An analysis of the impact of crude oil price shocks on the exchange rate in South Africa

A study submitted in partial fulfilment of the requirement

for the Master's degree in Economics

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ABSTRACT

Numerous studies have investigated the impact of oil price shocks on the exchange rates in developed economies. However, fewer studies have examined the effect of oil price shocks in developing economies. One study by Turhan, Hacihasanoglu and Soytas in 2012 examines the dynamic effect of oil price movements in thirteen developing markets, including South Africa. Another study by Kin and Courage (2014) investigate the effect of crude oil prices on the South African exchange rate, but their modelling, time period and variables differs. The intention of the current mini-thesis, however, is investigate the effect of crude oil prices on the exchange rate of South Africa from January 1980 to December 2014. The aim of this mini-thesis is to explore the impact of crude oil price movements on the volatility of the exchange rate on the South African market.

Currently emerging economies are consuming an increasing share of the world's oil and they have therefore become larger players in the global financial markets. Basher and Sadorsky (2006:224-227) state that as countries modernise and urbanise, their demand for crude oil and its related products tends to increase. The rising economic importance of the BRICS (Brazil, Russia, India, China and South Africa) economies implies that the possibility of the consumption of oil in the developing economies could surpass the global oil consumption of developed economies. It is important to note that future oil demand cannot be predicted, but oil demand growth is highly correlated with the growth in the industrial production of a country. The use of oil for energy consumption and the use of oil trading on the stock markets and the financial markets are all linked on the path of a country's economic growth.

In order to evaluate the link between the four variables of oil prices, exchange rates, manufacturing production index and the prime rate, qualitative research methods will be used. The methods which will be applied are the vector autoregressive model and the vector error correction mechanism.

This study reveals that the movement in Brent oil prices has a relatively insignificant impact on the movement of the South African rand on a monthly basis.

Key Words: Monetary policy, economic growth, VAR, exchange rate, oil price, stock market, South Africa

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List of Abbreviations

BRICS	Brazil, Russia, India, China and South Africa
VAR	Vector Autoregressive
VECM	Vector Error Correction Mechanism
EIA	Energy Information Administration
IRF	Impulse Response Function
NGP	National Growth Plan
GDP	Gross Domestic Product
LA VAR	Lag Augmented Vector Autoregressive
JJ	Johansen and Juselius
US	United States
OPEC	Organization of the Petroleum Exporting Countries
SVAR	Structural Vector Autoregressive
GARCH	Generalized Autoregressive Conditional Heteroskedasticity
PP	Phillips-Perron
ADF	Augmented Dickey Fuller
AIC	Akaike Information Criterion
CPI	Consumer Price Index
HQ	Hannan-Quinn information
SARB	South African Reserve Bank
BER	Bureau for Economic Research
IMF	International Monetary Fund
PPI	Producer price index
WPI	Wholesale price index

CHAPTER 1

Introduction

Crude oil is a strategic commodity and considered to be a primary source of energy. Basher and Sadorsky (2006:1) assert that crude oil is an essential commodity of modern economies as it can be used as a source of energy or as a form of raw material. As a source of energy, crude oil can be used to generate electricity and heat, as well as to power machinery and automobiles. It is a raw material for the production of many commodities such as petroleum products, cosmetics, detergents, plastics, paints and others.

Crude oil is a homogenous commodity and traded internationally on a daily basis. It has both a direct and indirect impact on the global economy, because it serves as an input into the production of goods and services in an economy. In both oil exporting and oil importing countries the price of crude oil forms part of the country's revenue structure and its balance of payments. This homogenous commodity could therefore have a direct impact on the health of the economy. Furthermore, because crude oil is a basic commodity or a raw material in many industrial and secondary goods, the price of crude oil would therefore have an indirect impact on the health of an importing or exporting economy. According to Maslyuk, Rotaru and Dokumentov (2013:2), the price movement of crude oil prices has an impact on the sentiments of the various investors and therefore has an impact on the stock market and the exchange rate of a country. Increases in crude oil prices can lead to the secondary effects of increases in fuel, electricity and other utilities prices, which could in turn result in escalations in the cost of production. These increases could have a negative effect on both the local and global economy.

In terms of economic size, South Africa is the second largest economy and is the largest energy consumer (Energy Information Administration (EIA), 2015) on the African continent. South Africa is not an oil-rich country and imports more than 90% of its crude oil from oil-rich nations such as Saudi Arabia, Nigeria, Angola and others (EIA, 2015). This implies that South Africa is exposed to crude oil price fluctuations. Nkomo (2009:20) states that this could have an impact on the economic growth and development of South Africa.

In the study by Basher, Haug and Sadorsky (2011:227) they state that the oil demand in emerging markets will outweigh the oil demand from developed markets in the future. Figure 1a below depicts how the demand for oil has increased in the Asian developing countries compared to the Asian industrialised countries over the years. Figure 1b[1] depicts energy consumption from 2004 to 2014. A downward trend in energy consumption in the developed markets compared with the improvement in oil consumption of the BRICS economies can be observed.

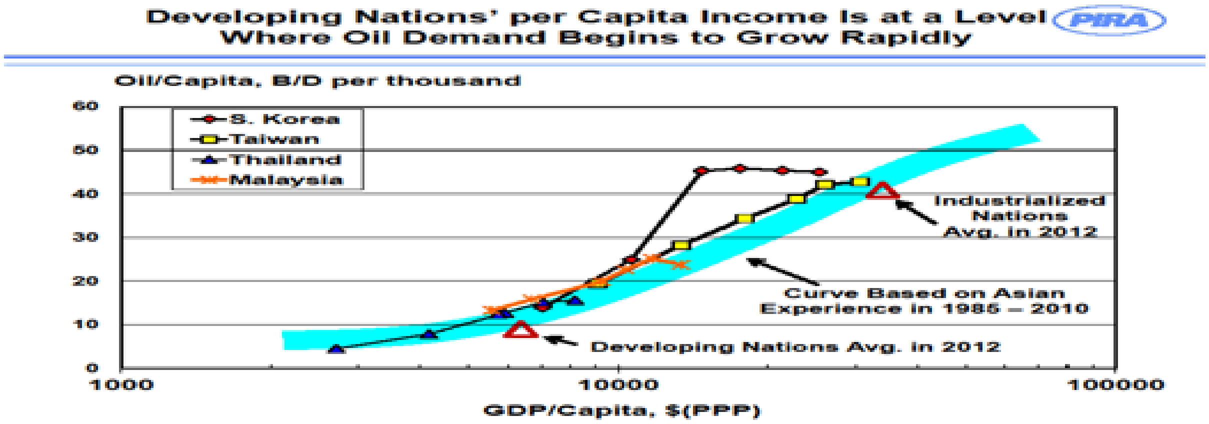
The GDPs of emerging markets account for a larger part of the global GDP as displayed in Figure 1c. This growth is likely to affect the changing aspects between crude oil prices, emerging stock market prices and exchange rates. These figures illustrate the increasing importance of the emerging markets in world growth.

As crude oil prices are priced in US dollars some studies found that exchange rate movements affect oil prices (Basher, Haug and Sadorsky, 2011: 230). However, Amano and Van Norden (1997:306) suggested that movements in the exchange rate have no effect on the price of oil. They stated that in the long run the price of oil is weakly exogenous and that the real exchange rate adjusts to the price of oil and not vice versa (Amano and Van Norden. 1997:306).

The main objective of this study is to establish whether there is a relationship between the crude oil price and the value of the South African rand. The empirical evidence suggests that the prices on the emerging stock markets respond negatively to an increase in the oil prices. If the oil price increases, the currency depreciates. This research will be able to establish if South Africa follows the same trend, in relative terms, as other emerging and developing markets, i.e. China, India and Brazil, or other small open economies such as Turkey or the Dominican Republic.

[1]. Figure 1b is the researcher's own interpretation of the data obtained from the BP statistical review of world energy dated June 2015; the developed economies include the United Kingdom, United States, Canada, and Australia.

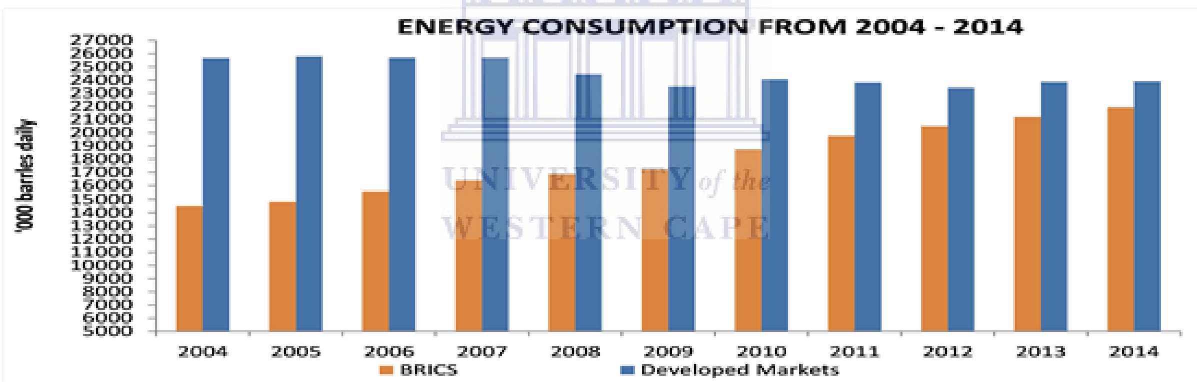
Figure 1a:



Source : PIRA Nov 13 Monthly World Oil Report

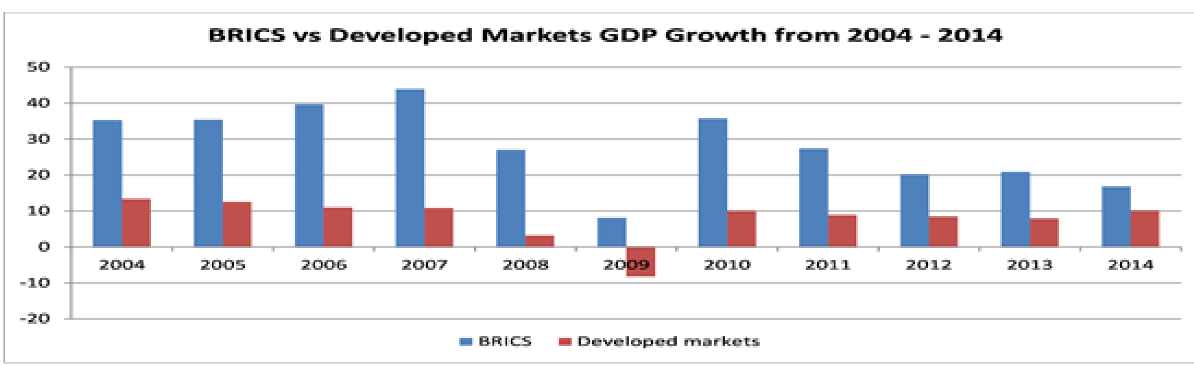
http://www.pira.com/

Figure 1b:



Source: BP Statistical Review of World Energy Jun2016

Figure 1c:



Source: IMF GDPGROWTH_APRIL 2016

1.1. Research problem

According to Roubini and Setser (2004:1), oil price shocks could slow down the rate of growth in an oil-importing country and could even have recessionary implications. The risk appetite of investors would reduce and foreign direct investment would be decreased. This would impact on the future economic vision of South Africa, specifically the New Growth Path (NGP), which promotes, amongst other things, employment and economic growth in South Africa (*National Development Plan: Vision 2030.* 2011:1010).

A number of studies have investigated the oil price shocks in developed economies, but only a few have investigated the impact of oil price shocks in the developing economies. Of the BRICS (Brazil, Russia, Indian, China and South Africa) developing economies, most of the emphasis has fallen on the Chinese, Indian, Brazilian and Russian economies with regard to economic growth and impact on the exchange rate. In the case of South Africa, most of the studies that have examined the impact of crude oil prices have focused more on the pass-through effect. Two studies evaluated the impact of crude oil price shocks on the South African rand. This study will therefore either confirm or refute the findings of Turhan, Hacihasanoglu and Soytas (2012) and Kin and Courage (2014). This study differs from the two studies in the frequency of data used, the time period applied as well as the models that are applied.

Oil price increases generate a current account deficit for oil-importing countries like South Africa. This means that the volatility in the price of oil will have an adverse effect on the terms of trade. The long-run expectation is that the oil-importing countries will experience depreciation of the domestic currency (Basher, Haug and Sadorsky, 2011: 237). This depreciation in the domestic currency will affect the stock prices of emerging stock markets mainly as a result of the risk appetite of investors being hampered. If the risk appetite of investors is hampered, they could reduce their investment in South Africa.

The problem that this research aims to investigate is the dynamic relationship between oil price movements and the movements in the exchange rate in South Africa.

1.2. Research question and hypothesis

This research will investigate the dynamic interaction between the changes in the price of crude oil relative to the changes in the Rand. Is there a correlation between crude oil prices and the value of the South African rand? It will also evaluate the impact of changes in the price of crude oil on the South African Rand, the manufacturing production index and the prime rate. The main hypothesis of this study is therefore to establish whether there is a relationship between the crude oil prices and the value of the South African Rand and how it impacts the value of the South African Rand.

1.3. Objective of the study

The main objective of this study is to establish whether there is a relationship between the changing crude oil prices and the value of the South African rand. The empirical evidence suggests that prices on the emerging stock markets respond negatively to any increase in oil prices, i.e. if the oil price increases, the currency depreciates. This research will be able to establish if South Africa follows the same trend, in relative terms, as other emerging and developing markets, i.e. China, Russia, Turkey and the Dominican Republic.

1.4. Significance of the study

The rationale of this study is to examine the impact of crude oil price movement on the South African rand. Changes in crude oil prices occur from a supply and demand perspective, but they are also influenced by geopolitical factors. For this reason, it would be of interest to evaluate how these movements impact on the South African exchange and thereby the South African economy.

1.5. Ethical statement

The research will strictly work in accordance with ethical research standards and the legal obligations of the South African economy. Ethical good practices of social science research will be adopted. This research will make use of official published data and therefore there is no possibility that any ethical standards will be compromised.

1.6. Study outline

This mini-thesis consists of six chapters. Chapter 1 provides an introduction to the study and the rationale for the study. Chapter 2 is a literature review on the effect of oil prices shocks, taking into account the macroeconomic impact of an oil price shock on the exchange rate as well as on the economy as a whole. Chapter 3 describes the South African economy and the factors affecting the South African rand. It also outlines factors affecting crude oil prices. Chapter 4 explains the methodology applied. Chapter 5 will describe the main results derived from the empirical findings. Chapter 6 draw some conclusions based on the findings of the study.

CHAPTER 2

Literature Review

The objective of this chapter is to review the literature on the influence of crude oil price shocks on industrialised and emerging markets, with an emphasis on the macro-economic factors that are affected by these movements.

The literature on the effect of crude oil price shocks on the exchange rates in industrialised countries is extensive. As a result, numerous studies have covered the effects of the volatility of crude oil price movements in both oil-exporting and oil-importing countries. But fewer studies have focused on evaluating the effects of crude oil price shocks in the crude oil-importing emerging markets. For this reason, this research intends to review the literature on the structural relationship between the exchange rates of various developed and developing countries and the crude oil price shocks. Jin (2008:98) stated that while the effect of crude oil price increases is good news for crude oil-exporting countries, it does not bode well for the crude oil-importing countries. They assume that likewise when there is a decline in crude oil prices, the opposite impact could apply.

