Exchange Rate Depreciation and the South African Economy: Growth, Inflation and the Interest Rate

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This dissertation has been presented in partial fulfilment of the requirements for the degree of Master of Commerce in Economics (MCMC)
Declaration

I, Evan Jones, declare that;

1) The research reported in this dissertation, except where otherwise indicated, and is my original research.

2) The dissertation has not been submitted for any degree or examination at any other university.

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Evan Wesley Speirs Jones (205514505)
Abstract

November 2010 saw the publication of South Africa’s New Growth Path (NGP), which among other things proposed that a depreciation of the Rand would significantly stimulate economic growth. This assertion by the NGP echoes the opinions of many politicians, trade unions and other special interest groups. In addition to a depreciated Rand, the NGP also stated that the South African Reserve Bank continue to target low stable inflation as well as maintain a low interest rate environment so as to encourage investment. There however exists a well-documented exchange rate pass through (ERPT) effect to domestic prices such that depreciations of a currency increase domestic prices. In addition, South Africa as an inflation-targeting country has a central bank that responds to inflationary pressures. Taken together, the ERPT effect and the inflation-targeting nature of the SARB call into question the consistency of the macroeconomic package outlined in the NGP. This dissertation thus sought to investigate how movements of the exchange rate affect real GDP, prices and interest rates. To accomplish this, a thorough literature review and empirical investigation has been conducted. To assess how real GDP, price and interest rates respond to movements of the exchange rate, a VARX model was estimated. The effect of an exchange rate movement on the model was then analyzed using impulse response functions and forecast error variance decompositions. The response of the South African economy to a change in foreign aggregate demand has also been assessed using dynamic multiplier functions. This research found that the South African real GDP responds positively to depreciations of the Rand, however prices and interest rates have too been found to increase following a depreciation of the Rand. This observed combination is consistent with the consensus view of the theoretical and empirical literature though at odds with the macroeconomic environment outlined in the NGP.
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Thank you to all those who are close to me for simply choosing to be there.

Thank you.
List of Acronyms

ADF: Augmented Dickey-Fuller
AIC: Akaike's Information Criteria
BEER: Behavioural Effective Exchange Rate
CPI: Consumer Price Index
DF: Dickey-Fuller
ERER: Equilibrium Real Exchange Rate
ERPT: Exchange Rate Pass Through
FEVD: Forecast Error Variance Decomposition
GLS-DF: Generalised Least Squares - Dickey-Fuller
HP: Hodrick-Prescott
HQIC: Hannan and Quinn Information Criteria
IMF: International Monetary Fund
IRF: Impulse Response Function
KPSS: Kwiatkowski, Phillips, Schmidt, Shin
NEER: Nominal Effective Exchange Rate
NGP: New Growth Path
PP: Phillips-Perron
PPP: Purchasing Power Parity
REER: Real Effective Exchange Rate
RER: Real Exchange Rate
SARB: South African Reserve Bank
SBIC: Schwarz's Bayesian Information Criteria
SSA: Sub Saharan Africa (n)
VAR: Vector Autoregression
VARX: Exogenous Vector Autoregression
WTO: World Trade Organisation
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Chapter One – Introduction

1.1 Background
November 2010 saw the publication of the New Growth Path (NGP) for South Africa, aimed at addressing unemployment, poverty and inequality through a host of micro and macroeconomic policies (Ibrahim, 2010). With regards to the macroeconomic policy environment, the NGP maintains that for the foreseeable future South Africa should follow looser monetary policy (lower interest rates) accompanied by a more restrictive fiscal stance (Ibrahim, 2010). Specifically the NGP outlined that the South African Reserve Bank (SARB) should continue targeting low stable inflation, but that it should also encourage a more competitive exchange rate as well as supporting investment by providing a low interest rate environment (Ibrahim, 2010). Additionally, a counter cyclical fiscal stance should be adopted to manage demand in support of a more competitive currency and a reprioritisation of fiscal expenditures towards infrastructure and skills development (Ibrahim, 2010). The combination of macroeconomic outcomes associated with a depreciated exchange rate articulated in the NGP, that of greater economic growth, low interest rates and low inflation appear inconsistent with prevailing economic theory, the South African economic experience as well as the South African institutional framework.

Generally, it is accepted that depreciations of the exchange rate facilitate economic growth. This occurs as a depreciated exchange rate serves to make a country’s exports cheaper in foreign currency terms as well making imports more expensive. By making exports relatively cheaper it is expected that a depreciation of the exchange rate increases demand for exports and thus stimulates economic activity. Similarly, by making imports more expensive, a currency depreciation may result in domestic expenditure switching away from imported goods, further stimulating domestic economic activity. Whilst these mechanisms appear straight forward there still exists much debate regarding the growth affects associated with depreciated exchange rates, indeed whilst there is a substantial body of literature supporting the view expressed above there is also evidence that suggests an insignificant or possibly even negative effect on growth. In the South African context too conflicting empirical evidence regarding the growth effects of exchange rate depreciations has been presented.

In contrast to the above inconsistency, there exists significant agreement regarding the effects of exchange rate movements on the price level. Through an effect referred to as exchange rate pass through (ERPT) effect, depreciations of the exchange rate are recognised as placing upward pressure on the domestic price level. This upward pressure stems primarily from the higher costs of imported
inputs and final goods (cost push inflation), increased demand for local production (demand pull inflation) and higher wages. Whilst there is little disagreement regarding the relationship between the exchange rate and the price level it has been observed that the degree of ERPT experienced by countries has been falling in recent years. There exist many explanations for this behaviour in the literature, one of the most compelling relates to the role of monetary policy in open economies. Specifically, where central banks are recognised to respond to inflationary pressures the effects of the exchange rate on prices appears to have reduced, though still an important channel of inflation.

With regards to the behaviour of the interest rate there is too, much agreement concerning its response to exchange rate depreciations. The South African Reserve Bank formally adopted a flexible inflation targeting framework in 2000 with which to fulfil its mandate of defending the internal value of the Rand i.e. keeping CPI inflation within a 3 to 6 percent target range (SARB, 2012). Additionally, prior to 2000 it has been suggested that the SARB had been practicing implicit inflation targeting. Much research into the behaviour of inflation-targeting central banks and specifically that of the SARB suggest that the exchange rate is an important variable in describing the interest rate setting behaviour of central banks. Because depreciations exert inflationary pressures within the economy central banks are likely to increase interest rates in a bid to keep inflation under control.

So whilst low interest rates, low and stable inflation and a more competitive exchange rate may well be an environment conducive to economic growth, given that depreciations of the exchange rate increase the price level and likely interest rates too, achieving the policy objectives outlined in the NGP appears dubious. It may well be that depreciations of the Rand stimulate the economy, that the ERPT effect is very small and that the SARB does not react to exchange rate movements, and if so then the macroeconomic environment described in the NGP would be entirely accurate. It thus appears that greater insight into the reaction of South African economy to exchange rate movements is needed. This dissertation has therefore sought to construct such understanding through an extensive review of the literature as well as the estimation of a vector autoregressive (VAR) model describing the South African economy. Following this analysis it is believed that a clearer picture of the South African economy’s response to a depreciation of the exchange rate has emerged, thus enabling an evaluation of at least one of the NGP’s policy recommendations.

1.2 Research Problem and Objectives
The primary research problem addressed in this dissertation is that of an evaluation of the response of the South African economy to a movement of the exchange rate and a comparison these results to those outcomes outlined in the NGP. To assess this response a VAR model has been estimated and used to construct relevant impulse response functions and other tools of analysis. By estimating
the expected behaviour of the South African economy to a movement of the exchange rate this dissertation hopes to shed light upon the feasibility of the macroeconomic policy mix outlined in the NGP as well as contributes to the understanding of the behaviour of the economy.

1.2.1 Main Objectives
The overall objective of this dissertation is to develop an understanding of the South African economy’s behaviour following a depreciation of the Rand. This understanding is sought to both add to the current understanding of the economy as well as to assess whether the outcomes of this policy prescription by the NGP are consistent with the behaviour of the South African economy. To do this a VAR model describing the South African economy has been estimated and the results interpreted using structural analysis tools such as impulse response functions (IRF), forecast error variance decompositions (FEVD) and dynamic multiplier functions (DMF). This model has been used to evaluate the effect of an exchange rate depreciation on the economy, and specifically whether;

- A depreciation of the rand leads to an increase in real GDP?
- A depreciation of the exchange rate affects the domestic price level. Is there significant pass through to domestic prices?
- A depreciation of the exchange rate affects the interest rate?
- The policy mix described in the NGP agrees with theoretical expectations and the outcomes of the empirical model?

The interpretation of the VAR analysis tools provide valuable insight into the above relationships and hence behaviour of the South African economy. Additionally the effect of an increase in foreign aggregate demand on output and exchange rates has been assessed.

1.3 Research Design and Methods
The research design of this dissertation consists of both a literature review and an empirical investigation. The purpose of the literature review is to develop a theoretical and empirical appreciation for the effects of exchange rate depreciations on real GDP, the price level and interest rates. The empirical analysis involves the analysis of South African economic variables as well as the estimation of a VAR.

The data used in this investigation were obtained primarily from the SARB, with price level and US real GDP figures coming from Stats SA and the US Department of Commerce respectively and taken from between 1990 - 2012. This data is discussed at length in Chapter 4 using graphical analysis of the time series to draw out the relationships of interest before being tested for nonstationarity. Given that there are two distinct monetary regimes within this period, the SARB officially adopting
flexible inflation targeting in 2000, as well as the presence of exchange rate controls in the 1990s, a full sample and a sample restricted to the current inflation targeting regime are used in the estimation of the VAR.

The estimation of the VAR used for the analysis of the South African economy follows closely in line with recent International Monetary Fund (IMF) working papers as well South African specific investigations. The endogenous variables included in the VAR are the real GDP, money supply, CPI, interest rate and the nominal effective exchange rate (NEER). Exogenous variables are included in the estimation of the VAR model to control for the external stance of the world economy that effect the economic development of South Africa.

The model described above has been exposed to shocks of the exchange rate variable to enable impulse response analysis and assist in understanding of the behaviour of the South African economy. Additionally FEVDs are used to illustrate the importance of the exchange rate in describing the observed forecast error of the impulse response functions. Owing to controversy regarding whether in the presence of nonstationary data to estimate in levels or first differences, both specifications have been adopted. A third ‘gap’ specification has also been estimated that utilises a variable’s deviation from its Hodrick-Prescott filter estimated trend. Multiple specifications of the VAR have been estimated as a robustness check on the results. Owing to the consistency that was achieved across specifications, only the results from the levels specification of the VAR are presented in Chapter 5 with the full set of impulse response and FEVD results presented in Appendix D and E respectively.

Following the estimation of the VAR the results generated are then compared to both the findings from the literature surveyed and the predictions of the NGP. This comparison between policy, literature and empirics enables a qualified assessment of the feasibility of the macroeconomic environment outlined by the NGP.
Chapter Two – Literature Review

2.1 Introduction
This section of the dissertation considers how a depreciation of the exchange rate may affect the South African economy. To develop this understanding in a coherent manner, focus is placed upon theoretical and empirical evidence relating to the effects of the exchange rate upon the three macroeconomic variables that are mentioned in the NGP as part of the proposed macroeconomic policy mix. That is, how a depreciation of the exchange rate is likely to affect output, inflation and interest rates, before these relationships are compared with those described in the NGP. Considering each of the three variables and their relationship to the exchange rate separately allows for a clearly segmented approach to the appraisal of the policy mix proposed by the NGP.

By following this threefold approach, the literature review sheds light on how a depreciation of the exchange rate should impact upon the key policy variables mentioned in the NGP. Specifically, the NGP proposed a growth enhancing macroeconomic environment that consists of a depreciated exchange rate as well as low inflation and interest rates. However it is important to ask whether such an outcome is consistent with the behaviour of a small open, inflation targeting country in the wake of an exchange rate depreciation. With the exchange rate acting as an important channel of monetary policy in a small open economy, it seems likely that depreciations likely result in higher rates of interest and inflation rather than the configuration outlined in the NGP. Thus, this literature review seeks to develop a consensus on how a depreciation of the exchange rate is expected to affect each of the variables mentioned in the NGP’s macroeconomic policy mix and compare this with the configuration outlined in the NGP.

The literature review is structured as follows; section 2.2 considers the possible growth effects associated with depreciations of the exchange rate and how the South African economy has responded to such depreciations. Section 2.3 looks at the relationship between the exchange rate and domestic inflation, also referred to as the exchange rate pass through (ERPT) effect. The effect that the exchange rate has upon the interest rate is discussed in section 2.4, which additionally includes a brief description of the monetary regime followed by the SARB. Finally, the literature review concludes with section 2.5, which provides an overview of the previous three sections and placing them in context with the NGP.

2.2 Exchange Rate and Growth
A competitive exchange rate has often been proposed as an important tool for inducing economic or export growth in developing countries. In South Africa, this view has fuelled proposals from various
politicians, trade unions, economists and international organizations for the Rand to be depreciated (Saville, 2010). One recent call for the depreciation of the Rand comes from NGP, claiming that a more competitive exchange rate is required to stimulate the South African economy and the export sector (Ibrahim, 2010). This assertion implies a belief that the Rand suffers from being overvalued and that this strength impedes economic growth, or alternatively, that an undervalued exchange rate would stimulate growth.

Since the financial crisis of 2008, calls for an exchange rate depreciation to stimulate the economy in South Africa and other parts of the world gained in strength. Yet the effectiveness of a depreciative exchange rate policy on economic growth is not immediately clear, and due to complex relationships its impact is not entirely predictable (Auboin & Ruta, 2011; Fang, et al., 2006). The literature regarding the role of the exchange rate on growth has adopted two main branches of analysis, that of exchange volatility and of exchange rate misalignments (Auboin & Ruta, 2011). This section of the literature review focuses on the effects of the latter, as a policy to depreciate the currency would either correct or reduce an exchange rate misalignment if overvalued or create an undervaluation if the exchange were at its equilibrium level.

The literature on the role of the exchange rate on the economic performance grew tremendously following the end of the Bretton-Woods era and its effect on the growth of developing economies is substantial (Auboin & Ruta, 2011). Prior to the early 2000s the exchange-rate growth literature focused on the effects of exchange rate volatility on economic growth, to this end results have been somewhat inconclusive finding that volatility exerts no obvious relationship on aggregate trade but does appear to affect bilateral trade (Auboin & Ruta, 2011; Huchet-Bourdon & Korinek, 2011; IMF, 1984). The other predominant strain of the exchange rate-growth literature has focused on the role of misalignments of the real exchange rate on growth as well as how depreciations (appreciations) of the exchange rate effect growth, and it is this branch that is discussed below.

2.2.1 Currency Misalignments
From the early 2000s, researchers paid increasing attention to the growth effects associated with exchange rate misalignments and hence the level of the exchange rate on economic growth (Auboin & Ruta, 2011). A resurgence in this research effort occurred in the wake of the 2008 financial crisis as it was suspected that some countries were attempting to export their way to recovery and that such behaviour would trigger a currency war (Auboin & Ruta, 2011). Whilst this literature is well established, it does not appear to have reached a consensus as to the effects of exchange rate misalignments upon growth.
Within this branch of the literature, two broad camps exist and for brevity, the two views are described as the ‘Washington Consensus’ and the ‘Conventional’ view. The Washington Consensus view suggests that misalignments are in-and-of-themselves deleterious to growth (Berg and Miao, 2010). Misalignments of the exchange rate result in distorted patterns of trade and misallocations of capital and thus suboptimal growth rates. The Conventional view suggests that over- and undervaluations of the exchange have differentiated effects upon the economy with the latter encouraging growth by stimulating exports and acting as a second-best solution to various market failures that exist in the tradables sector of a developing country (Easterly, 2005; Freund & Pierola, 2008; Rodrik, 2008). Overvaluations on the other hand hurt growth by making exports more expensive and imports more competitive than domestically produced goods (Rodrik, 2008; Johnson, et al., 2007). Later the ‘Structuralist’ view is briefly discussed though this view focuses on why depreciations may harm economic growth.

The only point of consensus that appears to have emerged from the literature is that an overvalued real exchange rate (RER) is harmful to growth. The real exchange rate describes the nominal exchange rate adjusted for the price levels between two countries and in this way describes the purchasing power of an exchange rate. The real exchange rate (RER) can be described as the nominal exchange rate \( e \) multiplied by the ratio of the price level between the home \( P \) and foreign country \( P' \)’s of two countries (Kipici & Kesriyeli, 2007):

\[
\text{RER} = e \frac{P'}{P}
\]

In this specification, a depreciation is represented as an increase of the RER and could result from both a nominal depreciation of the exchange rate or a decrease of the domestic price level relative to foreign prices. In this way depreciations of the nominal exchange rate can result in depreciations of the RER if not offset by an increase in the domestic price level. Depreciations of the RER effectively reflect an increase in the purchasing power foreigners (Kipici & Kesriyeli, 2007).

Alternatively, the RER describes the relative price of tradables to nontradables in an economy. This alternative conceptualisation has been well utilised in the empirical literature. It too describes the purchasing power of the currency, but by differentiating between tradable and nontradable goods provides a better description of a country’s competitiveness on the international market, though it is noted that data are rarely kept distinguishing between tradable and nontradable goods for developing countries (Kipici & Kesriyeli, 2007; Rodrik, 2008).

According to Aguirre and Calderón (2005) the calculation of exchange rate misalignments and their effects on economic growth are among the most controversial issues in open economy
macroeconomics. A RER misalignment is described as the deviation of the observed RER from an equilibrium real exchange rate (ERER) level. Three main approaches have been utilised in the estimation of this ERER, namely the purchasing power parity, black market premia and model based approaches.

Auboin and Ruta (2011) in a recent World Trade Organisation (WTO) survey of the exchange rate related international trade literature, identified two possible reasons why exchange rates can deviate from their equilibrium levels. Firstly, they recognised that exchange rates can deviate from their equilibrium levels as a direct result of intentional government interventions. Such direct intervention can take many forms but by far the most common include the institution of capital controls or direct intervention in the foreign exchange market.

The People’s Republic of China is an often cited example of a country directly intervening in the foreign exchange rate market. It has been argued that China has managed to maintain its exchange rate at artificially low levels by actively purchasing US treasury bills. Some commentators have argued that these activities have distorted the trade balance between these two countries. It has also been proposed that this policy of exchange rate manipulation is partly behind the phenomenal growth rates that China has managed to achieve and sustain (Huchet-Bourdon & Korinek, 2011).

The second reason why the exchange rate may deviate from equilibrium is due to unexpected consequences of domestic policies or financial market imperfections (Auboin & Ruta, 2011). When governments seek to fulfil domestic objectives such as to encourage investment, lower unemployment or lower inflation, it is possible that the tools used by the government push the exchange rate away from its equilibrium.

Even when cases of exchange rate misalignment can be identified, their causes are difficult to distinguish (Auboin & Ruta, 2011). Furthermore, whether these misalignments have any permanent or transitory effects on growth is a question requiring further debate and is discussed in the section below. The question that is relevant to this dissertation is whether one can reasonably expect an exchange rate depreciation to result in an increase in the South African growth rate. Depreciations of the nominal exchange rate can be thought of as either reducing the degree of overvaluation of the Rand or increasing its degree of undervaluation.

2.2.2 Misalignments and Economic Growth
The view that misalignments of the exchange rate (regardless of the direction) negatively affect the economic growth rate has been described as the Washington Consensus view (Berg & Miao, 2010). According to this view, misalignments of the RER alter the relative price of tradables to nontradables.
and in so doing can send incorrect price signals and thereby distort the market leading to suboptimal growth. These incorrect price signals can result in the misallocation of resources and thus in inefficient market outcomes which could impede economic growth (IMF, 1984). That misalignments of the RER are generally considered suboptimal is fairly well accepted in the literature both on a theoretical and an empirical level (Auboin & Ruta, 2011; Easterly, 2005; Johnson, et al., 2007; Rodrik, 2005 & 2008).

Aguirre and Calderòn (2005) sought to test whether misalignments of the RER impact negatively on economic growth. Using a panel of countries and estimates of the ERER derived from an ERER model, it was found that misalignments of the RER are negatively associated with economic growth and that reductions in RER misalignments would be growth enhancing (Aguirre & Calderòn, 2005). These findings are supported by later investigations by Johnson et al. (2007) in their comparative analysis of the growth performance of East Asian and African economies. It was found that over the sample period those East Asian countries that were able to avoid overvaluations of their RER, were able to sustain high levels of economic growth whereas African countries who tended to exhibit greater degrees of RER misalignments had not been able to sustain such growth (Johnson, et al., 2007).

It has however been suggested that the effects of exchange rate misalignments are not simply deleterious to growth but that the direction of the deviation from equilibrium plays an important role in determining the effect of the misalignment on economic growth (Aguirre & Calderòn, 2005). This differentiated effect of exchange rate misalignment shall be explored in the section below.

2.2.3 The Differentiated Effects of Over- and Undervaluations
Many economists have discussed the potential negative growth effects associated with misalignments of the exchange rate, with much of the supporting evidence coming from instances of overvalued exchange rates. This has led to some hypothesising that there exists a differentiated affect between over- and undervaluations of the exchange rate. The negative effects that a RER overvaluation can have on economic growth have been well documented (Johnson, et al., 2007; Rodrik, 2008). However there exists only limited and tentative evidence on the positive growth effects accruing from an undervaluation of the real exchange rate.

Overall, evidence from the literature suggests that overvaluations of the RER tend to negatively affect economic performance whilst there is tentative support for the finding that small undervaluations of the RER can be growth enhancing (Johnson, et al., 2007). Whilst there is evidence in the literature that suggests a devaluation of the RER can encourage growth there is support that the converse is also true. It should also be noted the effects of an exchange rate devaluation on
growth tend to be small, possibly suggesting at more complicated interaction within the economy (Auboin & Ruta, 2011).

The exact mechanism that causes an overvaluation of the RER to produce negative growth effects has unfortunately not been formalised, but it has been suggested that overvalued real exchange rates are connected to macroeconomic instability (Auboin & Ruta, 2011; Rodrik, 2008). Overvalued RER’s are generally associated with economies experiencing foreign exchange shortages, large current account deficits, and among other things corruption (Rodrik, 2008). This perceived instability can deter investment and result in lower levels of economic growth. Additionally, since the RER describes the relative price of tradables to nontradables in the economy, an overvalued RER results in tradables being more expensive than they otherwise would be in equilibrium (Rodrik, 2008).

It has been suggested that undervalued real exchange rates are able to assist developing economies overcome various market failures that affect the tradables sector (Johnson, et al., 2007; Rodrik, 2008). Market failures and poor institutions have been identified as common impediments to growth in developing countries that could be mitigated through an undervalued RER (that may arise from a competitive devaluation) as it serves to make domestically produced tradable goods relatively cheaper on the global market (Easterly, 2005; Johnson, et al., 2007; Rodrik, 2005 & 2008).

