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Master of Management in Finance & Investments (MMFI) Thesis

The relationship between oil prices and the South African Rand/US Dollar exchange rate

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RESEARCH THESIS SUBMITTED TO THE FACULTY OF COMMERCE, LAW & MANAGEMENT IN PARTIAL FULLFILMENT OF THE REQUIREMENTS OF THE MASTER OF MANAGEMENT IN FINANCE & INVESTMENTS DEGREE

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ABSTRACT

In this study we examine the relationship between international oil prices and the South African Rand/US Dollar exchange rate. We also determine the direction of causality between these two variables. We further ascertain the magnitude of the influence of oil prices to the exchange rate compared to other theoretically driven macroeconomic variables. A forecasting exercise is also undertaken to determine whether oil prices contain information about future Rand/Dollar exchange rate. Drawing from the works of Aliyu (2009) and Jin (2008) we use VAR based cointegration technique and vector error correction model (VECM) for the long run and short run analysis respectively. The results show that there is a unidirectional causality running from oil prices to exchange rate and not the other way round. We also find that a 1% permanent increase in oil prices results in 0.17% appreciation of the Rand against the US Dollar; a 1% permanent increase in money aggregates results in 21.3% depreciation of the Rand and a 1% increase in business cycles results in 0.29% depreciation of the Rand in the long run. A 1% increase in inflation and interest rates is found to result in a 0.09% and 0.005% depreciation on the Rand respectively. Our short run analysis indicates that 4.4% of the Rand/Dollar exchange rate disequilibrium can be corrected within a month. Oil prices are found to contain some information about the future Rand/US Dollar exchange rate when the VAR model is used for forecasting. This study has shown there is a causal relationship between oil prices and the strength of the Rand against the Dollar and, therefore, recommends diversification of the economy and more use of green energy. Strategies to reduce capital flight and trade-related capital is also recommended by this study.

Key Words: Exchange rate, Oil price, forecasting, vector autoregressive (VAR) model, cointegration, vector error correction model (VECM), causality

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LIST OF ABBREVIATIONS AND ACCRONYMS

ADF	Augmented Dickey Fuller
AIC	Akaike Information Criteria
AR	Autoregressive
ARCH	Autoregressive conditional heteroscedasticity
ARIMA	Autoregressive integrated moving average
BC	Natural log of business cycle
BIC	Schwarz Bayesian Information Criteria
CointEq1	Cointegration equation 1
CointEq2	Cointegration equation 2
DW	Durbin-Watson
EXC	Natural log of exchange rate
FRED	Federal Reserve Economic Data
GARCH	Generalised Autoregressive Conditional Heteroscedasticity
GDP	Gross Domestic Product
IMF	International Monetary Fund
INF	Natural log of inflation differential
INT	Natural log of interest rate differential
IRP	Interest Rate Parity
M1	Narrow money aggregate
M2	Broad money aggregate
MAPE	Mean Absolute Percentage Error
MD	Natural log of money aggregate
MS-VECM	Markov-Switching Vector Error Correction Model
NEER	Nominal effective exchange rate
OECD	Organisation of Economic Co-operation and Development
OLS	Ordinary Least Squares
OP	Natural log of oil prices
OPEC	Organization of Petroleum Exporting Countries
PP	Phillips Perron
PPP	Purchasing Power Parity
RMSE	Root Mean Squared Error
UIP	Unified Interest Rate Parity
US	United States of America
USD/EUR	United States Dollar per Euro
VAR	Vector autoregressive
VECM	Vector Error Correction Model
ZAR	South African Rand
ZAR/USD	South African Rand per US Dollar
ZARUSD	South African Rand per US Dollar

CHAPTER 1. INTRODUCTION

1.1 Background and problem statement

The increasing volatility of currencies and oil prices around the world has attracted numerous research papers on the influence of oil prices on exchange rates and vice-versa. One of the major reasons behind the spawning of this kind of research is the fact that volatile exchange rates make international trade and investment decisions to be more difficult because it increases exchange rate risk (Englama, Duke, Ogunleye, & Isma'il, 2010).

While most of the studies on this subject have been conducted for oil-exporting countries and major currencies such as the Euro, Australian Dollar, Canadian Dollar to name just a few, there is still paucity of literature that has been published to specifically put the Rand under the microscope. The justification of the scarcity of literature on the relationship between the two asset classes could be the fact it has been hardly two decades after the unified floating Rand, hence a shorter data series.

However, we believe that the South African Rand has been a floating currency for quite some time now and has increasingly undergone high volatilities against the US Dollar since 1994. It deserves a chance too for studies around its volatility and its impact to financial markets and the South African economy at large. A further depreciation of the local currency has been observed lately despite the recent drop in crude oil prices. Such an observation is still a puzzle to economists and the investor community because previous studies that have been done have found that an increase in oil prices leads to a depreciation of the Rand (Kin & Courage, 2014). This is one of the indications that clarity on what has more influence in appreciating or depreciating the local currency is still less distinct.

In as much as modelling and forecasting exchange rates could be seen as an academic exercise, it still remains equally important to market participants and policy makers to know whether an exchange rate is gravitating towards its long term equilibrium or moving away. However, ever since the breakdown of the Bretton Woods agreements, previous exchange rate models such as the interest rate parity (IRP) model, the uncovered interest rate parity (UIP) model and the purchasing power parity (PPP) have been discredited by recent findings (Ghalayini, 2013). The

existence of unexpected information that plays a bigger role in predicting exchange rate fluctuations than interest rate differentials was speculated by Isard (1995).

Simpson (2002) describes the exercise of identifying the relationship between economic prices and exchange rates as a challenging task that cannot be rewarding at times. This can be justified by the failure of basic theories in explaining the future exchange rate value using past values(Ghalayini, 2013).

Arising from such issues, it is of utmost importance to fill the knowledge gap of ascertaining whether exchange rates are driven by economic fundamentals such as oil price fluctuations and to what degree do such fundamentals have power to forecast exchange rates. It is with regret though that we have not yet come across a model that can successfully predict changes in exchange rates.

This paper intends to fill that knowledge gap by examining the relationship between crude oil prices and the South African Rand/US Dollar exchange rate and further analyse the strength and direction of causality between the two variables using nominal data from 1996 to 2015. Nominal data is preferred for this study compared to real data because nominal values are not adjusted for inflation over time. They remain as they are. It is at the interest of this study to further ascertain whether crude oil price fluctuations better explain the South African Rand/US Dollar exchange rate compared to other theoretically driven macro-economic fundamentals and whether crude oil price fluctuations contain useful information which can improve the forecasting of the South African Rand/US Dollar exchange rate.

The need for better exchange rate risk management for firms (especially those firms with dollarized liabilities), forex traders and monetary policy makers like the central banks has motivated undertaking this study. Finding information that can make a positive contribution towards profitable currency risk management is the main deliverable for this research project.

1.2 History of crude oil prices and the South African Rand/US Dollar exchange rate

1.2.1 History of crude oil prices

The recent crush in oil prices is not new. History indicates that just like all commodity prices, the international price of crude oil has always been undergoing strong volatility as a result of

frequent changes in the demand and supply of crude oil. We will look briefly at some of the major events that resulted to the crude oil price fluctuations dating back to 1979.

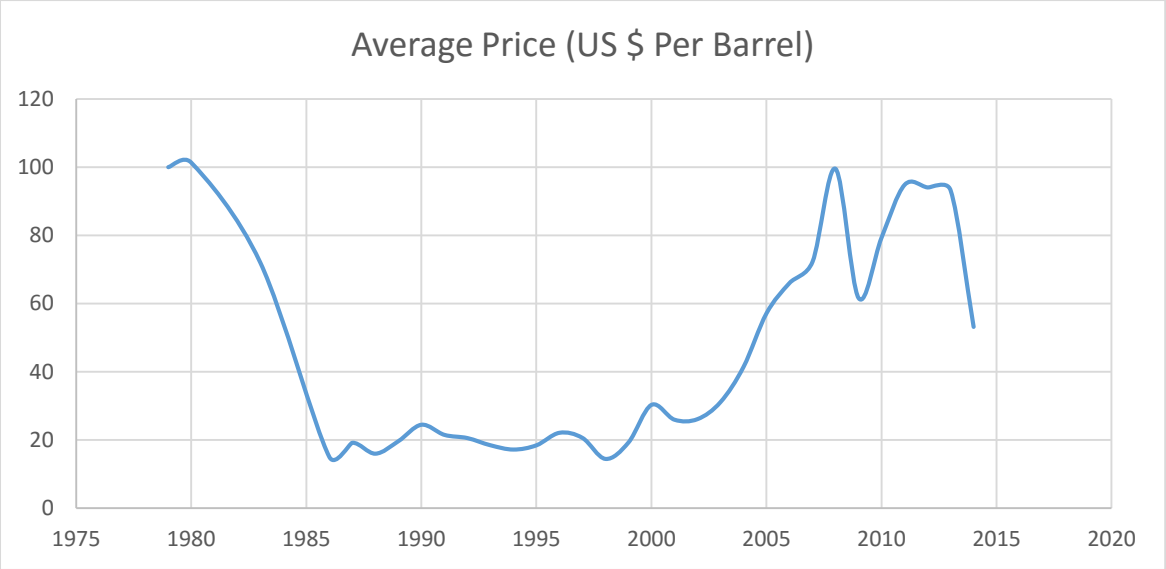
(Phillips, 1979) records that between 1978 and 1979, the oil industry in Iran (one of the largest oil producers in the world) experienced a long series of strikes from workers in the oil firms. These workers' slow down almost brought the oil industry to a dead stop. Consequently, production to major oil markets such as the US was cut. Crude oil prices shot up to around US $101.14 per barrel due to the increasing demand (Federal Reserve bank Economic Data, 2014).

According to data from the Federal Reserve Bank of St Louis, the period 1980 – 1986 saw a tremendous reduction in the price of crude oil to $25 a barrel as a result of poor demand response to the supply shocks. However, between 1986 and 1990, Saudi Arabia and Iran increased their production to regain market share as the war ended and that pushed crude oil prices up to about $64 a barrel.

Between 1990 and 1994, Iran began to invade Kuwait and that resulted in a drop in Kuwait exports resulting to a drop in the price of crude oil to $27 a barrel. The Asian financial crisis of 1998 further crushed crude oil market to $16 a barrel (IMF, 1998). After the crisis, prices recovered and crushed again to $26 a barrel in 2001 as a result of the invasion of Iraq that raised concerns about the Middle East stability. Between 2002 and 2007 Asia drove the rising demand for oil while oil production stagnated and this resulted to an alarming increase in the price of crude reaching a peak of $146 a barrel in mid-2008, just around the Global Financial Crisis of 2007-2008. However, the Global Financial Crisis, plunged down oil prices again to a low of $46 around December 2008.

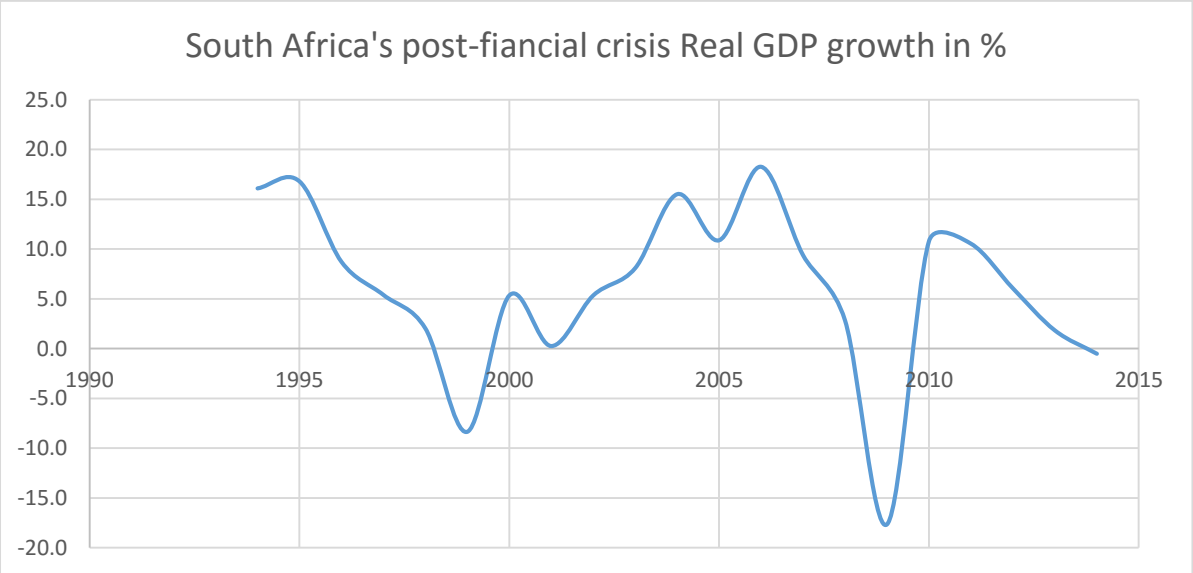
From 2009 – 2011, oil prices picked up following recovery from the global crisis reaching a maximum of $116 in 2011. Between 2011 and 2014 there was an Arab Spring and civil war that disrupted Libyan output which ultimately compromised the price of oil to $86 a barrel in September 2011. However, the oil market regained momentum again until June 2014 where a strong non-OPEC oil production, weak demand growth and OPEC's shift towards maintain a market share was observed. These circumstances forced the price of oil to plunge to an all-time low rate of $48 per barrel by January 2015. In the year 2015, the trend of oil prices had been on the decline and as of October, the price was at $43 a barrel and prices are expected to fall further as the market searches for new equilibrium (Ro, 2014). We have also included figure 1.2 for giving a better appreciation of the behaviour of the South African economy as the price of oil fluctuated before and after the financial crisis of 2008

Figure 1.1 Crude oil prices since 1979



Source: Federal Reserve Bank of St Louis

Figure 1.2 South Africa's Average GDP growth rate post financial crisis



Source: Federal Reserve Bank of St Louis

1.2.2 History of the ZARUSD exchange rate

Ever since the dual exchange rate regime was abolished in March, 1995, the South African Rand has seen an unprecedented depreciation against the US Dollar in the subsequent years. In

this section, we review the history of the Rand against the US Dollar dating back to 1979 as we have done for crude oil prices above.

