# The Impact of Exchange Rates on the Chemical Industry in South Africa

Research submitted in fulfilment of the requirements for the Master of Management in Finance and Investment (MMFI) at the University of the Witwatersrand

By

**Pfarelo Mutwanamba**

Supervisor(s): Dr. Odongo Kodongo
Wits Business School
University of the Witwatersrand
Johannesburg, South Africa

MMFI 2014

## Declaration

By submitting this thesis electronically, I declare that the work presented in this masters research is my own, original work, and that I am the authorship owner thereof (unless to the extent explicitly otherwise stated and except as acknowledged in the text) and that I have not previously in its entirety or in part submitted it for obtaining any qualification at any other university.

Pfarelo Mutwanamba April 30, 2015

## Acknowledgements

- First of all, my sincere gratitude goes to God Almighty for the aid, guidance, protection and making it possible for me to complete this research.

- Secondly, I would like to thank my supervisor Dr. Odongo Kodongo for his invaluable assistance in the preparation of this research and, of course, great advice given throughout the year 2014. More importantly I am greatly indebted to him for his optimism and encouragements that have in many ways kept me going through the year.

- Thirdly, I would also like to thank the 2014 Masters of Management in Finance & Investment (MMFI) students for their massive support. Takalani Mangenge, Longay Mugimba and Kojo Mensah to mention a few.

- Fourthly, to my wife Millicent Mutwanamba for being my immediate source of inspiration and for her consistent support, thank you. To all my family members and friends, thank you.

- Finally, to my colleague & mentor Mr. Dewald van Tonder thank you, and a big appreciation to everyone who believes in me.

## Dedication

---

“The family is both the fundamental unit of society as well as the root of culture. It…is a perpetual source of encouragement, advocacy, and emotional refuelling that empowers a child to venture with confidence into a greater world and to become all that he can be”.

**Marianne E. Neifert**

“Family is what grounds you”

**Angelina Jolie**

“Without a family, man, alone in the world, trembles with the cold”

**Andre Maurois**

I dedicate this to my late father, Mr. Edson Mutwanamba, my loving and caring mother Mrs. Tshavhungwe Mutwanamba, my delightful sister Nkhumiseni Mutwanamba, my two marvellous brothers Tsumbedzo Mutwanamba & Khwathisani Mutwanamba and of course my lovely wife Millicent Mutwanamba as well as my incredible daughter Ngeletshedzo Mutwanamba.

## Abstract

In February 2000, South African economy adopted a free floating rand regime and implemented the inflation target framework of the South African Reserve Bank (SARB)'s monetary policy. Since then we have seen an enormous increase in the volatility of the rand (ZAR). On the domestic market front, more concerns have been around the potential deleterious effects exchange rate fluctuations could impose on the domestic prices of chemical products – South Africa. The developments of such concerns are based on the downside or the rand depreciation against currencies of the major economies from which South Africa imports the raw materials and finished products. Previous studies have been conducted in some of the emerging markets analysing the pass-through relationship, however the issue has remained highly ambiguous. Therefore, this study investigates the basic relationship between exchange rate and pricing of final product in the Chemical Industry in South Africa.

In order to make sure that valid and accurate economic presentations of the estimations are inferred, the study conducts various econometrics analyses viz., the unit root and stationarity tests are subjected to Augmented Dickey Fuller (ADF) statistics. Autocorrelation and spectral analysis is adopted to estimate the degree of linear connection between variables using the Durbin-Watson (DW) test statistic. Cointegration tests were also conducted in detail to ascertain the long run relationship amongst variables in time series. VAR estimations were tested to generate the impulse response and variance decomposition analysis. Such econometrics techniques were employed on a monthly time series data (USD-Rand exchange rate and Prices of chemical products) for the period 2000 to 2013.

The results suggest that there exist no statistically significant relationship between the prices of the chemical products and exchange rate volatility i.e. the prices of the chemical products are not particularly influenced by the movement of exchange rate. The results however show somewhat a great amount of sensitivity to different definitions of variables used.

**Keywords**: Exchange Rates and Pricing, Cointegration, Chemical Sector – South Africa

## List of Abbreviations and Acronyms

| | |
|---|---|
| ADF | Augmented Dickey-Fuller |
| CLRM | Classical Linear Regression Model |
| CMLV | Cumulative values for each year |
| CPI | Consumer Price Index |
| DW | Durbin-Watson |
| ERPT | Exchange Rate Pass-Through |
| FOB | Free On Board |
| LOP | Law of One Price |
| PPP | Purchasing Power Parity |
| SA | South Africa |
| OLS | Ordinary Least Squares |
| SARB | South African Reserve Bank |
| SARS | South African Revenue Services |
| SSA | Sub Saharan Africa |
| StatsSA | Statistics South Africa |
| VAR | Vector Auto-regression Model |
| VECM | Vector Error Correction Model |
| ZAR | South African Rand |
| LM | Lagrange Multiplier Test |
| BG | Breusch-Godfrey Test |
| BJ | Bera-Jarque Test |

| | |
|---|---|
| GBP | Great Britain Pounds |
| RR | Ramsey Reset Test |
| WAMZ | West Africa Monetary Zone |
| ICC | International Chamber of Commerce |
| DTI | The Department of Trade & Industry |
| RFQ | Request for Quotation |
| KPSS | Kwiatkowski-Phillips-Schmidt-Shin |
| UK | United Kingdom |
| SBIC | Schwartz Bayesian Information Criterion |
| AIC | Akaike Information Criterion |
| FX | Foreign Exchange |
| SD | Standard Deviation |
| SE | Standard Error |

## List of Figures

## List of Tables

**Contents**

---

# CHAPTER ONE

# BACKGROUND OF THE STUDY

## 1.1 Introduction

The basic relationship between exchange rates and domestic prices is rapidly turning into a significant area of study in the developed and emerging countries (Aron et al., 2012; Dong & Nam, 2013; Ocran, 2010). With Reference to the figures released by StatsSA (**Table 1** – South African Import Value Indices, 2014), it is clearly evident that the channel of sourcing raw materials and, to an extent, finished products, in the chemical industry in South Africa has been mainly through imports. With this in consideration, exchange rate has been identified as one of the keys factors which play a very illustrious part in the import process particularly in the context of the South African economic environment (Aron et al., 2012).

This study assesses the impact of exchange rate volatility on the domestic prices of chemical products by local chemical businesses. The general idea is to draw on pricing models in the South African chemical industry to explain the price adjustments in terms of the market concentration with regards to all the components of pricing and whether the exchange rate component, as one of the determinants of the final price, is significant.

Since 1994, South Africa adopted three main regimes namely dual exchange rate regime, which comprises a governed and controlled float commercial rand and autonomous float financial rand, which was in effect from September 1985 to February 1995, unitary exchange rate (managed float rand) from March 1995 to January 2000 and from February 2000 to present the country adopted a free and autonomous floating rand, and implemented the inflation target framework of the South African Reserve Bank (SARB)'s monetary policy (Mtonga, 2011).

Under dual exchange rate regime, commercial transactions on both the current and capital accounts were managed utilizing different/ separate FX-foreign exchange rates. While the precise format of this composition of exchange rate regime could differ according to the governments' distinct/individual policy objectives in pursue, the all-important key target was that these separate exchange rates could be regulated in order to achieve certain policy goals. The dual exchange rate regime was made up of the financial and commercial rand. The principal rate was a commercial rand, and this was exercised/applied/employed on all business transactions by residents of the country – South Africa. The principal rate was pronounced a floating rate; however this was subjected to an authoritative intercession approach by the South African Reserve Bank (SARB).

On the other hand, financial rand was designated a secondary rate which was only exercised/applied/employed on all capital transactions of non-residents. Essentially, the intention was to insulate the South African economic environment from fluctuations in non-resident capital transactions, looking at the clamorous political situation and economic deterrent in particular. It was mainly for this reason that the pricing of the financial rand rate was determined under comparatively free market conditions. The thinness of the market was, however, instrumental in its volatility. In spite of the regime change, the policies and regulations on exchange controls on all resident transactions remained in existence. Mismatch of the application of principal rate to the domestic residents and secondary rate on all non-residents imported goods made it complex to identify whether there is any implication of this regime into domestic prices, however, one could argue that this regime eliminates any impact of the imported costs into prices in the domestic market (Mtonga, 2011).

The floating exchange rate regime, on the other hand, should have much bigger effect of the prices as the currency exchange rates are determined by the market forces i.e. the imported products costs should then form part of the final prices in the local market. This will be explored further in the next chapters of this study. Lastly, the unitary exchange rate regime which was seen by De Kock Commission as a long-term objective “under which an independent and flexible rand find its own level in well-developed and competitive spot and forward foreign exchange markets in South Africa, subject to Reserve Bank ‘intervention’ or ‘management’ by means of purchases and sales of foreign exchange but with no exchange control over non-residents and only limited control over residents", the view on the exchange rates relative to the imported goods affects domestic prices in one way or another (Mtonga, 2011; Van der Merwe, 1996; De Kock Commision, 1985).

We have seen some developing interest recently in the examination and assessment of the exchange rate volatility with the monetary policy behaviour and the inflation trend. Quite a handful of recent literatures found some factual support for the relationship but the results were inconclusive. According to Campa & Goldberg (2001) a positive interrelation between the exchange rate and raising price levels exists. Their study does not, however, indicate the nature to which the exchange rate affects the pricing of the final product in the local market.

While the debate in developed and mature economies regarding exchange rate pass-through (ERPT)[1] has moved-on from one of estimation to the task of explaining the observed low exchange rate pass-through, the discussion in most emerging and frontier markets revolves around the level of pass-through. The case of South Africa is even more pertinent since the rate of inflation has fallen considerably over the years. From an average of about nineteen percent in 1986 the inflation has dropped to ten percent in 1993 and bottomed out at one percent in 2004 before peaking up again at twelve percent in 2008 and now averaging six percent per year on year basis (Ocran 2010).

For the implementation of appropriate monetary and exchange rate policies, the level and rate to which exchange rate fluctuations pass-through to product prices is a vital important issue under debate. It is thought that a low exchange rate pass-through generates much significant freedom for the objective of undertaking an unconventional monetary policy and to make it simple for the implementation of inflation targeting framework (Choudhri & Hakura 2001).

Furthermore, a handful number of previous studies have been more apprehensive with the exchange rate pass-through to import costs. Kiptui et al. (2005) suggested that a complete discernment of exchange rate pass-through is vital for a variety of reasons, viz:

The first reason is that the rate and level of exchange rate pass-through is a ballpark of intercontinental macroeconomic transmission and therefore has insinuations for the timing of intercession of the monetary policy. Thus, the extent and rate of pass-through is crucial to the application of the monetary policies and the prediction of raising price levels. Moreover, the advocacy of the framework of targeting inflation needs sufficient knowledge and statistics of the rate and enormity of exchange rate pass-through (ERPT) to inflation.

---

[1] A percentage change – in the value of the local currency, of the prices of imports emanating from a percentage variation in the exchange rate between two economies. Percentage change in the import prices normally would gain a path into retail and consumer prices (see Goldberg & Knetter, 1997).

Secondly, complete discernment of exchange rate pass-through (ERPT) at the microeconomic and macroeconomic levels provides intuitions into the insight of market conditions and the power of domestic sectors compared to their worldwide counterparties.

Lastly, even with highly elastic demand – a small rate of exchange rate pass-through (ERPT) would make it practical for the flow of trade transactions to stay comparatively the same by the level of the exchange rate fluctuations i.e. if the prices of the chemical products respond slowly to the movement of the currency rate (the rand fluctuations) and if the trade flows respond quietly to the respective price movement, therefore the adjustment process of the comprehensive balance of payments could be seriously affected and somewhat held back.

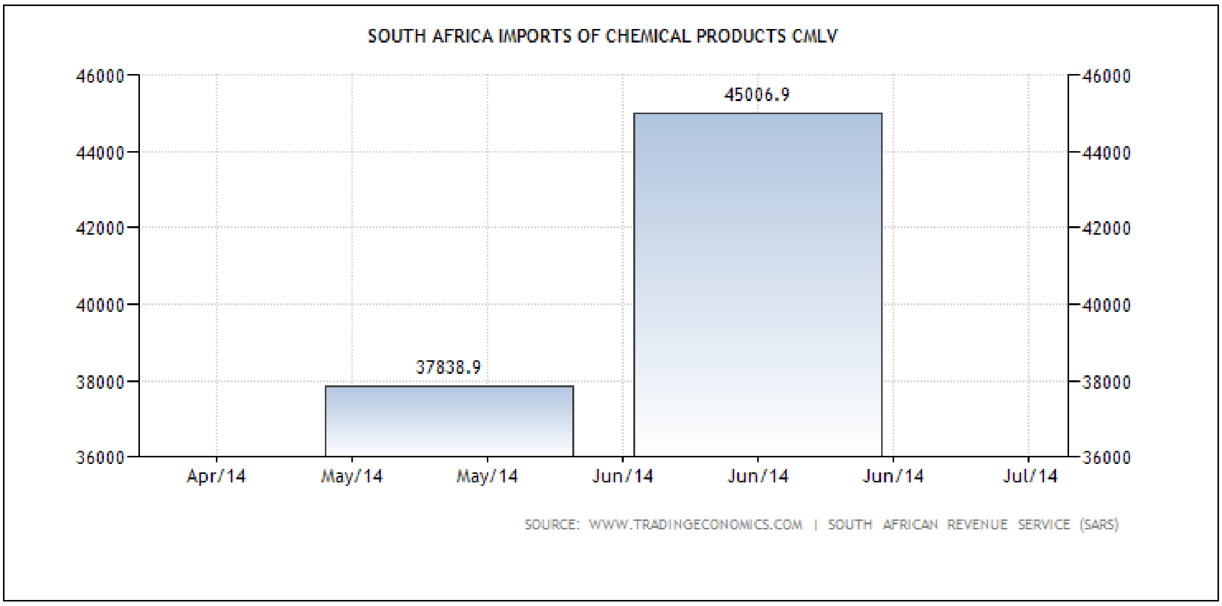
In particular, this study will explore the basic relationship between the exchange rate changes over the time period from 2000 until 2013 and domestic prices of the chemical products – South Africa for the same period using time series data surfacing the same period. Considering that South Africa adopted the floating exchange rate regime and implemented the inflation target framework of the South African Reserve Bank (SARB)'s monetary policy in February 2000, it would be vitally prudent and fundamentally important to assess the relationship between exchange rate and domestic prices from the onset until recently in order to ensure that the analysis properly capture the rand movements going back since the implementation of this particular regime. It must be noted that transaction price exposure arises in every international transaction wherein either the buyers/ sellers face the transaction price exposure.

Further, it should also be noted, notwithstanding the capabilities that South Africa manufactures some of world sophisticated quality goods for export and domestic use – the country remains, however, a major importer of many world class goods from the global markets and this then positions the country in a net importer category. From pharmaceuticals & chemicals to telecommunications, the South African economy is an advanced consumer of the latest offerings from international sources around the global economy.

The chemical sector is also one of the main importers of the raw materials from major economic hubs around the world. This is substantiated on the Figure 1 (South Africa Imports of Chemical Products – CMLV) and Table 1 (South Africa imports value indices, January 2014).

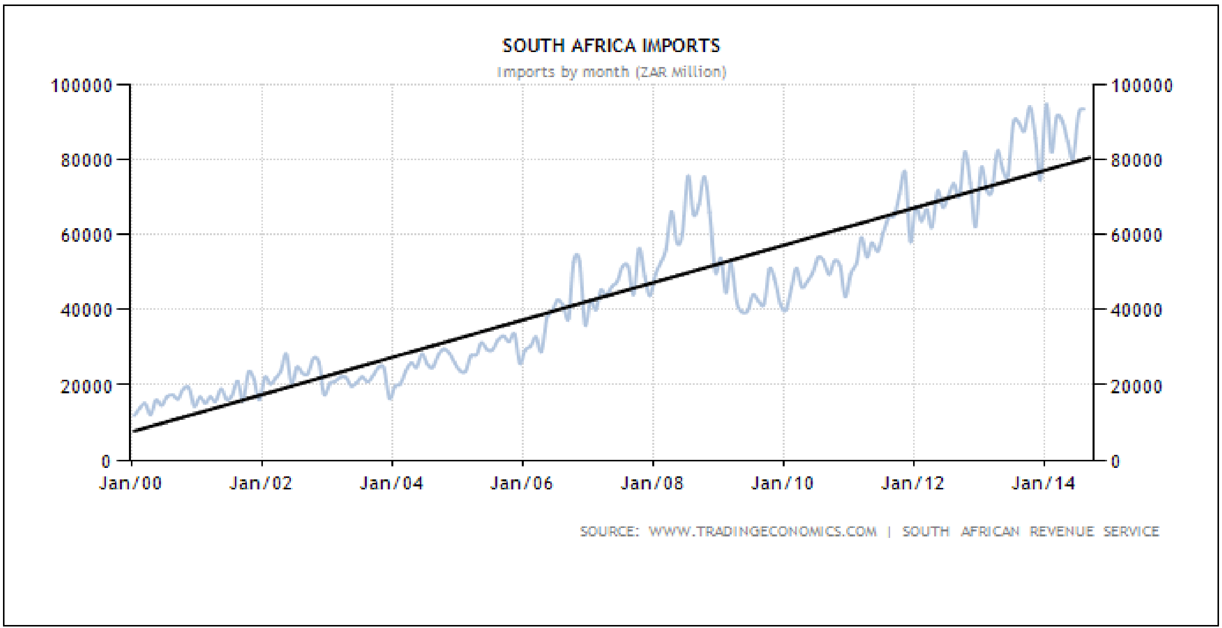
South Africa accounts for imports of chemical products using cumulative values for each year (CMLV). The actual figures for June 2014 stand at 45006.90 (ZAR million) compared to its previous 37838.90 (ZAR million) for May 2014.

Figure 1**: South Africa Imports of Chemical Products CMLV**




Source: Data compiled from www.tradingeconomics.com/ South African Revenue Service (SARS)

Figure 2: **South Africa Imports (Imports by Month 2000 – 2014)**




Source: Data compiled from www.tradingeconomics.com/ South African Revenue Service (SARS)

Figure 3: **South Africa Imports Prices (2000 – 2014)**


Source: Data compiled from www.tradingeconomics.com/ South African Revenue Service (SARS)

Figures 1, 2 & 3 presents the reflection of the trend on the imports and confirm the fact that there has been a very large amount of imports flowing into South Africa – generally within different sectors of the economy. Looking at ZAR 45006.9 million – South Africa imports of chemical products CLMV for June 2014 on the Figure 1, it is indeed evident that the chemical industry plays a prominent role with regards to sourcing products from the global players. Between 2000 – 2014 the slopes of the South Africa's imports and the import prices of the chemical products (both raw materials and finished products combined), which are exchange rate adjusted, have been on the upward trend which might be a suggestion of the effect of several macroeconomic factors viz: - rand exchange rate to other major currencies of various international markets.

Table 1: **South Africa import value indices, January 2014**

| Product | | | Weight | Index (2012=100) | | | Percentage change | |
|---|---|---|---|---|---|---|---|---|
| | | | | Jan 2013 | Dec 2013 | Jan 2014 | Jan 2014 vs. Dec 2013 | Jan 2014 vs. Jan 2013 |
| All items | | | 100,00 | 105,2 | 125,7 | 127,3 | 1,3 | 21,0 |
| Crude petroleum | | | 17,11 | 105,8 | 122,5 | 123,9 | 1,1 | 17,1 |
| Food products | | | 6,65 | 104,7 | 106,6 | 108,5 | 1,8 | 3,6 |
| | Fats and oils | | 3,55 | 98,6 | 96,4 | 97,8 | 1,5 | -0,8 |
| | Grain mill products | | 3,10 | 112,0 | 119,4 | 121,9 | 2,1 | 8,8 |
| Clothing and footwear | | | 4,38 | 99,8 | 109,4 | 111,6 | 2,0 | 11,8 |
| | Clothing | | 2,63 | 98,5 | 111,6 | 112,9 | 1,2 | 14,6 |
| | Footwear | | 1,75 | 101,7 | 106,2 | 109,9 | 3,5 | 8,1 |
| Other transportable goods, except metal products, machinery and equipment | | | 26,06 | 109,2 | 135,1 | 138,2 | 2,3 | 26,6 |
| | Paper and paperboard | | 1,70 | 106,5 | 126,3 | 128,4 | 1,7 | 20,6 |
| | Coke oven and refined petroleum products | | 7,51 | 127,3 | 193,6 | 204,7 | 5,7 | 60,8 |
| | Basic chemicals | | 5,46 | 103,4 | 117,8 | 118,7 | 0,8 | 14,8 |
| | Pharmaceutical and other chemical products | | 6,33 | 104,6 | 111,9 | 112,6 | 0,6 | 7,6 |
| | | Pharmaceutical products | 3,59 | 99,6 | 109,2 | 109,4 | 0,2 | 9,8 |
| | | Other chemical products | 2,74 | 112,3 | 116,4 | 117,7 | 1,1 | 4,8 |
| | Rubber and plastic products | | 2,89 | 100,5 | 118,3 | 119,7 | 1,2 | 19,1 |
| | Other transportable goods | | 2,17 | 118,6 | 118,8 | 110,3 | -7,2 | -7,0 |
| Metal products, machinery and equipment | | | 45,80 | 103,6 | 126,3 | 127,1 | 0,6 | 22,7 |
| | Basic metals | | 3,95 | 99,7 | 112,9 | 114,6 | 1,5 | 14,9 |
| | Fabricated metal products | | 2,09 | 110,2 | 123,4 | 124,4 | 0,8 | 12,9 |
| | General purpose machinery | | 6,52 | 100,9 | 123,5 | 121,4 | -1,7 | 20,3 |
| | Special purpose machinery | | 7,44 | 103,4 | 123,4 | 122,7 | -0,6 | 18,7 |
| | | Machinery for mining, quarrying and construction, and parts thereof | 3,05 | 105,0 | 122,5 | 123,1 | 0,5 | 17,2 |
| | | Agricultural and forestry machinery and parts thereof | 1,00 | 104,5 | 132,0 | 131,8 | -0,2 | 26,1 |
| | | Other machinery and parts thereof | 3,39 | 102,5 | 123,4 | 121,3 | -1,7 | 18,3 |
| | Office, accounting and computing machinery | | 2,98 | 105,6 | 122,4 | 123,5 | 0,9 | 17,0 |
| | Electrical machinery and apparatus | | 4,32 | 103,3 | 119,7 | 120,3 | 0,5 | 16,5 |
| | Radio, television and communication equipment and apparatus | | 6,09 | 102,8 | 161,0 | 164,5 | 2,2 | 60,0 |
| | Medical appliances, precision and optical instruments, watches and clocks | | 2,88 | 97,1 | 131,5 | 132,6 | 0,8 | 36,6 |
| | Transport equipment | | 9,53 | 108,1 | 119,6 | 121,2 | 1,3 | 12,1 |
| | | Vehicles | 7,25 | 105,4 | 117,0 | 118,5 | 1,3 | 12,4 |
| | | Bodies and parts of vehicles | 1,58 | 104,6 | 122,4 | 123,8 | 1,1 | 18,4 |
| | | Other transport equipment | 0,70 | 123,5 | 125,2 | 128,5 | 2,6 | 4,0 |

Source: Data compiled from Statistics South Africa (2014)

Looking at the weighting of the imported product categories from Table 1, basic chemicals product category weighs 5.46 (which is 11th overall). The overall weight, when "other chemicals" product category is included, becomes 8.2 (5th overall). In light of all these observations and placing the exchange rate volatilities into the framework, the following questions arise: 1) what happens to the selling prices of final chemical products in the domestic market – South Africa? 2) Is there a significant impact of the rand depreciation to the domestic prices? These are some of the important questions, surrounding this study, which will be answered in the next sections/ chapters of this thesis.