Empirical evidence indicates that currently emerging economies are consuming an increasing share of the world's crude oil production and have therefore become larger players in the global financial markets. In line with this view, Basher and Sadorsky (2006:224-227) state that as countries modernise and urbanise, their demand for crude oil and its related products tends to rise. Furthermore, they emphasise that the rising economic importance of emerging economies has the potential to surpass the global crude oil consumption of developed economies. As a result, this is one of the major factors that influence the price at which crude oil is traded, as illustrated in figure 1b. However, Lechtaler and Leinert (2012:21) also studied the impact of crude oil price increases due to demand increase in the emerging markets and found that the demand for crude oil did not contribute in a major way to the increase of crude oil production. Lechtaler and Leinert conducted their study from February 2003 to February 2010, whereas Basher et al. conducted their study from December 1992 to October 2005.

It is important to note that the use of crude oil for energy consumption and the use of crude oil on the stock or financial markets are all linked on the path of a country's economic growth (Basher and Sadorsky, 2006:224-227). Furthermore, it should be noted that the time period of a study could provide different results and therefore different conclusions could be arrived at by the various researchers.

2.1 Macroeconomic effects of crude oil price increase

The movement of crude oil prices is affected by various factors such as supply and demand, as well as political, geopolitical, seasonal, real and speculative perceptions. As emphasised by Basher and Sadorsky (2006), crude oil is an essential commodity to most economies. Crude oil is a raw material for many secondary and final commodities such as petroleum products, cosmetics, detergents, plastics, paints, etc. Crude oil can also be used to generate electricity and heat, as well as to power machinery and automobiles. It is homogenous and internationally traded. The movement in the price of crude is tracked daily and it has both a direct and an indirect impact on the global economy, as it is an input into the production of goods and services in an economy. Given that both fuel and electricity are products that are derived from crude oil, an increase in the price of crude oil can lead to higher fuel and electricity prices, which pushes the cost of production higher. As South Africa is a relatively small but open economy with a floating exchange rate, these exogenous shocks could have a negative effect on the South African rand. However, according to Eberhard (2011:1), South Africa derives most of its electricity from coal production and not crude oil refining, so the effect of a crude oil price shock might not be negative on the currency.

Crude oil price shocks have been analysed in different ways. Hamilton (2008:1) explored three different ways of understanding the changes in crude oil prices. He analysed the basic correlation of historical data; he also examined the economic theory of how crude oil should react over time and tried to ascertain the fundamental determinants of supply and demand of crude oil. He concludes that changes in crude oil prices are likely to be unpredictable. From an investor's perspective, if crude oil prices could be predicted reliably, investors or traders would enter into future contracts that would always be beneficial for the firm and possibly lead to job creation and economic growth (Hamilton, 2008:1, 4, 6-8).

Basher, Haug and Sadorsky (2011:227) stated that crude oil demand in emerging markets will outweigh crude oil demand from developed markets in the future. GDP in emerging markets have accounted for a larger part of the global GDP. This growth is likely to influence the dynamics between crude oil prices and exchange rates.

In addition Driesprong, Jacobson and Maat (2004:5) are of the view that what makes crude oil price fluctuations interesting is that they are an important macro-economic variable in the world economy. This has a direct impact on local and international consumption and can act as a catalyst to the stock traders. The changes in the price of crude oil therefore have a direct effect on the growth of an economy. These movements might even affect international stability.

Roubini and Setser (2004:2) allude to the fact that a crude oil price shock can have a stagflationary outcome on the macro economy of a country that imports crude oil. Like Hamilton, Amano and van Norden, Roubini claimed that crude oil price shocks have been a contributing factor to each of the US and global recessions for the past thirty years.

In conclusion, as crude oil is considered to be one of the most basic universal commodities in modern economies, the impact on both the local and global economy could be significant. Hamilton suggests that crude oil price movements could be unpredictable and can therefore affect different economies differently, depending on various local as well as global factors affecting the relevant economy.

2.1.1. Crude Oil Price and economic growth

Blanchard and Gali (2007:3) investigate why the macro-economic influences during the 1970s were so unlike those of the 2000s. They state that during the 1970s macro-economists viewed crude oil price shocks as an important cause of economic fluctuations. However, during the 1990s the world experienced two crude oil price surges, yet the growth in inflation and GDP in the developed world has remained relatively stable. According to De Gregorio, Landerretche and Nielson (2007:158), globalisation and increased competition worldwide could be considered another reason why the pass-through effects of crude oil price changes have been reduced. This could have limited the ability of producers to pass their higher costs on to consumers.

James Hamilton (2003:363, 365, 377, and 394) referred to a crude oil price shock as an increase in the net price of crude oil. He stated that the net crude oil price surge is the relative amount by which crude oil prices in the current quarter exceed those of the previous four quarters. A crude oil price rise is more important to predict GDP growth in an economy than what an oil price fall is. He emphasised that a crude oil price increase on the demand side, given the Keynesian assumption of rigid wages, would lead to higher overall price levels and thereby reduce employment. Hamilton (2003: 365) stated that the economic analyses demonstrate the linear association between the log of crude oil price and the log of GDP.

Yet the study by Jin (2008:98) asserted that critical factors which discourage economic growth are sharp crude oil price increases coupled with intense fluctuating movements in the exchange rate. He found that crude oil price surges had different impacts on the economic growth of China, Japan and Russia from 1999 to 2007. In China and Japan, which are both crude oil-importing countries, a crude oil price rise had a negative effect on economic growth, whereas in Russia, which is a crude oil-exporting country, it had a positive impact on economic growth.

A few studies have been conducted on the impact of crude oil price shocks in South Africa. In particular, Hollander (2012:1) investigated the macro-economic impact of crude oil price shocks in South Africa. Hollander's (2012:2) focus was on the supply side of the related crude oil price increases. His study is based on the work done by Bruno and Sachs (1985). He analysed the impact of crude oil price shocks on inflation and output, closely examining the role of monetary and wage setting policies when crude oil prices increased. His study also highlighted the dynamic interaction between real wages, employment and the aggregate mark-up. Hollander claimed that these variables were found to be a core part of the fluctuations in the South African business context. Similar to Blanchard and Gali, Hollander concluded that increases in the price of crude oil had a significantly lower impact on the economy of South Africa over the past forty years. Hollander (2012:3) claims that it would be realistic to assume that economic developments in the South African market do not meaningfully affect the price of global crude oil. Therefore, unexpected nominal crude oil price movements are identified as exogenous to the South African market.

Several authors studied the effect of crude oil price movements on the economic growth of an economy and all arrived at different conclusions. Similar to the impact of crude oil price movements on the macro-economic state of an economy, so does the impact vary on economic growth depending on the type of economy that is being investigated.

2.1.2. Crude oil price and inflation

Crude oil price increases could affect inflation through various macroeconomic policies. Various studies have investigated the effects and found that the pass-through outcome of oil price escalations on inflation have reduced over the years.

De Gregorio et al. (2007:157) emphasised that current macro-economic models demonstrated how inflation shocks are related to the complete cost structures in an economy. The effects of crude oil shocks on inflation should differ according to the anticipated persistence of the shock. Hence one could argue that the pass-through effect of the recent crude oil price shocks (such as those of 1990 and 1999) was lower than the 1970s and 1980s, as the expectation was that the shocks were only temporary rather than the long-lasting hikes that they turned out to be. They also found that for the last thirty years the pass-through effect of crude oil price increases on inflation has decreased worldwide and not only in the United States.

De Gregorio et al. (2007:155, 157) further asserted that the recent crude oil price shocks have had mild effects on the global economy. They argued that the modern view of economic authorities is to have stricter monetary policies. They claimed that strict control of inflation targeting would lead to reduced crude oil pass-through effects. This would either be through the direct compensatory effects of interest rates or through the increased credibility of monetary policies.

The study by De Gregorio et al. (2007:160) looked at the impact of crude oil price shocks and inflation on a quarterly basis from 1973 to 2006 in both industrial and emerging economies. They found that in the industrialised economies the inflation rates reduced materially from the mid-1970s to 1980. Inflation increased in the 1980s and thereafter continued to fall, until it finally stabilised at a rate of 2% per annum. On the other hand, in the emerging economies the inflation rates were similar to those of the industrialised economies in the early and mid-1970s. Thereafter they continued to increase steadily in the 1980s and 1990s, after which they began to fall and hover around an inflation rate of 5% per year in the 2000s.

Blanchard and Gali (2007:63) mentioned that one factor that contributed to the mild effects on prices, wages, output and employment could be the increased credibility of the monetary policies adopted by the various governments. They also concluded that crude oil price escalations must have overlapped with other large escalations of a different nature at that point in time.

However, Hollander’s (2012:2, 6) findings from 1984Q1 to 2010Q1 concluded that oil price shocks led to higher inflation in South Africa. But the overall data are consistent with global developments. Hollander’s finding is also similar to that of De Gregorio et al. (2007) and Blanchard and Gali (2007) in that crude oil price escalation have had a lower impact on the business cycles of an economy. This is with regards to real wage rigidity, credible monetary policy and shares in oil consumption and oil production.

Nkomo (2006:29) stated that, given South Africa is an oil-dependent economy; it is exposed to the increased input prices and has to manage the imported inflation. He further claimed that when crude oil prices increase, it partly accounts for the escalation in domestic inflation and will impact on the South African rand.

2.1.3. Crude oil price and exchange rates

According to Basher, Haug and Sadorsky (2011: 230), crude oil prices are US dollar-based and some studies found that exchange rate movements are affected by crude oil prices. However, Amano and Van Norden (1997:313) suggested that movement in exchange rates has no effect on the crude oil price. They stated that the crude oil price is weakly exogenous and the real exchange rate alters in relation to the crude oil price and not the other way around.

Yet De Gregorio et al. (2007:155, 156, 158) found that the crude oil price shocks were accompanied by an appreciation of currencies as well as improved macro-economic policies in most countries. They stated that if the exchange rate flexibility in crude oil-importing countries is increased, then the volatility of crude oil price inflation, in terms of the domestic currency, should be increased. A flexible exchange rate may help to cushion the external shocks without their having a big domestic impact. Similarly, the study by Turhan, Hacihasanoglu and Soytas (2012:3) which examined the dynamic link between crude oil prices and the exchange rates of 13 emerging markets, including South Africa concluded that as oil prices increased, the emerging market exchange rates appreciated.

The study done in the US by Amano and van Norden (1997:313) examined the real versus the monetary shocks on the exchange rate movements. They found that there is a link between the effective exchange rate and crude oil price shocks. They also suggested that the implications of crude oil prices may be one of the main causes of persistent real exchange rate fluctuations.

Amano and van Norden (1997:304) predominantly explained short-run exchange rate activities and established that there is co-integration between the crude oil prices and the real effective US exchange rate. They found that the US exchange rates and crude oil price trended together.

A study by Chen and Chen (2007:403) investigated the relationship between real oil prices and the real exchange rates for the G7 countries. They used monthly panel data from 1972 to 2005 and used different measures of oil prices such as Dubai oil prices, Brent oil prices and West Texas Intermediate oil prices. The nominal exchange rate per country was deflated by the specific consumer price index and the real oil price was converted to the domestic currency and then deflated by the domestic consumer price index. Chen and Chen concluded that there is a co-integrating relationship between real oil prices and real exchange rates; similar to what was found in the study done by Amano and van Norden.

In 2012 Doğan, Ustaoğlu and Demez conducted a study on the long-run relationship between real oil price and the real exchange rate for Turkey. Turkey is similar to South Africa in that it is a non-oil-exporting developing economy with a floating exchange rate regime. They evaluated real monthly data from February 2001 to July 2011. Doğan et al. concluded that despite the implementation of monetary policies and measures to stabilise the economy, the impact of an increase in the real price of oil still resulted in the Turkish currency being negatively affected during this period. They further stated that the fluctuations in the real price of oil and the real exchange rate are important factors for developing economies as the fluctuations in these variables place strong pressure on an economy and negatively affect foreign trade (Doğan, Ustaoğlu and Demez, 2012:1294).

2.1.3.1 *Real exchange rates and terms of trade*

Various studies have tried to demonstrate how the exchange rates relate to the commodity price in the South African context.

Coudert, Couharde and Mignon (2013) conducted an investigation on the link between the terms of trade and the real exchange from 1980 to 2012 for sixty-nine commodity-producing economies, including South Africa. They asserted that the association between the prices of commodities prices and the real exchange rates goes through the terms of trade, which are primarily driven by the prices of commodities in the commodity-exporting economies. Coudert et al. further point out that the impact of the terms of trade on the real exchange rate has been investigated since the 1980s. These investigations explored the possible adverse effect the terms of trade had on the natural resources of an economy, which usually resulted in an increase in a country's income with a concomitant decline in the manufacturing sector of the economy. This phenomenon became known as the "Dutch Disease"[2] (Coudert, Couharde and Mignon, 2013:5).

Coudert et al. also stated that the real exchange rate can be defined in both internal and external terms. Internally, the real exchange rate can refer to the relative price between two sectors. In external terms, the real exchange rate can refer to the relative price of the consumption basket between two countries, namely the home or local country and the foreign country. They further suggested that due to the concept of purchasing power parity, which is based on the law of one price, the real exchange appreciated when the price of the non-tradable goods increased relative to the price of tradable goods. These results referred to commodity-exporting countries with an appreciation of the real exchange rate (Coudert, Couharde and Mignon, 2013:5).

Coudert et al. found that the real exchange rates of pegged commodity currencies rest on the performance of the commodity it is pegged too. For instance, currencies that are pegged to the United States dollar were inclined to weaken with the dollar in the late 2000s. For oil-exporting

[2] "Dutch disease" occurs when there is an increase in the natural resources and a decline in the manufacturing sector of a country due to the inflow of foreign currencies impacting on the terms of trade and the real exchange rate of a commodity-exporting country (Treviño, 2011:3).

countries they found that the nature of an oil shock steered the fluctuation in the real exchange rate (Coudert, Couharde and Mignon, 2013:6).

Furthermore, Aron, Elbadawi and Kahn (1997) performed a study on the elements of the real effective exchange rate of South Africa using quarterly data from 1970 to 1995. They studied six factors that influenced the real exchange rate over the twenty-five-year period. They analysed the influence of capital flows, the terms of trade, trade policy, foreign exchange reserves government spending and per capita real GDP (Gross Domestic Product) growth relative to the Organisation for Economic Co-operation and Development (OECD). They found that from 1970 to 1981 the price of gold was included in the terms of trade and had a dominant role with regard to the real exchange rate. However, during the 1980s they found that the fall in the significance of gold resulted in the price of gold having a lesser impact on the real exchange of South Africa (Aron, Elbadawi and Kahn, 1997:12-14).

According to Montiel (2003), the real exchange rate plays an integral part in guiding the apportionment of production and consumption in the local economy between the goods produced abroad and the domestically produced goods. He further confirms that the real exchange rate is simply the relative price of foreign goods in terms of local goods. For this reason the emerging economies are often encouraged to conduct their affairs in such a way as to get this particular macro-economic relative price correct (Montiel, 2003:311, 312).

2.2. Analysis of the empirical evidence

Jin (2008:106-7) analysed the effect of the exchange rate and crude oil price movements with regard to the economic growth of China, Japan and Russia. This study investigated quarterly data from 1999Q1 to 2007Q4. Jin (2008:100) applied the VAR (vector autoregressive) model with co-integration techniques to test the long-run effect of how real GDP in China, Japan and Russia adapted to the changes in the crude oil prices as well as to the changes in the exchange rates. In Japan, an oil-importing economy, they found that as oil prices increased, there was a decrease in economic growth and an appreciation of the Japanese yen. In China, which is an oil-importing and oil-exporting country, a similar result was found in the short-run, i.e. a crude oil price increase led to an appreciation of the yuan and economic growth declined. However, in Russia, which is an oil-exporting economy, the Russian rouble appreciated as the crude oil price increased and economic growth increased in contrast to China and Japan.

Jin (2008: 100) also used a LA-VAR (lag augmented vector autoregressive) model to test if the real exchange rate and the crude oil price Granger cause the economic growth of China, Japan and Russia. He found that Granger causality does exist between the international crude oil price and the economic growth of all the countries. His results also indicated that Granger causality existed between the real exchange rate of Russia and Japan and their real GDP. He further claimed that his findings suggested that the international crude oil price and the real exchange rate played a key part in the forecasting of growth in the Russian, Japanese and Chinese economies from 1999 to 2007.