Several market failures and institutional short-comings have been identified in the literature as probable impediments to growth that disproportionately affect the tradable sectors of developing countries and include, but are not limited to, learning externalities, coordination externalities, credit market imperfections and weak institutions (Auboin & Ruta, 2011; Easterly, 2005; Johnson, et al., 2007; Rodrik 2005 & 2008). Exchange rate depreciations, by increasing the profitability of producing tradables, can increase activity in these sectors enough to offset the negative effects of the market failures or overcome the disincentive to invest arising from weak institutions (Rodrik, 2008). Whilst exchange rate devaluations appear to be an effective industrial policy in developing countries they would are only a second best solution, as a depreciation of the exchange rate does not target the market failures or weak institutions directly (Johnson, et al., 2007; Rodrik, 2008).

According to the structuralist view developing countries could experience contractionary growth effects associated with a devaluation of the exchange rate (Acar, 2000). According to this view the growth constraints faced by developing nations are structural in nature, meaning that, for a given level of domestic income, the level of exports and imports are not sensitive to changes in the price which exchange rate depreciations would affect. The contractionary effects of a devaluation that are
identified by the structuralist view in developing nations are said to act through demand and supply side channels (Acar, 2000) and are summarised below in Table 2.1.

Table 2.1: Channels Associated with Contractionary Devaluations

<table>
<thead>
<tr>
<th>Demand</th>
<th>Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Import Costs</td>
<td>Imported Input Costs</td>
</tr>
<tr>
<td>Real Balances</td>
<td>Wage Indexation</td>
</tr>
<tr>
<td>Income Distribution</td>
<td>Cost of Working Capital</td>
</tr>
<tr>
<td>External Debt</td>
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<tr>
<td>Speculative Channel</td>
<td></td>
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<tr>
<td>Trade Liberalisation</td>
<td></td>
</tr>
<tr>
<td>Tax Channel</td>
<td></td>
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</tbody>
</table>

Of the channels outlined in Table 2.1, Acar (2000) argues that the imported cost and imported input cost channels are among the most significant growth-inhibiting channels to affect the economy. The former channel can depress economic growth if a country is experiencing a trade deficit, in which the price increase of imported goods associated with devaluation will result in a decrease in income as the price paid on imports increases and the price received on exports decreases in domestic currency terms (Acar, 2000). This implies that that the elasticity of demand for exports from developing countries is low and the volume of exports does not increase sufficiently to compensate for the increased cost of imports (Acar, 2000). It is noted that the greater the trade deficit of the country the more significant the effects of this channel will be (Acar, 2000). It is additionally argued that even if the Marshall-Lerner condition is satisfied a devaluation can still negatively affect output if domestic demand does not increase sufficiently quickly to offset the deterioration of the trade balance (Acar, 2000).

With regard to imported inputs costs, it is argued that devaluations make imported inputs more expensive in domestic currency terms, increasing the costs of production and hence raising the relative price charged domestically. Firms could then respond by decreasing output. In this context, as firms decrease their production in response to this negative aggregate supply shock so aggregate output and demand for labour fall (Acar, 2000).

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1 See Acar (2000) for a detail discussion as to how a devaluation of the exchange rate works through demand and supply channels in Table 1 to exert a negative force on economic growth.

2 Where the Marshall-Lerner condition states that for a devaluation of the exchange rate to yield a positive effect upon the trade balance the sum of the trade elasticities (exports and imports) need to be in excess of 1.
Given the points raised by the structuralist view, it is clear that in contrast to the popular view that exchange rate devaluations are growth enhancing, the structuralist view holds that a devaluation of the exchange rate can in fact impede economic growth in developing countries (Acar, 2000). So there is some debate at a theoretical level as to the effects of a devaluation of an exchange rate on a developing economy’s economic growth. It appears that overvaluations of the RER are agreed to be deleterious to economic growth in developing countries, however opinion appears split as to the effect of undervaluations and depreciations of the RER on economic growth.

2.2.4 International Empirical Evidence
Both Johnson et al (2007) and Rodrik (2008) have used a PPP based measure of RER overvaluation to account for growth accelerations in countries with weak institutions. This measure attempts to estimate the equilibrium RER for a country over a given period and then compares that estimated level with the observed real exchange rate level. The comparison between the actual and estimated level of the real exchange rate allows for the degree of over- or undervaluation of the RER to be observed. It is this deviation from the estimated equilibrium level that various authors have used to estimate the effects of RER misalignments on economic growth (Freund & Pierola, 2008; Johnson, et al., 2007; Rodrik, 2005 & 2008). Findings suggest that the avoidance of an overvalued, or uncompetitive exchange rate, is an important factor in sustaining economic growth in developing countries as they help mitigate various market failures that affect the tradables sector (Auboin & Ruta, 2011; Johnson, et al., 2007; Rodrik, 2008).

Using a PPP based measure of RER valuations, Johnson et al. (2007) and Rodrik (2008) found that countries whose currencies were not overvalued sustained levels of economic growth higher than those countries with overvalued RERs, even in the presence of market failures affecting the tradable sector. Johnson et al (2007) compared the growth performance of Sub Saharan African (SSA) countries to the performance of East Asian countries, both sets of countries were considered by the authors to suffer from poor institutions that impede trade. It was found that those East Asian countries that sustained high levels of economic growth were able to avoid an overvaluation of their exchange rate. In contrast SSAs experienced significantly lower growth than the East Asian countries and generally maintained overvalued exchange rates (Johnson, et al., 2007).

These findings concur with those of Aguirre and Calderòn (2005) who utilised a model based measure of the ERER to calculate misalignments of the RER rather than the PPP based measure used by the above studies. Using this measure, they found that misalignments generally impede growth whilst overvaluations exerted a stronger negative effect on growth. Differentiating between the effects of over- and undervaluations of the RER revealed tentative support for the idea that
Undervaluations could stimulate economic growth; however, this growth enhancing effect appears to exist only for small undervaluations up to 12% (Aguirre & Calderòn, 2005). The positive growth effects however become negative when undervaluations are greater than 25% (Aguirre & Calderòn, 2005). Devaluations are thus seen to be growth enhancing if they serve to decrease the degree of RER overvaluation or if they create a relatively small RER undervaluation but since some nonlinearity is observed, undervaluations can be deleterious to growth if they are large.

Investigating the proposed link between devaluations and economic growth, Rodrik (2008) worked from the basis that where an overvaluation of the RER impedes growth, then an undervaluation of the RER should encourage growth. Rodrik (2008) assumed that there exists a linear relationship between the valuation of a currency and the effect on growth and by implication that a decrease in the degree of overvaluation will have the same effect on growth as an increase in the degree of undervaluation (Rodrik, 2008). The assumption of a linear relationship between RER misalignments and growth, whilst in contrast to the findings of Aguirre and Calderòn (2005) is however consistent with much of the recent literature (Auboin & Ruta, 2011; Berg & Miao, 2010; Freund & Pierola, 2008; Johnson, et al., 2007).

Working from this standpoint, Rodrik (2008) sought to evaluate the growth effects of an exchange rate misalignment utilising an index of RER undervaluation developed from a PPP based measure of RER overvaluation similar to that used in other studies including Freund & Pierola, (2008) and Johnson et al (2007). This proxy for the degree of RER overvaluation was adapted by Rodrik (2008) to account for the Balassa-Samuelson effect which predicts that the price level of non-traded goods will be higher the larger a country’s GDP per capita.

Using a sample of 184 countries over approximately a fifty year period (1950 – 2004), Rodrik (2008) sought to establish whether exchange rate undervaluation is a significant determinant of economic growth. Following this approach a significant positive relationship between the degree of undervaluation and economic growth for developing countries was found. This observed positive effect however extends to only developing countries with developed countries not experiencing any significant growth affects associated with misalignments of their real exchange rate (Rodrik, 2008). The differentiated effect of RER undervaluations between developed and developing nations has been taken as evidence that developing nations are substantially more affected by weak institutions and market failures that impede growth of the tradables sector and that this sector is crucial to growth (Easterly, 2005; Johnson, et al., 2007; Rodrik, 2008).
Berg and Miao (2010) later confirmed the findings of Rodrik (2008) by rerunning Rodrik’s (2008) model as well as utilising an alternative model based measure of RER misalignment similar to that estimated by Aguirre and Calderòn (2000). Empirically they found no statistically significant difference between the two measures of misalignment once included in a growth regression (Berg & Miao, 2010). However, the growth effects of misalignments were only considered over a 5 year period or what they described as the medium term. Berg and Miao (2010) cautioned that in the very short run or in the long run, the effects of a devaluation could be negative or neutral respectively (Berg & Miao, 2010).

A related branch of the literature has considered directly the relationship between exchange rate devaluations and export growth. Whilst export stimulation may have contributed to the positive economic growth effects observed in the above studies, it was not explicitly accounted for. The studies examined above looked at aggregate economic activity, not differentiating between domestic or foreign demand for domestic output.

Movements of the exchange rate have the ability to affect the level of trade by affecting the foreign currency denominated price of goods and services traded between countries (Huchet-Bourdon & Korinek, 2011). In this way it has been suggested that exchange rate depreciations, by making exports cheaper, are able to boost economic activity by increasing export demand. Similarly an exchange rate depreciation also makes imported goods more expensive and as a result consumers may change their consumption patterns towards locally produced products, further stimulating domestic economic activity (El-Ramy & Abdel-Haleim, 2008; Rodrik, 2008).

The direct effects of exchange rate movements on economic activity described above are complicated when one considers that many manufactured products include imported content (Acar, 2000; Fang, et al., 2006). When this is the case, exchange rate depreciations make the domestic production of tradables more expensive. The incorporation of imported content in a country’s exports can lead to ambiguity in the effects of an exchange rate depreciation (Fang, et al., 2006; Huchet-Bourdon & Korinek, 2011; McPherson & Rakovski, 2000).

Empirical investigations into the effect of exchange rate depreciations on trade have yielded mixed results. Huchet-Bourdon and Korinek (2011) investigated the relationship of exchange rates and trade, focusing their efforts on trade between the Euro-zone, China and the US. They found that movements of the exchange rate affected exports of agricultural products significantly more than manufactures. This result probably stems from their being significantly more imported content in manufactured products and thus the depreciation of the exchange rate whilst decreasing the foreign
exchange rate denominated price also increases the cost of production. Heterogeneous goods have also been shown to accrue more market power allowing them to adjust their mark-ups rather than prices in response to the increased costs of inputs (Taylor, 2000). In this way the predicted positive effect on exports from an exchange rate depreciation are mitigated by the rising costs of imported content.

Additionally, altered specifications of their model revealed that movements of the exchange rate exhibited no long term effect on trade flows between countries (Huchet-Bourdon & Korinek, 2011). Overall Huchet-Bourdon and Korinek (2011) found that the short-run the effects of exchange rate movements on trade tend to be muted and the long-run effects are identified as being ambiguous and varying between model specifications. The ambiguous effects of exchange rate movements observed by Huchet-Bourdon and Korinek (2011) are supported by the earlier findings of Fang et al. (2006) who focused on the effects of exchange rate movements on trade levels of Asian economies. In addition, they examined the exchange rate risk associated with these movements. According to their model, a depreciation of the exchange rate is associated with significant positive effect on exports. However Fang et al. (2006) noted that the associated increase in exchange rate risk induced by the movement of the exchange rate exerted a negative effect on exports. Fang et al. (2006) remarked that the overall success of a depreciation an exchange rate in stimulating exports is difficult to determine as movements in the exchange rate affect sectors differently.

Following a different approach, Freund and Pierola (2002) identified 92 instances of export surges as well as the characteristics of these surges in a similar way as the identification of growth surges by Johnson et al (2007). It was found that export surges were most likely to occur in open economies following a depreciation of their exchange rate of 20% or greater. According to Freund and Pierola (2002) exchange rate depreciations were a significant factor in the determining the occurrence and sustainability of observed export surges. Additionally, exchange rate depreciations were noted as a preferable stimulus policy as all exporting industries are regarded to benefit, requiring no identification of specific industries by the government (Freund & Pierola, 2008). They, however, added that sustained exchange rate depreciations could lead to inflationary pressures that may in turn hurt growth (Freund & Pierola, 2008).

In contrast to reports of a significant, positive relationship between exchange rate depreciation and growth, there also exists a substantial albeit less reported body of literature that finds a significant
negative relationship as well as an insignificant relationship between exchange rate depreciations and economic growth (Oudusola & Akinlo, 2001).\(^3\)

To test whether exchange rate depreciations could be contractionary, Acar (2000) estimated a panel regression model encompassing 18 countries over a 25 year period between 1970-1994, that distinguished between the short, medium and long run effects of a depreciation\(^4\). The results indicate that in the short run depreciations exert a contractionary effect on the economy, as per the predictions made by the Structuralists. In the medium term the depreciation affects were observed to become expansionary and in the long run viewed to be neutral (Acar, 2000). Additionally, Acar (2000) differentiated between the effects on agricultural and manufactured output and found that the above results hold for both sectors.

Studies utilising VAR models whilst often not focusing of the growth effects of exchange rate depreciations have been able to provide some interesting insights. Oudusola and Akinlo (2001) utilise a six variable VAR model to analyse the response of the Nigerian economy to movements of the exchange rate. Their analysis of the impulse response functions (irf) obtained using a Cholesky decomposition; indicated a contractionary effect associated with a depreciation of the exchange rate in the first quarter following the depreciation. However, this initial negative effect turned positive in later quarters with the overall effect on growth left as ambiguous through showing no evidence of a negative long run effect on growth.

The findings of Oudusola and Akinlo (2001) appear broadly consistent with other studies that have utilised VAR models in that they find initial contractionary and inflationary effects associated with depreciations that tend to be neutral in the long-run. McPherson and Rakovski (2000) utilise a variety of approaches to analyse the Kenyan economy, their VAR model, however, found that a depreciation exerts no statistically significant direct effect upon output but rather acts indirectly through its influence on money supply, imports, agricultural production and foreign aid.

In contrast to the findings of McPherson and Rakovski (2000), El-Ramly and Abdel-Haleim (2008) estimated a simple 4 variable VAR for the Egyptian economy and found that a depreciation of the real effective exchange rate (REER) exerts a significant initial contractionary effect on the economy that lasts for up to 4 years. Utilising forecast error variance decompositions they found that a significant portion of the variation of real output (44.8 – 68.1\%) could be attributed to the change in

\(^3\) Oudusola and Akinlo (2001) provide an extensive review of studies that utilise a variety of estimation techniques that reveal both negative growth effects as well no long term effects on the economic growth rate of a country.

\(^4\) Acar (2000) defines the short run as within the same year as a depreciation and the medium run as the year following a depreciation of the exchange rate.
the REER (El-Ramy & Abdel-Haleim, 2008). Tsangarides (2010) obtained similar results to El-Ramy and Abdel-Haliem (2008) and Oudusola and Akinlo (2000) for the Mauritian economy when using a similar model to Oudusola and Akinlo (2000), however with a far more moderate output response. Tsangarides (2010) found that Mauritian output responded positively to an appreciation of the exchange rate only over the first 3 months thereafter becoming negative with the effects of the appreciation dying out within a year\(^5\). Adjusting the model to a structural VAR reveals an even more muted response function, with output exhibiting unstable variation around the pre-shock level of output (Tsangarides, 2010).

Similar results have also been achieved by Kamin and Klau (1998) using a panel error correction model for a sample of 27 countries for the period 1970-90. A devaluation of the RER negatively affected the growth rate of an economy in the short run. However, these negative effects were not found to extend to the long run. Additionally no positive growth effects arising from a devaluation of the exchange rate for their sample were found (Kamin & Klau, 1998). These findings are broadly consistent with results of aforementioned VAR models in that they find depreciations of the exchange rate to be contractionary in the short run, expansionary in the medium term and with little evidence of an effect on output in the long term (El-Ramy & Abdel-Haleim, 2008; Oudusola & Akinlo, 2001; Tsangarides, 2010).

Thus far the literature reviewed has shown that there are many theoretical arguments for and against possible expansionary effects of RER undervaluations and depreciations. The empirical literature additionally finds broad support for both positions. If a consensus can be teased from the literature it would be that misalignments in general hinder economic growth as they send incorrect price signals to the market thus resulting in an inappropriate allocation of resources. Depreciations can enhance growth when they represent a reduction in the degree of overvaluation. Depreciations that increase the degree of undervaluation have found some but limited support in the literature as a source of economic growth.

### 2.2.5 South African Evidence

The discussion thus far has not been specific to the South African economy. This section briefly considers research on the impact of exchange rate depreciations on output in the context of South Africa. The literature reviewed above revealed that if depreciations are to have a significant effect on the economic growth rate, it would be due to its effect on the degree of exchange rate misalignment. It has been shown robustly that a depreciation of the exchange that serves to

\(^5\) Tsangarides (2010) used appreciations rather than depreciations of the nominal effective exchange rate to generate his irfs.
decrease the degree of exchange rate misalignment is associated with positive growth effects. Depreciations that create or expand an undervaluation of the exchange rate have garnered less support as a growth enhancing strategy. It is thus important to consider the degree of exchange rate misalignment of the South African Rand, as the NGP proposed a depreciation of the exchange to encourage economic growth as it has been suggested that South Africa has an overvalued exchange rate.

Empirical investigations into the degree of exchange rate misalignment of the South African Rand have revealed a mixed picture. Using a model to estimate the behavioural equilibrium exchange rate (BEER), Mtonga (2006) sought to estimate how fluctuations of the exchange rate affect the competitiveness of South African exports. The BEER attempts to estimate the long-run relationship between the real exchange rate and a set of underlying fundamental variables (Mtonga, 2006). Deviations of the real exchange rate from this estimated level are considered by Mtonga (2006) to represent misalignments. Using this measure of RER misalignments, Mtonga (2006) found that the Rand exhibits a great deal of volatility, fluctuating between being over- and undervalued over the sample period.

Using a more conventional model based measure of the real exchange rate MacDonald and Ricci (2003) tentatively found that the Rand had actually remained under valued during the 1990s and early 2000s. This finding is in contrast to that of Mtonga (2006) though MacDonald and Ricci (2003) noted that there was a possibility that their model may estimate an equilibrium exchange rate higher than in actuality (MacDonald & Ricci, 2003).

The above findings are revealing as they both place the assertions of the NGP in some doubt as neither find that the Rand suffers from being overvalued. On the contrary there is tentative evidence that the Rand tends towards undervaluation. In light of these findings it seems that an overvalued exchange rate is an unlikely cause of slow economic growth in South Africa and a depreciation an unlikely accelerant. However if the conventional view of exchange rate misalignments hold then depreciations can still further stimulate economic growth by providing a second best solution to market failures as well as by making exports cheaper (Rodrik, 2008). With knowledge of the degree of RER misalignment of the Rand it is of interest to consider then how economic growth has thus responded to depreciations.

Rankin (2002) considered the effect of exchange rate depreciations on the level of South African exports over a thirty year period. An important motivation behind Rankin’s (2002) study was the observed contribution of export growth to total output growth over the 30 year period under
analysis. This same period additionally showed no sign of sustained overvaluation (MacDonald & Ricci, 2003; Mtonga, 2006). Rankin (2002) found that many sectors, including manufactures, within South Africa respond negatively to depreciations of the exchange rate. Specifically Rankin (2002) found that depreciations of the exchange rate are unlikely to generate an increase in South African exports.

In an analysis of the relationship between growth in the South African manufacturing sector and exchange rate depreciations Saville (2010) found little evidence of any significant relationship between the manufacturing sector’s growth and exchange rate depreciations. He has thus argued that the South African manufacturing sector is little affected by movements of the exchange rate. However, the SA manufacturing sector does appear to be significantly affected by the income growth of its trading partners (Saville, 2010). The importance of the aggregate demand of a country’s trading partners in explaining economic growth is an important determinant of export growth and the success of an export led growth strategy (Auboin & Ruta, 2011; Rodrik, 2008; Saville, 2010).

2.2.6 Concluding Remarks
The picture presented thus far is that of a tentative consensus that depreciations of a developing country’s exchange rate could lead to an increase in economic growth. Depreciations can act as a second-best solution to various market failures as well as making exports more competitive and switching import expenditure towards domestic consumption. It has been shown that depreciations of the exchange rate can exert significant growth stimulating effects for developing countries but an insignificant effect on the growth rates of more developed nations.

Where depreciations reduce the degree of overvaluation they have robustly been shown to be expansionary in nature. However, where depreciations serve to create or expand the degree of undervaluation the evidence appears less consistent. There is additionally a substantial body of literature that has found that devaluations exert contractionary effects on an economy in the short run with no significant long-run effects being observed. Both conventional and structuralist views insist that developing nations are more prone to their predicted effects due various characteristics embodied by these nations. Further investigation into the effects of exchange rate depreciations appears warranted due to the lack of consensus in the literature before a policy can be recommended for South Africa.
2.3 The Exchange Rate and Domestic Prices (Inflation)

The exchange rate is an important macroeconomic variable as it potentially has the ability to affect economic growth (as described in section 2.2) as well as influencing domestic prices and monetary policy (Jacobson, et al., 2001). The exchange rate pass through (ERPT) effect refers to the effect that changes in the exchange rate have on domestic prices (Ocran, 2010). The ERPT effect therefore describes those variations of the price level that are directly attributable to changes in the nominal exchange rate (Bhundia, 2002; Ocran, 2010). In this way, the degree of ERPT affects how changes in the nominal exchange translate through to the real exchange rate. Recall that an increase of the domestic price level relative to the international level results in an appreciation of the RER. Thus the increased price level resulting from a depreciation of the nominal exchange rate counter acts the initial depreciative effects on the RER.

Additionally, if inflation features in the loss function of a monetary authority then the degree of ERPT experienced by a country may influence the response of that authority to changes in the exchange rate. This section of the literature review considers how changes of the exchange rate affects domestic prices, empirical evidence quantifying the degree of ERPT to domestic prices as well as explanations as to the observed incompleteness of this effect.

The literature examining exchange rate effects on inflation often assume that the law of one price or purchasing power parity (PPP) and as such prices wholly adjust to absorb the effects of a nominal depreciation of the exchange rate (Bhundia, 2002; Edwards, 2006; Jacobson, et al., 2001). If pass through to prices were complete (or unitary) then a nominal depreciation would leave the real exchange rate unaffected thus providing no stimulus to exports or economic growth (Bhundia, 2002). Empirical investigations have however found little support for PPP holding in the short to medium run. Specifically, empirical investigations have observed that there is incomplete ERPT in the short to medium run (Bhundia, 2002; Ca’ Zorzi, et al., 2007; Ocran, 2010).

