we assume that  $Y_0$  is the initial value of  $Y$ , if we substitution that in the above equation, it can then be shown as:

$$Y_t = Y_0 + \sum u_t \quad (4.8)$$

Therefore,

$$E(Y_t) = E(Y_0) + E(\sum u_t) = Y_0 \quad (4.9)$$

$$\text{var}(Y_t) = t\sigma^2 \quad (4.10)$$

To add, it can be seen that the mean value of  $Y$  is the same as its first value, this then means that as the time frame is increasing to infinity, the variance of  $Y$  also increases

infinitely and this makes it nothing more than a nonstationary stochastic process. To show a random walk with drift, let us consider the equation below:

$$Y_t = \delta + Y_{t-1} + u_t \quad (4.11)$$

taking  $\delta$  as the drift parameter, a constant or intercept in the random walk model and  $u_t$  as the error term (random shock). A random walk with a drift is best shown by the two equations below and it is clear that as the mean and the variance increase overtime, leading to the drifting of  $Y$  from its initial value and when that situation prevail the conditions of stationary are violated.

$$E(Y_t) = Y_0 + \delta t \quad (4.12)$$

$$\text{var}(Y_t) = t\sigma^2 \quad (4.13)$$

Therefore, a deterministic trend process can be shown as below:

$$Y_t = \delta + \beta t + u_t \quad (4.14)$$

where

$u_t$  is the error term or random shock. In the context of the deterministic trend process, the mean changes whilst the variance does not change. Nonstationarity of time series give a wide range of analytical challenges. This starts from the fact that the character of time series data can be best studied for the period under consideration. This then means that it cannot be made general enough to show the character in some other time periods and that makes it not to be too useful especially for forecasting purposes (Gujarati 2004). Borrowing from Gujarati as well, the estimation of a model using nonstationary time series may also lead to unreliable and spurious regression results.

Nonstationary can only give reliable estimates if and only if there are theoretical underpinnings to interpret the long run relationships shown by the nonstationary series (Sims, 1992).

Spurious results come up due to different time series showing common long run trends. Some regression methodologies will be linking or assuming that these trends are valid from long run relationships that exist between variables without there being any economically justifiable relationships amongst the series under consideration. Empirically, results that show very high values of  $R^2$  and a low Durbin-Watson  $d$ -statistic best describe this situation of spurious regressions (Enders, 2010). As a result of the above mentioned reasons it is therefore of paramount importance to test for stationarity of data so as to be aware of which methodology is best suited to the behaviour of the data.

#### **4.2.2 Graphical analysis**

Checking for stationarity by using or plotting a time series accompanied by its correlogram before going further to formal stationarity testing is highly seen as a prerequisite in testing for stationarity. It then works as a confirmatory measure to the formal testing to see if the behaviour of the data is the same in those two different ways.

#### **4.2.3 Unit Root tests**

Unit root testing is the most traditional approach to examining the behaviour of time series data. According to the most cited Dickey and Fuller, (1979, 1981), the technique requires checking for statistically significant differences of the parameter on  $Y_{t-1}$  from the above given equations. The testing for unit roots in the time series data is done by running a simple random walk regression for all the variables with time series data in Eviews, Stata or any other statistical software the researcher will be using but in this case Eviews 9.5 will be used because it is current and has been upgraded. The variables will be regressed in Eviews 9.5 and each variable will be checked to see if  $\rho$  is equal to one (i.e., there is a unit root). If the  $\rho$  value is equal to one then we can say the

series has a unit root, and is hence nonstationary. The equation can best be shown in the two equations below (4.15) and (4.16) where  $Y_{t-1}$  is reduced from all sides.

$$Y_t - Y_{t-1} = (\rho - 1)Y_{t-1} + u_t \quad (4.15)$$

$$\Delta Y_t = \delta Y_{t-1} + u_t \quad (4.16)$$

Therefore  $\delta = (\rho - 1)$  and  $\Delta$  show the sign of the first difference estimator. The expression (4.17) shows a random walk not having both a constant and trend. Borrowing from Dickey and Fuller (1979) there are other available substitute regression equations to check if we have unit roots or not and they are shown as below.

1. Random Walk with drift: it has a constant but no trend

$$\Delta Y_t = \beta_1 + \delta Y_{t-1} + u_t \quad (4.17)$$

2. Random Walk with a stochastic trend: both a constant and a trend are contained in it  $\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + u_t$  (4.18)

Therefore  $u_t$  represents the disturbance term (error term) whilst  $t$  represents the trend variable. We can test the existence of unit roots in the time series variables using the hypotheses and we will be able to check if unit roots are present or not.

Below are both the null and the alternative hypotheses:

$H_0: \delta = 0 / \rho = 1$  (i.e., we have a unit root)- nonstationary

$H_1: \delta < 0 / \rho < 1$  (i.e., no unit root)-stationary

When the three equations (4.17), (4.18) and (4.19) are estimated using ordinary least squares (OLS), the hypothesis testing for unit roots can be done by making a comparison amongst the tabulated or those generated from Eviews 9.5 commonly known as the Dickey-Fuller (DF) test statistic or  $t$ -statistic, with the then computed  $\tau$ -statistic availed by dividing  $\delta$  or  $\rho$  coefficients by their respective standard errors to get  $\tau\delta$  or  $\tau\rho$ . If we see that the absolute value we computed of  $\tau$  is more than the critical  $\tau$ -statistic value, the null hypothesis  $\delta = 0$  or  $\rho = 1$  should be rejected in favour of the alternative, which then means that our time series variable is stationary or has no unit root. On the other hand, in the event that the calculated absolute value of  $\tau$  does not go beyond the critical  $\tau$ -statistic value then the null hypothesis cannot be rejected, and this means that the series is nonstationary.

We have to assume that the error terms are not correlated when we want to conduct the Dickey Fuller unit root tests. In the event that the error terms are correlated, this then means that we have to add sufficient lags to make sure that we will make the error term to be uncorrelated (Dickey and Fuller, (1981). The augmented Dickey Fuller unit root testing just like the Dickey Fuller can be tested by the three alternative regressing equations listed below, namely (4.19, 4.20 and 4.21).

$$\Delta Y_t = \delta Y_{t-1} + \sum_{i=1}^m a_1 \Delta Y_{t-i} + \varepsilon_t \tag{4.19}$$

$$\Delta Y_t = \beta_1 + \delta Y_{t-1} + \sum_{i=1}^m a_1 \Delta Y_{t-i} + \varepsilon_t \tag{4.20}$$

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^m a_1 \Delta Y_{t-i} + \varepsilon_t \quad (4.21)$$

therefore  $\varepsilon_t$  represent the disturbance term or error term and where  $\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2})$ ,  $\Delta Y_{t-2} = (Y_{t-2} - Y_{t-3})$ , and so on. The lag length decision or the number of lags to include in the regression is going to be determined by the Akaike Information Criterion (AIC). The Schwarz Bayesian Criterion can also be used as an alternative source of lag length criteria.

In addition to the DF and the ADF, the Phillips-Perron (PP) test is also another technique that is commonly used for unit root testing. An analysis by Phillips and Perron, (1988) argues the other techniques that are traditionally used for unit root testing were not doing enough and proposed a statistical technique that tolerates serial correlation in the time series data without the issue of adding sufficient lags to get error terms that are stationary. For the best illustration of the technique that tolerates serial correlation let us go back to equation (4.17). The said equation shows that the PP test give remedial measures to the value of  $\delta$  to take care of the correlation in the error term or  $u_t$ . This then means that the Phillips-Perron test is a generalised species of the DF test statistic that considers the less restrictive character or nature of the error process. Similarly to the other tests of unit root testing (DF and ADF) it is also possible for the PP test to be performed whilst including a constant, constant and trend or neither in a regression. The hypothesis testing technique and the limiting behaviour of the PP and that of the ADF are the same.

#### 4.2.4 Remedial Measures

Given the problems of nonstationary time series data in giving results that can be trusted, it is of paramount importance to transform the data to make it stationary. However, the nature and type of transformations to be done depend on the character of

the time series we have in hand (Enders, 2010). In the event that we have found out that the series is nonstationary because it has a deterministic trend, the most appropriate measure to make that series stationary is to remove the trend or to detrend the series and that can be done by regressing it on time. When we detrend a series to make it stationary, the series will be called trend stationary.

Another way to make nonstationary series in levels to be stationary is by differencing it and that will be a difference stationary process. The series that have been made stationary by first differencing once are said to be integrated of order one and that is shown as  $I(1)$ . The series that is differenced once is said to have one unit root. On the other hand a series that contains two unit roots implies that the data will need to be differenced twice in order to make it stationary. To add, if a series has to be differenced  $d$  times to make it stationary, it is said to be integrated of order  $d$ , presented as  $I(d)$ . Time series data that has order of integration that is of order zero  $I(0)$  is stationary in its levels and does not need to be differenced for it to be made stationary. The order of integration of the series will then decide if we can test for cointegration or not. Models that have variables of mixed integration are argued that it is not appropriate to test for cointegration. The argument is that cointegration is tested only if the model have all the  $I(1)$  series or all the  $I(2)$  series. A series that has variables that are stationary in levels cannot be tested for Co-integration since the variables are stationary (Sims 1992).

#### **4.3.0 Cointegration**

Cointegration is defined as the existence of a linear combination of nonstationary variables in a model (Enders, 2004). In order for cointegration to be tested, all the variables involved must be of the same order of integration. The conventional wisdom on cointegration does not allow stationary variables in levels to be tested. Basically if its variables are said to be co-integrated it then means that variables involved will be moving together in the long run or that there is a long-run equilibrium amongst the variables.

The previous section of this research cleared out the problems that can be encountered by a researcher in the event that trended or I(1) time series are used as it leads to spurious regressions. On the other hand, there are certain exceptions that arise when all the nonstationary time series variables in a model have the similar stochastic trend in common (Gujarati, 2004). Given such a situation, the variables are said to be cointegrated and OLS regression of the model can be run without the possibility of encountering unreliable and invalid results caused by spurious regressions.

The technique to test for cointegration invented by Granger in his 1981 paper and further extended by Engle and Granger in (1987), paved the way for researchers to find a justification for using nonstationary time series variables for estimation. This is so because it is clearly specified that although two or more time series variables have stochastic trends if they happen to have a long run relationship (equilibrium), they can move close to each other as time moves and their first or second differences will ultimately be stable and it means the series have been transformed to become a stationary series (Enders 2004). If estimation is done using stationary series then the problem of spurious regressions is dealt with. Benchmarking on the work of Cottrell, (2004) and Asteriou and Hall, (2007), if we consider two individual time series all I(1),  $Y_t$  and  $X_t$ , and suppose there is a linear combination of  $Y_t$  and  $X_t$ . then ;

$$Y_t = \beta_1 + \beta_2 X_t + u_t \quad (4.22)$$

Going to the residuals:

$$\hat{u}_t = Y_t - \hat{\beta}_1 - \hat{\beta}_2 X_t \quad (4.23)$$

From the above equations if  $\hat{u}_t \sim I(0)$ , meaning stationary, then  $Y_t$  and  $X_t$  have a long run relationship (cointegrated). Cointegration was defined by Engle and Granger (1987) in which they stated that time series  $Y_t$  and  $X_t$  are  $I(d, b)$  where  $d \geq b \geq 0$ , denoted



as  $Y_t, X_t \sim CI(d, b)$ , if  $Y_t$  and  $X_t$  are  $I(d)$  and where we have a vector  $(\beta_1, \beta_2)$ , which brings a linear combination of  $Y_t$  and  $X_t$ , this therefore means that  $\beta_1 Y_t + \beta_2 X_t \sim I(d - b)$ . The coefficient vector  $(\beta_1, \beta_2)$ , is what we label the cointegrating vector.

Ngalawa, (2009) and Enders, (2010) concur in the idea that if we have a situation where  $Y_t$  and  $X_t$  are integrated of different orders say one is  $I(0)$  and the other one is  $I(1)$  then they are deemed unbalanced and they cannot be cointegrated. If variables are of mixed orders of integration it is argued that their linear combination will be  $I(1)$  with the reason being that the behaviour of the  $I(1)$  series ( $X_t$ ) will override the behaviour of the  $I(0)$  series. Harris, (1995) argues that it can be possible to have mixed variables of different orders of integration in time series when estimating more than two series. In the event that we have such a case, then a subset of the higher order series must co-integrate to the order of the lower-order series.

The conventional wisdom of econometrics agrees that the presence and absence of cointegration between time variables shape the estimation technique to be used to determine the relationship of variables. An unrestricted VAR in levels can be run in the case where no cointegration relation exists amongst the series involved. All the VAR estimation requires the series to be integrated of the same order. In the case where we have nonstationary variables, we can still run a VAR but the non-stationary variables should start by being converted into stationarity through differencing.

However, when variables are cointegrated, a vector error correction model (VECM) is the best estimation technique to employ. This also depends with what the researcher is trying to achieve. If the research want the long-run implications of the model the VECM is the best but if short run implications are needed a SVAR in levels is the appropriate estimation technique to adopt using the restriction identification or the recursive identification (Ngalawa, 2009). Should we have a mixture of both  $I(0)$  and  $I(1)$  variables, the autoregressive distributed lag (ARDL) methods are the most superior

estimation technique to go for but we can still use VAR or VECM. Basically most macroeconomic series are nonstationary meaning that most of them are  $I(1)$ .

#### **4.3.1 Testing for Cointegration**

Karoro et al., (2009), argues that there are three techniques for which co-integration can be tested and these are single equation, vector autoregressive, and error correction techniques. Starting with the single equation cointegration approach, this technique is a house of tests such as the co-integrating regression Durbin-Watson, autoregressive distributed lag bounds testing approach, the Engle-Granger and augmented Engle-Granger, the dynamic ordinary least squares, the fully-modified ordinary least squares and lastly the canonical cointegrating regressions tests, all of these techniques do it by checking for unit roots in the residuals of the co-integrating regression. Moving to the Vector Autoregressive (VAR) approach as an alternative, it determines the number of cointegrating relations and does the estimation of the matrix of cointegrating vectors (Karoro et al., 2009). On the other hand the error correction approach diagnoses the coefficient of the error correction term against zero, which is a condition of the Granger representation theorem.

Referring to the literature the three most important and prominent procedures researchers use to test for cointegration are the Johansen (1988), Stock-Watson, (1988) and Engle and Granger (1987) techniques. All the techniques will be discussed but this study will dwell much with the Johansen and the fully-modified ordinary least squares in order to determine whether the time series variables involved have long run relationship (equilibrium) in the model.

##### **4.3.1.1 The Engle-Granger (EG) and Augmented Engle-Granger (AEG) Tests**

The Engle-Granger (EG) test works with the properties of the residuals of the series in determining whether the series are cointegrated or not. The tests done on the residuals will be just checking if the residuals are stationary or non-stationary. If they are

stationary then the series are said to be cointegrated. This test starts by doing the verification the order of integration of the entire time series variables in the model using unit root testing employing the ADF tests or other measures. Once this has been accomplished and the variables are found to be integrated of the same order, the hypothesised long run equilibrium or relationship (as shown in equation (4.24) below, as an example) is what is estimated using OLS. The estimated residuals will then be retained and tested to see if they are stationary. The equations that follow (4.25) and (4.26) in their order present the DF and ADF test equations of the estimated residuals.

$$Y_t = \beta_1 + \beta_2 X_t + e_t \quad (4.24)$$

$$\Delta \hat{e}_t = a_1 \hat{e}_{t-1} + v_t \quad (4.25)$$

$$\Delta \hat{e}_t = a_1 \hat{e}_{t-1} + \sum_{i=1}^n \delta_i \Delta + w_t \quad (4.26)$$

where  $\Delta$  shows the first difference operator,  $e_t$  represents the residuals from the cointegrating regression, and  $v_t$  and  $w_t$  are there as the random error terms. The EG and AEG hypothesis testing is conducted in the same manner just like any other single equation estimations like the DF, ADF and PP tests.

The null and alternative hypotheses are presented as:

$$H_0: a = 0 \text{ (no cointegration)}$$

$$H_1: a < 0 \text{ (there is cointegration)}$$

The hypotheses to be done will be tested by doing a comparison of the test statistic on the regression coefficient  $a$ , to a unique set of critical values but it then depends on the number of explanatory variables in the cointegrating regression calculated by Engle and Granger. If  $e_t$  is observed that it is  $I(0)$  then it means that  $H_0$  is rejected in favour of  $H_1$ , therefore  $Y_t$  and  $X_t$  are said to be cointegrated.

This technique is hailed by many researchers because of its simplicity; however, this technique comes with few elements that are criticised by other researchers for example, Koop, (2013), Gujarati, (2011), Maddala and Lahiri, (2009), Asteriou and Hall, (2007), and (Thomas, 1997). The EG method is argued to be having lower power in finite samples or as the sample size increases. Also it may be inconsistent in a situation where we have structural breaks present in the time series data. Another shortfall of this method is that of the stages in estimating it. In the event that an error made in the first step of the EG test is carried on to the second step, that will lead to an econometric problem of autocorrelation and therefore the long run equilibrium estimates will be having a biased report in finite samples. However, because of the above mentioned allegations about the technique, the study will substitute the technique with other methods to be discussed below.

#### **4.3.1.2 The Fully Modified Ordinary Least Squares (FMOLS) Test**

According to Philips and Hansen (1990) this cointegration technique carries the assumption that there exists only a single cointegrating vector and it comes with the adjustment of OLS estimates of the long run parameters and their associated  $t$ -values to accommodate for any bias as a result of autocorrelation and endogeneity problems within OLS residuals (Harris, (1995), Harris and Sollis, (2003) and (Phillips and Hansen, 1990). However, the outcome estimator is asymptotically not biased and its efficient normal asymptotical properties will be full and thus allowing for the employment of standard Wald tests using asymptotic chi-square ( $\chi^2$ ) statistical inference (Belke and Czudaj, 2010). In benchmarking the work of Belke and Czudaj, (2010), this study will consider the following  $(y_t, X_t')$  vector process:

$$y_t = X_t' \beta + D_t' \gamma_1 + u_{1t} \quad (4.27)$$

Where  $y_t$  is the nonstationary  $I(1)$  dependent variable and  $X_t'$  represent the stochastic explanatory variables under the governance of  $X_t = \Gamma_{21}' D_{1t} + \Gamma_{22}' D_{2t} + \varepsilon_{2t}$  with  $\Delta \varepsilon_{2t} =$

$u_{2t}$ . In addition to that,  $D = (D'_{1t}, D'_{2t})$  will come as the deterministic trend regressors and  $u_{1t}$  is the error term accompanied by a zero mean and covariance( $\Omega$ ). The FMOLS estimator is shown by the outline below:

$$\hat{\theta}_{FMOLS} = \begin{bmatrix} \hat{\beta} \\ \hat{\gamma}_1 \end{bmatrix} = [\sum_{t=1}^T Z_t Z_t']^{-1} \left[ \sum_{t=1}^T Z_t y_t^+ - T \begin{bmatrix} \hat{\lambda}_{12} \\ 0 \end{bmatrix} \right] \quad (4.28)$$

In this case  $Z_t = (X'_t, D'_t)'$ ,  $y_t^+ = y_t - \hat{\omega}_{12} \hat{\Omega}_{22}^{-1} \hat{u}_2$  is an indication of the data that has been transformed and  $\hat{\lambda}_{12}^+ = \hat{\omega}_{12} \hat{\Omega}_{22}^{-1} \hat{\Lambda}_{22}$  stands for the estimated bias speed of adjustment with the long-run covariance matrices  $\hat{\Omega}$  and  $\hat{\Lambda}$  and their respective elements, which are calculated using  $u_t = (\hat{u}'_{1t}, \hat{u}'_{2t})'$ .

#### 4.3.1.3 Canonical Cointegrating Regressions (CCR)

Developed by Park (1992), the Canonical Cointegration Regressions (CCR) is a non-parametric approach to statistical inference in a cointegrated model involving adjustments of the integrated processes using only stationary components to account for long run relationships between regressors and the error term. This technique is a formulation of transformed data. In addition it is applicable to a very wide range of co-integrating models, including all the models with deterministic and singular, together with the stochastic and regular cointegration. Borrowing from Han (1996), the CCR produce asymptotically robust estimators and chi-square tests. Taking equation (4.26), CCR estimation can be described as in the expression below:

$$\hat{\theta}_{CCR} = \begin{bmatrix} \hat{\beta} \\ \hat{\gamma}_1 \end{bmatrix} = \left[ \sum_{t=1}^T Z_t^* Z_t^{*'} \right]^{-1} \sum_{t=1}^T Z_t^* y_t^* \quad (4.29)$$

Therefore,  $Z_t^* = (X_t^{*'}, D_t^{*'})'$ ,  $X_t^* = X_t - (\hat{\Sigma}^{-1} \hat{\Lambda}_2)' \hat{u}_t$  and  $y_t^* = y_t - \left[ \hat{\Sigma}^{-1} \hat{\Lambda}_2 \tilde{\beta} + \begin{bmatrix} 0 \\ \hat{\Omega}_{22}^{-1} \hat{\omega}_{211} \end{bmatrix} \right]' u_t$

It represents all the data that was nonstationary in levels but was made stationary

through the transformations in the model. Hence,  $\tilde{\beta}$  is there as an estimate of the cointegrating equation using non-dynamic OLS.  $\hat{\Lambda}_2$ , shown in the second column of  $\hat{\Lambda}$  (is our estimation bias speed of adjustment or correction term), and finally  $\hat{\Sigma}$  stands for the contemporaneous covariance matrix estimated of the error terms.