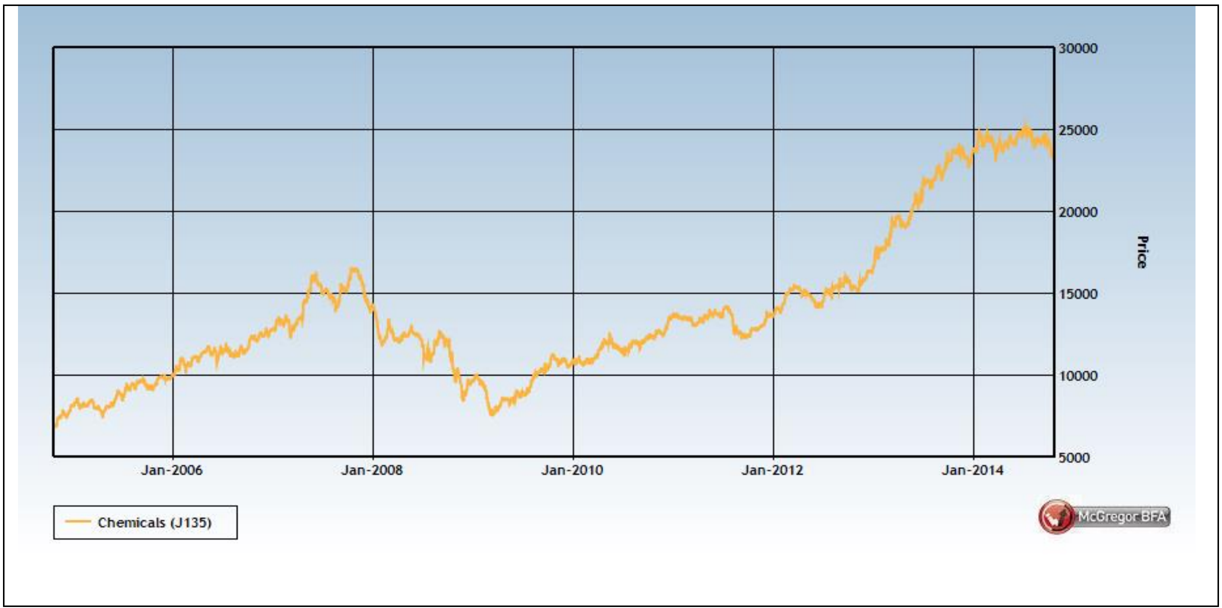
## 1.2 Problem statement

Chemical industry in the South African economic environment depends heavily on the imported raw materials to meet the sector's production objectives. The finished products which are key components in the merchandise businesses also form part of the imported products into the chemical sector in South Africa. The cost of imported goods (both raw materials and finished products) therefore constitute a big component of cost and is considered as one of the elements which impact the bottom-line figures of the companies, more especially when the local currency – rand (ZAR) depreciates. High levels of import costs in the chemical industry are certainly big factors which bring about the problem of exchange rate pass-through in the pricing of final products to the firms and customers in the local market.

For instance, the value of imported products (both raw materials and finished goods combined) in the sector changed from 40 billion in 2010 to 60 billion in 2012 representing a change of about 50 percent. The corresponding change in the USD-rand (ZAR) exchange rate during the same period was 26.5 percent; the average price of the representative commodity in the chemical industry changed from rand (ZAR) 145.00 to rand (ZAR) 160.00, which is a 10.3 percentage change. Given these observations, it is interesting to establish if currency fluctuations have an impact on pricing of products in the South African chemical industry.

The lack of consensus and conclusive evidence in the previous literatures on exchange rate and domestic prices (theoretically or otherwise) provide justification of the conflicting calls by different stakeholders on how best to manage the situation of the rand exchange rate fluctuations in the South African market. The calls to intentionally depreciate the rand (ZAR) currency come with some costs associated with interference to the market forces. Since South Africa is an open economy, the exchange rate is an important variable in the pricing process within the local market. In light of this information and Figure 4, 5 & 6, it gives me sufficient motivation to undertake this study in seeking to find out if exchange rate volatilities have a considerable impact in the local chemical businesses – South Africa. Failure to find the true relationship might result to customers suffering from exorbitant price levels (inflated prices), the wrong formulation of the monetary policy frameworks, and so on.

Figure 4: **Price History - FTSE/JSE Chemicals (J135)**

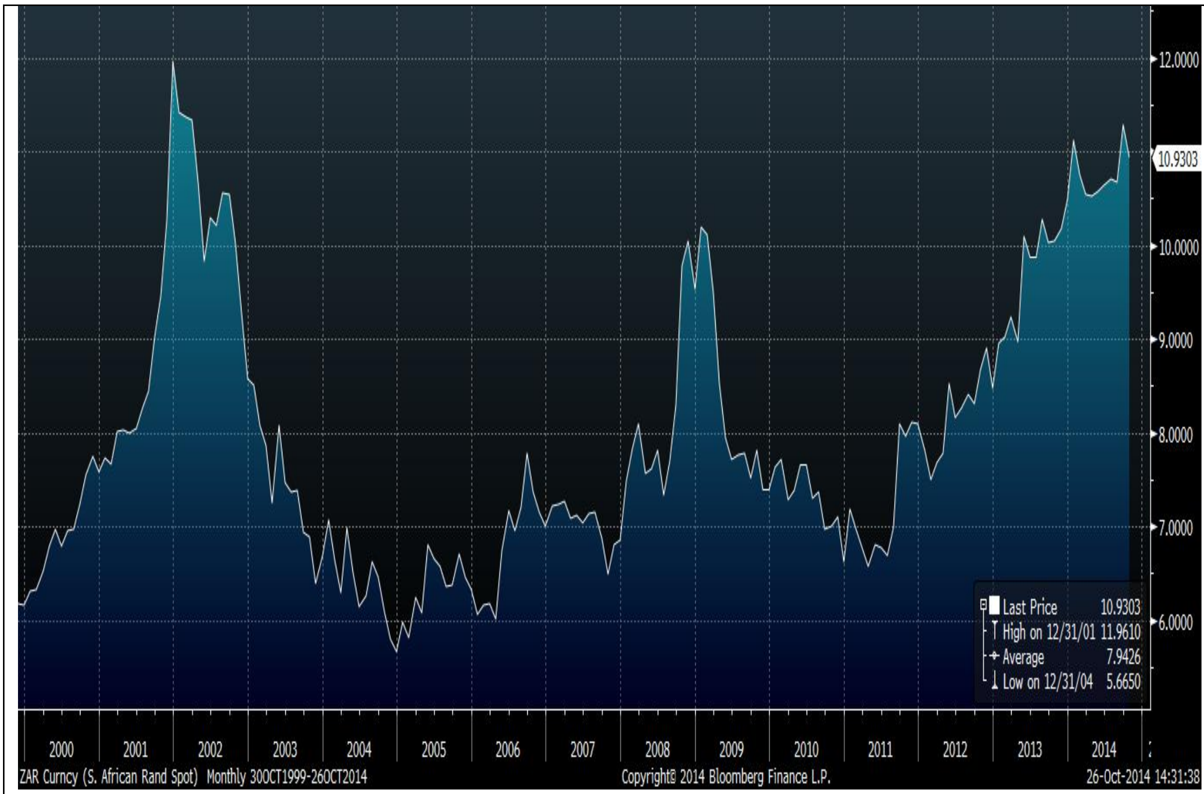



Source: Data compiled from I-NET BFA terminal

Figure 5: **Price Index Data (IMF South Africa PPI/ WPI)**


Source: Data compiled from Bloomberg terminal

Figure 6: **ZAR Currency (South African Rand Historical Data)**




Source: Data compiled from Bloomberg terminal

The study specifically seeks to address the problem in the following categories:

**Raw materials:** This scenario is applicable when the chemical companies import raw materials in order to meet the production objectives in their production environment, and sell the final product into the local market – South Africa.

**Finished products:** Some of the chemical companies import finished products from all the economic hubs across the world with a view to selling them in the domestic market – South Africa. What is the role of the exchange rate when pricing such products to the consumers? The study will provide answers to this question as well as more other questions relevant to this research/ thesis.

## 1.3 Research objectives

The broad resolution and purpose of this research paper is to explore and analyse the impact of exchange rates on the domestic prices of chemical products in the chemical sector in South Africa. The study covers the pass-through of import costs by the chemical companies into their final prices when they price their products to the end-users and/or customers. The evaluation is done on the fundamental basis of the manner in which the companies in the chemical industry price their final products.

I have noted the most common components of pricing as: cost of raw materials and shipment (if sale terms are not Free On Board-FOB)[2], other costs of production (labour and overhead), the research and development costs, marketing and distribution costs, taxes, and the exchange rate, if relevant (Kardasz, 1998). Therefore this thesis investigates and assesses the impact of exchange rates on the prices of chemical products in the local market.

It is, indeed, correct that the relationship between exchange rate volatilities and the pricing models are of serious concern and topical relevance. Looking at an emerging market like South Africa, the performance of the currency is a key element in several economic variables such as growth and prices. While there has been several previous studies around the exchange rate issue, there hasn't been any conclusive evidence nor consensus reached about the exchange rates and prices relationship. One of the obvious traits of the antecedent literatures has been the deducible assumption that depreciation of the currency eventually lead to high or expensive imports which in turn also result in exchange rate pass-through to the customers in the domestic market (Frankel at al. 2012; Goldberg 2006).

[2] Under the Incoterms 2010 – published by the ICC, FOB is only used for sea freight. It is used in line with the port of loading. This implies that the transportation of goods to the port of shipment including the loading charges will be paid by the seller of goods.

It is due to these intriguing observations that this study seeks to review the trend in exchange rates and pricing models and also evaluate the impact of the exchange rate movements/ changes/ volatilities on pricing in order to make proper recommendations. The evaluation of the impact of exchange rate will be presented systematically by firstly, the identification of price factors or components, and secondly, the establishment of the role of exchange rate in pricing.

The broad objective is explored by identifying the short and long run relationship between:

- Exchange rate fluctuations and domestic prices of chemical products – South Africa.

### 1.4 Research questions

This thesis pursues to impart resolutions to the questions outlined below:

I. Do exchange rate fluctuations/ changes/ volatilities have a significant impact on the pricing of chemical products within the chemical sector in the domestic market – South Africa?

II. In the context of specific imported raw materials and finished products, do the chemical companies include the exchange rate factor when pricing final products to the consumers in the domestic market – South Africa?

III. Considering all price determinants i.e. raw material costs, production and labour costs as well as distribution cots, what significant impact do the exchange rates changes have on the pricing of the final products in the chemical industries in the domestic market – South Africa?

### 1.5 Significance and relevance for the study

In the context of the South African economic framework within which sourcing of the major important raw materials and intermediate products in the chemical sector is heavily done through the import channels from all economic hubs around the world, this study is appropriate as it seeks to address the significant issues arising from the relationship between exchange rates changes and pricing of final product into the local market.

The study explores how fluctuations in exchange rates have impacted on the domestic prices in the chemical sector of South Africa during the period between 2000 and 2013. It is in this regard that the study serves to shed light on the interrelationship that exists between exchange rates changes and pricing model in the South African economy. As stated in the previous section of this study, neither economic postulation nor factual evidence provides clear-cut resolves to the debate of how much significant impact do the exchange rates fluctuations have in the pricing of the final product.

The basic relationship between exchange rates fluctuations and domestic prices has stimulated a lot of debate in South Africa and abroad. Many researchers are investigating this relationship, and the results of the factual literatures on the relationship between exchange rates and prices are inconclusive. It is, therefore, on this basis that this study adds value to the ongoing discourse on the relationship between exchange rates and pricing of the final products in the local market. The results of this study will hopefully make a contribution towards policy planning and formulation at all levels of government, in the banking sector, the business community, as well as labour unions. In particular, the results and findings of this study would also be essential in contributing to the existing theoritical & empirical literatures in the following approach:

I. Provision of a traditional evaluation of the relationship between the exchange rate fluctuations and the pricing model in the chemical industry in South Africa.

II. Incorporation of the possibilities of asymmetries and threshold impacts of the exchange rate fluctuations on the prices of chemical products in South Africa.

III. Establishment of the real relationship between exchange rates and prices, this study is the first one to empirically evaluate the threshold impact of exchange rate fluctuations on prices in the chemical sector within the South African economic context.

### 1.6 Structure of the research

The outline of the study is as follows: Chapter 2 will review the theoretical and empirical literatures around the impact of exchange rate fluctuations on the domestic prices. Both theoretical and empirical literatures pertaining to the relationship between exchange rates and prices will be looked at in detail. Particularly, the grounds and reasons around the empirical equivocation seen in the previous literatures will be assessed, and link them to the pricing models in the domestic market – South Africa. With a good emphasis on their limitations, this study will also provide a review and assessment of the empirical literatures from the previous studies in the domain of exchange rate impact on the domestic market. Chapter 3 will present a discussion on the proposed econometric methodologies applied for the analyses of the research objectives stated in Chapter 1. Research design, data description and the form of data will be discussed in this chapter. Chapter 4 presents the estimation techniques and the interpretation of the econometric results from the analysis. In closing, Chapter 5 will deliver summary and the concluding comments, as well as presenting the implications on policies and make proper recommendations where necessary. Limitations of the study as well as the directions for further research will be provided in the final section of Chapter 5.

## CHAPTER TWO

## REVIEW OF THE PREVIOUS LITERATURES

### 2.1 Introduction

For the objective of providing the proper conceptual framework and appropriate policy recommendations, it is crucial to present a theoretical framework which construct/ ground this study. The empirical literature is also presented in addition to various traditional literatures that will be discussed in the next sections of this study. An important objective of presenting empirical literature is to explore previous work done by others and also the application of the research methodologies in this or similar field to determine and identify the gaps.

A number of studies have been more concerned with and have put interest on the exchange rate pass-through to import prices. The main difference of this study to some of the traditional studies in the literatures is the fact that it examines and analyses the actual effect of the exchange rate volatilities on prices of the products, with specific emphasis on the chemical sector in the framework of the South African economy. Further, this study also examines whether the import price pass-through at sector level is crucially determined by macroeconomic factors such as exchange rates, demand, elasticities, market structures and so forth.

### 2.2 Theoretical literature review

Frimpong (2010) has found a positive long run, but insignificant relationship between exchange rate fluctuations and domestic prices – which therefore implied that the long run exchange rate pass-through in the Ghanaian economic framework is zero. In his paper, he also discovers a fragmentary and declining exchange rate pass-through to inflation in the Ghanaian economic environment, and this was in consistency with the discoveries on other African economies. His findings demonstrate a small but considerable pass-through in the short-run. He contends that the discoveries show the effectiveness of the effect of expansion in openness of the economy and strict tracking of the monetary policies by the Central Bank of Ghana. It is fundamental to consider that, notwithstanding a small degree of the pass-through, his findings imply that the effect of exchange rate changes is still considerable for domestic prices. While a smaller rate of pass-through accommodate somewhat for flexibility in policies, concerted efforts are necessary to lower the volatilities and slowing the rate of adjustments, Frimpong (2010) concludes.

Karoro, Aziakpono & Cattaneo, (2014), maintain that the long run equilibrium and consistency exchange rate pass-through is fragmentary but comparatively high. The high exchange rate pass-through to import prices underlines the vulnerability of the South African economy with regards to the flexible exchange rate policies and more importantly the increasing openness of the economy. Although it is not championed that the level of authoritative measures be applied/employed and/or exercised in exchange rate and other policies, it is important to observe the progression of exchange rate volatility carefully and apply prompt actions in monetary policies, so as to prevent any kind of upward inflationary risks.

Karoro, Aziakpono & Cattaneo, (2014), further affirmed a considerable asymmetry regarding the inclination of variation in exchange rates, and confirm that there is usually a higher percentage of exchange rate pass-through when the rand (ZAR) depreciates than when there is appreciation in the value of the unit. Therefore, this implies that in examining the fluctuations of the rand (ZAR), special observation must be given to the sentiments and behaviours which could result to fall in its value. It is also important that the focus is not only given to the higher percentage change but also on comparatively small percentage of fluctuations.

The impact of the exchange rate on businesses is dependent on a variety of components i.e. when the value of the rand (ZAR) depreciates; the effect is normally determined by elasticity of demand factor. For instance, if South African companies in the chemical sector or in general sells products which are price inelastic, the fall in the value of the foreign currency price will only have a comparatively small-scale increase in demand. The elasticity of demand measures how much the quantity demanded will change if another factor changes. For example, when price elasticity of demand is elastic, companies normally reduce prices since this normally encourages an increased demand of the products, which in turn result in an increased firms' total revenue. However, looking back at the period between 2009 and 2010 where we have seen a considerable fall in the value of the Pounds (GBP) during the boiling point of the recession in the global economy; in spite of lower prices – the United Kingdom's exports were tenuous and weak. If the companies import raw materials and finished products and trade them to a local market, there is a substantial prospect of losing out from depreciation in the value of the currency. To cover the loss, the firms normally price-in the exchange rate effect into their final product selling prices for the protection of their margins as well.

One potential issue of exchange rate depreciation is that it could generate a raise in prices of commodities. Exchange rate is one of the macroeconomic variables/fundamentals that considerably impact consumer price inflation in small or relatively open economies around the globe. However, it should be noted that for businesses using fixed contracts to buy and import raw materials, the short-term fluctuations in the exchange rate will bear small-scale effect due to the fact that fixed exchange contracts aid to minimize uncertainties about the exchange rate movements.

Given that the literature on developed countries appears to demonstrate that exchange rate pass-through in an environment of low inflation if more subdued, it would be interesting to ascertain the level of pass-through in South Africa. This would deepen the literature by bringing an emerging market economy outcome to bear on the current literature, and also indirectly contribute to the debate on the usefulness of the inflation targeting regime currently raging in the country.

Exchange rate pass-through essentially deals with the impact of the movements in the exchange rate on prices in the domestic markets, be it consumer prices, producer prices or import prices. Exchange rate pass-through is deemed incomplete when the effect of the currency movement in the exchange rate movements result in less than a unit change in a given domestic price (Ocran 2010).

Campa & Goldberg (2005) argue that there are three key elements that drive the nature of exchange rate pass-through. Such factors are: pricing sentiment and behaviour of exporters in the producer markets/ economies, the sensitivity of mark-ups to competitive conditions and existence of distribution costs that tend to widen the difference between import and retail costs. Further, they suggested that the last two significantly constitute a set of countervailing forces with a net effect that can impact exchange rate pass-through in one way or another. In general, if domestic prices reciprocate to supposed fall in the value of the currency one-to-one then the competitiveness that accrues from the fall in the value of the unit would be wiped out, as the real exchange rate would likely not change at all (Ito & Sato, 2008).

Ocran (2010) further suggests there is a strong link between external factors and consumer price inflation. Nonetheless, as far as the effect of exchange rate shocks is concerned, the impact on consumer price inflation, a major focus of monetary policy, is very modest (he suggested). Cheung & Senguta (2013) found strong evidence that indeed the currency volatility has a strong and significant impact on other macro-economic variables. The currency fluctuation was also found to have a negative impact on the firm's trade decisions.

Krugman (1987), suggests that a percentage of the exchange rate fluctuations could be passed-through into prices of traded products, and/ or even comprehended into the producer profit margins or mark-ups (i.e. pricing to market). Furthermore, he suggests that subsequent to a fall in the value of the importer's currency, which would otherwise normally increase the cost of goods imported, the exporter might cut the export price in local currency in the foreign market/ importer's domestic market. Other than anything-else, this is a kind of approach with a broad objective of maintaining the market share.

According to Krugman (1987), the mark-up prices differs from one industry to the other and is dependent on the demand curve specifically to an exporter in the particular country. Exporters who encounter high competition and, extensively, high elastic demand curve could lower their mark-ups in circumstances wherein the value of the importer's currency falls, so as to ensure preservation of the market share. Alternatively, the companies in the industries with limited competition and inelastic demand would normally pass-through the exchange rate fluctuations to protect their margins. Therefore, this suggests that exchange rate pass through is mainly dependent on the framework of how sufficient the demand is as well as the level of competition in the particular industry.

Jian (2008) reveals that the purchasing power of the customers is largely dependent on affluence and wealth as well as the prices of goods. The local buying power is normally impacted by a raise in price levels of the respective countries i.e. high inflation reduces the purchasing power of the customers and vice-versa.

Charles, Simon & Daniel (2008), argues that the exchange rate pass through to customers is largely dependent amongst other things on the quality of goods imported, the nature and levels of the demand elasticity, openness of the economy, and the Central Bank's monetary policies.

Paral et al., (1998), advocated that inflation is a topical of relevance in examining exchange rate pass through to customers. They affirm that an increasing rate of inflation instigated from the depreciation of the currency often raises price level of local and foreign products. It would be, therefore, precise to say that the depreciation of rand (ZAR) makes import of goods from foreign markets expensive; however, the deliberations at this stage are around the topic of whether this is the case with respect to the domestic prices. A complete understanding of the level and timing of pass through to domestic prices is crucially important in investigating the impact on various economies. Exchange rate pass-through could be significant wherein the prices reciprocate completely to exchange rate fluctuations.

Furthermore, Campa & Goldberg (2005) - hold a view that during the period of exchange rate fluctuations, the companies importing products might elect to pass-through the exchange rate component completely into the selling prices in the domestic market. It would be prudent to note that the empirical literature surrounding the exchange rate pass-through frequently challenges two main objectives viz., how much impact does the exchange rate fluctuation have on the selling prices charged to the customers and secondly the examination of the determinants of the pass-through elasticities.

Alper (2003) strongly viewed the roots of exchange rate pass-through into the local market as the LOP and PPP studies. LOP-Law of One Price relates to the intercontinental arbitrage stipulation for the standard consumption basket. The requirement is that such consumption basket must sell at the same price in a particular currency across the particular countries. If the LOP theories hold, the absolute purchasing power parity theory would also hold. The absolute PPP concept holds that the level of prices in one particular country is equivalent to the level of prices in the other country multiplied by the currency rate between the two specific countries.

Anaya (2000) suggested that if the purchasing power parity-PPP holds, the fluctuations of the currency translate into proportionate variation in price levels in the domestic market; that is the pass-through would be equivalent to one. These assumptions can hardly hold as some of the previous empirical literatures suggest. The relative-PPP, which maintains that the degree of exchange rate amongst different countries is about equal to the difference in raising price levels (inflation rate) of the two countries, becomes a subject of empirical investigations and analysis.

## 2.3 Theoretical and Empirical literature review

As indicated in the introduction section of this chapter, a number of studies have been more concerned with the exchange rate pass-through to import prices. A handful of the recent studies imply that consumer prices are not significantly impacted by the fluctuations of the exchange rates.

Engel (2002) suggested that intermediary companies alternate between both the local and foreign products on the basis of changes on relative prices; however Taylor (2000) cites that the current decline in the exchange rate pass-through is attributed to the lower levels of inflation which has been attained in many economies around the globe. He explains the relation between the exchange rates and prices in respect of the model of a firm's behaviour based on staggered price setting and monopolistic competition. He further suggests that the response of the firm's price to an increase in the costs (either as a result of depreciation or some other cause) is highly related with the persistence of the cost increase.

Razafimahefa (2012) has shown that the exchange rate pass-through to domestic prices in Sub-Saharan Africa (SSA) countries is partial and incomplete. On average, a 10 percent depreciation of local currency brings about 4 percent increases of domestic prices. Half of the increase occurs within the first quarter following the change in exchange rate, and the full impact generally takes place within four quarters. The magnitude of pass-through is estimated to have declined by 50 percent since the mid-1990s. This decline was associated with stronger macroeconomic performance and a stabilizing political situation, which strengthened the confidence in the business environment and deepened competition. Stronger performance on some important macroeconomic variables – income, inflation, broad money and fiscal balance are associated with lower pass-through. This is also reflected through the aggregated indicator of the quality of policies. To address the fear of pass-through and avoid large exchange rate induced inflation, Razafimahefa (2012) suggests that Sub-Saharan Africa policy makers should improve the overall macroeconomic policies. This seems to be particularly important for countries with flexible exchange rate regimes.

De Bandt, Tovonony & Razafindrabe, (2014), explored the link that exists between exchange rate pass-through and currency invoicing decisions of firms using aggregate data of monthly import price indices. With references to recent theoretical literature, namely Gopinath et al. (2010) and Burstein & Gopinath (2013) which addresses this important issue and argues that international transferral of exchange rate movements into import prices depends on which currencies are used (or predominantly used) for contract invoicing in the international trade; Olivier and Tovonony conclude that their findings confirm the importance of trading partners but also the important role played by the currency of the counter-parties' countries.

According to Dong & Nam (2013), the price misalignment representation creates resilient inevitability exchange rate predictability. Their discovery implies that price misalignment for the products such as seafood, electricity and frozen fish, have an element of predictability power for currency levels at short periods – normally one quarter. Furthermore, they highlighted the significance of heterogeneity at the micro levels for a complete understanding of the macro economy. "Goods level relative prices not only are impacted by exchange rate fluctuations, but also show predictive power for their future values when heterogeneity is accounted for."