Since the introduction of the Rand in 1961 until 1982, a Rand was worth $1.40. During this time, the Rand replaced the South African pound at R2 = 1 Pound. However, due to mounting political pressures, increasing international isolations for South Africa and sanctions due to apartheid, the currency was devalued and in 1985, the Rand was trading at R2.40 per Dollar (Mandalos, 2014). The local currency gravitated around that rate against the Dollar until 1989.

In the early 1990s, the signs were indicating that South Africa was destined for black majority rule and the frequent reforms that were being announced brought some doubts about the future of South Africa. Consequently, a further depreciation of the Rand against the Dollar was seen, reaching rates of about R3.60 per dollar in 1994, the year of the first democratic elections in South Africa.

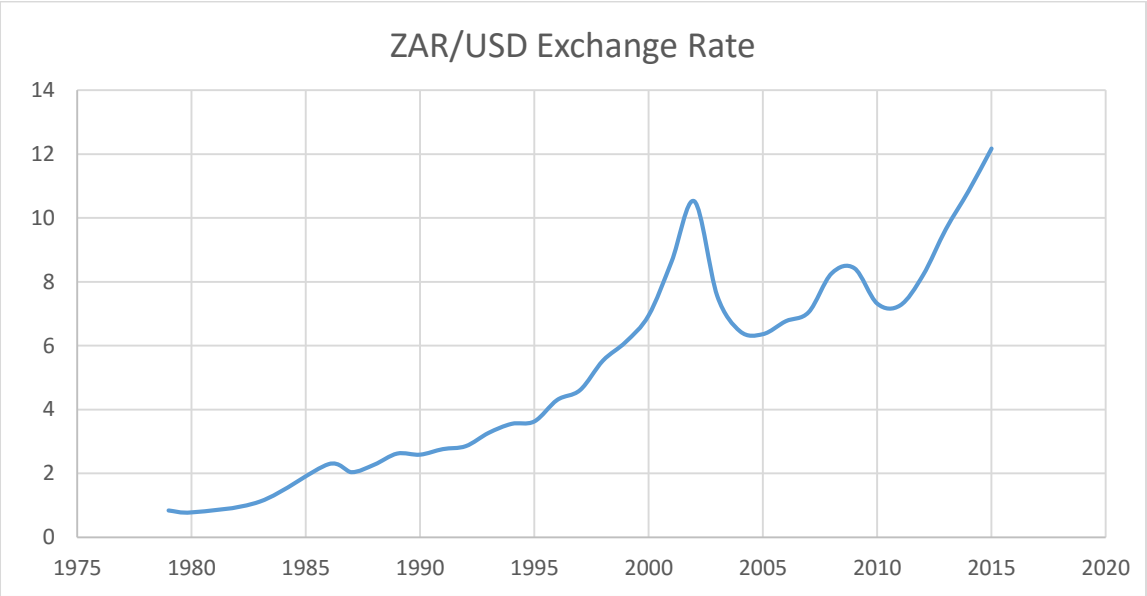
On the 10th March 1995, South Africa abolished the dual exchange rate system and regime, which resulted in a further sell-off for the local currency. By June 1996, the currency was trading at R4.50 against the US Dollar. Between 1998 and 1999, the election of President Thabo Mbeki and the appointment of Tito Mboweni as the first black South African Reserve Bank Governor, brought a lot of scepticism about the future stability of South Africa's economy and saw the value of the Rand slide further down to around R6.00 per US Dollar (Mandalos, 2014). The controversial 2001 land reforms in Zimbabwe which were soon followed by the September 11, 2001 US World Trade Centre attacks, saw the Rand incredibly crushing, reaching a historical rate of R13.84 against the US Dollar on the 21st December 2001.

This sudden depreciation of the Rand, led to a diligent investigation that was undertaken by the country authorities from which a great recovery was noticed. Between February 2003 and August 2008 the Rand fluctuated between R5.64 and R8.06 per US Dollar. However, the global financial crisis of 2008 which precipitated into a devastating recession drained all the efforts to improve the value of the local currency, plunging down the Rand to a shocking rate of R11.85 per US Dollar in October 2008.

From May 2009 to December 2012 the Rand recovered and traded between R6.64 and R8.66 per US Dollar. The beginning March 2013 saw the South African Rand taking a downward trend till today, where in September 2015 it reached one of the highest rates in its life time (R13.64 per US Dollar). At the time of conducting this study (October 2015), the monthly

trading range for the Rand was R13.29 – R13.64 according to data collected from the Federal Reserve Bank of St Louis.

Figure 1.3 History of South African Rand/US Dollar exchange rate



Source: Federal Reserve Bank of St Louis

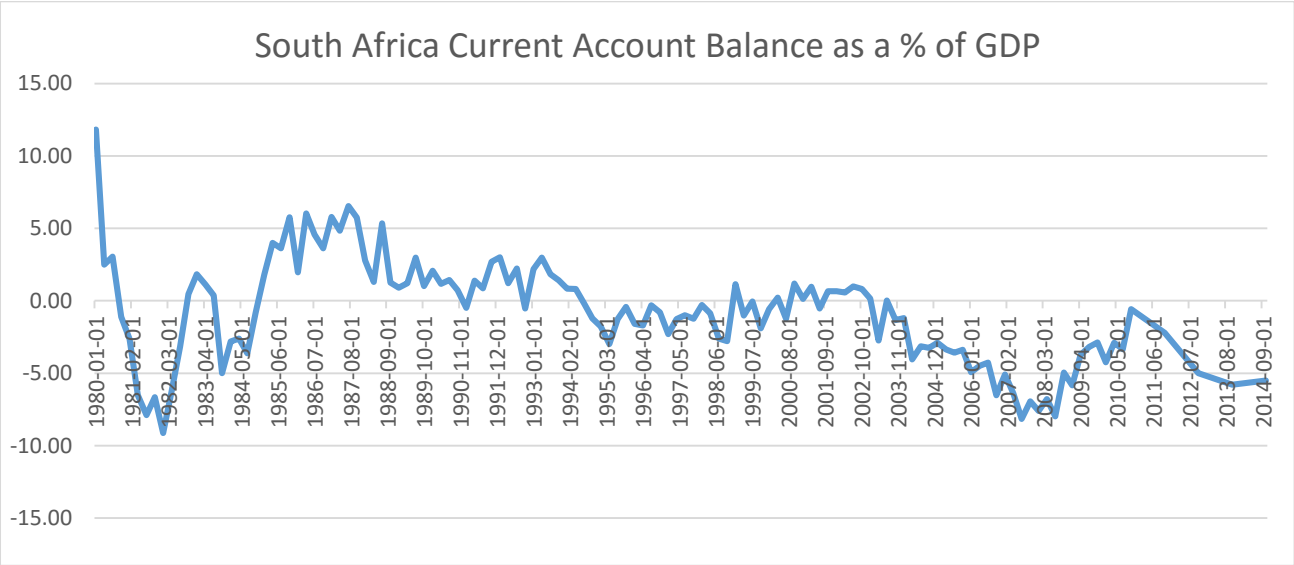
This persistent plunge in the value of the South African Rand against the US Dollar can be attributed to a number of factors. Historical data collected from the Federal Reserve Bank of St Louis Database indicates that South Africa's current account deficit has worsened in the past 4 years (See figure 1.3 below), reaching highs of 5.8 % in the year 2013. This increases foreign investors' risk aversion for South Africa and results in capital flight to safer markets (Mandalos, 2014).

Another major cause for concern as highlighted by the recent IMF staff visit of 1-9 June 2015 to South Africa to discuss the outlook, risks and policy challenges facing the South African Economy is the Eskom electricity crisis (IMF, 2015). There has been severe electricity shortages since 2008 which have paralysed growth, reduced economic activity and discouraged investment (IMF, 2015). This situation can worsen the current account deficit if it persists.

Since June 2014, when the OPEC decided to leave oil prices to be determined by the market, we have seen global crude oil prices dramatically dropping. On the one hand, past research findings found a negative relationship between the exchange rates and oil prices (Clostermann

& Schnatz, 2000; Kin & Courage, 2014). However, for the South African Rand/US Dollar exchange rate, it has not been the case with the recent drop in oil prices. Instead of the local currency gaining strength, it has depreciated further, which opens a debate on what factors are really driving the movement of the South African Rand and to what extent.

Figure 1.4 South Africa's current account deficit as a % of GDP



Source: Federal Reserve Bank of St Louis

1.3 Objectives of the study

The objectives of this study can be summarized as follows:

1. To determine the relationship between crude oil prices and the South African Rand/ US Dollar exchange rate and ascertain the direction of causality between the two variables.
2. To ascertain whether oil prices better explain the South African Rand/US Dollar exchange rate movement compared to other theoretically driven macro-economic variables.
3. To examine the ability of oil prices to forecast the volatility of the South African Rand/US Dollar exchange rate

1.4 Data & Methodology

This study will draw from the works of Chen and Chen (2007) and Aliyu (2009). It will adopt a VAR model and granger causality technique to get new insights into the relationships that

exist between oil prices, the ZARUSD exchange rate, inflation, interest rate, business cycles and money aggregates in South Africa. The VAR-based integration technique will be applied to examine the sensitivity of exchange rate volatility to changes in oil prices, interest rate, business cycles and money aggregates in the long run. Short run dynamics will be checked using a vector error correction model.

To check for time series properties for the variables used, unit root tests will be applied. The Augmented Dickey Fuller (ADF) and KPSS tests will be used to test for stationarity and further investigate the possibility of cointegration among the variables.

The study will attempt to determine how the exchange rate reacts in the long run to changes in oil prices, interest rates, business cycles (share price indices) and money aggregates (broad money supply). A vector auto regression model of order p (VAR (p)) adopted from Aliyu (2009) will be used. The short run effects of oil prices, interest rates, business cycles, inflation and money aggregates in the short run will be examined by using the short run vector error correction model (VECM).

Monthly data from 1996 to 2015 will be collected from the Federal Reserve Bank of St Louis Database. We will then analyse whether including oil prices and the other five variables as determinants of the ZAR/USD exchange rate improves the model's predictive power (forecasting power) as we compare the predictions of the VAR model with those of the VEC model.

1.5 Outline of the study

This paper has been organised into 5 (five) chapters. The next chapter reviews previous academic literature on the relationship between crude oil prices and exchange rates. Chapter 3 describes the methodology and data to be used in this study. Chapter 4 will be the empirical analysis aligned with the methodology and data from Chapter 3. In Chapter 5, we basically conclude and make recommendations for further research.

CHAPTER 2. LITERATURE REVIEW

2.1 Introduction

Ever since the breakdown of the Bretton-Wood system, there has been an increase in currencies' volatility around the world which has mobilized a number of studies that have been undertaken to examine the nature of the relationship between the exchange rates and other macro-economic fundamentals (Aliyu, 2009; Amano & Van Norden, 1998; Chinn & Alquist, 2000; Ferraro, Rogoff, Rossi, & National Bureau of Economic Research., 2012; Ghalayini, 2013; Gounder & Bartleet, 2007; Isard, 1995; Korhonen & Juurikkala, 2007; Rosenberg, 2003; Schaeffer, 2008; Schaling, Ndlovu, & Alagidede, 2014).

The purpose of this chapter is to articulate the theoretical concepts of this study. This chapter is organized as follows: Section 2.2 explores the fundamentals of exchange rate modelling and forecasting. It reviews the strengths and weaknesses for the exchange rate modelling and forecasting models. Section 2.3 reviews theoretical studies on the effects of oil prices and exchange rates. Section 2.4 reviews theoretical studies on the effects of exchange rates on oil prices. Section 2.5 explores literature on oil price's ability to forecast exchange rates. Section 2.6 concludes.

2.2 Fundamentals of Exchange Rate Modelling and Forecasting

Theoretically, currencies are expected to gravitate towards their real long-run equilibrium value over time (Ghalayini, 2013). However, to this day, economists still cannot unanimously define the exchange rate that determines the long run equilibrium value for any given currency. The methodology that can be used to determine this value is still unclear. Ever since the breakdown of the Bretton Wood Agreements, a number of exchange rate models have come up through research.

Messe and Rogoff (1983) attempted to compare structural exchange rate models and time series exchange rate models' performance in out-of-sample forecast when compared to the random walk model. They came up with forecasting puzzles and purchasing power parity (PPP) theories which are still being criticized for having limitations (Rosenberg, 2003).

The theory on the PPP model states that there exists a long run-run equilibrium between exchange rates and price levels. Cassel (1918) presented this theory and it is based on the law of one price which states that identical goods should sell at the same price in different countries and that the exchange rate between the two currencies should allow this to happen. So, this theory assumes no price arbitrage between the two countries or markets. If the same item doesn't have the same price in two different markets, arbitrage transactions will take place where you find that goods are moved from lower price market for trade in higher price market.

So, mathematically the PPP relationship can be represented as follows:

$$S_t = Q_t \frac{P_{US\ dollar\ market}}{P_{Rand\ Market}}$$

Where, S_t is the nominal exchange rate (US Dollars/Rand) , $P_{US\ Dollar\ Market}$ is the price level in the US dollar market and Q_t is the purchasing power of the US Dollar relative to the South African Rand.

In as much as the PPP received popularity among economists and forex strategists, it is also recognized that this model has limitations that could have severe impacts because it does not take into consideration other fundamental factors that have an impact on the long term path of exchange rates (Rosenberg, 2003).

In the contrary, Hauner, Lee, and Takizawa (2011) conducted a comprehensive analysis of the three fundamental exchange rate models namely Purchasing Power Parity, Interest Rate Parity (IRP) and Behavioural models. In their study they used survey data of market expectations to identify which of these three exchange rate models appear to more align with market forecasters. The exchange rate expectations were found to be more correlated to inflation differentials and productivity differentials which according to the authors, the PPP and Balasa-Samuelson effects were common inputs into the expectations of the exchange rate movement by forecasters.