#### 4.3.1.4. The Dynamic Ordinary Least Squares (DOLS) Test

Developed by Stock and Watson (1993), the dynamic OLS test is a parametric technique in which the lagged first difference terms are explicitly estimated (Saayman, 2010). The dynamic OLS test is just one of the alternative models to the EG approach. It goes further in handling the cointegrating regressions by multiplying the errors terms with lags leads and contemporaneous figures of the regressors ( $\Delta X_t$ ) (Saayman, 2010), such that the new cointegrating equation error term is orthogonal (correlations are interpreted causally) to the entire history of the stochastic regressors innovations (Belke and Czudaj, 2010). Serial correlations are the things that complicate dynamic OLS. Harris, (1995), provides a robust test for cointegration and gives estimates that are not biased of the cointegration relationship that are not biased. Stock and Watson (1993), argues that this technique will be assuming that the added  $q$  lags and  $r$  leads of  $\Delta X_t$  (as displayed in equation (4.30) below, completely remove the long-run correlation amongst the error terms,  $u_{1t}$  and  $u_{2t}$  below:

$$y_t = X_t' \beta + D_t' \gamma_1 + \sum_{j=-q}^r \Delta X_{t+j}' \delta + v_{1t} \quad (4.30)$$

The DOLS estimator of this expression is then provided as  $\hat{\theta}_{DOLS} = (\hat{\beta}', \hat{\gamma}_1')$ .

The DOLS is that kind of a technique that will allow the researcher to draw inferences concerning the relations between stochastically trending variables. In a situation where variables in a regression model have a long run relationship using the hypothesis testing, the cointegration between them can then be possibly estimated by a simple

cointegrating regression. Under such an environment the OLS estimation has chances of providing estimators that are super-consistent for the long run parameters (Enders, 2010). On the other hand, a major turn back of these techniques come into play as a result of their lack of systematic procedures to independently or separately estimate more than one cointegrating regression or when there are more than two or three variables in a model. According Stock and Watson (1993), under the assumption that there is only one cointegration vector, when there is actually more than one leads to inefficiency as only a linear combination of these vectors can be estimated.

### **3.1.5 The Johansen Test**

It is highly possible to get more than one cointegrating vector when there are more than two variables in the model and the most appropriate methodology for that fact is the Johansen approach. The approach was developed by Johansen (1988) then later refined by Johansen and Juselius, (1990,1992 and 1994). The method uses likelihood ratio tests in a VAR process to test the number of cointegrating vectors available amongst the variables under investigation. It is argued that variables in the model can form a number of equilibrium long run relationships governing their joint evolution. Under this technique, there are no prior restrictions needed or done on the co-integration space because it allows the hypothesis testing to perform and determine the long run relationships (Harris, 1995). It is a serious problem to assume that we only have a single cointegrating vector when actually there is more than one and this is the reason why the Johansen performs better than the single equation approaches (Asteriou and Hall, 2007).

The Johansen approach starts by checking the order of integration for all the variables in the model as it only takes nonstationary variables with the same order of integration. In the event that that the variables have mixed orders of integration, the Bounds testing approach will be the best to employ (Enders, 2010). The orders of integration are checked using the unit root testing. When there is certainty that the variables possess the same order of integration, and then optimal lag length will be needed. The lag length selection criteria are determined through either the Akaike Information Criteria (AIC) or

the Schwarz Bayesian Criteria (SBC). Enders, (2010), argues that in order to determine the best fit model with regards to deterministic components in the multivariate system and ascertain the rank of the quantity of cointegrating vectors the likelihood ratio tests should be used.

Johansen, (1988) uses the lambda trace and lambda maximum eigenvalue likelihood ratio tests to ascertain or determine the number of cointegrating vectors present but these two (trace and max eigenvalue) always find different numbers of cointegrating vectors available .

The trace and max eigenvalue tests are best defined as shown below:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^n \ln(1 - \hat{\lambda}_i) \quad (4.31)$$

$$\lambda_{max}(r, r + 1) = -T \ln(1 - \hat{\lambda}_{r+1}) \quad (4.32)$$

Therefore, (lambda)  $\lambda$  is the estimated value for the  $i$ th ordered eigenvalue from the cointegration coefficient matrix and  $T$  is the quantity of observations that are statistically allowed to be used. On the other hand the  $\lambda_{trace}$  statistic tests the null hypothesis that the number of cointegrating vectors is not more than or equals the number of long run relationships ( $r$ ) and an alternative hypothesis that is not specified. However, the  $\lambda_{max}$  statistic will be testing the null hypothesis that the number of cointegrating vectors is  $r$  against an alternative hypothesis that says there are  $r + 1$  cointegrating vectors in the model. Whenever we have a situation where the eigenvalues are far from zero, that is how  $\ln(1 - \hat{\lambda}_i)$  and  $\ln(1 - \hat{\lambda}_{r+1})$  become more negative, then we will have quite large  $\lambda_{trace}$  and  $\lambda_{max}$  statistics in that respective manner. Among the two tests, the trace test has been seen to be the most superior one since it is argued be adjustable for degrees of freedom and more robust on aspects like skewness and excess kurtosis.



The expressions below show the Johansen's mathematical illustrations articulating how the Johansen approach works. Let us make an assumption that there are three endogenous nonstationary  $I(1)$  variables  $Y_t, X_t$  and  $W_t$ , therefore the matrix notation for  $Z_t = (Y_t, X_t, W_t)$  is:

$$Z_t = A_1 Z_{t-1} + A_2 Z_{t-2} + \dots + A_k Z_{t-k} + u_t \quad (4.33)$$

From the above expression,  $Z_t$  is a  $k \times 1$  vector for endogenous variables,  $A_i$  is a  $k \times k$  matrix of all parameters in the model and  $u_t$  is a vector of independently and identically distributed transformations with means that are all zeros.

Below is an illustration of the Vector Error Correction Model (VECM). In the basic VAR, the VECM has an error correction term that is incorporated into the model the same with the bivariate cointegration. In the case of multivariate cointegration, it implies that the VECM be performed. The reason for the error correction term is basically the same as compared with the standard error correction model in its capacity to measure how variables branch off from the long run equilibrium. The VECM formulation for  $Z_t$  is given as:

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + \Gamma_2 \Delta Z_{t-2} + \dots + \Gamma_{k-1} \Delta Z_{t-k+1} + \Pi Z_{t-1} + u_t \quad (4.34)$$

Therefore,  $\Gamma_i = -(I - A_1 - A_2 - \dots - A_k)$  ( $i = 1, 2, \dots, k - 1$ ) and  $\Pi = -(I - A_1 - A_2 - \dots - A_k)$ . This methodology has useful information about the short run and long run adaptations to changes in  $Z_t$ . To add,  $\Gamma_i$  represents a  $3 \times 3$  coefficient matrix explaining the short run dynamic effects and  $\Pi$  comes in as the long run multiplier holding information in relation to the long run relationships in the model. Let us assume that we can decompose  $\Pi = \alpha \beta'$  therefore  $\alpha$  will incorporate the speed of adjustment to equilibrium coefficients. On the other hand,  $\beta'$  is a matrix of the coefficients in the long run meaning that the term  $\beta' Z_{t-k}$  included in equation (4.34) represents up to  $k - 1$

long run relationships that ensure  $Z_t$  inclines towards its long run equilibrium (Enders 2010).

Ngalawa, (2009) and Harris, (1995) concur that in the event that  $\Pi$  has a full rank for example,  $r = n$  linearly independent columns,  $Y_t, X_t$  and  $W_t$  are stationary or  $I(0)$ . Also if  $\Pi$  got a reduced rank of the form  $\leq (n - 1)$ , we then know that there are  $r \leq (n - 1)$  long run relation relationships (cointegrating vectors). To add, in the case that the rank  $\Pi$  is zero, which then means that all independent columns are not linear and also, there are no cointegrating relationships in the model. In general  $\Pi$  has a reduced rank and when there is a situation of multiple cointegrating vectors, chances are high that there will exist a cointegrating vector for at least each subset of  $n - r + 1$  variables and the long run relationships become slightly more difficult to clarify or translate. To show what we are discussing, let us assume that,  $r = 2$ , the illustration in equation (4.34) will now look like the model below:

$$\Pi_1 Z_{t-1} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \\ a_{31} & a_{32} \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{21} & \beta_{31} \\ \beta_{12} & \beta_{22} & \beta_{32} \end{bmatrix} \begin{bmatrix} Y_{t-1} \\ X_{t-1} \\ W_{t-1} \end{bmatrix} \quad (4.35)$$

therefore,

$$= \begin{bmatrix} a_{11}ec_1 & a_{12}ec_2 \\ a_{21}ec_1 & a_{22}ec_2 \\ a_{31}ec_1 & a_{32}ec_2 \end{bmatrix} \quad (4.36)$$

In the case where  $ec_1 = (\beta_{11}Y + \beta_{21}X + \beta_{31}W)_{t-1}$  and  $ec_2 = (\beta_{12}Y + \beta_{22}X + \beta_{32}W)_{t-1}$  are the two cointegrating relationships and their reversion back to the equilibrium through the speed of adjustment is shown as  $a_{11}$ ,  $a_{12}$ ,  $a_{21}$ ,  $a_{22}$ ,  $a_{31}$  and  $a_{32}$  respectively. However, although it is deemed one of the best in the multivariate case, there are also drawbacks identified by various researchers about the Johansen

approach. It is argued that it only performs better when the sample size is huge closing doors for models with no huge sample sizes. Also is said to be very sensitive when it comes to lags that will be included in the test. However, the presence of autocorrelation is one aspect that can make the Johansen approach not be very efficient.

#### **4.4.0 Vector Autoregressions (VAR)**

This is a framework by Sims (1980) after the 1970s macroeconomics chaos that rocked the international modelling after a wide range of models failed to perform as expected (Stock and Watson, 2001). The models before the crisis ranged from those with hundreds of equations and single equations and they focussed on relationships between a few variables and also univariate models. The coming in of the VAR raised hope in econometrics modeling and that is evidenced by the increased use of the VAR model mostly when researchers are investigating the effect of monetary policy shocks on growth, interest rates, inflation and other variables (Sims, Stock et al., 1990). A VAR is an easy model to capture the dynamics of multiple time series and it's an econometric or statistical that is very easy to use and make interpretations of the results. The VARs are models that will give the same number of equations to variables meaning that if you have seven variables you will have seven equations and it's normally known as an  $n$ -equation  $n$ -variable model. The general or basic issue under the VAR framework is the identification of structural shocks.

In a VAR the current value of variables is determined by its own lagged values and the current and lagged values of the other variables in the model and also with an error term or a shock. In the current dynamics of research, VARs hold the promise of the provision of the basic objective of macro econometrics and that are data description, forecasting, structural inference and policy analysis. VARs are being used by central bankers, academic researchers and organisational researchers because of their rich statistical characteristics that include interpretation of shocks to the economy.

According to Stock and Watson, (2001), the VARs have proven to be very reliable and efficient in issues like data description and forecasting and this is what the central

bankers normally do research for, to be able to foresee the effects of their decisions today and how they will benefit or affect the economy so that they will know by how much to adjust the interest rate to keep inflation down for example. The other two remain debatable and they depend on researcher's theoretical strength and ability to restrict the model to be able to interpret the correlations amongst the variables as causality and it's normally known as the identification problem. Identification according to Sims, Stock et al., (1990) cannot be solved by a statistical tool no matter how powerful it is. So it then demands the researchers to use their theoretical intuition to be able to deal with the problem.

According to Sims, Veres et al., (1986), Sims, Stock et al., (1990) and Stock and Watson, (2001), the VARs are in their dimensions or varieties namely the reduced form VAR, Recursive VAR and the Structural VAR. Every VAR estimation starts with the reduced form VAR and then using different restrictions to the reduced form depending on what the intention is will then give birth to the Recursive (RVAR) and the Structural VAR (SVAR).

#### **4.4.1 Reduced form VAR**

This is the initial estimation in the VAR model toolkit and it expresses each variable in the model as a linear function of its past values (lagged values) and the past values of the other remaining variables in the model and an error term that has to be uncorrelated. The correlations of the error term can lead to distortions in getting the reliable estimations from the model (spurious regression). In the reduced form VAR each and every equation is estimated by Ordinary Least Squares (OLS). The determination of the lagged values to include in the VAR is determined by different methods like the Akaike Information Criterion (AIC) and it can determine whether to use 1, 2 or 3 depending on the type of data being used in the model. One issue with the reduced form VAR is that if there are correlated variables in the model then the error terms can also be correlated (Stock and Watson, 2001).

A VAR is a simple adaptation of the AR(p) model to the multivariate issue and this research will consider a vector of variables  $y_t$ . In analysing a VAR model it starts from the reduced form VAR model of order  $p$ , where  $A$  is an  $(n \times n)$  matrix of autoregressive coefficients for  $j=1,2,\dots,p$ ,  $\alpha$  denotes an  $(n \times 1)$  vector of intercept terms allowing for the possibility of non-zero mean  $E(y_t)$  and  $e_t$  is an  $(n \times 1)$  dimension vector of white noise.  $\Sigma$  is an  $(n \times n)$  symmetric positive definite matrix.

$$Y_t = \alpha + A_1 y_{t-1} + A_2 y_{t-2} + \dots + A_p y_{t-p} + e_t \dots \dots \dots (1)$$

$$E(e_t) = 0$$

$$E(e_t e_t') = \Sigma$$

Considering :

$$Y_t = (Y_t' Y_{t-1}' \dots Y_{t-p+1}') \dots \dots \dots (2)$$

We can write the VAR as an AR(1) process:

$$Y_t = \begin{bmatrix} \alpha \\ 0 \\ \vdots \\ 0 \end{bmatrix} + \begin{bmatrix} A_1 & A_2 & \dots & A_{p-1} & A_p \\ 0 & 0 & \dots & 0 & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 1 & \dots & 1 & 0 \end{bmatrix} Y_{t-1} + \begin{bmatrix} e_t \\ 0 \\ \vdots \\ 0 \end{bmatrix} \dots \dots \dots (3)$$

Or as :

$$Y_t = \Gamma_0 + \Gamma_1 Y_{t-1} + e_t \dots \dots \dots (4)$$

Using lag operator notation, equation 8 can be written in the form:

$$(I_n - A_1 L - A_2 L^2 - \dots - A_p L^p) Y_t = \alpha + e_t \dots \dots \dots (5)$$

Or

$$A(L) Y_t = \alpha + e_t \dots \dots \dots (6)$$

On this,  $A(L)$  reflects an  $(n \times n)$  matrix polynomial in the lag operator  $L$ . The row  $i$ , column  $j$  element of  $A(L)$  is a scalar polynomial in  $L$ :

$$A(L) = (\delta_{ij} - \alpha_{ij}^{(1)} L^1 - \alpha_{ij}^{(2)} L^2 - \dots - \alpha_{ij}^{(p)} L^p) \dots \dots \dots (7)$$

$\delta_{ij}$  is unity if  $i=j$  and zero otherwise.

This vector  $Y_t$  is said to be covariance-stationary only when its first and second moments ( $E(y_t)$  and  $E(y_t y_{t-j}')$ ) are independent of the date  $t$ . When the process is covariance-stationary, then the expectation operator is applied on both sides of equation 8 to calculate the mean  $\mu$  of the process:

$$\mu = \alpha + A_1\mu + A_2\mu + \dots + A_p\mu \dots\dots\dots (8)$$

Or

$$\mu = (I_n - A_1 - A_2 - \dots - A_p)^{-1}\alpha \dots\dots\dots (9)$$

Equation (8) can be written in terms of deviations from the mean as:

$$(Y_t - \alpha) = A_1(Y_{t-1} - \mu) + A_2(Y_{t-2} - \mu) + \dots + A_p(Y_{t-p} - \mu) + e_t \dots\dots\dots (10)$$

It is very useful to rewrite equation (17) in terms of a VAR(1) process. Thus there are defined:

$$V_t = \begin{bmatrix} e_t \\ 0 \\ \vdots \\ 0 \end{bmatrix}; V_t (np \times 1) \dots\dots\dots (11)$$

Then into companion form

$$\xi_t = F\xi_{t-1} + V_t$$

$$E(V_t V_t') = Q \dots\dots\dots (12)$$

$$Q = \begin{bmatrix} \Sigma & 0 & \dots & 0 \\ 0 & 0 & \dots & 0 \\ \vdots & \vdots & \dots & \vdots \\ 0 & 0 & \dots & 0 \end{bmatrix}; Q (np \times np)$$

Equation (19) implies that:

$$\xi_{t+s} = V_{t+s-1} + FV_{t+s-1} + F^2V_{t+s-2} + \dots + F^{s-1}V_{t+1} + F^s\xi_t \dots\dots\dots (13)$$

For the process to be covariance-stationary, the consequences of any  $e_t$  must just die out in time. If the eigenvalues of  $F$  all lie inside the unit circle, the VAR is said to be covariance-stationary .

In the  $MA(\infty)$  representation.

The matrix  $\psi_s$  has the interpretation

$$\frac{\partial y_{t+s}}{\partial e_t} = \psi_s \dots\dots\dots (14)$$

So the  $i$ , column  $j$  element of  $\psi_s$  identifies the consequences of one unit increase in the  $j$ th variable's innovation at date  $t$  ( $e_{jt}$ ) for the value of the  $i$ th variable at time  $t + s$  ( $Y_{i,t+s}$ ), maintaining all other innovations at all dates constant.

The following section show the effects of the change of  $e_{jt}$  innovation by  $\delta_j$  on the value of the  $Y_{t+s}$  vector will be given by:

$$\Delta Y_{t+s} = \frac{\partial Y_{t+s}}{\partial e_{1,t}} \delta_1 + \frac{\partial Y_{t+s}}{\partial e_{2,t}} \delta_2 + \dots + \frac{\partial Y_{t+s}}{\partial e_{n,t}} \delta_n = \psi_s \delta \dots\dots\dots (15)$$

The plot of the row  $i$  , column  $j$  element of  $\psi_s$  as a function of  $s$  is called the impulse-response functions and these are to be used to check the issue of causality between the variables. Also it presents the response of  $Y_{i,t+s}$  to a one-time impulse in  $Y_{jt}$  with all other variables dated  $t$  or earlier held constant.

#### 4.4.2 Recursive VAR Approach

Bonato and Billmeier, (2002), argue that all a Recursive VAR does is to try and identify the structure of the whole model by a way of error term construction per each regression and try to make those error terms uncorrelated with those from the preceding equations. To achieve that the estimation of the VAR is done carefully including in some of the contemporaneous values of other variables in the same model as regressors as well.

McCarthy, (2000) is scholar who most studies using the recursive VAR framework especially on ERPT borrow the concept from. The assumption is that of a recursive

ordering of the variables in which the international supply shocks in this case represented by petrol prices and demand shocks represented by the output gap enter the model first to affect all the other variables in the model without them being affected by any other variable in the model. The supply and demand shocks are exogenous to the exchange rate in period  $t$ . These exogenous variables to the exchange rate are determined in each period by the expectations of the previous period and an error. So in the ordering of say, Petrol prices, output gap and exchange rate, then we would

- a) Exclude the contemporaneous values of output gap and exchange rate from the equation of petrol prices.
- b) Exclude the contemporaneous value of exchange rate from the equation of output gap
- c) Exclude no variable and meaning that we include petrol prices and output gap in the equation of exchange rate.

The model is going to have 7 variables and they are going to be ordered in a way that the consumer price will be affected by all the other variables in the model without it affecting any variable and that it is guided by the fact that the CPI is more of like inflation itself so we cannot allow it to affect any variable in the model.

$$\pi_t^{\text{petr}} = {}_{t-1}E_t(\pi_t^{\text{petr}}) + \varepsilon_t^{\text{petr}} \quad (\text{a})$$

$$Y_t = {}_{t-1}E_t(Y_t) + a_1 \varepsilon_t^{\text{petr}} + \varepsilon_t^y \quad (\text{b})$$

$$\Delta e_{t=t-1} = {}_{t-1}E_t(\Delta e) + b_1 \varepsilon_t^{\text{petr}} + b_2 \varepsilon_t^y + \varepsilon_t^{\Delta e} \quad (\text{c})$$

Where **petr** is the world oil prices (international supply shock) to South Africa since it is a small open economy and a price taker. This shock can be inflationary if the oil prices go up and deflationary when it goes down,  $Y_t$  measures the output gap in the country and will be measured using the difference between actual output and potential output,  $\Delta e_t$  is the change in the exchange rate and  $\varepsilon_t$  are the respective shocks which occur at each stage. This exchange rate shock feeds into domestic inflation through the finished



imported product or imported inputs by the manufacturers and then passed through to the producers and later to export and consumer prices.

$$\pi_t^{imp} = {}_{t-1}E(\pi_t^{imp}) + c_1\varepsilon_t^{petr} + c_2\varepsilon_t^y + c_3\varepsilon_t^{\Delta e} + \varepsilon_t^{imp} \quad (d)$$

$$\pi_t^{ppi} = {}_{t-1}E(\pi_t^{ppi}) + d_1\varepsilon_t^{petr} + d_2\varepsilon_t^y + d_3\varepsilon_t^{\Delta e} + d_4\varepsilon_t^{imp} + \varepsilon_t^{ppi} \quad (e)$$

$$\pi_t^{cpi} = {}_{t-1}E(\pi_t^{cpi}) + e_1\varepsilon_t^{petr} + e_2\varepsilon_t^y + e_3\varepsilon_t^{\Delta e} + e_4\varepsilon_t^{imp} + e_5\varepsilon_t^{ppi} + \varepsilon_t^{cpi} \quad (f)$$

$$\pi_t^{exp} = {}_{t-1}E(\pi_t^{exp}) + f_1\varepsilon_t^{petr} + f_2\varepsilon_t^y + f_3\varepsilon_t^{\Delta e} + f_4\varepsilon_t^{imp} + f_5\varepsilon_t^{ppi} + f_6\varepsilon_t^{cpi} + \varepsilon_t^{exp} \quad (g)$$

Other variables are: **imp** which is the import prices represented by the import price index for South Africa; **ppi**- producer price index for the national producers; **exp**- the export price index for goods exported by South Africa into the world market, these goods become cheap when the currency is depreciating and cheap under the periods of depreciation and finally the **cpi**- the consumer price index in the country formed by a basket of goods and services representing all the goods and services consumed by South Africans.