Rautava (2002:18) studied a similar topic to Jin's. He investigated how sensitive Russia's output and fiscal returns are to rise and fall in the price of crude oil and the Russian rouble. The study investigates quarterly data from 1995Q1 to 2001Q3. He also used VAR modelling and a co-integration framework to study the impact of these deviations on the GDP and fiscal revenues of the Russian economy. He concluded that the fluctuations in the price of crude oil and the real exchange rate impacted significantly on Russian output and fiscal revenues. His study, however, does not pursue the question of causality between the increase in crude oil price and the appreciation of the Russian rouble as this is more difficult to determine. Rautava's study quantified that in the long run a real appreciation of 10% of the Russian rouble is associated with a decrease of 2.4% in Russian GDP with a corresponding 10% increase in the crude oil prices, resulting in a 3% increase in federal government real revenues.

Akram (2002:28) investigated whether there is a non-linear link between the crude oil prices and the Norwegian exchange rate. The study investigated day-to-day observations from January 1986 to August 1998. He used figures and basic descriptive measures of daily crude oil prices and exchange rate observations. These results are formulated and tested within a multivariate framework. His study found that the strength of the negative correlation between the oil price and the exchange rate varied with the trend and the level in the price of oil. He claimed that an adjustment in the oil price has a stronger effect on the exchange rate when the oil price is below 14 USD per barrel. He also found that a non-linear relationship is only significant in the short run and that crude oil prices have no impact on the Norwegian exchange rate in the long run.

Dawson (2007:22) investigated the impact of a crude oil price increases on the Dominican peso. The study investigated monthly data from August 1991 to October 2002. The Dominican Republic is also a crude oil-importing country with a floating exchange rate like South Africa. Using a multivariate analysis similar to Akram (2002) and Rautava (2002), Dawson found that a 1% rise in the oil price led to a 2.9% depreciation of the Dominican peso. Through the co-integration analysis she found that the association between the exchange rates and the crude oil prices is more significant in the short run than in the long run. Her findings were similar to Akram's (2002) findings.

In the study by Amano and van Norden (1997:303) they used the Johansen and Juselius (JJ) approach to test for co-integration between the price of crude oil and the real US exchange rate. They claimed that regardless of which test statistic is used, the result is that co-integration is present between the real exchange rate and the real price of crude oil. Unlike Dawson and Akram, Amano and van Norden (1997:312) found that the long-run effects of crude oil price shocks are ambiguous. They also found that the US exchange rate appreciated when oil prices increased.

Nikbakht's (2009:90) study investigated the relation between crude oil prices and the exchange rates in seven OPEC countries. He also applied the JJ co-integration test, like Amano and van Norden, but his results were different. He found that the real oil prices are not co-integrated with the real exchange rates. When doing a panel co-integration test using the Pedroni test, he found that the real oil prices may be co-integrated with the real exchange rate. He further concluded that there is a long-run relationship between the price of crude oil and the real exchange rates, which differs from the studies done by Dawson and Akram. Nikbakht's study also claimed that exchange rate movements in these countries may have been triggered by the movements in the oil price. The study by Nikbakht differed from that of Amano and van Norden in the time period during which the tests were performed as well as the actual data used to do these tests. Nikbakht used monthly real oil prices and real exchange rates of seven OPEC countries from 2000M1 to 2007M12, whereas Amano and van Norden used the monthly real price of oil and real effective exchange rate from 1972M2 to 1993M1.

Huang and Guo (2007) studied the impact of oil price shocks, supply, demand and monetary shocks on the real exchange rate of China. They used monthly data from January 1990 to October 2005. They developed a four-dimensional structural vector autoregressive model (SVAR) to investigate the impact of the four shocks. They concluded real oil price shocks resulted in minor appreciation of the Chinese real exchange rate in the long run similar to Jin (2008). They also concluded that positive real supply shocks resulted in a depreciation of the Chinese real exchange rate, whereas positive real demand shocks resulted in appreciation of the Chinese real exchange rate. However, they stated that due to the tight capital control measures in place in China, the impact of monetary shocks was limited (Huang and Guo, 2007:414).

The study by Turhan, Hacihasanoglu and Soytas (2012:3) examined the dynamic link between crude oil prices and the exchange rates of 13 emerging markets, including South Africa. They used a daily data series and split the sample period into three different time frames before and after the financial crisis, covering daily prices from 3 January 2003 to 2 June 2010. They estimated three VAR models and report on the Granger causality test. They concluded that as oil prices increased, the emerging market currencies appreciated. They also found that increases in the price of oil have a stronger influence on the currencies of emerging markets after the financial crisis compared to before the financial crisis. In their findings only four countries' currencies depreciated from December 2008 to June 2010: Turkey, Argentina, Brazil and Russia. The remaining nine countries' currencies appreciated. Contrary to Turhan et al's study, Kin and Courage (2014) examined the impact of crude oil price on the exchange rate in South Africa on a monthly basis from 1994 to 2012. They conducted a Generalized Autoregressive Conditional Heteroscedasticity model (GARCH). They concluded as the oil prices increase the Rand depreciates. Dawson's study concurs with the study done by Kin and Courage of an oil-importing country where the currency depreciating as the crude oil price increase. It should also be noted that that the frequency of both Dawson and Kin et al studies' are similar, unlike the

Turhan et al. Turhan et al conducted a daily frequency and Dawson and Kin et al conducted monthly average frequency data

Crude oil price booms could discourage economic growth and the pass-through effect on inflation has reduced over the past thirty years. De Gregorio et al. (2007) and Blanchard and Gali (2007) concluded that this effect could be due to the stricter monetary policies. De Gregorio et al. (2007) found that the crude oil price shocks are accompanied by an appreciation of the exchange rates as well as improved macroeconomic policies in most countries.

From another perspective, Anoruo (2011:89) studied the relationship between the United States stock market revenues and the movement in crude oil prices from January 1974 to December 2009. He tested for linear and non-linear causal relationships between these two variables. He used the Bai and Perron multiple structural break tests and various unit root tests and to assess the stability of stock market revenues and the movement in crude oil prices. He concluded that stock market revenues and the changes in crude oil prices changes are stationary. He further confirmed that Bai and Perron tests revealed that stock market earnings and the movement in crude oil prices are structurally established or stable.

The studies of the various authors show different results depending, among other things, on the type of economy that was being examined. In a developed oil-importing country like Japan, a rise in the price of crude oil led to a fall in economic growth and an appreciation of the Japanese yen. China, on the other hand, is an emerging oil-importing and oil-exporting country and a similar result was found in the short run, i.e. a crude oil price increase also led to a strengthening of the yuan and a decline in economic growth.

However, Russia, an emerging oil-exporting country had a positive economic growth with an appreciating exchange rate. The Dominican Republic is also an oil-importing economy and the Dominican peso depreciated with an oil price increase. The study by Turhan et al. (2012) revealed that as oil prices increased, most of the emerging market exchange rates appreciated.

In summary, it is evident from the literature that the impacts of crude oil price movements are unpredictable (Hamilton, 2008). The increase in the price of crude oil can have a stagflationary influence on the local and global economy, and these escalations acted as a catalyst for the worst US and global recession for the past thirty years (Roubini and Setser, 2004:2). Different empirical results are found in different economies dependent on the frequency and time period of the relevant studies.

CHAPTER 3

The South African context

The objective of this chapter is to inform the reader of the South African history of the exchange rate regime employed in the economy. The factors influencing the exchange rate and the factors driving the volatility of crude prices will also be discussed in this chapter.

3.1. History of the South African exchange market

From the onset of the Second World War South Africa has had exchange control measures introduced as part of the Emergency Finance Regulations of the United Kingdom and Sterling Area Members. The objective was to ensure the free flow of funds between these countries, but to avert hard currencies from flowing out of the sterling Area. The sterling area exchange controls were step by step removed after the war (Eun, Kilic and Lai, 2012:6).

On 21 March 1960 there were mass demonstrations against the apartheid pass laws in a township called Sharpeville, Gauteng, South Africa during which several people were killed. This event became known as the Sharpeville massacre. After this massacre there was a mass outflow of capital from South Africa. This outflow of capital resulted in stricter exchange controls measures being introduced. From the 1960s to the 1980s the US imposed several economic and other sanctions against South Africa (Treverton and Varle, 1992:2, 3).

In order to manage the flows of capital and investment, the South African government operated with a dual exchange rate from 1985 to 1995. The one was a commercial exchange rate and the other was a financial exchange rate. Both rates were floating exchange rates. The financial exchange rate prescribed to the capital account transactions whereas the commercial exchange rate prescribed to the international trade and other current account transactions, (Eun, Kilic and Lai, 2012:3, 10).

The intention of the financial rand was to remove the direct connection between the local interest rate and foreign interest rates. This was to protect the capital account from certain types of variations and capital flows. Any capital outflow by the non-residents had to be tied back by an inflow of capital. This was achieved through flows in the financial rand rate (Aron, Elbadawi and Kahn, 1997:3). The rationale of a dual exchange rate was to separate foreign trade from exchange rate oscillations as well as to manage the official reserves from adjustments in the capital flows (Eun, Kilic and Lai, 2012:13).

The dual exchange rate regime was terminated in March 1995 (Eun, Kilic and Lai, 2012:12). Eun et al. (2012) concluded that, as in other countries which operated with a dual exchange rate regime, the dual exchange rate regime was highly successful in South Africa. Due to its strict control of all assets, there was no convergence of the financial rate and the commercial rate and therefore limited cross-rate arbitrage activities. Eun et al. (2012) also found no evidence of co-integration between the two exchange rates, implying that the financial rate could move away from the commercial rate without mean reverting.

Further tests done after the termination of the dual exchange rate proved that the capital account became volatile. This implies that with the dual exchange rate regime capital was more stabilised which led to greater capital flows during the period of economic and political turbulence in South Africa (Eun, Kilic and Lai, 2012:19).

Aron, Elbadawi and Kahn (1997) conducted a study on the contributing factors of the real effective exchange rate of South Africa using quarterly data from 1970 to 1995. They stated that during this period South Africa was faced with significant political and economic shocks which complicated the management of the exchange rate (1997:2). They also mentioned that from 1979 to 1988 some evidence suggests that intervention in the exchange rate was aimed at sustaining stability and profitability in the gold mining industry (1997:3). This was done by levelling the real rand price of gold. Aron et al. (1997) further stated that it would appear that from 1988 the Reserve Bank was more effective in stabilising the real effective exchange rate. This intervention was mainly done to avert excessive escalation of the real exchange rate at times when the nominal exchange tended to appreciate. This was done to protect the international competitiveness of the South African manufacturing exports and therefore the balance of payments. The result has been that the real exchange rate was far more stable on a trade-weighted basis. Aron et al. (1997:4) note that the South African Reserve Bank currently intervenes in the exchange rate movements only in order to iron out excessive fluctuations in order to maintain financial stability.

3.2. Factors influencing the South African rand

There are several factors that affect the exchange rate of an oil-importing economy such as South Africa. It is an open economy and the real exchange rate is a key factor in the functioning of this economy. Chen and Chen (2007:390) assert that it is a recognised fact that the fluctuations in the real exchange rate can be associated with to non-monetary shocks. These could be political, economic, social, technological, environmental and legal.

An oil price shock will increase prices in trading partner countries, thereby increasing local import prices (Wakeford, 2006:98). As South Africa operates as an open economy and is an emerging market, the main economic variables that are expected to impact on the South African rand would be monetary or foreign economic assumptions. Factors such as global monetary policies changes, oscillations in the foreign exchange rates of South Africa's main trading partners such as the European euro, US dollar, Japanese yen, Chinese yuan and British pound in particular, and foreign growth rates would impact on the South African rand.

The balance of payments and therefore the current account balance would have a major impact on the exchange rate. If the current account balance is in deficit, the local exports balance could be low and the import balance would be too big, which would result in fluctuations in the exchange rate. The inflation differential between the US consumer price index and the South African consumer price index also plays a big role in setting the exchange rate. If the South African inflation is too high, it will lead to constraints in the competitiveness of South African exports or produce, which leads to depreciation of the exchange rate. It is also crucial that the South African Reserve Bank ensures that it has sufficient reserves in order to defend the nominal exchange rate against big changes as a result of speculative attacks (Aron et al., 1997:26). Turhan et al. (2012:4) stated that through a movement in the balance of payments, a movement in the domestic exchange rate is expected too. To control inflation, foreign monetary authorities may increase interest rates, bringing about a decrease in consumption, investment and economic growth. The outcome would be that the demand for many export commodities would be reduced. (Wakeford, 2006:98).

Figure 2 below depicts clearly how the fluctuations in the exchange rate were controlled with the dual exchange rate system in nominal South African rand terms. It also displays the volatility in the exchange rates when the dual exchange rate was abolished and South Africa became an open economy.

Figure 2:

Nominal SA Rand First Difference Movement from 1980M1 to 2014M12

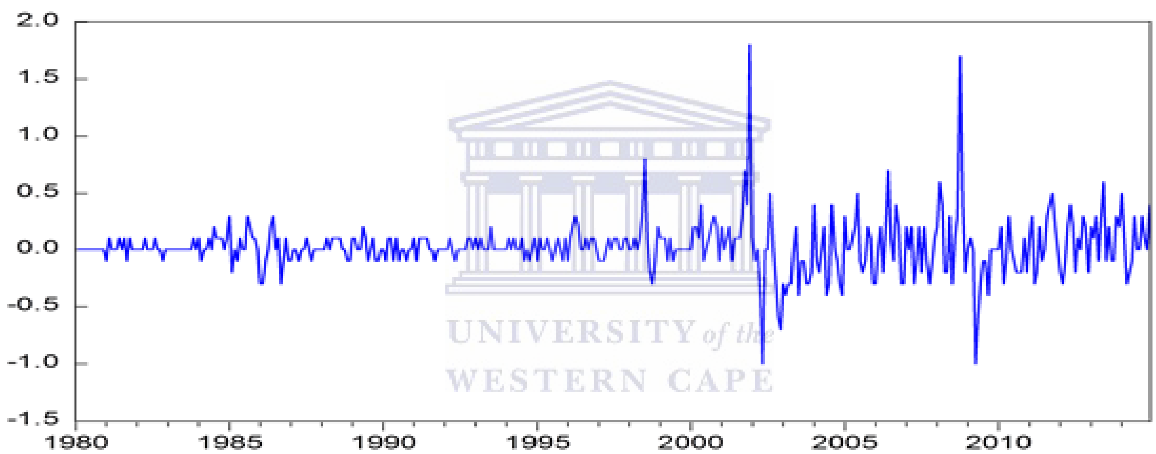
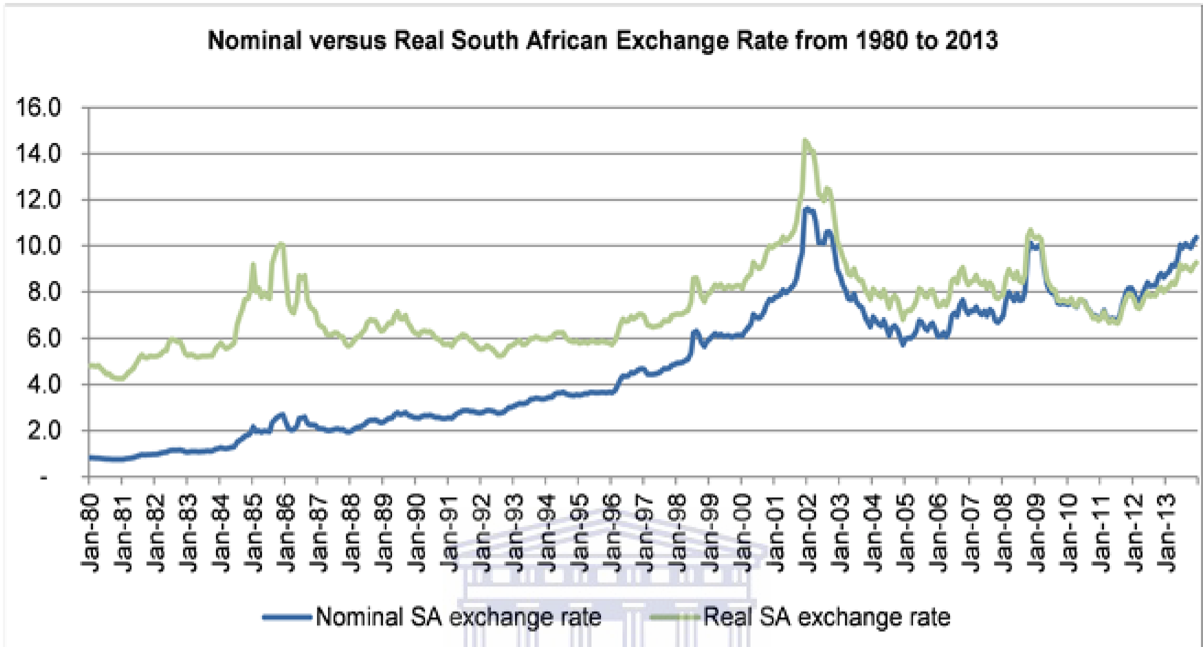


Figure 3 depicts the simultaneous progression of the nominal and the real South African rand in 2010 base year terms from 1980 to 2014. When analysing this figure it can be seen that in nominal terms the South African rand depreciated gradually during the apartheid years. On the other hand during the post-apartheid year, the South African nominal exchange rates are more exposed to the severe global shocks. However, in real terms it can be observed that the South African rand depreciated substantially when the infamous Rubicon Speech was made by the then President of South Africa, P. W. Botha, on 15 August 1985. During this speech Mr Botha was expected to raise confidence among the international community by ensuring that the uprising in the townships was being kept under control. But the opposite was achieved and the real South African rand depreciated by approximately 20% (Giliomee, 2008:2). Then in September 1986 the real South African rand appreciated by 12% when South Africa was asked by the United Nations to withdraw from Namibia (United Nations General Assembly, 1986-09-20).