On the other hand, Simpson (2002) in his study of the relationship between commodity prices and the Australian Dollar asserts that empirical tests of exchange rate theories are generally unrewarding and none of these theories stand up well to investigations. He states in his paper that fundamental models of exchange rate determination have estimation problems. The

models are often mis-specified. Simpson further explains that there is inconclusive and mixed evidence supporting the Purchasing Power Parity (PPP) hypothesis. He believes that inflation differentials alone cannot explain changes in the exchange rates. In agreement with Messe and Rogoff (1983), he claims that the random-walk hypothesis has outperformed more sophisticated econometric models in predicting future changes in exchanges rates.

Meese (1990) shared similar sentiments with Simpson and highlighted that the models themselves may not be linear or may have omitted some variables hence their accuracy can be inconclusive at times. This was further concurred by Rogoff and Stavrakeva (2008). In their paper, they alluded to the fact that understanding the link between exchange rates and macroeconomic fundamentals has been one of the central challenges in international finance. They also attested to the fact that in as much as exchange rates are an asset price and highly volatile, they also reflect macroeconomic fundamentals such as interest rates, purchasing power and trade balances.

Another important aspect highlighted by Rogoff and Stavrakeva (2008) is the fact that most of the exchange rate models are only able to forecast with better accuracy the long term horizons ie 2- 4 years whereas policy makers such as central banks are more interested in the short term (1 month to 1 year) horizon. So, short terms forecasts have been less succesfull according to Rogoff and Stravrakeva (2008).

Nonetheless, it is still at the interest of this study to find information that can assist in finding a profitable way for currency risk management and volatility forecasting for firms. The volatile exchange rates make international trade and investment decisions more difficult because it increases exchange rate risk (Englama et al., 2010).

2.3 The impact of oil prices on exchange rates

While much work has been done on the impact of oil prices on exchange rates in oil exporting countries(Akram (2004); Alberola, Lopez, Ubide, and Cervero (1999); Clostermann and Schnatz (2000)) , there has been less evidence on similar literature for energy importing countries such as South Africa. Kin and Courage (2014) alluded to the fact that although the relationship between oil prices and exchange rates has been established before, especially for oil exporting countries, the findings cannot be generalised for oil importing countries given the dynamics in situations and environments. Oil prices, being one of the major global

determinants of economic performance call for major financial institutions such as central banks and governments to closely monitor the fluctuations in the price of this commodity so as to effectively design policies to address volatile exchange rates (Kin & Courage, 2014). Next, we look at some of the studies that have been conducted on the impact of oil prices on exchange rates for purposes of identifying some of the variables to be included in the model of our study.

Aliyu (2009) conducted an empirical investigation on the impact of oil price shocks and exchange rate volatility on economic growth in Nigeria using quarterly data from 1986 to 2007. After analysing the time series properties of this data, the author went on to examine the nature of causality among the variables. For purposes of examining sensitivity of real economic growth to changes in oil prices and real exchange rate volatility in the long run, the Johansen VAR-based cointegration technique was applied. To take care of the short run dynamics, the vector error correction model was used. Results of this study revealed a unidirectional causality from oil prices to real GDP and bidirectional causality from real exchange rate to GDP and vice versa.

A comparative study on the impact of oil price shock and exchange rate volatility on economic growth was conducted by Jin (2008) where his study revealed that an increase in oil prices has a negative impact on economic growth in China and Japan and a positive impact on the Russia's economic growth. Precisely, a 10% increase in the international prices of oil was found to be associated with a 5.16% growth on Russia's GDP and a 1.07% decrease on Japan's GDP. On the one side, the appreciation of the real exchange rate had a positive relationship to Russia's GDP and a negative relationship to Japan's and China's GDP.

Another similar study on oil prices and exchange rate volatility in Nigeria was done by Englama et al. (2010). Over the past decade, Nigeria has been either an oil exporting country or an oil importing country and that also attracted such studies for purposes of understanding the extent to which volatility in oil prices affect Nigeria's exchange rate. We will recall that in as much as Nigeria is regarded as the biggest producer of oil in Africa, producing over 2 million barrels of oil per day, oil consumption in the country relies heavily on the import of refined petroleum ever since the collapse of local refineries in the late 1980's (Aliyu, 2009).

Specifically the empirical investigation by Englama et al. (2010) examined the effects of oil price volatility, demand for foreign exchange and external reserves on exchange rate volatility

in Nigeria using monthly data from 1999 to 2009. The results indicated that a 1% increase in the international prices of oil increases the exchange rate volatility by 0.54% in the long run and 0.02% in the short run. On the other hand, a 1% increase in the demand for foreign exchange, increases exchange rate volatility by 14.8% in the long run.

In a further quest to measure the impact of oil price shocks on economic growth, inflation, real wages and exchange rate, a multivariate framework approach was adopted by Gounder and Bartleet (2007). They examined short run impacts using linear and non-linear oil price transformation in New Zealand. Linear price changer, asymmetric price increase and net oil price variables were found to impact positively on the economy than asymmetric price decrease. Their findings established a direct link between oil price shock and economic growth and an indirect link through inflation and the exchange rate.

In a further attempt to contribute to the ongoing debate around the influence of oil prices on exchange rates (Rautava, 2004) attempted to examine the relationship between oil prices and real exchange rate in Russia. The study applied the vector autoregressive (VAR) modelling and cointegration techniques to assess the impact of international oil prices and the real exchange rate on the Russian economy and its fiscal policy. The study found that the Russian economy was significantly influenced by fluctuations in oil prices and the exchange rate through long run equilibrium conditions and short run direct impacts.

Coming to the South African context on this subject, Schaling et al. (2014) conducted a study to examine whether the South African currency (Rand) moves in line with commodity prices. In their study, they analysed the associated causality using nominal data between 1996 and 2010. This study addressed the long and short run relationship between commodity prices and exchange rates. The findings that were identified in the study were that the two assets are not co-integrated and the two variables are negatively related with strong and significant causality running from commodity prices to exchange rate and not vice versa. However, the study identified the strength of the relationship as significantly weaker compared to other OECD commodity currencies.

Kin and Courage (2014) also investigated the impact of the oil prices on the nominal exchange rate in South Africa using the generalised autoregressive conditional heteroscedasticity (GARCH) model. The authors used monthly time series data spanning the period 1994 to 2012. Their findings reveal that an increase in oil prices leads to a depreciation of the exchange rate.

In their further discussion of the results, they alluded to the fact that oil prices are a very important variable in determining the strength of the South African currency and its volatility. They further stated that a highly volatile exchange rate in South Africa can be recognised as a problem that has challenged South Africa for more than a decade.

2.4 The impact of exchange rates on oil prices

In macroeconomics, exchange rates have long been known for having a significant impact on the import and export of goods and services. Thus, exchange rates are expected to influence the prices of those products and services that are traded across different countries with different currencies. With South Africa importing more than 90% of its crude oil requirements (Kin & Courage, 2014), we expect the country to be exposed to an oil price shock that can come as a result of the weakening of the Rand against the Dollar, bearing in mind that the key economic sectors in South Africa (transport and agriculture) are heavily dependent on oil products. Another important factor to note is that the US Dollar is mainly used as the invoicing currency for international crude oil price trading. So, the volatility of the US Dollar is likely to result in the fluctuation of the international price of crude oil. Next we look at studies that have been conducted on the impact of exchange rates on oil prices.

An interesting piece of work in this area was done by Zhang, Fan, Tsai, and Wei (2008) where they conducted a research on the spill over effects of exchange rates on international crude oil prices. For purposes of analysing the effects of exchange rates on oil prices they used econometric techniques such as VAR based co-integration, VAR models and ARCH models to test the Granger causality between three spillover effects namely: mean spill over, volatility spill over and risk spill over. Their analysis of the influence of the US Dollar exchange rate on oil prices was based on a market trading perspective.

Key findings from the Zhang et al. (2008) study revealed that a long term equilibrium cointegration relationship exists between the US Dollar exchange rates and the international crude oil prices. What can be specifically noted from their study is that the increased change in volatility of the US Dollar exchange rate results in international price of crude oil picking up slowly reaching its highest point after 1 year. This then implies that the depreciation of the US Dollar was a key factor in driving up the international price of crude oil. Another key finding is that the influence of the US Dollar exchange rate on the on the price of crude oil proved to be significant in the long term not in the short-term.

On the other hand, Krichene (2005) used a structural equation model to establish a relationship between oil prices and changes in the nominal effective exchange rate (NEER) of the US Dollar and interest rates. He used a VAR based cointegration approach to analyse IMF crude oil price index data from 1970 to 2004. The theoretical framework that he used was based on the purchasing power parity and local price channel theories. Specifically, the finding that came out from this study was that both interest rates and the nominal effective exchange rate have an inverse influence on crude oil prices.

However, in as much as Beckmann and Czudaj (2013) acknowledge that the influence of exchange rates on oil prices is still not a clear cut, they argue that a finding that real effective exchange rates and real oil prices are cointegrated may either be driven by a relationship between the two variables in nominal terms or originate from price dynamics. Using a multivariate Markov-switching vector error correction model (MS-VECM), they show that the results in terms of the nature of causality between exchange rates and oil prices depends on the choice of the exchange rate measure. On top of that, they demonstrate that time-varying causality patterns mainly run from nominal exchange rates to nominal oil prices.

2.5 Determinants of exchange rate volatility

There is quite a debate in as far as determining the major factors that drive exchange rates' volatility across the globe. Different authors using different scenarios and different theories come up with different factors behind the movement of exchange rates. The failure of basic exchange rate theories such as the purchasing power parity (PPP), the Interest Rate Parity (IRP) and their limited explanation power has motivated the multivariate co-integration analysis which seeks to give clarity whether exchange rates are driven by economic fundamentals and to what degree (Ghalayini, 2013).

The birth of the Euro in 1999 motivated a number of studies to determine the long term value for this new currency and to ascertain whether this currency was undervalued or not. Chinn and Alquist (2000) in their attempt to find factors that explain the Euro/US Dollar exchange rate developed a monetary model for this Euro/US Dollar exchange rate to track its progress. This approach identified money stocks, interest rates, inflation rates and prices as variables that interact with the exchange rate. These variables were identified as determinants of the Euro/US Dollar exchange rate.

A similar piece of work was also done by Clostermann and Schnatz (2000) in attempting to empirically address the medium and short term forces that drive the Euro/US Dollar exchange rate. In their paper, they argue that if the PPP was the only driving force behind the nominal exchange rate, the real exchange rate would have to be constant over the same time horizon and however, econometrically that kind of relationship cannot be convincingly proven. Since the Euro was still new, they constructed a "synthetic" Euro/US Dollar exchange rate for the period 1978 to 1998. Using cointegration approaches, the authors were able to identify the international real interest rate differential, relative prices in the traded and non-traded goods sectors, the real price of oil and the relative fiscal position.

Another recent study by Kakkar and Yan (2014) where they attempt to provide clarity on the persistent deviations of nominal exchange rates. Real economic shocks such as sectoral technology shocks and monetary shocks were identified as the two major strands of shocks behind the persistent exchange rate volatilities. They also hypothesized a third factor that can affect exchange rates which is shocks to the global financial system. A proxy to this kind of shock was given as commodity prices such as gold or oil prices. Specifically, the main finding from this study was that sectoral total factor productivity differentials, real interest rate differentials and commodity prices which represented real technology shocks, monetary shocks and global financial system shocks respectively can successfully explain the medium to long term exchange rate volatilities for 14 exchange rates against the US Dollar using data from 1970 to 2006.

2.6 Exchange rate volatility forecasting and oil prices

An investigation to determine whether oil price shocks have a stable forecasting power to the nominal Canadian Dollar/US Dollar exchange rate was undertaken by Ferraro, Rogoff, and Rossi (2015). This study focused on determining whether a country's major commodity export can predict its exchange rate movements in a pseudo out-of-sample exercise. Using daily frequency data, they were able to capture co-movements between the two variables. Apart from the Canadian/US Dollar exchange and oil prices, they also demonstrated that the results are similar for other commodity prices/exchange rate pairs such as the South African Rand-US Dollar exchange rate and gold prices, Norwegian Krone-US Dollar exchange rate and oil prices and the Australian Dollar-US Dollar exchange rate and oil prices. The findings

suggested that knowing the future value of commodity prices can be useful in forecasting exchange rates as well.

Chen and Chen (2007) also conducted a similar exercise where above and beyond investigating on the long-run relationship between exchange rates and oil prices, they went to the extent of examining the predictive ability of oil prices on future exchange rates movements using data from the G7 countries, spanning the period 2005 to 2010. After running some predictive regressions, the results pointed out to the fact that real oil prices have significant forecasting power. However, the out-of-sample predictions indicated greater forecasting power in the long term than short term.

On the other hand, Chen, Rogoff & Rossi (2008) argued that exchange rates also contain some robust forecasting power over commodity prices. In their study, they introduce a concept of "commodity currencies" meaning currencies for countries where the main export is a commodity. What we can specifically note about their findings is that the relationship was found to hold for both in-sample and out-of-sample. In the contrary, due to the commodity price's tendency to be sensitive to current conditions due to both demand and supply, commodity prices tend to be inelastic. As a result, the reverse relationship of commodity prices forecasting exchange rates was found to be less robust.

A similar exercise was also pursued by Breitenfellner and Cuaresma (2008) where they performed an evaluation to determine whether changes in in the US Dollar/Euro exchange rate contains information about future changes in the international price of oil. For their preliminary analysis they ran Granger causality tests between changes in the oil prices and exchange rate using the VAR model and the results indicated a negative correlation between the two variables. The ultimate findings however were relatively inconclusive. Nonetheless, what we can specifically pick from this study is that it was able to show that including exchange rate information in the model significantly improves the forecast of future oil prices.

2.7 Literature Review Summary

The studies that we have just reviewed have given us important findings on a more general link between exchange rates and commodity prices. We have seen that in the case of commodity currencies there seems to be more evidence that commodity prices are affected by currencies than the other way round (Chen et al., 2008). On the other hand, there's still

many other studies from which we find that they suggest the opposite conclusion or an inconclusive finding (Aliyu, 2009; Rautava, 2004; Englama et al., 2010).