#### 4.4.2.1 Estimation procedure

Any type of a VAR starts with a reduced form VAR and after the traditional VAR has been run all the restrictions on the model can be done. The variables in the model will be arranged in the following order:

**(Petrol prices, output gap, exchange rate, import prices, producer prices, export prices, consumer prices)**

starting with a structural representation of linear dynamic equations of the following form:

$$A_0X_t = A(L)X_{t-1} + B\varepsilon_t \quad (16)$$

In this case  $X_t$  will be the p(=7)- dimensional set vector housing the variables being used in the model,  $A_0$  gives a description of the contemporaneous relationships

amongst the variables in the model,  $A(L)$  is the finite-order matrix polynomial in the lag operator  $L$  and lastly  $\varepsilon_t$  is a vector of structural disturbances that can be interpreted and it is drawn from the list of equations spelling out the system with covariance matrix and the equations are those above showing the recursive structure of the model. Under lenient conditions ( $A_0$  invertible), we can also show the  $p$ -dimensional Vector  $X_t$  in the following reduced form presentation:

$$X_t = A_0^{-1}A(L)X_{t-1} + e_t \quad (17)$$

In this case the VAR residual vector  $e_t = A_0^{-1}Be_t$  is n.i.i.d. with full variance-covariance (VCV) matrix. After the above structural form equation, then we will be able to derive the relationship between the VCV matrices (unobserved)  $\varepsilon_t$  and  $e_t$  (observed):

$$E(e_t e_t') = A_0^{-1}BE(\varepsilon_t \varepsilon_t')B'A^{-1} \quad (18)$$

In this case it then holds that  $\hat{\Sigma}_e = \hat{A}_0^{-1} \hat{B} \hat{B}' \hat{A}_0^{-1}$ . The identification demands the restrictions to be done on  $A$  and  $B$ . This ordering of the variables is best known as the Cholesky decomposition proposed by Sims, (1980), and it is the one also followed by McCarthy, (2000), Bonato and Billmeier, (2002) and others. On the issue of identification, the study will use the AB model proposed by (Amisano and Giannini, 1997). As iterated previously, identification is the problem of interpreting the correlations in a model in a causal manner and that problem cannot be solved by a model itself by theoretical restrictions on the model. The number of restrictions in the model is determined by the difference between the known and unknown parameters in the model. In general terms the number of restrictions for our exact identification is  $2n^2 - n(n+1)/2$  on  $A$  and  $B$  matrices.

On the AB model adopted from Amisano and Giannini, (1997), the  $B$  matrix is just there to identify structural shocks to the model. In short it is called the identification matrix. The non-zero elements in the identification matrix ( $B$ ) would then allow the structural shocks to affect more than a single variable in the model. By so doing the shocks will affect each and every variable in the model. Under this framework since the matrix  $B$  is

the identification matrix and it has non-zero off diagonal elements then matrix A is assumed to be lower triangular. In this scheme, the identification of shocks will be depending on the variable ordering and in this context our recursive ordering of the variable is what will determine the identification of structural shocks in the model. Since all the variables are assumed to be endogenous under the VAR framework, the degree of endogeneity when the variables are ordered recursively rises along the variable ordering:

$$A = \begin{pmatrix} 1 & 0 & \cdots & 0 \\ a_{21} & 1 & & \\ \vdots & & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{pmatrix}, B = \begin{pmatrix} b_{11} & & \cdots & 0 \\ 0 & b_{22} & & 0 \\ \vdots & & \ddots & 0 \\ 0 & 0 & 0 & b_{nn} \end{pmatrix} \quad (19)$$

In the VAR modelling, the contemporaneous correlations of the variables are then reflected in the cross-equation residual correlation. After restrictions are done of the matrix A and B then the Cholesky factorisation is done to so that is sets to zero all the residual correlations amongst the variables in the model prior to causal ordering. Once the required and necessary restrictions to the model are done then a number of exercises can then be done like the impulse response functions and variance decompositions.

#### **4.4.2.2 Impulse Response functions (IRFs)**

According to Karoro, et al., (2009), this is the unexpected shock to the i-th variable that doesn't affect the i-th variable directly but then it will be also affecting other variables in their endogenous nature through a dynamic lag structure on the model. In short this then means that the IRFs help to determine how the dependent variables respond to the changes or volatilities of each and every variable in the VAR.

Impulse response functions (IRFs) are basically the reaction of any dynamic system in response to some external change or shock. According to Bonato and Billmeier, (2002), IRFs show the estimated rate of response of each and every variable in the model to an

unexpected change in one of the shocks. In other words the IRFs give an indication of an impact of an upward unanticipated change in the ‘impulse’ variable on the “impulse” variable over the next several periods for example 10. The impulse response functions (IRFs) have three main outputs and these include the expected level of the shock in a given period surrounded by a 95% confidence interval and these are the low estimate and the high estimate and these make up the impulse response functions (Bonato and Billmeier, 2002).

In this case the IRFs will help the researcher to be able to observe the persistence of shocks, its size and also the size of the shocks coming from the exchange rate affecting the import prices down the chain to consumer prices. Since each variable is represented by an equation, a unit shock to the error is going to be analysed so that we can determine the effects of the shocks in the VAR over certain periods of time. This study will use the Cholesky decomposition because the ordering of the variables is important since our model is assuming causality running from the exchange rate to import prices and then to other price variables in our model. Also the Cholesky decomposition in the case of the degrees of freedom, it incorporates small samples in the estimation of the residual covariance matrix that will then be used to make the derivation of the Cholesky factor (Lutkepohl, 1991).

#### **4.4.2.3 Variance decompositions**

These indicate the ratio of the forecast error variance as a result of own shocks and shocks coming from other variables in the model. Variance decompositions show the proportion of the shifts in the dependent variables as a result of a 1% change in the other variable. In our context we want to see the change of the price variables as a result of a change in the exchange rate, to see by how much the price variables change when there is a shock in the exchange rate and the analysis goes down to the change in other price variables like the producer prices as a result of a shock in the import prices. So the first stage pass through will be analysed by a change in the import prices

as a result of shocks in the exchange rate and then the second stage pass through will be the effect of a change in the import prices to other price variables down the pricing chain. The variables are ordered in the sense that there is recursive causation in the variables. Exchange rate affects import prices and import prices will affect the producer prices and the producer prices will then affect the export prices and the consumer prices. Bonato and Billmeier, (2002) argue that in reality, own shocks or self-shocks help to highlight most of the forecast error variance of the time series data in a VAR.

#### **4.4.3 Granger Causality**

This is a statistical concept of causality between variables that is based solely on prediction. According to Granger, (1969) if a variable is helped to be predicted by the past values of another value then we assume that there is granger causality. If  $X_1$  helps to predict  $X_2$  then this has to mean that the past values of  $X_1$  should also contain information that can help to foretell  $X_2$  over and above the information contained in the lags or past values of  $X_2$  itself (Granger, 1969). Granger causality has a mathematical foundation that is based on linear regression modelling of stochastic processes. Also granger causality can have a feedback effect in the sense that (A) can granger cause (B) whilst (B) also granger cause (A) but this is not always the case.

#### **4.4.4 Structural VAR estimation**

The estimation of Structural Vector Autoregressions (SVARs) starts from the reduced form Vector Autoregression (VAR). According to Gottschalk (2001), the SVAR was modelled from the dynamic simultaneous equation models that were designed for policy analysis and also simulations. Basically the SVAR is better than the reduced form VAR because of the different puzzles the reduced form VAR most produce. There are the empirical puzzles that exist such as the exchange rate puzzle; liquidity puzzle and price puzzle (Gottschalk, 2001). The exchange rate puzzle is that when there is a positive interest rate shock, the exchange rate is expected to appreciate but the reduced form VAR can produce empirical results showing the exchange rate depreciating and that is

contrary to the expected theoretical underpinnings. On the other hand, the price puzzle comes into play when there is a contractionary money supply and the price level increases when it is expected to be decreasing. Finally the liquidity puzzle states that when the money supply increases the interest rate can be reported to be increasing whilst theory expect it to fall. So through identification, the SVAR is a better methodology for interpreting the effects of unexpected shocks into the model and that is why it provides better results as compared to a reduced form VAR. The main reason why this methodology was chosen is because the researcher wants to see the impulse response functions of the shocks to the price variables. In the reduced form VAR is some of the variables are correlated in the model then it means that even the error terms or residuals are correlated. Using a model with correlated residuals simply mean that the impulse response functions produced will not be true reflections of the shocks that need to be interpreted.

Sims, et al., (1986) argues that, the most crucial issue when it comes to structural models is identification of the empirical model. This is so because it is difficult to get all the values of the parameters from the data entered into the model alone. Hence there is need for theoretical restrictions to be done to the model. So without the identifying restrictions there cannot be any conclusion in regards to the parameters that can be obtained from the data, the reason being that a variety of different structural models produce the same reduced form.

#### **4.4.4.1 Structural VAR methodology**

P<sup>th</sup> order reduced form VAR

$$Y_t = A_1 Y_{t-1} + \dots + A_p Y_{t-p} + e_t \quad (20)$$

$Y_t$  – nX1 vector of endogenous variables

$A_1$  – the coefficient vector of lagged variables  $Y_{t-p}$

$e_t$  – the vector of serially uncorrelated reduced form errors with  $(e_t e_t') = \Sigma$

Below is the more compact form of the reduced form:

$$A(L)Y_t = e_t \quad (21)$$

A(L) – is the matrix polynomial in the form of a lag operator L

The following stage shows the structural for of a VAR:

$$B(L)Y_t = u_t \quad (22)$$

Therefore B(L) – a p<sup>th</sup> order matrix polynomial in the lag operator

$$B(L) = B_0 + B_1L + B_2L^2 + \dots + B_pL^p \quad (23)$$

U<sub>t</sub> – nX1 vector of structural innovations, with:

$$E(u_t u_t') = \Omega \quad (24)$$

The following equations show the relationship between the structural and reduced model.

$$B_0 A(L) = B(L) \quad (25)$$

$$B_0 e = u$$

$$\Sigma = (B_0^{-1})\Omega(B_0^{-1})$$

#### 4.4.4.2 Structural VAR Identification

The SVAR laid out above in a primitive line of equations will not be directly estimated because of the deep-rooted feedback in a VAR process (Enders, 2004). However, the information in the VAR system can be recovered by the estimation of a reduced form VAR in the lag operator as shown below:

$$Ay_t = \partial + \phi(L)y_{t-i} + B\mu_t \quad (26)$$

where  $\phi(L)$  is an ( $n \times n$ ) finite order matrix polynomial in the lag operator L.

Pre-multiplying a reduced for VAR equation by  $A^{-1}$  give the reduced form VAR of order p, which in standard form matrix can be written as:

$$y_t = \psi_0 + \sum_{i=1}^p \psi_i y_{t-i} + \varepsilon_t \quad (27)$$

where  $\psi_0 = A^{-1}\Omega$  ;  $\psi_i = A^{-1}\Phi_i$  ; and  $\varepsilon_t = A^{-1}B\mu_t$  is an  $(n \times n)$  vector of error terms that are assumed to be having zero means, variances that are constant and finally error terms that are not correlated with all the variables in the right hand side and also their lagged values but in some cases they may be correlated across the equations (Enders, 2004). The variance covariance matrix of the residuals regressed in the above equation is best defined as  $\Sigma = E(\varepsilon_t, \varepsilon_t')$ . When the reduced form VAR is estimated then the structural economic shocks are then separated from the estimated reduced form residuals by imposing restrictions using the AB matrices as adopted from Sims, stock and Watson, (2000) on the parameters of the matrices in the equation (28) below that is built from the above equation (27):

$$A\varepsilon_t = B\mu_t \quad (28)$$

The statistical independence assumption of the structural innovations like  $E(\mu_t, \mu_t') = 1$ , and the variance covariance matrix that is constant for the reduced form equation residuals i.e.  $E = (\varepsilon_t, \varepsilon_t')$  will then be imposing restrictions on A and B matrices with B matrix as an identity matrix as presented in the equation (29):

$$A\Sigma A' = BB' \quad (29)$$

For the restrictions to be sufficient for identification, a total of  $2n^2$  unknown elements must be identified since matrices A and B are all  $(n \times n)$  and upon which  $n(n + 1)/2$  restrictions are then imposed by equation (29) above. In order to make the make AB identified, this therefore means that , at least  $2n^2 - n(n + 1)/2$  or  $n(3n - 1)/2$  supplementary restrictions will be required. There are several ways to make the AB matrices to be identified but this research is only going to talk about two of them. The first approach is the recursive identification or factorisation which is based on the Cholesky decomposition of matrix A and this was developed by Sims (1980). This approach assumes that all the elements of the A matrix are recursively related meaning to say that the variables to be run in the reduced form VAR will be recursively ordered in their way of causation and therefore matrix A will be lower triangular.



This approach's identification of structural shocks is dependent on the ordering of the variables with the most endogenous variable ordered last (Ngalawa, 2009). This then means that in the ordering of the variables, the first variable will have no contemporaneous relationships with all the variables in the model meaning that its reduced form shock is the same as its structural shock. The second variable will have contemporaneous interactions only with its own and the previous structural shock. Going on the third variable, this variable is contemporaneously affected by its own shock and then the two previous structural shocks and the chain goes like that up until to the seventh variable. The first approach will make the system to be exactly or just identified (Ngalawa, 2009).

The second approach uses structural factorisation as an identification tool and most recent literature on SVAR have used this approach. This approach uses relevant economic theory to impose the restrictions on the elements of matrices A and B (Sims and Zha, 1998, Sims, 1986 and Ngalawa, 2009). The SVAR model will be identified using the assumption of orthogonality of the structural shocks  $\mu_t$  ; simultaneous feedback in the opposite direction is allowed for in the model and the imposition of restrictions on the model reflects the exchange rate transmission mechanism followed by the monetary policy makers.

The SVAR will be have seven variables which include output gap (gap), nominal effective exchange rate (Ner), consumer price index (cpi), petrol prices (ptr), producer price index (ppi), export price index (exp01) and import price index (imp). Output gap and the petrol prices will enter the model as policy variables representing the demand shocks and the supply shocks in the economy. The other five variables will enter the model representing the exchange rate transmission mechanism. According to the second approach to identification, the structural shocks in the equation (28) will be identified in the following way:

$$A = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & a_{34} & a_{35} & a_{36} & a_{37} \\ a_{41} & a_{42} & 0 & 1 & 0 & 0 & 0 \\ a_{51} & a_{52} & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & a_{64} & 0 & 1 & 0 \\ 0 & 0 & a_{73} & a_{74} & a_{75} & a_{76} & 1 \end{pmatrix} \quad \varepsilon_t = \begin{pmatrix} \varepsilon_t^{gap} \\ \varepsilon_t^{ptr} \\ \varepsilon_t^{ner} \\ \varepsilon_t^{cpi} \\ \varepsilon_t^{imp} \\ \varepsilon_t^{ppi} \\ \varepsilon_t^{exp01} \end{pmatrix}$$

$$B = \begin{pmatrix} b_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & b_{55} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & b_{66} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & b_{77} \end{pmatrix} \quad \mu_t = \begin{pmatrix} \varepsilon_t^{gap} \\ \varepsilon_t^{ptr} \\ \varepsilon_t^{ner} \\ \varepsilon_t^{cpi} \\ \varepsilon_t^{imp} \\ \varepsilon_t^{ppi} \\ \varepsilon_t^{exp01} \end{pmatrix}$$

From the matrices A and B, the non-zero coefficients  $a_{ij}$  and  $b_{ij}$  in their respective manner show that any residual  $j$  in these matrices  $\varepsilon_t$  and  $\mu_t$  in the same manner has an immediate impact on variable  $i$ . The first two equations are modeled to capture the external shocks that can affect exchange rate shocks and then the exchange rate shocks to the prices will be quantified by the variance decompositions and the impulse response functions. The issue of modelling responses of exchange rate to others variables in an SVAR is now a standard across a wide range of studies especially those that are investigating the transmission mechanisms. These studies include Ngalawa, (2009), Cheng, (2006), Becklemans, (2005), Borys and Horvath, (2007) and Piffanelli, (2001).

#### 4.4.4.3 SVAR, stationary and Cointegration

The data will be tested for stationarity to see if variables are stationary in levels or not because for a research study to use any type of a VAR, the variables should be integrated of the same order (Sims, 1980). However, if the variables are seen to be

nonstationary in their levels, the research is going to proceed to run a Structural VAR in levels since useful information can be lost when data is being transformed to stationarity through differencing. This idea is borrowed from the canonical paper of Sims, Stock and Watson, (1990). The paper demonstrates that the common practice of transforming models to stationarity by difference or Cointegration operators is unnecessary because most monetary variables like exchange rate and prices mostly have distributions that are not affected by nonstationary especially when one is using high frequency data and not a very long sample size. This then means that all the hypotheses can be tested without starting by transforming the data to stationarity. In this research, the main issue is not about the integration of the data but to see whether the coefficients we are estimating have a nonstandard distribution if in fact the variables we are regressing on each other are integrated.

In the SVAR literature, the Sims, Stock and Watson idea has been largely accepted by many researchers with a study from Germany by Bernake and Mihov, (1997, p.1037) clearly stating that we can include output, prices and reserves in levels despite having observed that they are nonstationary. Their motivation for running the model in levels is based on the fact that, levels specification yields consistent and reliable estimates even if Cointegration exists or not. They go on to say that a differences specification is inconsistent if some variables are cointegrated. Since some information is lost in the process of transforming data to be stationary, the situation can be worse especially with the imposition of restrictions on the model to make it identified. In the case that false restrictions to the model are made, the inferences will be highly inaccurate and this situation can be worsened if the data is transformed through differencing. Some of the studies that followed the same approach of estimating the SVAR in levels when the variables are, Brischetto and Voss, (1999), Ramaswamy and Sloek, (1998), Sims, (1992), kim, (1999), Ngalawa, (2009), Dungey and Pagan, (2000), Piffaneli, (2001).

On the other hand there is a large number of other studies that have used SVAR with differenced data with the most common factor being that they were worried about the long-run implication of their models. This will be done by putting Cointegration

restrictions on the VAR depending with the Cointegration equations in the model and the restrictions per equation will be done according to the number of Cointegration equations in the model. This mean to say that is a researcher finds out that the model gave 2 Cointegration equations, 2 restrictions per equation will be done, and if there are 3 Cointegration equations then 3 restrictions to the VAR will be done (Ngalawa, 2009). In being rationale to the issue Haug et al., (2005), concurred that for the long-run implications of any VAR model, the Vector Error Correction Model (VECM) will be the best model to adopt. This study is concerned about the short-run implications of the model. Haug et al however, made it clear that for the short run it is best to run the VAR since its parameters are estimated consistently by least squares with variables in levels without unleashing cointegrating restrictions available in the data. However, when faced with cointegration analysis in the data, a VAR can do accurate and precise modelling with non-stationary variables when the researcher is concerned about the long run implications of the model through cointegration restrictions to the model (Johansen, 1988). In identifying long run relationships in a model there are some other papers that have used cointegration analysis for identification in a linear cointegrating model with variables that are differenced ones for example; King et al., (1991) , Lutkepohl and Wolters, (1998), Ehrmann, (1998), Garratt et al., (2003).

While the debate on whether to transform the non-stationary data by differencing or by using cointegration operators when running a SVAR has mostly followed Sims, Stock and Watson (1990), there are other studies and researchers who are still following the traditional way of first transforming the data to make it stationary through differencing without putting a difference whether the motive for research is short run or long run implications of the model taking for example (Enders 2004, Sanusi, (2006), Aleem, (2014), Nogueira, (2008) among more others.

#### **4.4.5 Conclusion**

The chapter has outlined the models and econometric illustrations that the research will employ in order to analyse the data in the next chapter. The type of data that this research is using is time series data and there are certain demands that need to be met before you run any model when you are using this kind of data. For the analysis of the exchange rate transmission mechanism to be analysed, data will be checked for its stationarity since the VAR framework deals with data of the same integration, also data will be checked to see if there are any co-integration relationships and then the Recursive VAR and the Structural VAR will be run to see the impulse responses of a 1% change in the exchange rate. The study is particularly concerned about the short-run implications of the models and this then means that even if the variables are cointegrated with more than one vector, the VECM will not be modelled.

## CHAPTER 5

### EMPIRICAL ANALYSIS AND RESULTS

#### 5.1 Introduction

In this chapter the researcher reports the findings of the empirical analysis in line with the econometric set up that was discussed in the previous chapter. There are pre-estimation analyses that will be done before analysing the main results of the study. The data was transformed into natural logs mainly because the study wants to analyse the elasticities of exchange rate changes to price variables in the model. All the data was also tested for stationarity as a way to check their order of integration since the VARs demand variables with the same order of integration. Also the lag length to be used was revealed before the estimation of the main results to see the correct lags to include in the model. Cointegration testing was done as well to see if the variables have got a long-run relationship amongst them. The empirical work analysis is to be conducted in a manner where granger causality will be done to check the causality between the variables in the model. For direct and indirect Exchange Rate Pass-Through (ERPT), the variance decompositions from both the SVAR and Recursive VAR will be used. The effect of exchange rate changes to import prices (direct) and the effect of exchange rate and import price changes to other price variables down the chain (Indirect) is the main focus of the analysis. Also the impulse response functions will also be analysed from both estimations to see the response of price variables as a result of a shock in the exchange rate.

