NELSON MANDELA UNIVERSITY

The effect of the exchange rate on inflation in South Africa

by

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DECLARATION:

In accordance with Rule G5.6.3, I hereby declare that the above-mentioned treatise/ dissertation/ thesis is my own work and that it has not previously been submitted for assessment to another University or for another qualification.

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Executive summary

The depreciation of the rand in recent years has been one of the indicators of recession in South Africa. The unpredictability of the rand and its volatility has led to great inflationary pressure. The process of examining the relationship between South Africa's exchange rate and inflation rate has become increasingly relevant down the years. This study analyses the relationship between exchange rate and inflation in South Africa from 1994Q1 to 2017Q4. Its objective is to establish the effect of the exchange rate on inflation in South Africa. The non-linear autoregressive distributed lag (NARDL) model is employed as the method of estimation.

Trends in exchange rate and inflation between 1980 and 2017 are analysed. Monetary régimes and shifts in inflation down the years are discussed. Key events like the Asian financial crisis of 1998, the introduction of the inflation targeting framework in 2000, the significant depreciation of the rand in 2001 and the global financial crisis in 2008/09 all contributed majorly in the way the country's monetary policy and inflation take the form they have today. The literature identifies the exchange rate pass-through, purchasing power parity (PPP) and absolute power parity (APP) as exchange rate theories, all in which are discussed in detail. Empirical evidence suggests a predominantly positive relationship between inflation rate and exchange rate in other African countries as well as in developed countries. The exchange rate pass-through in South Africa appears to have lessened down the years.

The NARDL model is discussed in detail in the research methodology chapter. The main reason for using this method of estimation is to capture asymmetry effects that may exist between inflation and exchange rate. First and second generation unit root tests, like Ng-Perron, DF-GLS and KSS, are discussed in detail to capture the stationarity of the variables. The variables of interest include nominal effective exchange rate, Brent crude oil prices, prime lending rate, unemployment rate and M3 money supply. This is done in line with the literature. The vector autoregressive (VAR) model is briefly discussed in the research methodology chapter.

The findings of the study reveal that an appreciation in the exchange rate decreases the inflation rate. The results also reveal that a depreciation in the exchange rate decreases the inflation rate, which happens not to be in line with economic theory. This implies that a depreciation has a negative effect on inflation. A positive relationship between oil price and inflation is found to exist. A negative relationship is found to exist between M3 money supply and inflation. There is a positive relationship between prime lending rate and inflation. The study found that the Phillips curve does not hold in South Africa. The estimated VAR model results reveal that there exists unidirectional causality running from nominal effective exchange rate to inflation rate. The impulse response function reveals a negative relationship between exchange rate and inflation. Therefore, the study proposes that policymakers evolve means of evaluating exchange rate volatility, and that lending rates be made flexible. This will help curb inflation in South Africa.

Keywords: exchange rate, inflation, appreciation, depreciation, NARDL, VAR.

Table of contents

Chapter one: Introduction

Chapter two: Overview of inflation and exchange rate in South Africa

Chapter three: Literature review

Chapter four: Research methodology

Chapter five: Empirical results and discussions

List of figures

List of tables

Chapter one: Introduction

1.1 Background

South African policymakers have managed to direct the inflation rate toward the target range of 3% to 6% upon implementing the inflation targeting framework in February 2000 (Ncube & Ndou, 2011). There are four reasons for South Africa's implementation of a formal framework in terms of inflation targeting: to develop surety of the South African Reserve Bank's (SARB's) monetary policy stance, to enhance the cooperation between monetary policy and other economic policies, to enhance the Reserve Bank's sense of accountability, and to directly impact the inflationary expectations of investors. This is expected to result in an inflation rate decrease (Mpofu, 2011). During this period the Reserve Bank took it upon itself to consider economic growth when setting interest rates. During the inflation targeting era, the Reserve Bank left the exchange rate to be determined by market forces and as a result making it more volatile (Ncube & Ndou, 2011). In terms of this context, the need to investigate the relationship between inflation and exchange rate arises. Therefore, this study aims to analyse the relationship between inflation and exchange rate in South Africa.