Mann (1986) reveals the exchange rate volatility, as a macroeconomic variable, as a determinant of the exchange rate pass-through. He argues that exchange rate volatility might create awareness for importers to make adjustments on their profit margins to reduce the amount of pass-through.

Leith (1991) tests the exchange rate and prices in cointegration framework for a small open economy, Botswana. He finds that in contrast to large industrialized countries, the movements in exchange rates and foreign price levels completely pass-through to the domestic prices. However, the adjustment is not instantaneous; half-life of the pass through is found to be fifteen months.

Quite a handful of previous studies on the subject matter of exchange rate pass-through have paid much attention to the impact of exchange rate changes on domestic prices with emphasis on the consumer price inflation (refer to Choudhri & Hakura 2001, McCarthy 2006).

McCarthy (2006) has found a negative exchange rate pass-through to import rates/costs for the case of two economies observed i.e., Belgium and Netherlands. He also maintained that pass-through in Sweden and Switzerland is very small and insignificant. However, the studies done on emerging economies like South Africa (see Bhundia (2002), reveals that the pass-through elasticities are much higher on the import rates, with producer rates and consumer price levels coming after import rates, thus implying that the shocks from the exchange rate have a small-scale impact. In addition, the level of shocks to producer prices contain a significant effect on consumer price inflation, so that the framework designed towards protecting upward inflationary pressures at the producer price level may reduce consumer price inflation.

Restrepo & Garcia (2001), reflect that the pass through to the inflation levels is significant and complete in the long run for Chile. Furthermore they suggest that there is a positive correlation between the levels of exchange rate pass-through, production activities, the rate of wages and that the foreign prices are positively associated with the inflation.

Aron et al. (2014), in their empirical investigation, maintain that microeconomic data reflects considerable distinction in the regularity of the movement in prices amongst a basket of different kind of products. For instance, this is very substantial for food as compared to footwear and clothing. They further suggested that there are also considerable differences over a period of time in the case of the alcohol and tobacco prices. Alcohol and tobacco prices are often altered annually after the budget speech by the Minister of Finance. Most of the prices do not change in a frequent basis (i.e. every month or quarter) at the microeconomic levels.

Furthermore Aron et al. (2014) demonstrated high rate of exchange rate pass-through in which they discovered for food products i.e. more that forty percent after a period of two years on all categories with the exception of tea, coffee, and cocoa as well as other assorted categories. The pass-through for food in entirety is an approximate forty six percent after a period two years. Fascinating enough, if the quality of different kind of elements amongst different food categories is not taken into consideration – it is estimated that the overall pass-through eventually drops to twenty five percent and the percentage of the pass-through for consumer price index-CPI basket considered drops by around nine percent from thirty percent to twenty one percent.

Mustapha (2012)[3], suggests that the pass-through is rapid, therefore fluctuations in exchange rates would pass-through to domestic consumer prices very quickly, within the first 12 months. The rapid reflection of exchange rate pass-through on prices may be due to large depreciations in local currencies against the US dollar and high exchange rate volatility as these countries are highly dollarized. He maintains that, in Ghana, the pass-through is fast and complete. His results for Sierra Leone seem counter-intuitive which may be due to the fact that the country emerged from a decade of civil war in 2002 and the ongoing economic reforms. In case of Nigeria, Mustapha (2012) concludes that the Nigerian economy has the least pass-through whereas Guinea – an economy with the highest inflation rate has a fast but incomplete pass-through and only second to Ghana.

### 2.4 Summary and conclusion

As discussed in the prior sub-sections of this particular chapter, the objective of Chapter 2 is to review the previous work done by others, and to provide an assessment and analysis of the theoretical and empirical literatures done to explore the relationship between exchange rate fluctuations and domestic prices. The reflections in the review of some of the previous literatures have concluded consistency in the impact of the movements of exchange rate on domestic prices. As such the extant of the gateway impact of the currency fluctuations seem to have been ignored and this might be the exact reason of the ambiguities and why the literatures have not reached any agreement on this issue.

It would be fundamental to consider that most of the previous theoretical literatures dispensed in the prior sections of this study have been emphasizing so much on the exchange rate pass-through to the domestic prices in general. Some of those studies found partial or incomplete pass-through.

---

[3] In his study about the ERPT in Countries of the proposed West African Monetary Zone (WAMZ) which considered a group of six countries in West Africa viz. Nigeria – Africa's largest oil producer, Gambia – an economy that depends heavily on peanut exports, Ghana, Guinea, Sierra Leone and Liberia – which joined the WAMZ ten years later (in 2010) after its formation in 2000.

For example, Frimpong (2010) & Razafimahefa (2012) cited some important macroeconomic variables i.e. income, inflation, broad money and fiscal balance as key factors associated with lower pass-through and they hold that the quality of the monetary and fiscal policies is crucial to eliminate the pass-through completely.

Gopinath et al. (2010) and Burstein & Gopinath (2013) however argue that international transference of exchange rate movements into import price levels depends on which currencies are used for invoicing. Currently, there is no literature breaking down the exchange rate and pricing relationship into the chemical sector environment, so in light of this limitation, this study will address the gap by absorbing threshold impact into the framework for the provision of a detailed analysis of the true relationship between exchange rate and domestic prices of the chemical products in the South African economic system.

**CHAPTER THREE**

# EMPIRICAL MODELS AND ESTIMATION PROCEDURES/ METHODOLOGIES OF THE STUDY

## 3.1 Introduction

The broad back-bone of Chapter 3 is the reflection on the type of data utilized to derive the econometric results in this study, the research design presentation as well as a detailed discussion on the proposed econometric tools and statistical techniques applied to evaluate the research objectives discussed in Chapter 1.

## 3.2 Data description

Given the nature of the dataset, this study utilises the time series data techniques to impart answers to the questions outlined on the previous sections of this study. The data, which covers both exchange rates and the prices of chemical products, are collected over a period 2000 through 2013.

The estimation sample comprises six JSE listed companies (see Appendix 5) in the chemical sector in South Africa that import materials from the foreign markets, produce and sell the final products into the local (South African) market. In addition to sourcing such raw materials for the objective of meeting their production requirements, the study incorporates import of the finished goods/ products either for the purpose of utilising such products in the production environment or re-sale to the domestic markets.

Sources of the data collected for variables utilized directly or indirectly in contriving the empirical presentations are summarised below:

I. Trade figures on imported chemicals products – obtained from Statistics South Africa (StatsSA).

II. USD-Rand[4] exchange rates – obtained from Bloomberg software, plus the South African Reserve Bank publications.

---

[4]USD is used as the standard unit of currency in international markets for commercial transactions.

III. Chemical products (most common chemical products) used in study – obtained from Statistics South Africa (StatsSA) and the South Africa Department of Trade & Industry (DTI).

IV. A Price Index of chemical products – obtained from Statistics South Africa (StatsSA).

### 3.3 Research design

In order to deliver a reliable and valid representation of the factors or variables pertaining to this study as well as identifying the casual links/ basic relationships between the USD-Rand exchange rate and domestic prices of the products in the chemical sector – South Africa, the study makes use of both the descriptive and explanatory/ analytical techniques to impart answers to the research questions and unravel the problems identified and outlined in Chapter 1.

In the examination of the true relationship between exchange rate and prices of the chemical products – in the South African economic environment, it will be important not to completely ignore the price determinants. Such determinants have been identified as (1) shipment (if sales terms are not Free On Board-FOB), (2) other costs of production (labour and overhead), (3) research and development costs, (4) marketing and distribution costs, and, (5) taxes. Procurement, a component considered to be a crucial point of sourcing raw materials, was identified as another determinant. The cost of procurement process, which includes identifying the suppliers for specific products as well as engaging them into the RFQ (Request for Quotations) process, would normally be built into the final selling prices to customers.

Furthermore, to ensure that proper answers are provided for the questions raised in Chapter 1 – the study employs the quantitative data which is evaluated using different econometrics methods discussed in details in the next sections. However, it should be acclaimed that previous literatures discussed in Chapter 2 of this study will also be considerably considered in addition to the empirical findings/ results, in order to answer the questions posed in Chapter 1. It is also fundamentally important to note that the study makes use of the secondary data i.e. the government, internet and published data which has been assembled from a variety of sources including, StatsSA, Bloomberg and the South African Reserve Bank amongst others.

## 3.4 Econometric tools or statistical techniques

This sub-section is arranged as follows: firstly, the discussion on stationarity and unit root testing using the ADF and KPSS techniques; secondly, an overview of the autocorrelation analysis is provided; thirdly, the discussion on the cointegration tests. An overview of VAR and VECM also provided for the purpose of providing the complete understanding, and of-course VECM is to be employed in case a set of variables are found to have one or more cointegrating vectors in order to analyse both the long and short terms relationships and to adjust any deviations from the equilibrium. Impulse response, variance decompositions and diagnostic checks are also discussed in detail.

### 3.4.1 Stationarity and unit root testing

Challis & Kitney, (1991), have defined stationarity as a transcendence of the procedure in which the statistical framework i.e. mean and the SD – standard deviation, of the approach do not vary with time.

The first step is to make sure and be certain that time series data is integrated of the same order I(1). To attain this, the unit root tests for the examination of whether the data series is stationary are carried out. In the investigation and evaluation of the unit root and stationarity of the time series data, the variables will be subjected to the Augmented Dickey-Fuller (ADF). Due to the weak power of ADF, as well as its weakness of not taking into consideration the possible autocorrelation in error process, $\varepsilon_t$ – this study adopts Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests to complement the ADF results. By testing both the unit root hypothesis and stationarity hypothesis, it is thus easier to distinguish series that appear to be stationary, series that appear to have a unit root, and series in which the results are not conclusive to determine whether they are stationary or integrated.

Stationarity and/or non-stationarity of the series can substantially impact its sentiment & behaviour and, to some degree, its properties. For instance, a regression of an economic variable on the other variables could reflect a considerable high $R^2$ if the variables trend over a substantial period of time. This could happen regardless of whether the variables are related or not. On the other hand, if economic variables in the estimation are non-stationary, then it can be concluded that inference for asymptotic tests analysis will be invalid. Therefore, "*t*-ratios" will not follow a "*t*-distribution" (Brooks, 2008).

This study adopts two models often utilized to denote non-stationarity of the series,

1. Random walk:

$$\mathbf{y_t = \alpha + y_{t-1} + \mu_t} \tag{1}$$

2. Procedure of deterministic trend:

$$\mathbf{y_t = \alpha + \beta_{t-1} + \mu_t} \tag{2}$$

where:

***$\mu_t$*** => iid in both the random walk and deterministic trend.

As discussed in the previous section, the ADF technique will be applied to test unit root of time series. Blungmart (2000) states a weakness of Dickey-Fuller tests as that of not taking into consideration the possible autocorrelation in error process, $\varepsilon_t$. The OLS estimates of coefficients are normally not efficient and t-stats biased if the $\varepsilon_t$ is autocorrelated. Given this view, the ADF tests are populated and of course preferred to Dickey-Fuller statistics. ADF test statistics modifies the work done by Dickey and Fuller in 1979 and 1976 respectively.

The aim of the Dickey-Fuller theory is to test the hypothesis that ø = 1 in:

$$\mathbf{y_t = \text{ø} y_{t-1} + \mu_t} \tag{3}$$

Formulated hypotheses are, therefore:

**$H_0$**: Unit root presence in time series.

**$H_1$**: Stationarity of time series data.

It is fundamental to note that rejecting null hypothesis would confirm and concludes that there are no unit root issues within the time series data.

Standard Augmented Dickey-Fuller test estimates the following equation:

$$\boldsymbol{\Delta y_t = \alpha_0 + \alpha_1 t + \delta y_t + \mu_t} \tag{4}$$

where:

$y_t$ => dependant variable/ time series;

Δ=> first difference;

t => time/ trend;

& $\mu_t$ => the noise.

Gujarati (2004) suggests that if the $\mu_t$ are not autonomous or independent in the equation (4) above, then the Dickey-Fuller statistics will be skewed. As indicated in the prior discussions, the deficiency of the Dickey Fuller test is the issue of not taking into consideration the potential autocorrelation in the error process, $\mathcal{E}_t$. The Dickey-Fuller test is only plausible where there is no association of the error terms.

The Augmented Dickey-Fuller test estimates the following equation:

$$\boldsymbol{\Delta y_t = \beta_1 + \beta_{2t} + \delta y_{t-1} + \textstyle\sum_{i=1}^{m} \alpha_i \, \Delta y_{t-2} + \mathcal{E}_t} \tag{5}$$

where:

$\mathcal{E}_t$ => a pure white noise error term, and

$\Delta y_{t-1} = (y_{t-1} - y_{t-2})$, $\Delta y_{t-2} = (y_{t-2} - y_{t-3})$, $\Delta y_{t-3}$ => $(y_{t-3} - y_{t-4})$, and so forth.

According to Gujarati (2004) the number of lags to consider is normally calculated empirically, with the proposition being to include enough terms to ensure that the error term $\mathcal{E}_t$ in the equation (5) above is not correlated. The value of the ADF statistic is then compared with the critical value. Should the calculated value of Augmented Dickey-Fuller be greater that the set critical values, then the null hypothesis that the series have unit root is rejected, thus implying the stationarity of the series.

In addition to the information and equations above, the following three cases are vital for this study when the first difference methodology is applied in the time series data to achieve stationarity:

**a.** For a flat time series – slow turning around zero, the following equation will be applied:

$$\Delta y_t = \theta y_{t-1} + \alpha_1 \Delta y_{t-1} + \alpha_2 \Delta y_{t-2} + \ldots + \alpha_p \Delta y_{t-p} + \alpha_t \tag{6}$$

**b.** For a flat time series - potentially turning around a non-zero value, the following test equation will be applied:

$$\Delta y_t = \alpha_0 + \theta y_{t-1} + \alpha_1 \Delta y_{t-1} + \alpha_2 \Delta y_{t-2} + \ldots + \alpha_p \Delta y_{t-p} + \alpha_t \tag{7}$$

**c.** For a time series which has a trend – slow-turning around a trend line, the following test equation will be applied:

$$\Delta y_t = \alpha_0 + \theta y_{t-1} + yt + \alpha_1 \Delta y_{t-1} + \alpha_2 \Delta y_{t-2} + \ldots + \alpha_p \Delta y_{t-p} + \alpha_t \tag{8}$$

The number of augmenting lags (p) is calculated by minimizing SBIC and/or minimizing the AIC. The lags are collapsed until the last lag is statistically significant.

To restrain the development of improper resolves in the analysis, the Schwartz Bayesian approach is preferred to Akaike information criterion due to the fact that it specifies a prior distribution for variances of unique factors (Martin & McDonald, 1975).

The KPSS test has been developed to complement the unit root testing procedures (Augmented Dickey Fuller) as the last is seen to have low power with regards to near unit-root and long-run trend processes.

Kwaitkowski et al. provide a simple test of the null hypothesis of trend stationarity against the alternative of a unit root. For their test procedure, Kwaitkowski et al. considered three component representation of the observed time series ($Y_1, Y_{2,\ldots,} Y_N$) as the sum of a deterministic time trend, a random walk and a stationary residual:

$$Y_t = \beta t + (r_t + \alpha) + e_t \tag{9}$$

Where:

- $r_t = r_{t-1} + \mu_t$ is a random walk, the initial value $r_0 = \alpha$ serves as an intercept,
- t is the time index
- $\mu_t$ are independent identically distributed $(0, \delta^2_u)$

The null and the alternative hypothesis are formulated as follows:

**H₀**: $Y_t$ is trend stationary, that is $(\delta^2_u = 0)$

**H₁**: Yt is a unit root process.

It is important to note that the standard KPSS test is oversized for highly autoregressive processes due to the fact that it employs a semiparametric heteroskedasticity and autocorrelation consistent covariance estimator (HAC) of the long run variance of the process with an important positive finite sample bias. Further, some long run variance estimators which work well under the null, lead to inconsistency of the KPSS type test under random walk alternatives, i.e., the power of the test for some relevant alternatives does not approach 1 as the sample size increases (Hobijn, Franses & Ooms 1998).

Statistically, when the computed p-value is less than (greater than) the critical value, the null hypothesis of stationarity in data is rejected (accepted). Similarly, when calculated t-values are greater than (less than) the critical values, the null hypothesis is rejected (accepted).

### 3.4.2 Auto-correlation and the spectral analysis

Brooks (2008, p.28) advocated that autocorrelation refers to the interrelationship of economic variables in a time series with their historical values. It is also referred to as the "lagged correlation" and/or "serial correlation", which denotes the association amongst representatives of a series of numbers organized over time. The positive link of the variables might be deemed a type of "persistence", and a propensity that the system would remain in a similar condition from one analysis to another.

The auto-correlation analysis, for examining serial dependence, and the spectral analysis, for the examination of cyclic behaviour, is also a very important technique in this study. The reciprocity of two or more economic variables determines the level of linear interaction between them. For instance, if *y* and *x* are correlated, it implies that *y* and *x* are regarded in an absolutely symmetrical way. Since autocorrelation is different to causation, this does not imply that the movements in *x* cause movements in y and vice-versa. Therefore, it is rather inferred that evidence for a linear association amongst the variables exists and that the changes in the variables are ordinarily interrelated to an extent given by the correlation coefficient (Brooks, 2008).

The graphical or informal examination of the autocorrelation from the time series charts is very instinctive and largely dependent on skills and knowledge. It is a good recommendation, however, to certainly visualize the time series graphs as a first step in the assessment and analysis of persistence (Draper & Smith 1981).

In order to check the autocorrelation, which is caused by misspecification, data manipulation (before receipt & after receipt), event inertia and spatial ordering, the study adopts the Durbin-Watson (DW) test statistic to check any presence of autocorrelation in the residuals from the regression analysis. Autocorrelation analysis is important in this study as it complicates the application of statistical tests and the identification of significant covariance or correlation between time series. A simple correlogram will be done, in addition to D-W statistic, to supplement the D-W statistics results in analysing the autocorrelation.

### 3.4.3 Johansen cointegration, VAR and VECM

There are several methods of testing for cointegration, but two often stand above the rest namely the Engle-Granger approach and the Johansen (1988) technique.

The evolution of the notion of non-stationary time series assessment has been propelled by the finding that numerous macroeconomic variables in the time series analysis could potentially accommodate the unit roots. Under the circumstances wherein the linear conjunction/ combination of non-stationary time series became stationary, the non-stationary time series are pronounced to have cointegrating relationship (Engle & Granger, 1987). Stock & Watson (1988) suggest that such cointegrating equation is inferred as a long run relationship amongst the variables. To ensure that models estimated are not factitious, it is essential to run the cointegration analysis. Engle & Granger (1987) has defined the cointegration as the variables which are integrated of the same order. Therefore, this implies that the variables which are integrated of different orders cannot be cointegrated i.e. for conitegration using Engle-Granger or Johansen methods, all the series have to be integrated of the same order. For example, if x is I(1) and y is I(2), then it is essential to work with x and the first difference of y so that both be I(1).

Engle-Granger approach, often termed the two-step procedure, has the propensity of the rejection of null hypothesis of no cointegrating equation on the cut-off point (Kremers, Ericcson & Doldado, 1992). Due to this reason and also in addition to the estimation of the vector error correction model, the coefficient on $\varepsilon_t$ might become highly statistically significant. If the two variables/ series appear to move together over time, it is thus a suggestion that there is an existence of equilibrium relationship between the variables/ series. Therefore, this is the reflection that even though the variables are non-stationary in the short run, if they are cointegrated, their differences will be transformed into stationarity over time as they progress closely together.

Since the Engle-Granger two-step procedure is often seen to have lower power i.e. it is vulnerable to errors found in step 1 being transferred to step 2 of the analysis, the tests for cointegration – in this study will be subjected to the Johansen (1988) approach. Short run analysis will be conducted if the cointegration is not found and both the long run and short run analysis (VECM) will follow if cointegration is found.

The Johansen technique for cointegration requires testing for existence of cointegration and determination of the cointegrating vectors in the estimation. A general VAR framework is utilized to achieve this. The VAR model explains the evolution of endogenous variables over the same sample period (t = 1,…,T). The variables are collected in a k x 1 vector, which has the *i*-th element, $y_{i,t}$, the time t observation of the *i*-th variable.

For example, a *p*-th order VAR, denoted VAR (p), is:

$$\mathbf{y_t = c + A_1y_{t-1} + A_2y_{t-2} + \dots + A_Py_{t-}p + e_t} \qquad (10)$$

The VAR-vector autoregressive framework is a conventional framework utilized to explain the dynamic correlation amongst stationary variables. Dolado et al. (1999) suggest that the VAR framework must be rearranged to accommodate a stable evaluation of the relationships amongst the series. The vector error correction (VEC) model is just a special case of the VAR for variables that are stationary in their differences (for instance, I(1)). In order to substantiate the use of vector error correction model (VECM), cointegration tests must be performed first. A vector error correction model is intended to be used with the series that are known to be cointegrated. Vector error correction model has cointegration relations built into the stipulation so that it moderates the long-run sentiment and behaviour of the endogenous variables to intersect to their cointegrating relationships while allowing for short-run adjustment dynamics (Brooks 2008, p. 350). Further, Brooks states that the cointegration term is also commonly known as the correction term considering that the divergence from long-run equilibrium is rectified gradually through a series of partial short-run adjustments estimated.

Brooks (2008) argues that the problems of the Engle-Granger approach incorporate/ include the potential deficiency when testing for unit root, skewness in the contemporaneous equation as well as the difficulties of completing or running hypothesis tests about the actual cointegrating relationships.

In light of the shortfalls of the Engle-Granger approach discussed in the previous sections of this chapter, the vector error correction model is seen as an alternative approach for long and short term analysis wherein the cointegration is found (Johansen, 1991: 1995). The rationale behind being that this methodology utilizes the utmost prospect evaluation and analysis to a vector error correction model to concurrently ascertain the long run and short run determinants of the dependant variable in the estimation. The rate of the adjustment coefficient (which is a measure of the level at which variables revert back to their equilibrium after a shock), is allotted by this approach (Greene, 2000).

It is fundamental to note that, in order to specify the number of lags to be considered in the vector error correction model, the vector autoregressive model is crucial, and must be performed for the variables in the model. Greene (2000) goes further to describe four important steps applied when implementing the Johansen procedure, such steps are:

Step 1: Assess the order of integration of all variables in the series. Cointegration approach requires the tests to determine the order of integration. All the variables should be integrated of the same order before proceeding with the cointegration test.

Step 2: This step involves setting-up the proper lags of the model as well as evaluation of the model and identification of the rank of π.

Step 3: The third step involves an analysis of the normalised co-integrating vector(s) and speed of adjustment coefficients is made.

Step 4: It is in this step wherein the number of co-integrating vectors is determined. The fourth step involves applying informal tests on the vector error correction model to discern and ascertain whether the estimated model is reasonable.

If the economic variables in the estimation are found to be cointegrated, the vector error correction model should be done to determine the differences between long and short run impacts of variables. According to Enders (2004), the notion of first differencing nullifies important and functional information endowed and/or found in the cointegration relationships.

### 3.4.4 Impulse response functions/ analysis

To trace and determine the response of the dependant variable to shocks from each independent variable, this study applies impulse-response analysis for the models examined.

Brooks (2008) stresses that impulse-response analysis detects the receptiveness of the dependent variable in the vector autoregressive to shocks in the system to each of the other variables. Further, he states that impulse-response analysis is applied on the vector error correction model, and the shock normally dies away if the system is substantial and stable.

### 3.4.5 Variance decompositions analysis

After performing the impulse-response analysis, further information on the link between exchange rates and domestic prices of the chemical products – South Africa is observed using the variance decomposition investigation. Brooks (2008) explains that variance decomposition examination dispense the percentage of changes in the dependent variables that are due to its own shocks, against shocks to other variables. Enders (2004) unravel that the forecast variance decompositions explain the movement of variables as a result of the shocks on the particular variables or as a result of shocks from the other variables in the estimation. Variance decompositions provide an indication on the separation of the disparity in endogenous variables into shocks. Therefore, error variance decompositions illustrate the importance of the random change impacting on the other variables in the vector autoregressive system. Variance decomposition is useful in evaluating how shocks reverberate through a system (i.e. to assess the pass-through of external shocks to each economic variable).