#### 5.2 Descriptive statistics

On the descriptive statistics of the data, the presentation in the table below shows that there is an asymmetrical distribution of variables like consumer price index (LCPI), export price index (LEXP01), import price index (LIMP), nominal effective exchange rate (LNER), producer price index (LPPI) and petrol price index (LPTR). This distribution of

the series is best explained by the evaluation of a wide range of statistical measures as shown in the table below. The mean and the median of the data when showing identical or almost identical properties it then means that the variables in question are normally distributed. The only exception here is the output gap that has different statistics for the mean and the median most probably because it is the only variable that is not a price proxy and also it is a percentage and hence not in the log form of the others. The maximum and minimum estimates do not show too much variation amongst the price variables and this can suggest that the series is stable. Although the output gap is a bit different from others there is not much difference with others. On the skewness, the values are close to zero for all the price variables and the output gap is not too far from others since it is at 1,5 . The positive figures mean that the distributions have got a long tail to the right as compared to the left. On the other hand the negative figures show that the distribution is skewed to the left or that the series have a distribution with a long tail to the left side than the right side. In addition, the Kurtosis coefficient measures the boldness or the thickness of the distribution tails. In the event that the coefficient is three this then mean to say that there is a normal distribution. If the coefficient is below three, it means that there is a sign of a platykurtic distribution of the series or that the series has a fat distribution. The Jarque-Bera (JB) test statistic will be checked for normality testing as well. This kind of normality testing uses a double hypothesis or joint hypothesis that the Kurtosis and Skewness coefficients are 3 and 0 in that respective manner. The Jarque-Bera (JB) test will then have to follow a chi-square distribution with two degrees of freedom under the null hypothesis of normal distribution. In its absolute value, if the test statistic of the Jarque-Bera (JB) is greater than the critical value chi-square at a chosen level of significance the alternative hypothesis may be accepted with the null rejected. If the probability value (p value) of the JB test is seen to be very low, which is a situation that normally takes place when the value of the statistic is way different from 0. Given that circumstance, the hypothesis of normal distribution for the observations may be rejected. As for this research the value of the p value looks very low for all the variables and this might show that the distributions are not normally distributed.

**Table 5.1 Descriptive statistics results**

	GAP	LCPI	LEXP01	LIMP	LNER	LPPI	LPTR
Mean	0.472760	4.399691	4.514414	4.446133	4.535609	4.867289	4.180622
Median	-0.365000	4.398145	4.520722	4.398182	4.552998	4.885450	4.168156
Maximum	21.74800	4.760463	4.922896	4.964940	4.823452	4.979489	4.776599
Minimum	-8.130000	4.058371	4.116158	4.142954	4.151926	4.747537	3.539419
Std. Dev.	4.661690	0.209753	0.200516	0.246466	0.199683	0.073903	0.390843
Skewness	1.522721	0.171949	0.411774	0.769447	-0.316684	-0.299150	-0.036655
Kurtosis	7.668174	1.626914	2.413041	2.588768	2.116078	1.576446	1.697704
Jarque-Bera Probability	217.4660 0.000000	14.02542 0.000900	7.159259 0.027886	17.76114 0.000139	8.277321 0.015944	16.69129 0.000237	11.90945 0.002594
Sum	79.42370	739.1480	758.4215	746.9504	761.9823	817.7045	702.3446
Sum Sq. Dev.	3629.136	7.347367	6.714511	10.14446	6.658861	0.912105	25.51059
Observations	168	168	168	168	168	168	168

Source: Estimation results

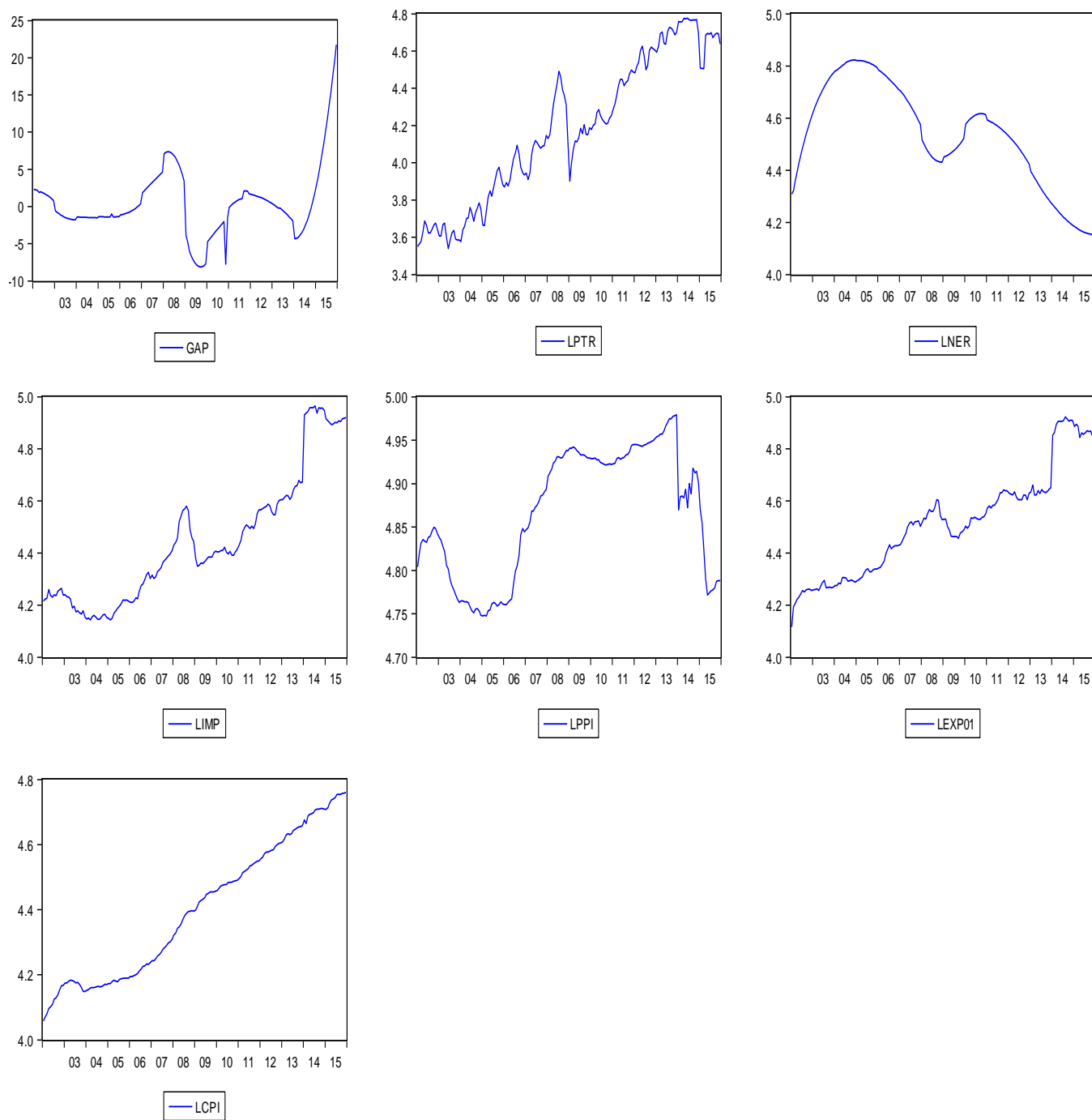
### 5.3 Graphical inspection

Graphs for all the variables were plotted in their level form and it can be observed that they are all showing aspects of nonstationary. Export, import and consumer price indices are showing an upward trend increasing for the entire period from 2002 to 2015. The producer price index is showing volatility for the entire period not showing a clear trend but have a slump for the period 2004 to 2007 then it rises again before it hits another slump for the period 2013 into 2014 then goes down further in 2015. The output gap and the nominal effective exchange rate (NEER) are also showing volatility although with no a clear trend visible but decreasing. The output gap has shown a very large increase for the period 2013 to 2015 whilst the NEER has been on a downward trajectory since from the period 2005 up to 2015 showing a clear trend and that shows



the Non-stationarity of the data. There is no exhibition of time independency and mean reverting tendencies amongst the variables hence they are deemed non-stationary.

**Figure 5.1 Graphical plots of variables in levels**



Source: Own calculation

#### 5.4 Stationarity tests

To confirm the Non-stationarity of the data as shown by the visual inspection of the variables, the study employed the formal unit root tests comparing the results of the Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) tests. Using Eviews 9.5, all the variables were tested for stationarity in their levels, including an intercept and automatic choice for lag length employing a maximum of 13 lags as given by the Schwarz information criteria (SIC). The stationarity of the variables is important to be known by the researcher since choosing the right model to estimate the results demand that kind of the knowledge. If one uses variables that are nonstationary, there is an argument that the results may be spurious especially for single equation models. Also models like the VAR demand variables with the same order of integration to estimate them. Only if all the variables are I(1) or I(0) is when one can estimate a VAR. If the variables are of mixed integration one has to consider some other models to run. In the previous chapter this research's methodology suggested the Recursive VAR and the Structural VAR to be run so as to analyse the impulse response functions and the Variance error decompositions.

As shown by table 5.2 below the results show the order of integration for the variables.

**Table 5.2 Unit root table**

Variable	ADF @ 1%		Phillips-Perron @ 1%		I(d)
	Levels	1 <sup>st</sup> Diff	Levels	1 <sup>st</sup> Diff	
Gap	-0326162	-4.227060	-0.062317	-12.11775	I(1)
Cpi	0.346201	-10.27714	0.074533	-10.93125	I(1)
Ppi	-0.906680	-6.992048	-1.214282	-12.21109	I(1)
Imp	0.402233	-11.12141	0.077252	-11.24372	I(1)
Ptr	-1.224015	-9.539517	-1.147970	-8.466560	I(1)
Ner	-1.171132	-3.117750	-0.604433	-4.016799	I(1)

Exp01	-1.060832	-12.46426	-1.115891	-12.48133	I(1)
-------	-----------	-----------	-----------	-----------	------

Source:Own Calculation

Table 5.2 indicates that two methods to determine the stationarity of the variables were employed and all the variables were found to be stationary after they had been first differenced. This means that no variable was stationary in its levels but only after they had been transformed. All the stationarity testing methods were employed under the null hypothesis that the data generating processes has a unit root. In employing the ADF and the PP, in the event that the test statistic computed is more than the critical value then this meant that the alternative hypothesis will be accepted meaning that there is no unit root or that the series is stationary.

All the three unit root equations were employed, namely with a constant term, without a deterministic component and with a time trend. The estimations were done from the least restrictive conditions to the most restrictive one and when the deterministic condition was found that's when the restrictions would stop. Actually there were no restrictions that were done if any of the deterministic conditions were observed to be significant.

### **5.5 Lag length selection criteria**

Lags to include in a model play a very important role and using different lags provides different results as well. Before the estimation of any model in this case a VAR, it is important to firstly determine the selection of the unrestricted VAR of order ( $p$ ). The maximum or sufficient number of lags to include when testing for cointegration and then the VAR according to most research is determined by the Akaike Information Criteria (AIC), Schwarz Information Criteria (SIC) and Hannan-Quinn Information Criteria (HAIC) basically because the VAR or VECM methodologies are very sensitive to the number of lags included in the model.

In the determination of the number of lags to be included in the model, the unrestricted VAR should be estimated and all the variables should be in their level form with maximum number of lags, then re-estimating the model whilst the lags are being

reduced by one lag up until a model with zero lags is estimated (Harris,1995). Among the models that had been run using different lags, the values of the AIC , SIC and HAIC) will be checked together with other diagnostic checks like the normality tests and autocorrelation tests, hence a model with the least AIC and SIC values and with diagnostic checks that pass the needed criteria will then be considered as the good model to be run and the lag length from that model will be considered as the optimal lag length for both cointegration tests and VAR or VECM estimation.

Taking results of the unrestricted VARs that were run using different lags, the lag selection criteria are found and the summary results from using 8 lags show that the for the AIC the least value is at 3 lags and from the general concept of lag selection the optimal lags to use for the model will be 3. As for the SIC and the HQ, the lowest figures for these statistics are at lag 1 and according to them a single lag looks like the optimal lag length the research should adopt. However the research employed the results from the AIC since it is argued to be superior among them all because of its ability to deal with small samples (Enders, 2010). So the study employed three lags for both co-integration and VAR estimation.**Table 5.3 Lag length selection**

VAR Lag Order Selection Criteria  
 Endogenous variables: GAP LPTR LNER IMP LPPI LEXP01 LCPI  
 Exogenous variables: C  
 Date: 09/26/16 Time: 15:51  
 Sample: 2002M01 2015M12  
 Included observations: 160

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-75.31042	NA	6.60e-09	1.028880	1.163419	1.083512
1	1871.683	3699.288	3.28e-19	-22.69604	-21.61973*	-22.25899*
2	1944.696	132.3345	2.44e-19	-22.99619	-20.97811	-22.17672
3	2013.710	119.0498*	1.92e-19*	-23.24637*	-20.28652	-22.04448
4	2036.729	37.69325	2.69e-19	-22.92161	-19.01998	-21.33729
5	2075.289	59.76876	3.15e-19	-22.79111	-17.94772	-20.82438
6	2101.348	38.11135	4.37e-19	-22.50435	-16.71918	-20.15519
7	2146.063	61.48278	4.88e-19	-22.45079	-15.72384	-19.71921
8	2180.972	44.94518	6.28e-19	-22.27465	-14.60593	-19.16065

\* indicates lag order selected by the criterion  
 LR: sequential modified LR test statistic (each test at 5% level)  
 FPE: Final prediction error  
 AIC: Akaike information criterion  
 SC: Schwarz information criterion  
 HQ: Hannan-Quinn information criterion  
 Source: Own calculation

## 5.6 Cointegration results

The most detail about cointegration was discussed in chapter four. This study used the superior cointegration technique, the Johansen technique which used two tests to determine the number of cointegrating equations in a model namely the maximum eigenvalue statistic and the trace statistic. The cointegration test specification used was that of an intercept and no trend in the cointegration equation and then test VAR. The study assumes that given the fact that  $p$  is the number of variables and  $r$  is the rank or the number of cointegrating vectors in a model, the trace test statistic analyses the null hypothesis that  $r \leq p$  versus the alternative one. On the other hand the maximum eigenvalue analyses or tests the null hypothesis that the amount of cointegrating vectors is  $r$  versus another one that says is  $+1$ . In all the cases the null hypothesis can be rejected if it is observed that the test statistic computed or found is more than the critical value. On the other hand it cannot be rejected should the test statistic be less than their critical values. The testing criteria for both the tests happen in a sequence to

tell how many cointegrating equations are available amongst the variables in the model, for example  $r=0,1,2$  upto  $n-1$ . In the case that the null hypothesis of at most zero cointegrating equations is rejected in favour of the alternative then the test will proceed to the null hypothesis of at most one against an alternative hypothesis that there is at most two equations and it goes like that up until when the test statistic is less than the critical value. Looking at the table 5.3 below where the summarised cointegration results of the Johansen are presented, at 5 percent significance level, the null of zero or no cointegration equations is rejected by the trace and the maximum eigenvalue tests because the test statistics are higher than the critical values (Trace 152.5993 versus a critical value of 125.6154) and (Max Eigen 53.84199 versus a critical value of 46.23142). Moving to the next null hypothesis of at most one is shows that the null for the trace statistic has been rejected again (trace statistic 98.75732 versus a critical value of 95.75366) but the null hypothesis of at most one for the Max Eigen has been accepted (Max Eigen 36.24792 versus a critical value of 40.07757). Since the null hypothesis of the at most one cointegrating equation for the Trace test was rejected we move on to the next null hypothesis of at most two cointegrating equations. The null of at most two equations is accepted since the value for the critical value is now more than the test statistic (Trace 62.50940 versus a critical value of 69.81889). This means that from the analysis we have two contradicting results from the Trace and the Max Eigen statistic with the former say there are two and the later saying there is only one cointegrating equation amongst the variables. However, this research is going to consider the results of the Trace statistic test meaning that there are two cointegrating equations amongst the variables. This is based on the fact that the Trace statistic test is argued to be superior to the maximum Eigen value test and it is argued that the Trace test can be adjusted for degrees of freedom and is more robust to skewness and excess kurtosis.

**Table 5.4 Johansen Cointegration Test results**

<b>Null</b>	<b>Trace</b>	<b>5% C.V</b>	<b>Max Eigen</b>	<b>5% C.V</b>
-------------	--------------	---------------	------------------	---------------

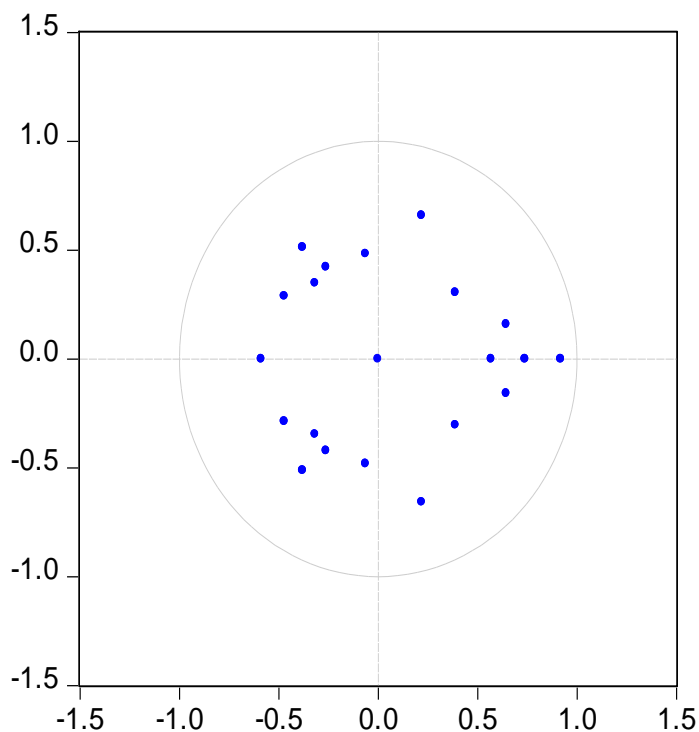
	<b>statistic</b>			
r=0	152.5993	125.6154	53.84199	46.23142
r<=1	98.75732	95.75366	36.24792	40.07757
r<=2	62.50940	69.81889		

### **5.7 VAR stability test**

In checking the stability of the model, the study employed the Autoregressive (AR) roots of the VAR in level form. The diagram below shows that none of the roots are lying outside the circle except for a few that are exactly at the circle, hence the stability of the VAR is confirmed. According to Lutkepohl (1996), if all the roots are inside the circle or if each root has a modulus that is below one, then it means that all the endogenous variables in the VAR are stationary be it in levels or when they are differenced. When an unrestricted VAR was run and the AR tests were done, the roots were not outside but some of them were on the circle line. On the modulus examination, in levels there were some roots that were above one although below 1.2 but that was a sign that the model was not stable and the variables were nonstationary. When variables were differenced, the highest modulus is 0.91 a figure that is less than 1 followed by a modulus with 0.73 a figure that is way below 1. A VAR approach may be the most appropriate since all the roots are inside the circle and below 1, hence the short run implications of the model can be successfully achieved. On the other hand the modulus that is 0.91 is almost close to one a thing that makes the Johansen cointegration approach a successful model to analyse the cointegration effects in the model.

### **Figure 5.2 AR roots diagram**

## Inverse Roots of AR Characteristic Polynomial



Roots of Characteristic Polynomial  
 Endogenous variables: D(GAP) D(LPTR) D(LNER) D...  
 Exogenous variables: C  
 Lag specification: 1 3  
 Date: 10/05/16 Time: 15:18

Root	Modulus
0.919276	0.919276
0.739171	0.739171
0.219758 + 0.658854i	0.694537
0.219758 - 0.658854i	0.694537
0.645402 - 0.158168i	0.664501
0.645402 + 0.158168i	0.664501
-0.378851 + 0.512501i	0.637326
-0.378851 - 0.512501i	0.637326
-0.586421	0.586421
0.569159	0.569159
-0.472200 - 0.286885i	0.552518
-0.472200 + 0.286885i	0.552518
-0.260434 + 0.421831i	0.495749
-0.260434 - 0.421831i	0.495749
0.390070 + 0.304755i	0.495005
0.390070 - 0.304755i	0.495005
-0.062319 + 0.482371i	0.486380
-0.062319 - 0.482371i	0.486380
-0.316083 - 0.346901i	0.469306
-0.316083 + 0.346901i	0.469306
-0.001384	0.001384

No root lies outside the unit circle.  
 VAR satisfies the stability condition.

Source: Own calculation

### 5.8 The VAR model Estimation

This study estimated a Recursive VAR (Cholesky factorisation) as the main model and it will be compared with the Structural VAR using sign restriction as its identification and the impulse response functions will be restricted by the structural factorisation. The recursive ordering of the model took the form (GAP LPTR LNER LIMP LPPI LEXP01 LCPI). The level of endogeneity decrease as we get to the last variable on the ordering. Using 3 lags an unrestricted VAR was estimated. The unrestricted VAR was then used to estimate the Recursive VAR that used the A/B matrix to make the A matrix lower triangular and the B matrix an identity matrix. The Structural VAR (SVAR) that used sign restriction for its identification also used the A/B matrix, it is not recursive. Also the impulse response functions and variance decompositions are also going to be used to understand the relationship between the changes in exchange rate and price indices.



Benchmarking from the study of Ngalawa, (2009), it is argued that all the Recursive VAR and the SVAR bring the best results if they are estimated in their level forms basically because the impulse response functions give reliable estimates when the data is in levels. It is known that when the data is differenced, some of the information may be lost. On the issue of cointegration, there is a wide range of past studies that have run a VAR in levels even when there is cointegration existing amongst the variables. This is motivated by the objective the research intends to achieve at the end. If a study want the long run implications of the model, one can estimate a VECM but if the intentions are the short run implications of the model then one must only make sure that the SVAR or Recursive model is just or exactly identified and the lags are sufficient enough to make the residuals orthogonal (Becklemans, (2005), Cheng (2006) and Ngalawa, (2009). The SVAR that is identified by sign restrictions is allowed to be over identified or just identified.