Figure 3:



Knedlik (2006:9) discussed on the crisis of the South African rand from 1996 to 2001. In this paper, he pointed out that after the first democratic election of South Africa in 1994; the country was faced with a huge capital inflow. During 1996 the currency depreciated by approximately 15% in real terms from February to April 1996. This was due to the monetary expansion policies followed by the South African Reserve Bank (SARB), which led to concerns about increasing public debt, an increasing current account deficit and rising inflation. The South African Reserve Bank intervened in the spot as well as the forward currency markets, which stabilised the depreciation.

From March to August 1998 the real South African rand weakened by approximately 21% due to the debt default in Russia and the financial crisis in Asia, which impacted on the emerging market currencies. Bhundia and Ricci (2005) stated that the South African short-term interest rates and long-term bond yields increased by 700 basis points. During the 1998 currency crisis the SARB intervened in the forward markets by borrowing South African rands and converting them to United States dollars. The SARB then used the United States dollars to buy United States assets, but this still led to further depreciation of the rand. During the 1996 and 1998

SARB interventions, they managed to build up a large net open forward position. However, during the 1998 currency crisis the SARB decided to reduce the net open forward position, which helped to strengthen the currency. As South Africa is a commodity-export country, Bhundia and Ricci (2005) also suggested that the South African rand could have depreciated due to downward pressure on the commodity prices. This impacted on commodity exports and therefore depreciated the South African currency (Bhundia and Ricci , 2005:156, 162-3).

From June to December 2001 the real South African rand depreciated by approximately 37%. During this period both the long-term bond yields and the short-term interest rates remained relatively stable, unlike during the currency crisis of 1998. In 2001 the SARB did not intervene either. At this time the then President of South Africa, Thabo Mbeki, commissioned an investigation into the currency depreciation. It was chaired by Senior Councillor John Myburgh and became known as the Myburgh Commission of Inquiry. Bhundia and Ricci assert that the announcement made by the SARB on 14 October 2001 could have been a cause of the sharp depreciation of the rand. SARB announce that it would tighten exchange controls. Many observers disagreed with his assertion. Bhundia and Ricci further asserted that the commodity downturn in 2000 could also have been a cause of the depreciation of the South African rand. However, Bhundia and Ricci states that Clarida and Gali (1994) and Bhundia and Gottschalk (2003) used exchange rate models and found empirically that nominal shocks were the driving force for both the 1998 and 2001 depreciation of the rand (Bhundia and Ricci, 2005:163,166).

The following sharp depreciation of the real South African rand took place from September to November 2008. The South African currency depreciated by approximately 25%, which was mainly due to the global financial crisis.

In summary, there are several global factors that affect the South African rand. As empirically proven by Clarida and Gali (1994) and Bhundia and Gottschalk (2003), the South African rand is mainly driven by nominal shocks which have no long-run impact on the equilibrium of the South African economy (Bhundia and Ricci, 2005:166).

CHAPTER 4

Research methodology

4.1. Introduction

According to Roubini and Setser (2004:1), shocks in oil prices could result in the rate of economic growth in an oil-importing country to slow down and could even have recessionary implications. The risk appetite of investors would be reduced and foreign direct investment would be minimised. These would impact on the future economic vision of South Africa, specifically the New Growth Path (NGP) which promotes, amongst other things, employment and economic growth in South Africa (NGP, 2011:1010). Hollander (2012:3) states that it would be realistic to assume that economic developments in the South African market do not meaningfully affect the price of global crude oil. Therefore, unexpected nominal crude oil price movements are identified as exogenous to the South African market.

This chapter is structured as follows. It will firstly elaborate on the research problem, followed by a discussion of the choice of variables that will be utilised. The econometric model that will be used is the vector autoregressive (VAR) model. Various tests will be conducted, such as the Bai and Perron test, which examines for structural breaks, the Augmented Dickey Fuller (ADF) and Phillip-Perron (PP) unit root test, which investigate whether the variables are stationary or not, and the Johansen test, which is used to examine whether co-integration exists between the variables. If it is found that the variables co-integrate, then the vector error correction (VECM) model will be the concluding test.

It is argued that the unit root tests such as PP or ADF tests could be inclined not to reject the null hypothesis of a unit root, even if there is a permanent change in the data (Perron, 1989:1361). For this reason, before stationarity of the time series is considered, some structural break tests are implemented. This is done by using the Bai and Perron test, which is utilized to examine for structural breaks when analysing time series data. With the Bai and Perron test, the null hypothesis is that no structural breaks exist. However, the alternative hypothesis of the Bai and Perron test is that a number of unknown structural breaks exist (Bai and Perron, 2003:75). As this is a large series of data, it is recommended to check for structural breaks first. The Johansen co-integration test will test if the Brent oil price and the South African rand are co-integrated and if they have a long run association. If the two variables are not co-integrated, then an unrestricted VAR model will be applied. If they are co-integrated the VECM will be used.

4.2. Research problem

This study will investigate the hypothesis if a correlation exists between the real oil prices and real South African rand, according Roubini and Setser' assertion above. With reference to the studies done by Coudert et al. (2013) and Aron et al. (1997), it will test the effect of the real exchange rates on the terms of trade. However, this study will only test the effect of oil price movements on the real exchange rate and not the impact of other tradable commodities on the real exchange rate. The other tradable commodities that could be studied are import and export commodities such as coal, iron ore, steel and others.

4.3. Model

Various empirical statistical models can be applied in this research as it will make use of time series data. The most common methodology applied in much of the literature reviewed such as Rautava (2002), Jin (2008) and Turhan et al. (2012) – was the vector autoregressive (VAR) methodology.

4.3.1. Introduction to VAR methodology

The VAR methodology looks comparable to a simultaneous equation model because a number of endogenous variables are studied together. Each endogenous variable is analysed by either its past or lagged values. It can also be analysed by the lagged values of all the other endogenous variables in the model. There are usually no exogenous variables in the model (Gujurati, 2003:837).

The VAR methodology is one of the most common estimation techniques used in econometrics. The reason for this is that it provides a clearer identification of the relationship of various economic variables (De Gregorio et al., 2007:175). The advantage of adopting a vector autoregressive approach is that all the variables would be treated as endogenous. The researcher would not need to give past assumptions of explanatory and response variables. It also implies that each variable depends upon the lagged values of all the variables in the system. There should not be any theoretical difference between an endogenous and an exogenous variable. Sims therefore developed the VAR model as a different model to the conventional large-scale macro-econometric model (Kilian, 2011:1).

4.3.2. Different types of VAR models

The VAR methodology was applied in different forms by various authors.

4.3.2.1 Rolling VAR

De Gregorio et al. (2007:175) made use of the rolling VAR methodology as it encompasses a clearer identification of the relations of different economic variables. The benefit of the rolling VAR methodology, according to Gregorio et al., is that it is allows an unregulated manner of analysing variable changes and fluctuations over time. However, the disadvantage of this methodology is that the model requires more data and higher frequency to account for lags.

4.3.2.2. Lag-Augmented VAR

Jin (2008:100), on the other hand, utilised the lag-augmented (LA) VAR to check if the oil price and the real exchange rate Granger cause to the economic growth of Japan, China and Russia. The LA VAR has an artificially augmented lag in its regression and because of this it usually shows a fairly weak power of the test. This makes the regression inefficient even if the empirical size of the test is satisfactory (Chigira and Yamamoto, 2003:1-2).

4.3.2.3. Bivariate and other VARs

Turhan et al. (2012:16) made use of a bivariate VAR model in order to examine the effect of oil price movements in the exchange rates of thirteen emerging markets.

Huang and Guo (2007), Bjørnland (2008), Killian (2011) and Basher et al. (2012) all made use of the structural vector autoregressive models (SVAR). According to Gottschalk (2001:1), the structural vector autoregressive model (SVAR) is a common tool to analyse the monetary transmission mechanism and real business cycle fluctuations.

In another study Rautava (2002:10) made use of the VAR model and a co-integration framework to study the influence of oil price and real exchange rate movements on GDP and fiscal revenues.

4.3.2.4. Granger causality and direction of influence

Both Henriques et al. (2008:1006) and Jin (2008:100) made use of the LA-VAR technique when they evaluated the Granger causality test. They stated that the LA-VAR technique avoided the prior test of integration or co-integration. On the other hand, Amano and van Norden (1997:307) used the vector error correction model when they evaluated the Granger causality test. Turhan et al. (2012: 17) made use of the VAR approach to report the Granger causality result.

The presence of a link between variables does not automatically prove causality or the direction of influence. Gujurati (2003) affirmed that in time series regressions the circumstances may be somewhat different in that happenings in the past can cause events to occur today, but events in the future cannot predict events in the past. (Gujurati, 2003:696)

Amano and van Norden (1997:305) stated that understanding the apparent causal association between oil prices and the US exchange rate is thought-provoking both for economic and econometric reasons. From an economic perspective, they stated that causality might explain the long-run connection between oil prices and the US exchange rate. They found that Granger causality flows from crude oil prices to the exchange rate and not vice versa. From an econometric perspective they stated that Granger causality has essential consequences for inference and for assessing the accuracy of conditional forecasts.

In summary, after investigating all the possible types of VARs, the researcher will make use of the general VAR methodology, similar to Rautava (2002), in order to test the hypothesis whether there is a correlation between the real oil prices and the value of the real South African rand.

4.4. Choice of variables

This study investigates the hypothesis of a dynamic relationship between oil price fluctuations and real exchange rate movements in South Africa.

This study will make use of the average monthly data from 1980M1 to 2014M12. The number of observations that are used would therefore be 420 data points. There are four variables used, namely the South African rand, the Brent oil prices, the manufacturing production index and the prime interest rate. The exchange rate and the Brent oil price data that are utilised are obtained on a daily basis, but a monthly average[3] is derived. For both the Brent crude oil prices and the South African rand variables the daily closing prices are used to derive the monthly average price. The South African rand will be used in indirect terms, i.e. expressed as US dollars in local currency. The South African manufacturing production index and the prime interest rate are obtained on a monthly basis. Both the South African and the US consumer price indexes are obtained on a monthly basis. The US consumer price index will be applied to deflate the Brent oil price and the South African consumer price index will be applied to deflate the South African rand and the South African manufacturing production index. The base period for both consumer price indices is 2010.

According to Montiel (2003:311), developing markets are encouraged to use real prices because of the important role of the exchange rate in allocating resources. Consistent with the study of Chen and Chen (2007), Basher et al. (2012) and Doğan et al. (2012), monthly variables in real terms will be applied. Other studies such as Rautava (2008) also applies the real variables, but on a quarterly basis. For these reasons and as discussed earlier, both the South African rand and the Brent crude oil price will be expressed in real terms.

Chinn (2005) states that when deciding on using the real exchange rate, the researcher needs to consider which measure is the most appropriate for the specific study with regards to the theoretically implied measure or the real-world counterpart. The researcher also needs to consider which measure is conceptually most appropriate or the one where the largest volumes of data are available.

[3] The five day daily rates are used for both the exchange rates and the Brent oil prices. These rates are then averaged over the sum of week days for the specific month.

The researcher will make use of secondary data. The data sources of the variables were acquired from the Bureau for Economic Research (BER), who obtained them from different institutions such as the South African Reserve Bank, the International Monetary Fund (IMF) and Thomas Reuters.

As South Africa is an emerging market, the researcher will make use of the real prices. For this reason there are several price deflators that can be used to convert the price from a nominal to a real value. The consumer prices index (CPI), the producer price index (PPI), the wholesale price index (WPI) and the export index can be used as deflators on a monthly basis.

Chinn explained that there are several drawbacks with each of these indices, but in a two country scenario the use of CPI as a deflator yields the correct measure of inter-country relative prices (Chinn, 2005:119-120). For this reason the study will utilise the CPI as the deflator to obtain the South African real exchange rate (explanation of formula in Appendix A). The Brent crude oil prices, the South African rand and the manufacturing production index will be expressed in real terms since the main aim is to study the effects of the former variables on the latter variable.

Brent crude is extracted from the North Sea and is used as the point of reference crude for South African petroleum products. As is expected in studies focusing on the effect of crude oil prices, this study does not use import prices as a whole but only FOB (Free On Board) crude oil prices. A similar method is followed by several studies, including Jiménez-Rodríguez and Sánchez (2004:11) and Chen and Chen (2007:393).

Brent crude oil is then defined in real terms by deflating with the United States consumer price index. This is done so that the Brent oil prices are expressed in US dollar terms. According to Jin (2008:100), this approach of evaluating oil prices has two key advantages. The first advantage is that the real crude oil prices denote a common shock globally and domestically. Secondly, if inflation is positive, then an exact shock to the nominal price would prompt a weakening response on real variables. Therefore converting the variables to real variables, will avoid undesirable effects.

4.5. Vector autoregressive model

The main hypothesis of this research is to establish if the real Brent oil price movement impacts on the movement of the real South African rand. The VAR will be applied to empirically test the relationship between the real oil price and the real exchange rate. As Henriques and Sadorsky (2008:1000) affirmed, the VAR model has an advantage where no prior assumptions regarding the distinction between the response variables and the explanatory variables needed to be provided by the researcher. It is assumed that all the variables are treated as endogenous and the lagged variables will be used.