### 3.4.6 Diagnostic checks

The diagnostic tests are very important in the examination of the impact of exchange rates on domestic prices of chemical products in South Africa. These analyses affirm the framework evaluation results attained by the models estimated. Furthermore, diagnostic checks are useful to determine the stochastic properties of the estimations such as serial correlation, heteroscedasticity, normality, and many more. (Some of these properties are discussed briefly in the subsections below).

Such analyses are not only important in econometrics but also crucial in other variety of specialities where linear regression is employed. Breiman (2001) suggests it is fundamental to examine the goodness-of-fit of the time series data, specifically not only repeated analyses proposed for an assured course of the back-up. Furthermore, the null hypothesis will always be rejected given that there is sufficient data at hand. The question is not whether the model is wrong (it always is**!**) but if the irregularities are of a serious nature.

#### 3.4.6.1 Autocorrelation LM (Lagrange Multiplier) tests

The BG – Breusch-Godfrey test statistics are employed to examine the credibility of some of the modelling estimations intrinsic in involving and/or applying regression-like estimations to the monitored/ observed data series. Particularly, the BG test statistics check the existence of serial dependence which was not incorporated in a recommended model approach and it, if exists, will imply that the wrong inference would be done from other output/ tests results, or that sub-optimal evaluations of the model framework are attained if it is not captured and given the consideration. The BG test statistics – LM test is the analysis for autocorrelation in the error terms in the estimation model. It applies the residuals from the model being estimated in a regression analysis, and a test statistic is derived. The LM test centers on the value of the $R^2$ for the auxiliary regression. If one or more coefficients in an equation are statistically significant, then the value of $R^2$ for that equation will be relatively significant.

The BG – Breusch-Godfrey test statistics follow the following procedure:

$$\mathbf{y_t = \alpha_0 + \alpha_1 x_{t,1} + \alpha_2 x_{t,2} + \mu_t} \quad (11)$$

where:

the residuals might follow an AR(*P*) autoregressive equation given below:

$$\mathbf{\mu_t = \mathit{p}_1\mu_{t-1} + \mathit{p}_2\mu_{t-2} + \ldots \mathit{p}_p\mu_{t-p} + \varepsilon_t} \quad (12)$$

Breusch & Godfrey – 1979 and 1978 respectively proved that when the usual $R^2$ statistic is computed, then the asymptotic estimation below can be utilized for the distribution of the test statistic,

$$\mathbf{\mathit{n}R^2 \approx X^2_{\mathit{p}}} \quad (13)$$

where:

the null hypothesis $H_0$ : {$p_i$ = 0 for all *i*} holds that there is no serial correlation of any order up to *p*. Hence, *n* is the number of data-points available.

### 3.4.6.2 Residual normality test

The tests for residual normality are normally utilized to ascertain if the set of the data employed is well-modelled by a normal distribution and more fundamentally to determine the normal distribution of the random variable central to the data set. The most well-known statistic employed to test for normality is the BJ – Bera-Jarque test statistics. It is prudent to note that Bera-Jarque statistic applies the property of a normally distributed random variable and that the whole distribution is characterised by the mean and the variance (1st two moments). Within the null hypothesis of the symmetric distribution of series, the BJ test statistic asymptotically follows

$X^2$. If residuals from the model are either considerably biased or leptokurtic or both, then this will result in the rejection of the null hypothesis.

### 3.4.6.3 Heteroscedasticity

Brooks (2008, p. 148), suggested a number of commonly used statistical tests for heteroscedasticity. One commonly used is White's (1980) test statistics for the analysis of heteroscedasticity. The test is fundamentally important due to the number of assumptions it possesses i.e. it surmises that the regression model estimated is of a linear approach or structure. The null hypothesis for the White test is homoscedasticity and if we fail to reject the null hypothesis then there is no presence of heteroscedasticity. If we reject the null, then we have heteroscedasticity.

### 3.4.6.4 Misspecification tests

Misspecification errors happen when some of the important variables are omitted from the model (erroneously or otherwise). The most commonly used statistical technique is the Ramsey Reset (RR) test which will also be applied in this study to determine whether there is any omission of variables on the examination of the impact of exchange rates on the chemical industry – specific to the prices of chemical products in the South African market. It is important to understand that if the assumption of no misspecification does not hold, then the model should be re-described and perhaps estimated using a different method, depending on the exact nature of the misspecifications.

## CHAPTER FOUR

## EMPIRICAL ANALYSIS AND PRESENTATION OF THE RESULTS/ FINDINGS

### 4.1 Introduction

This chapter outlines the findings and results of the econometric analyses regarding the relationship between exchange rates and the domestic prices of the chemical products in the South African economic environment. The main aim of the econometric analyses in this chapter is to present the results and address the questions raised in Chapter 1. Results from this chapter explain the impact of exchange rates on prices of the chemical products within the South African economy using time series data for the period between 2000 and 2013. This chapter is organised as follows: First is the presentation of the unit root tests analysis done for the determination of the data stationarity, this is then followed by auto-correlation and spectral analysis. The cointegration tests which are vital part of this study are presented and discussed thereafter, and then followed by impulse response analysis, variance decompositions and diagnostic checks.

### 4.2 Unit root test results

The first step of the Johansen procedure is to test for unit root/ stationarity in time series. Testing for the order of integration is standard in applied econometric work. The two most important motives behind unit root tests are, first: determining the order of integration is crucial for setting up an econometric model and do inference; and second: economic theory suggests that certain variables should be integrated, a random walk or martingale process. It is in this situation wherein it’s fundamental to perform detailed tests and carefully finding critical values (Sjo, 2008). There are two well-known methods to test whether time series are stationary or not, viz. the graphical method which is informal and then the formal test. In this study, the presentation is firstly done by showing the visual plot of graphs before the formal tests. Then the formal tests are performed applying the Augmented Dickey-Fuller and KPSS techniques. According to (Brooks, 2008) the unit root tests are fundamental as they provide intuition into the structural breaks, trends and stationarity of the data set.

Figure 7: **Plot of variable USD-Rand exchange rates for 2000-2013**

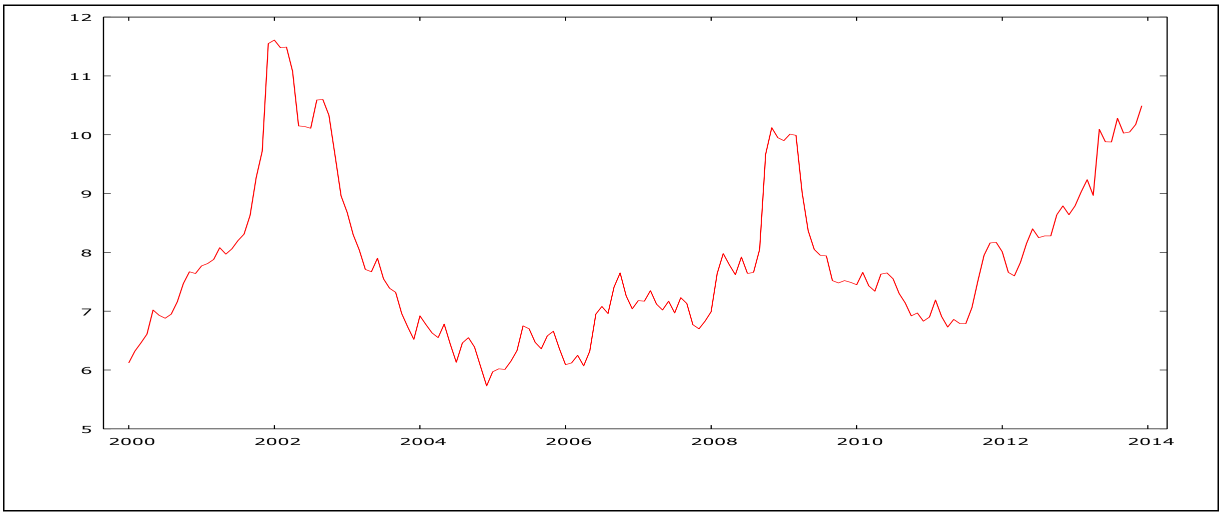
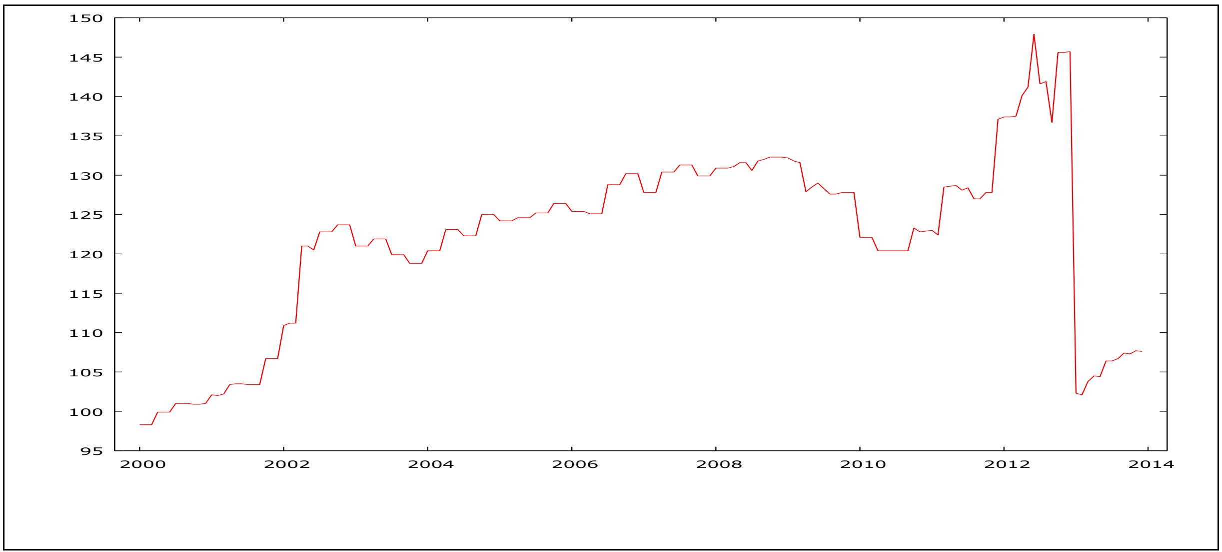



Figure 8: **Plot of variable chemical products prices for 2000-2013**




Using an informal methodology of visual plots, time series data which alternate around the zero mean denote stationarity. Therefore, looking at the Figures 7 and 8 above, which reflect the series before differencing; – it can be noted that the series are non-stationary due to the fact that the mean for both variables is not zero.

As we can see from Figure 8, there was a drop in the prices of chemical products around 2013 – and this sudden drop in the prices is due to the cyclical and volatility in the sector. The chemical sector experienced alternating periods of tight supply and overcapacity. Quite remarkably, the intervals of stringent supply have culminated price increases and raising profit margins, and have been subsequently succeeded by intervals of considerable volume and additional capacity, which lead to the oversupply, price decreases and a decline in profit margins.

Figure 9: **Plot of first differenced variable USD-Rand exchange rates for 2000-2013**

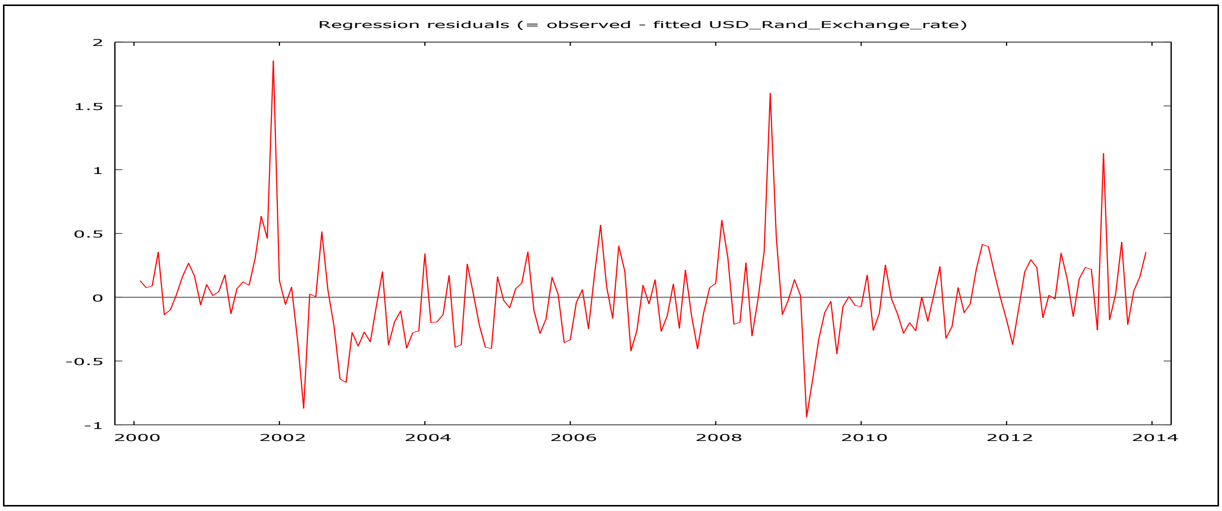
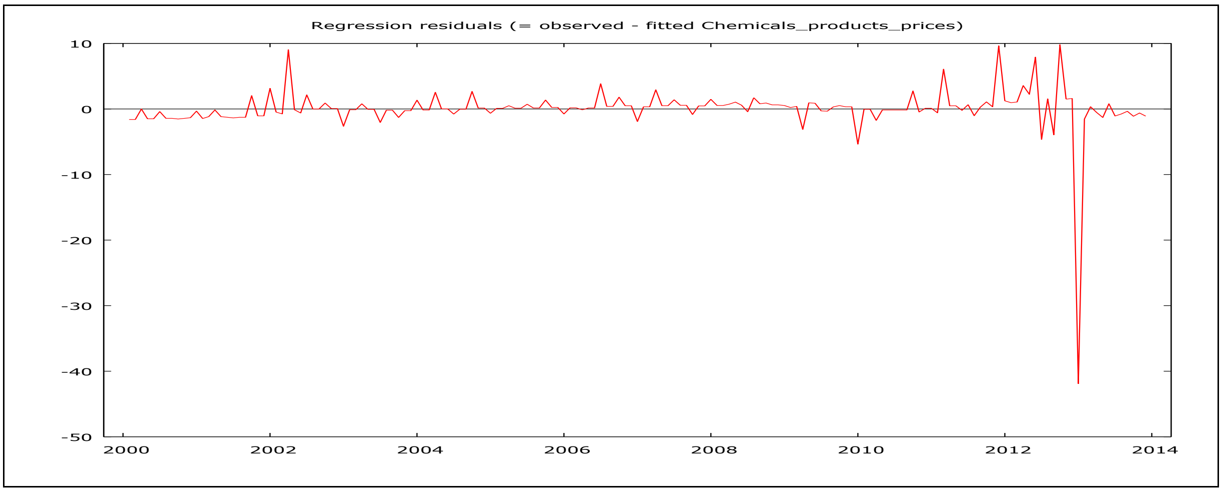



Figure 10: **Plot of first differenced variable chemical products prices for 2000-2013**




Subsequent to differencing, Figures 9 and 10 reflect stationarity of the series, in both variables (USD-Rand exchange rate and the prices of chemical products), as their mean fluctuates around zero. The basic interpretation of this is, therefore, that the non-stationary series become stationary after differencing. For the objective of avoiding spurious regressions, the first order integrated series ensures that the economic data is stationary. Nelson & Plosser (1982) suggest that although a sizeable quantity of macroeconomic variables in the time series seems to be non-stationary in levels, the variables often become stationary when first differenced. The results found in (Figures 9 and 10) confirm the pioneering work Nelson & Plosser (1982) have done.

Due to informality of graphical techniques, it should be noted that the findings above are not sufficient to conclude that the data is stationary; therefore additional results are computed to substantiate such graphical findings. Formal tests were concluded in a form of ADF test statistics and the results are presented in Table 2 and Table 3 below.

Table 2: **Stationarity results of the variable, USD-Rand exchange rate – ADF test**

ADF regression
OLS => observations from 2000:01-2013:12 (T=>168)
Variable => d_USD_Rand_Exchange_rate

| | **Co-efficient** | **Standard error** | **T-ratios** | **P-values** |
|---|---|---|---|---|
| constant | 0.0116 | 0.0268 | 0.4336 | 0.6652 |
| USD_Rand_Exc~1 | -0.5971 | 0.1811 | -3.2970 | 0.0150 ** |
| differenced_USD_Rand_E1 | -0.1477 | 0.1763 | -0.6452 | 0.5198 |
| differenced _USD_Rand_E2 | -0.1477 | 0.1641 | -0.9003 | 0.3694 |
| differenced _USD_Rand_E3 | -0.0602 | 0.1505 | -0.4001 | 0.6896 |
| differenced _USD_Rand_E4 | -0.0516 | 0.1382 | -0.3731 | 0.7096 |
| differenced _USD_Rand_E5 | -0.1338 | 0.1279 | -1.0460 | 0.2970 |
| differenced _USD_Rand_E6 | -0.2162 | 0.1156 | -1.8700 | 0.0635 * |
| differenced _USD_Rand_E7 | -0.1954 | 0.1010 | -1.9350 | 0.0549 * |
| differenced _USD_Rand_E8 | -0.0515 | 0.0875 | -0.5894 | 0.5565 |

AIC: 111.813 BIC: 142.439 HQC: 124.251

MIC = -1.10394 for k = 10
MIC = -1.20527 for k = 09
MIC = -1.33015 for k = 08
MIC = -1.25727 for k = 07
MIC = -0.894418 for k = 06
MIC = -0.700533 for k = 05
MIC = -0.891147 for k = 04
MIC = -1.11986 for k = 03
MIC = -1.16006 for k = 02
MIC = -1.01380 for k = 01

5% critical values for ADF,

p-value = 0.0150**

Table 3: **Stationarity results of the variable chemical products prices – ADF test**

| ADF regression<br>OLS => observations from 2000:01-2013:12 (T=> 168)<br>Dependent variable => d_Chemicals_products_prices | | | | |
|---|---|---|---|---|
| | **Co-efficient** | **Standard error** | **T-ratios** | **P-values** |
| constant | 7.67935 | 3.43985 | 2.232 | 0.0270 ** |
| Chemicals_prod~1 | -0.0623041 | 0.0280201 | -2.224 | 0.1979 |
| d_Chemicals_pr~1 | -0.00661959 | 0.0778115 | -0.08507 | 0.9323 |
| d_Chemicals_pr~2 | 0.012131 | 0.0777674 | 0.156 | 0.8762 |
| d_Chemicals_pr~3 | -0.152902 | 0.0776528 | -1.969 | 0.0507 * |
| | | | | |
| AIC=> 910.464 BIC=>925.964 HQC=> 916.757 | | | | |
| | | | | |
| MIC = 20.8727 for k = 10 | | | | |
| MIC = 21.3743 for k = 09 | | | | |
| MIC = 19.9494 for k = 08 | | | | |
| MIC = 20.3261 for k = 07 | | | | |
| MIC = 22.3291 for k = 06 | | | | |
| MIC = 17.6617 for k = 05 | | | | |
| MIC = 17.4163 for k = 04 | | | | |
| MIC = 14.5722 for k = 03 | | | | |
| MIC = 17.6239 for k = 02 | | | | |
| MIC = 16.9339 for k = 01 | | | | |

5% critical values for ADF

p-value = 0.0270**

The output from Tables 2 and 3 reflects the Augmented Dickey-Fuller test results. At the specified significance level of 0.05 (or 5%), the null hypothesis that the series have unit root is rejected, thus maintaining that the series are stationary. The p-values of 0.0150** and 0.0270** respectively are statistically less than a specified critical level of 5%.

Furthermore the tests from the USD-Rand exchange rate variable have a unit-root null hypothesis: a = 1. When testing with constant model: (1-L) y = b0 + (a-1)*y(-1) + ... + e, the results show that the t-statistic => tau c(1) = -3.297 and reflect the p-value of 0.01503. Testing with constant and trend model=> (1-L) y = b0 + b1*t + (a-1)*y(-1) + ... + e, on the other hand, shows the test-statistic = -3.34 and p-value of 0.05986 results. By the same token, the results computed for the prices of chemical products reveal the following: 1. with constant model, the test statistic = -2.22355 and the p-value = 0.1979; and 2. with constant and trend model, the test statistic = -1.56696 and the p-value of 0.8061. It must be noted that if the calculated Augmented Dickey-Fuller value is greater than the critical value, we reject the null hypothesis that the series have unit root, therefore concluding that the series are stationary. Furthermore, the computed p-values came out lower that the alpha (a=1), thus we reject the null hypothesis. In conclusion, it is apparent that both differenced variables are stationary, hence the rejection of the null hypothesis of the unit root.

As discussed in Chapter 3, comparison of the output from the ADF framework with the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test statistic provides the possibility to determine whether the series is stationary, non-stationary due to the presence of a unit root, or as it may potentially happen – data do not contain information sufficient to make inference. Tables below present the results of the KPSS tests.

Table 4: **KPSS test – USD-Rand exchange rate variable**

| KPSS test for USD_Rand_Exchange_Rate (incl. trend analysis) | | | |
|---|---|---|---|
| | | | |
| T=>168 | | | |
| Lags=>12 | | | |
| t-stats=>0.128688 | | | |
| | | | |
| | 0.1 or 10% | 0.05 or 5% | 0.01 or 1% |
| Critical/ significance levels | 0.12 | 0.148 | 0.216 |
| Interposed p-value 0.084 | | | |

Table 4 presents t-stats, interposed p-value and the 1%, 5% and 10% critical values. The output from Table 4 reveals that we reject the null hypothesis of stationarity at the 0.1 significance level. Since the t-statistics => 0.128688 is greater than the critical value of 0.12 this indicates non-stationarity. Further, we cannot reject the reject the null hypothesis at 0.01 and 0.05 significance levels as our t-statistics is less that the calculated critical levels; therefore this implies that the variable is stationary.

Looking at Table 5 below, it can be inferred that the variable (price of chemical products) is stationary. Using the same inference method as applied for the USD-Rand exchange rate variable above, the calculated t-stats => 0.22315 is greater than the critical values at 10%, 5% and 1%

significance levels. If we take the 0.05 (5%) significance level utilized for the interpretation of the ADF (Augmented Dickey Fuller) results shown in Tables 2 and 3 above, we can conclude that both ADF and KPSS test statistics disclose the data stationarity on both variables (USD_Rand exchange rate and prices of the chemicals products). As such, it is not necessary to go further and utilise the first differences in testing stationarity of either variable. As it is evident on the output shown in Table 6 below, the first differences in the prices of the chemical products yield the non-stationarity results. In conclusion, the KPSS test provides the same results as the ADF statistical tests done in the prior discussion.

Table 5: **KPSS test – The variable prices of chemical products**

| | | | |
|---|---|---|---|
| KPSS test for Prices_of_Chemical_Products (incl. trend analysis) | | | |
| | | | |
| T=>168 | | | |
| Lags=>12 | | | |
| t-stats=>0.223159 | | | |
| | | | |
| | 0.1 or 10% | 0.05 or 5% | 0.01 or 1% |
| Critical/ significance levels | 0.12 | 0.148 | 0.216 |
| | | | |

Table 6: **KPSS test – The variable prices of chemicals products, after first difference**

| | | | |
|---|---|---|---|
| KPSS test for d_Prices_of_Chemical_Products (incl. trend analysis) | | | |
| | | | |
| T=>167 | | | |
| Lags=>12 | | | |
| t-stats=>0.0384111 | | | |
| | | | |
| | 0.1 or 10% | 0.05 or 5% | 0.01 or 1% |
| Critical/ significance levels | 0.12 | 0.148 | 0.216 |
| | | | |

### 4.3 Autocorrelation analysis using Durbin-Watson statistics

Autocorrelation analysis is an important test to determine and check for the presence of autocorrelation in residuals. It implies that the adjacent observations are correlated, and if they are, then the least-squares regression underestimates the standard error of the coefficients. For instance, the monthly prices of the chemical products might depend on the preceding observation (i.e. previous/ historical selling prices). Within the framework estimations to investigate the impact of the exchange rate in the prices of chemical products – South Africa, the tests for autocorrelation in this study are based on the Durbin Watson statistics to determine whether or not the autocorrelation between adjacent error terms is zero.