**Table 5.5 lower triangular (Cholesky identification)**

---



---

Estimated A matrix:						
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
-0.000849	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.001507	0.007239	1.000000	0.000000	0.000000	0.000000	0.000000
-0.004716	-0.155666	-0.058488	1.000000	0.000000	0.000000	0.000000
0.001129	-0.021497	0.205718	0.254667	1.000000	0.000000	0.000000
0.000986	0.037881	0.007659	-0.479996	0.500260	1.000000	0.000000
-0.000209	-0.017112	0.015559	-0.056623	-0.024131	-0.001442	1.000000
Estimated B matrix:						
0.928205	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.042302	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.006722	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.023699	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.009339	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.014203	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003797

---



---

Source: Own calculation

## Table 5.6 Variance Decompositions for the Recursive VAR

### Table 5.5.1 Variance Decompositions of Gap

Month	Gap	LPetr	LNer	LImp	LPPi	LExp	Lcpi
1	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3	96.04023	1.283923	0.003658	1.492156	0.305112	0.846205	0.028718
6	87.72491	0.685368	0.227648	8.423025	0.233434	2.661904	0.047070
9	82.14585	0.953101	0.167942	13.37906	0.708521	2.552399	0.093135
12	75.54125	1.739021	0.140452	18.23237	2.231982	1.9366608	0.178318
15	67.72678	2.571823	0.147453	23.44549	4.339251	1.473645	0.293732
18	59.50163	3.221619	0.133254	28.72341	6.544966	1.455290	0.419828
21	51.54898	3.602731	0.108092	33.67711	8.584547	1.939391	0.539151
24	44.29167	3.715607	0.137080	38.04372	10.33260	2.841807	0.637519

Source: Estimation results

Table 5.5.1 represents the number of fluctuations in the Output gap that are accounted for by the other 6 variables in the model. The highest fluctuations in the output are caused by itself followed by the import prices which account for 8.42% change in the gap after 6 months, accounting for 18.23% fluctuations after one year and 38.04% after 2 years. A shock to producer prices accounts for 2.23% fluctuations in the gap after a year and 10.33% after 2 years. Petrol price changes also account for 3.71% after 2 years with a shock to export prices contributing 2.84 after 2 years as well. A paltry fluctuation of 0.63% in the output gap is accounted for by a 1% change in the consumer prices in South Africa after 2 years.

### Table 5.5.2 Variance Decompositions of Petr

Month	Gap	LPetr	LNer	LImp	LPPi	LExp	Lcpi
1	0.149202	99.85080	0.000000	0.000000	0.000000	0.000000	0.000000
3	0.113283	78.92134	4.482563	1.747146	2.315128	6.077889	6.342655
6	1.061174	59.91271	14.64445	5.683387	2.463716	8.071741	8.166331

9	2.001786	55.65796	17.81814	4.799889	2.274532	8.588686	8.859008
12	3.416840	52.69422	18.02093	4.326296	2.145865	9.413884	9.981961
15	5.489470	49.81355	17.15468	4.018290	2.051354	10.60198	10.87068
18	8.037495	46.81688	16.05823	3.745522	1.963338	11.92643	11.45211
21	10.80825	43.88312	15.01161	3.511955	1.861811	13.16822	11.75503
24	13.59634	41.16552	14.08620	3.365342	1.750590	14.18589	11.85011

Source: Estimation results

Referring to table 5.5.2 above, there is a sign that a 1% change in the exchange rate causes the petrol prices to fluctuate by 14.64% after only 6 months and 18.02% after one year. The impact goes down after two years to 14.09%. Also for the South African economy a shock to the export price causes a quick but significant fluctuation in the petrol prices as it can be seen, export price shock accounts for 8.07% change in petrol prices after 6 months, 9.41 after a year and 14.18 % after 2 years. This then means that for South Africa the impact of export prices can be felt for a long period up to 24 months and the impact of the shock increases as time goes by. The output gap is not spared as its shock accounts for 3.41% after one year and 13.59% after two years and also the shock to the output gap has an impact that increases as time increases at an almost constant rate. A shock to the consumer prices in South Africa accounts for an 8.86% fluctuation in the petrol prices and the impact increases at a decreased rate as time increases because there is not much change in the fluctuations after one year or after 18 months into two years.

**Table 5.5.3 Variance Decompositions of Ner**

Month	Gap	LPetr	LNer	LImp	LPPi	LExp	Lcpi
1	2.354510	2.667371	94.98812	0.000000	0.000000	0.000000	0.000000
3	2.388379	6.844196	90.33782	0.245117	0.097690	0.063719	0.023078
6	2.146955	11.42875	84.13532	1.761034	0.140327	0.341225	0.046390

9	2.938828	15.89964	75.02748	4.335927	0.080957	1.587257	0.129918
12	4.239509	18.74741	66.12051	7.296086	0.060485	3.270413	0.265578
15	5.796742	20.10584	58.89964	9.903508	0.064406	4.798592	0.431270
18	7.541305	20.45737	53.26174	12.08126	0.058144	5.980762	0.619419
21	9.451365	20.15086	48.73347	13.98404	0.047892	6.812305	0.820065
24	11.48482	19.40688	44.93504	15.76470	0.061716	7.326860	1.019977

Source: Estimation results

Shocks to Petrol prices and import prices in South Africa have topped the list of the variables in the model when it comes to spearheading fluctuations in the nominal effective exchange rate (NER). Shocks to these price indices account for 11.43% and 1.76% fluctuations to the exchange rate after six months respectively. After one year the two account for 18.74% and 7.30% in that respective manner. A shock to petrol prices in South Africa accounts for 19.40% change in the exchange rate after 24 months or two years with an import price shock accounting for 15.76% fluctuations in the exchange rate. This makes empirical sense considering the volatility of the exchange rate and the huge depreciation of the rand as witnessed in a couple of years back. The impact of the petrol prices is most after 18 months but after 24 months it falls downwards a little whilst the impact of the import prices continue to increase as times increases as well. Export prices and the output gap follow since they contribute or account for 7.32% and 11.48% after two years respectively. Consumer prices do not have much of an impact on the fluctuations of the exchange rate since they account for 0.26% after one year and a small change of 1.02% after 24 months. Producer prices also do not have much influence when it comes to changes in the exchange rate accounting only 0.060% after one year and 0.062 % after 24 months. This makes sense since the exchange rate is much more exogenous and is much likely to be caused by the fluctuations that are also external.

**Table 5.5.4 Variance Decompositions of Imp**

Month	Gap	LPetr	LNer	LImp	LPPi	LExp	Lcpi
1	0.781105	7.239151	1.138707	90.84104	0.000000	0.000000	0.000000
3	0.332516	17.98192	6.283664	73.55774	0.271225	1.566000	0.006936
6	0.220024	17.94449	17.26925	61.65791	0.536504	2.325386	0.046438
9	0.168047	18.86955	23.77284	54.61253	0.409978	2.022860	0.144197
12	0.162058	19.88513	27.53935	49.85845	0.340090	1.824097	0.390817
15	0.239121	20.71780	29.65781	46.58561	0.314429	1.761160	0.724077
18	0.454114	21.27551	30.78469	44.25409	0.298521	1.824723	1.108352
21	0.850421	21.55913	31.26594	42.51916	0.284860	2.004336	1.516159
24	1.450192	21.59582	31.30407	41.16426	0.273811	2.283184	1.928661

Source: Estimation results

Table 5.5.4 depicts the results of the direct effects of exchange rate changes to import prices. In the context of exchange rate pass through, these are referred to as direct effects of exchange rate changes to import prices and the effects will go down to other prices through the changes in import prices. The fluctuations in import prices according to table 5.5.4 are largely accounted for by own shocks of cause but shocks to the exchange rate accounts for the highest percentage fluctuations in the import prices. After a shock to the exchange rate, the import prices respond by 17.27% after only 6 months. The effect of a shock into exchange rate will increase the fluctuations in the import prices to 27.54% after one year. These results confirm or agree with the findings from studies by Parsley (2010) and (Aron et al., 2014). They found that the import prices were being accounted for by the exchange rate by the same magnitude. The effect of a shock to exchange rate on prices will increase as time goes by but at a decreasing rate after one year. This can be observed by a steady increase in the fluctuations from 15 months to 21 months since the fluctuations increased from 29.66% to 31.27% respectively. After 24 months the shock to the exchange rate will contribute to a 31.30% fluctuation in the import prices. This then means that the effect increases with time and

its effect will be felt mostly after 2 years with half of the effects experienced 6 months after the shock has taken place. It should be a worrying factor for the monetary policy makers because the arguments in the literature suggest that pass-through decreases with time but from the look of these results ERPT is not looking as if decreasing meaning to say that it will continue to cause more pressure on the average inflation figure.

Petrol prices are not spared since they account for quite significant fluctuations in the import prices. A shock to the petrol prices leads to a 7.24% change in import prices after only 1 month meaning that the shock to import prices is immediately felt in the South African economy because the percentage is quite big and very significant. The fluctuations will then increase by more than 100% after 6 months increasing from 7.24% to 17.98% after only 3 months. The fluctuations after a shock to the petrol prices are immediate and they are quickly influential on the prices the South African importers pay. This is basically because petrol or oil prices are one of the main production and operation costs that are immediately felt by any producer and that will force producers to quickly adjust their prices to remain making profits in business. However, the effect will be increasing at a decreasing rate over 6 months, 12 months, 18 months and finally 24 months (17.94%, 19.96%, 21.27% and 21.59% respectively).

On the other hand producer prices, and export and consumer prices do not contribute anything significant when it comes to fluctuations in the import prices. This is within the expectations since import prices are mostly contributed to by the external factors not factors within the South African economy. After one year the three price variables only account for 0.34%, 1.82% and 0.39% in their respective order. After 2 years they account for 0.27%, 2.28% and 1.92% respectively. Lastly, the output gap does not account for significant fluctuations in the import prices only accounting for a paltry 0.16% after one year and 1.45% after 2 years.

**Table 5.5.4 Variance Decompositions of Ppi**

Month	Gap	LPetr	LNer	LImp	LPPi	LExp	Lcpi
1	1.629139	0.535440	0.144573	31.46831	66.22254	0.000000	0.000000
3	0.951495	0.468924	0.077299	23.94796	71.61680	2.789398	0.148126
6	1.096553	1.108002	0.053899	19.78374	64.87103	12.44314	0.643629
9	1.687362	1.960381	0.064576	19.36639	55.33631	20.47879	1.106199
12	2.399255	2.567834	0.068211	20.44503	47.31474	25.72858	1.476352
15	3.288594	2.893923	0.056016	21.32654	41.31630	29.35240	1.766228
18	4.379413	2.983025	0.089239	21.64238	36.91392	32.01979	1.972240
21	5.638373	2.891878	0.228496	21.50329	33.62994	34.00258	2.105445
24	7.002867	2.695304	0.517092	21.09406	31.10058	35.41006	2.180042

Source: Estimation results

It is in line with the ERPT literature that a shock in the import prices will immediately be felt by the local producers in South Africa. According to table 5.5.5 above, the same results from other research are confirmed. A shock to import prices accounts for 31.47% fluctuations in the producer prices only one month after the shock meaning that the producer prices in South Africa quickly respond to changes in the exchange rate. However, although the effects are immediate, they decrease at almost a decreasing rate as time increases up to one year before it starts to increase again. This is observed by a decrease in the fluctuations in the producer by 23.94% after 3 months down from 31.47% after one month. After 6 months the shock in the import prices will account for 19.78% changes in the producer prices down from 23.94%. After one year the impact of the import price shock will account for 20.45%, after 18 months 21.64 and 21.09% meaning that the effect increased from 12 months up to 18 months although at a constant rate. After 24 months the effect starts to increase as well.

The direct effect of a shock to the exchange on producer prices is very insignificant since it cannot even contribute to a one percent change in producer prices. The shock accounts for only 0.14% after one year, 0.06% after 6 months and finally 0.54% after 24

months. This is within the expectations of the research since the effects of the exchange rate changes are more direct on the import prices; hence the fluctuations of the producer prices are most influenced by the changes in the import prices. Export prices are one of the major contributors to the changes in the producer prices in South Africa according to table 5.5.5 with the effects of its shock having incremental effects on the fluctuations in the producer prices as time increases. Export price shocks account for 0.00% fluctuations in the producer price after one month with the effect increasing to 12.44% after 6 months. After one year, the shock accounts for 25.73% changes in the producer prices before it reaches 34.41% after 2 years. This means that the effect of a shock to export prices is not immediately felt but the producer prices by the impact of the shock increases as time goes by. The connection between the export and producer is that when the rand depreciates, the exporters' demand may increase and that will force the exporter to demand more from the local producers in South Africa and that will mean more production in South Africa that, in turn, will push up producer prices through the wage increments that may be demanded by the workers when they are producing more than before. The effect of these is two-way as there is causation from both sides.

Other variables like the petrol prices and consumer prices do not account for large fluctuations in the producer prices but their contribution cannot be given a blind eye. The petrol and consumer prices shocks in South Africa account for 2.56% and 1.47% fluctuation respectively in the producer prices after one year. After 2 years the impact of the shock increases to 2.69% and 2.18% in that respective manner. The impact is felt immediately after a shock to the petrol price as compared to consumer prices. On another note the output gap contributes significantly to the petrol price fluctuations mainly after 2 years. The changes to the output gap will probably result in a 2.39% fluctuation in the producer prices after one year, with the impact going up to 7% after 2 years.



**Table 5.5.6 Variance Decompositions of Exp**

Month	Gap	LPetr	LNer	LImp	LPPi	LExp	Lcpi
1	0.533504	1.040528	0.244823	47.94586	3.650655	46.58463	0.000000
3	0.200588	3.161420	2.712578	52.62616	2.261413	38.93788	0.099959
6	0.110789	8.307306	6.761774	52.78190	1.343184	30.59662	0.098427
9	0.139391	12.28780	11.03752	50.57675	0.922906	24.88619	0.149444
12	0.189926	15.22524	14.50028	47.65541	0.733282	21.33410	0.361753
15	0.213614	17.35319	16.98243	44.88656	0.636310	19.20506	0.722847
18	0.205552	18.87653	18.61052	42.55458	0.586949	17.97064	1.195219
21	0.197774	19.92795	19.58251	40.66691	0.570732	17.31078	1.743348
24	0.239872	20.60082	20.07132	39.13309	0.582249	17.04016	2.332496

Source: Estimation results

Referring to table 5.5.6 on the variance decompositions of export prices, it can be noted that many of the fluctuations in the export prices are influenced by shocks from the import prices. This is according to the researcher's expectations since import prices contribute much or shape the pricing decisions of other goods and services of cause through the producer prices depending on the type of the good. A shock to the import prices is likely to lead the export prices to fluctuate by 47.95% after only one month before it increases to 52.78% after 6 months then it goes down to 47.63 after one year. This then means that shocks to the import prices are quickly felt in the export prices especially within 6 months of the shock. However, the effects of the shock will be felt mostly after 6 months then it starts to go down but it is very high within the 6 month period. After 2 years the shocks to the import prices account for 39.13% fluctuations in the export prices.

Although they are not immediately felt, the direct effects of exchange rate changes to export prices play a very big role in the fluctuation of the export prices. A month after the shock, the exchange rate account for a paltry 0.24% change in the export prices but the impact takes a toll increase especially from 6 months up to 24 months. Within a 6

month period export prices fluctuate by 6.76% before they go on a 14.50% fluctuation after 18 months because of an expected shock in the exchange rate. 20.07% is the rate the export prices will fluctuate by when there is a shock to the exchange rate after two years. This makes economic sense because when the rand depreciates we expect the South African exporters to push volumes since those who are importing from South Africa will need less money they needed in previous periods to buy the same quantity of goods and services from South Africa. On the other hand if the rand appreciates, the demand for South African products abroad can decrease because the goods will be expensive as compared to the period during which the rand had appreciated. So, if the exchange rate fluctuates it means that the foreign prices of the South African goods will be forced to change but there are a wide range of things that influence the rate at which these prices change and they range from menu costs, market structure, size of the firm and the level of competition in the foreign market for the South African exporters.

Petrol price shocks cannot be spared when it comes to export price fluctuations since they have a significant contribution to make to the changes in the export prices. One month after a shock in the petrol prices hits the economy, export prices fluctuate by 0.24% and the impact of the shock increases to 6.76%, 14.50% up to 20.07% after 6, 12 and 24 months respectively. It can be observed that the effect of an unexpected shock in the petrol prices increases as times increases. Although its immediate impact is not huge, the fluctuations that are accounted for by a shock to the petrol prices are very significant especially between 6 months to 24 months. Output gap, consumer and producer prices do not make significant contributions to the changes in the export prices. It is an unexpected situation for the producer prices to have that less impact and it is counter to the expectations of the researcher. The producer prices and the import prices were assumed to be big contributors of the changes in export prices but from the results import prices are contributing the most. Unexpected shocks in the Producer prices account for 3.05% after a month but the impact goes down to 1.34% after six months before it goes further down to 0.73% in 12 months' time and 0.58% after 2 years. Although the effect of the shock as if it is immediately felt in the export prices it

is its magnitude which is a worrying factor but the reason could be the fact that producer prices have not been changing much because of the low commodity demand on the world market and the adjustment of the prices especially for a small economy like South Africa not being easy to adjust.

**Table 5.5.7 Variance Decompositions of Cpi**

Month	Gap	LPetr	LNer	LImp	LPPI	LExp	Lcpi
1	0.049859	12.08930	0.509994	7.462778	0.213292	0.222828	79.45195
3	0.885543	10.52094	1.355123	6.094655	0.887275	3.918448	76.33802
6	3.670916	9.275269	5.448824	6.851516	0.442134	8.266873	66.04447
9	5.849393	9.896844	9.137072	4.677520	0.451711	12.55039	57.43707
12	8.026712	10.74619	11.55272	3.286247	0.627021	16.65267	49.10843
15	10.28326	11.58727	12.91464	2.470927	0.883797	20.39127	41.46884
18	12.56960	12.17691	13.50537	2.066469	1.115065	23.44894	35.11764
21	14.86844	12.44859	13.55714	1.951903	1.257844	25.77248	30.14359
24	17.19078	12.42041	13.25392	2.056376	1.298107	27.43853	26.34188

Source: Estimation results

Table 5.5.7 shows the results of the variance decompositions of the consumer prices in South Africa. It is within the researcher's expectations to see that all the variables in the model are contributing to the fluctuations in the consumer prices. Since the model used a recursive approach, all the variables in the model have an effect without them being affected much by the fluctuations of the consumer prices. On the consumer prices the producer prices were expected to have made a mark but from the look of things the producer prices have got a paltry effect of 0.21% after one year, 0.89% after six months, 0.63% in the period up to one year and only an increase to 1.29% after two years. The assumption behind this is either that the producer prices takes time to have an effect in the consumer prices or either the prices are sticky in South Africa especially after the changes in the exchange rate. There is quite a lot of competition amongst the local producers in South African and goods that are coming from abroad. The need for survival in the case of local producers is what might make the prices sticky and not

being passed on much to the consumer prices which means that the consumer and export prices are being shaped by other variables in and outside this model.

The petrol prices appear to be having the highest immediate impact when it comes to fluctuations in the consumer prices. A month after an unexpected shock in the petrol prices, consumer prices respond by 12.09% whilst import prices account for 7.46% in the same period. In the case of petrol prices, their impact on the fluctuations in the consumer prices increase as time goes by. The petrol prices start by having a higher impact then the impact decreases before it starts to increase again. As for the import prices (indirect pass through) it has an immediate cause of fluctuations and then it goes down at an increasing rate. After 6 months petrol prices account for 9.27% fluctuation in the consumer prices whilst import prices contribute a 6.85% fluctuation. After 24 months (2 years) the impact on petrol prices to consumer prices starts to increase again since it accounts for 12.42% a figure that is greater than that at six month and one year. However, the impact of the import price shock although significant, goes down as time goes by from 7.46% after one year to 3.29% in a period up to one year and 2.06% after 2 years.