Furthermore, we can clearly see that there are definitely mixed findings on the influence of oil prices and exchange rates and vice versa. It is apparent that there is currently no clear cut on whether including exchange rate information improves the forecast of oil prices or not and vice versa. The findings are really dependent on the country being studied or currency being studied. They cannot be generalised across all currencies in the world. The findings are dependent on whether nominal or real variables are used or whether the currency in question is a commodity currency or depending on whether the country is an oil-exporting country or not. Our attempt is to contribute to this body of literature by considering nominal data for the South African Rand/US Dollar exchange rate and oil prices employing VAR based co-integration techniques from Aliyu (2009) and further examining the ability of oil prices to forecast future South African Rand/US Dollar exchange rate.

CHAPTER 3. METHODOLOGY AND DATA

3.1 Introduction

In this chapter we highlight the methods in which the empirical work in this study will be carried out. We aim at providing a theoretical basis for exchange rate modelling and forecasting using VAR analysis, co-integration techniques and Vector Error Correction modelling. We also discuss in detail the data used in the study, its sources and construction of variables. The rest of the chapter is organized as follows: section 3.2 discusses the theoretical models to be used in this study and section 3.3 describes the data to be used for analysis.

3.2 Exchange rate modelling and forecasting for a net oil importing economy.

Research has since indicated that the fluctuation of international oil prices can have some ripple effects on economic activity and these effects are expected to be different for oil importing countries and oil exporting countries (Al-Ezzee, 2011). While the increase in oil prices can be considered as good news for oil exporting countries, it can be considered as bad news for oil importing countries and the reverse is true (Amano & Van Norden, 1998).

This study attempts to establish the relationship between oil prices and the South Africa Rand/US Dollar exchange rate. Further we will establish whether international oil prices contain some useful information for forecasting the South African Rand/US Dollar exchange rate both in the short and long run. We will adopt the framework approach used by Aliyu (2009) to get new insights on the link between the ZARUSD exchange rate , international oil prices, inflation, business cycles interest rates and money aggregates. For the forecasting exercise we will employ the approach used by Breitenfellner and Cuaresma (2008).

3.3 Test for stationarity

3.3.1 Augmented Dickey Fuller Test

The time series properties (stationarity and unit root) of the variables that will be used in our model will be examined using the Augmented Dickey-Fuller (ADF) test and KPSS test. These

tests are important to ascertain whether cointegration techniques can be applied to study possible long run relationship among the variables (Dickey and Fuller, (1979)). The following equation will be used:

$$\Delta y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 trend + \sum_{j=1}^{p} \beta_j \Delta y_{t-j} + \varepsilon_t \qquad (1)$$

Where Δy_t denotes the first difference of y_t that comprises of either the international oil prices or the ZARUSD exchange rate, p is the lag length of the augmented terms for y_t, α_0 is a constant and α_2 is a coefficient on a time trend. Equation (1) above allows us to determine whether y_t is a stationary series.

Null hypothesis

H_0 :Series contains a unit root

H_1 :Series doesn't contain a unit root

3.3.2 Test for stationarity - KPSS test

We also use this second method to test for stationarity in our data series. We still use equation (1). However the null hypothesis for this test is as follows:

H_0 :Series is stationary

H_1 :Series is non stationary

Differences are taken on the variables until we are not able to reject the null hypothesis

3.4 Lag length selection

The vector error correction model and the Granger test which we are going to do in the next subsections will critically depend on an optimal choice of the lag length. Too long or too short a lag could result in potential errors in our model specification. This was also highlighted by Lee (1997) where he alluded to the fact that if the lag length is too long or too short, there could be biasness in model specification and it can cause a loss to the degrees of freedom. Braun and Mittnik (1993) further demonstrated the importance of lag length determination by showing that if lag length estimates for a VAR model are inconsistent with the true lag length, even their

impulse response functions and variance decompositions become inconsistent. Also, choosing higher lag lengths than the correct ones could result to mean square forecast errors and choosing lower lag lengths than correct one could result to autocorrelated errors (Lütkepohl, 1993).

For the purpose of our study, we do a step-wise test to the monthly data lags from zero to three in line with Simpson (2002) and use both the Akaike (AIC) and Schwarz Information Critera to find the appropriate number of lags. We also confirm the appropriateness of the lag length choice by testing for autocorrelation in the residuals. If there is autocorrelation in the residuals, we modify the lag length until there is no autocorrelation.

3.5 Test for autocorrelation

In this section we aim at identifying whether residuals from our model are correlated over time. The importance of this test was highlighted by Breusch (1978) where he alluded to the fact that if the residuals of a linear model are autocorrelated, the ordinary least squares (OLS) estimates tend to be inefficient and in dynamic models, the least squares estimates tend to be both inefficient and biased.

To address this problem of autocorrelation, some standard pioneering work of Durbin and Watson (1971) proposed a Durbin-Watson test statistic approach. However, we acknowledge that this test statistic can have some challenges when some of the regressors are lagged values of the dependent variable. An important contribution by Durbin (1957) and Durbin (1970) showed that it was possible to construct valid tests for autocorrelation using the OLS estimates under the null hypothesis that no autocorrelation is present.

In this study, we test for autocorrelation drawing from Durbin's work using the below hypothesis:

H_0: There is no autocorrelation in the residuals

H_1: Residuals are autocorrelated

If p-values for the autocorrelation test are greater than 5%, we cannot reject the null hypothesis.

3.6 Long run analysis: VAR and cointegration test

In time series analysis, when it can be ascertained that all variables used in a model are integrated of the same order, a general approach is normally employed. Firstly, we perform an estimation whether stable, long run dependencies exists. This step basically aims at determining whether the variables are cointegrated.

Granger (1988) noted that cointegration between two or more variables can be a sufficient test for the presence of causality in at least one direction. The concept of Granger causality test suggests that x is a cause of y if it contains some useful information in forecasting y. That is to say x is able to increase the accuracy in predicting y. We acknowledge the fact that the Granger test is sensitive to the number of lags in the regression and hence in this study we will use both the Akaike (AIC) and Schwarz Information Critera to find the appropriate number of legs.

In this study, the vector autoregressive (VAR) modelling with cointegration techniques will be used to examine how the ZARUSD exchange rate is affected by fluctuations in international oil prices, inflation, business cycles and money aggregates in the long run. There are two popular approaches for testing for cointegration. The first one was developed by Engle and Granger (1987) called a two-step estimator and the other one by Johansen(1988) and Johansen and Juselius (1990) called the maximum likelihood estimator. From an econometric point of view, cointegration between two variables indicates a long-term relationship between them, given by their stationary linear combination or cointegration equation (Aliyu, 2009).

Johansen and Juselius (1990) on the other hand, developed the maximum likelihood estimator for cointegration analysis. We estimate a VAR model of order p (VAR(p)) from which we can run the Johansen's cointegration test as follows:

$$EXC_t = \phi_0 + \sum_{i=1}^{p} \phi_i EXC_{t-1} + \varepsilon_t \qquad (2)$$

This VAR can be re-written in the vector error correction model (VECM) as:

$$\Delta y_t = \phi_0 + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-1} + \Pi y_{t-1} + \varepsilon_t \qquad (3)$$

Where y_t is a (6 x 1) matrix of ZARUSD exchange rate (EXC_t), oil price (OP_t), inflation (INF_t), business cycle (BC_t), money aggregates (MD_t) and interest rate (INT_t). ϕ_0 is the (6 x 1) intercept vector and ε_t is a vector of white noise process. Γ_i is a (6 x 6) matrix of coefficients and it contains information pertaining to the short run relationships among the variables. Π is a matrix that contains long run information in the data. In the event that the rank of Π is r, where r ≤ n-1, then Π can be decomposed into two n x r matrices α and β such that $\Pi = \alpha\beta'$ and β is a matrix of cointegration vectors (Aliyu, 2009; Cheung and Lai 1983).

Null Hypothesis:

$\boldsymbol{H_0}$: There is no cointegration between the variables

Alternate Hypothesis:

$\boldsymbol{H_1}$: There exists cointegration between the variables.

3.7 Short-Run analysis: Error correction model

Granger (1988) suggests that if there is evidence of cointegration between two or more variables, then an error correction model should also exist between those variables which can be used as a representation for short run dynamic relationships between the variables in question. An estimate of the error correction model can be written in the following form:

$$\Delta EXC_t = \emptyset_0 + \sum_{i=1}^{p-1} \emptyset_i \Delta EXC_{t-1} + \varphi ECT_{t-1} + u_t \qquad (4)$$

Where Δ is the difference operator. ECT_t is the error correction term derived from the long run cointegration relationship. u_t is the white noise error term. All other terms are as described before.

3.8 Granger Causality Test

Al-Ezzee (2011) argues that the models highlighted above do not fully explore the causal relationship between the variables because simple correlation doesn't necessarily indicate causation. Theory states that if two variables are cointegrated and of order one, then there must be a Granger causality (Granger, 1969; Engle, 1982) between those two variables in at least one direction.

Assuming two stationary series, x and y we estimate a bi-variate VAR model which can written as follows:

$$x_t = \alpha + \sum_{i=1}^{p} \beta_i x_{i-1} + \sum_{j=1}^{q} \gamma_j y_{t-j} + u_{x,t} \qquad (5)$$

$$y_t = \delta + \sum_{i=1}^{p} \theta_i y_{i-1} + \sum_{j=1}^{q} \phi_j x_{t-j} + u_{y,t} \qquad (6)$$

Suppose x and y are stationary variables and p and q are the lag lengths for x and y respectively, equations (6) and (7) above are valid for testing the causality of lagged changes on the ZARUSD exchange rate (where x is the stationary exchange rate series) and lagged changes on oil prices (where y is a stationary oil price series).

We attempt to test causality and its direction between the ZARUSD exchange rate and oil price data series. We base our attempt from the theoretical concept that if two variables are cointegrated and of order one, then there must be a Granger causality (Granger, 1969) between those two variables in at least one direction. So the idea is that OP_t (oil prices) causes EXC_t (ZARUSD exchange rate) if past values of OP_t can explain EXC_t and vice versa.

We examine the p-values of the coefficients for significance at 5% significance level. If the coefficients of oil prices (explanatory variable) are statistically significant, we reject the null hypothesis and conclude that they Granger cause the ZARUSD exchange rate (dependent variable).

Null hypothesis for equation (5):

H_0: OP does not Granger cause EXC

Null hypothesis for equation (6)

H_0: EXC does not Granger cause OP

3.9 Oil price's ability to forecast ZARUSD exchange rate

In this section we aim at evaluating whether fluctuations in international oil prices contain information about the future changes ZARUSD exchange rate. For this purpose we compare the predictions of the vector autoregressive (VAR) model and VEC model.

The specification of the VAR and VEC models can be interpreted as a monetary model of exchange rate determination with an added international oil price variable (Frenkel (1976); Meese and Rogoff (1983)). Frenkel assumes that the USD/ EURO exchange rate is determined by changes in the relative money supply (money aggregates), output and interest rate changes in the US and the Euro zone.

Specifically, for the purpose of examining the ability of the USD/EUR exchange rate to forecast international oil prices, Breitenfellner and Cuaresma (2008) drawing from the works of Frenkel specified two competing models as follows:

$$\Delta p_t = \phi_0 + \sum_{k=1}^{p} \phi_k \Delta p_{t-k} + \varepsilon_t \qquad (7)$$

And

$$\Delta v_t = \Theta_0 + \sum_{k=1}^{p} \Theta_k \Delta v_{t-k} + u_t \qquad (8)$$

Where $v_t = f(p_t, e_t, m_t, y_t, i_t)$ and $p_t = \ln(oil\ prices)$, $e_t = \ln\left(\frac{US}{EUR} exchange\ rate\right)$, $m_t = \ln\left(\frac{M1_{t,US}}{M1_{t,EUR}}\right)$, $y_t = \ln\left(\frac{industrial\ production_{t,US}}{industrial\ production_{t,EUR}}\right)$ and $i_t = (interest\ rate_{t,US} - interest\ rate_{t,EUR})$

Θ_0 is a 5 dimensional vector of intercept terms and Θ_k is a 5 x 5 matrix of parameters.

For short run dynamics, Breitenfellner and Cuaresma (2008) specified a VEC model as follows:

$$\Delta v_t = \Gamma_0 + \sum_{k=1}^{p} \Gamma_k \Delta v_{t-k} + \alpha\beta' v_{t-1} + u_t \qquad (9)$$

Where β is the cointegration vector defining the long run equilibrium among the variables and α is a column vector capturing the adjustment speed for each the components of v_t.

We aim at ascertaining whether including oil prices in our model improves the forecasting accuracy for the ZARUSD exchange rate. For that purpose we compare the predictions of the vector autoregressive (VAR) model and the vector error correction model (VECM) when oil prices have been included as the explanatory variable and when oil prices have not been included.

For the VAR model we use equation (8) and for the VECM we use equation (9). We estimate these models using monthly data from January 1996 to December 2009 and then produce out-of-sample forecasts. The observations corresponding to January 2010 is added to the estimation sample and we re-estimate the models and repeat the procedure for this new in-sample period. We repeat the procedure until 36 months of out-of-sample observations.

For each iteration in the procedure, we examine the following measures of forecasting accuracy; root mean squared error (RMSE) and mean absolute percentage error (MAPE). These measures are defined as follows:

$$RMSE = \sqrt{\frac{\sum_{t=1}^{T} e_t^2}{T}} \qquad (10)$$

$$MAPE = \frac{1}{T}\sum_{t=1}^{T} 100\frac{|e_t|}{y_t} \qquad (11)$$

Where T= is the number of observations, e_t = forecast error and y_t is the future value of a variable of interest at time t.

3.10 The Data

All the data series in this study were collected and formulated over the sample period 1996:01 to 2015:11. The data series used in this study and their sources is described as follows:

3.10.1 ZARUSD Exchange Rate

For the exchange rate data series, nominal ZAR/USD exchange rate data was collected from the Federal Reserve Bank of St Louis database. This is monthly average data running from 01

January 1996 to 01 November 2015 which makes a sample size of 239. These monthly averages are already pre-computed from daily exchange rates by the Federal Reserve Bank system.