The following vector autoregressive model of order p (or simply, VAR (p)) is applied where order of p refers to the number of lags:

$$\gamma_t = c + \sum_{i=1}^{\rho} \Phi_i \gamma_{t-1} + \mathcal{E}_t \qquad (2)$$

In equation 2 γ_t is the vector of response time series or endogenous variables at time t and where γ_t has 4 elements, namely Brent$_t$, which represents the real Brent crude oil price in US dollar terms; the real South African rand; the real South African manufacturing production index; and the real prime rate. Two of these vectors are in the first difference logarithmic forms, namely Brent oil and the manufacturing index; the rand exchange rate and prime rate are in real terms. The variable c is a vector of constant and $\mathcal{E}_t$ denotes the white noise error term, which is assumed to be independent. Φ_i is the i^{th} matrix of autoregressive coefficients where $i = 1,2,3,... \rho$. Φ_i are $n \times n$ matrices for each i.

There are several lag-length information criteria that can be utilised in order to decide on the ideal lag length for the VAR (p). Liew (2004:2) stated that if the sample size is relatively large, where the observations are greater than 120, then the Hannan-Quinn criterion (HQC) is the most accurate to return the true lag length. According to Gujurati (2003:538), following the principle of parsimony, the information criterion with the smallest value would be chosen as it offers a good fit to the data. As this study is conducting monthly observations from January 1980 to December 2014, the sample size will be relatively big with the number of observations being

420. For this reason this research will employ the Hannan-Quinn criterion (HQC) to determine the ideal lag length of "p" as it would give the most accurate to return the true lag length.

4.6. Structural breaks

It is argued that the unit root tests such as ADF or PP tests could be inclined not to reject the null hypothesis of a unit root even if a permanent change in the data exists (Philips and Perron, 1988:1361). For this reason before stationarity of the time series is considered, some structural break tests are implemented.

This is done firstly as oil prices and exchange rates may have been influenced by major incidences during the period which is being appraised. Secondly, if there are structural breaks, then the test for stationarity will be compromised. The tests suggested by Bai and Perron (1998, 2003), which accept for multiple structural adjustments will be applied, similar to Anorou (2011), which studied structural breaks in time series data.

The Bai and Perron multiple structural break evaluation involves three types of assessments. They include the SupF type, the SupF (l+1|l) and the double maximum statistics – UDmax and WDmax. The variable of interest Y is regressed on a constant; it is then inspected for structural breaks. The assessments are centred on the ensuing model with m breaks (m+1 regime):

$$\gamma_t = \beta_t + \mu_t \text{ for } t = T_{j-1} + 1, \ldots T_j, \; j = 1, \ldots m + 1 \qquad (3)$$

where variable γ_t is stationary in period t. Variable βt denotes the mean variable in the j^{th} regime.

$T_1, \ldots, T_m$ are symbols that denote the break points, which are unknown by assumption.

In equation 3, y is assessed through ordinary least squares technique.

In equation 4 below, Bai and Perron (1998) examine an F-statistic of the grouping given below:

$$\text{SupFT}(b) = \text{FT}(\lambda 1 \dots \dots, \lambda b), \quad (4)$$

where $\lambda_1 \dots\dots, \lambda_b$ lessen the overall sum of squared residuals ST $(T\lambda_i)$ with I = 1,…,b (b is the amount of breaks identified by the procedure).

Five structural breaks with a trimming factor of 0.15 are assumed by this research (i.e. M=5). Bai and Perron (1998) suggested two test statistics known as the double maximum statistics (i.e. UDmax and WDmax) to check the null hypothesis of no or zero breaks in the time series compared to the alternate of an unlimited number of breaks given an upper bound M.

The UDmax procedure is expressed as follows:

$$\text{UDmax} = \max 1 \leq m \leq M\ \text{SupFT}(m) \quad (5)$$

Bai and Perron also examine a different set of weights along the lines that the low p-values are equal for all values of m. This specific form of test is represented as the WDmax. Bai and Perron suggested that the researcher should first test the results from the UDmax and WDmax to see if at least one structural break exists before deciding on the amount of structural breaks to be applied to the data. The break points are then chosen by reviewing the test statistics from the SupF (l+1|l) procedures, which includes consecutive testing of the null hypotheses against a number of other possibilities. For example, the null hypothesis of l breakpoint is verified against the alternative hypothesis of l+1breakpoints. Subject to the results from the SupF(l+1|l) procedures, the Schwarz Information Criterion (SIC), the modified Schwarz Information Criterion (LWZ) (Liu,Wu and Zidek, 1994) and the consecutive techniques can be used to choose the exact amount of structural breaks in the data. If structural breaks exist, then it will be treated as exogenous dummy variable in the VAR model. Results of these formal tests are outlined in Chapter 5 below.

4.7. Stationarity

Dawson stated that real exchange rates are affected concurrently by seasonal, cyclical components and trends. This analysis is consistent with the study done by Chen and Chen (2007:394). For these reasons they are considered to be non-stationary. Chen and Chen (2007:394) also asserted that the real oil prices are non-stationary too. These results are consistent with those of Amano and van Norden (1997:303). In order to secure stationarity of the time series, the natural logarithms of all the variables in first-order differences are used. This is similarly done in the study by Dawson (2006:14, 18). Gujurati, on the other hand, declared that unit root tests have over the past several years become widely popular to test for stationarity or non-stationarity (Gujurati, 2003:814).

4.8. Unit root test

Jin (2008:102) stated that there are two key reasons why it is necessary to perform unit root testing and co-integration analysis when considering time series variables. The first reason is the risk of a false presumption that two variables are correlated, while they might in fact not be correlated. This could prevent the study of long-run relationships among levels of non-stationary variables using ordinary estimation methods. The second reason is that the risk of running the first differences of variables could result in relevant information being lost. If the variables are found to be non-stationary, then co-integrating methods should be applied to understand the real behaviour of the long-run dependencies of the variables.

According to Jin (2008:102), macro-economic data often appear to display a stochastic trend. As the occurrence of such a trend can influence the statistical behaviour of alternative estimators, the determinants of the order of integration of the data are important. These trends can be removed by differencing the variables once. Variables that are regarded as non-stationary in levels, and become stationary after applying the first difference, are considered to be integrated of order 1 or I (1). By using the unit root testing, stationary variables can be easily identified even if they require repeated differencing. The researcher therefore investigates the order of integration with the appropriate unit root tests.

Gujurati (2003:818-9) found that there are several unit root tests that can be performed. The reason why there are so many unit root tests is because these tests vary in size and power. Variation in size refers to the level of significance of the test, while variation in power relate to the probability of rejecting the null hypothesis when it is false. Gujurati (2003) further state that the traditional unit root tests have low power and this implied that a unit root may be found even though it does not exist. There are four explanations for this. The first reason is that the power depends on the length of time of the series. When the size of the sample is large, the power is greater. The second reason is if $p \sim 1$, then the unit root will be declared non-stationary. Thirdly, these unit root tests assume the time series is integrated of order 1, but if the time series is integrated of order higher than 1, then it will have more than one unit root. The fourth reason is if there are structural breaks in the time series, then the unit root tests might not capture them. The null hypothesis of most of the unit root test with time series data is that the series is non-stationary or has a unit root. The alternative hypothesis is that the time series is stationary.

The series of unit root tests that are performed in this research include the Augmented Dickey Fuller Test (ADF) and the Phillips-Perron (PP). These two unit root tests are similar to the unit root tests conducted by various authors such as Jin (2008), Dawson (2006), Rautava (2002) and Chen and Chen (2007).

4.8.1. Augmented Dickey Fuller test

The Augmented Dickey Fuller test is the improved adaptation of the Dickey-Fuller test. The Dickey Fuller test is used to test for unit roots in time series samples. The ADF is used with larger and more complex samples. The Dickey Fuller test presumed that the error term $\mathcal{E}_t$ was not correlated whereas the ADF considers the error term ε^t to be correlated. The ADF test considers the lagged values of the dependent variable γ_t (Gujurati, 2003:817). ADF is used to examine whether the variables are integrated in the same order. The below regression formula which includes a trend and constant, is applied for the ADF test.

$$\Delta\gamma_t = \beta_O + \delta_t + \beta_{1\gamma_{t-1}} + \sum_{i=1}^{m} \gamma_i \Delta\gamma_{t-1} + \mathcal{E}_t \qquad (6)$$

The $\Delta\ \gamma_t$ describes the first difference of γ_t and the term m is the lag length of the augmented terms for γ_t. The above equation allows for testing of the variable γt to be a stationary series. The null hypothesis in the ADF test is that γ_t has a unit root or is non-stationary.

Results of these formal tests are outlined in Chapter 5 below.

4.8.2. Phillips-Perron test

An additional test is applied to test the detection of a unit root in the time series. This test is also useful in order to check the strength or the robustness of the ADF unit root test. The Phillips-Perron (PP) differs from the ADF test primarily in how it deals with serial correlation and heteroskedasticity in the errors. According to Gujurati (2003:818), the Phillips-Perron unit root test uses nonparametric statistical approaches in order to handle the serial correlation in the error term. With the Phllips-Perron test, it is not required to select the level of serial correlation as it is with the ADF test. Similar to ADF, the null hypothesis for the PP unit root test is that the variable has a unit root. The alternative hypothesis is that the variable was generated by a stationary process.

PP unit root test is depicted in equation 4 below with no lagged difference terms added to this test.

$$\gamma_t = \alpha\gamma_{t-1} + u_t \tag{7}$$

γ_t is the time series integrated to order of 1, where α is equal to 1 multiplied by the lagged of the time series, where μ_t is a stationary auto-correlated error term with mean zero.

PP unit root test can be viewed as a more inclusive concept of unit root non-stationarity. The tests are comparable to ADF tests, but the Dickey Fuller (DF) statistic has been made robust by the Newey West heteroscedascity and auto-correlation (HAC type corrections). The ADF, on the other hand, adds lagged difference terms to the regressand in order to take care of serial correlation. The disadvantage of the PP test is that it is based on asymptotic theory similar to ADF. It only works well with large sample data. As this study has a sample size of 420 observations, the PP unit root test will be suitable to be applied to this study. The same methodology of unit root tests has been followed by several authors such as Chen and Chen (2007) and Jin (2008).

Results of these formal tests are outlined in Chapter 5 below.

4.9. Co-integration test

When using the time series analysis and integration of the same order are found in the tested variables, then the next step is to estimate if a steady long-run dependency exists among the variables. For this reason the researcher test whether the variables are co-integrated or not.

If no co-integrating relationship is found between the real South African rand and the real price of oil, then the standard VAR model will be applied. If the real South African exchange rate and the real price of oil are found to be co-integrated, then the co-integrating vectors or the long-run equilibrium relations among the variables need to be determined.

The Johansen co-integration test is applied as an initial point in the VAR model. The Johansen co-integration test encompasses the log likelihood ratio tests for the number of co-integrating connections and the maximum likelihood of approximations of co-integrating vectors. Two different likelihood tests are proposed by Johansen in non-stationary time series which is known as the trace test and the maximum eigenvalue test. Lütkepohl, Saikkonen and Trenkler (2000:17) stated that the trace test has a tendency to have a more heavily distorted sizes than the maximum eigenvalue test; however, their power performance is better than the maximum eigenvalue test.

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

$$\lambda_{max}(\mathrm{r}, \mathrm{r}+1) = -\mathrm{T} \ \ln\left(1 - \hat{\lambda}_r + 1\right) \qquad (8)$$

As per equation 8, the T represents the sample size, n denotes the total sum of variables, and λ denotes the i^{th} largest acknowledged correlation between residuals. The top equation represents the trace test where the null hypothesis test if there are r co-integrating vectors versus and alternative of n co-integrating vectors. The bottom equation represents the maximum eigenvalue test where the null hypothesis test if there are r co-integrating vectors versus an alternative of r+1 co-integrating vectors.

Results of these formal tests are outlined in Chapter 5 below.

4.10. Vector Error Correction mechanism

Engle and Granger (1987:251) stated that if variables co-integrate, then the variances from the equilibrium are stationary with finite differences, even though the series might be non-stationary and the differences might be infinite. After testing for co-integration and the variables are found to be co-integrated, it suggests that a long-run equilibrium link exists between the two variables. However, it is assumed that disequilibrium would exist in the short run and would therefore need to be tested. the error correction mechanism (ECM) popularised by Engle and Granger corrects the disequilibrium. The theorem known as the Granger Representation Theorem states that if two variables are co-integrated, then the link between the two variables can be expressed as ECM (Gujurati, 2003:825).

The ECM equation is depicted in equation 9 below, where Y – Xβ symbolizes the error correction mechanism and the parameter α gives the speed of adjustment towards the long-run equilibrium. Stationary variables are represented by variable Z and ε_t represents an error term with β and Y being the vectors of parameters. Δ denotes the first difference operator and variable Y represents the South African rand variable, with X being the price of Brent oil.

$$\Delta\gamma_t = \alpha(\gamma_{t-1} - X_{t-1}) + \sum_{i=0}^{k} Z_{t-i}\gamma_i + \mathcal{E}_t \qquad (9)$$

Results of these formal tests are summarised in Chapter 5 below.

In conclusion, this chapter outlined the choice of variables, the model and all the tests that will be conducted to investigate the influence of the movement of Brent oil prices on the South African rand, the manufacturing production index and the real prime rate. The structural break, unit root, stationarity, co-integrating test were all run in the software package of Eviews with the subsequent VAR models too.

CHAPTER 5

Empirical results

The aim of this chapter is to present the empirical results derived from the various tests and analysis that were performed in the previous chapters.

Figure 4:

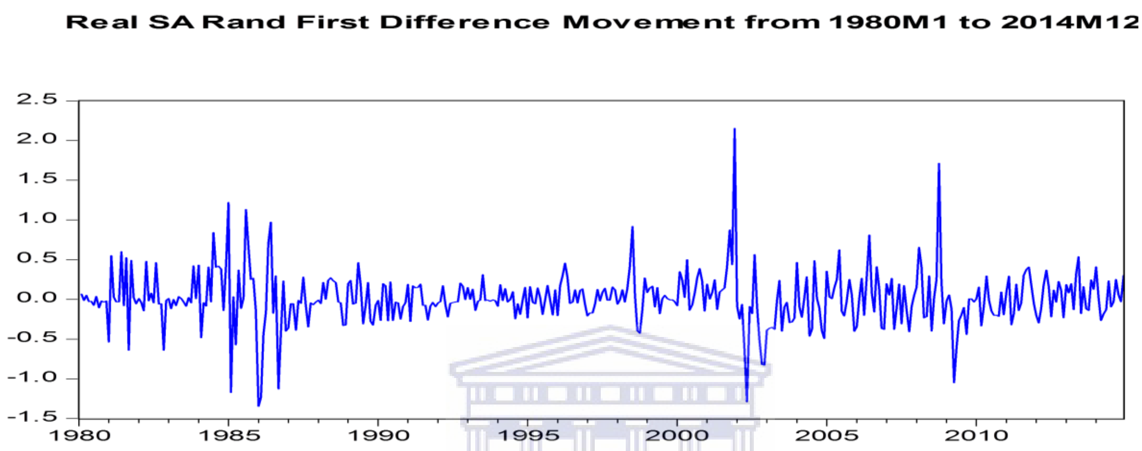


Figure 4 represents the first difference of the South African rand/dollar exchange rate from 1980M1 to 2014M12 in real and not nominal terms as depicted in figure 2. As per the graphical representation it can be observed that the South African rand was volatile from 1980 to 1987 and thereafter it was quite stable. In line with the findings of the De Kock Commission, these were the turbulent years and on the 15 August 1985 Rubicon speech delivered by then President P.W. Botha resulted in the South African rand depreciating by approximately 20% month on month in nominal and real terms.

The subsequent unusual spikes in the exchange rate occurred in 1998, 2001-2003 and then 2008-2009. These events all happened after the abolition of apartheid when South Africa re-entered the global arena. As South Africa has a flexible exchange rate, all these events represent global uncertainties which had a negative impact on the South African rand. As discussed in Chapter 3, the 1998 fluctuation of the real South African rand was a consequence of the debt default in Russia and the financial crisis in Asian markets which impacted on the emerging market currencies. The real South African rand depreciated by approximately 21% from March 1998 to August 1998. There were several reasons for the 2001-2003 fluctuation of the real South African rand, one being the manipulation of the South African rand by traders and possibly the domino effect of the commodity downturn in 2000. The real South African rand depreciated by approximately 37% during this period. The 2008-2009 depreciation of the real South African rand was driven by the global financial crisis. During this period the real South African rand depreciated by approximately 25%.