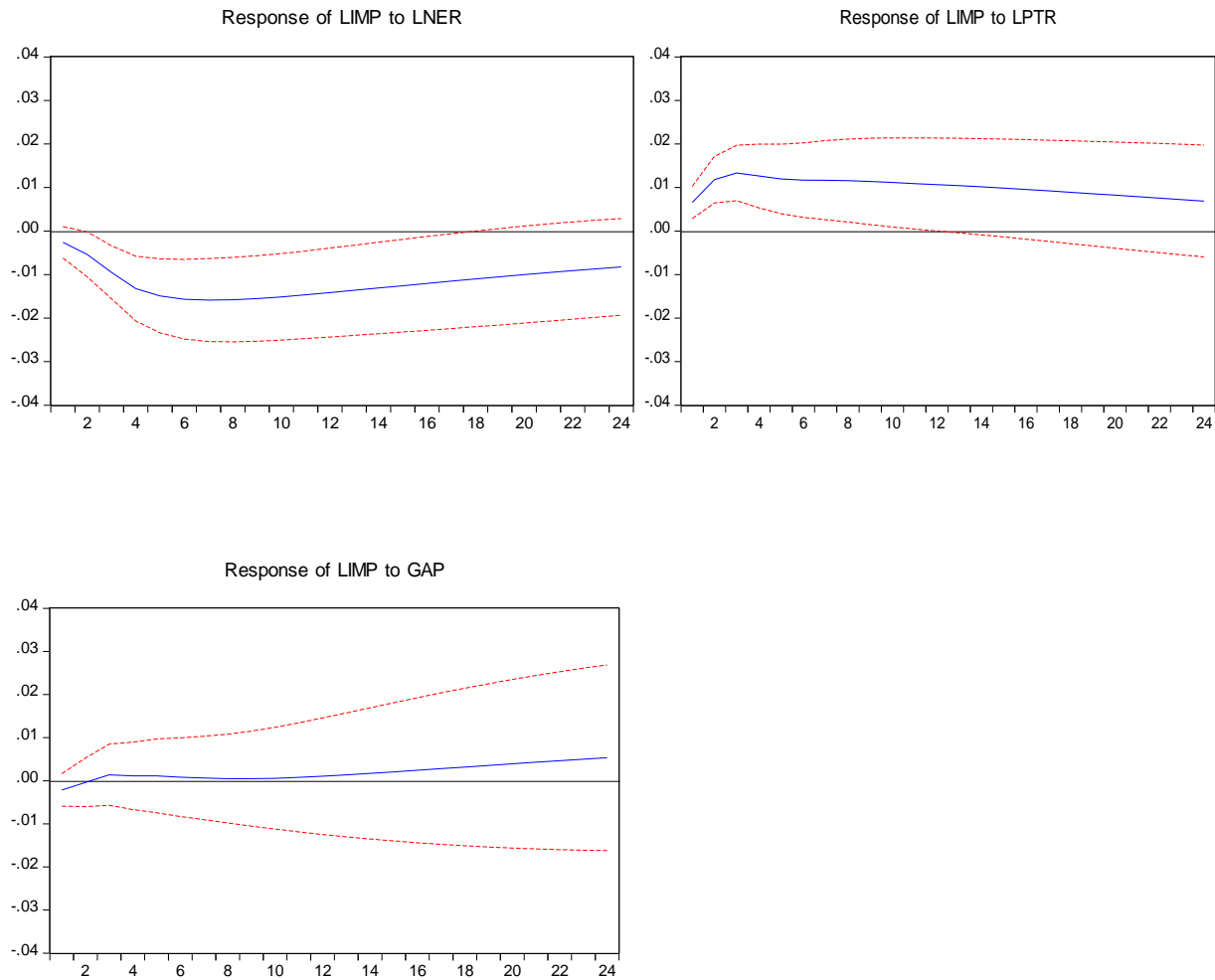
Direct ERPT is significant for consumer price increases as time elapses as can be observed from table 5.5.7 above. As a result of an unexpected shock in the exchange rate, the consumer prices respond by 0.51% after one month before they fluctuate by 1.36% after 3 months. The exchange rate accounts for a 5.49% fluctuation in the consumer prices after 6 months then by 11.55% after a period of 12 months (1 year). It can be observed that the effect of the shock increases as time increases. In the 24<sup>th</sup> month, the fluctuations in the consumer prices as a result of a shock to the exchange rate rise 13.25%. This confirms previous work of previous researchers on South Africa as they have also seen the effects of exchange rate changes to consumer prices at around the same range for example Razafimahefa, (2012), Rigobon, (2007) and Aron, et al. (2014) who found ERPT to CPI as 12%, 13% and 10% respectively.

The output gap's impact after one month on the fluctuations in the consumer prices is highly insignificant with only 0.05% changes in the consumer prices accounted for by the shock in the output gap. However, as expected by the researcher, the impact of the output gap on prices is not something that is expected to be felt by the consumer prices instantly but after some time and if the gap continues to narrow or when the economy is near full employment. The impact of the output gap can start to be felt by the economy through consumer price fluctuations after 12 months when a shock to the output gap accounts for 8.03% before the impact increases to 17.19% after 24 months. It is not surprising to see the way how the consumer prices respond to shocks in the output gap because prices do not respond immediately to the growth of the economy but after some time like 1 year or 2 years. In the same way as the consumer prices respond to the output gap, the impact of export price shock on consumer prices is not felt immediately by the South African economy's consumer prices. One month after a shock in the export prices, the consumer prices fluctuate by 0.22% before the shock accounts for 3.91% after 3 months. The impact of the exports on the economy is an increase in money supply and growth to the economy and that is inflationary to the economy. If the net exports increase, that can boost the growth of the economy and the growth of the economy means more production and assuming wage increases that will stimulate high demand. After 6 months the shock accounts for 8.27%, 16.65% after 12 months before the impact of the shock increase to 27.44% after 24 months.

### **5.9 Impulse response functions**

In this section we analyse the impulse response of import prices, producer, export and consumer prices to an unexpected shock in the system. Impulse responses identify the responsiveness of the endogenous variables in the VAR when a shock is put to the error term such as  $u_1$  and  $u_2$  on the equations in the system (Ngalawa, 2009). A unit shock of the exchange rate is applied to each of the above mentioned variables to see its effect on the VAR system. According to McCarthy (2000), in the calculations of the impulse response functions, ordering of the variables is important and this study has adopted the Cholesky degrees of freedom that are adjusted in Eviews 9.5.

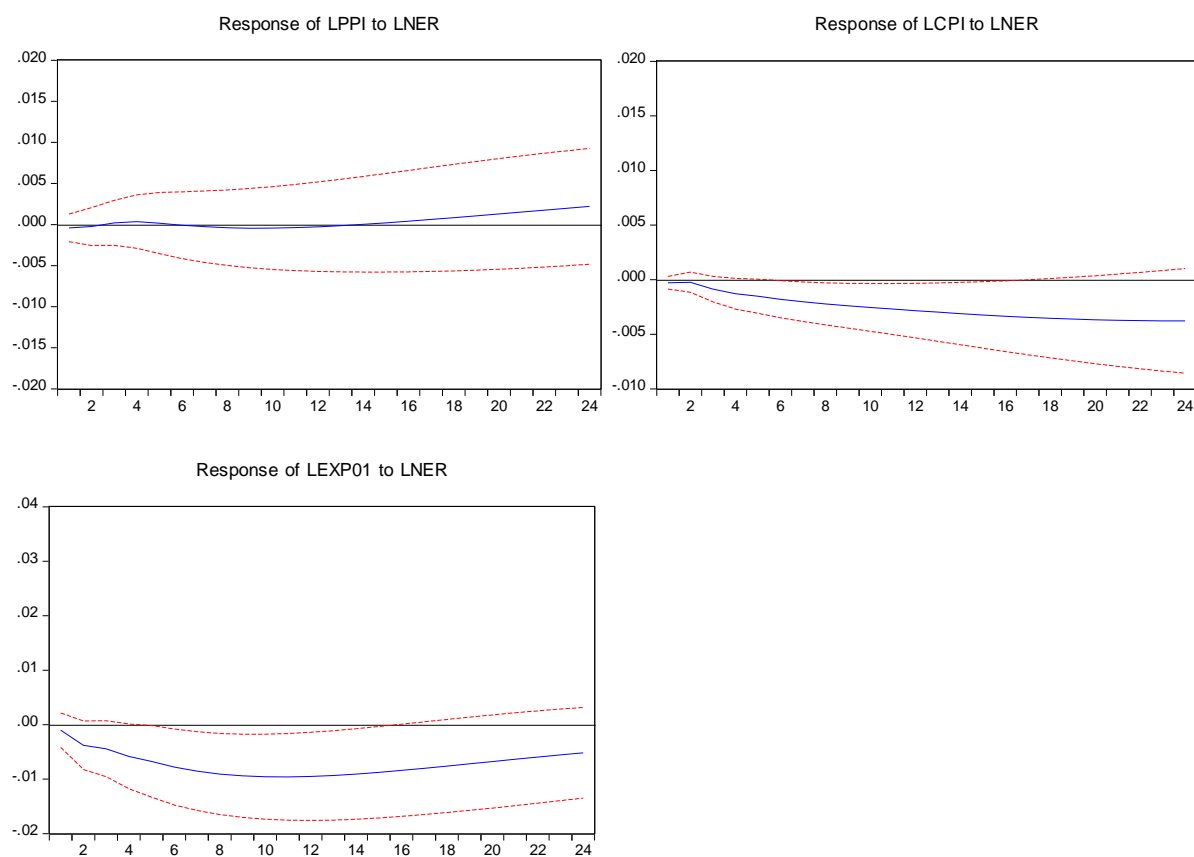
**Fig 5.3 Response of import prices**



The above figure shows the response of import prices to shocks in the exchange rate, output gap and petrol prices. On the horizontal axis is the time scale in months up to 24 months and the dashed lines are analytic confidence intervals that were obtained from variance-covariance matrices after the final iteration. An unexpected shock in the exchange rate corresponding to an unanticipated 1 percent change in the exchange rate is not immediately felt by the import prices in the South African economy. The shock is mostly felt between 4 to 6 months then its impact become less and less as time goes by. This means that the import prices respond to exchange rate changes with a

lag. Import prices respond positively after a shock in the petrol prices also showing no immediate response. The petrol price shock is mostly felt by the import prices between 2 to 4 months then its impact goes down with time. There is an immediate negative response in the import prices as a result of an unexpected shock in the output gap between 0 to 2 months. In the fourth month is when the import prices respond positively to a shock in the petrol prices. Import prices respond positively at an increasing rate from the 10<sup>th</sup> month onwards.

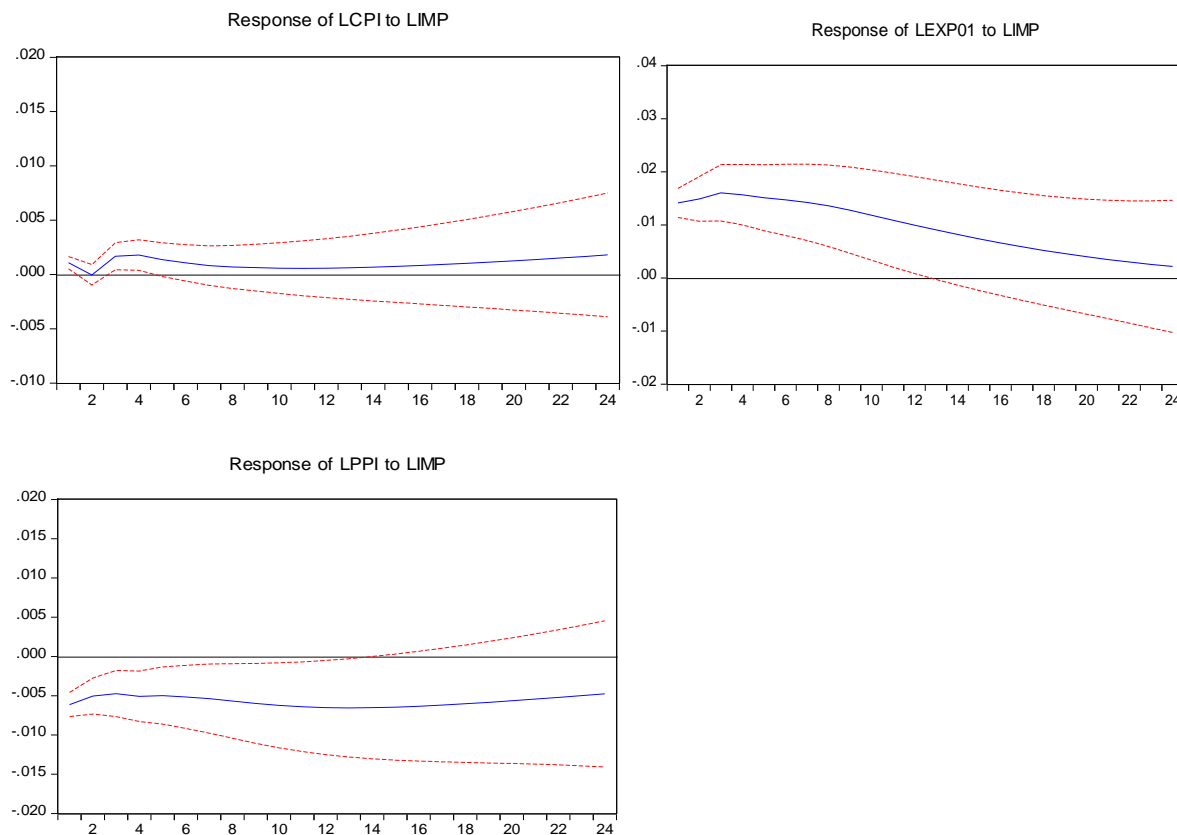
**Fig 5.4 Response of other price variables to an exchange rate shock**



From figure 5.4 shows the responses of the consumer, export and producer prices after a shock to VAR coming from the exchange rate. Producer prices show a sluggish response to exchange rate changes after a few months. It starts to respond positively from the 16th month onwards. Consumer and export prices show a contemporaneous response to the shock in the VAR. The impact of the shock is felt most after a year and

after that the impact slows down. Although consumer prices show a contemporaneous response to exchange rate prices, the impact is greater after a year and keeps on increasing.

**Fig 5.5 Response of export, producer and consumer prices to an import shock**



The impact of an unexpected import price shock down the pricing chain is immediately felt by the producer prices and the export prices with the impact fading away after 2 years in the export prices. Producer prices show a constant negative response with the shock felt considerably after one year but then the impact goes down with time at a constant rate. Consumer prices respond sluggishly to a shock in the VAR coming from the import prices. The shock will increasingly be felt in the consumer prices after a year (12 months) as it goes on increasing with time.



## **5.10 Structural VAR results analysis**

The ordering of the variables in this estimation was non-recursive and the restrictions that produced the impulse responses were done using the theoretical understanding of the causation among the variables. The ordering were done in the following manner ;petrol prices (shock 1), import prices (shock 2), output gap (shock 3), producer prices (shock 4), consumer prices (shock 5), export prices (shock 6) and exchange rate( shock 7). This section will just focus on the responses of price variables to an exchange rate shock and the response of price variables to an import price shock comparing them with the ones under a recursive VAR.

### **5.10.1 Identification assumptions**

- Industrial production and inflation of the small open economies is deeply impacted by the world or outside shocks
- Output and prices do not respond contemporaneously to changes in domestic monetary policy variables.
- Production responds to domestic price and exchange rate with a lag
- Inflation is affected by world shocks and the current state of the industrial production
- Exchange rate is one of the most volatile variables in the model and is quick to react to almost all shocks be they from outside or inside, nominal or real
- Every variable in the model is affected by the petrol price shocks

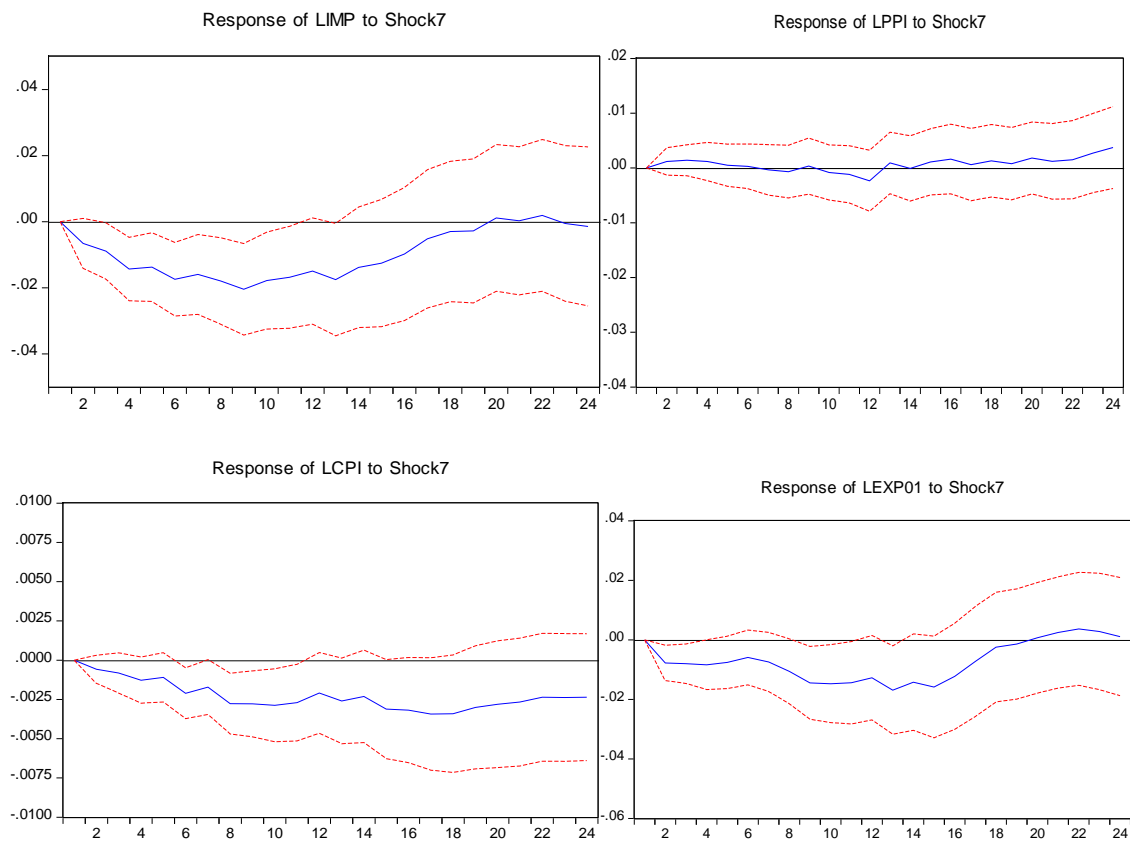
The assumptions above were adapted from the work of Ngalawa (2011) in his paper on monetary transmission mechanism for Malawi. The reseacher added some assumptions that are appropriate for South Africa.

Restrictions made to the SVAR according to the above mentioned assumptions:

$$A = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ C_1 & 1 & 0 & 0 & 0 & 0 & C_{18} \\ C_2 & 0 & 1 & C_{10} & C_{13} & 0 & 0 \\ C_3 & C_7 & 0 & 1 & 0 & C_{16} & 0 \\ C_4 & 0 & 0 & C_{11} & 1 & 0 & 0 \\ C_5 & 0 & 0 & 0 & C_{14} & 1 & 0 \\ C_6 & C_8 & C_9 & C_{12} & C_{15} & C_{17} & 1 \end{pmatrix} \quad \varepsilon_t = \begin{pmatrix} \varepsilon_t^{gap} \\ \varepsilon_t^{ptr} \\ \varepsilon_t^{ner} \\ \varepsilon_t^{cpi} \\ \varepsilon_t^{imp} \\ \varepsilon_t^{ppi} \\ \varepsilon_t^{exp01} \end{pmatrix}$$

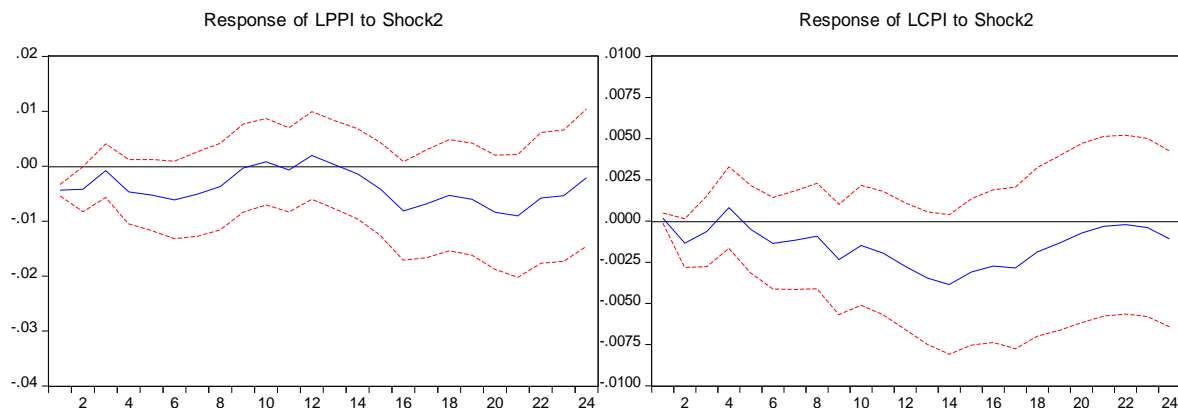
Matrix B was just an identity matrix just like in the Recursive VAR situation

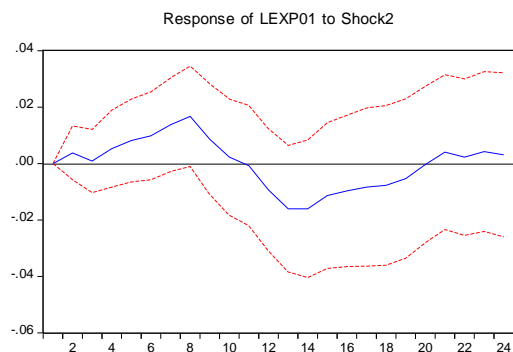
**Fig 5.6 Impulse responses of import, Producer, export and consumer prices to an exchange rate shock**



Drawing an analysis from the results from the non-recursive VAR, the impulse responses of the import prices do not look much different from those of the recursive VAR, the only difference being that, the impact moves more quickly from negative to positive than it does under the recursive estimation. In the recursive it comes back steadily but never comes back to zero but under the non-recursive it comes to zero after 20 months. This means that the identification of the shocks under the non-recursive is a bit strict and tight as compared to the sluggish response shown under the non-recursive. The impact of an unexpected shock in the VAR to consumer prices according to figure 5.6 is also not different from the recursive because it behaves in the same for 2 years and fluctuates in the same manner. The only difference noticed between the responses of consumer prices to an exchange rate shock is that under the non-recursive the consumer prices fluctuate a lot but look steady and calm in the recursive estimation for the entire 2 years. Looking at the impact of the exchange rate shock to the export prices, under the recursive the impact looks steady and negative for the entire period of 2 years but under the non-recursive identification the impact quickly comes back to positive after 20 months and stays positive above zero with time.