The period 1996 to 2015 was selected so that we can capture some significant movements in the ZAR/USD exchange rate which includes scenarios such as the Rand crises of 1996, 1998, 2001, 2008, 2014 and 2015.

3.10.2 International oil price

For the international oil prices data series, monthly Brent crude oil prices were collected from the Federal Reserve Bank of St Louis database. Again, monthly average data running from 01 January 1996 to 01 November 2015, making a sample size of 239 was obtained.

3.10.3 Inflation

This variable was chosen as one of the exogenous variables because it is mainly advanced by basic exchange rate theories such as the purchasing power parity theory. The inflation variable will be measured as the natural log of consumer price indices in South Africa divided by the consumer price indices in the United States. Monthly consumer price index data for both South Africa and the US was obtained from OECD database running from 1 January 1996 to 1 March 2015, making a sample size of 231. Index units: 2010 = 100.

3.10.4 Interest Rate

Interest rate differentials is one other variable favoured by basic exchange rate theories such as the interest rate parity (IRP) theory hence the reason why it has been chosen as one of the explanatory variables for the ZARUSD exchange rate. This variable will be measured as the natural log of the difference between South Africa's interest rates and United States interest rates.

Interest rate monthly data for both South Africa and the US was collected from the OECD database running from 01 January 1996 to 01 March 2015.

3.10.5 Business Cycle

Business cycles are normally referred to as economic cycles, meaning the economy-wide fluctuations in production, trade and general economic activity over a longer period (several months or years) in a free-enterprise principled economy. This variable has been chosen because it has been considered by some literature as possibly influencing exchange rate movement (Ghalayini, 2013).

Share price indices are believed to closely track business cycles (Francis & Rudebusch, 1999). The South Africa's and US's all share indices will be used as computed by the OECD to capture the business cycle variable. These indices are normalised such that their levels in 2010 = 1. The share price ratio that will be captured is natural log of the South Africa's nominal share price divided by the US nominal share price indices. Monthly data spanning from 1 January 1996 to 1 March 2015 has been collected from the OECD database making a sample size of 231.

3.10.6 Money Aggregate

The breakdown of the Bretton Woods system motivated a monetary approach to exchange rate forecasting among researchers (Meese and Rogoff (1983); Frenkel (1976)). This approach states that the relative price of the two currencies is influenced by the supply and demand for money in the two countries.

The money aggregate variable measures the stock of money in circulation in a given country. For the purposes of our study, we assume that the broad money aggregate (M2) differential impacts the ZAR/USD exchange rate. The broad money index rate which will be computed as the natural log of South Africa's M2 divided by US's M2 as our money aggregate variable. Monthly data series for the M2 spanning from 1 January 1996 to 1 December 2013 making a sample size 216 was collected from the OECD database.

Broad money aggregate is preferred over narrow money (M1) aggregate because M2 basically contains M1. Other short and medium term deposits of households, local governments, public and private nonfinancial corporations and financial corporations are also taken into account.

CHAPTER 4. EMPIRICAL ANALYSIS

4.1 Introduction

In this chapter we present an analysis of the empirical results for our model. We first present the data descriptive statistics and analysis thereof. We look at the data descriptive statistics, time series properties and scatter plots for the key variables in our study. Subsequent sections contains the empirical analysis of the results from Engle-Granger test for cointegration, vector error correction model and Granger causality. Finally we present an analysis of empirical results on the test for oil price's ability to forecast the ZARUSD exchange rate.

4.2 Analysis of the data

We use the GRETL software for our data analysis. Considering the size of our data sample, we will use a conventional significance level of 5%.

4.2.1 Descriptive statistics

Table 4.1 below summarizes the descriptive statistics for the variables of interest in this study. The natural log has been taken on all data series to improve the interpretability and appearance of data on graphs.

Table 4.1 Descriptive statistics

	Exchange rate	Oil price	Money aggregate	Inflation	Interest rate	Business cycle
Variance	0.0733	0.4974	0.0000	0.0258	0.1792	0.1268
Skewness	-0.0688	-0.2057	-0.6827	0.1015	-0.1828	-0.1503
Median	1.9887	3.9076	1.2195	2.1352	1.8429	-0.4211
Mean	1.9980	3.8083	1.2187	2.1598	1.9055	-0.3904
Std. Deviation	0.2707	0.7053	0.0067	0.1605	0.4233	0.3561
Minimum	1.2923	2.2844	1.1988	1.8456	0.7227	-1.1447
Maximum	2.6494	4.8882	1.2325	2.4743	2.7936	0.5134
Kurtosis	-0.1596	-1.1992	0.7559	-0.8570	-0.2115	-0.6485

The ZARUSD exchange rate data indicate a standard deviation of about 0.2702. This tells us that we shouldn't expect a bigger spread of the data around its mean. The skewness is negative

which shows that the data may not be normally distributed, and the tail of the distribution points towards the left. The negative kurtosis indicates that the exchange rate data has a heavier tail and a sharper peak than a normal distribution. The mean and median are almost similar, which means we can expect outliers in this data series and a more symmetric distribution. The centre of the distribution is shifted towards the left hence the mean of 1.9980.

Oil price data series on the other hand indicate a standard deviation of 0.7053, which is a bit higher than the exchange rate series. The oil price series has a greater spread when compared to exchange rate series. Its skewness is negative. Therefore, the tail of its distribution points towards the left. Its kurtosis is also negative but higher than of exchange rate series which means that its peak is also sharper than that of a normal distribution. The oil price series has a mean of 3.8083 which means the centre of the distribution is shifted towards left.

4.3 Scatter plots

Figure 4.1 below shows that there is a weak positive linear relationship between exchange rate and oil prices. The correlation coefficient for the 2 variables is 0.4622. This implies that we can expect oil prices to move in the same direction as the ZARUSD exchange rate.

Figure 4.1 Scatter plot for ZARUSD exchange rate and oil prices

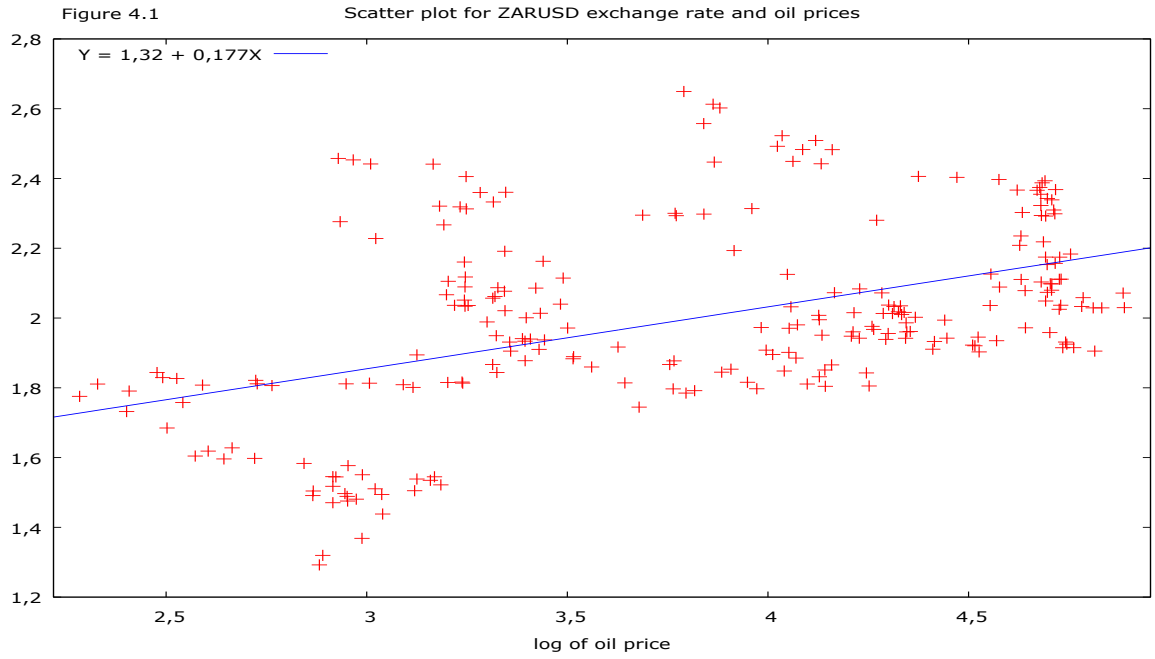


Figure 4.2 below depicts the nature of the relationship that exists between the ZARUSD exchange rate and the amount of money in circulation (money aggregates). These data series

have a correlation coefficient of -0.5939, which is a strong negative relationship. That is to say, the weakening of the Rand (high ZARUSD exchange rate) may be associated with a reduction of the money aggregate ratio.

Figure 4.2

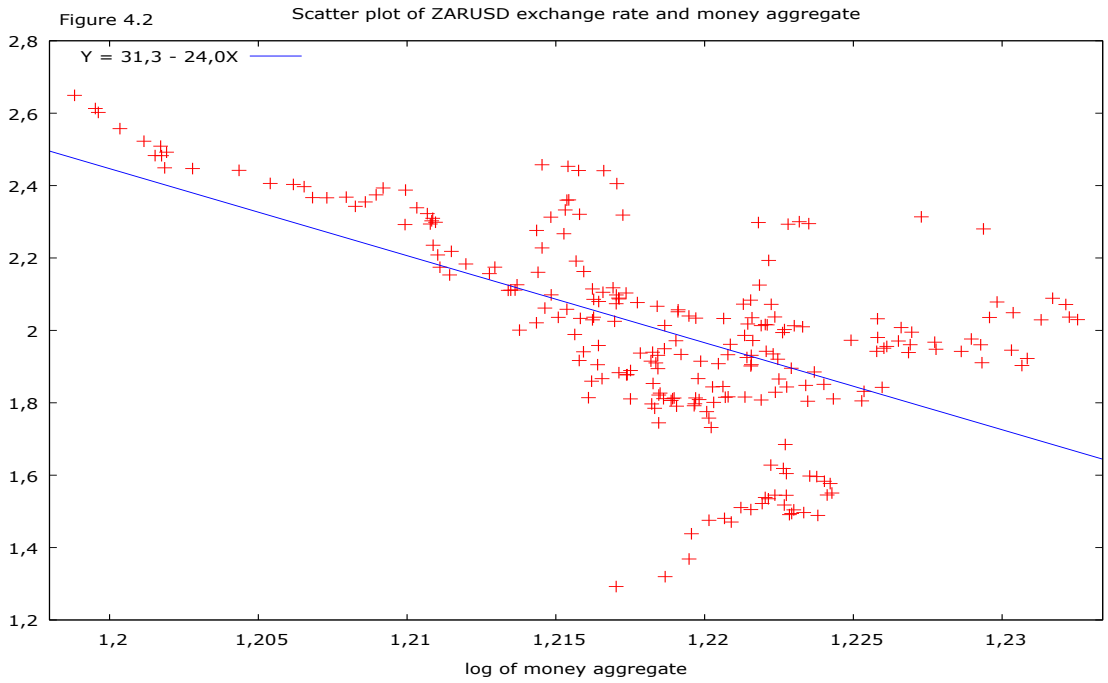
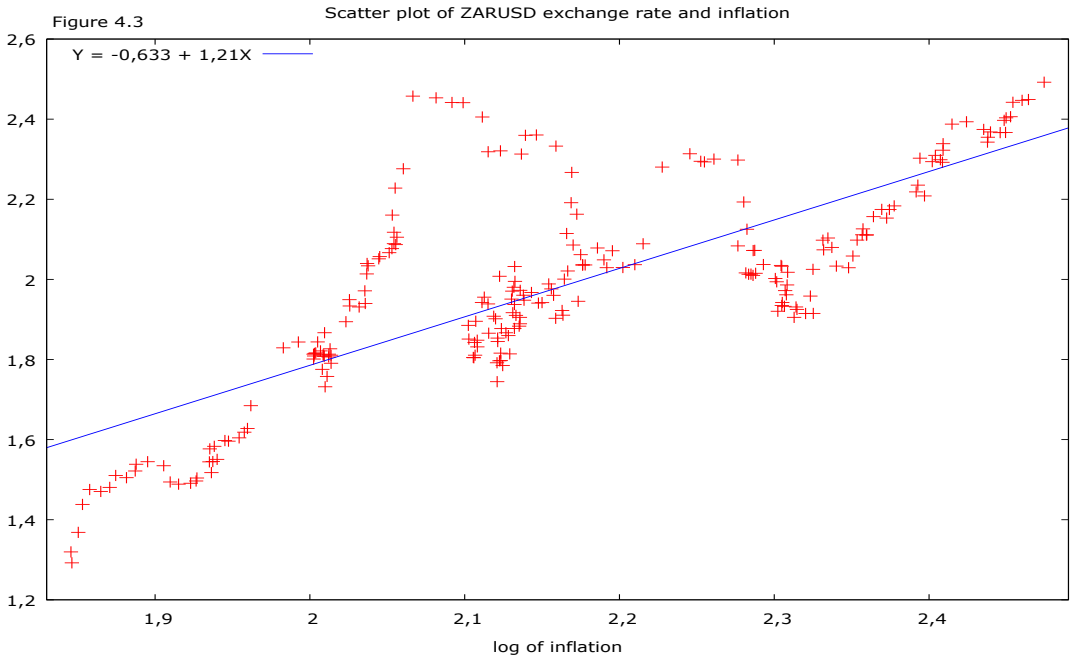
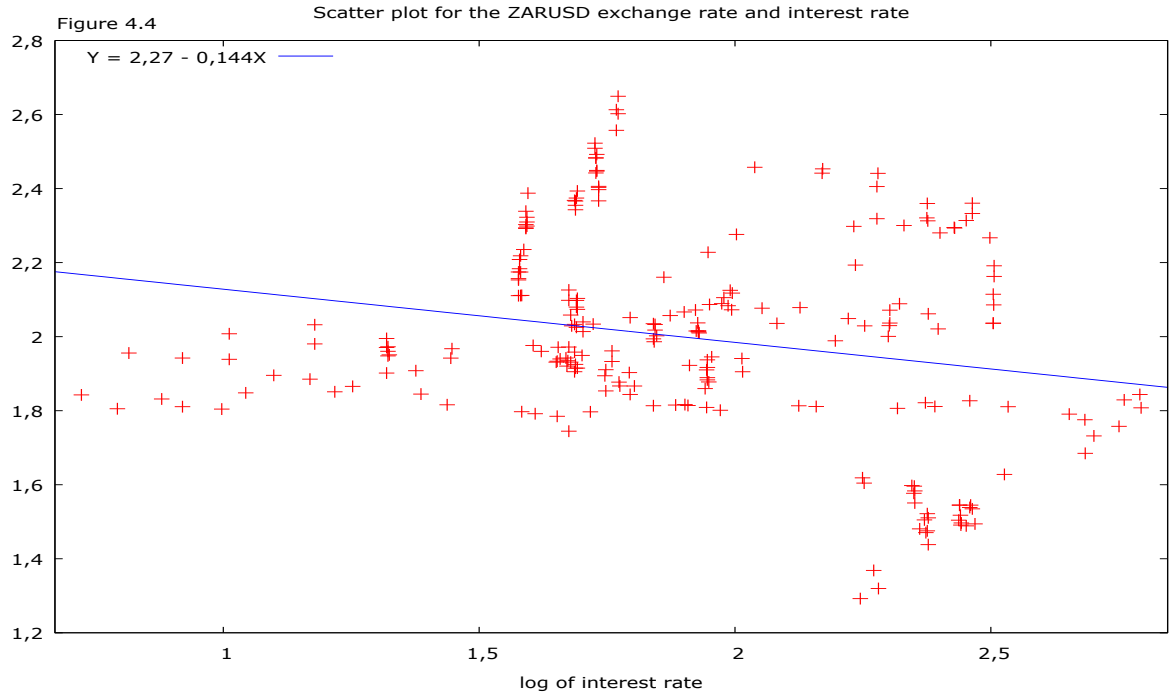