As illustrated in figure 5 and figure 6, which refer to section 4.4, when evaluating the real oil prices and the real exchange rates, the results reveal that the observations are not normally distributed. Transforming variables to the logarithmic format is common in regression models as this is a convenient way of transforming a highly skewed variable into one that is a more normal variable. Transforming the variables into logarithmic format is also common when a non-linear association exists between the independent and the dependent variables. For these reasons the natural logarithms was used to make the real Brent oil price, the manufacturing production index and the real rand variables more linear. This follows the methods adopted by Nikbakht (2010), Rautava (2002), Dawson (2007), Chen and Chen (2007), Basher et al. (2012) and Doğan et al. (2012).

Figure 5:
Histogram of the Real South African Rand and the Log of Real South African Rand from January 1980 to December 2014

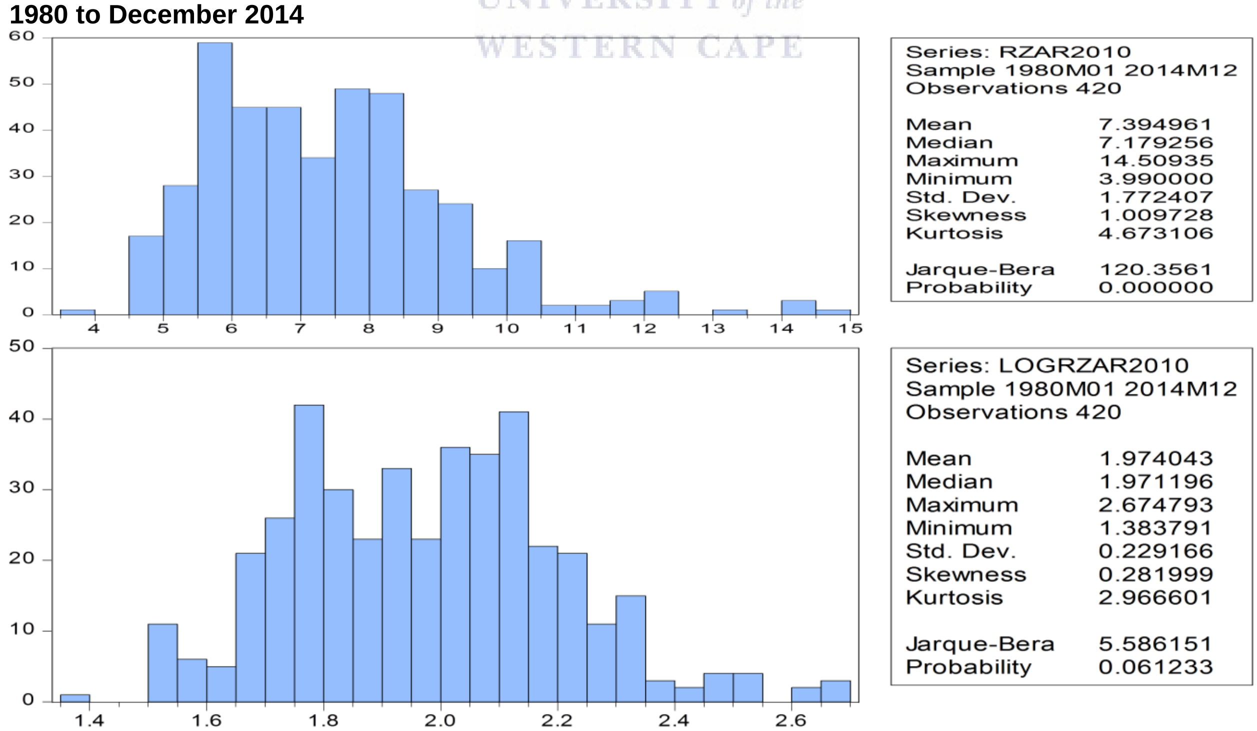
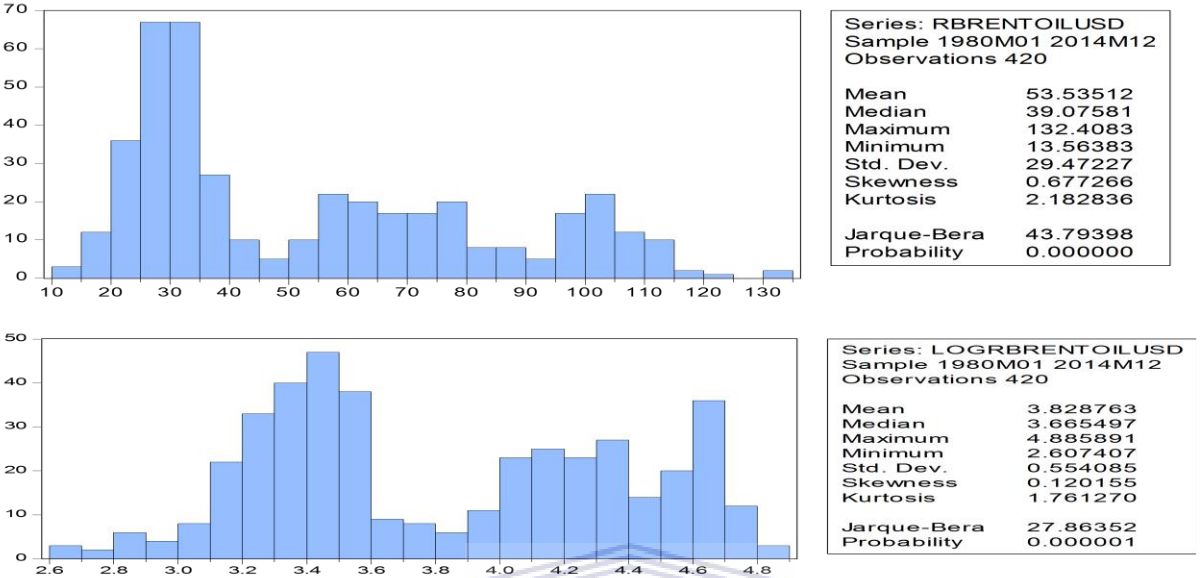


Figure 6:
Histogram of the Real Brent Oil Price and the Log of Real Brent Oil Price in from January 1980 to December 2014



With reference to section 4.6, when testing for the number of structural breaks with all the variables as a group a result of either two to five structural breaks are returned for the sample period from 1980M01 to 2014M12. Brent oil in US dollars is the independent variable and the SA Rand, Manufacturing Production Index and the SA Prime Rate are all the dependent variables. All these variables were tested in real terms. The variables were tested on the nominal and real level. Further, in order to test for linearity of the variables, the researcher chose to test for the log of the first-order difference of the real Rand, the real Brent oil and the real manufacturing production index. The results of no structural breaks were returned. Similar to Chen and Chen (2007) and Doğan et al. (2012) which found that no structural breaks were returned when similar variables were transformed similar variables. The SA real prime rate however does return four structural breaks. For this reason, the researcher will account for the structural breaks in the VAR and VECM models.

With reference to section 4.7 and 4.8, given the evidence of no structural[4] breaks within the sample period for three of the variables in the real first-order differences terms, that is Brent, Rand and Manufacturing Production Index, the researcher tested for the ADF and PP unit roots. The variables are tested in various forms. It is tested in level nominal, level real, first difference nominal, first difference real, logarithms real and first difference logarithms terms. For all the variables in level nominal terms the t-statistics value is less negative than the 1% critical values and the p values are greater than 5%, which implies the variables are non-stationary and the null hypothesis of a unit root existing cannot be rejected. The logarithm which makes the variables more linear is applied and the results are that the variables remain non-stationary. All three variables are then tested in the real first-order difference terms and the t-statistics values is more negative than the 1% critical values and the p values are less than 5%, which implies the variables are stationary and the null hypothesis of a unit root existing is rejected. The first-order difference of the log variables in real terms is applied and all three variables are stationary. In this case the alternative hypothesis is accepted and the null hypothesis is rejected.

With reference to section 4.8.1, Chen and Chen (2007:394) and Nikbakht (2009:86) state that, in accordance with the ADF tests, all real exchange rates are integrated of order one (I (1)). These results are in agreement with well-documented proof of the non-stationary behaviour of real exchange rates from the literature. It is also apparent that real oil prices are non-stationary. Amano and Norden, (1997:303) also confirm that the real exchange rate and the price of oil are integrated of order one (I (1)).

With reference to section 4.9, testing the Johansen co-integrating relationship between Brent oil in US dollars, the SA rand, the manufacturing production index and the prime rate, it was found that the variables are co-integrated in the long run. It has at least one co-integrating relationship. The optimum lag interval that is returned for the HQ information criterion with these real level variables is 2 lags. As these real level variables are not stationary and the variables need to be in first-order difference to make them stationary. The first difference is applied, which makes the

[4] When structural breaks were found, exogenous dummy variables were created. In the VAR and VECM models the results were similar with or without dummy variables. For this reason, the researcher reported the results without the dummy variables.

variables stationary. Only once the variables are stationary can the unrestricted VAR model be applied.

The first-order difference of the log variables in real terms is applied to the three stationary variables. The variables are stationary and the p-value is less than 5%, therefore implying it is significant. It has also been assumed the variables are integrated of same order. (Gujurati, 2003:812) The optimum lag interval that is returned for the HQ information criterion is 1 lag. Several lags are applied and in order to obtain better results and the optimum lag intervals used are 2 lags. (Liew, 2004:2)

The Johansen co-integrating test is applied and the trace statistics value is larger than the critical value. This indicates that the null hypothesis of no co-integrating is rejected. For these reason the unrestricted VAR model is executed. The VAR model is then extended to the VECM as at least one co-integrating relationship is found.

The researcher executed several unrestricted VAR models and the model that is applied represent the first-order difference of the log variables in real terms for Brent and the manufacturing production index with the Rand and prime rate denoted in real terms. An impulse response function is done as well as the VECM is executed for the response of a shock of the first-order difference of the Brent log variable in real terms on the real Rand, first-order difference of the manufacturing production log variable in real terms and the real prime rate. It can be observed that a rise in the real Brent oil price movement has a minimal impact on the real South African rand in the VAR model. On the other hand, with the result of the VECM model it could be perceived that the impact of the real Brent oil prices could possibly have a negligible depreciating effect on the currency. Similarly the shock of an oil price increase has an insignificant or negative effect on the real prime rate. There is a positive relationship on the real Manufacturing Production Index when the Brent oil price increases. Variance decomposition discloses that a Brent oil price shock have a 0.17% fluctuation in the real Rand after two months and only 0.52% impact on the real Rand after 24 months. The impact of an oil shock on the manufacturing production index is 9.98% after 24 months and 0.18% on the real prime rate after 24 months.

The results derived from this study are similar to small oil importing developing countries yet unlike the results derived from several other studies. A study by Huang and Guo (2007:414) found that the real oil price movements led to an insignificant appreciation of the real Chinese exchange rate in the long run. Then again, the study by Jin (2008:100) on the Russian economy, which is an oil-exporting economy, established that oil price increases have a substantial impact on the real Russian rouble, while the real Russian exchange rate appreciates too. He also found that the Japanese real effective exchange rate appreciates as crude oil prices rise. Japan is an oil-importing country much like South Africa, also imports crude oil. On the other hand, the study by Doğan, Ustaoğlu and Demez (2012:1299) on the Turkish economy found that the real oil prices have a negative effect on the Turkish real exchange rate. Likewise the study on the Dominican Republic (Dawson, 2006:22) found that as oil prices rise, the Dominican peso depreciates. However, this is more relevant in the short run than in the long run association between the real oil price and the Dominican peso. The study by Turhan, Hacihasanoglu and Soytas (2012) found that after the global financial crisis in 2008 the importance in the movement of oil prices increased, but the impact of this increase was not permanent. They found that as the oil price the emerging markets' exchange rate appreciated, including South Africa. On the other hand, Kin and Courage (2014) found that the impact of crude oil shocks led to depreciation in the exchange rate in South Africa. The current study covers a longer period than both Turhan et al (2012) and Kin et al (2014) studies. The results differ from Turhan et al, but concurs to a certain degree with the Kin et al. concurs. In conclusion, the South African rand and Brent oil prices are assumed to have an insignificant long-run association.

CHAPTER 6

CONCLUSION

Recognising the effect of Brent oil prices in the global financial and stock market in both developed and emerging economies, this study set out to investigate the effect of Brent oil prices on the South African Rand, the Manufacturing Production Index and the prime rate on a monthly basis from 1980 to 2014.

The research methodology followed was based on work by several authors, among others, Jin (2008); Chen and Chen (2007) and Turhan et al. (2012). Jin (2008) found that as oil prices increase, the real effective exchange rate appreciates and, in the case of Russia, economic activity improves. In the case of Japan and China economic activity decreased as oil prices increased, with the real effective exchange rate appreciating. Chen and Chen (2007) found that there are co-integrating relationships between real oil prices and real exchange rates for the G7 economies. Turhan et al. (2012) found that as oil prices increased, the real exchange rate in emerging markets appreciated. Their study included South Africa. Studies done on developing markets such as Turkey (Doğan et al., 2012) and the Dominican Republic (Dawson, 2006) found that the real exchange rate of the relevant economy would depreciate as the oil prices increased. A recent study done by Kin and Courage (2014) on the effect of oil prices on the exchange rate in South Africa established that as oil prices increase, the Rand depreciates.

In conclusion, the result of this study suggests that a crude oil price shocks has an insignificant impact on the Rand. The empirical evidence further suggests that there is a trivial long run relationship between the movement of crude oil prices and the South African rand, manufacturing production index and the prime interest rate. It can be assumed that other factors have an impact on the South African rand and that the movement in the crude oil prices will have a secondary effect on the economy, if any. A consideration of other factors affecting the South African rand is beyond the scope of this study.

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APPENDICES:
REAL EXCHANGE RATE:

Montiel (2003) stated that the classification of the real exchange rate in analytical models is the assumed production structure of the model. As South Africa is a small oil importing country, according to the Montiel's descriptions its production structure contains two goods. This is known as the Swan-Salter or dependent economy model where one good is produced and consumed locally (known as the non-traded or the domestic good) and the other is produced and consumed both locally and abroad (known as the traded or the foreign good). Montiel defined the real exchange rate as the number of units of the non-traded or domestic product necessary to purchase one unit of the foreign or traded product (Montiel, 2003:313-314).

The real exchange rate can be explained using the below equation:

$$r = e\ (P^f / P^h) \qquad (1)$$

Where r represents the real exchange rate
e represents the nominal exchange rate
P^f represents the foreign price level
P^h represents the home or domestic price level

In equation 1 the variables P^f and P^h is representing the US CPI and the SA CPI respectively. As per equation 1, this is known as the internal real exchange rate as it is the domestic currency of the traded and non-traded goods. In the South African context, the real South African exchange rate in 2010 ZAR terms versus 2010 USD terms is obtained by multiplying the nominal exchange by the US consumer price index divided by the South African consumer price index.