There are several channels through which a change in the exchange rate affects domestic prices (Kaseram, et al., 2004). Primary among these is the direct effect on domestic prices through the effect on the domestically denominated currency prices of imported goods (Bhundia, 2002). Indirect exchange rate effects on domestic prices include the wage demands from labour unions seeking to secure compensating wage increases for the now more expensive imported goods as well as demand-pull inflation (Kaseram, et al., 2004). In this instance demand pull inflation may occur if the exchange rate depreciation stimulates economic growth either through stimulating exports and/or import-competing industries as consumers switch to relatively cheaper domestically produced goods (Bhundia, 2002; Kaseram, et al., 2004).
2.3.1 Sources of Incomplete Pass-Through

Empirical investigations have found that the ERPT tends to be incomplete and differs significantly between countries (Ca' Zorzi, et al., 2007; Gagnon & Ihrig, 2004). Many reasons for this incomplete transfer through to domestic prices and tradable goods exist as well as for why there are differences in the degree of ERPT between countries. Crucially, the degree of ERPT depends on the importance of imported goods and services in the production of goods and services as well as the inclusion of imported goods in the CPI basket (Bhundia, 2002; Kaseram, et al., 2004; Smets & Wouters, 2002; Taylor, 2000). The higher the proportion of imported content in domestic output, more sensitive the cost of production will be to changes in the exchange rate.

Several additional reasons as to why ERPT is incomplete and inconsistent between countries exist and include the presence of imperfect competition, the degree of openness and the role of monetary policy (Ca' Zorzi, et al., 2007). Dornbusch (1987) originally proposed and formalised how the competitive environment of domestic firms influences the exchange rate effect on prices. If firms are operating in an imperfectly competitive market they may respond to changes in the exchange rate by adjusting their mark-up (Ca' Zorzi et al, 2007; Ocran, 2010; Taylor, 2000). Additionally, small countries tend to act as price takers in the global market when the production of goods and services are not concentrated within that country (Taylor, 2000). This price-taking behaviour of firms in small countries leaves them having to internalise the effects of exchange rate movements through changes in their mark-ups so that prices remain competitive internationally (Dornbusch, 1987).

The homogeneity of goods also plays a significant role in determining the effect of exchange rate movements on prices. Specifically, homogeneous goods, such as commodities, tend to be significantly more sensitive to exchange rate movements than more heterogeneous manufactures (Dornbusch, 1987). It has been argued that this is owing to the market power that differentiated goods tend to accrue in comparison to their homogeneous counterparts (Taylor, 2000). By affording producers the opportunity to adjust their mark-up on goods rather than solely the price, an imperfectly competitive market can result in a lower degree of pass-through from exchange rate movements (Dornbusch, 1987). Reduction of mark-ups and hence lower profit margins allow firms to avoid increasing their prices in response to higher costs that result from exchange rate depreciations.

The degree of openness of a country has been assumed a significant determinant of the sensitivity of a country’s domestic prices to changes in the exchange rate (Ca' Zorzi, et al., 2007; Romer, 1993; Smets & Wouters, 2002). However, empirical evidence suggests a more complex relationship at play with openness able to enhance or diminish the degree of ERPT. Openness may result in a direct
positive relationship between the exchange rate and the domestic price level as open economies likely have a greater proportion of imported goods consumed than their more closed counterparts. Movements of the exchange rate can then exert a greater influence on the domestic price level by affecting the domestic currency denominated price of a greater proportion of goods in the domestic consumption basket of a more open economy (Ca' Zorzi, et al., 2007; Smets & Wouters, 2002).

Conversely, the openness of the economy could have a negative effect on inflation due to stabilization policies followed by open economies (Ca' Zorzi, et al., 2007; Romer, 1993). According to Romer (1993), open economies are likely to recognise that expansionary monetary policies depreciate their currency and induce inflation, and by recognising this trade-off, will follow unexpected expansionary monetary policies less often. In this respect, movements of the exchange rate are recognised as an important channel for the transmission of monetary policy in small relatively open economies with depreciations acting as an expansionary policy (Jacobson, et al., 2001). Ca' Zorzi et al (2007) using VAR analysis for a cross section of countries found little support for the hypothesis that the openness of a country is positively correlated with the degree of ERPT experienced noting only a weak relationship between ERPT and openness. Ca' Zorzi et al (2007) rationalize their finding of a weak relationship between the degree of ERPT and openness to Romer's (1993) observation.

It has additionally been proposed that the inflationary environment of a country is positively correlated with the degree of ERPT observed (Taylor, 2000). Countries with low inflation rates tend to experience low levels of ERPT and vice versa. Taylor (2000) argues that high inflation rates are associated with greater inflationary persistence and in the presence of such persistence exchange rate movements are believed to be less transitory. Because of the perceived permanence of the exchange rate movement, producers are more likely to respond to exchange rate movements by changing their prices (Ca' Zorzi, et al., 2007; Taylor, 2000). Ca' Zorzi et al (2007) find that apart from two outliers (Turkey and Argentina) their sample provided support for the hypothesis proposed by Taylor (2000) as well as that by Romer (1993).

Monetary policies pursued by nations play a significant role in determining the degree of ERPT experienced (Ca’ Zorzi, et al., 2007). Specifically, monetary authorities that react in a credible manner to inflationary pressures, whilst exhibiting lower inflation levels, also experience lower levels of ERPT (Flamini, 2007; Gagnon & Ihrig, 2004). Monetary authorities that pursue inflationary targeting as their official regime have increased their credibility in fighting inflationary pressures and this increased credibility has been shown to reduce inflation (King, 2004; Lanzafame & Nogueira Jr, 2011). Firms in countries that have lower levels of inflation, due to the commitment of their
monetary authorities, are less like likely to adjust their prices in response to exchange rate fluctuations as central banks are expected respond to inflationary pressures, stabilising inflation over the long run (Gagnon & Ihrig, 2004).

Gaggan and Ihrig (2004) test their hypothesis that countries with credible monetary authorities experience lower ERPT by estimating how the monetary stance within a country affects the pass through of real exchange rate fluctuations to inflation for a sample of 20 industrial countries between 1971 and 2000. They found that a monetary policy stance that was more responsive to perceived inflationary pressures was also associated with lower rates of ERPT. Additionally, and seemingly in confirmation of the relationship described by Taylor (2000) it was found that nations with lower rates of inflation also experienced lower degrees of ERPT (Gagnon & Ihrig, 2004). The degree of ERPT decreases following the implementation of a formal inflation-targeting regime that serves to increase central bank credibility and successfully moderate inflation (Flamini, 2007; Lanzafame & Nogueira Jr, 2011).

2.3.2 South African Empirics
Evidence from various studies looking at the degree of ERPT in South Africa have generally found that the pass-through to domestic prices tends to be consistent with international experience in that it is incomplete and differentiated across commodities (Bhundia, 2002; Kaseram, et al., 2004; Ocran, 2010). Using a VAR model based on the IMF model of inflation for South Africa, as well as drawing from various other South African studies, Kaseram et al. (2004) attempted to quantify the various drivers of South African inflation. Following this approach, nominal depreciations of the exchange rate show a significant effect on inflation, though the observed effect is that of incomplete pass-through to domestic prices (Kaseram, et al., 2004).

Also using a VAR model to analyse the South African economy, Ocran (2010) considered how changes in the exchange rate affect prices moving down the distribution chain. It was found that the ERPT to consumer prices is a rather modest at 12.4%. These findings are in line with those of Bhundia (2002) who utilised a similar VAR model to that of Kaseram et al (2004) and found that the pass through to consumer prices was approximately 12.5%.

The low degree of ERPT observed in the South African context possibly arises due to domestic firm’s pricing-to-market in the presence of imperfect competition (Bhundia, 2002; Taylor, 2000). Significant frictions in the price-setting behaviour of firms could act as an impediment to firms responding timeously and completely to changes in the exchange rate (Bhundia, 2002). Additionally, the modest degree of ERPT observed in South Africa could stem from the flexible-inflation targeting regime of the SARB – economic agents perceive that the SARB reacts in a credible manner to inflationary
pressures and, thus, the SARB successfully maintains a moderate level of inflation (Burger & Marinkov, 2008; Flamini, 2007; Taylor, 2000).

The inflationary effect of exchange rate depreciations observed in the South African setting is consistent with experiences in other nations. Tsangarides (2010), utilising Cholesky decompositions, has illustrated that appreciations of the exchange rate induce a reduction in the degree of CPI inflation experienced in the Mauritian economy. Using a similar model, depreciations of the exchange rate were found to increase the rate of inflation in the Kenyan economy (Oudusola & Akinlo, 2001). Both these studies found that whilst the exchange rate had a significant influence on inflation, the observed effect was relatively mild.

Incomplete ERPT however has an important implication for the RER as the incomplete pass through to prices allows a nominal depreciation of the exchange rate to translate into a real depreciation. A quick and complete adjustment of prices to a change in the exchange rate would erode at any competitive advantage that would arise from a nominal depreciation (Ocran, 2010). In the South African setting it was found that following a nominal depreciation of the Rand it would take approximately 12 months for relative prices to adjust and return the RER back to its original, pre-nominal shock level (Bhundia, 2002). Thus a nominal depreciation of the Rand results in the economy experiencing a real depreciation for approximately 12 months before prices adjust sufficiently to return the RER to its original level.

2.3.3 Concluding Comments
Thus far it has been shown that depreciations of the exchange rate are a significant influence on the rate of inflation. However, depreciations are not reflected in one-for-one movements of the domestic price level. Instead, ERPT tends to be incomplete and differentiated across countries and between commodities. It has shown that low inflationary environments, inflation-targeting regimes, the market power of firms as well as the openness of an economy influence the degree of ERPT experienced by an economy. Even though ERPT is incomplete and has decreased following the institution of inflation-targeting, movements of the exchange rate still exercise significant influence over the price level. This significant, though muted, effect on inflation has been documented in South Africa with Ocran (2010) and Bhundia (2002) finding a significant pass-through coefficient of approximately 12%, additionally the SARB has recognised a long-run pass-through of 78% (Bhundia, 2002).

The observed relationship between exchange rate movements and the rate of inflation have consequences for both the behaviour of the SARB and the integrity of the macroeconomic policy package outlined in the NGP. It has been shown that depreciations of the nominal exchange rate
exert moderate inflationary pressure upon the price level. The ERPT effect thus calls into question whether it is feasible to simultaneously promise a low inflationary environment together with a depreciated exchange rate.

2.4 The Exchange Rate and Interest Rates
The third relationship examined in this literature review is that between the exchange rate and the interest rate, or more specifically the exchange rate and the behaviour of SARB. This is an interesting relationship for three distinct reasons. Firstly, the reaction functions of small economies are traditionally modeled as closed and use Taylor rules that lack the explicit inclusion of an exchange rate variable (Edwards, 2006). Secondly, and related to the above, South Africa is an inflation targeting nation and understanding whether the SARB explicitly considers exchange rate variations in determining policy or whether it waits for the effects of the exchange rate movement to appear in other variables is of interest from an operational point of view (Edwards, 2006). The third reason why this relationship is of interest is that it speaks to the very consistency of the macroeconomic policy package proposed for South Africa in the NGP. If the SARB reacts to movements of the exchange rate it calls into question whether it is feasible to maintain a low interest rate environment whilst pursuing a competitive exchange rate.

As discussed in the previous sections, the exchange rate is an important channel of monetary policy in a small open economy as it has the potential to affect domestic prices and output (Jacobson, et al., 2001; Svensson, 1997). This has potentially significant consequences for the conduct of monetary policy of a small open economy such as South Africa that explicitly targets inflation (Edwards, 2006). If indeed, the SARB does react to exchange rate variations then given that there has been no mention of an alteration to the mandate of the SARB, the congruency of maintaining a low interest rate environment in the presence of a more competitive currency is brought into question.

To draw out this dimension of the policy discussion presented thus far effectively; this section of the literature review considers the affect movements of the exchange rate have on the conduct of monetary policy in an inflation targeting setting. To do this, this section of the literature review consists of three sections, namely a discussion of inflation targeting and its application to South Africa, how the exchange rate features in the policy rule of inflation targeting central banks and the findings of empirical studies.

2.4.1 Inflation Targeting and the South African Context
Inflation targeting has become a popular framework for the conduct of monetary policy around the world (Bernanke & Mishkin, 1997). Central banks that have adopted this framework range from
large developed economies such as the UK to small developing countries such as South Africa. Additionally there has been a diverse implementation of inflation targeting across adopting nations (Bernanke & Mishkin, 1997), however Mishkin (2001) identifies five elements that are generally consistent across inflation targeting frameworks.

According to Mishkin (2001) inflation targeting requires that a central bank publically announces their commitment to a numerical target for inflation as well as exhibiting an institutional commitment towards achieving price stability to which other policy goals are subordinate (Mishkin, 2001). Additionally an inflation targeting central bank should follow an information inclusive strategy when considering policy actions as well as increasing the transparency of the policy making process and accountability of the monetary authority to achieve its goals (Mishkin, 2001).

A major criticism of inflation targeting is that if followed too strictly, it could lead to volatile interest, exchange and growth rates as well as an overall lowering of output (Mishkin, 2001; Svensson, 1997). Such volatility is induced through activist monetary policy that would be required to bring inflation back in line with the central banks specified target level with in a short period (Svensson, 1997). To prevent negative effects on other variables, Svensson (1997 & 2009) argues that central banks should - and observes generally do - relax the second element of an inflation-targeting regime outlined by Mishkin (2001). Instead of all goals being subordinate to the pursuit of price stability, the central bank should rather seek to gradually return inflation to its desired level, thus mitigating the volatility of other policy variables that would otherwise arise (Svensson, 1997).

In practice, inflation-targeting regimes have avoided practicing strict inflation targeting that follows a myopic approach to price level stabilisation, choosing rather to practice flexible inflation targeting. Flexible inflation targeting recognises that vigorous and sometimes large policy adjustments, that would be required to bring inflation back to the target level within a short period, can have adverse effects on the economy, and thus, rather seeks to stabilise the price level over a longer time horizon (Svensson, 1997).

Svensson (1997) has noted that a flexible inflation-targeting regime is optimal for open economies as the exchange rate channel of the monetary transmission mechanism is significant and that an open economy is subject to foreign as well as domestic shocks. As discussed in section 2.3, the exchange rate exerts an influence on the price level through both a direct and indirect channels (Jacobson, et al., 2001; King, 2004; Svensson, 1997). The exchange rate directly affects the price level through the inclusion of imported goods and services in the CPI basket as well as domestically produced goods.
that use imported inputs. Indirectly through affecting the demand for locally produced goods\(^6\). Interestingly Svensson (1997) has suggested that since the exchange rate directly effects inflation through the inclusion of imported goods in the CPI basket, price stabilisation also implies that a central bank should be required to counter exchange rate shocks. This behaviour is only likely to lead to an excessively variable exchange rate if the central bank were practicing a strict form of inflation-targeting and thus attempting influence inflation over a short period (Svensson, 1997).

It is this flexible framework that the SARB argues it has used since explicitly adopting inflation targeting in February 2000 (SARB, 2012). Since then the SARB has utilised flexible inflation-targeting in pursuit of its mandated defence of the internal value of the rand, keeping inflation between 3 and 6 percent. Apart from attributing some importance to the stability of other variables and seeking to curtail inflation in a gradual manner, the conduct of the SARB has been broadly consistent with the elements that Mishkin (2001) uses to describe an inflation-targeting regime (van der Merwe, 2004).

Accordingly the SARB has clearly announced its targeted range for inflation as well as expressed its commitment to pursue price stability. Additionally the SARB attempts to be transparent via the publication of inflation outlooks as well has publically announcing the outcomes of the quarterly meetings of the Monetary Policy Committee. Following such a meeting the Governor of the Reserve Bank announces the SARB’s interest rate decisions as well as its motivations for its decision on the REPO rate. The SARB uses all available information it can garner to create a forecast of future inflation, which then serves as an intermediate target for the conduct of monetary policy (Schaling, et al., 2009). This intermediate target used by the SARB is entirely consistent with a flexible inflation-targeting regime described by Svensson (1997) and allows the SARB to adopt a gradualist approach to managing the price level.

Commentators on the South African economy have noted that even under a fully-fledged inflation targeting regime, movements of the exchange rate are still an important consideration for policy makers (Ortiz & Sturzenegger, 2007; van der Merwe, 2004). Thus it is recognised that as a small open economy pursuing a clearly defined inflation target, South Africa needs to remain aware of movements of the exchange rate when conducting policy. This is not to suggest that the SARB should fixate over the stability of the exchange rate or pursue a specific level of the exchange rate. It does however mean that movements of the exchange are considered when developing monetary policy, as these movements will likely exert an influence on the price level (Edwards, 2006).

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\(^6\) Both the direct and indirect channels through which the exchange rate influences the price level were discussed in section 2.3.
Exactly how an inflation-targeting central bank of a small open economy responds to exchange rate movements is however not entirely clear as little empirical research has been conducted on the issue (Edwards, 2006). The next section follows Ball (1998) and Edwards (2006) in considering how an inflation targeting central bank of a small open economy should adjust the interest rate in response to a change in the exchange rate.

2.4.2 Inflation Targeting Central Banks and the Exchange Rate
As has been described earlier in this section the exchange rate is an important channel of monetary policy in a small open economy, yet the literature assessing the reaction functions of such central banks have typically imposed the assumptions of a closed economy (Edwards, 2006). It is noted by Edwards (2006) that whilst the literature on inflation targeting and the reaction functions of such central banks is voluminous, scarce mention is made of how the exchange rate should affect policy (Edwards, 2006). Thus, the behaviour of an inflation-targeting central bank to movements of the exchange rate has been largely ignored by mainstream literature leaving the conduct of such monetary authorities unclear (Edwards, 2006).

To understand how the exchange rate could feature in a central bank’s decision making process Edwards (2006) described how it is common practice to state the objective (or loss) function of a central bank. This objective function typically includes both the deviations from the targeted level of inflation as well as from potential output. The goal of the central bank in this setting is to minimise the loss to society with respect to these parameters (Ball, 1998; Edwards, 2006; Woglom, 2003).

\[ L = (\pi_t - \pi^*)^2 - \lambda(y_t - y^*)^2 \]  

(2.2)

In the above representation of a typical loss function, \( \pi_t \) represents actual inflation, \( \pi^* \) targeted inflation, \( y_t \) actual output and \( y^* \) potential output. The coefficient \( \lambda \) represents the relative importance a central bank places upon the output gap. Strict inflation targeters can be thought of as either placing a very low, or no weight at all upon the output gap, in which case lambda would be either very small or equal to zero (Green, 1996). Alternatively, a central bank following a flexible inflation targeting regime would attribute some weight to the output gap however still holding the stabilization of the price level as the primary goal and hence \( 0 < \lambda < 1 \) (Green, 1996).

The assumption is that the central bank’s recognizes that deviations from both targeted inflation and potential GDP are welfare reducing and as such seeks to formulate policy that minimize such loses. This assumption does not imply that central banks pursuing a flexible inflation-targeting regime have dual targets but simply recognizes that policies to bring inflation back on target have an effect on
output (Svensson, 1997). Thus, a central bank following a flexible inflation-targeting regime will seek to minimize the effect on output when attempting to contain inflation.

In this context, it can be seen clearly that the exchange rate should feature in the decision-making process if the exchange exerts an influence over the parameters in the objective function of the central bank. As it was shown in sections, 2.2 and 2.3 movements of the exchange rate can potentially exert a significant influence over both domestic prices and output. If a movement of the nominal exchange rate affects the degree of RER misalignment, it may affect economic growth. Additionally, if the pass through coefficient is significantly different from zero then the inflation parameter will be affected. It is however unclear whether the exchange rate should feature explicitly in the reaction function of a central bank (Edwards, 2006).

It has been proposed that if the economy is correctly modeled by the central bank, taking into account the effects of the exchange rate on the parameters in the objective function, then there is no need for an exchange rate variable to be placed explicitly within the reaction function of the central bank (Taylor, 2001). However if the effects of exchange rate movements exert a delayed effect on the parameters within the objective function, then a central bank may wish to act contemporaneously to such movements so as to pre-empt the effects on output and inflation. However, a central bank may also wish to wait for the effects of the exchange rate to work their way through the economy before reacting. In practice, it is noted that how a central bank chooses to react is an empirical matter (Edwards, 2006).

2.4.3 Taylor Rules for Small Open Economies and Optimal Policy

There has been a trend for central banks adopting official targets to act as anchors for monetary policy (Bernanke & Mishkin, 1997). This trend coupled with the debate surrounding rule based and discretionary policies has led to a significant volume of literature dedicated to estimating the reaction functions of central banks. However, Edwards (2006) notes that the majority of such studies neglect to include an exchange rate variable in the specification of the reaction function of the central bank and, in so doing, impose closed economy assumptions upon the model.

Typically, a Taylor rule uses information on the output gap and the inflation gap to predict the interest rate setting behaviour of central banks. When output or inflation is above potential or target respectively, one would expect the central bank to follow contractionary monetary policy (increase interest rates) in a bid to return inflation to its desired level. In the same context, the exchange rate can be included in this simple policy rule to analyse how a central bank responds to movements of the exchange rate (Edwards, 2006). The question of how a central bank reacts to movements of the
exchange rate can be addressed by simply augmenting a simple closed economy Taylor rule with an
exchange rate variable (Edwards, 2006; Taylor, 2001):

\[ i_t = f\pi_t + gy_t + h_0e_t + h_1e_{t-1} \]  \hspace{1cm} (2.3)

Equation 2.3 above is a representation of a Taylor rule where \( \pi_t \) and \( y_t \) represent the inflation and
output gaps experienced, with \( f \) and \( g \) being the coefficients that describe the importance of these
variables to the formation of interest rate policy. Contemporaneous and lagged exchange rate
variables have been included in the above specification with \( e_t \) and \( e_{t-1} \), that describe the exchange
rates deviation from equilibrium. The coefficients \( h_0 \) and \( h_1 \) thus describe the importance of
exchange rate deviations from equilibrium in the formation of monetary policy (Edwards, 2006).

The question of whether it is optimal for a small open economy to react to movements of the
exchange rate has been analysed by researchers using Taylor rules similar shown in equation 2.3
(Edwards, 2006; Taylor, 2001). Of interest, here is how a small open economy should react to the
exchange rate to minimise its loss function described in section 2.4.2. What coefficient values should
the central bank attribute to \( h_0 \) and \( h_1 \)? In a closed economy, or one where the exchange rate does
not feature in the reaction function of the central bank, then \( h_0=h_1=0 \). That is the interest rate is not
adjusted in response to either contemporaneous or lagged deviations of the RER from is equilibrium
level. However, it has been argued that in the open economy setting a central bank pursing optimal
monetary policy should react to the exchange rate and hence \( h\neq 0 \).