The results of the Durbin Watson tests are shown in the Table 7 below. The critical values and interpretation of the output are provided immediately thereafter.

Table 7: **Autocorrelation results of Durbin-Watson tests**

| Model 1 => OLS => observations from 2000:01-2013:12 (T = 168)<br>Dependent variable => Prices_of_Chemical_Products | | | | |
|---|---|---|---|---|
| | **Co-efficient** | **Standard errors** | **T-ratios** | **P-values** |
| constant | 131.8379167 | 5.197956964 | 25.36341059 | 5.45E-59 |
| USD_Rand_Exchange_Rate | -1.276964131 | 0.6552759 | -1.948742707 | 0.0530 |
| | | | | |
| Mean_dependent_variance | 121.8529762 | S.D._dep_variance | 11.43551525 | |
| Sum_squared_residuals | 21350.32505 | S.E._of regression | 11.34091777 | |
| $R^2$ | 0.022365441 | Adjusted $R^2$ | 0.016476076 | |
| F(1, 166) | 3.797598139 | P-value(F) | 0.053012046 | |
| Log-likelihood | -645.3497678 | AIC | 1294.699536 | |
| SBIC | 1300.947463 | Hannan-Quinn | 1297.235249 | |
| rho | 0.927770321 | D-W | 0.118176356 | |

5% critical values=>D-W statistic=>n = 168, k = 1

dL=>1.7357

dU=>1.7596

D-W stats = 0.118176

p-value = 0

To check whether any autocorrelation exists, the computed D-W statistic is compared with both lower and upper bounds (dL = 1.7357 and dU = 1.7596). If the D-W calculated value is greater that the upper bound, it implies that no correlation exists; if D-W value is lower than the lower bound, positive correlation exists, and if Durbin Watson is somewhere between the two bounds, then the test is inconclusive. From the output in Table 7 above, it can be concluded that autocorrelation exists between the two variables. Therefore, this implies that the USD-Rand exchange rate and the prices of the chemical products are dependent on their historical trend. It is important to note that this doesn't in any way imply causation.

In addition, the correlogram is done to supplement the Durbin Watson test statistics discussed above. Figures below are the correlogram results done to aid and to support the output from the D-W statistics.

Figure 11: **Plot of correlogram results – variable USD-Rand exchange rate**

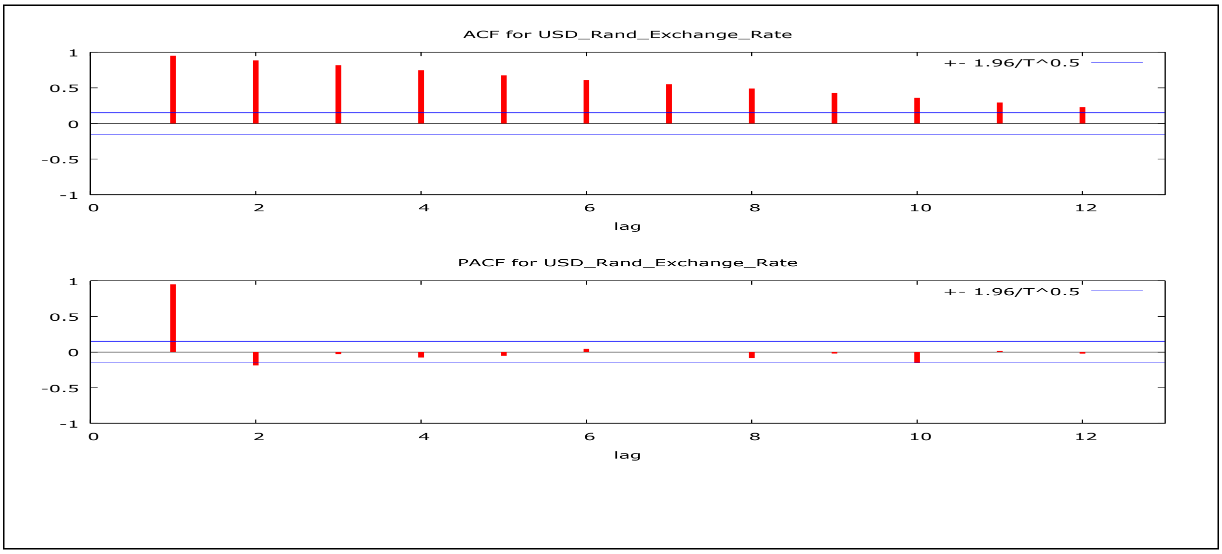
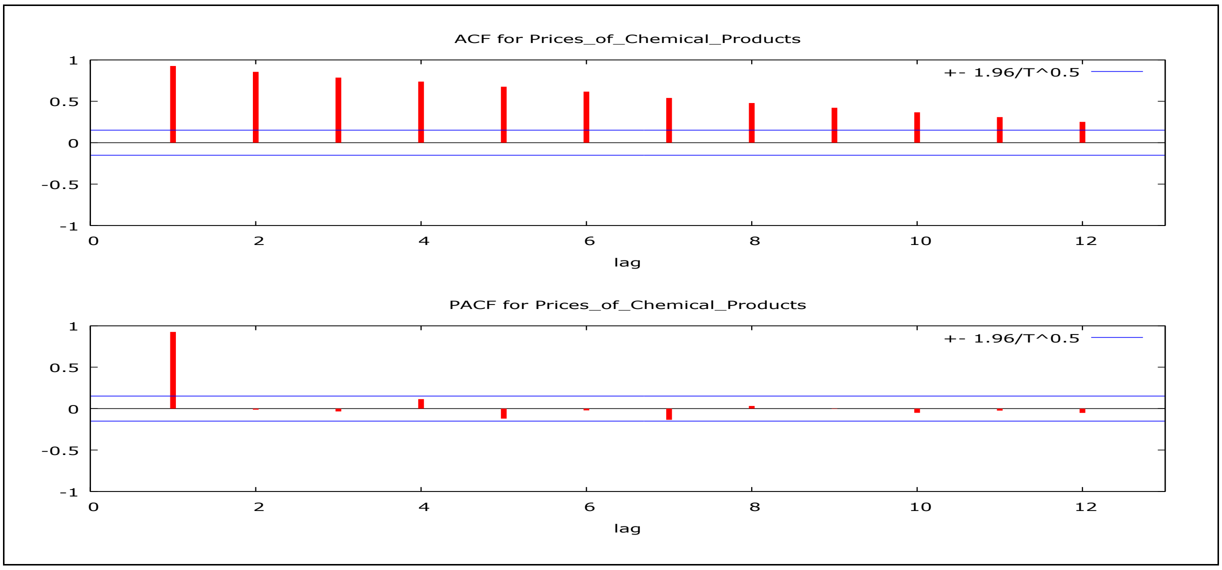



Figure 12: **Plot of correlogram results – variable chemical products prices**



The interpretation of results in the Figures 11 and 12 is that autocorrelation function (ACF) of the two variables shows statistically significance results at 1% from lag 1 – lag 12. The partial autocorrelation function (PACF), on the other hand, reveals that only lag 1 is statistically significant at 1%, lag 2 and lag 10 at 5% for the USD-Rand exchange rate. The second variable (prices of chemical products) shows lag 1 as statistically significant at 1% level and lag 10 at 10% level. (See Appendix 1 for the correlogram tables)

### 4.4 Cointegration tests

If the variables are integrated of the same order, it is fundamentally important to determine and ascertain whether there is any long-run equilibrium relationship which exists between those variables. Cointegration explains the presence of an equilibrium or stationarity relationships between two or more times series variables each of which is individually non-stationary. For the purposes of this study cointegration examines the long run relationship between the exchange rates and prices of chemical products – South Africa. It is very crucial to check whether there exists a long run relationship between the USD-Rand exchange rate and the chemical products prices in the domestic market – South Africa, in order for a viable economic conclusion to be reached from the results obtained. According to Andren (2007), the cointegration approach allows researchers to desegregate the long run and short run relations between variables within the integrated parameters. For obvious reasons discussed in the previous chapter, Johansen cointegration approach is preferred over the Engle and Granger residual-based methodology to test for cointegration.

Below are the cointegration tests results, which were computed in consideration of different cases i.e. without constant, with restricted constant, with unrestricted constant, with restricted trend & unrestricted constant as well as unrestricted trend & constant[5]. It is prudent to keep a trend & constant, otherwise the model would become too restricted. Therefore the interpretation of the cointegration results in this study will be based on the case - "unrestricted trend and constant".

---

[5] Tests using different considerations provide similar results (see Appendix 2)

Table 8: **The results of Johansen cointegration tests, Case 5 – Unrestricted trend and constant**

| | | | |
|---|---|---|---|
| Cointegration tests<br># of equa. =>2 Lags=>12<br>Period=>2001:01 - 2013:12 (T=> 156) | | | |
| **Case 5: Unrestricted trend and constant** | | | |
| **Log-likelihood = -6.80445 (incl. constant term: -449.513)** | | | |
| **Ranks** | **Eigenvalues** | **T. stats & p-values** | **Lmax stats & p-values** |
| Zero (0) | 0.098450 | 16.795 [0.0816] | 16.168 [0.0667] |
| One (1) | 0.004010 | 0.62687 [0.4285] | 0.62687 [0.4285] |
| Corr. size = 130 | | | |
| Rank | Trace stats & p-values | | |
| Zero (0) | 16.795 [0.0819] | | |
| One (1) | 0.62687 [0.4326] | | |
| Eigenvalues=> | 0.098450 | 0.0040103 | |
| **beta (cointegrating vectors)** | | | |
| Chemicals_produc~ | -0.150030 | -0.134270 | |
| USD_Rand_Exchang~ | -0.805820 | 0.583760 | |
| **alpha (adjustment vectors)** | | | |
| Chemicals_produc~ | 0.627110 | 0.193700 | |
| USD_Rand_Exchang~ | 0.079800 | -0.010280 | |
| **renormalized beta** | | | |
| Chemicals_produc~ | 1.000000 | -0.230010 | |
| USD_Rand_Exchang~ | 5.371000 | 1.000000 | |
| **renormalized alpha** | | | |
| Chemicals_produc~ | -0.094086 | 0.113070 | |
| USD_Rand_Exchang~ | -0.011973 | -0.006001 | |
| **long-run matrix (alpha * beta')** | | | |
| | Chemicals_produc~ | USD_Rand_Exchang~ | |
| Chemicals_produc~ | -0.120090 | -0.392260 | |
| USD_Rand_Exchang~ | -0.010592 | -0.070305 | |

1% critical level

| | | | |
|---|---|---|---|
| p-values | => rank Zero (0) | = 0.0819 & | rank One (1) = 0.4326 |
| eigenvalue | => rank Zero (0) | = 0.098450 & | rank One (1) = 0.0040103 |
| trace test | => rank Zero (0) | = 16.795 & | rank One (1) = 0.62687 |

Interpretation of the results and output in the Table 8 is provided in detail in the next paragraphs.

The output in Table 8 reveals the p-values at 0.0819 and 0.4326 for trace test and L-max test respectively for the rank 0. Therefore, at critical level 0.01 (1%) – the p-values are significantly higher than the critical level of 1% which implies that we cannot reject the null hypothesis that there is zero cointegrating vectors i.e. there is no cointegration. In this case, it is thus not necessary to go further down to the next variable(s). Likewise when analysing the results from other cases (see Appendix 2), again – the output from such cases reveals that the p-values at rank 0 (both trace test and L-max test) are significantly higher than the 1% critical level which means that the null hypothesis of zero cointegrating vector cannot be rejected at 1% level, which therefore confirms there is no cointegration. Using the Eigen values, the results yield the same inference as the above. The Eigen values for both ranks in Table 8 (0.098450 and 0.0040103) are lower than the calculated p-values. Therefore, no cointegrating equation exists at 1% significance level. Similarly, the application of the same method to explain the other cases (see Appendix 2) is utilized. Appendix 2 reflects that the Eigen values for rank 0 and 1 are again lower than the p-values. Fundamentally important, we see the trace values at a level greater than the 1% of critical values, thus the same inference similar to the results from Table 8.

By the same token; tests with differing assumptions show the same supposition. Therefore, it can be confirmed that no considerable long run relationship between the variables (USD-Rand exchange rate and Prices of chemical products) exists. This is inferred by utilizing both the trace statistics as well as the eigenvalues results.

The detection of no cointegrating equation in the discussions above implies that it is not necessary to engage in the vector error correction model analysis to check the divergence between the long and short run impacts of variables for the establishment of the nature of influence that exchange rate fluctuation has on prices of the chemical products in the domestic market – South Africa. The standard unrestricted VAR will, therefore, be done in order to generate and analyse the impulse responses and variance decompositions in the next sections.

## 4.5 Diagnostic checks/ analysis

Diagnostic checks/ analyses are important tests for this study due to the fact that should there be an issue in residuals from the evaluation and estimation, this will imply that the model is not efficient i.e. any problems encountered in the residuals from the model evaluated result in inefficiencies of the model and that the estimated specifications will be skewed. On this note, the analyses of prices of the chemical products were subjected to thorough diagnostics checks and analyses. The model was tested for normality, serial correlation, autoregressive conditional heteroscedasticity and stability as well as misspecifications.

Table 9: **LM tests (heteroscedasticity)**

| Heteroskedasticity – White's test<br>OLS=> observations from 2000:01-2013:12 (T=>168)<br>Dependent variable=>uhat^2 | | | | |
|---|---|---|---|---|
| | **Co-efficient** | **Std. errors** | **T-ratios** | **P-values** |
| Constant | -1571.57 | 457.979 | -3.432 | 0.0008 *** |
| USD_Rand_Exchang~ | 401.003 | 110.488 | 3.629 | 0.0004 *** |
| sq_USD_Rand_Exch~ | -22.8353 | 6.50446 | -3.511 | 0.0006 *** |
| | | | | |
| $R^2$ _unadjust. => 0.080839 | | | | |
| T-stats_TR^2 => 13.580912, | | | | |
| p-values_(Chi$^{-square(2)}$ > 13.580912) => 0.001124 | | | | |

5% critical values

From the results above, the null hypothesis homoscedasticity in the model is rejected as the calculated p-values are smaller than the 0.05 critical level. The decision to reject the null hypothesis of no heteroscedasticity implies that there is presence of heteroscedasticity in the model. The presence of heteroscedasticity means that the OLS estimate is not superlative, thus the original data must be transformed and re-run the tests to correct this problem. Table 10 below show the results after transforming the data.

Table 10: **LM tests (heteroscedasticity) – after transforming the data**

| Heteroskedasticity – White's test<br>OLS=> observations from 2000:02-2013:12 (T=>167)<br>Dependent variable=>uhat^2 | | | | |
|---|---|---|---|---|
| | **Co-efficient** | **Std. e errors** | **T-ratios** | **P-values** |
| d_USD_Rand_Excha~ | 14.2997 | 38.1774 | 0.3746 | 0.7085 |

| | | | | |
|---|---|---|---|---|
| sq_d_USD_Rand_Ex~ | 2.20928 | 34.9536 | 0.06321 | 0.9497 |
| | | | | |
| $R^2$ _unadjust => 0.000963 | | | | |
| | | | | |
| T-stats _TR^2 equals to 0.160863, | | | | |
| p-values_P($Chi^{-square(1)}$ > 0.160863) equals to 0.688363 | | | | |

Performing the tests again provide White's test a p-value of 0.688363 which is greater than the significance level of 0.05. Therefore this implies that the null hypothesis of no heteroscedasticity cannot be rejected indicating no presence of heteroscedasticity.

Figure 13: **Plot of the test statistics for Normality of residuals**

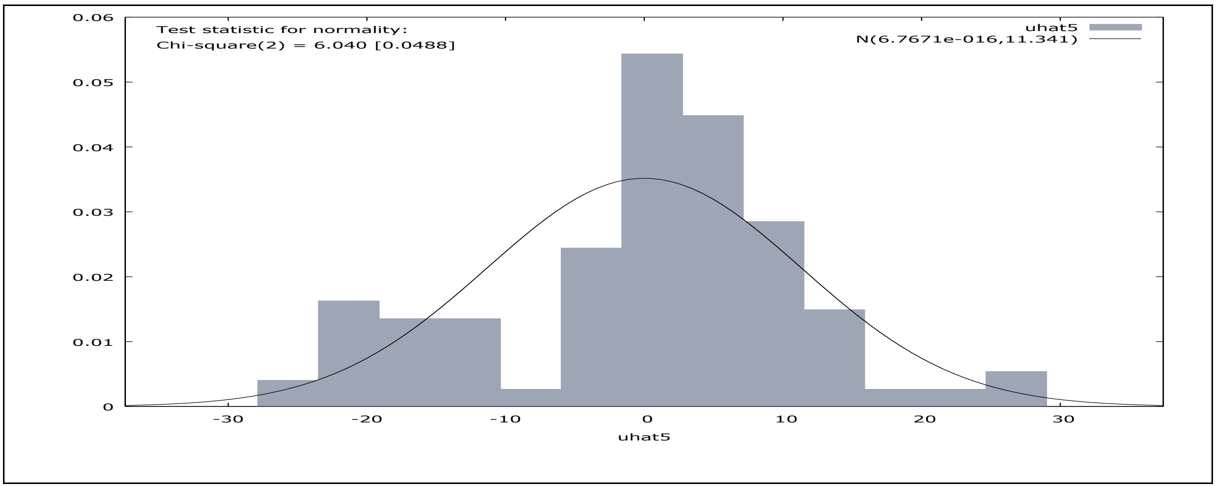
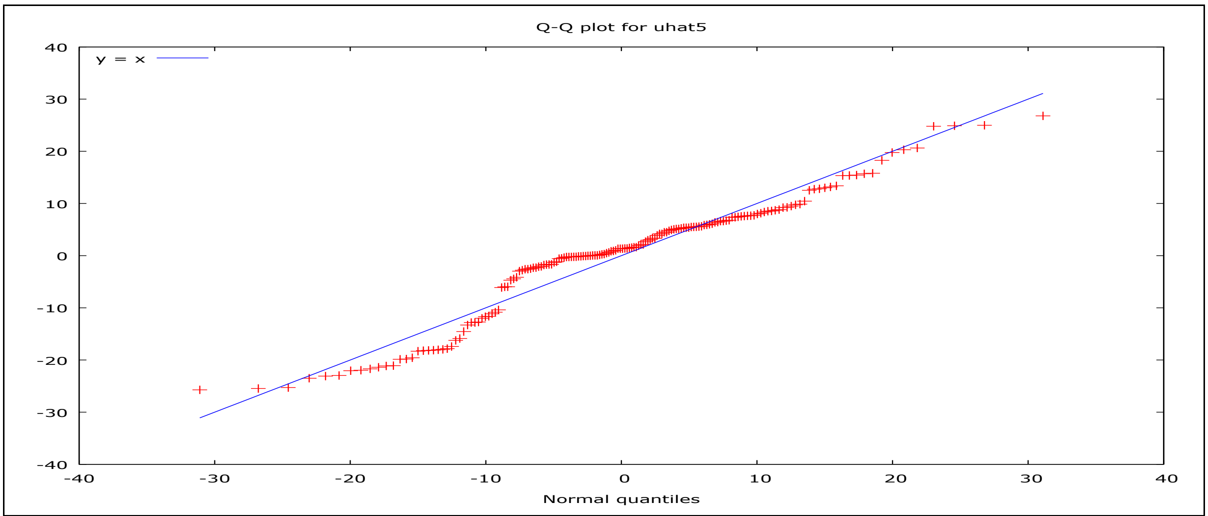



Figure 14: **Plot of the residual Q-Q**



Using the mean and standard deviations, it is clearly evident from the output in Figure 14 that the plotted points fit well along the normal line and this indicates that the process data is normally distributed.

Table 11: **Frequency distribution/ Residual distributions**

| Frequency distribution => uhat1, obs => 1-168<br># of bins => 13, Mean => 6.76707e-016 & Standard deviation => 11.3409 | | | | |
|---|---|---|---|---|
| | | | | |
| **Interval** | **Mid_point** | **Frequency** | **Relative** | **Cumulative** |
| | | | | |
| < -23.535 | -25.723 | 3 | 1.79% | 1.79% |
| -23.535 - -19.159 | -21.347 | 12 | 7.14% | 8.93% ** |
| -19.159 - -14.783 | -16.971 | 10 | 5.95% | 14.88% ** |
| -14.783 - -10.407 | -12.595 | 10 | 5.95% | 20.83% ** |
| -10.407 - -6.0311 | -8.2191 | 2 | 1.19% | 22.02% |
| -6.0311 - -1.6551 | -3.8431 | 18 | 10.71% | 32.74% *** |
| -1.6551 - 2.7208 | 0.53284 | 40 | 23.81% | 56.55% ******** |
| 2.7208 - 7.0968 | 4.9088 | 33 | 19.64% | 76.19% ******* |
| 7.0968 - 11.473 | 9.2848 | 21 | 12.50% | 88.69% **** |
| 11.473 - 15.849 | 13.661 | 11 | 6.55% | 95.24% ** |
| 15.849 - 20.225 | 18.037 | 2 | 1.19% | 96.43% |
| 20.225 - 24.601 | 22.413 | 2 | 1.19% | 97.62% |
| >= 24.601 | 26.789 | 4 | 2.38% | 100.00% |
| | | | | |
| Chi$^{\text{-square(2)}}$ equals to 6.040 and p-value equals to 0.04881 | | | | |

The p-value of 0.04881 implies a close run, therefore – this would mean that the null hypothesis of normality at the 95% confidence level cannot be rejected, but reject the null hypothesis at the 90% confidence level. At intervals -1.6551-2.7208, as we can see – there is a significant frequency distribution of 40 and 33 which is 24% and 20% respectively in relative frequency.

The next discussion is the analysis of the serial correlation. This study adopts the Breusch-Godfrey (B-G) statistics to test for the serial correlation. The B-G tests are presented in Table 12 in the next page. The 12 lags show that the results are driven from the monthly data, thus the chi-squared has 12 degrees of freedom. The output shows a very large chi-square for the Breusch-Godfrey test statistics and very small p-values (in all cases, LMF, TR^2 & Ljung-Box Q'), so the decision is to reject the null hypothesis of no serial correlation. Therefore, some sort of modification is required in this model to address the issue of serial correlation. In this case, this thesis will apply an alternative of studying the differences in the subsequent values of the variables rather than actual levels in the variables.

Table 12: **Test results of the serial correlation**

| | | | | |
|---|---|---|---|---|
| B-G test => autocorrelation => up to order 12<br>OLS=> observations from 2000:01-2013:12 (T=> 168)<br>Dependent variable=> uhat | | | | |
| | **Co-efficient** | **Std. errors** | **T-ratios** | **P-values** |
| Constant | -1.77623 | 2.00885 | -0.8842 | 0.378 |
| USD_Rand_Exchang~ | 0.223837 | 0.252961 | 0.8849 | 0.3776 |
| Price of Chem. products =>1 | 0.95682 | 0.0803445 | 11.91 | 1.36e-023 *** |
| Price of Chem. products =>2 | -0.016612 | 0.111289 | -0.1493 | 0.8815 |
| Price of Chem. products =>3 | -0.118473 | 0.111255 | -1.065 | 0.2886 |
| Price of Chem. products =>4 | 0.201033 | 0.11171 | 1.8 | 0.0739 * |
| Price of Chem. products =>5 | -0.0902546 | 0.112644 | -0.8012 | 0.4242 |
| Price of Chem. products =>6 | 0.120604 | 0.111807 | 1.079 | 0.2824 |
| Price of Chem. products =>7 | -0.191203 | 0.111874 | -1.709 | 0.0894 * |
| Price of Chem. products =>8 | 0.0655299 | 0.112701 | 0.5814 | 0.5618 |
| Price of Chem. products =>9 | 0.0314022 | 0.111696 | 0.2811 | 0.779 |
| Price of Chem. products =>10 | -0.0377997 | 0.111348 | -0.3395 | 0.7347 |
| Price of Chem. products =>11 | 0.0429632 | 0.111418 | 0.3856 | 0.7003 |
| Price of Chem. products =>12 | -0.0576808 | 0.0811719 | -0.7106 | 0.4784 |
| $R^2$ _unadjust. equals to 0.864538 | | | | |
| T-stats_ LMF = 81.904090, | | | | |
| p-values_ P(F(12,154) > 81.9041) = 1.88e-060 | | | | |
| Alt. stats_ TR^2 = 145.242362, | | | | |
| p-values_P(Chi-square(12) > 145.242) = 5.22e-025 | | | | |
| Ljung-Box Q' = 761.344, | | | | |
| p-values_P(Chi-square(12) > 761.344) = 3.2e-155 | | | | |

The output in Table 13 reflects the results after studying the differences in the subsequent values of the variables rather than actual levels in the variables. It is clear that the output is now reflecting very high p-values compared to the p-values found in the prior discussion. The output also reflects smaller chi-squared for all cases (LMF, TR^2 & Ljung-Box Q'), therefore – it can safely be inferred that the null hypothesis of no serial correlation cannot be rejected at 0.01, 0.05 and

0.10 significance levels. This implies no presence of serial correlation. To substantiate the above discussion, Table 13 is presented next.