Acording to Ncube & Ndou (2011), the level of flexibility in terms of inflation targeting is dependant on the central banks specified loss function. In the process of implementing strict inflation targeting, the central bank is heavily involved in maintaining the inflation near to an inflation target above the short horizon (Svensson, 1997). Ncube & Ndou (2011) state that this process requires meticulous activist policies, which include dramatic exchange rate and interest rate adjustments. They also state that flexible inflation targeting arises when the central bank provides weight to the stability of exchange rates, interest rates, output and employment to bring inflation to the preffered long-run target over a longer horizon, which requires less policy involvement and gradually returns inflation to target over a longer horizon.

The exchange rate may have adverse effects on inflation. The Reserve Bank states that the appreciation of the rand has had both a positive and a negative impact. It states that in one case it lowers South Africa's trade competitiveness, however it reduces inflationary pressures given the influence of the exchange rate on the consumer price index (SARB, 2012). An important concept to note in this regard is the exchange rate pass through, which can be defined as the percentage change in local or imported prices steered by a one-percentage-point change in the exchange rate between the currencies of importer and exporter (Sek *et al*, 2012). Due to exchange rate volatility it might be challenging to ascertain the true effect of an appreciation or depreciation on inflation. However, in terms of reducing inflation an appreciation of the rand would be more favourable.

Exchange rate volatility has a greater effect on small economies, as opposed to bigger economies. According to Aron *et al* (2012) monetary policymakers in small, open economies are presented with challenges such as greater imported inflationary pressures and the volatility of the exchange rate. This is the case in South Africa, as the rand's volatility has led not only to lower output but may also have influenced inflation. The extent of the rand exchange rate over the longer term could possibly be influenced by the inflation differential between South Africa and its international competitors and its main trading partners (SARB, 2007).

Maveé & Schimmelpfennig (2017) identify the possible drivers of South Africa's rand volatility as economic surpluses, the global factor and political uncertainty. Economic surpluses occur in the case where a marked gap between expected and actual values of key macroeconomic variables when data is released by relevant sources of information (Maveé & Schimmelpfennig, 2017). Global factors appear in the form of the price volatility in the main exported and imported commodities of South Africa as well as global financial-market risk perception and lastly, political uncertainty is measured by how often news reports mention government, politics and uncertainty in the same breath as South Africa (Maveé & Schimmelpfennig, 2017).

In recent years, the exchange rate has depreciated mostly due to political stability, which might have increased inflation and applied pressure on the Reserve Bank to increase interest rates. This may also have had a steady influence on inflation. The continued depreciation of the rand has already led to inflationary pressure, expected to reach 8% year on year (y/y) in 2016 (Deloitte, 2016). Higher interest rates may have a negative influence on growth. Since Cyril Ramaphosa took over as President the rand has appreciated slightly, which could ease inflationary pressures.

Exchange rate volatility tends to make economic decision making for firms, consumers and policymakers more difficult due to the potential it has to increase instability and uncertainty in each of these areas (Parsley, 2010). This could lead to increased inflationary pressure and lower output growth. An analysis of whether under an inflation targeting framework the exchange rate should affect monetary policy is of importance. It is necessary to understand the background of inflation targeting and the volatility of the exchange rate in South Africa to understand the effect the exchange rate has on inflation. This will enable policymakers to determine how to lessen the influence of the exchange rate on inflation.

1.2 Problem statement

The volatility of the exchange rate in South Africa is of interest and, according to Fowkes *et al* (2016), the rand is an unusually volatile currency. The reason for this is that it is determined by market forces, as opposed to it being fixed or pegged to a certain currency. This is an example of a floating exchange rate policy, which South Africa employs.