Figure 4.3 below shows the association between the ZARUSD exchange rate and inflation. The sampled data series shows a strong positive linear relationship between the two variables with a correlation coefficient of 0.7633. This could suggest that the weakening of the Rand against the Dollar has a strong relationship with the consumer price index ratio of South Africa and the US.

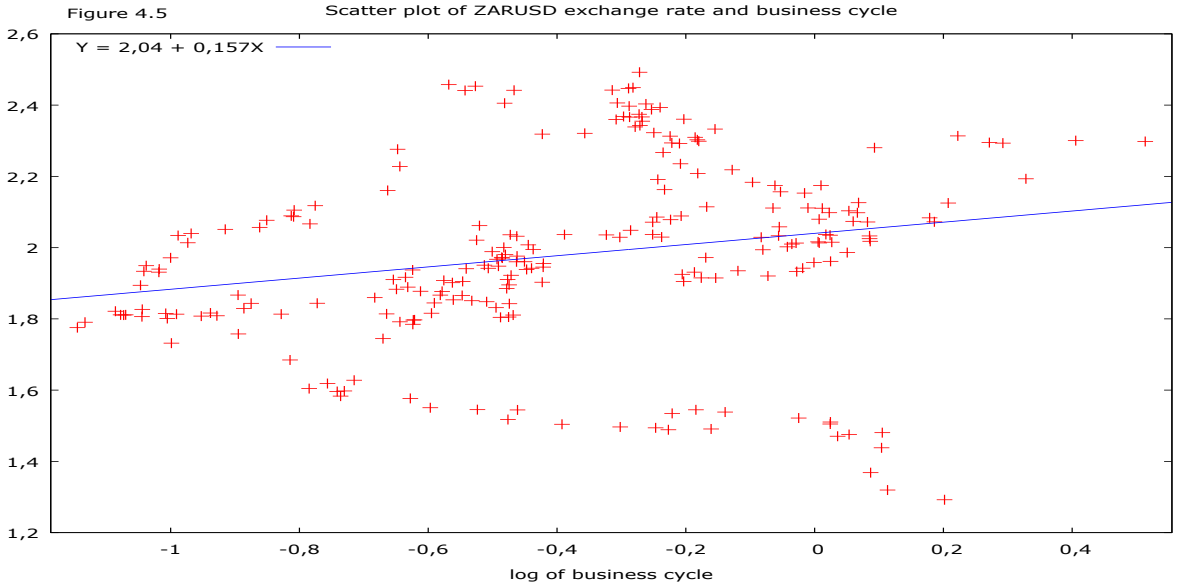


Next, figure 4.4 shows the relationship that exists between the ZARUSD exchange rate and interest rate differentials between South Africa and the US. The sample data series suggests a negative relationship between the two variables with a correlation coefficient of -0.2251.



Another weak positive correlation is observed between the ZARUSD exchange rate and business cycles (economy-wide fluctuations in production, trade and general economic activity) with a correlation coefficient of 0,2197. This could suggest that as the ratio of the

market share index between South Africa and the US increase (strengthening of the SA market or weakening of the US market), the ZARUSD exchange rate increases also.



4.4 Time series plots

Next, we look at the time series patterns and other observable features in our data series. For each plot we look at trends, co-movements, seasonality, data outliers and general variance of the data over time.

Figure 4.6 below depicts a time series plot for the ZARUSD exchange rate and oil prices over time. As suggested by the scatter plots, both the series seem to depict an upward trend, that is, the data measurements tend to increase over time and there is a constant. There seems to be also a co-movement between the two data series, with a slight delay on exchange rates. That is to say, exchange rates move after oil prices have made a fluctuation. There are no obvious outliers in our data series. There is also no constant variance in these series.

Figure 4.6

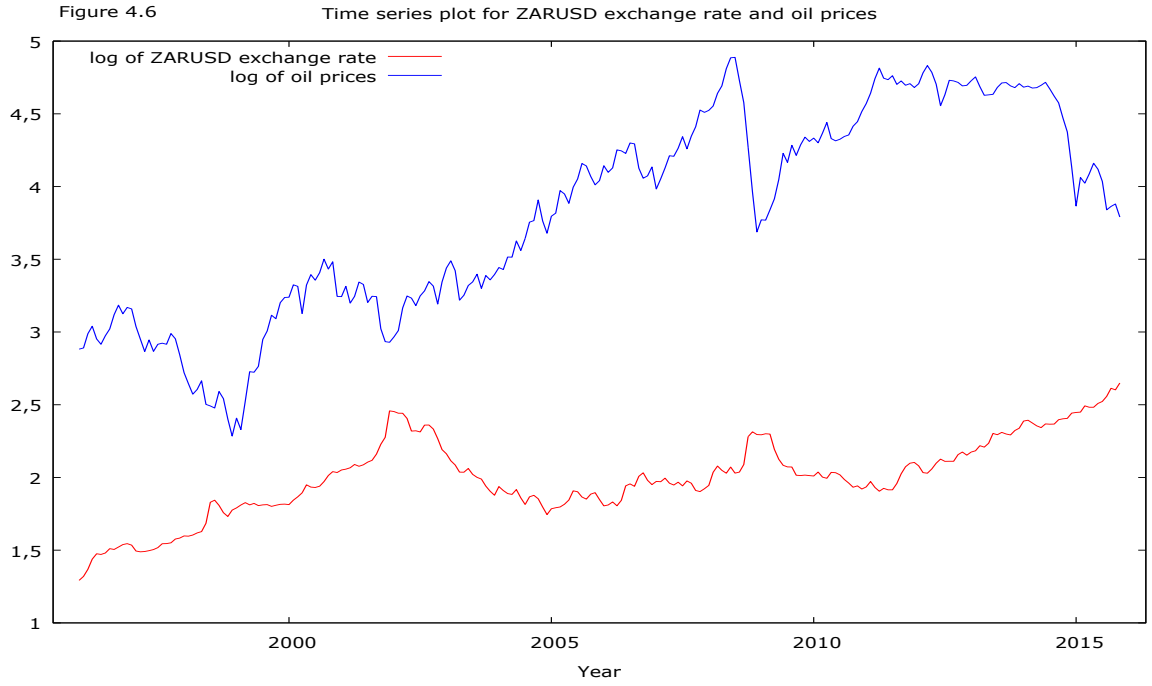


Figure 4.7 below shows the time series plot for money aggregates. It can be observed from the graph below that our data series has a downward trend and a constant. There is also no obvious seasonality in this data series.

Figure 4.7

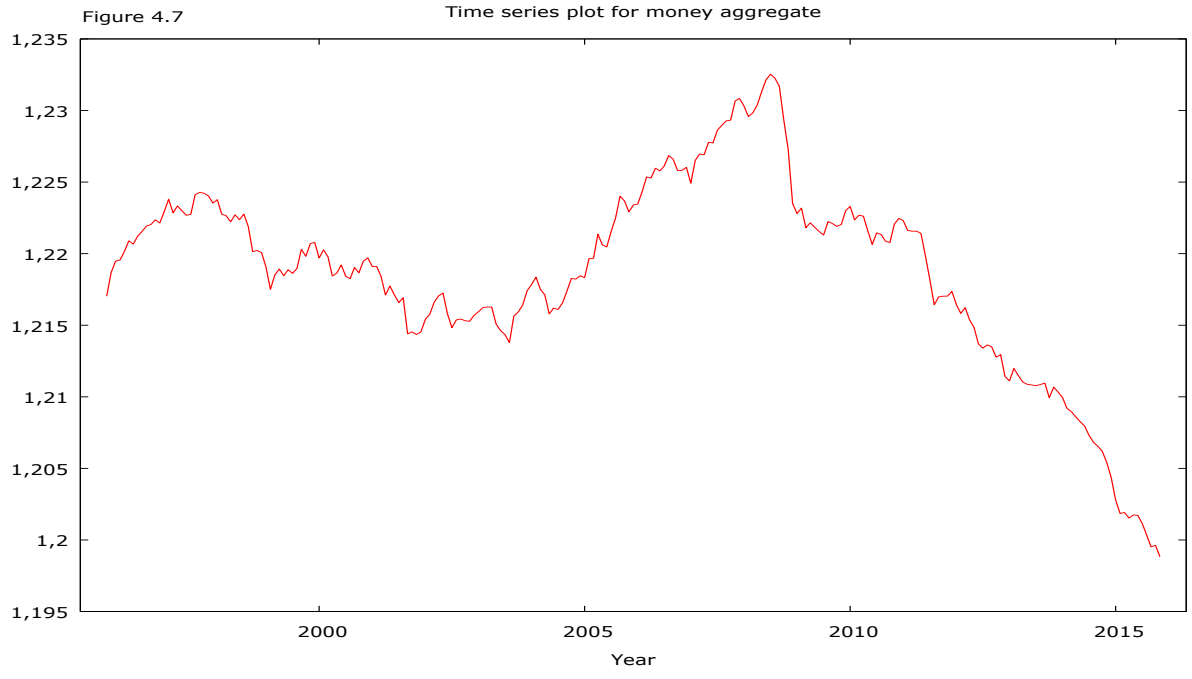


Figure 4.8 below shows the time series plot of inflation. The series has an upward trend with a constant. We also observe that even after the financial crisis of 2008 the direction of inflation was never altered yet other variables such as oil prices went down for a while before picking

up. We also observe a steep, steady growth on inflation. There is also no obvious seasonality in the data series.

Figure 4.8 Time series plot for inflation

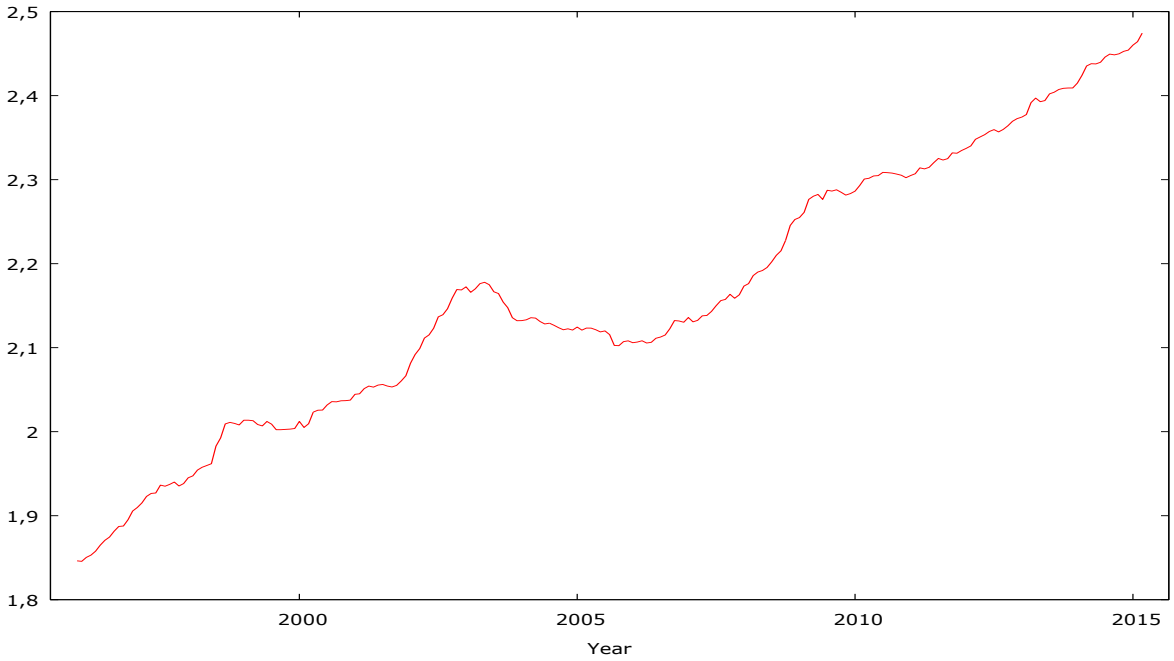
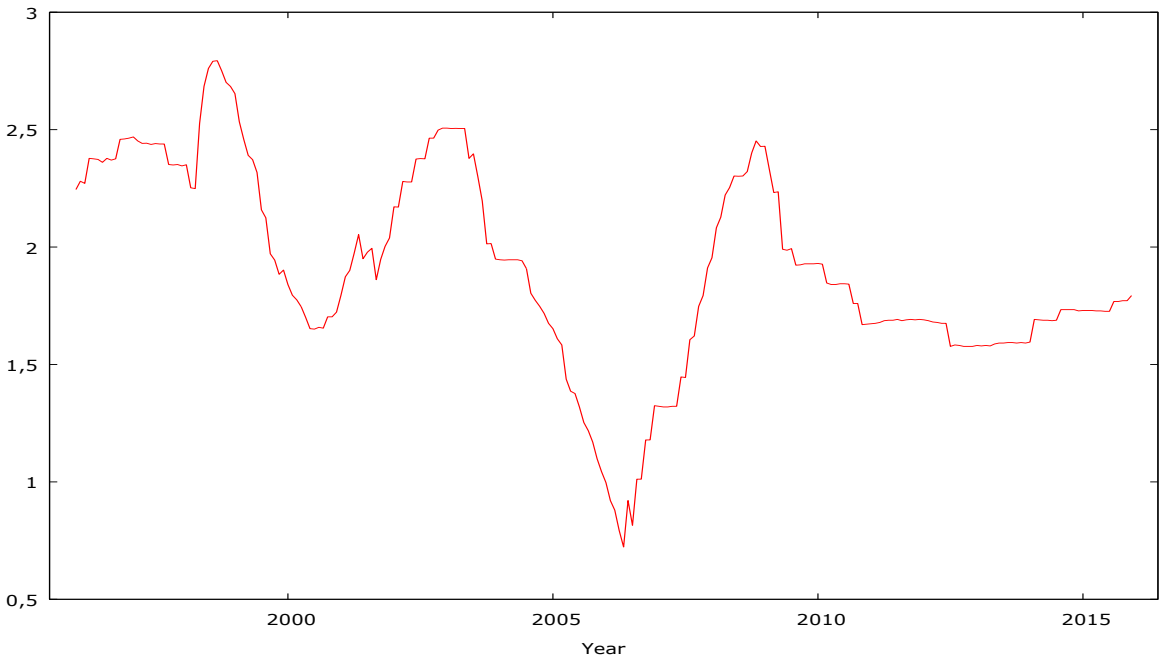