Unit Root Results:

Null Hypothesis: **DLOGRZARCPI** has a unit root
Exogenous: Constant
Lag Length: 7 (Automatic - based on HQ, maxlag=17)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.582162	0.0000
Test critical values:	1% level	-3.446044	
	5% level	-2.868353	
	10% level	-2.570464	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DLOGRZARCPI)
Method: Least Squares
Sample (adjusted): 1980M10 2014M12
Included observations: 411 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOGRZARCPI(-1)	-0.867191	0.131749	-6.582162	0.0000
D(DLOGRZARCPI(-1))	-0.016687	0.120743	-0.138202	0.8902
D(DLOGRZARCPI(-2))	0.044839	0.109410	0.409825	0.6822
D(DLOGRZARCPI(-3))	0.005127	0.098167	0.052231	0.9584
D(DLOGRZARCPI(-4))	0.004145	0.088229	0.046979	0.9626
D(DLOGRZARCPI(-5))	-0.102613	0.077009	-1.332470	0.1835
D(DLOGRZARCPI(-6))	-0.155863	0.065401	-2.383195	0.0176
D(DLOGRZARCPI(-7))	-0.198428	0.048944	-4.054150	0.0001
C	-0.000546	0.002028	-0.269263	0.7879

R-squared	0.473612	Mean dependent var	0.000164
Adjusted R-squared	0.463137	S.D. dependent var	0.055996
S.E. of regression	0.041029	Akaike info criterion	-3.527414
Sum squared resid	0.676723	Schwarz criterion	-3.439416
Log likelihood	733.8836	Hannan-Quinn criter.	-3.492603
F-statistic	45.21199	Durbin-Watson stat	1.993004
Prob(F-statistic)	0.000000		

Unit Root Results:

Null Hypothesis: **DLOGRBRENTOILUSD** has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on HQ, maxlag=17)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-15.23953	0.0000
Test critical values:	1% level	-3.445776	
	5% level	-2.868235	
	10% level	-2.570401	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DLOGRBRENTOILUSD)
Method: Least Squares
Sample (adjusted): 1980M03 2014M12
Included observations: 418 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOGRBRENTOILUSD(-1)	-0.725143	0.047583	-15.23953	0.0000
C	-0.001231	0.003912	-0.314619	0.7532

R-squared	0.358266	Mean dependent var	-0.000469
Adjusted R-squared	0.356723	S.D. dependent var	0.099707
S.E. of regression	0.079969	Akaike info criterion	-2.209575
Sum squared resid	2.660357	Schwarz criterion	-2.190266
Log likelihood	463.8011	Hannan-Quinn criter.	-2.201942
F-statistic	232.2432	Durbin-Watson stat	1.955675
Prob(F-statistic)	0.000000		

Unit Root Results:

Null Hypothesis: **DLOGRMANUFACT** has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on HQ, maxlag=17)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.27188	0.0000
Test critical values:	1% level	-3.445852	
	5% level	-2.868268	
	10% level	-2.570419	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DLOGRMANUFACT)
Method: Least Squares
Sample (adjusted): 1980M05 2014M12
Included observations: 416 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOGRMANUFACT(-1)	-1.188261	0.105418	-11.27188	0.0000
D(DLOGRMANUFACT(-1)	-0.145026	0.081147	-1.787195	0.0746
D(DLOGRMANUFACT(-2)	-0.193160	0.048161	-4.010684	0.0001
C	-0.007402	0.001334	-5.550721	0.0000

R-squared	0.676635	Mean dependent var	-1.65E-05
Adjusted R-squared	0.674280	S.D. dependent var	0.041534
S.E. of regression	0.023704	Akaike info criterion	-4.636768
Sum squared resid	0.231497	Schwarz criterion	-4.598011
Log likelihood	968.4477	Hannan-Quinn criter.	-4.621443
F-statistic	287.3669	Durbin-Watson stat	2.012372
Prob(F-statistic)	0.000000		

Unit Root Results:

Null Hypothesis: **RZARCPI** has a unit root
Exogenous: Constant
Lag Length: 8 (Automatic - based on HQ, maxlag=17)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.327961	0.1637
Test critical values:	1% level	-3.446044	
	5% level	-2.868353	
	10% level	-2.570464	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RZARCPI)
Method: Least Squares
Sample (adjusted): 1980M10 2014M12
Included observations: 411 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RZARCPI(-1)	-0.023462	0.010078	-2.327961	0.0204
D(RZARCPI(-1))	0.124030	0.048670	2.548379	0.0112
D(RZARCPI(-2))	0.114631	0.049006	2.339126	0.0198
D(RZARCPI(-3))	-0.024674	0.049210	-0.501409	0.6164
D(RZARCPI(-4))	-0.043136	0.048701	-0.885746	0.3763
D(RZARCPI(-5))	-0.121567	0.048631	-2.499762	0.0128
D(RZARCPI(-6))	-0.047054	0.048950	-0.961262	0.3370
D(RZARCPI(-7))	-0.024946	0.048794	-0.511254	0.6095
D(RZARCPI(-8))	0.233063	0.048545	4.800963	0.0000
C	0.240039	0.108608	2.210136	0.0277

R-squared	0.127740	Mean dependent var	-0.006863
Adjusted R-squared	0.108163	S.D. dependent var	0.540381
S.E. of regression	0.510320	Akaike info criterion	1.516473
Sum squared resid	104.4311	Schwarz criterion	1.614249
Log likelihood	-301.6352	Hannan-Quinn criter.	1.555152
F-statistic	6.525051	Durbin-Watson stat	1.997744
Prob(F-statistic)	0.000000		

Unit Root Results:

Null Hypothesis: **RPRIME** has a unit root
Exogenous: Constant
Lag Length: 12 (Automatic - based on HQ, maxlag=17)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.544030	0.1059
Test critical values:	1% level	-3.446692	
	5% level	-2.868638	
	10% level	-2.570617	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RPRIME)
Method: Least Squares
Sample (adjusted): 1982M02 2014M12
Included observations: 395 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RPRIME(-1)	-0.028471	0.011191	-2.544030	0.0114
D(RPRIME(-1))	0.022557	0.048884	0.461434	0.6448
D(RPRIME(-2))	0.101032	0.048639	2.077203	0.0385
D(RPRIME(-3))	0.115140	0.048649	2.366735	0.0184
D(RPRIME(-4))	-0.033703	0.048987	-0.688004	0.4919
D(RPRIME(-5))	0.021481	0.048714	0.440953	0.6595
D(RPRIME(-6))	-0.001519	0.048381	-0.031406	0.9750
D(RPRIME(-7))	0.070688	0.048294	1.463695	0.1441
D(RPRIME(-8))	0.130803	0.047845	2.733913	0.0066
D(RPRIME(-9))	0.020056	0.048010	0.417742	0.6764
D(RPRIME(-10))	-0.011360	0.047546	-0.238931	0.8113
D(RPRIME(-11))	0.091160	0.047204	1.931192	0.0542
D(RPRIME(-12))	-0.252370	0.047432	-5.320677	0.0000
C	0.184242	0.083555	2.205050	0.0280

R-squared	0.152358	Mean dependent var	0.003013
Adjusted R-squared	0.123436	S.D. dependent var	0.939847
S.E. of regression	0.879932	Akaike info criterion	2.616856
Sum squared resid	295.0009	Schwarz criterion	2.757880
Log likelihood	-502.8290	Hannan-Quinn criter.	2.672731
F-statistic	5.267859	Durbin-Watson stat	1.971547
Prob(F-statistic)	0.000000		

Johansen Co-integration Results:

Sample (adjusted): 1980M04 2014M12
Included observations: 417 after adjustments
Trend assumption: Linear deterministic trend
Series: BRENTOILUSD ZARUSD MANUFACT PRIME
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.085826	62.81583	47.85613	0.0011
At most 1	0.036901	25.39664	29.79707	0.1478
At most 2	0.022757	9.717995	15.49471	0.3031
At most 3	0.000285	0.118708	3.841466	0.7304

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.085826	37.41919	27.58434	0.0020
At most 1	0.036901	15.67864	21.13162	0.2442
At most 2	0.022757	9.599287	14.26460	0.2396
At most 3	0.000285	0.118708	3.841466	0.7304

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

BRENTOILUSD	ZARUSD	MANUFACT	PRIME
0.037822	0.119377	-0.018689	0.312353
-0.008190	-0.708886	0.175096	-0.024999
-0.042928	-0.058534	0.109737	0.068631
0.002318	-0.215577	-0.020561	0.066190

Unrestricted Adjustment Coefficients (alpha):

D(BRENTOILU	-0.467244	0.100034	0.431549	-0.020994
D(ZARUSD)	0.018001	0.027772	-0.015664	-0.001803
D(MANUFACT)	-0.390861	-0.080776	-0.146344	-0.014336
D(PRIME)	-0.082239	0.065568	-0.018537	0.005384

1 Cointegrating Equation(s): Log likelihood -2243.616

Normalized cointegrating coefficients (standard error in parentheses)

BRENTOILUSD	ZARUSD	MANUFACT	PRIME
1.000000	3.156263	-0.494140	8.258457
	(3.08791)	(0.73147)	(1.22361)

Adjustment coefficients (standard error in parentheses)

D(BRENTOILU	-0.017672
	(0.00658)
D(ZARUSD)	0.000681

Sample (adjusted): 1981M04 2014M12
Included observations: 405 after adjustments
Trend assumption: Linear deterministic trend
Series: DLOGRBRENTOILUSD RZARCPI DLOGRMANUFACT RPRIME
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.268254	239.8170	47.85613	0.0001
At most 1 *	0.204342	113.3266	29.79707	0.0000
At most 2 *	0.031488	20.74953	15.49471	0.0073
At most 3 *	0.019056	7.791983	3.841466	0.0052

Trace test indicates 4 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.268254	126.4904	27.58434	0.0000
At most 1 *	0.204342	92.57709	21.13162	0.0000
At most 2	0.031488	12.95755	14.26460	0.0796
At most 3 *	0.019056	7.791983	3.841466	0.0052

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

DLOGRBRENT	RZARCPI	DLOGRMANUF	RPRIME
3.315795	-0.092498	-98.32073	0.035014
18.54792	0.054314	3.009903	-0.034243
-0.165157	0.278701	1.947902	0.197507
-0.581252	0.282196	-1.922853	-0.125017

Unrestricted Adjustment Coefficients (alpha):

D(DLOGRBRE	-0.001383	-0.038391	0.002200	0.002873
D(RZARCPI)	-0.004399	-0.057024	-0.003754	-0.069332
D(DLOGRMAN	0.013282	-0.001319	-0.001056	-0.000423
D(RPRIME)	-0.062087	-0.066486	-0.161142	-0.016465

1 Cointegrating Equation(s): Log likelihood 522.6415

Normalized cointegrating coefficients (standard error in parentheses)				
DLOGRBRENT	RZARCPI	DLOGRMANUF	RPRIME	
1.000000	-0.027896	-29.65223	0.010560	
	(0.01028)	(2.44011)	(0.00595)	
Adjustment coefficients (standard error in parentheses)				
D(DLOGRBRE	-0.004586			
	(0.01474)			
D(RZARCPI)	-0.014588			

VAR Lag Order Selection Criteria:

VAR Lag Order Selection Criteria
Endogenous variables: DLOGRBRENTOILUSD RZARCPI DLOGRMANUFACT RPRIME
Exogenous variables: C
Sample: 1980M01 2014M12
Included observations: 400

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-780.9109	NA	0.000595	3.924555	3.964469	3.940361
1	547.1577	2622.935	8.42e-07	-2.635788	-2.436215*	-2.556755*
2	566.2171	37.26123	8.29e-07*	-2.651086	-2.291854	-2.508825
3	581.7993	30.15163	8.31e-07	-2.648997	-2.130106	-2.443509
4	598.2331	31.47058	8.29e-07	-2.651165*	-1.972616	-2.382451
5	608.5494	19.54938	8.54e-07	-2.622747	-1.784539	-2.290806
6	626.8821	34.37384*	8.44e-07	-2.634410	-1.636544	-2.239242
7	638.2213	21.03432	8.64e-07	-2.611107	-1.453582	-2.152712
8	647.8388	17.64808	8.93e-07	-2.579194	-1.262011	-2.057572

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

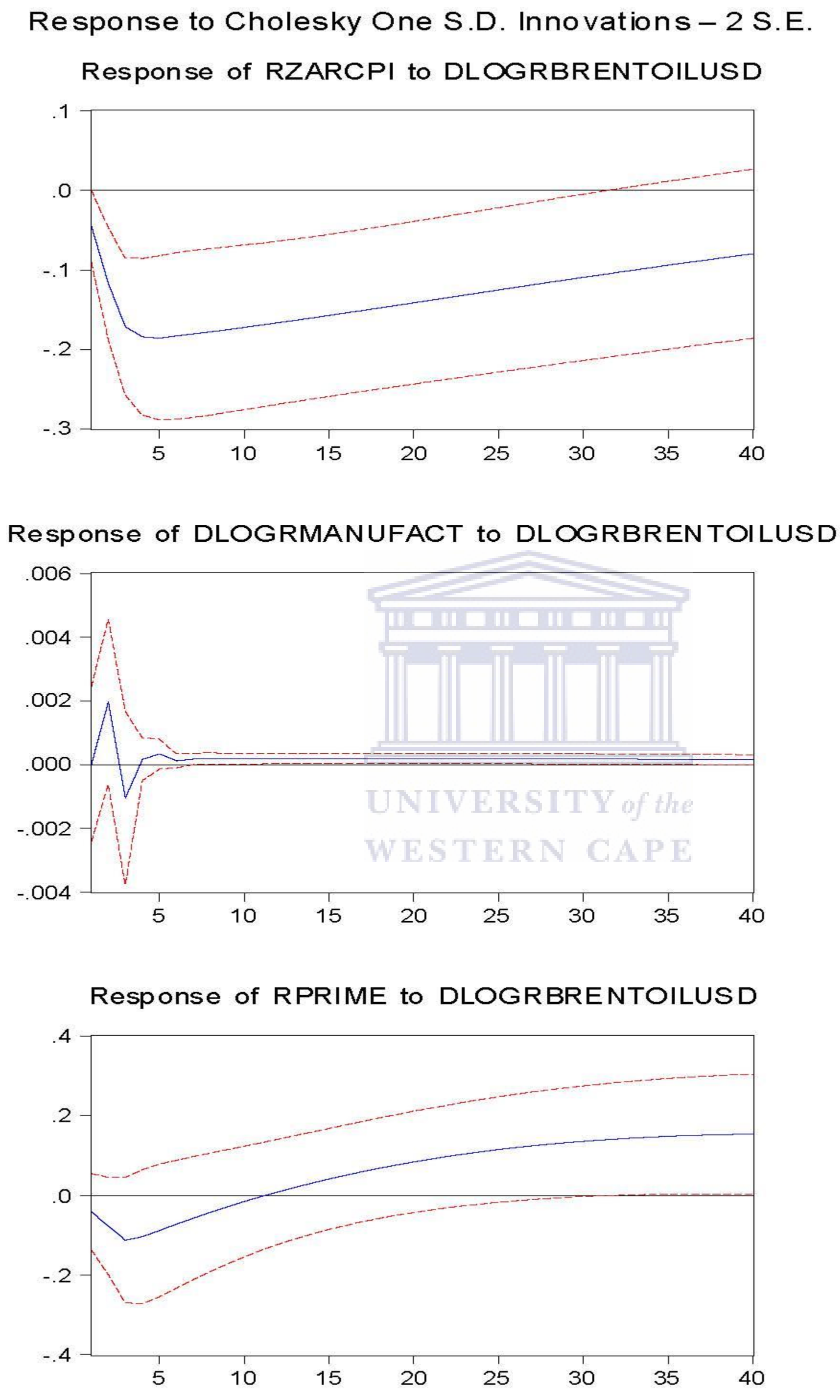
Vector Autoregressive Model:

Vector Autoregression Estimates
Sample (adjusted): 1981M03 2014M12
Included observations: 406 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	DLOGRBREN	RZARCPI	DLOGRMANU	RPRIME
DLOGRBRENTOILUSD(-	0.281136	-0.740558	0.027753	-0.688272
	(0.05046)	(0.32545)	(0.01485)	(0.58958)
	[5.57148]	[-2.27551]	[1.86862]	[-1.16738]
DLOGRBRENTOILUSD(-	-0.064224	-0.427665	-0.009542	-0.574325
	(0.05089)	(0.32822)	(0.01498)	(0.59462)
	[-1.26201]	[-1.30296]	[-0.63699]	[-0.96588]
RZARCPI(-1)	-0.004808	1.100510	-0.001027	-0.185661
	(0.00775)	(0.04996)	(0.00228)	(0.09052)
	[-0.62069]	[22.0259]	[-0.45038]	[-2.05114]
RZARCPI(-2)	0.004220	-0.118502	-0.000903	0.125185
	(0.00785)	(0.05061)	(0.00231)	(0.09169)
	[0.53781]	[-2.34141]	[-0.39114]	[1.36533]
DLOGRMANUFACT(-1)	0.198373	1.957664	-0.391495	-0.343910
	(0.17167)	(1.10719)	(0.05053)	(2.00579)
	[1.15557]	[1.76814]	[-7.74807]	[-0.17146]
DLOGRMANUFACT(-2)	-0.159798	1.561868	-0.161081	1.038328
	(0.16926)	(1.09166)	(0.04982)	(1.97767)
	[-0.94410]	[1.43072]	[-3.23328]	[0.52503]
RPRIME(-1)	-0.001387	0.029865	-0.001398	0.955480
	(0.00440)	(0.02836)	(0.00129)	(0.05137)
	[-0.31544]	[1.05316]	[-1.08040]	[18.5991]
RPRIME(-2)	0.002951	-0.019480	0.001836	0.011127
	(0.00432)	(0.02789)	(0.00127)	(0.05052)
	[0.68254]	[-0.69850]	[1.44268]	[0.22023]
C	-0.004382	0.139153	0.007857	0.863679
	(0.01877)	(0.12107)	(0.00553)	(0.21933)
	[-0.23345]	[1.14940]	[1.42216]	[3.93789]
R-squared	0.092229	0.961826	0.170706	0.955848
Adj. R-squared	0.073937	0.961056	0.153994	0.954959
Sum sq. resids	2.578108	107.2435	0.223354	351.9664
S.E. equation	0.080585	0.519745	0.023719	0.941576
F-statistic	5.041883	1250.331	10.21503	1074.343
Log likelihood	450.9484	-305.8451	947.4971	-547.0971
Akaike AIC	-2.177085	1.550961	-4.623138	2.739395
Schwarz SC	-2.088275	1.639772	-4.534328	2.828205
Mean dependent	-0.001319	10.42653	-0.006177	6.212734
S.D. dependent	0.083740	2.633735	0.025788	4.436595

Determinant resid covariance (dof adj.)	8.04E-07
Determinant resid covariance	7.35E-07
Log likelihood	562.7195
Akaike information criterion	-2.594677
Schwarz criterion	-2.239434

Impulse Response Function:



Vector Error Correct Mechanism:

Vector Error Correction Estimates
Sample (adjusted): 1981M04 2014M12
Included observations: 405 after adjustments
Standard errors in ( ) & t-statistics in []

Cointegrating Eq:	CointEq1	CointEq2		
RZARCPI(-1)	1.000000	0.000000		
DLOGRBRENTOILUSD(-	0.000000	1.000000		
DLOGRMANUFACT(-1)	967.2369 (78.6564) [12.2970]	-2.670102 (0.51067) [-5.22859]		
RPRIME(-1)	-0.402476 (0.19522) [-2.06167]	-0.000668 (0.00127) [-0.52675]		
C	-1.896107	-0.011730		
Error Correction:	**D(RZARCPI)**	**D(DLOGRBRE**	**D(DLOGRMA**	**D(RPRIME)**
CointEq1	-0.002690 (0.00278) [-0.96631]	-0.001957 (0.00043) [-4.55200]	-0.001300 (0.00012) [-10.4231]	0.002132 (0.00503) [0.42375]
CointEq2	-1.072258 (0.48904) [-2.19258]	-0.716662 (0.07553) [-9.48856]	0.019580 (0.02191) [0.89363]	-1.439054 (0.88368) [-1.62848]
D(RZARCPI(-1))	0.114286 (0.05138) [2.22422]	-0.003789 (0.00794) [-0.47742]	-0.001335 (0.00230) [-0.58003]	-0.229838 (0.09285) [-2.47547]
D(RZARCPI(-2))	0.098835 (0.05065) [1.95121]	0.008023 (0.00782) [1.02555]	0.001764 (0.00227) [0.77720]	-0.223982 (0.09153) [-2.44712]
D(DLOGRBRENTOILUSD	0.304197 (0.41585) [0.73150]	0.006759 (0.06423) [0.10524]	0.010701 (0.01863) [0.57436]	0.731212 (0.75143) [0.97310]
D(DLOGRBRENTOILUSD	-0.049505 (0.33209) [-0.14907]	-0.072854 (0.05129) [-1.42046]	-0.004679 (0.01488) [-0.31449]	0.062119 (0.60007) [0.10352]
D(DLOGRMANUFACT(-1)	1.382664 (1.94003) [0.71270]	0.190730 (0.29963) [0.63656]	-0.049150 (0.08692) [-0.56545]	-5.360971 (3.50557) [-1.52927]
D(DLOGRMANUFACT(-2)	1.936824 (1.11795) [1.73248]	-0.004190 (0.17266) [-0.02427]	-0.156910 (0.05009) [-3.13265]	-3.263178 (2.02009) [-1.61536]
D(RPRIME(-1))	0.035039 (0.02811) [1.24639]	-0.002645 (0.00434) [-0.60921]	-0.001507 (0.00126) [-1.19663]	-0.008544 (0.05080) [-0.16819]
D(RPRIME(-2))	0.008759	0.001965	0.001116	0.104782

	(0.02795)	(0.00432)	(0.00125)	(0.05051)
	[0.31336]	[0.45524]	[0.89109]	[2.07461]
C	-0.005104	-0.000438	-1.38E-05	0.013104
	(0.02597)	(0.00401)	(0.00116)	(0.04693)
	[-0.19651]	[-0.10915]	[-0.01187]	[0.27921]
R-squared	0.073304	0.374512	0.695232	0.048658
Adj. R-squared	0.049784	0.358636	0.687496	0.024512
Sum sq. resids	107.4946	2.564053	0.215785	350.9826
S.E. equation	0.522330	0.080671	0.023403	0.943832
F-statistic	3.116644	23.59080	89.87846	2.015171
Log likelihood	-306.0647	450.4452	951.6450	-545.6822
Akaike AIC	1.565752	-2.170100	-4.645161	2.749048
Schwarz SC	1.674499	-2.061352	-4.536413	2.857795
Mean dependent	-0.005303	-0.000443	-1.57E-05	0.017086
S.D. dependent	0.535839	0.100731	0.041863	0.955617
Determinant resid covariance (dof adj.)		7.90E-07		
Determinant resid covariance		7.08E-07		
Log likelihood		568.9300		
Akaike information criterion		-2.552741		
Schwarz criterion		-2.038661		

Vector Error Correct Mechanism:

Vector Error Correction Estimates
Sample (adjusted): 1981M04 2014M12
Included observations: 405 after adjustments
Standard errors in ( ) & t-statistics in []

Cointegrating Eq:	CointEq1
DLOGRBRENTOILUSD(-	1.000000
RZARCPI(-1)	-0.027896 (0.01028) [-2.71451]
DLOGRMANUFACT(-1)	-29.65223 (2.44011) [-12.1520]
RPRIME(-1)	0.010560 (0.00595) [1.77432]
C	0.041164

Error Correction:	D(DLOGRBRE	D(RZARCPI)	D(DLOGRMA	D(RPRIME)
CointEq1	-0.004586 (0.01474) [-0.31112]	-0.014588 (0.08648) [-0.16869]	0.044039 (0.00386) [11.4172]	-0.205868 (0.15571) [-1.32215]
D(DLOGRBRENTOILUSD	-0.441888 (0.04872) [-9.06947]	-0.362193 (0.28586) [-1.26702]	-0.004709 (0.01275) [-0.36931]	-0.045763 (0.51472) [-0.08891]
D(DLOGRBRENTOILUSD	-0.345271 (0.04733) [-7.29546]	-0.454135 (0.27767) [-1.63550]	-0.014036 (0.01239) [-1.13328]	-0.409658 (0.49997) [-0.81936]
D(RZARCPI(-1))	0.002884 (0.00877) [0.32895]	0.124196 (0.05143) [2.41479]	-0.001106 (0.00229) [-0.48217]	-0.218283 (0.09261) [-2.35712]
D(RZARCPI(-2))	0.014239 (0.00865) [1.64704]	0.108068 (0.05072) [2.13057]	0.001977 (0.00226) [0.87398]	-0.213217 (0.09133) [-2.33459]
D(DLOGRMANUFACT(-1)	0.136747 (0.33220) [0.41164]	1.302481 (1.94906) [0.66826]	-0.051004 (0.08694) [-0.58667]	-5.454460 (3.50942) [-1.55423]
D(DLOGRMANUFACT(-2)	-0.075912 (0.19128) [-0.39685]	1.830294 (1.12229) [1.63085]	-0.159373 (0.05006) [-3.18367]	-3.387386 (2.02077) [-1.67629]
D(RPRIME(-1))	0.001494 (0.00479) [0.31195]	0.041188 (0.02811) [1.46534]	-0.001365 (0.00125) [-1.08876]	-0.001375 (0.05061) [-0.02716]
D(RPRIME(-2))	0.005590 (0.00477)	0.014143 (0.02798)	0.001240 (0.00125)	0.111060 (0.05038)

	[1.17228]	[0.50550]	[0.99398]	[2.20459]
C	-0.000697	-0.005489	-2.27E-05	0.012655
	(0.00445)	(0.02610)	(0.00116)	(0.04699)
	[-0.15669]	[-0.21032]	[-0.01951]	[0.26931]
R-squared	0.228896	0.061951	0.694237	0.043805
Adj. R-squared	0.211326	0.040578	0.687270	0.022018
Sum sq. resids	3.160975	108.8115	0.216489	352.7729
S.E. equation	0.089457	0.524855	0.023411	0.945038
F-statistic	13.02803	2.898525	99.64995	2.010639
Log likelihood	408.0637	-308.5305	950.9852	-546.7125
Akaike AIC	-1.965747	1.572990	-4.646841	2.749197
Schwarz SC	-1.866885	1.671852	-4.547979	2.848059
Mean dependent	-0.000443	-0.005303	-1.57E-05	0.017086
S.D. dependent	0.100731	0.535839	0.041863	0.955617
Determinant resid covariance (dof adj.)		9.83E-07		
Determinant resid covariance		8.90E-07		
Log likelihood		522.6415		
Akaike information criterion		-2.363662		
Schwarz criterion		-1.928671		

Variance Decomposition of RZARCPI:

Period	S.E.	DLOGRBRENTUSD	RZARCPI	DLOGRMANUFACT	RPRIME
1	0.524855	1.09E-05	99.99999	0.000000	0.000000
2	0.803423	0.166619	99.28693	0.328664	0.217787
3	1.047551	0.413492	98.78567	0.417813	0.383024
4	1.244398	0.422723	98.74466	0.305923	0.526691
5	1.418507	0.44527	98.62737	0.298638	0.628722
6	1.571823	0.465041	98.57024	0.274487	0.690237
7	1.711432	0.475963	98.53402	0.249928	0.740083
8	1.840718	0.483494	98.49998	0.241614	0.774915
9	1.961082	0.489109	98.47908	0.231149	0.800657
10	2.074601	0.494262	98.46125	0.222513	0.821975
11	2.182255	0.49803	98.44614	0.217102	0.838727
12	2.284756	0.500981	98.43481	0.211754	0.852454
13	2.382897	0.503742	98.42475	0.207348	0.86416
14	2.477155	0.505977	98.41617	0.203834	0.874018
15	2.567937	0.507856	98.40901	0.200631	0.882505
16	2.655629	0.509563	98.40263	0.197884	0.889922
17	2.740515	0.511035	98.39705	0.195503	0.896414
18	2.822847	0.512328	98.39215	0.193363	0.902163
19	2.902847	0.513496	98.38775	0.191467	0.907291
20	2.9807	0.514537	98.38381	0.189769	0.911887
21	3.05657	0.515475	98.38026	0.188232	0.916033
22	3.130603	0.516328	98.37704	0.186842	0.919792
23	3.202925	0.517104	98.37411	0.185576	0.923214
24	3.273649	0.517813	98.37143	0.184417	0.926344

Variance Decomposition of DLOGRMANUFACT:

Period	S.E.	DLOGRBRENTUSD	RZARCPI	DLOGRMANUFACT	RPRIME
1	0.023411	8.64E-02	2.445808	97.467810	0.000000
2	0.02524	1.766044	3.252752	94.87505	0.106153
3	0.025354	1.7505	3.492324	94.13717	0.620005
4	0.025779	2.3147	3.378213	93.70729	0.599798
5	0.026022	2.98149	3.506567	92.90418	0.607759
6	0.026066	3.154949	3.494671	92.66857	0.681805
7	0.026152	3.645947	3.503965	92.15905	0.691043
8	0.02623	4.102042	3.534778	91.64837	0.714805
9	0.026284	4.428337	3.536165	91.28849	0.747007
10	0.026351	4.847139	3.550016	90.83604	0.766808
11	0.026415	5.246619	3.564912	90.39712	0.791346
12	0.026475	5.615333	3.574011	89.99426	0.816391
13	0.026538	6.003647	3.58646	89.57095	0.838938
14	0.0266	6.383228	3.598371	89.15585	0.862553
15	0.026661	6.754423	3.609255	88.75048	0.885846
16	0.026723	7.12705	3.620819	88.34357	0.908559
17	0.026785	7.49482	3.632044	87.94178	0.931353
18	0.026846	7.858546	3.643061	87.54453	0.953859
19	0.026907	8.219868	3.654135	87.14988	0.976118
20	0.026968	8.577561	3.665032	86.75917	0.998235
21	0.027029	8.931985	3.675831	86.37206	1.020123
22	0.02709	9.283374	3.686561	85.98825	1.041816
23	0.027151	9.631544	3.697175	85.60796	1.063326
24	0.027211	9.976634	3.707699	85.23103	1.084636

Variance Decomposition of RPRIME:

Period	S.E.	DLOGRBRENTUSD	RZARCPI	DLOGRMANUFACT	RPRIME
1	0.945038	0.015164	4.138853	2.36074	93.48524
2	1.324963	0.07239	2.492387	2.65396	94.78126
3	1.674977	0.217034	1.569873	3.178689	95.0344
4	1.961158	0.201748	1.213083	4.035713	94.54946
5	2.210903	0.186688	1.091226	4.431696	94.29039
6	2.436615	0.193036	1.006484	4.807647	93.99283
7	2.642872	0.190311	0.955424	5.106007	93.74826
8	2.833845	0.187257	0.919832	5.316674	93.57624
9	3.012982	0.187178	0.890608	5.487963	93.43425
10	3.182015	0.186446	0.86745	5.625744	93.32036
11	3.342475	0.185562	0.848856	5.736231	93.22935
12	3.495614	0.185156	0.833208	5.828748	93.15289
13	3.642314	0.184753	0.820038	5.906525	93.08868
14	3.783327	0.18435	0.808822	5.972873	93.03396
15	3.919274	0.184044	0.799118	6.030282	92.98656
16	4.050659	0.183776	0.790652	6.080284	92.94529
17	4.177915	0.18353	0.783204	6.12432	92.90895
18	4.301408	0.183315	0.776599	6.163381	92.8767
19	4.421452	0.183125	0.770702	6.198235	92.84794
20	4.538323	0.182953	0.765403	6.229559	92.82208
21	4.652259	0.182798	0.760618	6.257851	92.79873
22	4.76347	0.182657	0.756275	6.283527	92.77754
23	4.872143	0.182528	0.752314	6.306941	92.75822
24	4.978445	0.182411	0.748688	6.328376	92.74052