When the currency depreciates, people generally anticipate that inflation will rise in the near future. According to Sibanda *et al* (2015), the rand depreciated rapidly in 2001, which led to great inflationary pressure, leading in turn to a rise in the expected inflation for the years 2002 and 2003, for which inflation expectations averaged 8.4%. It emerges that 2002 was the year South Africa's inflation rate exceeded the 3%-to-6% target. Harmse (2006) states that it was a year of disquiet and frustration during which inflation worsened and moved beyond the 10% mark. This was due to the terrorist attack in the US on 11 September 2001 (known informally as 9/11, using the American style of giving the date). In the years 2008 and '09 inflation expectations were very high and the exchange rate depreciated (Sibanda *et al*, 2015). Furthermore, commodity price volatility and global market uncertainty also caused sprouts of rand volatility (Arezki *et al*, 2012; cited in Maveé *et al*, 2016).

Following the crisis the exchange rate depreciated by a considerable margin during the period 2014-'17. Maveé & Schimmelpfennig (2017) state that the rand/dollar rate depreciated due to domestic inflation surprises and the removal of finance minister Nhlanhla Nene, following which the rand plummeted to about R16/$1. At the end of November 2016, the attempt to prosecute Pravin Gordhan in connection with the alleged rogue unit at the South African Revenue Services also led the rand/dollar rate to depreciate (Maveé & Schimmelpfennig, 2017). This in essence depicts South Africa's exchange rate volatility and how that may have an adverse effect on inflation. The question that will need to be answered would be how to lessen the effect of the exchange rate on inflation, as this could be detrimental to South Africa's economy.

1.3 Research questions

The irregularity of the exchange rate's effect on inflation when the currency appreciates or depreciates will be analysed. These questions will be answered in the study:

1. What effect does depreciation have on inflation?

2. What effect does appreciation have on inflation?

1.4 Research aim

The aim of the study is to analyse the effect of the exchange rate on inflation in South Africa and to provide policymakers with the information needed to make informed decisions regarding monetary policy.

1.5 Research objectives

The primary objective of this study is to establish the effect of the exchange rate on inflation in South Africa. The secondary objectives are:

- To establish whether there are any feedback effects between inflation and exchange rate.
- To examine the long- and short-run relationships between exchange rate and inflation.
- To examine the effect of a depreciation or an appreciation on the inflation rate.

1.6 Significance of the study

The relationship between exchange rate and inflation has been examined by many studies, such as Mpofu (2011), Sibanda *et al* (2015), Schaling (2008) and many others. However, no South African study has used the non-linear autoregressive distributed lag (NARDL) technique. This study therefore aims to fill that gap by employing the NARDL technique, which is fairly new as it was introduced by Shin *et al* in 2014. It is advantageous to use this technique as it shows what happens if the exchange rate appreciates or depreciates. It thus tests for asymmetries in the exchange rate movements. This allows for robust empirical results even for small sample sizes.

Empirical literature has highlighted the importance of analysing the effect of the exchange rate on inflation and South Africa is no exception. According to Audu & Amaegberi (2013) the magnitude of this effect is a key for monetary policy as it determines whether the central bank should dedicate efforts to control nominal depreciatory pressures that may jeopardise the stability of prices. This will enable the Reserve Bank to make the essential adjustments to the monetary policy to achieve price stability.

Furthermore, this topic is of particular interest as the decline in the rand over the years has led to stagnant growth and a decline in foreign investments in the South African economy. As a result, the increase in the standard living due to increased inflationary pressure remains unmatched. The study will therefore provide recommendations to policy makers that will enable them to make sound decisions.

1.7 Research hypotheses

These hypotheses will be tested in this study:

H0: There is no relationship between exchange rate and inflation

H1: There is a relationship between exchange rate and inflation

H0: There is a negative relationship between exchange rate and inflation

H1: There is a positive relationship between exchange rate and inflation

1.8 Scope of the study

This study incorporates the period since full democracy and includes the period in which the framework of inflation targeting was introduced in South Africa, as well as the periods before and since the global financial crisis. It also includes the exchange rate policies and relevant literature on exchange rates and how they affect inflation. Time constraints limit the depth to which this study may reach, so further research will need to be conducted.