**Figure 5.7 Response of export, consumer and producer prices to an import price shock**





Producer prices and import prices are expected to have a positive relationship. As import prices go up because of exchange rate depreciations, the producer prices will also respond by going up. However, that situation has not been happening across the globe especially in the context of exchange rate pass through. Producers were not very willing to pass through the changes of sudden exchange rates to their customers mainly because of low commodity demand across the globe. The response of the producer prices to a shock in the import prices is slightly different for the two estimations. Although having a negative response for both estimations in the first 10 months, under non-recursive it fluctuates more than it does under recursive. Between 10 months and 14 months the impact fluctuates between zero and positive before it goes back to negative and fluctuates back to positive in periods after 24 months. This means that the adjustment of producer prices does not respond instantly to changes in import prices but they will adjust when the producers have seen that the depreciation is persistent. Under the recursive, it looks like coming back to positives but it does that sluggishly meaning it will take more than 2 years to come to positive.

There is a difference in the way the consumer prices are impacted by a shock to the import prices under both estimations. Under the recursive, the impact is positive throughout the entire period of 24 months meaning that the consumer prices do not take time to respond to changes in the import prices. The impact of the shock or the response to the import price shock is small under the recursive estimation whilst it is bigger and positive though volatile under the non-recursive. Export prices follow the pattern of the export prices in the sense that the pricing by the firms does not happen

instantly but the exporters wait and see if the fluctuation in the import prices caused by exchange rate fluctuations is a one-time depreciation or appreciation before they respond positively to changes in import prices after 20 months falling into 2 years.

### 5.11 Variance decompositions

**Table 5.5.8: Comparative variance decompositions**

Direct ERPT (Non-recursive)					Direct ERPT (recursive)			
IMP to NER	PPI to NER	CPI to NER	EXP to NER	Months	IMP to NER	PPI to NER	CPI to NER	EXP to NER
1.63	18.47	2.06	0.01	<b>1</b>	1.14	0.14	0.51	0.24
1.68	27.60	2.91	0.43	<b>3</b>	6.28	0.08	1.35	2.71
1.07	30.87	2.82	1.56	<b>6</b>	17.27	0.05	5.44	6.76
1.74	26.87	2.06	3.20	<b>12</b>	27.54	0.07	11.55	14.50
13.29	15.16	12.38	8.20	<b>24</b>	31.30	0.52	13.25	20.07

SOURCE: Estimation results

Under the non-recursive SVAR, the response of the import prices to a shock in the VAR coming from the exchange rate is sluggish with the import prices responding with 1.63% one month after the shock. The situation does not increase up to the 15<sup>th</sup> month where import prices fluctuate by 1.59% before the shock starts to be significantly felt in the economy when it fluctuates by 6.13% after 18 months, 11.77% after 21 months and finally by 13.29% after 2 years or 24 months. This then means that the import prices also respond slowly after a change in the exchange rate. With the way the rand devaluated with in the covered period between 2002 and 2015, the import prices were expected to have fluctuated with a huge margin but things did not happen like that. The argument behind such kind of developments is attributed to the structure of the South African economy which has an oligopolistic kind of set up. So it is not easy for prices to just change. Also, the issue of competition in other importing sectors can cause the prices to become sticky and then adjust later when the impact of the shock is insistent in the economy.

The Variance decompositions of the producer prices to a shock in the exchange rate show an instant significant fluctuation in the first month after the shock with a 18.47% , fluctuation. The producer prices fluctuate most after 6 months, fluctuating by 30.87% before the impact goes down to 26.87% after one year then the effect on the economy is steadily lessened and after 2 years the fluctuation is reduced by 15.16%. The response of the producer prices after an exchange rate shock is consistent with the expectation of the researcher because the producers are significantly affected by the value of the foreign currency when the rand depreciates. Producers bring in intermediate goods from the international market in order to produce and that is how their prices are affected.

Consumer prices slowly respond to an exchange rate shock in the first 15 months after the shock. However, the weight of the impact starts to increase 18 month the exchange rate shock. The impact is almost constant in the first year of the shock with the fluctuations not exceeding 3% for the entire year. The consumer prices are expected to behave in that manner because they are not really affected directly by the exchange rate. Their fluctuations are mostly caused by the shocks in the import prices and the producer prices. Also the export prices behave in the same way as the consumer prices are responding. They start by responding by a very small and slow fluctuation until after 9 months of the shock. From the 1<sup>st</sup> month to the 9<sup>th</sup> month after the shock, the fluctuation of the export prices does not exceed 2% before the impact of the exchange rate starts to increase in the 12<sup>th</sup> month fluctuating by 3.20%. Although the impact of the shock is bigger after 2 years, it shows that the exporters are not going to quickly adjust their prices as soon as the rand depreciates. The pricing system in the world market is determined by a wide range of factors that include menu costs, competition, the Chinese effect and the low world commodity prices that have been hampering the dreams of many economies when it comes to export led growth. It is either business settle for something less than getting nothing on the international market, hence adjusting prices is not easy.

In the second stage exchange rate pass-through for South Africa, Aron et al., (2014) assert that the producer prices are expected to have a higher pass through followed by either export prices or the consumer prices. However, from the results harvested from the non-recursive SVAR it looks like the empirical wisdom is defied as time goes. In the first month after the shock the expected trend is followed by the variables as we see the producer fluctuating by 1.71%, consumer prices fluctuate by 0.19% and finally, the export prices responding by 0.005%. As time went on the trend is broken because after 12 months the producer prices respond by 4.36%, export prices fluctuate by 32.17% and consumer prices become volatile by 42.92%. After 24 months the pattern does not change its structure but the impact of the shock increases with time for export and consumer prices and the producer prices are slow in their fluctuation with 4.22% response, 31.07% for export prices and a fluctuation of 51.61% for consumer prices. This is assumed to be caused by the fact that producer prices are sluggish in responding to anything to do with exchange rate volatilities. Also the justification for the consumer price behaviour is assumed to be high percentage of goods and services that respond significantly to changes in the exchange rate via the changes in the import prices.

In the first stage or direct ERPT, the import prices look sluggish within 12 months after the exchange rate shock in the non-recursive regime with the impact of the shock causing a lot of fluctuation after 18 months. However, under the recursive estimation the fluctuations after 3 months are quite significant and the impact of the shock is showing higher pass through under recursive although not complete. So there is a similar pattern being followed by the import prices in both estimations just that the impact of the shock is felt faster under the recursive approach.

The direct ERPT on the producer prices responds insignificantly under the recursive regime with the fluctuations insignificant, but it is shocking to observe that under the non-recursive the identification of the ER shock to the producer prices is very high and significant although not too volatile and the ERPT for producer prices is incomplete for both estimations though higher under the non-recursive regime.

The export prices show a pattern of response to the exchange rate shock similar to that of the import prices. They respond sluggishly in the first few months after the shock and then have a bigger impact later i.e. after 6 months under recursive and after 18 months in the other estimation.

On the other hand the consumer prices' response to the exchange rate shock in the VAR was completely the opposite. The fluctuation as a result of the shock is huge in the first few months under the recursive with the impact felt smaller and smaller as time went by unlike the situation under the non-recursive identification where the impact is small within the first few months before it grows in the later months for example after 18 months.



## CHAPTER 6

### SUMMARY, CONCLUSION AND POLICY RECOMENDATIONS

#### 6.1 Summary of findings and conclusion

This research has focussed on the exchange rate pass-through in South Africa which is the extent to which the changes of fluctuations in the exchange rate are fed into the domestic price level. The channel of the exchange rate into the domestic prices is assumed to go through the import prices then down the pricing chain until it reaches the consumer prices. The measures of pass-through are important to the South African economy for a number of reasons. The Reserve Bank or the monetary authorities see the exchange rate as one of the major channels of the monetary transmission mechanism. Exchange rate changes can be problematic to domestic prices especially for small open economies with floating exchange rate regimes such as South Africa. It is of paramount importance for the Reserve Bank to make an assessment of the extent to which the domestic prices are being affected by the exchange rate. A large pass-through associated with high wages and persistent supply shocks would cause a serious problem on the conduct of the monetary policy and that would require some form of interference on the exchange. Currently the focus of the monetary policy for South Africa is inflation targeting with a 3-6% band and the Reserve Bank is finding it difficult to curb inflation from deviating outside the upper band.

This research found an incomplete pass through for all price variables as reported from the estimation of the recursive VAR (Cholesky decomposition) and SVAR (structural decomposition). Although the results have not shown the pattern that is commonly seen in the literature, the import prices respond to exchange rate changes with a bigger magnitude than all the price indices and this is consistent with the ERPT literature. The fluctuations caused by the exchange rate changes to consumer prices are not as low as expected especially under inflation targeting 12.38% for SVAR and 13.25% for recursive VAR and this is evidenced by the inflation that is always in the top band of the target

and outside the band for some other months. Although not high in the first stage and second stages, the pass through to consumer prices is fast and persistent. These results are consistent with some other researches like Nogueira Junior (2007) and (Parsley 2012). The behaviour of the producer prices has shown to be responding sluggishly to changes in the exchange rate, which is argued to be a reflection of the competition in the domestic market and the oligopolistic nature in some of the markets in South Africa. Also the inflation targeting regime causes the monetary policy to be tight in some instances, with some agents in the economy having very low inflation expectations. Another argument might be the replacement or substitution of the foreign goods that were used in the local production by those that are locally produced. There are a lot of things that have been happening in the South African economy that are not consistent with economic theory. These include the failure of the South African economy to benefit from the extremely depreciated rand compared to trading partners; the economy remained with a balance of payments deficit which recurred for a number of years. That is also evidenced by the low and inconsistent export price changes after exchange rate fluctuations. The export prices respond very slowly, something which is pinned on the argument that there is low world commodity demand, so no matter how depreciated the rand is, the demand for the South African produced goods may still be low. That makes the adjustment of prices very discouraging so the exporters do not respond quickly to the exchange rate changes but maybe only after 6 to 8 months up to 24 months.

In the second stage of the pass through (from import to producer and consumer prices), the trend shown by the results under the recursive VAR validates the trend that is known in the ERPT literature. This means that the impact of the import price shock impacts the producer prices more than it does to the consumer prices. The pass through to producer prices is 21.09% whilst that of consumer prices is 2.05%.

## **6.2 Policy Implications and Recommendations**

The pressure from the depreciating rand on prices is causing a significant contribution to the average inflation in the country. However, several policy issues can be derived

from the findings of this study. First, monetary policy authorities in South Africa need to keep track of the contribution of the exchange rate volatilities on prices. Although the Inflation targeting framework succeed during the early years from its inception, the past 3 years have seen inflation in the upper band and outside the stipulated band for most parts of the year. This means that targeting inflation is currently not really working and the target is frequently missed. In the event that the current situation persists the following suggestions should be considered by the policy makers. The suggestions are that, either they need to scale up the band a bit to the right potential of the economy although this can have effects on the inflation expectations from the agents but the fact that the band is being missed is a worrying factor.

Also, the bank needs to extend its objectives from solely price stability but also to exchange rate stability since it is evident that targeting inflation only is not really of much help to the South African situation right now. If the Bank could adopt a managed float, that could help to stabilise the exchange rate and prices since it is evident enough that exchange rate changes are contributing highly to inflation. Achieving exchange rate stability will enable businesses to plan and when circumstances are certain in an economy most sectors can respond positively and the economy can attain some significant growth patterns.

### **6.3 Limitations to the study**

The main limitation to this study is the use of aggregated data and this might be one of the reasons why the impulse response functions are a quite weak. The research could have obtained better results if disaggregated data was used. Also the research covered a small sample period mainly because the objective was to cover the inflation targeting regime but if a large sample size was used the VAR framework could have produced better results.

### **6.4 Areas for Future and Further Research**

The study analysed the pass-through of exchange rate changes to import, producer, export and consumer prices in South Africa. However, the variables used were in

aggregate terms leaving a gap for disaggregated data. It has been argued that the import prices respond highly to exchange rate changes but it is not yet known which specific goods respond most to changes in the import basket. Also in the consumer price level basket, there are certain items like meat, bread and cereal, electricity that are thought to cause more trouble in terms of inflation but the magnitude of their contribution to headline inflation is not yet known.

## Reference List

- Amisano, G. and C. Giannini (1997). "Topics in Structural VAR Economics." Berlin et. al.
- Akinboade, O., et al. (2002). "The Dynamics of Inflation in South Africa: Implications for Policy\*(1)." *South African Journal of Economics* **70**(3): 213-223.
- Areosa, W. and M. Areosa (2012). "The Signaling Effect of Exchange Rates: pass-through under dispersed information." Available at SSRN 2126626.
- Aron, J., et al. (2014(a)). "Exchange rate pass-through to import prices, and monetary policy in South Africa." *Journal of Development Studies* **50**(1): 144-164.
- Aron, J., et al. (2014(b)). "Exchange rate pass-through in developing and emerging markets: A survey of conceptual, methodological and policy issues, and selected empirical findings." *Journal of Development Studies* **50**(1): 101-143.
- Aron, J., et al. (2014). "Exchange rate pass-through in developing and emerging markets: A survey of conceptual, methodological and policy issues, and selected empirical findings." *Journal of Development Studies* **50**(1): 101-143.
- Asteriou, D. and S. Hall (2007). "Applied Econometrics: a modern approach, revised edition." China: Palgrave Macmillan.
- Atkeson, A and Burstein, A.(2008). Pricing to market, trade costs and international relative prices." Staff report 404. Federal Reserve Bank of Minneapolis.
- Bailliu, J. and Fujii. E (2004). "Exchange rate pass-through and the inflation environment in industrialized countries: an empirical investigation."
- Bandit.O.T and Razafindrabe.T, (2014). Exchange rate pass-through to import prices in the Euro-area: A multi-currency investigation. *International Economics*138(2014)63–77
- Barhoumi, K. (2008).Differences in the longrun exchange rate pass-through into import prices in developing countries.JEL Classification: F14, C13, C23.
- Bell, T. (1993). "The impact of sanctions on South Africa." *Journal of Contemporary African Studies* **12**(1): 1-28.
- Bell, T. and G. Farrell (1997). "The minerals-energy complex and South African industrialisation." *Development Southern Africa* **14**(4): 591-613.

Belke, A. and R. Czudaj (2010). "Is euro area money demand (still) stable? Cointegrated VAR versus single equation techniques." *Applied Economics Quarterly* **56**(4): 285-315.

Bernanke, B. S. and I. Mihov (1997). "What does the Bundesbank target?" *European Economic Review* **41**(6): 1025-1053.

Bhundia, A. (2002). "An empirical investigation of exchange rate pass-through in South Africa." *Journal of development economics* **56**(2):78-98

Bonato, M. L. and M. A. Billmeier (2002). Exchange rate pass-through and monetary policy in Croatia, International Monetary Fund.

Borys, M. M., et al. (2009). "The effects of monetary policy in the Czech Republic: an empirical study." *Empirica* **36**(4): 419-443.

Brischetto, A. and G. Voss (1999). A structural vector autoregression model of monetary policy in Australia, Citeseer.

Bussiere, M and Peltonen, T, (2008). Exchange Rate Pass-through in the Global Economy, The Role of Emerging Market Economies. Bank of Finland Discussion Paper No. 25.

Bussière, M., et al. (2014). "Exchange rate pass-through in the global economy: the role of emerging market economies." *IMF Economic Review* **62**(1): 146-178.

Campa, J. M. and Goldberg. L (2005). "Exchange rate pass-through into import prices." *Review of Economics and Statistics* **87**(4): 679-690.

Cassim, R., et al. (2004). The state of trade policy in South Africa, Trade and Industrial Policy Strategies (TIPS)

Cheng, M. K. C. (2006). A VAR Analysis of Kenya's Monetary Policy Transmission Mechanism: How Does the Central Bank's REPO Rate Affect the Economy?, International Monetary Fund.

Choudhri, E. U. and D. S. Hakura (2015). "The exchange rate pass-through to import and export prices: The role of nominal rigidities and currency choice." *Journal of International Money and Finance* **51**: 1-25.

Cottrell, A. and R. Lucchetti (2004). Gnu regression, econometrics and time-series library–Gretl, Accessed on [<http://gretl.sourceforge.net>].

Donayre, L. and Panovska. I (2016). "State-dependent exchange rate pass-through behavior." *Journal of International Money and Finance* **64**: 170-195.

Dornbusch, R. (1987). "Collapsing exchange rate regimes." *Journal of Development Economics* **27**(1): 71-83.

Dickey, D. A. and W. A. Fuller (1979). "Distribution of the estimators for autoregressive time series with a unit root." *Journal of the American statistical association* **74**(366a): 427-431.

Dickey, D. A. and W. A. Fuller (1981). "Likelihood ratio statistics for autoregressive time series with a unit root." *Econometrica: Journal of the Econometric Society*: 1057-1072.

Dungey, M. and A. Pagan (2000). "A structural VAR model of the Australian economy." *Economic record* **76**(235): 321-342.

Edwards, L and Lawrence, R. Z. (2006). *South African Trade Policy Matters: Trade Performance and Trade Policy*. NBER Working Paper Series No. 12760.

Edwards, L. J. and R. Garlick (2008). "Trade flows and the exchange rate in South Africa."

Ehrmann, M., et al. (1998). "The ABC maltose transporter." *Molecular microbiology* **29**(3): 685-694.

Enders, C. K. (2010). *Applied missing data analysis*, Guilford Press.

Enders, W. and T. Sandler (2004). "What do we know about the substitution effect in transnational terrorism." *Researching terrorism: Trends, achievements, failures* **119**: 137.

Engle, R. F. and C. W. Granger (1987). "Co-integration and error correction: representation, estimation, and testing." *Econometrica: Journal of the Econometric Society*: 251-276.

Gaulier, G., et al. (2006). "Structural determinants of the exchange-rate pass-through." *CEPII Documents de Travail* **3**.

Ghardach, J. (2014). *The exchange rate pass through to import prices for developing countries*. Munich Personal RePEc Archive. Online at <http://mpra.ub.uni-muenchen.de/64938/>

Ghosh, A. And Rajan, R., (2006). *Exchange Rate Pass-Through in Asia: What does the Literature tell us?* Unpublished report for the APEA Conference. Seattle: University of Washington.

Ghosh, A. and R. S. Rajan (2009). "Exchange rate pass-through in Korea and Thailand: Trends and determinants." *Japan and the World Economy* **21**(1): 55-70.

Gomez et al., (2012) "Net ecosystem exchange modifies the relationship between the autotrophic and heterotrophic components of soil respiration with abiotic factors in prairie grasslands." *Global Change Biology* **18**(8): 2532-2545.

Gottschalk, J. (2001). "Kiel Institute of World Economics."

Gopinath, G., & Itskhoki, O. (2010). Frequency of price adjustment and pass-through. *Quarterly Journal of Economics*, 125(2), 675–727.

Guillermo S. B. and Rodríguez. B (2014). "Analyzing the Exchange Rate Pass-through in Mexico: Evidence Post Inflation Targeting Implementation." *Ensayos sobre Política Económica* **32**(74): 18-35.

Granger, C. W. (1969). "Investigating causal relations by econometric models and cross-spectral methods." *Econometrica: Journal of the Econometric Society*: 424-438.

Gujarati, D. (2004). *Basic Econometrics*. United States Military Academy, West Point, Tata McGraw-Hill.

Harris, R. and R. Sollis (2003). *Applied time series modelling and forecasting*, Wiley.

Harris, R. I. (1995). "Using cointegration analysis in econometric modelling."

Hyder, Z. and Shah S (2004). Exchange rate pass-through to domestic prices in Pakistan, *EconWPA*.

Hüfner, F. P. and Schröder M (2002). "Exchange rate pass-through to consumer prices: A European perspective."

<http://reports.weforum.org/global-competitiveness-report-20142015/economies/#economy=ZAF>

Ibrahim O and Erden L (2015). Time-varying nature and macroeconomic determinants of exchange rate pass-through. *International Review of Economics and Finance* 38 (2015) 56–66

International Monetary Fund (IMF) (2016). *World Economic Outlook: Recovery Strengthens, Remains Uneven* (April 2016). Washington: IMF.

Ito, T., Sasaki, Y. And Sato, K., (2005). Pass-Through of Exchange Rate Changes and Macroeconomic Shocks to Domestic Inflation in East Asian Countries. Discussion papers 05020, Research Institute of Economy, Trade and Industry. [On-line] Available: <http://ideas.repec.org/p/eti/dpaper/05020.html> [Accessed 11 May 2006].



Jacob, U, (2015). "Low Inflation Pass-Through and Pricing Power of Firms". *European Economic Review*, Vol. 44, pp. 1389–1408.

Jacob, P. and L. Uusküla (2016). "Deep habits and exchange rate pass-through."

Johansen, S. (1988). "Statistical analysis of cointegration vectors." *Journal of economic dynamics and control* **12**(2): 231-254.

Johansen, S. (1992). "Testing weak exogeneity and the order of cointegration in UK money demand data." *Journal of Policy modeling* **14**(3): 313-334.

Johansen, S. and K. Juselius (1990). "Maximum likelihood estimation and inference on cointegration—with applications to the demand for money." *Oxford Bulletin of Economics and statistics* **52**(2): 169-210.

Johansen, S. and K. Juselius (1994). "Identification of the long-run and the short-run structure an application to the ISLM model." *Journal of Econometrics* **63**(1): 7-36.

Jonsson, G. and A. Subramanian (2001). "Dynamic gains from trade: Evidence from South Africa." *IMF Staff Papers* **48**(1): 197-224.

Jooste, C. and Y. Jhaveri (2014). "The Determinants of Time-Varying Exchange Rate Pass-Through in South Africa." *South African Journal of Economics* **82**(4): 603-615.

Kabundi, A. and Schaling, E (2013). "Inflation and inflation expectations in South Africa: an attempt at explanation." *South African Journal of Economics* **81**(3): 346-355.

Kadane, J. B., et al. (1996). "Priors for unit root models." *Journal of Econometrics* **75**(1): 99-111.

Kara, A. and Nelson, E (2003). "The exchange rate and inflation in the UK." *Scottish Journal of Political Economy* **50**(5): 585-608.