Because a depreciation of the exchange rate is supposed to be expansionary and inflationary, it is
proposed that the overall response of the central bank should counter the effects of the exchange
rate movement (Ball, 1998; Edwards, 2006). Thus in the case of a depreciation the central bank
should respond with an overall tightening of the interest rate (contractionary monetary stance).
Though in his review of the ‘new normative macroeconomics’, Taylor (2001) found some disparity
amongst the various parameters found to minimise the loss function of a central bank.

Taylor (2001) discussed a simple rule of thumb proposed by Obstfeld and Rogoff (1995) where the
parameter \( h_0 < 0 \) and \( h_1 = 0 \). Thus, a central bank would increase the short-term interest rate in
response to a depreciation of the RER to impose a countervailing force upon the inflationary
pressure. The same can be said if \( h_0 < 0 \) and \( h_1 > 0 \) but \(|h_0|>|h_1| \) in this way the net policy response
will be consistent with the original rule of thumb proposed by Obstfeld and Rogoff (1995). An
alternative to this rule suggests that these parameters be set equal to one another such that \( h_1 = -h_0 \)
and, thus, that the monetary authority is to respond to changes in the exchange. Taylor (2001)
describes this as a better algebraic representation of a policy rule that responds to an appreciation of the exchange rate with a reduction of the interest rate.

In Taylor’s (2001) review of the effectiveness of such policy rules to minimize the quadratic loss functions faced by central banks he found that regardless of the choice of $h$ parameters, the net effect of a central bank responding to the exchange rate is an improvement of the loss function. However, the observed improvement in the loss functions was small following the inclusion of the exchange rate term. Taylor argues that this result might imply that a central bank need not be considered as explicitly reacting to the exchange rate but rather in a rational manner to the effects that the change in the exchange rate will have on future inflation and aggregate demand (Taylor, 2001). In this way, even if the $h$ parameters were jointly set to zero, a central bank still responds, though indirectly, to the exchange rate by recognizing the effects on output and inflation (Taylor, 2001).

The inclusion of exchange rate parameters in the policy response of a central bank improves the loss function of the central bank by reducing the observed variation of both output and inflation. However, this improvement of the loss function is significantly smaller than commentators expected (Taylor, 2001). Whilst it is of interest that a response to exchange rate may be welfare enhancing in terms of the effect on the objective function of the central bank, it is not the question of interest of this dissertation. Certainly, it is established that there is both a theoretical and empirical rationale for a central bank incorporating the exchange rate in its interest rate setting decision process. It is, however, unclear whether the exchange rate is explicitly included in the reaction function of an inflation targeting central bank or whether the central bank reacts in an implicit manner. To understand how the exchange rate actually features in the reaction function of an inflation targeting central bank section 2.4.4 considers the evidence gleaned from estimating the reaction functions of such central banks.

2.4.4 Empirical Evidence

Inflation targeting has gained widespread popularity as an operating procedure for central banks in both developed and developing nations. Following the widespread adoption many commentators have sought to evaluate the reaction functions (or Taylor rules) of these central banks to determine whether the exchange rate plays a significant role in the formation of monetary policy. It should be noted that there is much controversy regarding the evaluation of inflation targeting frameworks (Aizeman, et al., 2011) and what follows here is simply a consideration of whether the exchange rate is a significant variable in a Taylor rule. This approach has been chosen as Taylor rules of various
forms have become a standard tool for assessing the behaviour of a central bank (Aizeman, et al., 2011).

The original specifications of Taylor rules used in empirical analyses assumed economies were closed and thus unaffected by exchange rates (Edwards, 2006). However, if the exchange rate were an important determinant of the behaviour of a central bank, then not only would it appear as a significant variable in a regression but when excluded the resulting reaction function could lead to inaccurate parameter estimation and thus poor policy formation (Sánchez-Fung, 2011). Following this, a significant branch of literature has developed estimating the reaction functions for open economies and assessing the importance of the exchange rate in these Taylor rules (Aizeman, et al., 2011; Sánchez-Fung, 2011).

The overall result from such studies is that the exchange rate does feature as a significant determinant of the interest rate (Aizeman, et al., 2011; Sánchez-Fung, 2011; Edwards, 2006). This finding is consistent across both inflation-targeting and non-inflation-targeting countries, with the former placing lower but statistically significant weight upon the exchange rate (Aizeman, et al., 2011). These results of Aizeman et al (2011) broadly confirm the findings in the literature that the exchange rate is a significant determinant of monetary policy in inflation-targeting countries (Edwards, 2006; Jacobson, et al., 2001; Svensson, 1997; Sánchez-Fung, 2011). Whilst it is found that inflation-targeting nations generally react in a significant manner to movements of the exchange rate the result does not hold for all inflation targeting countries (Aizeman, et al., 2011; Edwards, 2006).

The exchange rate appears to be a more significant determinant of monetary policy in economies that historically have experienced high levels of inflation, exchange rate volatility or that rely significantly upon exports (Aizeman, et al., 2011; Edwards, 2006). Using a cross section of countries and seeking to evaluate the varying significance of the exchange rate in the reaction functions of central banks, Edwards (2006) found that inflation-targeting central banks place greater importance on the exchange rate when they have had a history of either high inflation or great volatility of the exchange rate.

Aizeman et al (2011) reiterated the observation by Edwards (2006) that there is a lack of empirical investigations focusing upon the interest rate setting behaviour of central banks in emerging economies. By using various sub-samples of inflation-targeting countries, Aizeman et al (2011) were able determine the characteristics that lead a central bank to attribute more weight to the exchange rate. Accordingly, they found that inflation-targeting countries that rely heavily upon commodity
exports place significantly more weight upon the exchange rate within their monetary policy reaction function. The findings across their sample of inflation-targeting countries lend support to the idea that the exchange rate is a significant factor in determining the interest rate setting behaviour of inflation targeting central banks in small open economies, though the weight placed on the exchange rate depends on the importance of commodities in their export basket.

It has been shown in various studies that the exchange rate is a significant determinant of monetary policy in Brazil, Canada, Turkey and the UK (Civcir & Akcaglayan, 2010; Lubik & Schorfheide, 2007; Sánchez-Fung, 2011). However the central banks of Australia and New Zealand appear not to react explicitly to movements of the exchange rate (Lubik & Schorfheide, 2007). Civcir and Akcaglayan (2010) found that in Turkey a depreciation of the NEER, not only evokes a significant contractionary response from the Turkish central bank, but also results in a decrease in the economic growth rate as well as an increase in inflation. Using a FEVD analysis, it was found that apart from the interest rate itself, movements of the exchange rate were the most significant determinant of the interest rate, accounting for up to 20% of the observed variation of the interest rate in the inflation-targeting period.

Using an autoregressive distributed lag (ARDL) model rather than the popular VAR approach, Sánchez-Fung (2011) found that the exchange rate is still a significant determinant of monetary policy in Brazil following its adoption of inflation targeting. This finding is of significance for the expected performance of South African monetary policy as Brazil is touted as a textbook example of a fully-fledged inflation-targeting regime (Sánchez-Fung, 2011) that it has been claimed the SARB follows (van der Merwe, 2004).

The finding that the exchange rate is an important predictor of monetary policy suggests that inflation targeting monetary authorities in small open economies view the exchange rate as an important forward-looking variable (Sánchez-Fung, 2011). This forward-looking characteristic implies that central banks recognise the effects that the exchange rate has upon variables within its objective function and choose to react in pre-emptive manner to change in the exchange rate rather than waiting for the exchange rate to affect the objective function variables in a later period (Edwards, 2006; Sánchez-Fung, 2011).

2.4.5 The South African Experience
According to Burger and Marinkov (2008), South Africa has experienced two rounds of inflation targeting starting with a period of implicit inflation targeting in the period between 1990 and 2000. This era of implicit inflation targeting gave way to the current regime of explicit flexible inflation targeting in February 2000. As discussed previously, flexible inflation targeting is a preferable
strategy for a small open economy as the central bank is not fixated on the short-term achievement of their inflation goal and, thus, its policy is less likely to induce output volatility (Svensson, 1997). A flexible inflation-targeting regime uses all available information to inform its policy behaviour and the policy considers inflation over a longer time horizon than its strict inflation-targeting counterpart (Svensson, 1997).

Following the official introduction of South Africa’s inflation targeting regime, many studies have attempted to estimate the reaction function of the SARB. The emphasis of these studies has generally been of estimating the strictness of the SARB on inflation or on comparing the behaviour of the SARB between periods. Few studies have therefore explicitly considered the importance of the exchange rate in the reaction function of the SARB. However, those studies that have included the exchange rate as part of the SARB reaction function have resulted in mixed findings.

Using a DSGE model calibrated for a small open economy Ortiz and Sturzenegger (2007) found that the SARB responds in a significant manner to movements of the exchange rate and in a similar degree to Canada and the UK. The IMF has also found that the SARB raises the interest rate in a statistically significant manner in response to depreciation of the exchange rate (IMF, 2005). These studies suggest that the SARB behaves like other small open inflation-targeting economies like Brazil, Canada and the UK by explicitly incorporating movements of the exchange rate in the reaction function.

Other studies have however revealed conflicting evidence, finding that the exchange rate is not a significant determinant of SARB policy (Naraidoo & Gupta, 2009; Woglom, 2003). Woglom (2003) in comparing the eras of explicit and non-explicit inflation targeting found that the exchange rate played virtually no role in the development of the interest rate in either period. Naraidoo and Gupta (2009) confirm the findings of Woglom (2003) whilst incorporating a simple learning rule into the formation of SARB policy.

2.4.6 Concluding Remarks
The mixed results obtained from various versions of SARB reaction functions estimated over the years leaves it in doubt as to how the SARB will react to the NGP’s proposed pursuit of a more competitive exchange rate. Certainly it has been shown that there are both theoretical and empirical reasons why a small open inflation targeting economy would react to the exchange rate. Additionally it has been shown that there exists ample examples of countries that do explicitly react to the exchange rate (Brazil, Canada, Chile and the UK) whilst there also exist others that do not (Australia and New Zealand).
Gaining a better understanding of the SARB’s response to an exchange rate depreciation is of critical importance as it speaks directly to the implementation of the NGP and its feasibility. If the SARB does increase the interest rate in response to a depreciation of the exchange then the proposed policy mix of the NGP of maintaining a low interest rate environment in the presence of a more competitive currency would be unattainable.

2.5 Concluding Comments

The purpose of the literature review has been to develop a broad understanding of how a depreciation of the exchange rate may affect the South African economy, thus assessing the feasibility of the NGP’s proposed macroeconomic environment. To do this the literature review has considered the effects of exchange rate depreciations on output, inflation and interest rates respectively. This format has been followed in order to systematically assess the proposed macroeconomic environment of the NGP. The NGP proposed that a depreciation of the rand will lead to an increase in the economic growth and thus a decrease in unemployment. It has also been proposed that this depreciation of the rand can be accompanied by a low interest rate and inflationary environment.

Broadly, it has been found that the proposed macroeconomic policy mix of the NGP stands at odds with the relationships between variables generally described in theoretical and empirical writings. Depreciations of the exchange rate have not been shown to consistently result in higher levels of economic growth. These ambiguous findings persist even when depreciations result in a reduction of a real exchange rate overvaluation or an increase in the degree of undervaluation. Indeed with the lack of support for the NGP’s assertion that the South African exchange rate is overvalued it appears unlikely that a depreciation will result in higher economic growth. Evidence from South Africa finds that South African exports and growth tend to exhibit an ambiguous response to depreciations of the exchange rate.

Depreciations have been found to exert inflationary pressure upon domestic prices. This significant ERPT effect has reduced over recent years though still remains a significant and substantial driver of domestic inflation. The ERPT effect is incomplete and often delayed, meaning that over the short run a nominal depreciation can result in a real depreciation of the exchange rate. Additionally, in the setting of a small open economy the exchange rate has been observed to be a significant determinant of interest rates in inflation targeting countries. Although the exchange rate is not explicitly targeted in such regimes, it is recognised that the variables within the objective function of a central bank are affected by the exchange rate. In that these variables are affected, it becomes
optimal policy for a flexible inflation targeting central bank to respond to movements of the exchange rate.

Considering the above relationships it appears that the macroeconomic policy package proposed in the NGP of a more competitive exchange rate, higher growth rate, low inflation and interest rates appears to be inconsistent with the literature and the recent experiences of the South African economy. Depreciations of the rand have not been shown to stimulate the economy in a robust manner. However, depreciations have been shown to have a significant and substantial impact upon domestic prices with mixed evidence regarding their significance in the interest rate setting behaviour of the SARB.
Chapter Three – Research Methodology

3.1 Introduction

The purpose of this study is to assess the effects of the exchange rate on the South African economy. Previous studies surveyed in Chapter Two have generally focused on the specific effects of exchange rate depreciations on variables such as real GDP, inflation and the behaviour of the central bank. Such studies reveal little of the dynamics of an economy or the effects of macroeconomic policy. To account for the interaction between endogenous variables Sims (1980) proposed the use of vector autoregressive (VAR) models.

According to Sims (1980) large scale macroeconomic models comprising of simultaneous equations required the imposition of ‘incredible’ identifying restrictions in order to uncover interactions consistent with economic theory. These identifying restrictions were described by Sims (1980) as ‘incredible’ as they were often difficult to justify on a priori grounds. Rather, Sims (1980) proposed that such large macro models could be estimated as an ‘unrestricted’ reduced form VAR, where ‘unrestricted’ implies that the model is free from a priori assumptions. These models impose no ‘incredible’ restrictions upon the variables and are thus argued to provide a better description of the data generating process and enable discrimination between different theoretical models of the economy (Baliano & Favero, 1998; Sims, 1980).

VAR models allow researchers to identify the response of macroeconomic variables to monetary policy impulses in an environment free of a priori assumptions (Sims, 1980). The response of macroeconomic variables to such impulses enables researchers to distinguish between the theoretical conceptions of the economy (Baliano & Favero, 1998). The literature reviewed in Chapter 2 showed that there exist alternative conceptions of how a depreciation of the Rand should affect economic growth. The conventional approach illustrated that a depreciation of the Rand should result in positive economic growth whereas the Washington consensus and structuralist views asserts that a depreciation of the currency will negatively affect economic growth in a developing country. These views predict very different outcomes for the economy following a depreciation of the exchange rate yet both outcomes appear to enjoy substantial support in the empirical literature.

The response of the South African economy to a depreciation of the exchange rate is analysed through the estimation of a VAR with exogenous variables. That is, the VAR is augmented to include exogenous variables that are believed to influence the performance of the South African. This VARX approach and variables included are consistent with both recent IMF studies (Cheng, 2006;
Tsangarides, 2010) as well as South African and international studies (Bhundia, 2002; Civcir & Akcaglayan, 2010; Ocran, 2010).

The endogenous variables of interest in the model are those identified in the NGP policy document and include real GDP, CPI inflation, the interest rate and the exchange rate\(^7\). Though not of particular interest to this study, the money supply is included as an additional variable in the specification of the VAR following previous attempts to model the effects of monetary policy and the monetary policy transmission mechanism (Bhundia, 2002; Cheng, 2006; Civcir & Akcaglayan, 2010; Tsangarides, 2010). Exogenous variables are included in the estimation of the VAR model to control for the external stance of the world economy and include the US real GDP, as a proxy for foreign aggregate demand, and the oil price. Whilst these exogenous variables are consistent with previous VAR studies the use of the US GDP as a proxy for foreign aggregate demand is further motivated in Chapter 4.

Owing to the controversy that exists in the times series econometric literature concerning both the detection of unit roots and the implications upon VAR inferences in their presence, various specifications of the VARX model are estimated in a bid to produce robust results. A typical method of dealing with nonstationary data series is to differentiate them until stationary. The difference stationary data series can then utilised within the VAR framework. This approach to handling the presence of nonstationary data has a significant degree of support, at least in so much as it is widely utilised in applied economic research (Ashley & Verbrugge, 2009; Gujarati, 2003).

There however exists strong resistance to the differencing of economic data in dealing with the presence of unit roots (Ashley & Verbrugge, 2009; Canova, 2007). It has been argued the presence of unit roots in the VAR context does not pose an immediate problem to the inference of VAR results (Canova, 2007). Accordingly, it is argued that unless the nonstationary data causes serious stability issues the VAR should be estimated with the data in levels (Canova, 2007). A criticism raised by this approach of the differencing of economic data is that in the differentiation process significant information is lost (Ashley & Verbrugge, 2009; Canova, 2007).

In addition to the levels and first differenced specifications, this study also incorporates a ‘gap’ model. The model utilises the variables deviations from the trend values as calculated by the Hodrick-Prescott filter. The ‘gap’ model, by observing a variable’s deviation from its trend attempts to better account for the behaviour a central bank whose behaviour can be describe via a Taylor rule similar to that presented in section 2.4.2 (Civcir & Akcaglayan, 2010; Edwards, 2006). The

\(^7\) The Nominal Effective Exchange Rate (NEER) is used as the measure of the exchange rate in this study.
implementation of the ‘gap’ model specification is interesting in that it illustrates a different set of information within the series that may be important to policy makers, results in stationary set of variables, as well as to the best knowledge of the author has not been utilised in the estimation of a VAR describing the South African economy.

Thus the VARX model describing the South African economy is estimated using three different specifications of the data series, levels, differences and gaps. These three specifications are also estimated controlling for different periods in South Africa’s monetary policy conduct. A 22-year sample (1999Q1 – 2012Q1) has been estimated under the assumption that there is not a significant difference between the conduct of monetary policy between the eras of implicit and explicit inflation targeting as suggested by Woglom (2003). A shorter sample period (2000Q1-2012Q1) limited to that of the explicit inflation targeting era has also been estimated, bearing in mind the implications of the Lucas critique, recognising that if the behaviour of the SARB or the economy were to change during the period then inferences drawn across periods would be inefficient. Additionally the presence of exchange rate controls in the early portion of the sample is expected to impact on the observable effect of exchange rate movements on the variables of interest.

From these three models estimated over two sample periods, the effects of an exchange rate depreciation on the South African economy are assessed through a variety of structural analysis techniques, namely, orthogonalised impulse responses functions (OIRF), cumulative orthogonalised impulse response functions (COIRF), forecast error variance decompositions (FEVDs) and dynamic-multiplier functions (DMF). The results from these analysis techniques assist in the assessment of the behaviour of the South African economy following a depreciation of the Rand.

3.2 Estimation of VAR Models

To formalise the discussion regarding the effects of a currency depreciation on the South African economy this dissertation has follows closely in the empirical methodology of Cheng (2006) and Tsangarides (2010). In accordance with these studies the South African economy is described using a VARX model with structural shocks being identified through a Cholesky decomposition. The variables chosen for inclusion in the model are consistent with the IMF studies and previous studies specific to South Africa and include real GDP, CPI, the interbank rate, the M3 money supply and the NEER.

3.2.1 Model Setup and Identification

The VAR model assumes that the behaviour of the South African economy can be described according to a structural equation represented below in equation 3.1:

\[ G(L)Y_t = C(L)X_t + \epsilon_t \]  

(3.1)
Here both \( G(L) \) and \( C(L) \) are \( n \times n \) and \( n \times k \) matrix polynomials in the lag operator \( L \), where \( Y_t \) and \( X_t \) represent \( n \times 1 \) and \( k \times 1 \) vector of endogenous and exogenous variables respectively with a \( \varepsilon_t \) being a \( n \times 1 \) vector of structural disturbances, with \( \text{var}(\varepsilon_t) = \Lambda \), where \( \Lambda \) is a diagonal matrix.

The vector of South African endogenous variables includes the real GDP, CPI, interbank rate, money supply and the NEER.

\[ Y_t = \begin{bmatrix}
\text{Nominal Effective Exchange Rate} \\
\text{Consumer Price Index} \\
\text{Real Gross Domestic Product} \\
\text{Money Supply} \\
\text{Interest Rate}
\end{bmatrix} \]

The vector of exogenous variables \( X_t \) consists of the US real GDP and the Brent crude oil price. Together these variables attempt to control for the stance of the world economy that is likely to affect the performance of the South African economy. In this respect the US real GDP serves as a proxy for the level of foreign aggregate demand facing the South African economy and the oil price proxies for possible aggregate supply shocks.

\[ X_t = \begin{bmatrix}
\text{US Real GDP} \\
\text{Oil Price}
\end{bmatrix} \]

A reduced form of the structural equation describing the South African economy can be obtained and is represented as equation 3.2. In this specification both \( A(L) \) and \( B(L) \) represent matrix polynomials with \( e_t \) being a vector of observable reduced form disturbances, where \( \text{var}(e_t) = \sum \).

\[ Y_t = A(L)Y_t + B(L)X_t + e_t \tag{3.2} \]

To identify the structural parameters of the structural equation from the reduced form equation, restrictions can be placed upon the contemporaneous structural parameters. To do this, the reduced form disturbances have been orthogonalised using the Cholesky decomposition to reveal a recursive structure. The use of a Cholesky decomposition to identify structural disturbances of the VAR requires a decision be made with regard to the ordering of the endogenous variables. The Cholesky ordering of the variables was determined through the use of Granger-causality tests to assess the degree of endogeneity of the variables before ordering them in order of increasing endogeneity (Tsangarides, 2010). Following this approach the variables have been ordered as follows; NEER, CPI, real GDP, money supply and the interest rate.\(^8\)

\(^8\) In the estimation of the VARX model all variables apart from the interest rate are represented in their natural logarithms.
The recursive structure of the Cholesky decomposition assumes that the contemporaneous coefficient matrix $G_{00}$ is lower-triangular and that the covariance matrix of the structural disturbances are diagonal, and thus structural shocks are orthogonal. The Cholesky decomposition thus imposes a recursive structure upon the contemporaneous correlations of the VAR system. According to this configuration the first variable in the system (NEER) will respond only to its own contemporaneous innovation with the second variable (CPI) responding to both its own innovation and that of the first variable, and so on. The last variable listed (Rate) responds contemporaneously to the innovations of all other variables but only affects other variables in the following period.

3.3 VAR Model Analysis

Following the estimation of the VARX model the interaction between the variables are assessed through the use of a variety of structural analysis techniques. These structural analysis techniques are utilised to uncover several relationships that are of interest to the investigation undertaken in this dissertation, namely, how the exchange rate effects real GDP, inflation and the interest rate, the importance of the exchange rate in determining the interest rate and whether an increase in foreign aggregate demand results in both increased economic growth and an appreciation of the exchange rate as described by Saville (2008). Techniques utilised to analyse the relationships of interest include, impulse response functions, forecast error variance decompositions and dynamic multiplier function analysis.