1.9 Layout of the study

Chapter two will discuss the trends in inflation and exchange rate in South Africa. Chapter three will provide an overview of the literature review. Chapter four will provide the research methodology and estimation techniques employed in the study. Chapter five will present the results and discussions of the study. Chapter six will present the summary, conclusion and recommendations based on the findings of the study.

Chapter two:
Overview of inflation and exchange rate in South Africa

2.1 Introduction

The purpose of this chapter is to review the trends in inflation and exchange rate in South Africa between 1980 and 2017. This will show a better understanding of how the two variables have performed down the years. Section 2.2 presents an overview of inflation in South Africa. Three distinct monetary policy régimes will be discussed in detail. Section 2.3 presents an overview of exchange rates in South Africa. The development of the exchange rate system will be discussed. Section 2.4 presents an analysis of the relationship between inflation and exchange rate in South Africa. Data is obtained for each variable and is illustrated in graphic format. Lastly, the chapter will be concluded in Section 2.5.

2.2 Overview of inflation in South Africa

Three distinct monetary policy régimes since 1980 have been identified in South Africa. During the 1980's the governor of the Reserve Bank was Gerhard de Kock, which is important to note given the performance of the monetary policy at the time. According to Burger & Marinkov (2008), monetary policy was not successful in controlling inflation during the period 1980-'89. In the early 1980s the Reserve Bank decided to try another approach which saw it return to more market-oriented economic policies (Rossouw, 2007).

The period 1981-'85 is what Rossouw (2007) describes as the period of stubborn inflation in which money supply growth targets served as an anchor for market-orientated monetary policy. In the period 1986-'89 the Reserve Bank adopted low-profile, adaptable money supply growth targets as opposed to fixed targets (Rossouw, 2007). This change turned monetary policy in a different direction, with the goal of controlling money supply. However, in 1988 the government again changed direction, its new goal being to combat inflation. One of the measures to achieve this was restricting government expenditure. Rossouw (2007) states that the government used a low-key control approach, as the focus was to retain wages and important prices in the economy at current levels, as opposed to increasing them. However, the government failed to achieve price stability during this period.