Table 13: **Test results of the serial correlation, after studying differences**

| | | | | |
|---|---|---|---|---|
| B-G test => autocorrelation => up to order 12<br>OLS=> observations from 2000:02-2013:12 (T=>167)<br>Dependent variable =>uhat | | | | |
| | **Co-efficient** | **Std. errors** | **T-ratios** | **P-values** |
| constant | 0.0006 | 0.3038 | 0.0019 | 0.9985 |
| d_USD_Rand_Excha~ | 0.2771 | 0.9182 | 0.3018 | 0.7632 |
| Price of Chem. products =>1 | 0.0061 | 0.0814 | 0.0754 | 0.9400 |
| Price of Chem. products =>2 | -0.0306 | 0.0811 | -0.3777 | 0.7062 |
| Price of Chem. products =>3 | -0.1473 | 0.0808 | -1.8240 | 0.0701 * |
| Price of Chem. products =>4 | 0.1159 | 0.0844 | 1.3740 | 0.1715 |
| Price of Chem. products =>5 | -0.0467 | 0.0843 | -0.5533 | 0.5808 |
| Price of Chem. products =>6 | 0.1450 | 0.0848 | 1.7090 | 0.0895 * |
| Price of Chem. products =>7 | -0.1150 | 0.0817 | -1.4080 | 0.1613 |
| Price of Chem. products =>8 | -0.0451 | 0.0842 | -0.5360 | 0.5927 |
| Price of Chem. products =>9 | 0.0106 | 0.0849 | 0.1242 | 0.9013 |
| Price of Chem. products =>10 | -0.0533 | 0.0809 | -0.6586 | 0.5111 |
| Price of Chem. products =>11 | 0.0227 | 0.0812 | 0.2795 | 0.7802 |
| Price of Chem. products =>12 | -0.0439 | 0.1938 | -0.2267 | 0.8209 |
| $R^2$ _unadjust equals to 0.079674 | | | | |
| T-stats_ LMF = 1.103788,<br>p-values_P(F(12,153) > 1.10379) = 0.361 | | | | |
| Alt. stats_TR^2 = 13.305572,<br>p-value_P(Chi-square(12) > 13.3056) = 0.347 | | | | |
| Ljung-Box Q' = 16.5388,<br>p-values_ P(Chi-square(12) > 16.5388) = 0.168 | | | | |

Following the presentation of the serial correlation analysis is the Ramsey Reset (RR) test statistics for analysing the model misspecifications. The output is presented in the Table 14 and interpretation follows the presentation of the results.

Table 14: **Ramsey Reset test results of the misspecifications**

| RR test regression<br>OLS=> observations from 2000:01-2013:12 (T=>168)<br>Dependent variable=>Prices_of_Chemical_Products | | | | |
|---|---|---|---|---|
| | **Co-efficient** | **Standard errors** | **T-ratios** | **P-values** |
| constant | -28901.6 | 504424 | -0.0573 | 0.9544 |
| USD_Rand_Exchang~ | 366.318 | 7036.88 | 0.05206 | 0.9585 |
| yhat^2 | 2.93023 | 45.5711 | 0.0643 | 0.9488 |
| yhat^3 | -0.00958811 | 0.125602 | -0.07634 | 0.9392 |
| t-stats=> F = 2.203713,<br>with p-value=> P(F(2,164) > 2.20371)=> 0.114 | | | | |

Critical levels - 1%, 5% and 10%

Table 14 in the prior page presents an indication and the evidence of nonlinearity. The misspecification tests were subjected to the Ramsey Reset statistics to check any omission of the important variables from the model. The output reflects the p-values at 0.114 which implies that at critical levels 0.01, 0.05 and 0.10, we cannot reject the null hypothesis – therefore concluding that the model is well specified which thus implies an indication of no omission of significant variables.

### 4.6 Impulse response analysis and variance decompositions

It has been noted, from the previous discussions, that Impulse-response analysis detects the receptiveness of the dependent variables in a vector autoregressive to shocks from each of the variables (see Brooks 2008). In lieu of the observations that no cointegrating relations was found between the exchange rate fluctuations and the prices of the chemical products in the domestic chemical sector – South Africa, a standard unrestricted VAR (see Appendix 3) instead of VECM was done to generate impulse-response and variance decompositions analyses. Figure 15 below is the presentation of the how the prices of the chemical products respond to a shock in USD-Rand exchange rate.

Figure 15: **Plot of impulse response analysis**

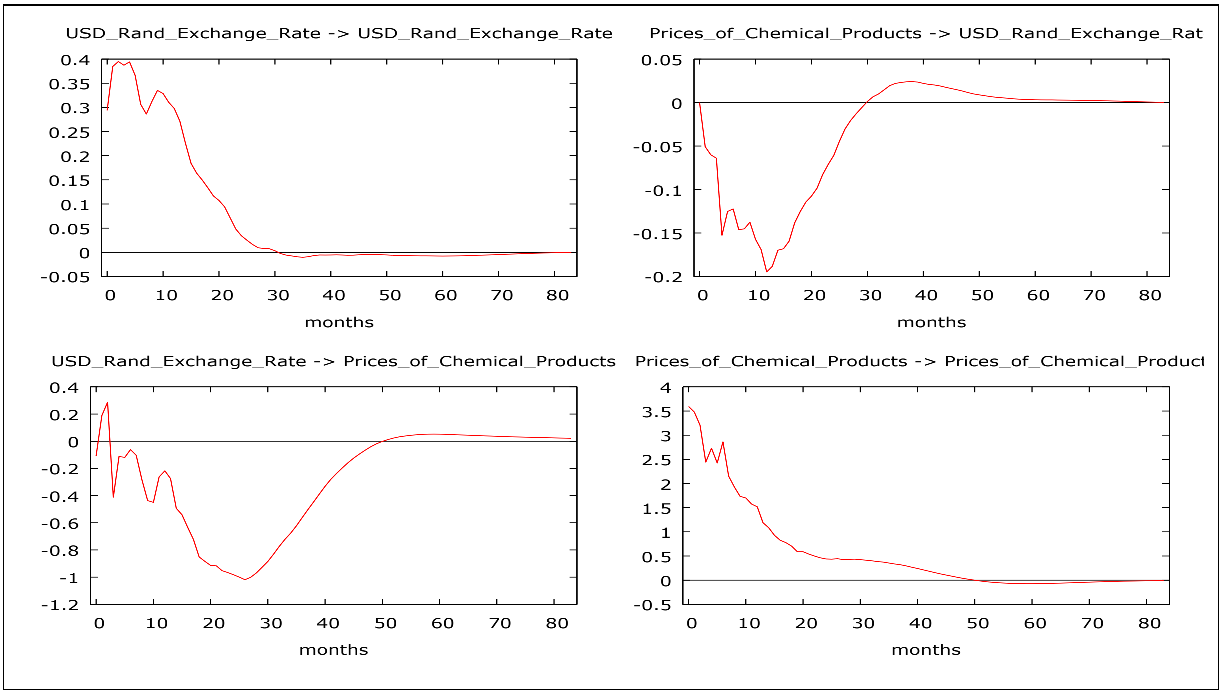



Figure 16: **Plot of the forecast variance decomposition – USD-Rand exchange rate**

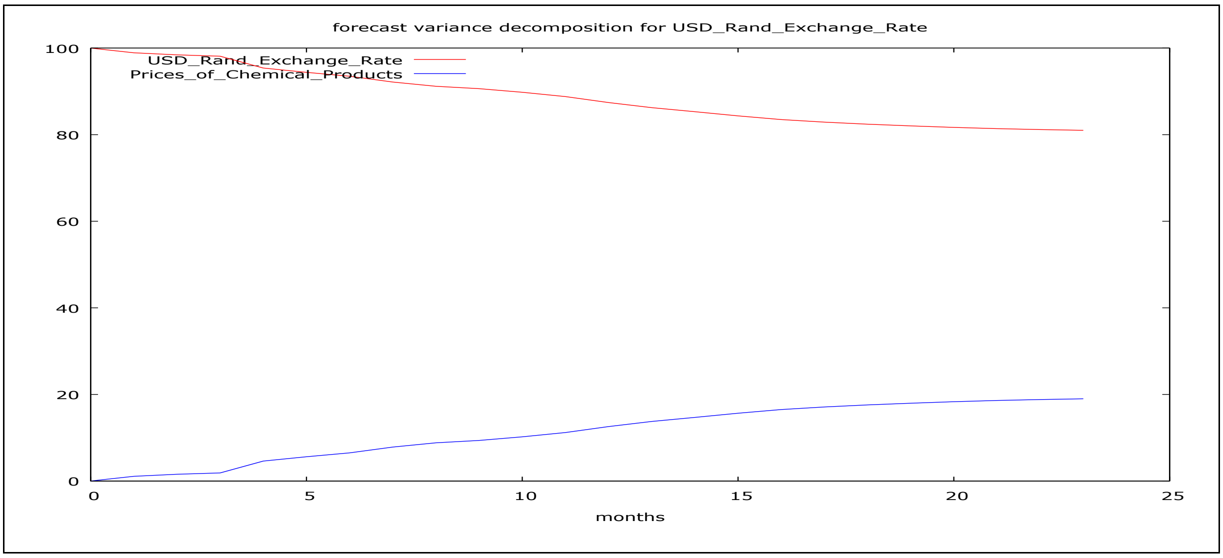
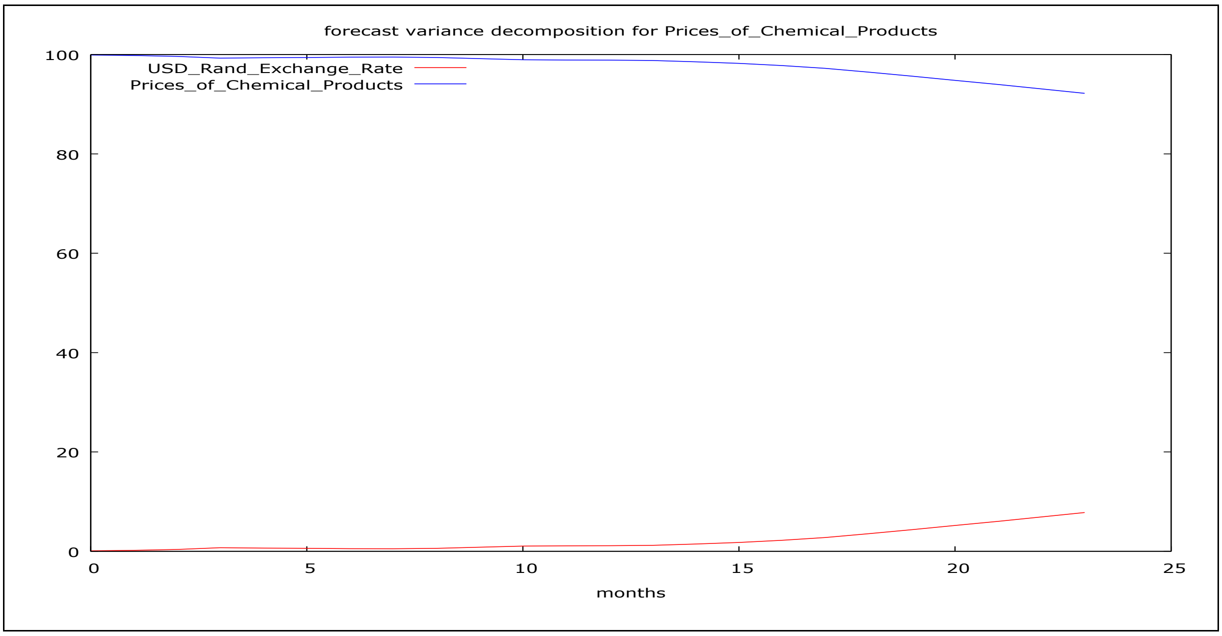


Figure 17: **Plot of the forecast variance decomposition – Prices of the chemical products**




The results from impulse response show that any responsiveness to the shock in the USD-Rand exchange rate dies away after 16.7 quarters. It can also be inferred that the results do not reveal a significant response to the shocks. Inconsequential impact is expected to be experience in the first 10 months. This finding is in line with Razafimahefa's (2012) study for Sub-Saharan African countries. The 3rd quadrant in Figure 15 shows that a depreciation of the exchange rate initially leads to a rise in prices of chemical products to about 0.3 and then the prices drastically drop to as low as -1.

On the other hand, the variance decomposition indicates how much the contribution by each variable to the other variable is in the autoregression i.e. it reports the movement in the prices of chemical products and examinations of the comparatively importance of USD-Rand exchange rate in influencing its movements and vice versa. Figure 15 and Figure 16 confirm that more than 90% of the movement in each of the two variables is explained by its own variations, while the other variable and openness of the economy explain the rest of the remaining movements. (see Appendix 7: Analysis of the variance decomposition forecast, which discloses the percentage of the shock that is explained by its own variable and the percentage explained by the other variable).

**CHAPTER FIVE**

# CONCLUSIONS, POLICY IMPLICATIONS & RECOMMENDATIONS AND LIMITATIONS OF THE STUDY

## 5.1 Introduction

Chapter 5 presents the summary findings from the econometric results presented in the previous chapter with regards to the relationship between exchange rate fluctuations and prices of the chemical products in the chemical sector in South Africa. The main purpose of the econometric results derived in Chapter 4 is the determination of whether there is any significant impact of the exchange rate volatility into the pricing model of the chemical products in the sector. As per discussions in Chapter 4, the results were computed using different – and relevant econometric techniques on the variables USD-Rand exchange rate and prices of chemical products using the monthly time series data from 2000:1 to 2013:12.

This chapter is organised as follows. Section 5.2 presents the summary of the study and concluding remarks; section 5.3 discusses the policy implications and recommendations; and the last section will provide the limitations of the study and areas for further research.

## 5.2 Summary and conclusions of the study

This study analyses the impact of exchange rate fluctuations on the chemical industry – South Africa, with more emphasis on the prices of the chemical products.

Existing theoretical and empirical works were reviewed and documented under the literature review section of the study[6]. The first chapter was the introduction and background of the study. It is in this chapter wherein all the ground work necessary to the study and the research objectives, statement of problem and the organisation of study were discussed.

The methodology of the study was provided in Chapter 3 followed by Chapter 4 which presented the estimation, analysis and interpretation of the results.

[6] refer to Chapter 2 for the detailed theoretical and empirical discussions.

Graphical method/ analysis was utilized to complete a prelude assessment of the time series data and to describe the behaviour and trends of variables over the study period. An overview of South African trends showed that real exchange rates were not stable as symbolised by fluctuations over the study period. The rand exchange in South Africa is not fixed by the government; it is determined by the forces and demand in the foreign exchange market.

Chapter 4 analysed the impact of exchange rate behaviour on prices of the chemical products using the proposed methodology outlined in Chapter 3. The results were presented in four different sections. The analyses of this relationship began by firstly examining the properties of time series data, using formal and informal analyses for stationarity. Presentation of the unit root was subjected to Augmented Dickey-Fuller and KPSS tests for stationarity. The ADF analysis revealed that the two variables in the data series are non-stationary at levels and became stationary when first differenced. This, therefore, implies that the series were integrated of the same order I(1). The KPSS statistics which were done to complement the ADF also affirmed similar output as that of the ADF test statistics.

Following the unit root/ stationarity analysis was the presentation of the autocorrelation analysis to check for the presence of autocorrelation in residuals. The tests for autocorrelation were based on the Durbin Watson statistics to determine whether or not the autocorrelation between adjacent error terms is zero. The results revealed the evidence that there is autocorrelation between the two variables, implying that the USD-Rand exchange rate and the prices of the chemical products are influenced by their historical trend. It was also important to test the autocorrelation using a different method in order to supplement the D-W statistics, and the correlogram tests were conducted in this regard. It must be noted that following results from model Durbin-Watson statistic, contrary to theoretical proposition and prior expectation, a positive correlation between exchange rate volatility and prices of chemical products was found. The serial correlation in the diagnostic analysis revealed a very large chi-square for the Breusch-Godfrey test statistics and very small p-values (in all cases, LMF, TR^2 & Ljung-Box Q'), resulting in a decision to reject the null hypothesis of no serial correlation. After studying the differences in the subsequent values of the variables rather than actual levels in the variables, the issue of the presence of serial correlation was corrected i.e. the output provided very high p-values and smaller chi-squared for all cases (LMF, TR^2 & Ljung-Box Q').

The cointegration results were presented subsequent to unit root and autocorrelation analysis using the Johansen approach. The trace and eigen-values cointegration tests were used to test for cointegration, and the results showed that there is no long run cointegration relationship between the two variables (USD-Rand exchange rate and prices of chemical products).

Due to this finding, vector error correction model analysis, to check the divergence between the short and long run impact of variables for the establishment of the extent of effect that exchange rate fluctuations have on prices of the chemical products in the domestic market – South Africa, were ignored. Thus, only a standard unrestricted VAR was tested to generate and check for the impulse response and variance decompositions.

Diagnostic checks for normality, serial correlation, autoregressive conditional heteroscedasticity and stability were also presented. The results indicate that we reject the null of no heteroscedasticity, and also revealed a close run in terms of residual distribution – implying that we accept the null hypothesis of normality at the 96% confidence level, but reject the null hypothesis at the 90% confidence level. It should, however, be noted that – after transforming the data, the output reflected no presence of heteroscedasticity. Using the Breusch-Godfrey to test for the serial correlation, the results from the original data provided an indication of rejection of the null hypothesis of no serial correlation as outlined in the prior discussion. The impulse-response analysis and variance decomposition tests were provided to determine the responsiveness of the variables from shocks and reciprocal importance of shocks in explaining variations in the variables.

Following an extensive review of theoretical and empirical literatures, it became apparent that exchange rate is a key component in explaining domestic prices. It was also evident that reflections in the review of some of the previous literatures have concluded consistency in the impact of the movements of exchange rate on domestic prices. As such the extant of the gateway impact of the currency fluctuations seem to have been ignored and the sentiment is that this might be the exact reason of the ambiguities and why the literatures have not reached any agreement on this issue.

As such, this thesis suggest that the exchange rate plays part in the pricing of the chemical products but the currency fluctuations do not bring about significant impact in the variation of the prices of chemical products. The cointegration results confirm no cointegration relationship between the domestic prices of the chemical products and the exchange rate. Then the question would be – where do the effects of exchange rate fluctuations go/ flow to? It will be interesting then to answer this question and I propose this discussion as an area for further research. It can, however, be suggested that – rather than exchange rate fluctuations, other price determinants (identified in the prior chapters of this study) might be key factors which constitute a bigger direct long run impact on the prices the chemical products. The openness[7] of the economy is also rather thought to be significant in the exchange rate and prices relation. Although openness is presumed to be the most important factor in determining the pass through relationship to prices of the chemical products, the pattern of the fluctuations and persistency of exchange rate is herein seen to have insignificant and incomplete relationship to the prices in the chemical sector.

### 5.3 Policy implications and recommendations from the study

Findings in this study have quite a number of policy implications around the exchange rate, domestic prices and inflation framework. One of the views regarding the exchange rate depreciation is that of a positive effect on the economic growth as the depreciation boost the export.

Notwithstanding that the currency depreciation raises concerns and poses upside risk on the inflation prospects, boosting the exports is considered one of the key factors in the growth of the economy. Since this study revealed no cointegrating relationship between the exchange rate and prices of the chemicals products – it could be inferred that there is not a danger of seeing exorbitant prices in the chemical sector as a result from the currency depreciation. It must be noted that – since the results provided no cointegrating relationship between the two economic variables (USD-Rand exchange rate and prices of chemical products), policy recommendations cannot be made.

---

[7] Dependency of domestic production to imported intermediate goods

## 5.4 Limitations of the study and areas of further research

Despite attaining the purposes of this study, which necessitate the determination of the impact of exchange rate on the chemical sector, one of the limitations of the study is data availability of the prices for specific chemical products – limiting the study to utilize the price index. Additionally, the study did not use all available measures to determine and analyse price determination. This was also mainly due to the data constraints required for other price determinants by some of the measures and/ or models.

The areas for future/ further research which came out from this study are the following:

1. The impact of exchange rate fluctuations on prices of the chemical products: An emphasis on the pricing model of specific chemical products.
2. How much significance does the exchange rate fluctuations have on the performance and the bottom line of the companies in the Chemical sector?
3. Determination of the appropriate exchange rate levels that minimises the exchange rate pass-through to consumer prices.

## REFERENCES


Alper, K., (2003), “Exchange Rate Pass-Through to Domestic Prices in Turkish Economy,” 2003.

Anaya, J.A.G., (2000), “Exchange Rate Pass-Through and Partial Dollarization: Is there a Link?” **Centre for Research on Economic Developments and Policy Reform, Working Paper no. 0081**.

Andren, T., (2007), “Econometrics”, **United Kingdom: Thomas Andren & Ventus publishing ApS.**

Andrianaivo, M., & Yartey, C.A., (2010), ”Understanding the growth of African financial markets”. **African Development Review, 22, pp. 401-403**.

Angel, C., (2002), “The Responsiveness of Consumer Prices to Exchange Rates and the Implication of Exchange Rate Policy: A Survey of Few Recent New Open Economy Macro Models”. **National Bureau of Economic Research, Working Paper no. 8725**.

Arize, A.C., (1996), “Real Exchange-Rate volatility and Trade Flows: The Experience of Eight European Economies”, **International Review of Economics and Finance, Vol. 5, no.2, pp. 187-205**.

Aron, J., Creamer, K., Muellbauer, J. & Rankin, N., (2014), **The Journal of Development Studies (2014)**: “Exchange Rate Pass-Through to Consumer Prices in South Africa: Evidence from Micro-Data,” **DOI: 10.1080/00220388.2013.847178.**

Aron, J., Farrell G., Muellbauer, J., & Sinclair, P., (2012), “Exchange Rate Pass-Through to Import Prices, and Monetary Policy in South Africa.” **South African Reserve Bank Working Paper, WP/12/08**.

Balasa, B., (1964), “The Purchasing – Power Parity Doctrine: A Reappraisal”, **Journal of Political Economy, vol. 72 no. 6, pp. 584-596**.

Bhundia, A., (2002), “An Empirical Investigation of Exchange Rate Pass-Through in South Africa,” **IMF Working Paper no. 02/165 (Washington: International Monetary Fund)**.

Blungmart, M., (2000), “The Augmented Dickey-Fuller test.” **Journal of Econometrics**.

Breiman, L., (2001), “The Two Cultures (with comments and a rejoinder by the author)”, **Statist. Sci 16 (2001), no 3, 199—231. Doi:10.1214/ss/1009213726. http://projecteuclid.org/euclid.ss/1009213726.**

Breusch, T.S., (1978), “Testing for autocorrelation in dynamic linear models.” **Australian Economic Papers ,17, 334-55. http://dx.doi.org/10.1111/j.1467-8454.1978.tb00635.x**

Breusch, T.S., (1979), “Conflict among Criteria for Testing Hypothesis: Extensions and Comments,” **Econometrica, Econometric Society, vol.47(1), pages 203-07, January.**

Brooks, C., (2008), “Introductory Econometrics for Finance,” **second edition, Cambridge University press.**

Brown, S.P.A., & Phillips, K.R., (1986), “Exchange Rates and world oil prices” **Economic Review, Federal Reserve Bank of Dallas, March 1986**.

Burstein, A., & Gopinath, G., (2013), “International Prices and Exchange Rates,” January 2013.

Campa, J., & Goldberg, L., (2001), “Exchange Rate Pass-Through into Import Prices: A Macro or Micro Phenomenon.” **National Bureau of Economic Research, Working Paper no. W8934. College Of Management Sciences, 2.Redeemers University, K/M 46/85 Lagos/Ibadan Expressway, Redemption City, Mowe, Ogun State, Nigeria**.