3.3.1 Impulse Response Functions (IRF)

To assist in the interpretation of the effects of the exchange rate upon the South African economy both impulse response and cumulative impulse response functions are estimated. Impulse response functions trace out the effects of a one-unit shock to a variable’s error term the on the dependent variables of the equations that comprise the VAR (Stock & Watson, 2001). Shocks to the VAR model are introduced via the vector of residual terms with non-zero error terms inducing changes in the system that can then be traced through the system to reveal the endogenous relationships that exist. Cumulative impulse response functions calculate the accumulated effect of a shock upon the dependent variable and thus help in interpreting a shocks overall effect over a given time period. The estimation of impulse response functions implemented in this dissertation assumes a symmetric response of variables to shocks (Lutkepohl, 2005). Whilst a simplifying assumption, possibly
abstracting away from real world asymmetric responses of variables, the approach followed here is consistent with previous studies (Bhundia, 2002; Civcir & Akcaglayan, 2010; Cheng, 2006; Oudusola & Akinlo, 2001; Ocran, 2010; Tsangarides, 2010)

The use of a Cholesky decomposition imposes a recursive structure upon the VAR system ensuring that innovations in the residual vector enter the system sequentially rather than contemporaneously thus enabling shocks to be structurally identified (Lutkepohl, 2011). To achieve the effects of a Cholesky decomposition upon the impulse response functions using *Stata 11* when not imposing a lower triangular form upon the contemporaneous coefficient matrix directly upon the VAR via the estimation of a structural VAR then orthogonalised impulse response functions (OIRF) must be estimated. The orthogonalisation of the IRFs achieves the recursive structure imposed by the lower triangular matrix of the Cholesky decomposition. Thus in the analysis of the VARX model both orthogonalised- and cumulative orthogonalised impulse response functions are estimate.

### 3.3.2 Forecast Error Variance Decompositions (FEVD)

Forecast error variance decompositions describe the fraction of the observed forecast error variance of a variable that can either be attributed to that variables own shock or that of another endogenous variable (Stock & Watson, 2001). Importantly the implementation of the FEVD considers that portion of the observed variation that is attributable to the orthogonalised shock of a variable.

The FEVDs, when used in conjunction with IRF analysis, here implemented via the estimation of OIRF and COIRFs enable an analysis of the composition of a variable’s observed movements and thus assess the relative importance of a variable in explaining the behaviour of the system. Such analysis is important when attempting to account for the behaviour of the economy, or that of the central bank.

### 3.3.3 Dynamic Multiplier Functions (DMF)

Dynamic multiplier functions (DMF) or transfer functions enable the effects of a one-unit change in an exogenous variable on an endogenous variable traced out over a specified time horizon, holding all else constant. The utilization of DMFs enables the effect of changes in foreign aggregate demand (proxied by US real GDP) upon South African real GDP and the Rand to be assessed. It has been suggested that increases in foreign aggregate demand serve to both appreciate the currency as well as stimulate South African real GDP (Saville, 2010).
Chapter Four – Data Analysis

4.1 Introduction
To investigate the effects of an exchange rate depreciation on the South African economy a series of five endogenous and two exogenous variables have been observed over a 22 year sample period between 1990Q1 to 2012Q1. This period captures both the period of implicit inflation targeting between 1990 and 2000 as well as the 12 year explicit inflation targeting period from 2000 until 2012 (Burger & Marinkov, 2008). This chapter presents the analysis of the data, its statistical properties as well as the VAR diagnostics important to ensuring accurate inference of the VAR results as per Lutkepohl (2011).

The proposed macroeconomic policy environment described in the NGP guided the selection of South African variables included in the empirical model. Specifically, measures of real GDP, the price level, interest rate, money supply and the exchange rate have been included. Once estimated, it is hoped that the VAR output will reveal how the South African economy responds to the exchange rate and specifically whether one can expect a depreciation of the Rand to stimulate growth without producing inflationary pressures and eliciting a contractionary response from the SARB. Exogenous variables have been included in the specification of the model described previously in Chapter 3 to both improve the specification of the model as well as bring the estimation in line with contemporary efforts by the IMF (Cheng, 2006; Tsangarides, 2010). To this end two exogenous variables have been included in the model, US real GDP and the oil price. The US real GDP has been included to serve as a proxy for foreign aggregate demand and the oil price seeks to proxy for possible aggregate supply shocks (Cheng, 2006; Tsangarides, 2010).

This chapter outlines the various data sources used, data transformations, data issues as well as the statistically properties of the data series and those of the estimated VARX model. Section 4.2 outlines the various data sources used in the compilation of the dataset as well as the nature of the data with section 4.3 providing a description of how some data may have been transformed. Section 4.4 provides a variable-by-variable description of the time series properties of the dataset. Finally sections 4.5 and 4.6 test for the presence of unit roots in the data series and the various diagnostic checks implemented in the process of model checking and selection respectively.

4.2 The Data and Their Sources
The majority of South African data as well as the oil price were obtained from the SARB with a reweighted historical CPI data series coming from Statistics South Africa. US economic data was obtained from the US Department of Commerce. The variables chosen for inclusion in the VARX
model reflect the macroeconomic environment outlined in the NGP as well as exogenous variables that should intuitively exert a significant impact upon the South African economy. Additionally, considering the behaviour of these variables in a full sample that combines the implicit and explicit inflation-targeting regimes and another that isolates the current period of explicit inflation-targeting is consistent with the modelling practice of Civcir and Akcaglayan (2010). Table 4.1 below describes the variables utilised in the estimation of the VARX model as well as their sources.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Code</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>South African Real GDP</td>
<td>GDP measured at 2005 constant prices (Real GDP)</td>
<td>KBP6006L</td>
<td>SARB</td>
</tr>
<tr>
<td>Price Level</td>
<td>Reweighted CPI (2008=100)</td>
<td>NA</td>
<td>Statistics South Africa</td>
</tr>
<tr>
<td>Money Supply</td>
<td>M3 money supply (Nominal)</td>
<td>KBP1374N</td>
<td>SARB</td>
</tr>
<tr>
<td>Exchange Rate</td>
<td>Nominal Effective Exchange Rate (Nominal)</td>
<td>KBP5376M</td>
<td>SARB</td>
</tr>
<tr>
<td>Interest Rate</td>
<td>Interbank Rate (Nominal)</td>
<td>NA</td>
<td>SARB</td>
</tr>
<tr>
<td>US Real GDP*</td>
<td>US GDP measured in 2005 constant prices (Real GDP)</td>
<td>GDPC1</td>
<td>US Department of Commerce: Bureau of Economic Analysis</td>
</tr>
<tr>
<td>Oil Price*</td>
<td>Spot price of Brent Crude (Dollars)</td>
<td>KBP5344M</td>
<td>SARB</td>
</tr>
</tbody>
</table>

*Indicates a variable considered to be exogenous.

The variables chosen are consistent with previous studies undertaken in both the South African and international setting. The natural logarithms of all the variables, apart from the interest rate, are used in the estimation of the VARs in levels with the first differences of the variables used in the variables used in the estimation of the VARs in differences. First differencing variables expressed in their natural logarithms allows for the variables to be interpreted as percentage changes. Section 4.3.1 describes how a Hodrick-Prescott filter is used to calculate a variable’s deviation from its trend so as to create a gap variable used in the estimation of the gap specification VAR.

Bhundia (2002) used a similar suite of variables (barring the exogenous variables) to assess the degree of ERPT in South Africa whilst various IMF investigations used a similar set of variables to describe the monetary transmission mechanism of developing economies (Cheng, 2006; Tsangarides, 2010). Similarly, Aizeman et al (2011) and Sanchez-Fung (2011) utilised comparable variables for a pool of countries to assess the role of the exchange rate on monetary policy in
inflation-targeting countries. Civcir and Akcaglayan (2010) also used the deviation from trend of a similar set of variables within a reduced form VAR to estimate a 'gap' model to assess the effects of the exchange rate on the Turkish economy as well as drawing inferences on the exchange rate effects on growth and the price level.

Thus the choice of variables selected for this inquiry into the consistency of the NGP proposed macroeconomic environment following a depreciation of the currency appear to be broadly consistent with contemporary approaches that have focused on more specific relationships. It is hoped that by using a VAR to assess the response of macroeconomic variables to monetary shocks, recommendations can be made whether the theoretical model of the South African economy guiding economic policies is consistent with the historical behaviour of the economy.

4.3 Data Transformation
Some of the data downloaded from the SARB and Statistics South Africa websites were not immediately usable for meaningful economic analysis due to data being reported in different frequencies. To make the data usable in an econometric setting the decision was made to transform the data into quarterly averages. Table 4.2 below describes the frequencies of the variables obtained from the various statistical agencies.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA RGDP</td>
<td>Quarterly (Seasonally adjusted)</td>
</tr>
<tr>
<td>CPI</td>
<td>Monthly</td>
</tr>
<tr>
<td>M3</td>
<td>Monthly</td>
</tr>
<tr>
<td>NEER</td>
<td>Monthly</td>
</tr>
<tr>
<td>Interbank Rate</td>
<td>Daily</td>
</tr>
<tr>
<td>US GDP</td>
<td>Quarterly (Seasonally adjusted)</td>
</tr>
<tr>
<td>Brent Crude Price</td>
<td>Monthly</td>
</tr>
</tbody>
</table>

Some of the recent IMF studies which encountered similar frequency inconsistency issues have advocated interpolating the quarterly data across the monthly time series. Whilst this approach is attractive as it provides more data points for the researcher, it is the position taken in this dissertation that such a procedure would impose an artificial relationship between variables. It is believed that the process interpolation essentially imposes a functional form upon the series that is unlikely to reflect the true variation of the data and thus generate biased results. Rather it seems prudent to aggregate the more frequent data into quarterly averages. Whilst such a procedure does result in the loss of a significant number of observations it avoids imposing a relationship between variables that may well not exist.
4.3.1 Hodrick-Prescott Filter
The Hodrick-Prescott (HP) Filter has become a standard, though not uncontroversial procedure for removing cyclical variations from a times series (Baum, 2006). The HP filter acts as a highpass filter and attempts to reveal cyclical variations in a time series \( x_t \) by seeking to minimize the problem below with respect to the time trend \( \tau_t \) (Baum, 2006).

\[
\min \sum_{t=1}^{T} (x_t - \tau_t)^2 + \lambda ((\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1}))^2
\]

The minimisation of the problem above requires the selection of a penalty parameter \( \lambda \) that is selected by the user. This parameter penalises fluctuations in the second differences of a time series \( x_t \). In the case of quarterly data, setting \( \lambda \) to 1600 has been found to yield robust results (Baum, 2006). Having solved the minimisation problem, the cyclical variation \( z_t \) can then be revealed by removing the calculated trend from the observed time series, \( z_t = x_t - \tau_t \). This observed variation around the estimated time trend is often treated as a proxy for the business cycle. As a proxy for the business cycle \( z_t \) is of interest to economists as it represents the observed deviations from potential GDP (Baum, 2006). As such the information contained in \( z_t \) may be significant in explaining the behaviour of inflation targeting central banks such as the SARB. The HP-filter has also been used to calculate gaps for the log transformed exchange rate, money supply, CPI, US GDP and oil price so as to create a similar gap model as used by Civcir and Akcaglayan (2010).

4.4 Time Series Plots and Descriptive Statistics
The South African economy has undergone significant developments over the 22 year period under consideration. Most notable among these developments include South Africa’s re-entry to the world economy following the end of apartheid, the country’s first fully democratic election, the official adoption of a flexible inflation targeting regime, the progressive relaxing of exchange rate controls as well as the financial crisis of 2008. This section of the data analysis chapter presents graphical representations of the data used in the analysis of the South African economy as well as a brief description of the characteristics of the series in question. The statistical properties of the data have been further probed in section 4.4 through the use of a series of unit root tests, with the statistical properties of the VARX model being analysed in section 4.5.

4.4.1 GDP and Economic Growth
The South African economy suffers from high levels of unemployment and income inequalities that disproportionately affect the black South African population. Economic growth has been identified as a necessary prerequisite for sustainably decreasing the level of unemployment, increasing the

\[9\] Where black refers to all racial categories that were discriminated against by the former apartheid regime.
economic involvement of previously disadvantage South Africans as well reducing the degree of income inequality (Patel, 2010).

Figure 4.1 below shows the performance of the South African economy over the 1990Q1 - 2012Q1 period in real terms. The diagram has been augmented with the trend real GDP calculated using the HP filter described above. The output gap, calculated using the HP-filter discussed above, has also been included for illustrative purposes and is measured on the right-hand axis. It is clear to see that the South African economy has been subject to significant expansions and contractions, or deviations from trend output.

Figure 4.1: South African Real GDP (1990Q1 - 2012Q1)

Real GDP clearly falls below our proxy for potential GDP at least four times over this 22 year period. These deviations from potential output coincide with the uncertainty surrounding the South African economy in the early nineties, the down turn of the global economy associated with the dot com bubble, the September 9/11 tragedy and ensuing Iraq war and the associated hike in oil prices. The final downturn clearly observable from the data series is that associated with slowdown in global economic growth following the financial crisis of 2008.

Likewise at least three clear expansionary periods are observed in the data series. Two of these periods can be clearly ascribed to the sense of optimism in the South African economy following the successful completion of the nation’s first fully democratic election and its re-integration into the world economy. The third expansionary period is clearly owing to the exuberance of the world
economy in the run up to the eventual financial crisis that was preceded by the bursting of the US subprime-fuelled real estate bubble. To better illustrate the relationship between South Africa’s real GDP performance and foreign aggregate demand Figure 4.2 graphs the relationship between the output gaps of South Africa and the US.

Figure 4.2: South African and US Output Gaps (1990Q1 - 2012Q1)

Figure 4.2 illustrates that economic performance of South Africa tends to follow that of the US. This trend appears to be more present in the later portion of the sample from the early 2000s onwards, than in the 1990s. The above figure suggests that the South African economy has been growing increasingly dependent upon foreign aggregate demand, here proxied by the US output gap. The observed increasingly close correlation between these two variables likely stems from the growing significance of international developments as South Africa becomes increasingly more integrated following the end of apartheid and the relaxing of foreign exchange controls.

4.4.2 The Exchange Rate (Rand)
The relationship between the exchange rate and economic growth is of particular importance to this inquiry in light of the NGP’s prediction that a depreciation of the Rand should stimulate economic growth. To analyse the relationship between the exchange rate and the performance of the South African economy the nominal effective exchange rate (NEER) has been chosen as it represents the exchange rate of the Rand valued against a trade weighted basket of currencies. The performance of the NEER over the 22 year period under consideration is graphed below and shows a steady trend of
depreciation. Following Cicir and Akcaglayan (2010) a trend version of the NEER has also been calculated using the HP filter.

Figure 4.3: The South African NEER and Misalignments (1990Q1 - 2012Q1)

As the data series shows, the South African Rand has depreciated significantly since the 1990s and this rate of depreciation has slowed since the early 2000s. The deviation of the NEER from its trend level reveals an interesting pattern. Prior to the 2000s the NEER depreciated at a more rapid rate than in the inflation-targeting period. Deviations of the NEER from the HP-filter estimated trend also appear to hint at a relationship South African output. Figure 4.4 below illustrates the relationship the South African output gap and the deviation of the NEER from its trend.
The relationship between exchange rate deviations from trend and the output gap when graphed in Figure 4.4 is not immediately apparent. There are clearly some instances where positive deviations of the NEER from its trend correspond with a positive output gap, and vice versa. This trend is more apparent in the latter half of the sample. However, the more observable trend appears to be the co-movement of the exchange rate and output gap. That is, accelerations of the South African growth rate, as represented by positive changes in the output gap data series tend to follow appreciations of the NEER relative to its trend. This behaviour too is more evident in the latter half of the sample period likely attributable to the more open nature of the South African economy.

This second relationship described above is consistent with that proposed by Saville (2010) that appreciations of the Rand could be associated with economic growth due the effects that foreign aggregate demand has on the Rand. Additionally, because foreigners must first purchase South African Rands before purchasing South African output it is reasonable to observe an appreciation of the currency prior to an expansion of the economy (Saville, 2010). The increased demand for the South African exports results in both an appreciation of the Rand and a stimulus to the economy. Likewise, a fall in foreign aggregate demand will result in a decrease in South African exports and hence a depreciation due to the fall in demand for the South African currency.

4.4.3 Consumer Prices (Inflation)

The official mandate of the South African Reserve Bank (SARB), like many other central banks, is the pursuit of price stability in the economy. With the explicit adoption of a flexible inflation-targeting
framework in 2000, the role of the SARB became specifically the protection of the internal value of the South African rand. Prior to the adoption of the current inflation-targeting regime it has been proposed that the SARB practiced implicit inflation targeting during the 1990s through the pursuit of price stability (Burger & Marinkov, 2008).

The behaviour of the domestic consumer price level has been somewhat erratic over the sample period. The era of implicit inflation targeting saw a steady decline in the level of inflation to within the current regime’s target band. The current inflation-targeting regime has only experienced moderate success in maintaining inflation within the 3 – 6% band with the SARB failing to maintain the targeted rate of inflation in 26 out of 49 quarters (Burger & Marinkov, 2008).

Figure 4.5: South African CPIX Inflation (1990Q1 - 2012Q1)

The most recent round of inflationary pressures where the SARB failed to maintain the rate of inflation to within the target band occurred during the build-up to and onset of the financial crisis. This period coincided with aggregate demand initially being above trend before quickly falling below and an exchange rate that was depreciated relative to its trend level. Moreover, it should be noted that over this period the SARB raised interest rates.

Like the real GDP and NEER described above, a gap variable has also been calculated for the CPI. The CPI series and the CPI gap shown below clear show that South Africa experienced inflationary pressures during the early 2000s and in the build-up to the financial crisis.
4.3.4 Interest Rates

The interest rate is an important variable in the context of the economy as it constitutes the policy tool of the SARB in its quest to contain inflation. Following the adoption flexible inflation targeting by the SARB, a new policy tool was instituted (the REPO rate) to act as the Reserve Bank’s tool of choice in its attempts to influence the future path of inflation. Given that the REPO rate was created only in 2000 poses a problem for empirical analysis as the time period being considered predates 2000. For this reason a suitable proxy for the REPO rate that is both highly correlated with the REPO rate and exists over the entire period under analysis was sought. It was found that both the 30 day Treasury Bill rate and the interbank rate are highly correlated with the REPO rate.
Both the Treasury bill rate and the interbank rate were considered as possible proxies for the REPO rate due to their visually close correlation and their existence over the entire period as is described in Figure 4.7 above. However, it was found that the interbank rate exhibited a higher degree of correlation with the REPO rate and thus selected as the proxy for the SARB policy rate.

**Figure 4.7: South African Interest Rates (1990Q1 - 2012Q1)**

**Figure 4.8: South African Inflation and Interest Rates (1990Q1 - 2012Q1)**
Figure 4.8 above illustrates the interbank rate and the CPI inflation rate. It is observable that in the current inflation-targeting period the SARB has increased interest rates in the presence of inflationary pressures. Such responses from the SARB are less observable in the implicit inflation-targeting period and are likely due to the macroeconomic uncertainty characterising the South African economy at that time coupled with the relaxation of exchange rate controls. That said there appears to be three clear interest rate hikes that match neatly with inflationary pressures experienced in 1998, 2002/3 and 2008 with subsequent loosening of monetary policy following the down turns in economic activity. This behaviour is consistent with the behaviour of a flexible inflation targeting regime.

4.4.5 Money Supply (M3)
Although the money supply is not a variable of interest in this study it has been included in the estimation of the VAR to retain consistency between the IMF studies this dissertation is following. That said the behaviour of the M3 money supply is interesting in that we observe rapid creation of money during the periods of inflation and rapid economic growth. This rapid creation of the nominal money supply is highlighted through the creation of a gap variable.

Figure 4.9: South African Money Supply (M3) (1990Q1 - 2012Q1)

4.4.6 The Oil Price
The oil price has been included in the estimation of the VAR model as an exogenous variable that attempts to capture supply-side shocks that may impact upon the South African economy. The
behaviour of the Brent crude oil price is of interest in itself as it experienced rapid acceleration following the September 9/11 attacks and the ensuing Iraq war. The price of oil saw a significant drop following the 2008 financial crisis and afterwards a sustained recovery to the present.

Figure 4.10: Brent Crude Oil Price (1990Q1 - 2012Q1)

The oil price was chosen as a proxy for aggregate supply due to its importance in the South African economy which is dependent upon foreign reserves. The oil price has also been identified as a major driver of South African inflation (Bhundia, 2002). The inclusion of the oil price in a VAR setting is also consistent with previous IMF attempts to capture the dynamics of the monetary policy transmission mechanism.

4.4.7 The US GDP
The performance of the US economy has been selected as a proxy for foreign aggregate demand facing the South African economy. As discussed in section 4.4.1 and illustrated in Figure 4.2, the performance of the South African economy appears to be closely linked to that of the American economy. Like the South African GDP data series discussed earlier an HP filter has been utilised to extract the cyclical and trend components from the observed data series. The US real GDP data series and cyclical components are illustrated below in Figure 4.11.
4.5 Unit Root Tests

4.5.1 Unit Root Testing Methodology
This section briefly describes and reports the findings of the various tests for unit roots in the above data series with the detailed results being reported in Appendix A. Multiple tests have been employed owing to variations in the size and power of individual tests (Gujarati, 2003). Three tests for nonstationarity and a fourth test for stationarity have been employed. It is hoped that by following a comprehensive approach to the unit root testing procedure that a robust finding regarding the orders of integration of the data can be achieved.

According to Gujarati (2003) nonstationarity of economic data is common place; yet failing to account for integrated series can have serious consequences. However, other authors disagree with the view that the nonstationarity of a series is of concern for the estimation of a VAR model (Canova, 2007). Additionally there is debate regarding the ability of tests to correctly identify the presence of a unit root in a data series. Traditional unit root tests suffer in terms of the power and size of their results (Canova, 2007; Gujarati, 2003). The issue relating to the size of unit root test results imply that the level of significance of the test is highly dependent upon the model chosen by the researcher to describe the underlying data generating process whereas the power of the test reflects the likelihood of accepting the null hypothesis too readily. Typically assumptions regarding the inclusion of intercept or time trends are based upon theory or visual inspection of the data (Gujarati, 2003).
To test of the nonstationarity of a data series the Augmented Dickey-Fuller test (ADF), Generalised Least Squares Dickey-Fuller test (GLS-DF) and the Phillips-Perron (PP) test have been implemented. These three tests are based upon the original Dickey-Fuller (DF) test for unit roots and all have the null hypothesis that the series is nonstationary. These modified tests sought to improve the power of the original test by correcting for the effects of serial correlation. The ADF test augments the original DF test with the lagged first differences of the dependent variable to control for serial correlation (Dickey & Fuller, 1979). The GLS-DF test handles the issue of serial correlation of the residuals by first detrending the data series, using generalised least squares, and then performing the DF test (Schwert, 1989). This re-specification has been shown to be more powerful that the ADF (Elliot, et al., 1996). The PP test on the other hand uses the Newey-West heteroscedascity and autocorrelation consistent covariance matrix estimator to make the test statistics robust to serial correlation (Phillips & Perron, 1988).

The Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test differs from the tests mentioned above as it has a null hypothesis of stationarity (Kwiatkowski, et al., 1992). This test is often used in conjunction as a complementary test to tests derived from the original DF test. The KPSS test has been implemented using a quadratic spectral kernel to calculate the long-run variance of a series with optimal lags obtained through the use of the automatic bandwidth selection routine (Newey & West, 1994). According to Hobijn et al (1998) the use of both the quadratic spectral kernel and the automatic bandwidth selection routine yield the best performance in small samples.

4.5.2 Unit Test Results
The unit root tests described above were conducted for both the full sample period and the restricted inflation targeting period. The detailed results of the tests described above are presented in Appendix A with the conclusions drawn from those tests summarised below in table 4.3.
Table 4.3: Summary of Unit Root Test Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Full Sample Result</th>
<th>Inflation Targeting Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>lngdp</td>
<td>I(1)</td>
<td>I(1)</td>
</tr>
<tr>
<td>Δlngdp</td>
<td>I(0)</td>
<td>I(0)</td>
</tr>
<tr>
<td>lngap</td>
<td>I(0)</td>
<td>I(0)</td>
</tr>
<tr>
<td>incpi</td>
<td>I(0)/I(1)</td>
<td>I(1)</td>
</tr>
<tr>
<td>Δincpi</td>
<td>I(0)</td>
<td>I(0)</td>
</tr>
<tr>
<td>lnpgap</td>
<td>I(0)</td>
<td>I(0)</td>
</tr>
<tr>
<td>lnm3</td>
<td>I(1)</td>
<td>I(1)</td>
</tr>
<tr>
<td>Δlnm3</td>
<td>I(0)</td>
<td>I(0)/I(1)</td>
</tr>
<tr>
<td>mgap</td>
<td>I(0)</td>
<td>I(0)</td>
</tr>
<tr>
<td>interbank</td>
<td>I(1)/I(0)</td>
<td>I(0)/I(1)</td>
</tr>
<tr>
<td>Δinterbank</td>
<td>I(0)</td>
<td>I(0)</td>
</tr>
<tr>
<td>lnneer</td>
<td>I(1)</td>
<td>I(0)/I(1)</td>
</tr>
<tr>
<td>Δlnneer</td>
<td>I(0)</td>
<td>I(0)</td>
</tr>
<tr>
<td>deflnneer</td>
<td>I(0)</td>
<td>I(0)</td>
</tr>
<tr>
<td>lngdp_us</td>
<td>I(1)</td>
<td>I(1)</td>
</tr>
<tr>
<td>Δlngdp_us</td>
<td>I(0)</td>
<td>I(0)</td>
</tr>
<tr>
<td>lnusgap</td>
<td>I(0)</td>
<td>I(0)</td>
</tr>
<tr>
<td>noil</td>
<td>I(1)</td>
<td>I(1)</td>
</tr>
<tr>
<td>Δnoil</td>
<td>I(0)</td>
<td>I(0)</td>
</tr>
<tr>
<td>noilgap</td>
<td>I(0)</td>
<td>I(0)</td>
</tr>
</tbody>
</table>

The results of the unit root tests presented above show that all the variables contained within the levels representation of the VARX model are with some degree of certainty all I(1) processes. In the full sample there is some uncertainty regarding the order of integration of the CPI and interest rate variables. Likewise in the restricted inflation targeting sample uncertainty arises with regard to the interest rate, exchange rate and the differenced money supply variables. These uncertainties highlight the some of the controversy surrounding the use tests to uncover the presence of unit roots (Canova, 2007; Gujarati, 2003).

It is partly due to the unit root results that the VAR is estimated in levels, differences and with gap variables. The levels specifications appears to contain variables that are all I(1) processes, likewise the differences model should contain only variables that are stationary after differencing. Though not all tests applied to the data confirm this. Tests on the gap specification all suggests that variables are I(0) processes.

4.6 VAR Specification and Model Checking

4.6.1 VAR Order Selection
The number of lags chosen for inclusion in the estimation of the VAR models was based initially upon various information criteria and subsequently upon VAR model diagnostic checks. The lag order
selection process involved the utilisation of three standard information criteria to select the appropriate number of lags to include in the models. These procedures include the Akaike Information criteria (AIC), Hannan-Quinn information criteria (HQIC) and the Schwarz’s Bayesian information criteria (SBIC).

The AIC tends to recommend higher lag orders than either of the other two information criteria with the SBIC generally recommending the fewest lags, though it is possible for all three procedures to return the same recommendation (Canova, 2006; Gujarati, 2003; Lutkepohl, 2005 & 2011). These procedures have been found to be robust to both I(1) and I(0) processes. The lag orders suggested by these procedures for each of the models estimated are presented below.

<table>
<thead>
<tr>
<th>Table 4.4: Suggested Lag Order per Information Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Levels</td>
</tr>
<tr>
<td>Differences</td>
</tr>
<tr>
<td>Gap</td>
</tr>
</tbody>
</table>

The lag selection procedures implemented recommend a variety of possible lag orders, and as we would expect the AIC generally recommends the highest numbers number of lags with SBIC recommending the fewest lags. The differenced model on the other hand received consistent estimates of the correct lag order. To assess which of the above lag orders to utilise in the model for structural analysis, the effects of the various lag orders on the residual autocorrelation of the VAR models was then assessed.

### 4.6.2 Autocorrelation

To test for autocorrelation of the VAR residuals in the various models a Lagrange multiplier test was implemented as per Johansen (1995). The Lagrange multiplier test was chosen over the portmanteau test for autocorrelation owing to the former being better suited to smaller samples (Lutkepohl, 2005). The null hypothesis of the Lagrange multiplier test is that the residuals are not autocorrelated. Table 4.5 below summarises the results of the Lagrange-multiplier test for the three models and across both sample periods.
According to the Lagrange Multiplier test in the full sample, the inclusion of two lags in the levels and gap model, as indicated by the AIC result, results in residuals that are not autocorrelated whilst just a single lag is required in the differences model. In the inflation-targeting sample, however, the Lagrange Multiplier test indicates that in order for the residual series of the levels and gap model not to be autocorrelated, three lags should be included in the estimation whilst the differenced model again has non-serially correlated residuals with the inclusion of only a single lag. The table below summarises the order of VAR’s to be estimated and analysed in chapter 5.

Table 4.6: Summary of Selected VAR Orders

<table>
<thead>
<tr>
<th>Model</th>
<th>Full Sample</th>
<th>Inflation-Targeting Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levels</td>
<td>VAR(2)</td>
<td>VAR(1)</td>
</tr>
<tr>
<td>Differences</td>
<td>VAR(1)</td>
<td>VAR(1)</td>
</tr>
<tr>
<td>Gap</td>
<td>VAR(2)</td>
<td>VAR(3)</td>
</tr>
</tbody>
</table>
Though for impulse response analysis to deliver meaningful economic interpretations then not only does the system need to identified – here achieved through a Cholesky decomposition - but parameters of the system also must be stable (Lutkepohl, 2011). What follows in section 4.6.3 are the results of the tests for stability of the above estimated VAR parameters.

### 4.6.3 VAR Stability

In order for inference of the VAR to occur using structural analysis techniques one must ensure that the variables are not only covariance stationary but that the VAR is also invertible and has an infinite order moving-average representation (Lutkepohl, 2011). If these conditions hold then a VAR is considered to be stable and then IRF and FEVDs have known interpretations (Lutkepohl, 2011). A VAR is considered stable if the modulus of the eigen values in the A matrix are less than one (Hamilton, 1994; Lutkeohl, 2005).

For each VAR the stability condition is checked and it is found that all possess eigen values whose moduli are all strictly less than one and are thus considered to be stable. On the grounds of the voluminous nature of the stability test output these have been placed in Appendix B.

### 4.6.4 Normality of Residuals

Whilst Lutkepohl (2005 & 2011) observes that the normality of residuals is not a necessary requirement for the inference of VAR results, primarily a concern if the intention is to conduct hypothesis tests, the non-normality of residuals may indicate deficiencies in the specification of the model. As the analysis in this dissertation has focused on the use of impulse response analysis, the normality of the residuals is not a primary concern. However for completeness the Jarque-Bera test for the normality of the residuals have been estimated for all specifications of the VAR with the results presented in full in the appendix. Table 4.7 below presents the p-values from the Jarque-Bera tests performed on the residuals of the VAR equations.

<table>
<thead>
<tr>
<th>Equation</th>
<th>Full Sample (1990Q1-2000Q1)</th>
<th>IT Sample (2000Q1-2012Q1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>levels</td>
<td>differences</td>
</tr>
<tr>
<td>NEER</td>
<td>0.00988</td>
<td>0.06271</td>
</tr>
<tr>
<td>CPI</td>
<td>0.62481</td>
<td>0.25959</td>
</tr>
<tr>
<td>RGDP</td>
<td>0.21760</td>
<td>0.78663</td>
</tr>
<tr>
<td>M3</td>
<td>0.42916</td>
<td>0.60108</td>
</tr>
<tr>
<td>Interbank</td>
<td>0.00000</td>
<td>0.00000</td>
</tr>
</tbody>
</table>
The results from the Jarque-Bera test for normality of the residuals indicate that there is some concern over the behaviour of the residuals, in particular with regards to the interest rate equation from the full sample specification of the VAR. In general however there is a weak rejection of the null hypothesis of non-normality of the residuals. The results of the Jarque-Bera tests generally improved when the inflation targeting sample was considered in isolation from the full sample. This improvement suggests that the consideration of the inflation-targeting sample isolation represents an improvement of the specification of the model.

In terms of the normality of the residuals it appears that the model specified in first differences and drawn from the inflation-targeting period is the best specified and if the inquiry of this dissertation involved hypothesis testing then it would be this specification that should be utilised. However the inquiry has relied upon impulse response analysis and as such the normality of the residuals is not of primary concern but rather with the VAR is stable as discussed in the preceding subsection (Lutkepohl, 2005 & 2011).

4.6.5 VAR Specification
There is currently substantial debate regarding whether levels or first differences should constitute the default model specification when data are nonstationary or near-unit root but stationary. Indeed Ashley and Verbrugge (2009) note that practitioners tend to hold very strong views on which specification of a VAR should be estimated in the presence on nonstationary data. Owing to the disagreement present in the literature some space has been dedicated here to briefly discuss the issues in choosing a default specification as well as motivating the specification choices adopted in this dissertation. It should be noted that the focus here is not to provide a thorough review of the relative merits of either specifications but simply to recognise the controversy and justify the specifications adopted in this dissertation.

VARs have been estimating in levels since Sims (1980) and still enjoy implementation today (Canova, 2007; Gujarati, 2003; Oudusola & Akinlo, 2001). However use of the levels specification has required significant justification following advances in the understanding of economic time series behaviour. Specifically, the recognition of the widespread presence of unit roots in economic data as well as the ‘spurious regressions’ that can arise from independently generated integrated time series (Ashley & Verbrugge, 2009). It has also been recently shown by Granger et al. (2001) that ‘spurious regressions’ can easily arise in stationary data that are near to unit root.

Given the implications of nonstationary data on regression results many practitioners have opted to rather estimate VARs with differenced data. By differencing, practitioners are able to transform the data into a stationary process that should allow for estimation of a VAR free from spurious
relationships. However by differencing the data practitioners are essentially creating new variables as well as losing out on the long-run relationships that exist between variables (Canova, 2007).

Practitioners arguing for the continued use of VARs in levels have argued that the diagonal lag structure of the VAR model estimated in levels is free to mimic a first differenced data generating process and that the $R^2$ obtained from levels models are typically greater than their differenced counterparts (Ashley & Verbrugge, 2009). The latter motivation for the use of levels over differenced data in VARs should however be viewed with caution as the higher $R^2$ does not imply a better fit as the use of transformed data in the differenced model means that the data in the two models is essentially different (Ashley & Verbrugge, 2009).

Additional evidence for the continued use VARs estimated in levels comes from research into cointegrated systems (Ashley & Verbrugge, 2009). Research from the cointegration literature indicates that the coefficients obtained from the estimation of a VAR in levels are efficient asymptotically when the explanatory variables appear within a cointegrating relationship (Toda & Phillips, 1993). Furthermore it has been implied that some hypothesis tests will also have the usual asymptotic distribution even without the presence of a cointegrating relationship (Ashley & Verbrugge, 2009).

In an attempt to aid practitioners in choosing which specification of the VAR to estimate in the presence of persistent data Ashley and Verbrugge (2009) conducted a Monte Carlo investigation into the effects upon the estimation and inference of VARs following various specifications. Their findings were interesting as it appears the appropriateness of the specifications depends not only upon the data itself but also on the desired inference. Specifically it was found that if the researcher’s intentional is to conduct Granger-causality analysis then estimating a VAR in differences or in a vector error correction model is far superior to a levels specification.

Interestingly if the researcher’s intention is to conduct impulse response analysis then it was found that it was most efficient to estimate the VAR in levels with a trend term. It was found by Ashley and Verbrugge (2009) a VAR estimated in levels produced significantly better impulse response functions and confidence intervals than a VAR estimated in differences. The IRFs of VARs estimated in levels were found to be robust to the presence of stationary, nonstationary and cointegrating relationships (Ashley & Verbrugge, 2009). It was also noted that unless the researcher is sure that the data are $I(1)$ processes and their intention is to utilise IRF analysis then the data should not be differenced but rather estimated in levels with a time trend. Only if the data are $I(1)$ processes and there exists no
cointegrating relationship was estimating the VAR in differences was found to be preferable to a levels specification (Ashley & Verbrugge, 2009).

Table 4.3 above and the complete table of unit root results found in Appendix A illustrate that one cannot conclude with certainty that the data are I(1) processes. Additionally, using the Johansen (1995) test for cointegration and the selected VAR orders described in Table 4.6 as the maximum lag orders\(^\text{10}\) of the underlying VAR it was found that in the full sample their appears to be at least 1 cointegrating relationship whilst in the later explicit inflation targeting period there appear to be at least 2 cointegrating relationships\(^\text{11}\). The results for the Johansen test for cointegration can be found in Appendix C.

Based on the findings of Ashley and Verbrugge (2009) described above and the South African data showing signs of cointegration and not wholly being an I(1) process, it is believed that a levels specification of the VAR appropriate as this dissertation is focused on impulse response analysis. That is, a VAR estimated in levels is taken as the default specification for the purposes of presenting results below in Chapter 5. However, the VAR is still estimated in differences and according to the gap specification with these results being presented in Appendix D, E and F. The estimation of multiple VAR specifications is hoped to serve as a robustness check given the great deal of disagreement surrounding the appropriate specification of a VAR in the presence of nonstationary data.

### 4.7 Concluding Comments

The data described above in section 4.4 illustrated that the transitional nature of the South African economy in the 1990s appears to have played a major role in the development of these series. Specifically, the gradual relaxation of exchange rate controls and the removal of the financial rand have likely impacted on the relationship between the exchange rate and real GDP between sample periods. Additionally the removal of sanctions and South Africa’s greater integration with the world economy too are expected to affect the behaviour of variables between sample periods. There are also two monetary policy regimes described within the 22 year sample. Whilst some have argued that there is little difference in the conduct of monetary policy between the era of implicit- and explicit inflation targeting, in light of the more open economy experienced by the current regime, it seems prudent that the focus of the analysis be drawn from this period.

\(^{10}\) The Johansen test for cointegration is sensitive to the maximum lags including in the underlying VAR. To control for this, the maximum lags included in the Johansen test were chosen on the basis of the Hannan and Quinn Information Criteria (Aznar & Salvador, 2002) (Gonzalo & Pitarakis, 1998).

\(^{11}\) The full results of the Johansen test for cointegration appear in appendix C.
It has been discussed that there exists significant debate over which VAR specification is most suited for inference purposes in the presence of nonstationary data. Recent developments in this debate have suggested that the use of a VAR estimated in levels yields robust estimates of impulse responses and their confidence intervals in the presence of stationary, nonstationary and cointegrating relationships. If the data were definitely an I(1) process and there were no cointegrating relationships then using a VAR in differences would be optimal. However the data is not confirmed as being an I(1) process and Johansen tests indicate at least one and two cointegrating relationships in the full and explicit inflation-targeting periods respectively. In light of this, the default specification presented in Chapter 5 below is that of a VAR estimated in levels with the alternative specifications results presented in the appendix.

In total six VARX models are estimated and analysed, consisting three specifications for both the full sample and the current inflation-targeting period. These three models consist of a levels VAR whose variables are all (possibly) I(1) processes, a differences model whose variables are all stationary and a 'gap' model which uses the variable deviations from their trend values which are all indicated to be I(0) processes. Lag orders of the VARs have been selected according to information criteria and ensuring that there is no autocorrelation of the residual series. All VARs are found to be stable allowing for meaningful interpretations of impulse response functions and forecast error variance decompositions.

It should be noted that the focus of this dissertation is not in assessing the changes in behaviour of variables or the conduct of the SARB between periods. The full sample period is estimated under the admittedly unlikely assumption that there is no change in the relationships between the variables over the 22 year period under consideration. However, given the significant changes to the South African economy in the 1990s it is believed that inferences drawn from only the explicit inflation targeting period will provide a better representation of how the economy may respond to movements of the exchange rate and thus for an assessment of the proposed macroeconomic stance in the NGP.
Chapter Five – Results

5.1 Introduction
This chapter of the dissertation presents the interpretation of the results obtained from the structural analysis procedures conducted on the estimated VARX models. In total six models have been estimated accounting for the three specifications discussed in Chapter 4 and the two periods under consideration. The structural analysis procedures include orthogonalised impulse response functions (OIRF), cumulative impulse response functions (COIRF), forecast error variance decompositions (FEVD) and dynamic multiplier functions (DMF) as described in Chapter 3. The results obtained from these procedures derived from the levels specification of the VAR are discussed below, with the output of the alternative specifications reserved for the appendix. The multiple specifications employed here have yielded results that are broadly consistent with one another.

To maintain consistency throughout this dissertation the results are presented in a similar format to that of Chapter 2. That is, the results from the OIRF, COIRF and FEVDs for the effect of the exchange rate on real GDP, CPI and the interbank rate are discussed in sections 5.2 – 5.4 respectively. The results from the dynamic multiplier functions are then discussed in section 5.5 before the concluding remarks on the results are presented in section 5.6.

As discussed earlier there are six models estimated in this dissertation, to distinguish between them easily within the results section, a simple naming paradigm has been adopted and is summarized in Table 5.1 below.

Table 5.1: Model Naming Paradigm

<table>
<thead>
<tr>
<th>Specification</th>
<th>Sample Period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full (1990Q1 – 2012Q1)</td>
</tr>
<tr>
<td></td>
<td>Inflation Targeting (2000Q1 – 2012Q1)</td>
</tr>
<tr>
<td>Levels</td>
<td>levlong</td>
</tr>
<tr>
<td></td>
<td>levshort</td>
</tr>
<tr>
<td>Differences</td>
<td>difflong</td>
</tr>
<tr>
<td></td>
<td>diffshort</td>
</tr>
<tr>
<td>Gap</td>
<td>gaplong</td>
</tr>
<tr>
<td></td>
<td>gapshort</td>
</tr>
</tbody>
</table>

12 Appendix D, E and F contain the impulse response, forecast error variance decomposition and dynamic multiplier function results respectively.
Essentially the models that use the full sample period are described as ‘long’ and the inflation-targeting period is described as ‘short’. These different sample periods have then estimated using alternative specifications, VARs estimated in levels have been given the prefix ‘lev’ and the difference and gap models the prefixes ‘diff’ and ‘gap’ respectively. The results discussed below primarily relate to the levels specification from both periods, hence the ‘levlong’ and ‘levshort’ with the output from the alternative specifications located in the appendix whilst the results still being discussed this chapter. Table 5.2 below provides a brief description of the variables used in each of the VAR specifications estimated as part of this dissertation.

Table 5.2 Variable Names and Descriptions

<table>
<thead>
<tr>
<th>VAR Model</th>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Levels</strong></td>
<td>lnneer</td>
<td>Natural logarithm of the nominal effective exchange rate (NEER).</td>
</tr>
<tr>
<td></td>
<td>lncpi</td>
<td>Natural logarithm of the consumer price index (CPIX).</td>
</tr>
<tr>
<td></td>
<td>lngdp</td>
<td>Natural logarithm of the South African Real GDP (2005 constant prices)</td>
</tr>
<tr>
<td></td>
<td>lnm3</td>
<td>Natural logarithm of the M3 money supply</td>
</tr>
<tr>
<td></td>
<td>interbank</td>
<td>The interbank bank rate</td>
</tr>
<tr>
<td></td>
<td>lngdp_us</td>
<td>Natural logarithm of the US real GDP (2005 Constant Prices)</td>
</tr>
<tr>
<td></td>
<td>lnoil</td>
<td>Natural logarithm of the Dollar denominated Brent crude oil price</td>
</tr>
<tr>
<td><strong>First Differences</strong></td>
<td>Dlnneer</td>
<td>First difference lnneer</td>
</tr>
<tr>
<td></td>
<td>Dlncpi</td>
<td>First difference of lncpi</td>
</tr>
<tr>
<td></td>
<td>Dlngdp</td>
<td>First difference of lngdp</td>
</tr>
<tr>
<td></td>
<td>Dlnm3</td>
<td>First difference of lnm3</td>
</tr>
<tr>
<td></td>
<td>Dinterbank</td>
<td>First difference of interbank</td>
</tr>
<tr>
<td></td>
<td>Dlngdp_us</td>
<td>First difference lngdp_us</td>
</tr>
<tr>
<td></td>
<td>Dlnoil</td>
<td>First difference of lnoil</td>
</tr>
<tr>
<td><strong>Gap</strong></td>
<td>deflnneer</td>
<td>Deviation of lnneer for HP-filter calculated trend</td>
</tr>
<tr>
<td></td>
<td>Incpigraph</td>
<td>Deviation of lncpi from HP-filter calculated trend</td>
</tr>
<tr>
<td></td>
<td>Ingap</td>
<td>Deviation of lngdp from HP-filter</td>
</tr>
<tr>
<td></td>
<td>mgap</td>
<td>Deviation of lnm3 from HP-filter calculated trend</td>
</tr>
<tr>
<td></td>
<td>Dinterbank</td>
<td>First difference of interbank</td>
</tr>
<tr>
<td></td>
<td>Inusgap</td>
<td>Deviation of lngdp_us from HP-filter calculated trend</td>
</tr>
<tr>
<td></td>
<td>lnoilgap</td>
<td>Deviation of lnoil from HP-filter calculated trend</td>
</tr>
</tbody>
</table>
5.2 Real GDP

5.2.1 Real GDP Impulse Response Analysis

Impulse response analysis has been used to assess the behaviour of South African real GDP to a one standard deviation of the NEER. A one standard deviation of the exchange rate, being an absolute number represents an appreciation of the exchange rate, though due to assumption of symmetry, inferences can be made as to the behaviour following a depreciation of the Rand (Bhundia, 2002; Civcir & Akcaglayan, 2010; Cheng, 2006; Ocran, 2010; Tsangarides, 2010). Figure 5.1 below illustrates the OIRF and COIRF results of real GDP to an appreciation of the NEER for the full period and the current inflation-targeting regime.