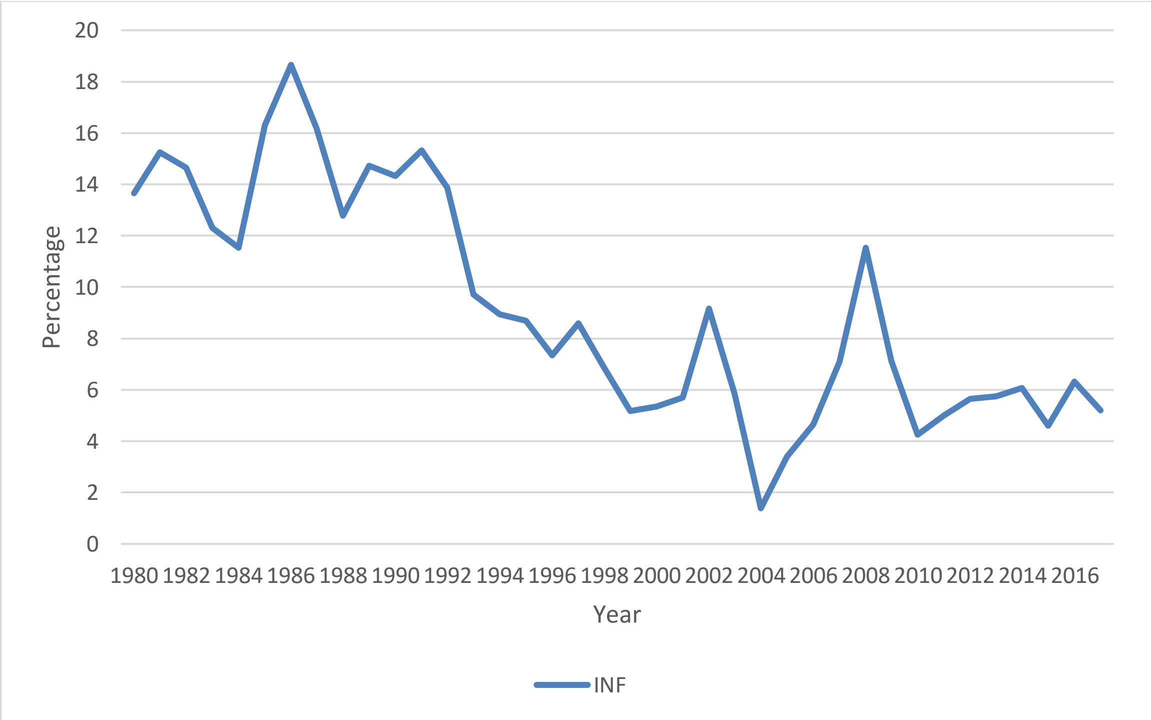
The period 1990-2000 saw a significant improvement in attempts to combat inflation by the Reserve Bank. Burger & Marinkov (2008) characterise this period as one of implicit inflation targeting. Some argue that this was when inflation was regarded to be South Africa's core economic problem. It is also when Dr Chris Stals was governor of the Reserve Bank. His task was to combat inflation, among other factors. The idea was that through a disciplined monetary and fiscal approach, it would be possible to reduce the inflation rate in South Africa over the next few years (Stals, 1989:10; cited in Rossouw, 2007). According to Rossouw (2007) up until 1992 inflation was in the double digits and was a result of the market not believing in the governor. By the mid-1990s inflation dropped to single-digit figures. According to (Burger & Marinkov, 2008) towards the late-1990's the Reserve Bank recognised the problem of using money supply targets given the rapid growth in M3 resulting from the deepening and opening of the South African financial system in the 1990's. A noticeable characteristic of the period was that the Reserve Bank prospered in lowering inflation – its ultimate policy objective (Burger & Marinkov, 2008). During this period inflation was at an average annual rate of about 9.9% (Rossouw, 2007).

The third period, from 2000 to the present, was marked by the Reserve Bank's adoption of an inflation-targeting régime, starting in February 2000. The Reserve Bank's objective later shifted from implicit to explicit inflation targeting in search of low inflation. The target range proposed was 3% to 6%. According to Van der Merwe (2004), the benefit of specifying the inflation target as a range as opposed to a specific point is the option available to the central bank under such an approach. The focus was now on the protection of the internal value of the rand, in the hope that a low and steady inflation rate would lead to a stable exchange rate (Burger & Marinkov, 2008). According to Rossouw (2007), monetary policy during this period achieved its objective, relative price stability, which he states is confirmed by the fact that CPIX (consumer price index excluding mortgage costs) stayed within the target range of 3% to 6% between September 2003 and April 2007. Inflation during this period appears to have stabilised thanks to the adoption of the inflation targeting framework. This indicates that the explicit inflation targeting régime may have been more successful in keeping inflation at lower levels than the implicit inflation targeting régime.

Since 1980 the evolution of monetary policy in South Africa indicates that the monetary policy framework is to a degree guided by the circumstances of the time. It appears that from time to time the Reserve Bank adapts its objective and modifies the monetary policy accordingly. In 2005 the Reserve Bank altered its main goal from the accomplishment and preservation of financial stability to achieving and maintaining price stability in the interest of stable and sustainable economic growth (Mashele, 2010). However, this can cause uncertainty.

As indicated above, the inflation targeting framework was introduced in February 2000. The inflation target range of 3% to 6% has remained in place for close on two decades. There has now been a change, from attaining an average rate of 3% to 6% a year to achieving a continuous rate of 3% to 6% a year, in which the Reserve Bank employs the repo rate as its key tool for controlling inflation (Mashele, 2010). As mentioned previously, there are four reasons for South Africa's implementation of a formal framework in terms of inflation targeting: to develop surety of the South African Reserve Bank's (SARB's) monetary policy stance, to enhance the cooperation between monetary policy and other economic policies, to enhance the Reserve Bank's sense of accountability, and to directly impact the inflationary expectations of investors. Figure 2.1 below gives an indication of inflation in recent decades.