Campa, J., & Goldberg, L., (2005), “Exchange Rate Passs-Through into Import Prices,” **The Review of Economics and Statistics, 87(4): 679-690**.

Challis, R.E., & Kitney, R.I., (1991), “Biomedical signal processing, Part 1 Time-domain methods.” **Medical and Biological Engineering and Computing, 28, 509-524.**

Charles, A., Simon, H., & Daniel, A., (2008), “Effect of Exchange Rate Volatility on the Ghana Stock Exchange,” **African Journal of Accounting, Economics and Banking Research, Scheme 3**.

Cheung, Y.W., & Sengupta, R., (2013), “Impact of Exchange Rate Movements on Exports: An Analysis of Indian non-financial sector firms,” **Journal of International Money and Finance, Elsevier, vol. 39 C, pages 231-245**.

Choudhri, E.U, & Hakura, D., (2001), “Exchange Rate Pass-Through to Domestic Prices: Does the Inflationary Environment Matter?” **IMF Working Paper**.

De Bandt, O., & Razafindrabe, T., (2014), “Exchange rate pass-through to import prices in the Euro-area: A multi-currency investigation”. **International Economics, 138 (2014) 63-77**.

De Bandt, O., Razafindrabe, T., (2014), “Does nominal rigidity mislead our perception of the exchange rate pass-through?”, **EconomiX Working Papers 2014-36, University of Paris West – Nanterre la Defense, EconomiX.**

De Kock Commission (1985), “Inquiry into the monetary system and monetary policy in South Africa: Final report”. **Pretoria: Government Printer**.

Dickey, D.A., & Fuller, W.A., (1979), “Distribution of the Estimators for Aitoregressive Time Series with a Unit Root,” **Journal of the American Statistical Association, Vol. 74, Issiue 366 (Jun., 1979), 427-431**.

Dolado, J., & Marmol, F., (1999), “Asymptotic Inference for Nonstationary Fractionally Integrated Processes,” **Computing in Economics and Finance 1999, 513, Society for Computational Economics**.

Dong, W., & Nam, D., (2013), “Exchange rates and individual good’s price misalignment: Evidence of long-horizon predictability.” **Journal of International Money and Finance, 32 (2013) 611-636**.

Dornbusch, R., (1987), “Exchange Rates and Prices,” **American Economic Review, 77, pp. 93-106**.

Draper, N.R., & Smith, H., (1981), “Applied Regression Analysis,” **New York, Wiley, 1966. P 407**.

Enders, W., (2004), “Applied Econometric Time Series”, Wiley, New York.

Engle, R.E., & Granger, C.W.J., (1987), “Cointegration and Error-Correction: Representation, Estimation and Testing”, **Econometrica, vol.55, pp. 251-76**.

Engel, R., (2002), “Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroskedasticity Models,” **Department of Finance, New York University Leonard N. Stern School of Business, New York. NY 10012 and Department of Economics, University of California, San Diego (rengle@stern.nyu.edu).**

Frankel, J., Parsley D., & Wei S.J., (2012), “Slow pass-through around the world: a new import for developing countries?” **Open Economies Review, 2012 – Springer**.

Frimpong, S., (2010), “Exchange Rate Pass-Through in Ghana,’ **International Business Research**.

Garcia, C.J., & Restrepo, P.G., (2001), “Price Inflation and Exchange Rate Pass-Through in Chile,” **Working Papers Central Bank of Chile 128, Central Bank of Chile**.

Godfrey, L.G., (1978), “Testing for higher order serial correlation in regression equations when the regressors include lagged dependent variables.” **Econometrica, 46, 1303-1310. http://dx.doi.org/10.2307/1913830**

Godfrey, L.G., (1979), “Misspecification Tests in Econometrics: The Lagrange Multiplier Principle and other Approaches,” **Econometric society monographs.**

Goldberg P.K., & Knetter M.M., (1997), "Good Prices and Exchange Rates: What have we learned." *Journal of Economic Literature*, 35 (3), pp. 1243-1272.

Goldberg, L., & Tille, C., (2006), "The Internationalization of the Dollar and Trade Balance Adjustment," **Federal Reserve Bank of New York, staff reports**.

Gopinath, G., Itskhoki, O., Gourinchas, P.O., & Rigobon, R.,(2010), "Currency choice and exchange rate pass-through". **American Economic Review, 100(1) : 306 – 336.**

Greene, W.H., (2000), "Simulated Likelihood Estimation of the Normal-Gamma Stochastic Frontier Function," **Working Papers 00-05, New York University, Leonard N. Stern School of Business**.

Gujarati, D.N. (2004), "Basic Econometrics". **4th Edition, Paperback – January 1, 2004**.

Hansen, H., & Juselius, K. (1995), "CATS in RATS: Cointegration Analysis of Time Series", **Evanston IL: Estima**.

Himilton, J.D., (1983), "Oil and the Macro-economy since world war II", **Journal of political economy, April 1983, pp. 95-103**.

Hobijn, B., Franses, P.H., & Ooms, M., (1998), "Generalization of the KPSS-test for stationarity." **Econometric Institute Report, no. 9802/A http://www.cur.nl/few/ei/papers.**

Ito, T., & Sato K., (2008), "Exchange rate changes and Inflation in Post-Crises Asian Economies: Vector Autoregression Analysis of the Exchange Rate Pass-Through", 2008.

Jian, H., (2008), "Dependence Structures in Chinese and U.S. Financial Markets: A Time-varying Conditional Copula Approach," **Departmental Working Papers 0808, Southern Methodist University, Department of Economics, revised Nov 2008**.

Johansen, S., & Juselius, K., (1990), "Maximum Likelihood Estimation and Inference on Cointegration with Application to the Demand for Money," **Oxford Bulletin of Economics and Statistic, 52**.

Johansen, S., (1988), "Statistical Analysis of Cointegration Vectors", **Journal of Economic Dynamics and Control, vol. 12, pp. 231-254**.

Johansen, S., (1992), "Determination of Cointegration Rank In the Presence of a Linear Trend", **Oxford Bulletin of Economics and Statistics, vol. 54, no. 3, pp. 383-97**.

Johansen, S., (1995), "Likelihood – Based Inference in Cointegrated Vector Autoregressive Models," **Oxford University Press**

Johansen, S., (1991), "Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Model," **Econometrica, vol. 59, No.6 (November, 1991), 1551-1580.**

Kardasz, S.W., (1998), "Determinants of domestic and import prices in Canadian manufacturing industries," **Empirical Economics, 1998, vol. 23, issue 4, pp 593-610**.

Karoro, T.D., Aziakpono, M.J., & Cattaneo, N., (2014), "Exchange Rate Pass-through to Import Prices in South Africa: Isthere Asymmetry?", **Department of Economics,Rhodes University.**

Kremers, J.J.M, Ericsson, N.R., & Doldado, J.J, (1992), "The power of Cointegration Tests", **Oxford Bulletin of Economics and Statistics, vol.54, no.3, pp. 325-48**.

Krugman, P., (1987), "Pricing-to-Market and Failure of Absolute Purchasing Power Parity," 1987.

Leith, C., (1991), "The Exchange Rate and the Price Level in a small Open Economy," **Journal of Policy Modelling, 13(2), pp. 309-315**.

Liu, L.X., & Zhang, L., (2008), "Momentum Profits, Factor Pricing, and Macroeconomic Risk". **The review of financial studies, vol. 21, no. 6, 2008**.

Mann, C., (1986), "Prices, Profits Margins, and Exchange Rates,". **Federal Reserve Bulletin. 72, pp. 366-379**.

Martin, J.K., & McDonald, R.P., (1975), "Bayesian estimation in unrestricted factor analysis: A treatment for Heywood cases. **Psychometrika 40, pp 505-517**.

McCarthy, J., (2006), "Pass-through of exchange rates and import prices to domestic inflation in some industrialized economies". **Federal Reserve Bank of New York – June 29, 2006.**

Mtonga, E., (2011), "Did it matter? Monetary Policy Regime Change and Exchange Rate Dynamics in South Africa".

Mustapha, I.B., (2012), "Exchange Rate Pass-Through in Countries of the Proposed *West African Monetary Zone* (WAMZ)," **Review of Economics & Finance, submitted on 26/ July/ 2012.**

Nelson, C., & Plosser, C., (1982), "Trends and Random Walks in Macroeconomics Time Series: Some Evidences and Implications", **Journal of Monetary Economics, vol. 10, pp. 130-62**.

Obstfeld, M., & Kenneth R., (1996), "Foundation of International Macroeconomics," (**MIT press**).

Ocran, M.K., (2010), "Exchange Rate Pass-Through to domestic prices: The case of South Africa," **Prague Economic Papers, University of Economics, Prague, vol 2010(4), pages 291-306**.

Paral, Aaron, Ben & Alass, (1998), "Exchange rate effects and inflation targeting in a small open economy: a stochastic analysis using FPS

Razafimahefa, I.F., (2012), "Exchange Rate Pass-Through in Sub-Saharan African Economies and its Determinants," **Working Paper no. 12/141, June 2012**.

Restrepo, J.E., & Garcia, C.J., (2001), "Price Inflation and Exchange Rate Pass-Through in Chile," **Working Papers Central Bank of Chile 128, Central Bank of Chile.**

Rodrik, D., (2007), "The Real Exchange Rate and Economic Growth: Theory and Evidence," **Kennedy School of Government Harvard University Cambridge: Working Paper, 2007**.

Rodrik, D., (2008), "The Real Exchange Rate and Economic Growth," **Kennedy School of Government Harvard University Cambridge: Working Paper MA 02138, 2008**.

Salvatore, D., (2007), "The Euro-dollar Rate Defies Prediction African." **Journal of Policy Modeling, 27(4)**.

Sibanda, K., (2012), "The impact of Exchange Rate on Economic Growth: A Case Study of South Africa," **Ehinomen1 C., Ibrahim T. 1.Department of Economics and Business Studies.**

Sjo, B., (2008), "Testing for Unit Roots and Cointegration."

Stock, J.H., & Watson M.W., (1988), "Variable Trends in Economic Time Series," **Journal of Economic Perspectives – Vol 2, no. 3 – 1988, pg 147-74**.

Tarawalie, B., (2010), "Real Exchange Rate Behaviour and Economic Growth: Evidence from Sierra Leone," **SAJEM 13(1)**.

Taylor, J. (2000), "Low Inflation, Pass-Through, and the Pricing Power of Firms," **European Economic Review, 44(7), pp. 1389-1408**.

Tejvan, P., (2013), "Effect of the exchange rate on business" November 4, 2013 in business.

Todani, R.K., & Munyama, T., (2005), "Exchange Rate Volatility and Exports in South Africa," **[Online]: Available http://www.tips.org.za/files/733.pdf.[Accessed on 25 January, 2007]**.

Van der Merwe, E.J., (1996), "Exchange Rate Management Policies in South Africa: Recent Experience and Prospects". **South African Reserve Bank, Occasional Paper. 1996.**

Warjiyo, P., & Hutubarat, R.A., (2002), "Exchange Rate and Inflation Expectation Channels of Monetary Policy Transmission: Experience of Indonesia", **SEACEN Conference, Fiji, October, 2002**.

White, H., (1980), "A Heteroskedasticity-consistent covariance matrix and direct test for heteroskedasticity." **Econometrica, pg 817-838**.

Yang, D.T., & Hao, Z., (1997), "Rural-Urban Disparity and Sectoral Labour Allocation in China," **Working Paper, pp. 97-102**.

Yin-Wong, C., & Rajeswari, S., (2013), "Impact of Exchange Rate Movements on Exports: An Analysis of Non-Financial Sector Firms," **CESifo Working Paper Series 4214, CESifo Group Munich.**

Zheng, S.J., (2005), "Exchange Rate Volatility and Trade/ Productivity in Australia," Nov 2005.

## APPENDICES

Appendix 1 – Correlogram tables for autocorrelation tests

| Autocorrelation function for USD_Rand_Exchange_Rate | | | | |
|---|---|---|---|---|
| | | | | |
| **LAG** | **ACF** | **PACF** | **Q-stat.** | **[p-value]** |
| | | | | |
| 1 | 0.9506 *** | 0.9506 *** | 154.5417 | [0.000] |
| 2 | 0.8857 *** | -0.1867 ** | 289.4976 | [0.000] |
| 3 | 0.8188 *** | -0.0301 | 405.5527 | [0.000] |
| 4 | 0.7482 *** | -0.0756 | 503.0381 | [0.000] |
| 5 | 0.6755 *** | -0.0508 | 582.9945 | [0.000] |
| 6 | 0.6107 *** | 0.0463 | 648.7446 | [0.000] |
| 7 | 0.5518 *** | 0 | 702.7644 | [0.000] |
| 8 | 0.4900 *** | -0.0854 | 745.6162 | [0.000] |
| 9 | 0.4296 *** | -0.0196 | 778.7627 | [0.000] |
| 10 | 0.3604 *** | -0.1514 ** | 802.2439 | [0.000] |
| 11 | 0.2939 *** | 0.0152 | 817.9546 | [0.000] |
| 12 | 0.2305 *** | -0.0209 | 827.6815 | [0.000] |

| Autocorrelation function for Prices_of_Chemical_Products | | | | |
|---|---|---|---|---|
| | | | | |
| **LAG** | **ACF** | **PACF** | **Q-stat.** | **[p-value]** |
| | | | | |
| 1 | 0.9258 *** | 0.9258 *** | 146.5689 | [0.000] |
| 2 | 0.8553 *** | -0.0124 | 272.4184 | [0.000] |
| 3 | 0.7853 *** | -0.0334 | 379.171 | [0.000] |
| 4 | 0.7374 *** | 0.1148 | 473.8525 | [0.000] |
| 5 | 0.6755 *** | -0.1208 | 553.792 | [0.000] |
| 6 | 0.6161 *** | -0.0209 | 620.7025 | [0.000] |
| 7 | 0.5400 *** | -0.1348 * | 672.4364 | [0.000] |
| 8 | 0.4791 *** | 0.0321 | 713.4016 | [0.000] |
| 9 | 0.4216 *** | -0.0034 | 745.3364 | [0.000] |
| 10 | 0.3671 *** | -0.0502 | 769.7009 | [0.000] |
| 11 | 0.3089 *** | -0.0237 | 787.0624 | [0.000] |
| 12 | 0.2512 *** | -0.0515 | 798.6168 | [0.000] |

Appendix 2 – Johansen cointegration tests, Case 1 to Case 4

| | | | |
|---|---|---|---|
| Cointegration tests for no constant<br># of equa. => 2<br>Lags=> 12<br>Period=>2001:01 - 2013:12 (T = 156) | | | |
| **Case 1: No constant** | | | |
| **Log-likelihood = -15.4811 (including constant term: -458.19)** | | | |
| **Rank** | **Eigenvalues** | **T-test & p-values** | **Lmax stats& p-values** |
| 0 | 0.022958 | 3.6264 [0.7545] | 3.6231 [0.6884] |
| 1 | 0.000020978 | 0.0032727 [0.9771] | 0.0032727 [0.9740] |
| **Corr_size = 132** | | | |
| Ranks | Trace stats & p-values | | |
| 0 | 3.6264 [0.7649] | | |
| 1 | 0.0032727 [0.9741] | | |
| Eigenvalues=> 0.022958 2.0978e-005 | | | |
| **beta (cointegrating vectors)** | | | |
| USD_Rand_Exchang~ | 0.7603300 | 0.2251100 | |
| Prices_of_Chemic~ | -0.0497970 | -0.0062405 | |
| **alpha (adjustment vectors)** | | | |
| USD_Rand_Exchang~ | -0.0436270 | -0.0004183 | |
| Prices_of_Chemic~ | 0.1654900 | -0.0161850 | |
| **renormalized beta** | | | |
| USD_Rand_Exchang~ | 1.0000000 | -36.0730000 | |
| Prices_of_Chemic~ | -0.0654930 | 1.0000000 | |
| **renormalized alpha** | | | |
| USD_Rand_Exchang~ | -0.0331710 | 0.0000026 | |
| Prices_of_Chemic~ | 0.1258300 | 0.1258300 | |
| **long-run matrix (alpha * beta')** | | | |
| | USD_Rand_Exchang~ | Prices_of_Chemic~ | |
| USD_Rand_Exchang~ | -0.0332650 | 0.0021751 | |
| Prices_of_Chemic~ | 0.1221800 | -0.0081398 | |

Appendix 2 continues…

| | | | |
|---|---|---|---|
| Johansen test=>Cointegration | | | |
| # of equations =>2 | | | |
| Lags=>12 | | | |
| Period=>2001:01 - 2013:12 (T=>156) | | | |
| **Case 2: Restricted constant** | | | |
| **Log-likelihood = -8.47846 (including constant term: -451.187)** | | | |
| **Ranks** | **Eigenvalues** | **T-test & p-values** | **Lmax stats & p-values** |
| 0 | 0.089473 | 17.632 [0.1112] | 14.622 [0.0777] |
| 1 | 0.019107 | 3.0096 [0.5875] | 3.0096 [0.5864] |

| | | | |
|---|---|---|---|
| **Corr_size = 131** | | | |
| Ranks | | Trace stats & p-values | |
| 0 | | 17.632 [0.1157] | |
| 1 | | 3.0096 [0.5865] | |
| Eigenvalues=> 0.089473 0.019107 | | | |
| **beta (cointegrating vectors)** | | | |
| USD_Rand_Exchang~ | | 0.7567200 | -0.5972600 |
| Prices_of_Chemic~ | | 0.0953480 | 0.0740680 |
| const -17.751 -4.2688 | | | |
| **alpha (adjustment vectors)** | | | |
| USD_Rand_Exchang~ | | -0.0640140 | 0.0294680 |
| Prices_of_Chemic~ | | -0.7865600 | -0.3595500 |
| **renormalized beta** | | | |
| USD_Rand_Exchang~ | | 1.0000000 | -8.0637000 |
| Prices_of_Chemic~ | | 0.1260000 | 1.0000000 |
| const | | -23.4570000 | -57.6340000 |
| **renormalized alpha** | | | |
| USD_Rand_Exchang~ | | -0.0484410 | 0.0021827 |
| Prices_of_Chemic~ | | -0.5952000 | -0.0266310 |

| **long-run matrix (alpha * beta')** | | | |
|---|---|---|---|
| | USD_Rand_Exchang~ | Prices_of_Chemic~ | const |
| USD_Rand_Exchang~ | -0.0660410 | -0.0039210 | 1.010 |
| Prices_of_Chemic~ | -0.3804600 | -0.1016300 | 15.49 |

Appendix 2 continues…

| | | | |
|---|---|---|---|
| Johansen test=>Cointegration<br># of equation =>2<br>Lags=>12<br>Estimation period=>2001:01 - 2013:12 (T = 156) | | | |
| **Case 3: Unrestricted constant** | | | |
| **Log-likelihood = -8.47846 (including constant term: -451.187)** | | | |
| **Ranks** | **Eigenvalues** | **T-test & p-values** | **Lmax stats & p-values** |
| Zero (0) | 0.088707 | 17.329 [0.0245] | 14.491 [0.0440] |
| One (1) | 0.018025 | 2.8376 [0.0921] | 2.8376 [0.0921] |

| | | |
|---|---|---|
| **Corr_size = 131** | | |
| Ranks | Trace stats & p-values | |
| Zero (0) | 17.329 [0.0259] | |
| One (1) | 2.8376 [0.0951] | |
| Eigenvalues=> 0.088707 0.018025 | | |
| **beta (cointegrating vectors)** | | |
| USD_Rand_Exchang~ | -0.7567900 | -0.6378200 |
| Prices_of_Chemic~ | -0.0962190 | 0.0734470 |
| **alpha (adjustment vectors)** | | |
| USD_Rand_Exchang~ | 0.0628570 | 0.0289610 |
| Prices_of_Chemic~ | 0.7931600 | -0.3446100 |
| **renormalized beta** | | |
| USD_Rand_Exchang~ | 1.0000000 | -8.6840000 |
| Prices_of_Chemic~ | 0.1271400 | 1.0000000 |
| **renormalized alpha** | | |
| USD_Rand_Exchang~ | -0.0475700 | 0.0021271 |
| Prices_of_Chemic~ | -0.6002600 | -0.0253100 |
| **long-run matrix (alpha * beta')** | | |
| | USD_Rand_Exchang~ | Prices_of_Chemic~ |
| USD_Rand_Exchang~ | -0.0660410 | -0.0039210 |
| Prices_of_Chemic~ | -0.3804600 | -0.1016300 |

Appendix 2 continues…

| |
|---|
| Johansen test=>Cointegration |
| # of equations=>2 |
| Lags=>12 |
| Period=>2001:01 - 2013:12 (T=>156) |
| **Case 4: Restricted trend, unrestricted constant** |

**Log-likelihood = -6.80445 (incl. constant term: -449.513)**

| **Ranks** | **Eigenvalues** | **T-test & p-values** | **Lmax stats & p-values** |
|---|---|---|---|
| Zero (0) | 0.10356 | 20.677 [0.1967] | 17.054 [0.1060] |
| One (1) | 0.022954 | 3.6226 [0.7908] | 3.6226 [0.7926] |

**Corr_size = 130**

| Ranks | Trace stats & p-values |
|---|---|
| Zero (0) | 20.677 [0.2037] |
| One (1) | 3.6226 [0.7927] |

Eigenvalues=> 0.10356 0.022954

| **beta (cointegrating vectors)** | | |
|---|---|---|
| USD_Rand_Exchang~ | -0.7661900 | 0.4359800 |
| Prices_of_Chemic~ | -0.1477700 | -0.0187680 |
| trend | 0.0161100 | -0.0172850 |

| **alpha (adjustment vectors)** | | |
|---|---|---|
| USD_Rand_Exchang~ | 0.0753450 | -0.0288460 |
| Prices_of_Chemic~ | 0.7578400 | 0.4321100 |

| **renormalized beta** | | |
|---|---|---|
| USD_Rand_Exchang~ | 1.0000000 | -23.2300000 |
| Prices_of_Chemic~ | 0.1928600 | 1.0000000 |
| trend | -0.0210270 | 0.9209700 |

| **renormalized alpha** | | |
|---|---|---|
| USD_Rand_Exchang~ | -0.0577290 | 0.0005414 |
| Prices_of_Chemic~ | -0.5806500 | -0.0081099 |

**long-run matrix (alpha * beta')**

| | USD_Rand_Exchang~ | Prices_of_Chemic~ | trend |
|---|---|---|---|
| USD_Rand_Exchang~ | -0.0703050 | -0.0105920 | 0.001 |
| Prices_of_Chemic~ | -0.3922600 | -0.1200900 | 0.004 |

## Appendix 3 – VAR Estimations

VAR=>lags 12
OLS=>observations from 2001:01-2013:12 (T = 156)
Log-likelihood = -451.18728
Determinant_ of cov.matrix = 1.1148259
AIC=> 6.4255
BIC=> 7.4030
HQC=> 6.8225
Portmanteau test=> LB(39)=> 61.0788, df=> 108 [0.9999]