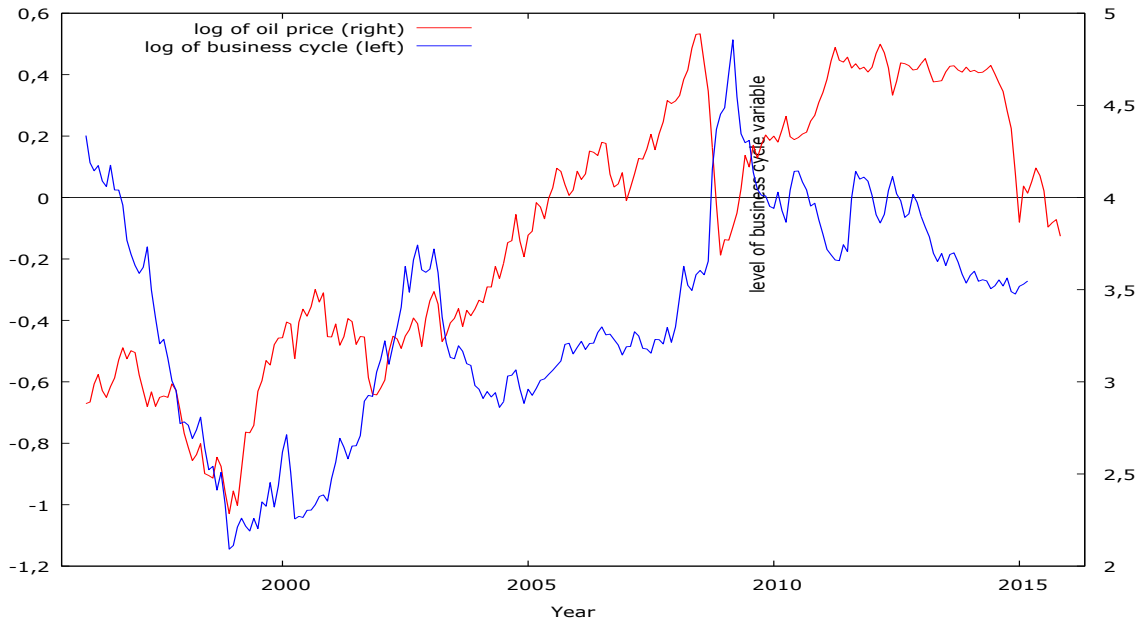
Figure 4.9 below shows that interest rate differentials between South Africa and the US have a downward trend and a constant. We observe no obvious seasonality between the two data series.

Figure 4.9 Time series plot for interest rates



The business cycle data series also seem to have an upward trend and its co-movement with oil prices is not so strong as shown in figure 4.10 below. The variance for the data series is not constant due to the upward trend. There is however, no obvious seasonality in the data series.

Figure 4.10 Time series plot for business cycle and oil price



4.5 Data tests and estimations

Having done the preliminary analysis above, we proceed to perform formal analysis and tests on the data. We conduct a formal test for stationarity, cointegration test, short run analysis and granger causality test between the ZARUSD exchange rate and international oil prices.

4.5.1 Test for stationarity and unit root

We use the ADF and KPSS test to test the null hypothesis of a unit root and the null hypothesis of stationarity respectively. The null hypothesis of unit root is accepted if the ADF test statistic is negative and the p-value is bigger than 5% (0.05). Table 4.2 below shows that for all the variables, we fail to reject the null hypothesis of unit root at the level of the variables because our p-values are all bigger than 5%. However, upon taking first differences of the data, we reject the null hypothesis of unit root which shows that our data series has no unit root at first differences.

The KPSS tests on the other hand shows that at the level of the variables, we reject the null hypothesis of stationarity because for all the variables, our test statistic is bigger than the 1%

critical value. However, at the first difference of the variables, we fail to reject the null hypothesis of stationarity. Thus, both the ADF and KPSS test confirm that our series are I(1) which means we can proceed and test the data for cointegration in the next sections.

Table 4.2 Stationarity and unit root test

	ADF				KPSS			
	Level of variable		First difference		Level of variable		First difference	
	Test statisitc	p-value	Test statistic	p-value	Test statistic	1% critical value	Test statistic	1% critical value
Exchange rate	-1.8386	0.6860	-4.3175	0.0029	0.2215	0.2170	0.1493	0.2170
Oil price	-1.5569	0.8098	-7.6229	0.0000	0.3878	0.2170	0.0830	0.2170
Money aggregate	-0.0805	0.9952	-6.9678	0.0000	0.7499	0.2170	0.1537	0.2170
Inflation	-1.5209	0.8228	-3.8728	0.0131	0.4072	0.2170	0.1647	0.2170
Interest rate	-1.5524	0.8115	-5.1298	0.0001	0.2630	0.2170	0.0662	0.2170
Business cycle	-2.8859	0.1670	-5.2424	0.0000	0.3235	0.2170	0.1763	0.2170

4.5.2 Lag length selection

We do a step-wise test to the monthly data lags from zero to three in line with Simpson (2002) and use both the Akaike (AIC) and Schwarz Information Critera to find the appropriate number of lags. We also confirm the appropriateness of the lag length choice by testing for autocorrelation in the residuals. If there is autocorrelation in the residuals, we modify the lag length until there is no autocorrelation. Table 4.3 below indicates the best values marked with asterisk for each information criteria.

Table 4.3 Lag selection information criteria

	Information Criteria	
Lags	AIC	BIC
1	-31.4405	**-30.7988***
2	-31.7059	-30.5142
3	**-31.7515***	-30.0097
4	-31.7246	-29.4328
5	-31.5499	-28.708
6	-31.4356	-28.0438
7	-31.3841	-27.4422
8	-31.3166	-26.8246

The asterisks (*) indicate the best (minimized) values of the information criteria. AIC= Akaike information criterion and BIC= Schwarz Bayesian criterion

Based on the values given, we choose a lag of 3 whose appropriateness will be confirmed in the next subsection when testing for autocorrelation.

4.5.3 Test for autocorrelation

We test for autocorrelation using the below hypothesis:

H_0: There is no autocorrelation in the residuals

H_1: Residuals are autocorrelated

If p-values for the autocorrelation test are greater than 5%, we cannot reject the null hypothesis. Table 4.4 below shows that p-values are greater than 5% for all the variables and hence we fail to reject the null. This means that we will have consistent estimates because our data is independently distributed.

Table 4.4 Autocorrelation tests

Variable	p-value
Exchange rate	0.775
Oil price	0.71
Money aggregate	0.179
Inflation	0.378
Interest rate	0.299
Business cycle	0.202

4.5.4 Long run analysis: Engle Granger test for cointegration

We have already confirmed in subsection 4.5.1 that all our data series are I(1); meaning that they are stationary and have unit root at first differences. Next, we perform an OLS regression on equation (2) and then test the residual term for stationarity. Table 4.5 shows the result for stationarity test on the residuals.

Table 4.5 Stationarity test on the residual term

ADF		KPSS	
Test statistic	**p-value**	**Test statistic**	**1% critical value**
-2.2064	0.0264	0.3659	0.739

The ADF test has a p-value less than 5% which means we reject the null hypothesis of unit root on the residual term. The KPSS test statistic is smaller than the 1% critical value which means

that we fail to reject the null hypothesis of stationarity on the residual term. Since the residuals have been found to be stationary, it means there exists at least one cointegration relationship among the variables and we can reject the null hypothesis of no cointegration among the variables.

4.5.5 Long run analysis: Johansen test for cointegration

We have already ascertained that the residuals are stationary in subsection 4.5.4. We proceed and perform the Johansen test for cointegration and the results have been shown in table 4.6 below. The results show that we are able to reject the null hypothesis of no cointegration at 2 cointegration equations at most. This means that there exists a long run association among the variables; that is to say the variables tend to move together in the long run. Both the Engle-granger and Johansen test show that there exists a long run relationship among the variables.

Table 4.6 Johansen test for cointegration

No. of cointegration equations	Eigenvalue	Trace statistic	p-value
None*	0.1644	124.16	0.0002
At most 1*	0.1574	83.206	0.0031
At most 2	0.1022	44.161	0.1151

Notes: When p-values are more than 0.05, we reject the null hypothesis of no cointegration at 5% significance level

4.6 Long run estimates

Since we have already ascertained that there is a long run cointegration among the variables, we also estimate cointegration vectors (normalized β) at the same time. Table 4.7 below shows the normalized cointegration coefficients.

Table 4.7 Cointegration vector of the ZARUSD exchange rate

Cointegration coefficients						
CointEq 1	**EXC**	**OP**	**MA**	**INF**	**INT**	**BC**
p-value = 0.0002	1.0000	-0.1670	21.3210	0.0052	0.0921	0.2889
CointEq2						
p-value = 0.0031	1.1677	1.0000	-4.3421	-4.1709	0.3584	-0.6068

From table 4.7 above, we derive a cointegration equation between ZARUSD exchange rate, oil prices, money aggregates, inflation, interest rates and business cycle as follows:

$$EXC_t = -0.167OP_t + 21.32MA_t + 0.0052INF_t + 0.092INT_t + 0.2889BC_t \quad (12)$$

From equation (12) we deduce that a 1% permanent increase in oil prices results in a 0.17% appreciation of the ZARUSD exchange rate. This result is similar to the findings by Jin (2008), Englama, Duke, Ogunleye, and Isma'il (2010) and Aliyu (2009). This finding is also aligned with expectations because as the international oil price strengthens, the US Dollar weakens since US is one of the biggest importers of crude oil and hence the appreciation of the Rand/US Dollar exchange rate in the long run.

We also deduce from equation (12) that a 1% permanent increase in the money aggregate ratio results in a 21.3% depreciation of the ZARUSD exchange rate. Again, this is as per expectations because an increase in the money aggregate ratio simply means that there is less demand for the Rand than there is for the US Dollar. The finding is similar to that of Ghalayini (2013). We also note that this variable has the highest elasticity compared to the other macro-economic variables. We also deduce that a 1% increase in inflation results in a 0.005% depreciation of the ZARUSD exchange rate. Theoretically, we expect such relationship to exist as per the purchasing power parity theory of Cassel (1918). Also, the model enables us to deduce that a 1% permanent increase in interest rates results in 0.09% depreciation of the ZARUSD exchange rate. This is also a similar finding to previous studies conducted by Ghalayini (2013), Hauner, Lee, and Takizawa (2011) and Englama et al. (2010). We also observe that a 1% increase in business cycle (economy-wide fluctuations) results to a 0.29% depreciation of the ZARUSD exchange rate. This is also an expected finding due to the fact that an increase in economic fluctuations means higher volatility of the South Africa's all share index compared to the US all share index. We note that our model shows that in the long run, money aggregates has more influence on the ZARUSD exchange rate with an elasticity of 23.32, followed by business cycle with an elasticity of 0.2889, followed by oil prices with an elasticity of -0.167 then interest rates and lastly inflation.

4.7 Short run analysis: vector error correction modelling

We investigate the parameters of the error term implied by the cointegration vectors for the ZARUSD exchange rate to determine if they are appropriately signed and significant. 3 lags as specified by our lag selection criteria is used to determine the effects of oil prices, money aggregate, inflation, interest rate and business cycle in the short run.

Table 4.8 below shows the regression coefficients for the VECM model.