Figure 5.1: Response of Real GDP to a One Standard Deviation of the NEER (levels)

The impulse responses illustrated above describe starkly different reactions of the real GDP to movements of the exchange rate. Additionally these differences in the response of real GDP to the exchange rate between the full sample and when the inflation-targeting period is estimated separately are reflected consistently across the multiple model specifications estimated. See Figures
D3, D4, D5, D6, D9, D10, D11 and D12 for the full OIRF and COIRF results for the difference and gap models for both sample periods.

The impulse response analysis from the full sample (levlong) suggests that an appreciation of NEER results in a small short-lived negative effect on real GDP, quickly becoming positive. The COIRF indicates that the effect of the NEER appreciation on real GDP shows virtually no accumulated effect by the second quarter, thereafter turning positive. The results achieved from the VARs estimated in differences and gap model over this period too reflect the above-described trend (Figures D3, D4, D5 and D6). The initial negative response of real GDP in the differences specification from the full sample are slightly more pronounced than the levels model above, with a small-accumulated negative impact observed until the second quarter with the gap specification over this period showing a more muted response to the exchange rate.

The results obtained from estimating the inflation-targeting period in isolation illustrate a far more pronounced negative response of the real GDP to an appreciation of the NEER. The OIRF of real GDP indicates a negative response following an appreciation of the NEER for up to four quarters in the levels specification with an initial impulse of -0.001. The COIRF analysis reveals that the accumulated response of real GDP following the appreciation of the NEER remains negative for eight quarters, or two years having peaked after 4 quarters at -0.05 in the levels specification. The results of the differences and gap model too confirm the above findings that an appreciation of the exchange rate negatively affects real GDP to a greater extent when the inflation-targeting period is estimated in isolation of the full sample; see figures D9, D10, D11 and D12 in Appendix D.

The results of the real GDP to a once-off one standard deviation in the NEER are different between periods but behave consistently between model specifications within a sample period. Whilst the full set of impulse response functions for the alternative, specifications appear in Appendix D, Table 5.3 takes the opportunity to summarize these findings briefly.
Table 5.3: Summary of Real GDP Impulse Response Results

<table>
<thead>
<tr>
<th>Model Estimated</th>
<th>OIRF</th>
<th>COIRF</th>
</tr>
</thead>
<tbody>
<tr>
<td>levlong</td>
<td>Small negative effect in 1st quarter, thereafter positive.</td>
<td>No accumulated effect by 2nd quarter, thereafter positive and increasing until the 7th quarter.</td>
</tr>
<tr>
<td>levshort</td>
<td>Large negative effect up to the 4th quarter, thereafter turning positive.</td>
<td>Negative accumulated affect lasting to the 8th quarter.</td>
</tr>
<tr>
<td>difflong</td>
<td>Small negative effect in 1st quarter, thereafter positive.</td>
<td>Small accumulated negative response until the 2nd quarter, thereafter positive.</td>
</tr>
<tr>
<td>diffshort</td>
<td>Negative response over first two quarters.</td>
<td>Accumulated negative response up to 5 quarters.</td>
</tr>
<tr>
<td>gaplong</td>
<td>Small negative response up to the 3rd quarter, thereafter turning positive.</td>
<td>Shows no accumulated negative response by the 3rd quarter, after which becoming positive.</td>
</tr>
<tr>
<td>gapshort</td>
<td>Negative response observed until the 3rd quarter, thereafter positive.</td>
<td>Accumulated negative response lasting up to the 5th quarter.</td>
</tr>
</tbody>
</table>

Indeed, it is interesting to note that when the full sample period is used in the estimation of the VAR it indicates that there is only a very small initial decrease in real GDP resulting from an appreciation of the NEER, but when the shorter inflation-targeting period is used, this effect is far more pronounced. Multiple influences associated with the transitory nature of the South African economy in the 1990s are suspected as reasons for the differences observed in the effect of the exchange rate on real GDP between samples. Specifically, South Africa is more integrated with the world economy in the inflation-targeting period than it was in the 1990s, the 2000s saw the official adoption of inflation targeting, and the 1990s saw the gradual relaxation of exchange rate controls. Indeed looking at the exchange rate series more carefully in Chapter 4 revealed that the 1990s saw a steady depreciation of the NEER, only by the 2000s did this trend abate. It is believed that this change in behavior of the exchange rate coupled with South Africa’s more integrated stance with the world economy and the official adoption of inflation targeting accounts for the behavioural changes between models.

These responses of the real GDP to a one standard deviation of the NEER illustrate the response to an appreciation of the NEER; this behaviour can be used to draw inferences as to how real GDP would respond to a depreciation of the Rand. This is because the estimation of the VAR described in
Chapter 3 assumes both symmetry and linearity of the responses of variables (Lutekohl, 2005). However, whilst this is an assumption of the model that allows for such inference, it is recognised that such an assumption is not necessarily an accurate description of reality. Future studies could look to relax these assumptions and so provide an in-depth understanding of the real GDPs response to movements of the exchange rate.

The impulse responses drawn from the inflation-targeting period suggest that a depreciation of the Rand would increase real GDP. Whilst the findings drawn from full sample suggest that within the first four quarters following, the movement of the exchange rate there is little effect on real GDP. The findings here indicate that for the inflation-targeting period, the behaviour of South African real GDP is consistent with the conventional view of exchange rate depreciations and economic growth described in Chapter 2. The full sample period, however, reveals only a very weak relationship between economic growth and exchange rate depreciation. Thus for the current inflation-targeting period it appears that a depreciation of the Rand is consistent with stimulating real GDP as per the proposal of the New Growth path.

5.2.2 Real GDP Forecast Error Variance Decompositions
The forecast error variance decompositions indicate that in both samples and across all specifications, the majority of the variation of the real GDP’s forecast error variance is attributable to its own variations. Of interest, here however is to what extent the exchange rate accounts for the forecast error of real GDP. The contributions of the NEER to the real GDP’s forecast error variance for the full sample and inflation-targeting period are presented below in Figures 5.2 and 5.3 respectively with the complete set of FEVDs for real GDP between sample periods and specifications presented in the Appendix E. See Figures E1, E2 and E3 for the full sample FEVDs and Figures E10, E11 and E12 for FEVDs from the inflation target period.
The FEVDs illustrated above indicate that the NEER accounts for a greater degree of the forecast error of the real GDP series in the inflation-targeting era compared to the full sample period. Specifically, whilst the contribution of the NEER to the forecast error of real GDP in the levels and first difference specification reach around 10 and 15 percent within the estimated forecast horizon in both the full- and inflation targeting periods, in the latter period they reach this contribution much sooner, by the second quarter.
According to the FEVDs above, by the fourth quarter in the full sample the exchange rate accounts for a maximum of only 4.5 percent of real GDP’s forecast error, achieved in the first difference specification and only 1.2 percent in the levels specification. By the fourth quarter, the gap model indicates virtually no contribution to the forecast error of real GDP at 0.14 percent. In contrast, by the fourth quarter in the inflation-targeting period the NEER contributes 15 percent of the forecast error of real GDP in the levels specification and 10 and 6.5 percent in the gap and difference specifications respectively. The larger contribution of the NEER to the forecast error of real GDP in the inflation-targeting specific period suggests that real GDP has become more sensitive to movements of the exchange rate.

That the NEER contributes more to the forecast error variance of real GDP when the inflation-targeting sample is considered in isolation from the full sample suggests that, being more open during this period has left South African output more sensitive to movements of the exchange rate. As discussed in Chapter 4, the 1990s saw a gradual relaxation of exchange rate controls as well as the re-entry of South Africa to the international economy. Inclusion of this period in the full sample likely places a downward bias on this relationship, thus it is expected that the results drawn from the inflation-targeting era provide a more accurate depiction of relationship between real GDP and the exchange rate.

The above results obtained via OIRF, COIRF and FEVD analysis suggest that not only does South African real GDP respond more noticeably in the inflation-targeting period to exchange rate movements but also a greater proportion of the observed forecast error is attributable to the exchange rate. It has been found that the response of real GDP to the exchange rate is consistent with the both the behaviour proposed in the NGP and that of the conventional view of exchange rate depreciations described in Chapter 2. Additionally, in as far as the NEER’s deviation from its trend can be considered as a representation of a misalignment of the exchange rate, overvaluations of the NEER negatively impact on real GDP and vice versa.

5.3 The Price Level

5.3.1 Price Level Impulse Response Analysis

According to the ERPT effect described in Chapter 2, depreciations of the exchange rate result in an increase in the domestic price level through both direct and indirect channels and vice versa. Additionally, empirical studies have observed that there has been a decrease in the degree of ERPT

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13 Here it is not argued that the NEER’s deviation from its trend represents an accurate description of an exchange rate misalignment though it should be noted that the HP Filter did generate a remarkably similar result to equilibrium exchange rate calculated by McDonald and Ricci (2003).
in recent times. One of the explanations of this trend focuses on the role of monetary authorities of small open economies or those with inflation-targeting regimes. To investigate the relationship between the price level and an exchange rate shock impulse responses have been estimated and analyzed. Due to the similarity of the results between the VAR specifications only the VAR in levels results are presented here with the results for the first difference and gap models presented in the appendix D. See Figures D3, D4, D5 and D6 for the OIRF and COIRFs from the full sample and Figures D9, D10, D11 and D12 for the inflation-targeting period. Figure 5.4 below illustrates the OIRF and COIRF results for the levels specification of the VARX model across the full sample and the inflation-targeting period.

Figure 5.4: Response of CPI to a One Standard Deviation of the NEER (levels)

Irrespective of the specification of the model or time period chosen, the NEER exerts a significant and substantial effect on the domestic price level. Figure 5.4 above illustrates that in both periods an appreciation of the NEER exercises significant downward pressure on the level of consumer prices. This downward pressure on consumer prices arising from an appreciation of the NEER results in lower rates of inflation. The difference model shows that an appreciation of the NEER results in a reduction in the rate on change in the CPI series whereas the gap model shows that the exchange
rate appreciation results in a lowering of the CPI’s deviation from trend that is a negative effect upon the inflation gap.

The OIRF and COIRFs from the levels and difference models suggest that the current inflation-targeting period has experienced a lower degree of exchange rate pass through in comparison with the sample as a whole. Specifically the COIRFs show that the accumulated response of the CPI to an exchange rate movement is less in the inflation-targeting period as opposed to the full sample period. Though the levels and differences models suggest that the degree of ERPT has reduced in the inflation-targeting period, the effect of the exchange rate on domestic prices remains substantial. In contrast to the results of the levels and differences models that indicate a reduced degree of exchange rate pass through, the gap model whilst confirming that the exchange rate has a significant effect on prices also suggests that the price level is more sensitive to the exchange rate in the inflation-targeting period. Table 5.4 below presents a summary of the results obtained from the various models.

Table 5.4: Summary of CPI Impulse Response Results

<table>
<thead>
<tr>
<th>Model Estimated</th>
<th>OIRF</th>
<th>COIRF</th>
</tr>
</thead>
<tbody>
<tr>
<td>levlong</td>
<td>Significant and substantial effect observed. Stronger NEER results in lower CPI</td>
<td>Significant and substantial accumulated response to NEER movement.</td>
</tr>
<tr>
<td>levshort</td>
<td>Similar result to levlong though effect last only to the 7th step and not as large.</td>
<td>Significant accumulated response, though less than in levlong.</td>
</tr>
<tr>
<td>difflong</td>
<td>Significant and sizable negative response. Appreciations of NEER lower CPI inflation.</td>
<td>Significant and sizable negative accumulated response to NEER. Appreciations of the NEER lowers CPI.</td>
</tr>
<tr>
<td>diffshort</td>
<td>Significant negative response to change in NEER. Response less than in difflong</td>
<td>Accumulated negative response significant though less than in difflong.</td>
</tr>
<tr>
<td>gaplong</td>
<td>Significant negative response.</td>
<td>Significant negative accumulated response.</td>
</tr>
<tr>
<td>gapshort</td>
<td>Significant negative response, greater than gaplong.</td>
<td>Significant accumulated negative response, greater than gaplong.</td>
</tr>
</tbody>
</table>

Assuming again that responses are symmetrical, the results across all specifications indicate that following a depreciation of the exchange rate, the South African economy is likely to experience
inflationary pressures. This finding is consistent with the exchange rate pass-through literature surveyed in Chapter 2. Additionally impulse responses from the levels and first difference specifications indicate that there is a decrease in the degree of ERPT experienced in the inflation-targeting period as compared to the full sample period. This decrease in the degree of ERPT too is consistent with the literature as well as previous South African investigations (Bhundia, 2002; Ca' Zorzi, et al., 2007). Only in the gap model does the degree of ERPT appear to increase in the inflation-targeting period. Whilst this is interesting, changes in the degree of ERPT or their causes in not the focus of this dissertation, rather of interest here is whether one can reasonably expect the South African price level to increase following a depreciation of the exchange rate.

In this regard, following the analysis of the CPI response to an appreciation as represented by a one standard deviation of the NEER it appears very likely that depreciations will result in inflationary pressures. However, it is recognised that the assumption of symmetrical responses of the CPI to movements of the exchange rate may well be unrealistic. Indeed, it is well appreciated that prices tend to be sticky downwards, thus it is expected that the impulse responses overstate the behaviour of the CPI following an appreciation. Thus, future research should consider the possibility of such asymmetric responses of the price level to movements of the exchange rate. However, whilst recognizing the possible shortcoming this dissertation has followed closely in the empirical footsteps of previous studies that have estimate the ERPT effect, also not accounting for asymmetric responses (Bhundia, 2002; Ocran, 2010). This represents an interesting future extension to this research area.

5.3.2 Price level FEVD

The analysis of the FEVDs indicates that a significant degree of forecast error of the CPI series across specifications and sample periods is attributable to NEER. To aid in the comparison of results only the contribution of the NEER to the forecast error of CPI is depicted in Figure 5.5 below with the full set off FEVDs presented in Appendix E. See specifically Figures E4, E5 and E6 for a description of the relative contributions to the forecast error from the full sample and Figures E13, E14 and E15 for the inflation-targeting period.
The FEVDs indicate that the NEER is a significant determinant of the forecast error of the domestic price level in both the full- and inflation targeting specific periods. In the full sample the NEER accounts for approximately 25 to 45 percent of the observed forecast error for the CPI from the fourth quarter, with the NEER contributing more to the forecast error of the levels and gap model than in the first difference specification. This trend is exaggerated in the inflation-targeting sample with the NEER accounting for about 45 and 80 percent of the observed forecast error from the fourth quarter, with the NEER contributing the most to the forecast error in the levels and gap.
model and the least in the first difference specification. These results indicate that the NEER accounts for a greater degree of the price level variability in the inflation-targeting period. The larger contribution of the NEER to the forecast error of the CPI is likely a result of South Africa’s greater degree of openness to the world economy as well as its dependence upon foreign inputs leaving the price level more sensitive to the costs of imports.

The FEVDs from both sample periods and across specifications indicate that the NEER has a significant effect on the domestic price level. Specifically, a significant degree of the behavior described by the impulse responses is directly attributable to the NEER. Overall, the behavior of the impulse responses of the CPI to NEER and the FEVDs indicate a well-defined ERPT effect consistent with economic theory and empirical studies. Specifically the degree of EPRT appears to have reduced in the inflation-targeting period and the proportion of the forecast error attributable to the NEER has increased. The decreased ERPT is likely owing to a stronger stance toward inflation adopted in the inflation-targeting regime as well as the recognition of the exchange rates role in predicting future inflation. The increased contribution of the exchange rate to the observed forecast error of the CPI is likely to stem from the South African economy being significantly more open to the international economy and thus more susceptible to changes in the prices of imports in this sample period. The exact causes of the relationships described above are beyond the scope of this dissertation, here it is important to observe that the models indicate that exchange rate depreciation are likely to cause inflationary pressures in the South African economy.

5.4 The Interest Rate

5.4.1 The interest Rate Impulse Response Functions
Given that the South African price level is significantly affected by movements of the exchange rate and that the SARB has had price stability as a policy objective across the entire sample in some form, one would expect the interest rate to respond to the exchange rate. To understand the SARB’s reaction to movements of the exchange rate, impulse responses of the interbank rate to a one standard deviation of the NEER have been estimated and analyzed. Due to the similarity between the results, only the responses from the levels specification are presented below in Figure 5.7 with the results of the first difference and gap model reported in Appendix D, see Figures D3, D4, D5 and D6 for OIRF and COIRFs for the full sample and Figures D9, D10, D11 and D12 for the inflation-targeting period OIRF and COIRFs.
The results obtained from the impulse response analysis indicate that in both periods the interbank responds negatively to movements of the NEER. That is, there is a decrease (increase) of the interbank rate following an appreciation (depreciation) of the NEER. This behaviour is consistent with the behaviour of an inflation-targeting reserve bank in that appreciations of the exchange rate lead to lower inflationary pressures in the economy and thus a reduction in the official policy rate (Aizeman, et al., 2011; Ball, 1998).

The OIRF and COIRFs indicate that whilst in both periods the interbank rate responds negatively to movements of the exchange rate that there are still some differences in the behaviour between periods worth noting. The OIRFs illustrate that the initial response of the interbank rate to an exchange rate movement in the inflation-targeting period are less pronounced than in the full sample, with initial responses of -0.19 and -0.4 for the inflation-targeting period and full sample respectively. Additionally, the peak response of the interbank rate occurs later and is of greater magnitude in the inflation-targeting sample with a response of -0.61 occurring in the third quarter versus the peak response of -0.53 in the first quarter for the full sample.
The results of the OIRFs indicate that whilst the initial response of the interbank rate in the inflation-targeting period is lower than the in the full sample it reaches a greater maximum response. This suggests that the SARB may be showing a preference towards interest rate smoothing in the inflation-targeting period. The results of the OIRFs also appear consistent with the interest rate setting behaviour of a central bank practicing flexible inflation targeting as discussed in Chapter 2. A central bank practicing flexible inflation targeting will choose to reign inflation in over a longer period, responding to inflationary pressures gradually so as not to induce economic instability.

The COIRFs indicate that whilst the inflation-targeting period exhibits a more gradual response of the interbank rate to exchange rate movements, the accumulated response in this period is actually larger than when the sample is estimated as a whole. Specifically the when the full sample exhibits a maximum accumulated response of the interbank rate of -2.6 compared to a maximum accumulated response in the inflation-targeting period of -3.1. These COIRF results indicate that whilst interest rates in the inflation-targeting period respond more gradually to exchange rate movements in total the response is greater than when the sample is taken as a whole.

Table 5.5: Summary of Interbank Rate Impulse Response Results

<table>
<thead>
<tr>
<th>Model Estimated</th>
<th>OIRF</th>
<th>COIRF</th>
</tr>
</thead>
<tbody>
<tr>
<td>levlong</td>
<td>Significant negative response</td>
<td>Significant negative accumulated response.</td>
</tr>
<tr>
<td>difflong</td>
<td>Significant negative response.</td>
<td>Significant accumulated negative response.</td>
</tr>
</tbody>
</table>

Table 5.5 above briefly summarizes the results for the various specifications of the VAR estimated. All models indicated that the interbank rate responds negatively to an appreciation of the exchange rate and hence positively to a depreciation. Both the levels and difference models suggest that the SARB responds in both a more gradual though persistent manner to movements of the exchange
rate. Only in the gap model does the behaviour of the interbank rate appear more subdued in the inflation-targeting period.

These findings suggest that the SARB responds in a significant manner to movements of the exchange rate. Specifically following a depreciation of the exchange rate the SARB is likely to respond by increasing the interest rate. According to the levels and first difference specification, this response is also going to be larger in the inflation-targeting period. This behaviour may indicate that the SARB is responding to the exchange rate in an attempt to preempt the inflationary effects of exchange rate movements, though it may also be an artifact of the exchange rate controls present in the early part of the sample.

5.4.2 Interest Rate FEVD

Though the impulse responses indicate that the SARB is likely to react in a contractionary manner in response to a depreciation of the NEER, it is however unclear what proportion of the forecast error is attributable to the NEER. Examining this provides some insight into the interest rate setting behaviour of the SARB. That is, to what extent does the exchange rate explain the observed forecast error of the interest rate? Below Figures 5.8 and 5.9, illustrate the relative contributions of the NEER to the forecast errors of the interbank rate represented by model specification in the full sample and inflation-targeting specific estimations of the VAR. The complete FEVDs for the various specifications and sample periods are presented in Appendix E, see specifically Figures E7, E8 and E9 for the full sample and Figures E16, E17 and E18 for the inflation-targeting sample.

Figure 5.8: Contribution of NEER to the FEVD of Interbank Rate (1990Q1 – 2012Q1)
The contribution of the NEER to the forecast error of the interest rate tells an interesting story between the two sample periods. In the full sample, the exchange rate’s contribution to the forecast error of the interest rate is highly consistent across model specifications, accounting for between 14 and 20 percent of the observed variance, the greatest proportion being in the levels specification between the first and fifth quarter. The NEER however contributes significantly more to the forecast error of the interest rate when the inflation-targeting period is considered in isolation. In the inflation-targeting sample, the exchange rate contributes between 17 percent and 67 percent of the observed forecast error variance of the interest rate by the fourth step, with the greatest contribution to the forecast error stemming from the levels, first difference and gap specifications respectively.

The greater importance of the exchange rate in explaining the forecast error of the interest rate suggests that in the inflation-targeting period, the SARB may recognize to a greater degree the inflationary effects of the exchange rate and thus incorporates movements of the exchange rate more explicitly in its interest rate setting behaviour. That is, it appears that rather than responding to the inflation induced by exchange rate movements the SARB may be responding to exchange rate movements in a bid to curb inflation preemptively. Such behaviour by an inflation targeting country would be consistent with that described by Ball (1998) and Svensson (1997) as well as that observed by Aizeman et al. (2011) in their cross-country investigation of the reaction functions of inflation-targeting countries.
The importance of the exchange to the contribution of the forecast error of the interest rate indicates that the exchange rate is an important variable for describing the interest rate setting behavior of the SARB. Additionally, its significance in predicting the forecast error suggests that the SARB treats movements of the exchange rate as a predictor of future inflation and thus adjusts the interest rate in response to the exchange rate in the inflation-targeting period. This behavior indicates that the SARB may recognize the inflationary effects of the exchange rate and respond directly to movements of the exchange rate rather than waiting for the inflationary effects to filter through to domestic prices.