Equation_1: USD_Rand_Exchange_Rate

| | Co-efficient | Standard errors | T-ratios | P-values |
|---|---|---|---|---|
| Constant | 1.0105 | 0.468606 | 2.156 | 0.0329 ** |
| USD_Rand_Excha~ 1 | 1.30404 | 0.08725 | 14.95 | 4.28E-30*** |
| USD_Rand_Excha~ 2 | -0.348034 | 0.143539 | -2.425 | 0.0167** |
| USD_Rand_Excha~ 3 | 0.0235884 | 0.146817 | 0.1607 | 0.8726 |
| USD_Rand_Excha~ 4 | 0.0176454 | 0.146519 | 0.1204 | 0.9043 |
| USD_Rand_Excha~ 5 | -0.0472073 | 0.149061 | -0.3167 | 0.752 |
| USD_Rand_Excha~ 6 | -0.124791 | 0.150295 | -0.8303 | 0.4079 |
| USD_Rand_Excha~ 7 | 0.156467 | 0.150548 | 1.039 | 0.3006 |
| USD_Rand_Excha~ 8 | 0.20557 | 0.150728 | 1.364 | 0.175 |
| USD_Rand_Excha~ 9 | -0.24394 | 0.154228 | -1.582 | 0.1161 |
| USD_Rand_Exch~ 10 | -0.00290956 | 0.157102 | -0.01852 | 0.9853 |
| USD_Rand_Exch~ 11 | 0.0278607 | 0.151927 | 0.1834 | 0.8548 |
| USD_Rand_Exch~ 12 | -0.0343263 | 0.0902345 | -0.3804 | 0.7043 |
| Prices_of_Chem~ 1 | -0.0141207 | 0.00705966 | -2 | 0.0475** |
| Prices_of_Chem~ 2 | 0.0153679 | 0.00988632 | 1.554 | 0.1225 |
| Prices_of_Chem~ 3 | -0.00320316 | 0.00997153 | -0.3212 | 0.7485 |
| Prices_of_Chem~ 4 | -0.0257433 | 0.0100481 | -2.562 | 0.0115** |
| Prices_of_Chem~ 5 | 0.043031 | 0.0103654 | 4.151 | 0.0000591*** |
| Prices_of_Chem~ 6 | -0.0219801 | 0.010874 | -2.021 | 0.0453** |
| Prices_of_Chem~ 7 | -0.00595886 | 0.0109975 | -0.5418 | 0.5889 |
| Prices_of_Chem~ 8 | 0.0157099 | 0.0109388 | 1.436 | 0.1533 |
| Prices_of_Chem~ 9 | -0.00641029 | 0.0106942 | -0.5994 | 0.5499 |
| Prices_of_Che~ 10 | -0.0055976 | 0.0106088 | -0.5276 | 0.5986 |
| Prices_of_Che~ 11 | 0.000566596 | 0.0105176 | 0.05387 | 0.9571 |
| Prices_of_Che~ 12 | 0.00441766 | 0.00726393 | 0.6082 | 0.5441 |

Mean_dependent_variance => 7.887238 Standard deviation => 1.360007
Sum_squared_residuals => 13.45985 Standard errors => 0.320542
$R^{-squared}$ => 0.953051 $R^{-squared}$ _adjust. => 0.944450
F(24, 131) => 110.8025
F_p-value/s => 3.60e-75
Rho=> -0.003512 DW=> 2.004625
Restrictions: F-stats of zero

Lags of USD_Rand_Exchang~ F-stats(12, 131) = 197.08 [0.0000]
Lags of Prices_of_Chemic~ F-stats(12, 131) = 1.9473 [0.0342]
VARS, lag 12 => F-stats (2, 131) = 0.24903 [0.7799]

Appendix 3 continues…

| Equation_2: Prices_of_Chemical_Products | | | | |
|---|---|---|---|---|
| | **Co-efficient** | **Standard errors** | **T-ratios** | **P-values** |
| Constant | 15.4968 | 5.73706 | 2.701 | 0.0078** |
| USD_Rand_Excha~1 | 0.997673 | 1.06819 | 0.934 | 0.352 |
| USD_Rand_Excha~2 | -0.96238 | 1.75733 | -0.5476 | 0.5849 |
| USD_Rand_Excha~3 | -2.46707 | 1.79746 | -1.373 | 0.1722 |
| USD_Rand_Excha~4 | 4.40094 | 1.7938 | 2.453 | 0.0155** |
| USD_Rand_Excha~5 | -2.63684 | 1.82492 | -1.445 | 0.1509 |
| USD_Rand_Excha~6 | 0.665004 | 1.84003 | 0.3614 | 0.7184 |
| USD_Rand_Excha~7 | 0.362681 | 1.84313 | 0.1968 | 0.8443 |
| USD_Rand_Excha~8 | -1.27761 | 1.84534 | -0.6923 | 0.4899 |
| USD_Rand_Excha~9 | 0.595917 | 1.88818 | 0.3156 | 0.7528 |
| USD_Rand_Exch~10 | -0.184771 | 1.92336 | -0.09607 | 0.9236 |
| USD_Rand_Exch~11 | 1.73225 | 1.86002 | 0.9313 | 0.3534 |
| USD_Rand_Exch~12 | -1.60625 | 1.10472 | -1.454 | 0.1483 |
| Prices_of_Chem~1 | 0.96782 | 0.0864301 | 11.2 | 7.81E-21*** |
| Prices_of_Chem~2 | -0.0304532 | 0.121036 | -0.2516 | 0.8017 |
| Prices_of_Chem~3 | -0.151498 | 0.12208 | -1.241 | 0.2168 |
| Prices_of_Chem~4 | 0.242816 | 0.123018 | 1.974 | 0.0505* |
| Prices_of_Chem~5 | -0.0941398 | 0.126901 | -0.7418 | 0.4595 |
| Prices_of_Chem~6 | 0.130728 | 0.133128 | 0.982 | 0.3279 |
| Prices_of_Chem~7 | -0.3043 | 0.134641 | -2.26 | 0.0255** |
| Prices_of_Chem~8 | 0.218235 | 0.133921 | 1.63 | 0.1056 |
| Prices_of_Chem~9 | -0.0596516 | 0.130927 | -0.4556 | 0.6494 |
| Prices_of_Che~10 | -0.0677794 | 0.129881 | -0.5219 | 0.6027 |
| Prices_of_Che~11 | 0.139052 | 0.128765 | 1.08 | 0.2822 |
| Prices_of_Che~12 | -0.0924579 | 0.0889309 | -1.04 | 0.3004 |

Mean_dependent_variance => 123.5314 Standard deviation => 10.05527
Sum_squared_residuals => 2017.450 Standard errors => 3.924332
$R^{\text{-squared}}$ => 0.871269 $R^{\text{-squared}}$ _adjust. => 0.847685
F-stats(24, 131) => 36.94272
F_P-value => 6.73e-47
Rho -0.005433 D-W stats 2.009966

Restrictions: F-stats of zero:

Lags of USD_Rand_Exchang~ F-stats (12, 131) = 0.83701 [0.6123]
Lags of Prices_of_Chemic~ F-stats (12, 131) = 66.041 [0.0000]
VARS, lag 12 F-stats (2, 131) = 1.6560 [0.1949]

Entire estimation:
$H_0$: Longer lag => 11
$H_1$: Longer lag => 12
Test: $Chi^{\text{-square(4)}}$ => 4.48417 [0.3444]

Info. Criteria_comparing:
Lag 12: AIC equal to 6.42548, BIC = 7.40300, HQC = 6.82250
Lag 11: AIC equals to 6.40294, BIC = 7.30226, HQC = 6.76820

Appendix 4 – USD-Rand & Prices of chemical products

| Dates | USD-Rand Exchange rate | Chemicals products prices |
|---|---|---|
| 2000 - January | 6.12 | 98.30 |
| 2000 - February | 6.32 | 98.30 |
| 2000 - March | 6.46 | 98.30 |
| 2000 - April | 6.61 | 99.90 |
| 2000 - May | 7.02 | 99.90 |
| 2000 - June | 6.93 | 99.90 |
| 2000 - July | 6.88 | 101.00 |
| 2000 - August | 6.95 | 101.00 |
| 2000 - September | 7.16 | 101.00 |
| 2000 - October | 7.47 | 100.90 |
| 2000 - November | 7.67 | 100.90 |
| 2000 - December | 7.64 | 101.00 |
| 2001 - January | 7.77 | 102.10 |
| 2001 - February | 7.81 | 102.00 |
| 2001 - March | 7.88 | 102.20 |
| 2001 - April | 8.08 | 103.40 |
| 2001 - May | 7.97 | 103.50 |
| 2001 - June | 8.06 | 103.50 |
| 2001 - July | 8.20 | 103.40 |
| 2001 - August | 8.31 | 103.40 |
| 2001 - September | 8.63 | 103.40 |
| 2001 - October | 9.27 | 106.70 |
| 2001 - November | 9.72 | 106.70 |
| 2001 - December | 11.55 | 106.70 |
| 2002 - January | 11.61 | 110.90 |
| 2002 - February | 11.48 | 111.20 |
| 2002 - March | 11.49 | 111.20 |
| 2002 - April | 11.08 | 121.00 |
| 2002 - May | 10.15 | 121.00 |
| 2002 - June | 10.14 | 120.50 |
| 2002 - July | 10.11 | 122.80 |
| 2002 - August | 10.59 | 122.80 |
| 2002 - September | 10.60 | 122.80 |
| 2002 - October | 10.33 | 123.70 |
| 2002 - November | 9.65 | 123.70 |
| 2002 - December | 8.96 | 123.70 |
| 2003 - January | 8.68 | 121.00 |
| 2003 - February | 8.30 | 121.00 |
| 2003 - March | 8.04 | 121.00 |
| 2003 - April | 7.71 | 121.90 |
| 2003 - May | 7.67 | 121.90 |
| 2003 - June | 7.90 | 121.90 |
| 2003 - July | 7.55 | 119.90 |
| 2003 - August | 7.39 | 119.90 |
| 2003 - September | 7.32 | 119.90 |
| 2003 - October | 6.96 | 118.80 |
| 2003 - November | 6.73 | 118.80 |
| 2003 - December | 6.52 | 118.80 |

Appendix 4 continues…

| | | |
|---|---|---|
| 2004 - January | 6.92 | 120.40 |
| 2004 - February | 6.77 | 120.40 |
| 2004 - March | 6.63 | 120.40 |
| 2004 - April | 6.55 | 123.10 |
| 2004 - May | 6.78 | 123.10 |
| 2004 - June | 6.44 | 123.10 |
| 2004 - July | 6.13 | 122.30 |
| 2004 - August | 6.46 | 122.30 |
| 2004 - September | 6.55 | 122.30 |
| 2004 - October | 6.39 | 125.00 |
| 2004 - November | 6.06 | 125.00 |
| 2004 - December | 5.73 | 125.00 |
| 2005 - January | 5.97 | 124.20 |
| 2005 - February | 6.02 | 124.20 |
| 2005 - March | 6.01 | 124.20 |
| 2005 - April | 6.15 | 124.60 |
| 2005 - May | 6.33 | 124.60 |
| 2005 - June | 6.75 | 124.60 |
| 2005 - July | 6.70 | 125.20 |
| 2005 - August | 6.47 | 125.20 |
| 2005 - September | 6.36 | 125.20 |
| 2005 - October | 6.58 | 126.40 |
| 2005 - November | 6.66 | 126.40 |
| 2005 - December | 6.36 | 126.40 |
| 2006 - January | 6.09 | 125.40 |
| 2006 - February | 6.12 | 125.40 |
| 2006 - March | 6.25 | 125.40 |
| 2006 - April | 6.07 | 125.10 |
| 2006 - May | 6.32 | 125.10 |
| 2006 - June | 6.95 | 125.10 |
| 2006 - July | 7.08 | 128.80 |
| 2006 - August | 6.96 | 128.80 |
| 2006 - September | 7.41 | 128.80 |
| 2006 - October | 7.65 | 130.20 |
| 2006 - November | 7.26 | 130.20 |
| 2006 - December | 7.04 | 130.20 |
| 2007 - January | 7.18 | 127.80 |
| 2007 - February | 7.17 | 127.80 |
| 2007 - March | 7.35 | 127.80 |
| 2007 - April | 7.12 | 130.40 |
| 2007 - May | 7.02 | 130.40 |
| 2007 - June | 7.17 | 130.40 |
| 2007 - July | 6.97 | 131.30 |
| 2007 - August | 7.23 | 131.30 |
| 2007 - September | 7.13 | 131.30 |
| 2007 - October | 6.77 | 129.90 |
| 2007 - November | 6.70 | 129.90 |
| 2007 - December | 6.83 | 129.90 |

Appendix 4 continues…

| | | |
|---|---|---|
| 2008 - January | 6.99 | 130.90 |
| 2008 - February | 7.64 | 130.90 |
| 2008 - March | 7.98 | 130.90 |
| 2008 - April | 7.79 | 131.10 |
| 2008 - May | 7.62 | 131.60 |
| 2008 - June | 7.92 | 131.60 |
| 2008 - July | 7.64 | 130.60 |
| 2008 - August | 7.66 | 131.80 |
| 2008 - September | 8.05 | 132.00 |
| 2008 - October | 9.67 | 132.30 |
| 2008 - November | 10.12 | 132.30 |
| 2008 - December | 9.95 | 132.30 |
| 2009 - January | 9.90 | 132.20 |
| 2009 - February | 10.01 | 131.80 |
| 2009 - March | 9.99 | 131.60 |
| 2009 - April | 9.02 | 127.90 |
| 2009 - May | 8.37 | 128.50 |
| 2009 - June | 8.05 | 129.00 |
| 2009 - July | 7.95 | 128.30 |
| 2009 - August | 7.94 | 127.60 |
| 2009 - September | 7.52 | 127.60 |
| 2009 - October | 7.48 | 127.80 |
| 2009 - November | 7.52 | 127.80 |
| 2009 - December | 7.49 | 127.80 |
| 2010 - January | 7.45 | 122.10 |
| 2010 - February | 7.66 | 122.10 |
| 2010 - March | 7.43 | 122.10 |
| 2010 - April | 7.34 | 120.40 |
| 2010 - May | 7.63 | 120.40 |
| 2010 - June | 7.65 | 120.40 |
| 2010 - July | 7.55 | 120.40 |
| 2010 - August | 7.30 | 120.40 |
| 2010 - September | 7.14 | 120.40 |
| 2010 - October | 6.92 | 123.30 |
| 2010 - November | 6.97 | 122.80 |
| 2010 - December | 6.83 | 122.90 |
| 2011 - January | 6.90 | 123.00 |
| 2011 - February | 7.19 | 122.40 |
| 2011 - March | 6.91 | 128.50 |
| 2011 - April | 6.73 | 128.60 |
| 2011 - May | 6.86 | 128.70 |
| 2011 - June | 6.79 | 128.10 |
| 2011 - July | 6.79 | 128.40 |
| 2011 - August | 7.06 | 127.00 |
| 2011 - September | 7.52 | 127.00 |
| 2011 - October | 7.95 | 127.80 |
| 2011 - November | 8.16 | 127.80 |
| 2011 - December | 8.17 | 137.10 |

Appendix 4 continues…

| | | |
|---|---|---|
| 2012 - January | 8.01 | 137.40 |
| 2012 - February | 7.66 | 137.40 |
| 2012 - March | 7.60 | 137.50 |
| 2012 - April | 7.83 | 140.10 |
| 2012 - May | 8.15 | 141.20 |
| 2012 - June | 8.40 | 147.90 |
| 2012 - July | 8.25 | 141.60 |
| 2012 - August | 8.28 | 141.90 |
| 2012 - September | 8.28 | 136.70 |
| 2012 - October | 8.64 | 145.60 |
| 2012 - November | 8.79 | 145.60 |
| 2012 - December | 8.64 | 145.70 |
| 2013 - January | 8.79 | 102.30 |
| 2013 - February | 9.02 | 102.10 |
| 2013 - March | 9.24 | 103.80 |
| 2013 - April | 8.97 | 104.50 |
| 2013 - May | 10.09 | 104.40 |
| 2013 - June | 9.88 | 106.40 |
| 2013 - July | 9.88 | 106.40 |
| 2013 - August | 10.28 | 106.70 |
| 2013 - September | 10.03 | 107.40 |
| 2013 - October | 10.05 | 107.30 |
| 2013 - November | 10.17 | 107.70 |
| 2013 - December | 10.49 | 107.60 |

Appendix 5 – J135 Chemical index, and list of chemical products

| **Names(Index and companies)** | **Codes(Index and companies)** | **Full Names(Index and companies)** | |
|---|---|---|---|
| FTSE/JSE Africa Index Series | | | |
| JSE-CHES | J135 | Chemicals Index | JSE Indices |
| | | | |
| AECI | AFE | A E C I LIMITED | Chem_companies |
| AFROX | AFX | AFRICAN OXYGEN LTD | Chem_companies |
| DELTA | DTA | DELTA EMD LTD | Chem_companies |
| OMNIA | OMN | OMNIA HOLDINGS LIMITED | Chem_companies |
| ROLFES | RLF | ROLFES TECHNOLOGY HLDNGS | Chem_companies |
| SPANJRD | SPA | SPANJAARD LIMITED | Chem_companies |

Appendix 5 continues…

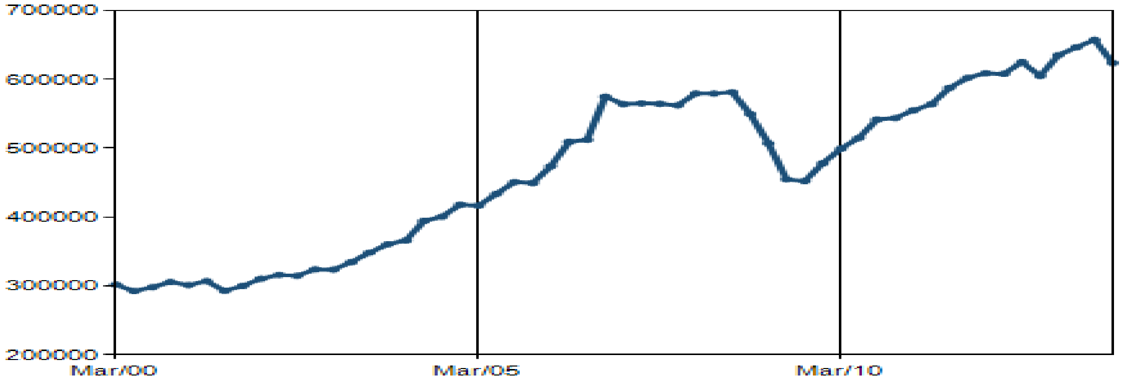
| **List of the common chemicals products - imports into South Africa** | | |
|---|---|---|
| **Categories** | | **Products_Chemicals** |
| | | |
| Industrial Chemicals | | Sodium hydroxides products |
| Organic products | | Acrylonitrile products |
| Industrial ceramics | | Silica brick products |
| Petrochemicals | | Styrene related products |
| Agricultural Products | | Insecticides materials |
| Polymers or Polyurethanes | | Polyester products |
| Industrial elastomers | | Neoprene/ Polyurethane materials |
| Oleochemicals | | Soybeans products |
| Explosives category | | Nitrocellulose products |
| Fragrances and flavors | | a. Benzyl benzoate, b.coumarin and c.vanillin |
| Industrial gas | | a. Nitrogen, b.oxygen, c.acetylene and d.nitrous oxide |

Appendix 6 – Import of goods (Quarterly figures 2000:Q1 – 2013:Q4)

| **Data: Imports of goods (South African economic environment)**<br>**Imports of goods**<br>**Constant 2005 prices. Seasonally adjusted at annual rate…** | |
|---|---|
| **Date** | **Value** |
| Q4/13 | 623,901.00 |
| Q3/13 | 657,529.00 |
| Q2/13 | 646,502.00 |
| Q1/13 | 635,180.00 |
| Q4/12 | 604,950.00 |
| Q3/12 | 625,397.00 |
| Q2/12 | 607,979.00 |
| Q1/12 | 608,966.00 |
| Q4/11 | 602,288.00 |
| Q3/11 | 587,739.00 |
| Q2/11 | 563,800.00 |
| Q1/11 | 555,061.00 |
| Q4/10 | 543,611.00 |
| Q3/10 | 541,522.00 |
| Q2/10 | 514,973.00 |
| Q1/10 | 499,114.00 |
| Q4/09 | 477,973.00 |
| Q3/09 | 452,029.00 |
| Q2/09 | 454,674.00 |
| Q1/09 | 507,032.00 |
| Q4/08 | 549,574.00 |
| Q3/08 | 581,379.00 |
| Q2/08 | 579,428.00 |
| Q1/08 | 579,579.00 |
| Q4/07 | 562,228.00 |
| Q3/07 | 564,515.00 |
| Q2/07 | 565,146.00 |
| Q1/07 | 563,947.00 |
| Q4/06 | 574,887.00 |
| Q3/06 | 512,079.00 |
| Q2/06 | 509,044.00 |
| Q1/06 | 473,838.00 |
| Q4/05 | 449,305.00 |
| Q3/05 | 450,905.00 |
| Q2/05 | 433,557.00 |
| Q1/05 | 416,469.00 |
| Q4/04 | 417,912.00 |
| Q3/04 | 400,568.00 |
| Q2/04 | 394,201.00 |
| Q1/04 | 365,827.00 |
| Q4/03 | 360,318.00 |
| Q3/03 | 348,216.00 |
| Q2/03 | 334,496.00 |
| Q1/03 | 323,546.00 |
| Q4/02 | 323,958.00 |

Appendix 6 continues…

| | |
|---|---|
| Q4/01 | 299,844.00 |
| Q3/01 | 292,729.00 |
| Q2/01 | 306,624.00 |
| Q1/01 | 301,051.00 |
| Q4/00 | 305,589.00 |
| Q3/00 | 297,760.00 |
| Q2/00 | 292,271.00 |
| Q1/00 | 301,636.00 |




Appendix 7 – Analysis of the variance decomposition forecast

| **Decomposition of variance for USD_Rand_Exchange_rate** | | | |
|---|---|---|---|
| **period** | **std. error** | **USD_Rand_Exchange_rate** | **Chemicals_products_prices** |
| | | | |
| 1 | 0.2937 | 100.0000 | 0.0000 |
| 2 | 0.4866 | 98.9117 | 1.0883 |
| 3 | 0.6295 | 98.4393 | 1.5607 |
| 4 | 0.7419 | 98.1319 | 1.8681 |
| 5 | 0.8539 | 95.3944 | 4.6056 |
| 6 | 0.9376 | 94.3949 | 5.6051 |
| 7 | 0.9939 | 93.4969 | 6.5031 |
| 8 | 1.0445 | 92.1538 | 7.8462 |
| 9 | 1.0998 | 91.1780 | 8.8220 |
| 10 | 1.1579 | 90.6293 | 9.3707 |
| 11 | 1.2139 | 89.7935 | 10.2065 |
| 12 | 1.2644 | 88.8040 | 11.1960 |
| 13 | 1.3135 | 87.4261 | 12.5739 |
| 14 | 1.3544 | 86.2406 | 13.7594 |
| 15 | 1.3835 | 85.3074 | 14.6926 |
| 16 | 1.4058 | 84.3394 | 15.6606 |
| 17 | 1.4243 | 83.4901 | 16.5099 |
| 18 | 1.4388 | 82.8970 | 17.1030 |
| 19 | 1.4504 | 82.4232 | 17.5768 |
| 20 | 1.4596 | 82.0290 | 17.9710 |
| 21 | 1.4675 | 81.6837 | 18.3163 |
| 22 | 1.4738 | 81.3941 | 18.6059 |
| 23 | 1.4778 | 81.1807 | 18.8193 |
| 24 | 1.4803 | 81.0132 | 18.9868 |

Appendix 7 continues…

| Decomposition of variance for Chemicals_products_prices | | | |
|---|---|---|---|
| **period** | **std. error** | **USD_Rand_Exchange_rate** | **Chemicals_products_prices** |
| | | | |
| 1 | 3.5962 | 0.0890 | 99.9110 |
| 2 | 5.0071 | 0.1887 | 99.8113 |
| 3 | 5.9529 | 0.3665 | 99.6335 |
| 4 | 6.4475 | 0.7211 | 99.2789 |
| 5 | 7.0029 | 0.6368 | 99.3632 |
| 6 | 7.4112 | 0.5945 | 99.4055 |
| 7 | 7.9450 | 0.5233 | 99.4767 |
| 8 | 8.2322 | 0.5031 | 99.4969 |
| 9 | 8.4595 | 0.5892 | 99.4108 |
| 10 | 8.6466 | 0.8192 | 99.1808 |
| 11 | 8.8237 | 1.0466 | 98.9534 |
| 12 | 8.9670 | 1.0991 | 98.9009 |
| 13 | 9.0973 | 1.1252 | 98.8748 |
| 14 | 9.1788 | 1.1951 | 98.8049 |
| 15 | 9.2557 | 1.4597 | 98.5403 |
| 16 | 9.3179 | 1.7773 | 98.2227 |
| 17 | 9.3759 | 2.2121 | 97.7879 |
| 18 | 9.4357 | 2.7710 | 97.2290 |
| 19 | 9.5003 | 3.5368 | 96.4632 |
| 20 | 9.5594 | 4.3487 | 95.6513 |
| 21 | 9.6210 | 5.1953 | 94.8047 |
| 22 | 9.6797 | 6.0297 | 93.9703 |
| 23 | 9.7392 | 6.9127 | 93.0873 |
| 24 | 9.7979 | 7.8025 | 92.1975 |