Table 4.8 Short run model

Variable	Coefficient	Std. Error	t-ratio	p-value
Const	1.222	0.3589	3.45	0.0008***
d_EXC_1	0.2746	0.0716	3.832	0.0002***
d_EXC_2	-0.1472	0.073	-2.015	0.0452**
d_OP_1	-0.0573	0.0276	-2.079	0.0388**
d_OP_2	-0.0519	0.029	-1.787	0.0754*
d_MA_1	-0.8334	3.576	-0.2332	0.8158
d_MA_2	-0.8396	3.4299	-0.2448	0.8069
d_INF_1	-0.9942	0.6096	-1.631	0.1044
d_INF_2	-0.094	0.5498	-0.171	0.8644
d_INT_1	0.0826	0.0389	2.124	0.0349**
d_INT_2	0.0856	0.0408	2.095	0.0374**
d_BC_1	0.0064	0.0442	0.1441	0.8856
d_BC_2	0.0137	0.0439	0.3119	0.7554
ECT	-0.0443	0.0131	-3.377	0.0009***
R-squared	0.2262			
Adjusted R-squared	0.1792			
DW statistic	1.9413			

One asterisk (*) indicates significance at 10%, two asterisks(**) indicates significance at 5% and three asterisks (***) indicates significance at 1%

The sign of the error correction term is negative and the error correction parameter is statistically significant at 1%, which implies that there exists long run causality running from oil price, money aggregate, inflation, interest rates and business cycle to ZARUSD exchange rate. The error correction term coefficient of -0.0443 suggests that about 4.4% of the ZARUSD exchange rate disequilibrium can be corrected within a month (since we are using monthly data) after a shock of oil price or interest rates. The significance of this estimated relationship is measured by R-squared which shows that oil prices and interest rates account for approximately 22.62% of the variability in the ZARUSD exchange rate. They are all at least 10% statistically significant. The coefficients for money aggregate, inflation and business cycle

are not statististically significant in the short run and therefore, they don't exact any influence on the ZARUSD exchange rate in the short run.

4.8 Granger causality test

We present the Granger causality tests in table 4.9 below. At this stage we focus on only two variables (oil prices and exchange rates). We use first differences of our variables because we have already ascertained that they are stationary in section 4.5.1.

Table 4.9 Granger causality test

	F-statistic	**p-value**
Null hypothesis	**1 lag**	
OP doesn't granger cause EXC	4.2207	0.0410
EXC doesn't Granger cause OP	2.9224	0.0887
	2 lags	
OP doesn't granger cause EXC	3.4302	0.0340
EXC doesn't Granger cause OP	1.4751	0.2309
	3 lags	
OP doesn't granger cause EXC	2.6098	0.0523
EXC doesn't Granger cause OP	0.9589	0.4129

Note: We reject the null hypothesis of no Granger causality at 5% significance level

From table 4.9, we choose 2 lags as it is the average between AIC and BIC and we see that at 5% significance, we reject the null hypothesis that OP doesn't Granger cause EXC and conclude that oil prices Granger causes the ZARUSD exchange rate and the ZARUSD exchange rate doesn't Granger cause oil prices. This implies that there is only a unidirectional causality between the two variables running from oil prices to the ZARUSD exchange rate. This kind of relationship simply means that the Rand has no influence whatsoever in the determination of the international price of oil. So South Africa can only be a victim of circumstances that have prevailed in the oil market at that particular time and accept whatever oil price is decided by the market. This finding is almost similar to that of Schaling, Ndlovu, and Alagidede (2014) where they were investigating the causality between the Rand and commodity prices as an index.

4.9 Oil price's ability to forecast ZARUSD exchange rate

We run an out of sample forecast for the VAR and VEC models as specified in equation (10) and (11). We then analyse the quality of the forecast when oil prices have been included as explanatory variables and when they have not. Table 4.10 and 4.11 below summarize the forecasting results.

Table 4.10 Out of sample forecast including oil prices

OIL PRICES INCLUDED						
	VAR Model			VEC Model		
Months ahead	RMSE	MAPE	Running Average of MAPE	RMSE	MAPE	Running Average of MAPE
1	0.0129	0.64%	0.64%	0.0132	0.66%	0.66%
6	0.0406	1.31%	0.98%	0.0318	1.42%	1.04%
12	0.0308	0.80%	0.92%	0.0300	1.40%	1.16%
18	0.0328	1.28%	1.01%	0.0299	1.37%	1.21%
24	0.0384	1.56%	1.12%	0.0286	1.29%	1.23%
30	0.0390	1.31%	1.15%	0.0285	1.25%	1.23%
36	0.0396	1.59%	1.21%	0.0281	1.20%	1.23%

Notes: RMSE= Root Mean Square Error, MAPE = Mean Absolute Percent Error

Table 4.11 Out of sample forecast excluding oil prices

OIL PRICES EXCLUDED						
	VAR Model			VEC Model		
Months ahead	RMSE	MAPE	Running Average of MAPE	RMSE	MAPE	Running Average of MAPE
1	0.0146	0.75%	0.75%	0.0086	0.43%	0.43%
6	0.0825	3.62%	2.19%	0.0303	1.33%	0.88%
12	0.0298	1.06%	1.81%	0.0282	1.29%	1.02%
18	0.0315	1.23%	1.67%	0.0296	1.32%	1.09%
24	0.0391	1.58%	1.65%	0.0277	1.21%	1.12%
30	0.0412	1.66%	1.65%	0.0277	1.20%	1.13%
36	0.0425	1.73%	1.66%	0.0267	1.14%	1.13%

From table 4.10 and 4.11 above we observe that for the VAR model, the quality of the forecast (MAPE) improves significantly if oil price has been included as an explanatory variable in the

regression. However the VEC model tells the opposite. The quality of the forecast improves if we exclude oil price as an explanatory variable. Another important observation that we make is that the quality of the forecast in the short run (1-18 months) is superior on the VAR than on the VEC model when oil price has been included. So we conclude that oil price do contain some information about the future ZARUSD exchange rate in the short run and the VAR model can better predict the Rand if information about oil prices is included.

CHAPTER 5. CONCLUSION

5.1 Introduction

In this chapter we make some concluding remarks. We first summarize the strand of literature we have used in this study to investigate the relationship that exists between exchange rates and oil prices in general. We also give a summary of the methodology that we have used in this research. A brief summary of the data stylised facts, VAR model analysis, Granger causality, error correction modelling and oil price's ability to forecast the Rand is also presented. We provide some insights on the implications for ZARUSD exchange rate risk management for firms and monetary policy makers. Lastly, we make some recommendations for future research in this subject.

5.2 Literature

From the literature survey that we have conducted, we have observed that there seems to be more evidence supporting Chen et al., (2008) that commodity prices are affected by the exchange rate in the case of commodity currencies. However, we also find another strand of literature with opposite findings (Aliyu, 2009; Rautava, 2004; Englama et al., 2010). We have also observed that there are clearly mixed findings about the relationship that exists between exchange rates and oil prices and these findings cannot be generalised across all currencies of the world. The findings are basically dependent on whether the country in question is an oil-exporting country or whether the currency being studied is a commodity currency or whether nominal or real data was used. We also noticed a scarcity of literature that relates to the relationship between the South African Rand/US Dollar and oil prices. This study is meant to add to that knowledge gap and make a contribution to the South African Rand-Oil prices specific literature.

5.3 Methodology

We first examined the stationarity and unit root properties of all the variables to be used in our model using the ADF and KPSS test. Then we performed an optimal lag length selection procedure as highlighted by Simpson (2002) and we used both the Akaike (AIC) and Schwarz

Information Critera to find the appropriate number of lags. The Engle-granger and Johansen test for cointegration were then run on the data series to ascertain whether a long run relationship exists among the variables. Upon ascertaining that there exists cointegration among the variables we then estimated the VAR (p) model using cointegration vectors (normalized β). To capture the short-run dynamics of our variables, we also estimated the vector error correction model. We further attempted to fully explore the causal relationship that exists between the ZARUSD exchange rate and international oil prices by performing a Granger causality test. Lastly, we examined whether including information about oil prices in our models (VAR and VECM) improves the forecasting accuracy of the ZARUSD exchange rate.

5.4 Empirical Results

We empirically examined the relationship between the ZARUSD exchange rate and international oil prices. We find that all our nominal data series are co-integrated of order 1; meaning that they are stationary at first differences. The results of the Engle-Granger test for cointegration provided evidence of cointegration among the variables and the residual term of the OLS regression was also found to be stationary, confirming that there is at least one cointegration relationship among the variables. The Johansen test for cointegration also confirmed the same.

The empirical results have further shown that the ZARUSD exchange rate is mainly influenced by money aggregate followed by business cycle and oil price in the long run. Specifically, a 1% increase in the money aggregate results in a 21.3% depreciation of the ZARUSD exchange rate, which is a similar finding to that of Ghalayini (2013). Theoretically, we do expect a result of this nature because a high money aggregate ratio could mean more Rands in circulation compared to the US Dollar, which can be translated to less Demand for foreign exchange for the Rand compared to the US Dollar.

Also, a 1% increase in oil prices results in a 0.17% appreciation of the ZARUSD exchange rate. This result is as per expectations because as oil prices increase, we expect the US to pay more Dollars on fuel since she is currently largest importer of oil and hence a weakening of the Dollar. If the Dollar weakens, then the Rand should gain strength against the Dollar. Jin(2008) and Englama et al. (2010) also found similar results for the Nigerian economy. Business cycle is another variable that was found to have a higher influence on the ZARUSD exchange rate

where a 1% increase in the economy-wide fluctuations results to a 0.29% depreciation of the ZARUSD exchange rate. This result also aligns with expectations because an increase in business cycle means that there is higher volatility in the South Africa's all share index compared to the US all share index.

Empirical evidence has also shown that a 1% increase in interest rates results in a 0.09% depreciation of the ZARUSD exchange rate. We acknowledge the fact that theoretically when interest rates go up, we expect an increase in asset returns for foreign investors and hence a high attraction for foreign investment which ultimately increases the demand for local currency. However, we will note that interest variable that has been used in this study is a differential between South Africa and the US. Hence, the purchasing power parity between the two economies eventually results in a net depreciation of the Rand if all other variables remain constant in the long run.

We went on to estimate a vector error correction model (VECM) for our short run analysis. We deduced from the model that only 4.4% of the ZARUSD exchange rate can be corrected within a month after a shock from oil prices or interest rates. That is to say, only oil prices and interest rates proved to have an influence on the ZARUSD exchange rate in the short run and these two variables account for 22.62% in the variability of the ZARUSD exchange rate.

The Granger causality test has given us evidence of a unidirectional causality running from oil prices to the ZARUSD exchange rate with a significance level of 5%. Causality running from the ZARUSD exchange rate to oil prices was found to be statistically insignificant. This then means that the Rand has no influence in the determination of international oil prices. The South African Rand can only be a victim of circumstances that have prevailed in the oil market at that particular time. This finding is consistent with that of Schaling et al. (2014).

The last empirical work that we have undertaken in this study is determining whether including information about oil prices improves the forecast quality for the ZARUSD exchange rate. When oil price variable is included in the regression, the forecast quality significantly improves in the short term (1- 18 months ahead) for the VAR model compared to the VEC model. . In the long run (19 – 36 months ahead), the VEC model proves to have superior forecasting capabilities than the VAR, both when oil prices are included and when they are excluded in the regression.

Our findings are consistent with Englama et al. (2010) and Jin (2008); and it suggests that the fluctuation in exchange rates for net oil importing economies is not only caused by oil price

movements but even other macro-economic variables do. Particularly, the demand for foreign exchange (money aggregate) is found to have the highest influence on the exchange rate in both studies. However, our evidence is in disagreement with conclusions from Kin and Courage (2014) who concluded that an increase in oil prices results in depreciation of the exchange rate.

5.5 Implications and recommendations for future research

5.5.1 Monetary policy makers

From the empirical evidence that we have obtained, we have seen that money aggregate has a very high influence on the ZARUSD exchange rate in the long term. This then means that monetary policy makers such as the South African Reserve Bank should focus more on strategies that are going to attract foreign investment and thus increase the demand for the Rand. There is also a need for strategies to address capital flight and loss of trade-related capital in South Africa. Issues of financial liberalization and nationalization of some private companies are some of the issues that may need to be effectively addressed. Future research work that can shed more light in that area can assist contribute to the knowledge of stabilizing the Rand.

South Africa is an increasingly oil dependent economy. The empirical evidence has indicated that the South African economy doesn't influence the oil market and this calls for exchange rate management policies that incorporate the movement of oil prices. There is an urgent need for effectively managing this apparent risk going forward. South Africa needs to engage in rigorous strategies to go for greener energy and diversify the economy to reduce dependence on oil for energy and thus minimize the effects of oil price shock. Future research can provide more light on how South Africa can effectively manage the risk of oil price shocks as a mean to stabilize the local currency.

5.5.2 Firms

We also learn from the empirical evidence that firms with Dollarized liabilities need better ZARUSD exchange rate forecasting techniques. Empirical evidence has shown that oil prices have an influence on the ZARUSD exchange rate, both in the short term and in the long term. Incorporating oil prices in the exchange rate forecasting models can be help reduce exchange rate risk in their trading. This study has shown that the VAR model can better forecast the

ZARUSD exchange rate in the short run compared to the VECM. Further research work can include other models such as the random walk, ARIMA and GARCH models to determine the best model that should be used for forecasting the ZARUSD exchange in the short run and in the long run.

5.6 Overall conclusion

We have shown that there is a negative relationship between the nominal ZARUSD exchange rate and international oil prices. We have further ascertained that these two data series are cointegrated. This study has also shown that there is a unidirectional causality running from international oil prices to the ZARUSD exchange rate and there is no causality running from the ZARUSD exchange rate to international oil prices. We have also demonstrated that international oil prices do have a long run influence on the ZARUSD exchange rate but the magnitude of the influence is less than that of money aggregate and business cycle. Interest rates and inflation have been found to have less influence on the ZARUSD exchange rate when compared to international oil prices. In the short run, only oil prices and interest rates have been found to have an influence on the ZARUSD exchange rate. We have also demonstrated that oil prices do contain some power to help improve the forecast of the ZARUSD exchange rate when the VAR model is used.

The findings in this study have implications which we believe are significant to both policy makers and market participants. They speak to the approach that should be adopted by central banks, monetary policy makers and firms with exposure to the ZARUSD exchange rate. We suggest capital flight management strategies and exchange rate management policies that incorporate future movements of oil prices. We also recommend currency hedging strategies for firms with dollarized liabilities.

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