5.5 The Effect of the US Aggregate Demand on South African Real GDP

The impulse response analysis presented above indicates a relationship between real GDP and the exchange rate that is in line with the conventional view presented in Chapter 2 as well as that held by many politicians and the NGP: That is, it appears that depreciations of the exchange rate are associated with positive economic growth. This result appears both intuitive and straightforward; though as the literature covered in Chapter 2 revealed, in the South African context empirical evidence regarding the exchange rate effects on economic growth are mixed.

Both Rankin (2002) and Saville (2010) found ambiguous effects on economic activity resulting from movements of the exchange rate in the South African context. A possible explanation for these results has been alluded to by the comparison of the full- and inflation-targeting samples. It appears that some of the ambiguity in the results may arise from estimating models that include both pre- and post-exchange rate control data. Mixing South African economic data from the 1990s that exhibit substantial changes in terms of exchange rate, monetary policy regime, governing party, etc. with data from the current and relatively more stable inflation-targeting regime appears problematic. However, a thorough investigation to establish whether not controlling for the transitional characteristics of the South African economy has resulted in some of the ambiguity in the reported exchange rate growth relationship is warranted, though this lies beyond the scope of this dissertation.

A second possible explanation for the observed ambiguity in relationship between the exchange rate and real GDP was offered by Saville (2010), and takes into account the fact that South Africa is a small open economy as well as recognizing the dynamic nature of the mechanisms under consideration. Saville (2010) suggested that a positive correlation between appreciations of the South African exchange rate and real GDP may result from the feed-through effect from foreign aggregate demand upon the foreign exchange rate market as and then domestic output. This relationship was alluded to graphically in Figure 4.2 and 4.4 where positive movements of the US
real GDP gap and the NEER’s deviation from trend tend to precede positive movements of the South African real GDP gap.

In order for foreigners to purchase from South Africa, they first need to purchase South African Rands. Thus, before an increase in foreign aggregate demand can result in the purchase of South African output, South African Rands must first be purchased and this increased demand for the currency results in an appreciation of the Rand, ceteris paribus (Saville, 2010). Only once South African Rands have been purchased can the South African economy be stimulated via foreign aggregate demand.

To test this explanation, dynamic multiplier functions are estimated which expose the endogenous variables of the VAR to a one-time increase of an exogenous variable. Whilst both oil and US GDP have been included as exogenous variables to the VAR, only the responses of the NEER and real GDP to the one-time change in US real GDP are estimated. The complete set of dynamic multiplier functions for the NEER and real GDP are presented in the appendix for easy comparison, with only the response of the levels specification presented in Figure 5.10 below. See Appendix F for the dynamic multiplier functions for the difference and gap VAR specifications in Figure F1 and F2 respectively.
The DMFs estimated for South Africa’s real GDP and NEER in response to a one-time increase in US real GDP, show relationships that are only in partial agreement with those suggested by Saville (2010). In the levels specification above, an increase in the real GDP of the US has a significant positive affect upon South African real GDP with the effect being substantially larger in the inflation-targeting period. This finding between foreign aggregate demand and the performance of South African real GDP is consistent for the levels and gap specifications for both sample periods and in the first difference specification for the inflation-targeting period. The behaviour exhibited in the first difference specification of the full sample is however very muted.

However, the behaviour of the NEER to an increase in US real GDP does not appear to behave consistently with the description of Saville (2010). Broadly speaking all but the DMF from the levels specification of the full sample period indicate that an increase in US real GDP results in an initial appreciation of the Rand. Even whilst the results indicate that increases in foreign aggregate demand appreciate the Rand, the effects do not appear sustained, becoming negative by the third quarter in all specifications apart from the full sample’s levels specification, which anomalously illustrates a negative initial response before appreciating towards its trend level. This result of an
initial negative response in the levels full sample model is believed to stem from the sustained depreciation of the Rand observed during the 1990s.

The results from the dynamic multiplier functions provide some evidence that increases in US real GDP, here used as a proxy for foreign aggregate demand, both serve to increase South African real GDP and appreciate the exchange rate. Thus, the model presented here provides some support for the relationship proposed by Saville (2010).

5.6 Concluding Remarks
The New Growth Path has advocated a depreciation of the Rand to facilitate economic growth in South Africa; it went further to state that the SARB should continue to target inflation whilst providing a low interest rate environment to encourage investment. This section of the dissertation sought to analyse a Cholesky ordered VARX model of the South African economy to assess how the real GDP, price level and interest rates respond to movements of the exchange rate.

The results from the impulse response analysis indicate that the South African economy responds favourably to depreciations of the exchange rate as per the policy prediction of the NGP. FEVD analysis also indicated that the exchange played a significant role in contributing to the forecast error of real GDP. Additionally it was found that the relationship between real GDP and the exchange rate was stronger when the inflation-targeting period is considered in isolation from the more transitional 1990s. These findings are robust across model specifications.

The price level was found to be significantly affected by the exchange rate, specifically depreciations of the exchange rate were found to be inflationary and FEVD analysis showed the that the exchange rate was a significant determinant of the forecast error. Interestingly the results suggest that the degree of ERPT has declined in the inflation-targeting period, a result consistent with much of the ERPT literature covered in Chapter 2. It also was found that the proportion of the forecast error of the CPI explained by the NEER has actual increased in the inflation-targeting period, which may be indicative of South Africa being more open in comparison to the 1990s. The results here indicate that whilst a depreciation of the Rand appears to stimulate real GDP it also results in higher prices.

The NGP also expressed how the SARB should seek to create an environment conducive to investment by keeping interest rates low. The results of the impulse responses indicate that the interest rate responds significantly to movements of the exchange rate. Specifically all specifications concur that a depreciation of the exchange rate will result in an increase in the interest rate, here proxied by the interbank rate. Additionally the contribution of the NEER to the forecast error of the interbank rate dramatically increases when the inflation-targeting period is estimated in isolation.
This increase in the behaviour may be suggestive of the SARB placing greater weight on movements of the exchange rate as a predictor of future inflation in this period.

The results thus indicate that whilst a depreciation of the exchange rate is likely to stimulate economic growth it does so at a price. A weaker exchange rate results in higher prices on imported goods, which in turn increases the price level. South Africa having a central bank that targets inflation will respond to inflationary pressures, thus as a depreciation raises the price level the SARB will respond by raising the interest rate, resulting in an environment that discourages investment. Overall, the net effect of a depreciation of the exchange rate appears to be that of increased real GDP, price level and interest rates, one not wholly consistent with that outlined in the NGP. The macroeconomic environment of a more competitive exchange rate, higher economic growth, low stable inflation and low interest rates appears inconsistent and hence unachievable.
Chapter Six – Conclusion

This dissertation has sought to understand how South African real GDP, prices and interest rates are likely respond to movements of the exchange rate. This inquiry was inspired by the publication of the New Growth Path in November 2010. This document outlined a series of policies aimed at improving South Africa’s growth potential. The macroeconomic environment outlined in the NGP included a more competitive exchange rate, low inflation and low interest rates. This combination stood out as being suspicious given that there is both a well-documented exchange rate pass through effect, in which depreciations of a currency translate into higher domestic prices, and that assuming the SARB holds to its official mandate, would likely respond to the higher inflation via interest rate increases. To assess the response of these variables to a movement of the exchange rate both an in-depth literature review and an empirical analysis have been conducted.

The purpose of the literature review was to develop a broad understanding of how a depreciation of the exchange rate may affect the South African economy, thus providing grounds for the assessment of the feasibility of the NGP’s proposed macroeconomic environment. To do this the literature review considered the effects of exchange rate depreciations on real GDP, inflation and interest rates respectively. Broadly, it has been found that the proposed macroeconomic policy mix of the NGP stands at odds with the relationships between variables generally described in theoretical and empirical studies. Depreciations of the exchange rate have not been found to consistently result in higher levels of economic growth. These ambiguous findings persist even when depreciations result in a reduction of a real exchange rate overvaluation or an increase in the degree of undervaluation. In the South African case too, depreciations of the exchange rate have not been found to robustly stimulate economic growth.

Depreciations of currencies, however, have been found to exert inflationary pressures upon domestic prices. This ERPT effect has reduced over recent years internationally, although it still remains a significant and substantial driver of domestic inflation. The observed ERPT effect is that of incomplete and often delayed pass through to prices, meaning that over the short run a nominal depreciation can result in a real depreciation of the exchange rate. Additionally, in the setting of a small open economy the exchange rate has been observed to be a significant determinant of interest rates in inflation targeting countries. Although the exchange rate is not explicitly targeted in such regimes, it is recognised that the variables within the objective function of a central bank are affected by the exchange rate. Given that such variables are affected, it becomes optimal policy for a flexible inflation targeting central bank to respond to movements of the exchange rate.
The empirical portion on the investigation was conducted through the structural analysis of a series of VARX models estimated over a 22 year period (1990Q1 – 2012Q1) and a 12 year inflation targeting specific period (2000Q1-2012Q1). As there is significant debate over which VAR specification is most suited for inference purposes in the presence of nonstationary data, multiple specifications were estimated. Recent developments in this debate suggested that the use of a VAR estimated in levels yields robust estimates of impulse responses and their confidence intervals in the presence of stationary, nonstationary and cointegrating relationships.

In total six VARX models were estimated and analysed, consisting of three specifications for both the full sample and the current inflation-targeting period. These three models consist of a VAR in levels, a first differenced model and a gap model. Lag orders of the VARs were selected according to information criteria and ensuring no autocorrelation of the residual series. All VARs are found to be stable allowing for meaningful interpretations of impulse response functions and forecast error variance decompositions.

The results from the impulse response analysis illustrated that the South African economy responds favourably to depreciations of the Rand as per the policy prediction of the NGP. FEVD analysis also indicated that the exchange played a significant role in contributing to the forecast error of real GDP. It was additionally found that the relationship between real GDP and the exchange rate was stronger in the inflation-targeting period. These findings were found to be robust across model specifications.

The price level was found to be significantly affected by the exchange rate, specifically depreciations of the exchange rate were found to be inflationary and FEVD analysis showed the that the exchange rate was a significant determinant of the forecast error of CPI. Interestingly the results suggest that the degree of ERPT has declined in the inflation-targeting period, a result consistent with much of the ERPT literature covered in Chapter 2. It was also found that the proportion of the forecast error of the CPI explained by the NEER has increased in the inflation-targeting period, which may be indicative of South Africa being more open in comparison to the 1990s. The results here indicate that whilst a depreciation of the Rand appears to stimulate Real GDP it also results in high prices.

The results of the impulse responses additionally indicate that the interest rate responds significantly to movements of the exchange rate. Specifically all specifications of the VARX model indicate that a depreciation of the Rand would result in an increase in the interest rate, here proxied by the interbank rate. Additionally the contribution of the NEER to the forecast error of the interbank rate dramatically increased when the inflation-targeting period was estimated in isolation. The increase in the contribution to the forecast error suggests that the SARB has been placing a
greater weight on movements of the exchange rate as a predictor of future inflation in the inflation-targeting period.

The VARX model estimated in this dissertation suggests rather robustly that at least in the inflation-targeting period a depreciation of the Rand would likely result in increased economic growth, inflation and interest rates. The observed effect of the exchange rate on economic growth over the whole sample is rather more ambiguous, though the observed effect on the CPI and interest rates remains substantial. A possible cause for the subdued response of real GDP to the exchange rate when the full sample was estimated may be due to the presence of exchange rate controls and the lower degree of integration with the international economy. This cause however has not been explicitly tested, though would explain why previous investigations into the response of the South African to movements of the exchange rate have yielded ambiguous results.

Whilst having cast significant doubt over the consistency of the macroeconomic environment outlined in the NGP, the results obtained from this investigation do not present the full picture as an implicit assumption made in the conduct of the structural analysis and estimation of the VAR was that of symmetry of responses. Whilst this assumption is standard in the estimation of VARs it does not necessarily reflect accurately the behaviour of variables. Indeed it is very likely that there are asymmetries and nonlinearities present in the relationships between variables.

By allowing for asymmetric responses of variables, future research could attempt to ascertain whether the response of real GDP, CPI and interest rates are affected by the direction of the exchange rate movement. It is quite possible that appreciations of the exchange rate could affect the economy differently to depreciations. Indeed, it is recognized that prices tend to be downwardly sticky with greater flexibility in an upward direction. Allowing for such asymmetry and assessing whether there does exist a significant difference between the specifications, would add greater depth to the current understanding of the relationship between the exchange rate and the responses of real GDP, inflation and interest rates. Future research could also investigate whether there exists nonlinearities in the responses of variables, as it is quite possible that variables will respond differently to large movements of the exchange rate than they would to small movements.

It may also be of interest to investigate from where the growth promoting effects of an exchange rate depreciation arise. That is, whether the economy is stimulated from greater export volumes or from expenditure-switching behaviour.

This dissertation set out with the aim of exploring how a depreciation of the Rand would affect real GDP, the price level and interest rates. This exploration of these relationships was inspired following
a reading of the NGP, which proposed that a growth enhancing macroeconomic environment for South Africa includes a depreciated exchange rate, low stable inflation and low interest rates. This dissertation has found that whilst depreciations of the Rand appear to stimulate the economy, they are associated with higher prices and interest rates and, thus, the macroeconomic environment proposed by the NGP appears unachievable.
References


Appendix
### Appendix A: Unit Root Test Results

#### Table A1: Unit root test results: Full sample (1990Q1 - 2012Q1)

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADF t-statistic</th>
<th>Regressors</th>
<th>DF-GLS t-statistic</th>
<th>Regressors</th>
<th>Z(t) Statistic</th>
<th>Regressors</th>
<th>PP t-statistic</th>
<th>Hypothesis</th>
<th>Result</th>
</tr>
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<tbody>
<tr>
<td>lngdp</td>
<td>-3.182***</td>
<td>a</td>
<td>-1.91</td>
<td>a</td>
<td>-140.3</td>
<td>a</td>
<td>0.371*</td>
<td>Trend stationary</td>
<td>I(1)</td>
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<tr>
<td>Δlngdp</td>
<td>-3.63*</td>
<td>b</td>
<td>-2.929*</td>
<td>b</td>
<td>-3.947*</td>
<td>c</td>
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<td>Level stationary</td>
<td>I(0)</td>
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<td>-3.622*</td>
<td>b</td>
<td>-2.96*</td>
<td>c</td>
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<td>Level stationary</td>
<td>I(0)</td>
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<td>c</td>
<td>-0.759</td>
<td>a</td>
<td>-3.649**</td>
<td>a</td>
<td>0.411*</td>
<td>Trend stationary</td>
<td>I(0)/I(1)</td>
</tr>
<tr>
<td>Δlngpi</td>
<td>-3.659*</td>
<td>b</td>
<td>-2.192**</td>
<td>b</td>
<td>-4.774*</td>
<td>b</td>
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<td>I(0)</td>
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<tr>
<td>lnG3</td>
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<td>a</td>
<td>-1.595</td>
<td>a</td>
<td>0.213**</td>
<td>Trend stationary</td>
<td>I(1)</td>
</tr>
<tr>
<td>ΔlnG3</td>
<td>-3.391*</td>
<td>b</td>
<td>-4.168**</td>
<td>b</td>
<td>-6.170*</td>
<td>b</td>
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<td>I(0)</td>
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<td>mGAP</td>
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<td>-2.339**</td>
<td>c</td>
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<td>a</td>
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<td>I(1)/I(0)</td>
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<td>Δinterbank</td>
<td>-1.769**</td>
<td>d</td>
<td>-1.192</td>
<td>a</td>
<td>-1.922</td>
<td>a</td>
<td>0.336*</td>
<td>Trend stationary</td>
<td>I(1)</td>
</tr>
<tr>
<td>Δlnneer</td>
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<td>c</td>
<td>-5.125</td>
<td>b</td>
<td>-6.039*</td>
<td>c</td>
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<td>I(0)</td>
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<td>Δlnneer</td>
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<td>a</td>
<td>0.336*</td>
<td>Trend stationary</td>
<td>I(1)</td>
</tr>
<tr>
<td>deflnneer</td>
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<td>c</td>
<td>-3.489</td>
<td>b</td>
<td>-3.41*</td>
<td>c</td>
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<tr>
<td>lngdp_us</td>
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<td>b</td>
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<td>a</td>
<td>-0.329</td>
<td>a</td>
<td>0.295*</td>
<td>Trend stationary</td>
<td>I(1)</td>
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<tr>
<td>Δlngdp_us</td>
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<td>b</td>
<td>-5.414*</td>
<td>b</td>
<td>0.323</td>
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<td>c</td>
<td>-1.866***</td>
<td>b</td>
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**Note:** All variables apart from gap, interbank and defneer are expressed in logs. The asterisks indicate rejection of the null hypothesis at 1 percent (*), 5 percent (**) and the 10 percent (***) level. Lag length for the ADF and DF-GLS tests were selected using SBIC and SIC respectively with lag length selection for the PP test relying upon the default Newey-West lag selection formula, 4(T/100)^2/9. The KPSS test utilised a quadratic spectral kernel to automatically determine optimal lag length. The null hypothesis for all but the KPSS test is that of nonstationarity, with the KPSS testing specifically for either trend or level stationarity. ADF: Augmented Dickey-Fuller Test; DF-GLS: Dickey-Fuller GLS Test; PP: Phillips-Perron Test; KPSS: Kwiatkowski, Phillips, Schmidt, and Shin Test. Additional Regressors: a - Trend and constant; b - Constant, notrend; c - No constant, no trend; d - Drift and constant.
<table>
<thead>
<tr>
<th>Variable</th>
<th>ADF t-statistic</th>
<th>Regressors</th>
<th>DF-GLS t-statistic</th>
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<th>KPSS t-statistic</th>
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<th>Result</th>
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<td>a</td>
<td>-1.743</td>
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Note: All variables apart from gap, interbank and defneer are expressed in logs. The asterisks indicate rejection of the null hypothesis at 1 percent (*), 5 percent (**) and the 10 percent (*** ) level. Lag length for the ADF and DF-GLS tests were selected using SBIC and SIC respectively with lag length selection for the PP test relying upon the default Newey-West lag selection formula, 4(T/100)^2/9. The KPSS test utilised a quadratic spectral kernel to automatically determine optimal lag length. The null hypothesis for all but the KPSS test is that of nonstationarity, with the KPSS testing specifically for either trend or level stationarity. ADF: Augmented Dickey-Fuller Test; DF-GLS: Dickey-Fuller GLS Test; PP: Phillips-Perron Test; KPSS: Kwiatkowski, Phillips, Schmidt, and Shin Test. Additional Regressors; a - Trend and constant; b - Constant, notrend; c - No constant, no trend; d - Drift and constant.
Appendix B: VAR Stability Tests - Unit Root Circles

Figure B1: VAR(2) Levels Specification (1990Q1-2012Q1)

Figure B2: VAR(1) First Difference Specification (1990Q1-2012Q1)
Figure B3: VAR(2) Gap Specification (1990Q1-2012Q1)

Figure B4: VAR(1) Levels Specification (2000Q1-2012Q1)
Figure B5: VAR(1) First Difference Specification (2000Q1-2012Q1)

Figure B6: VAR(3) Gap Specification (2000Q1-2012Q1)
Appendix C – Cointegration Tests

Table C1: Johansen Tests for Cointegration (1990Q1-2012Q1)

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Table C2: Johansen Tests for Cointegration (2000Q1-2012Q1)

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Appendix D: Impulse Response Results

Figure D1: Levels VAR OIRF to an Impulse of the NEER (1990Q1-2012Q1)

Figure D2: Levels VAR COIRF to an Impulse of the NEER (1990Q1-2012Q1)
Figure D3: Difference VAR OIRF to an Impulse of the NEER (1990Q1-2012Q1)

Figure D4: Difference VAR COIRF to an Impulse of the NEER (1990Q1-2012Q1)
Figure D5: Gap VAR OIRF to an Impulse of the NEER (1990Q1-2012Q1)

Figure D6: Gap VAR COIRF to an Impulse of the NEER (1990Q1-2012Q1)
Figure D7: Levels VAR OIRF to an Impulse of the NEER (2000Q1-2012Q1)

Figure D8: Levels VAR COIRF to an Impulse of the NEER (2000Q1-2012Q1)
Figure D9: Difference VAR OIRF to an Impulse of the NEER (2000Q1-2012Q1)

Figure D10: Difference VAR COIRF to an Impulse of the NEER (2000Q1-2012Q1)
Figure D11: Gap VAR OIRF to an Impulse of the NEER (2000Q1-2012Q1)

Figure D12: Gap VAR COIRF to an Impulse of the NEER (2000Q1-2012Q1)
Appendix E – Forecast Error Variance Decompositions

Figure E1: Levels VAR FEVD of Real GDP (1990Q1 – 2012Q1)

Figure E2: Difference VAR FEVD for Real GDP (1990Q1 – 2012Q1)
Figure E3: Gap VAR FEVD for Real GDP (1990Q1 – 2012Q1)

Figure E4: Levels VAR FEVD for CPI (1990Q1 – 2012Q1)
Figure E5: Difference VAR FEVD for CPI (1990Q1 – 2012Q1)

Figure E6: Gap VAR FEVD for CPI (1990Q1 – 2012Q1)
Figure E7: Levels VAR FEVD for Interbank Rate (1990Q1 – 2012Q1)

Figure E8: Difference VAR FEVD for Interbank Rate (1990Q1 - 2012Q1)
Figure E9: Gap VAR FEVD for Interbank Rate (1990Q1 – 2012Q1)

Figure E10: Levels VAR FEVD for Real GDP (2000Q1 – 2012Q1)
Figure E11: Difference VAR FEVD for Real GDP (2000Q1 – 2012Q1)

Figure E12: Gap VAR FEVD for Real GDP (2000Q1 – 2012Q1)
Figure E13: Levels VAR FEVD for CPI (2000Q1 – 2012Q1)

Figure E14: Difference VAR FEVD for CPI (2000Q1 – 2012Q1)
Figure E15: Gap VAR FEVD for CPI (2000Q1 – 2012Q1)

Figure E16: Levels VAR FEVD for Interbank Rate (2000Q1 – 2012Q1)
Figure E17: Difference VAR FEVD for Interbank Rate (2000Q1 – 2012Q1)

Figure E18: Gap VAR FEVD for Interbank Rate (2000Q1 – 2012Q1)
Appendix F – Dynamic Multiplier Functions

Figure F1: Difference VAR DMF of South African Real GDP and NEER (1990Q1 -2012Q1) and (2000Q1-2012Q1)

Figure F2: Gap VAR DMF of South African Real GDP and NEER (1990Q1 -2012Q1) and (2000Q1-2012Q1)
Letter of Ethical Clearance