Karoro, T. D., et al. (2009). "EXCHANGE RATE PASS-THROUGH TO IMPORT PRICES IN SOUTH AFRICA: IS THERE ASYMMETRY? 1." *South African Journal of Economics* **77**(3): 380-398.

Kiptui, M., et al. (2005). "Exchange Rate Pass-Through: To What Extent Do Exchange Rate Fluctuations Affect Import Prices and Inflation in Kenya?" *Policy Discussion Paper* **1**.

Koop, G. and D. Korobilis (2013). "Large time-varying parameter VARs." *Journal of Econometrics* **177**(2): 185-198.

Korap, L. (2007). Impact of exchange rate changes on domestic inflation: the Turkish experience. *Journal of development economics* **14**(2):34-60

Knetter, M. M. (1994). "Is export price adjustment asymmetric?: evaluating the market share and marketing bottlenecks hypotheses." *Journal of International Money and Finance* **13**(1): 55-70.

Lafèche, T (1996). The Impact of Exchange Rate Movements on Consumer Prices. *Bank of Canada Review* (Winter), pp. 21-32.

Lütkepohl, H. and D. S. Poskitt (1991). "Estimating orthogonal impulse responses via vector autoregressive models." *Econometric Theory* **7**(04): 487-496.

Lütkepohl, H. and J. Wolters (1998). "A money demand system for German M3." *Empirical Economics* **23**(3): 371-386.

Maddala, G. S. and K. Lahiri (2009). *Introduction to econometrics*, Wiley.

Marks, S. and S. Trapido (2014). *The politics of race, class and nationalism in twentieth century South Africa*, Routledge.

Marston, R. C. (1990). "Pricing to market in Japanese manufacturing." *Journal of International Economics* **29**(3): 217-236.

Mboweni, T. (2003). African economic integration. Address to the 5th Annual African Development Finance Conference.

McCarthy, J. (2000). "Pass-through of exchange rates and import prices to domestic inflation in some industrialized economies." *FRB of New York Staff Report*(111).

Mihaljek, D. And Klau, M. (2008). *Exchange Rate Pass-Through in Emerging Market Economies: What Has Changed and Why?* BIS Papers, Bank for International Settlements, Number 35.

Mirdala, R. (2014). "Exchange Rate Pass-through to Consumer Prices in the European Transition Economies." *Procedia Economics and Finance* **12**: 428-436.

Mirdala, R. (2015). *Exchange Rate Pass-Through in the Euro Area*. MPRA Paper No. 68862, posted 17 January 2016 05:41 UTC

Mishkin, F. S. (2009). "Globalization, macroeconomic performance, and monetary policy." *Journal of Money, Credit and Banking* **41**(s1): 187-196.

Mwase, N. (2006). An empirical investigation of the exchange rate pass-through to inflation in Tanzania, International Monetary Fund.

Neiman, B. (2007). Exchange Rates and Prices: The Case of Australian Manufactured Imports. Unpublished course notes in Economics and Management Systems 433. Berlin: Springer.

Nell, K. S. (2000). Imported inflation in South Africa: An empirical study, University of Kent, Department of Economics.

Ngalawa, H. P. (2009). "paper presented at the 14th Annual Conference of the African Econometric Society, 8-10 July 2009, ". Dynamic effects of monetary policy shocks in Malawi," Abuja, Nigeria.

Nogueira Junior, R. P. (2007). "Inflation targeting and exchange rate pass-through." *Economia Aplicada* **11**(2): 189-208.

Nogueira, R. and M. Leon-Ledesma (2008). Exchange rate pass-through into inflation: The role of asymmetries and nonlinearities, School of Economics, University of Kent.

Nusrate, M., et al. (2013). "Exchange rate pass-through to external and internal prices: A developing country perspective." *The Journal of Applied Business and Economics* **15**(3): 128.

Oyinlola, M. A. and Babatunde. M (2009). "A bound testing analysis of exchange rate pass-through to aggregate import prices in Nigeria: 1980-2006." *Journal of Economic Development* **34**(2): 97.

Ouliaris, S., et al. (2016). "Quantitative Macroeconomic Modeling with Structural Vector Autoregressions—An EViews Implementation."

Ozkan, I. and Erden L (2015). "Time-varying nature and macroeconomic determinants of exchange rate pass-through." *International Review of Economics & Finance* **38**: 56-66.

Park, S.-H. (1992). "Decomposition of industrial energy consumption: an alternative method." *Energy Economics* **14**(4): 265-270.

Parsley, D. C. (2012). "Exchange rate pass-through in South Africa: Panel evidence from individual goods and services." *Journal of Development Studies* **48**(7): 832-846.

Peltzman, S. (2000). "Prices rise faster than they fall." *Journal of political economy* **108**(3): 466-502.

Pesaran et al., (2001). Prices Rise Faster than They Fall. *Journal of Political Economy*, 108 (3): 466-502.

Pollard, P. and Coughlin C (2003). 'Size matters: Asymmetric exchange rate pass-through at the industrial level', Federal Reserve Bank of St. Louis, Working paper 2003-029C.

Phillips, P. C. and B. E. Hansen (1990). "Statistical inference in instrumental variables regression with I (1) processes." *The Review of Economic Studies* **57**(1): 99-125.

Phillips, P. C. and P. Perron (1988). "Testing for a unit root in time series regression." *Biometrika* **75**(2): 335-346.

Piffanelli, A., et al. (2001). "Radionuclide therapy for painful bone metastases: an italian multicentre observational study." *The Quarterly Journal of Nuclear Medicine and Molecular Imaging* **45**(1): 100.

Ramaswamy, R. and T. Sloek (1998). "The real effects of monetary policy in the European Union: What are the differences?" *Staff Papers* **45**(2): 374-396.

Razafimahefa, I. F. (2012). "Exchange rate pass-through in Sub-Saharan African economies and its determinants."

Reginaldo, J. (2007). *The Effects of Foreign Exchange Movements in Developing countries.* *Review of Economics and Statistics*, 71 (3): 505-511.

Reyes, J. (2007). "Exchange rate passthrough effects and inflation targeting in emerging economies: what is the relationship?" *Review of International Economics* **15**(3): 538-559.

Rigobon, R. (2007). *Through the Pass-Through: Measuring Central Bank Credibility.* CID Working Paper No. 143, Center for International Development, Harvard University.

Saayman, A. (2010). "A panel data approach to the behavioural equilibrium exchange rate of the ZAR." *South African Journal of Economics* **78**(1): 57-75.

Sanusi, A. R. (2010). "Exchange rate pass-through to consumer prices in Ghana: Evidence from structural vector auto-regression." *West African Journal of Monetary and Economic Integration* **10**(1).

Savoie-Chabot, L. and Khan. M (2015). "Exchange Rate Pass-Through to Consumer Prices: Theory and Recent Evidence." *Bank of Canada Discussion Paper* **9**.

Shambaugh, J. (2008) *A New Look at Pass-Through*, *Journal of International Money and Finance*, 27(4): 560-591

Sikwila, M. N. "Inflation Impact of an Exchange Rate Adjustment: The Case of Zimbabwe." *Management, Informatics and Research Design*: 166.

Sims, C. A. (1980). "Macroeconomics and reality." *Econometrica: Journal of the Econometric Society*: 1-48.

Sims, C. A. (1992). "Interpreting the macroeconomic time series facts: The effects of monetary policy." *European Economic Review* **36**(5): 975-1000.

Sims, C. A., et al. (1990). "Inference in linear time series models with some unit roots." *Econometrica: Journal of the Econometric Society*: 113-144.

Sims, C. A. and T. Zha (1998). "Bayesian methods for dynamic multivariate models." *International Economic Review*: 949-968.

Sims, R. R., et al. (1986). "The reliability and classification stability of the Learning Style Inventory." *Educational and Psychological measurement* **46**(3): 753-760.

South African Reserve Bank, (2002). Exchange Rate Pass-Through and South African Import Prices. SARB Working Paper WP/02/03. Pretoria: South Africa.

South African Reserve Bank, (2004). Experience of Inflation targeting in S.A. SARB Quarterly Bulletin, (December) No. 242: S103.

South African Reserve Bank, (2007). Quarterly Bulletin Time Series. [On- line]. Available: <http://www.reservebank.co.za/>.

South African Reserve Bank, (2016) Monetary Policy Review (MPC) bulletin.

Savoie-Chabot, L. and M. Khan (2015). "Exchange Rate Pass-Through to Consumer Prices: Theory and Recent Evidence." Bank of Canada Discussion Paper **9**.

Statistics South African, (2015). The statistics bulletin. Available: <http://www.statsa.co.za/>

Statistics South African, (2016). The statistics bulletin. Available: <http://www.statsa.co.za/>

Stock, J. H. and M. W. Watson (1988). "Testing for common trends." *Journal of the American statistical association* **83**(404): 1097-1107.

Stock, J. H. and M. W. Watson (1993). "A simple estimator of cointegrating vectors in higher order integrated systems." *Econometrica: Journal of the Econometric Society*: 783-820.

Stock, J. H. and M. W. Watson (2001). "Vector autoregressions." *The Journal of Economic Perspectives* **15**(4): 101-115.

Taylor, J. B. (2001). "The role of the exchange rate in monetary-policy rules." *The American Economic Review* **91**(2): 263-267.

Thomas, R. L. (1997). *Modern econometrics: an introduction*, Addison-Wesley Longman.

Wang, J, (2011). Pricing-to-market in U.S. Imports and Exports: A Time Series and Cross-sectional Study, *The Quarterly Review of Economics and Finance*, 38: 843-861.

World Bank (2016). *Global Economic Prospects*, Vol. 9, March 2016. Washington DC: World Bank.

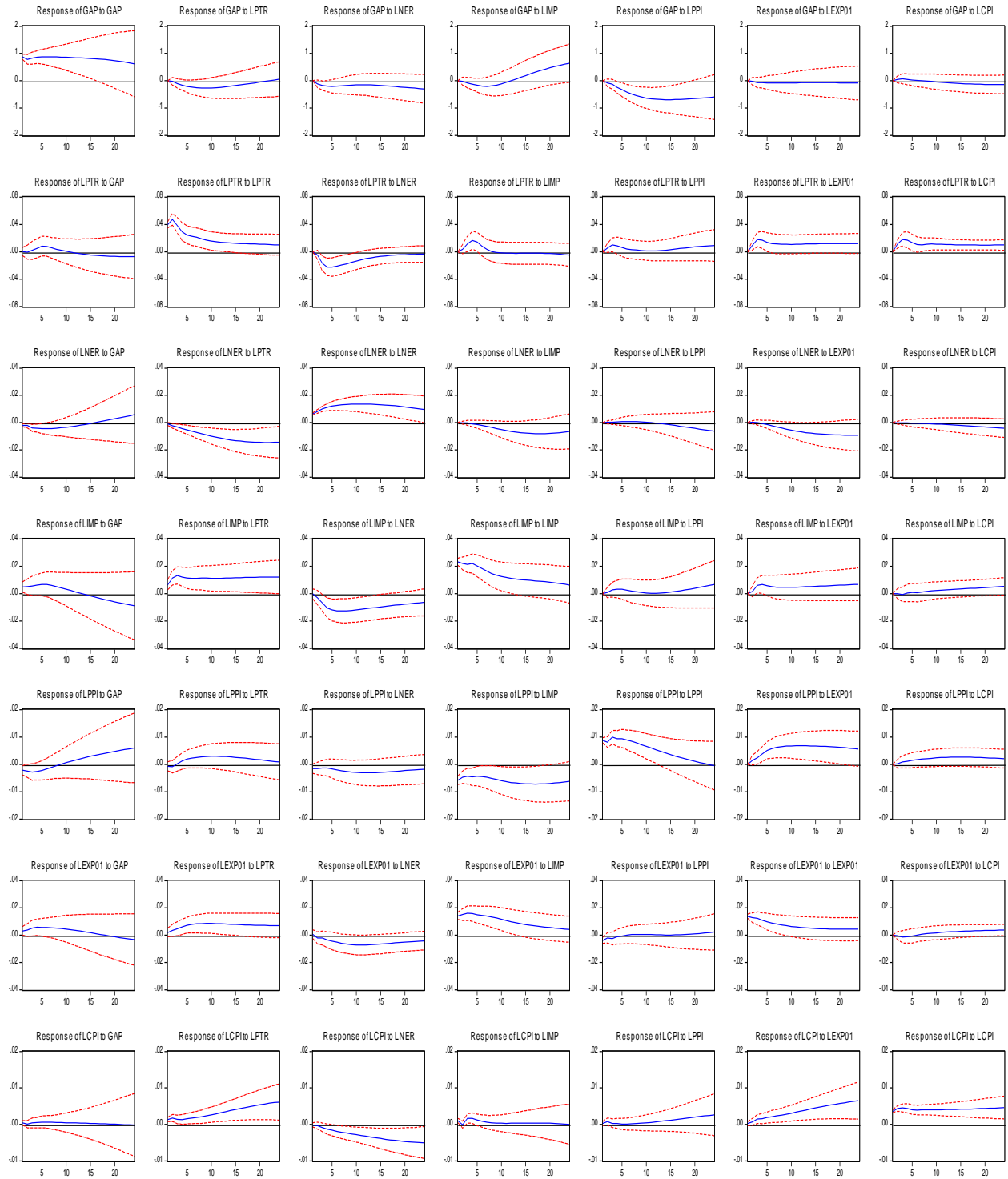
World Bank (2016). *South Africa Economic Update: Fiscal Policy and Redistribution in an Unequal Society*. Working Paper No. 92167.



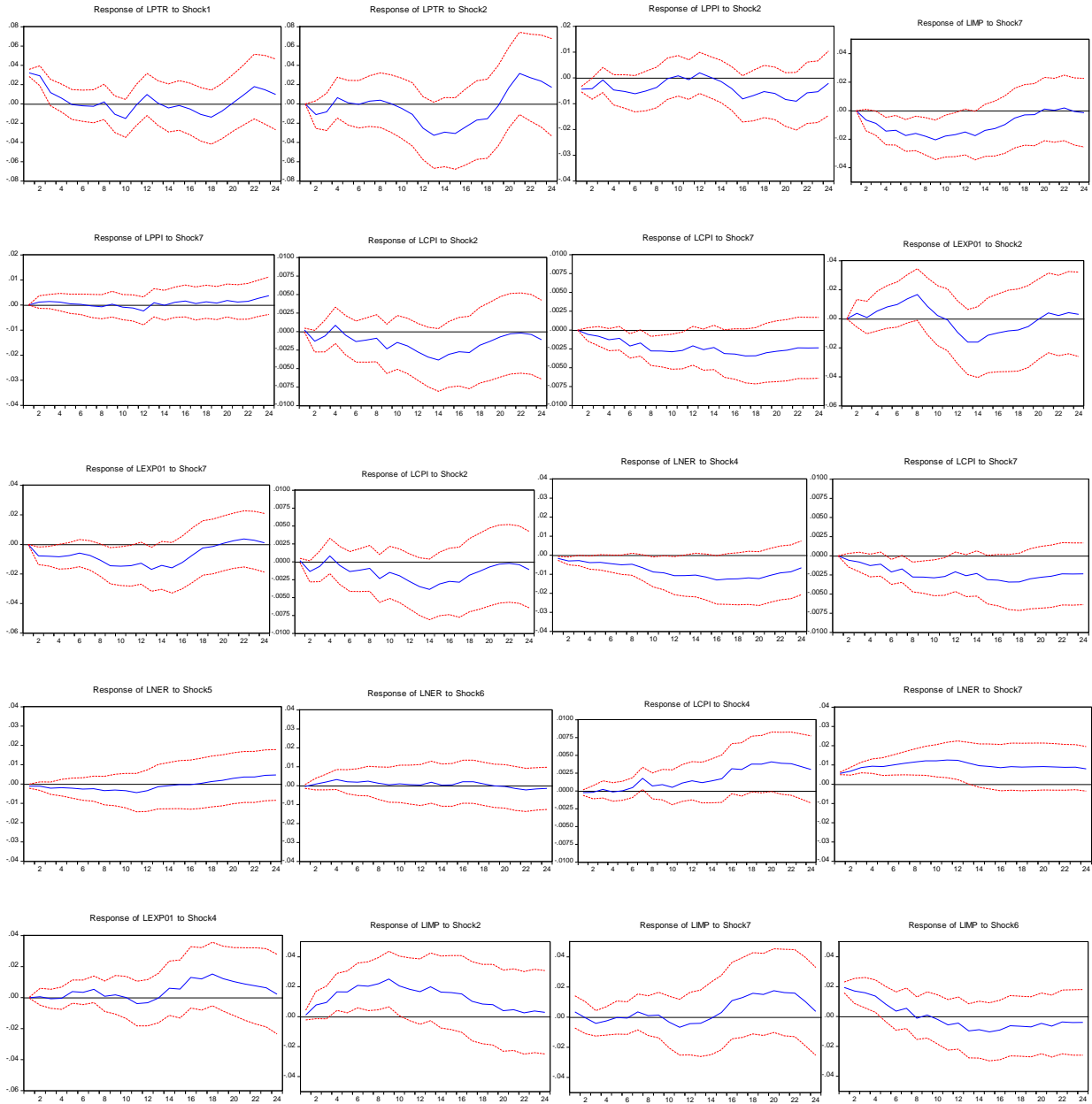




### Appendix (iii): Impulse response function-Recursive VAR



## Appendix (iv): Impulse response function for the SVAR



## Appendix (v) : Johansen cointegration

Date: 09/26/16 Time: 15:57  
 Sample (adjusted): 2002M05 2015M12  
 Included observations: 164 after adjustments  
 Trend assumption: Linear deterministic trend  
 Series: GAP LCPI LEXP01 LIMP LNER LPPI LPTR  
 Lags interval (in first differences): 1 to 3

### Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.279857	152.5993	125.6154	0.0004
At most 1 *	0.198302	98.75732	95.75366	0.0306
At most 2	0.143188	62.50940	69.81889	0.1665
At most 3	0.122449	37.16546	47.85613	0.3398
At most 4	0.071756	15.74378	29.79707	0.7302
At most 5	0.021140	3.532208	15.49471	0.9376
At most 6	0.000172	0.028150	3.841466	0.8667

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level

\* denotes rejection of the hypothesis at the 0.05 level

\*\*MacKinnon-Haug-Michelis (1999) p-values

### Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.279857	53.84199	46.23142	0.0065
At most 1	0.198302	36.24792	40.07757	0.1269
At most 2	0.143188	25.34394	33.87687	0.3621
At most 3	0.122449	21.42167	27.58434	0.2515
At most 4	0.071756	12.21157	21.13162	0.5269
At most 5	0.021140	3.504058	14.26460	0.9076
At most 6	0.000172	0.028150	3.841466	0.8667

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

\* denotes rejection of the hypothesis at the 0.05 level

\*\*MacKinnon-Haug-Michelis (1999) p-values

## Appendix (vi): Granger Causality

## Pairwise Granger Causality Tests

Date: 09/26/16 Time: 16:01

Sample: 2002M01 2015M12

Lags: 3

Null Hypothesis:	Obs	F-Statistic	Prob.
LCPI does not Granger Cause GAP	165	1.30858	0.2736
GAP does not Granger Cause LCPI		1.09263	0.3540
LEXP01 does not Granger Cause GAP	165	2.75200	0.0445
GAP does not Granger Cause LEXP01		0.27040	0.8467
LIMP does not Granger Cause GAP	165	2.12550	0.0992
GAP does not Granger Cause LIMP		0.37086	0.7741
LNER does not Granger Cause GAP	165	0.61127	0.6086
GAP does not Granger Cause LNER		1.66672	0.1764
LPPI does not Granger Cause GAP	165	1.29747	0.2773
GAP does not Granger Cause LPPI		0.27069	0.8465
LPTR does not Granger Cause GAP	165	3.09707	0.0285
GAP does not Granger Cause LPTR		0.37496	0.7712
LEXP01 does not Granger Cause LCPI	165	9.33928	1.E-05
LCPI does not Granger Cause LEXP01		1.19813	0.3124
LIMP does not Granger Cause LCPI	165	12.7482	2.E-07
LCPI does not Granger Cause LIMP		2.16572	0.0942
LNER does not Granger Cause LCPI	165	3.97466	0.0092
LCPI does not Granger Cause LNER		2.84754	0.0394
LPPI does not Granger Cause LCPI	165	11.2691	1.E-06
LCPI does not Granger Cause LPPI		1.33361	0.2654
LPTR does not Granger Cause LCPI	165	3.11301	0.0280
LCPI does not Granger Cause LPTR		3.35717	0.0204
LIMP does not Granger Cause LEXP01	165	1.58180	0.1959
LEXP01 does not Granger Cause LIMP		1.32075	0.2696
LNER does not Granger Cause LEXP01	165	2.00684	0.1152
LEXP01 does not Granger Cause LNER		4.77490	0.0033
LPPI does not Granger Cause LEXP01	165	0.69124	0.5587
LEXP01 does not Granger Cause LPPI		2.91197	0.0362
LPTR does not Granger Cause LEXP01	165	2.44497	0.0660
LEXP01 does not Granger Cause LPTR		3.17737	0.0257
LNER does not Granger Cause LIMP	165	3.02247	0.0314
LIMP does not Granger Cause LNER		4.24079	0.0065
LPPI does not Granger Cause LIMP	165	1.45198	0.2298
LIMP does not Granger Cause LPPI		4.13341	0.0075
LPTR does not Granger Cause LIMP	165	5.62894	0.0011
LIMP does not Granger Cause LPTR		1.28136	0.2827
LPPI does not Granger Cause LNER	165	0.27571	0.8429
LNER does not Granger Cause LPPI		1.21694	0.3054
LPTR does not Granger Cause LNER	165	5.14241	0.0020
LNER does not Granger Cause LPTR		2.16313	0.0945
LPTR does not Granger Cause LPPI	165	1.10988	0.3469
LPPI does not Granger Cause LPTR		0.38016	0.7674