Figure 2.1 Annual inflation rate in South Africa



Source: World Bank (2018)

As seen in Figure 2.1, inflation hit double digits in the early 1980s, reaching a high of 18.65% in 1986, the highest rate recorded. According to Burger & Marinkov (2008) this was due to the Reserve Bank's lack of efficiency in adopting an effective inflation-combating stance following the international inflationary problems of the 1970s. As a result, inflation reached double digits as shown. In 1990 the inflation rate was 14.32%. Even though it was still in double digits, it appeared to have improved since the 1980s. The inflation rate continued to decrease to a low of 7.35% in 1996 – a significant improvement. This was partially attributable to Reserve Bank governor Dr Chris Stals, as the ultimate policy objective of the SARB at the time was to reduce inflation, which it succeeded in doing (Burger & Marinkov, 2008). This was a respectable achievement, as it was not an easy task.

Inflation rose to 9.16% in 2002. This was attributable to the currency crisis of 2001 (Harmse, 2006). This crisis was a result of 9/11, in which the effect of the attacks on New York's World Trade Centre and the Pentagon was felt worldwide. The figure decreased significantly in 2004, reaching a low of 1.36%. Harmse (2006) states that this was a result of prudent fiscal policies and the recovery in the exchange value of the rand.

The figure increased sharply to 11.54% in 2008, which was attributable to the global financial crisis of 2007-'09 (Sibanda *et al*, 2015). The figure then declined sharply to 4.25% in 2010. Some would argue that this was due to the Fifa World Cup, hosted by South Africa. This event brought the country an economic boost, leading to relative price stability. Since 2010 the inflation rate has largely managed to stay within the target rate of 3% to 6%, apart from 2016.

2.3 Overview of exchange rate in South Africa

According to Van der Merwe (1996), the development of the South Africa exchange rate system can be split into five periods since the Second World War: 1945-'71, 1971-'79, 1979-'85, 1985-'94, and 1994-'95. However, a sixth period is that from 1995 to the present will also be discussed. For the purposes of this study, the focus will be on the periods since 1980.

According to Van der Merwe (1996), the period 1979-'85 was one of substantial reform in exchange rate arrangements, the development of the market for foreign exchange and a floating exchange rate system was the aim. He states that during 1981 and '82 the Reserve Bank applied a form of variable dollar pegging and conditions were not conducive to more extreme reform of the exchange rate policy and foreign exchange market. The then South African minister of finance in 1983 lifted exchange control over non-South Africans and abolished the dual exchange rate system (Van der Merwe, 1996). This was a much-needed decision taken for the benefit of the economy at the time.

From 1985 to ’94 the foreign exchange market weakened in the sense that anti-apartheid sanctions were imposed on South Africa, which resulted in the Reserve Bank turning to greater intervention and firmer exchange controls in the market (Van der Merwe, 1996). Eun, Kılıç & Lai (2012) attest this and recall that in 1985 South Africa declared a state of emergency and reinstated the dual exchange rate system. In May 1988 there was a decline in the gold price, which led to a crisis in the South African mining industry. This led to a depreciation of both the commercial and the financial rands and a widening of the financial rand discount during this period (Eun, Kılıç & Lai, 2012).

In 1990, the bans on aggressively anti-apartheid political parties, such as African National Congress (ANC), Pan Africanist Congress (PAC), and South African Communist Party (SACP) were lifted, and Nelson Mandela was freed from prison. Eun, Kılıç & Lai (2012) state that this induced political stability which led eventually to an appreciation of the rand. In 1994, Mandela was elected president of South Africa, which led to greater investor confidence and an appreciation in the rand’s value. Many in the country were hopeful as democracy was no longer a dream but a reality.

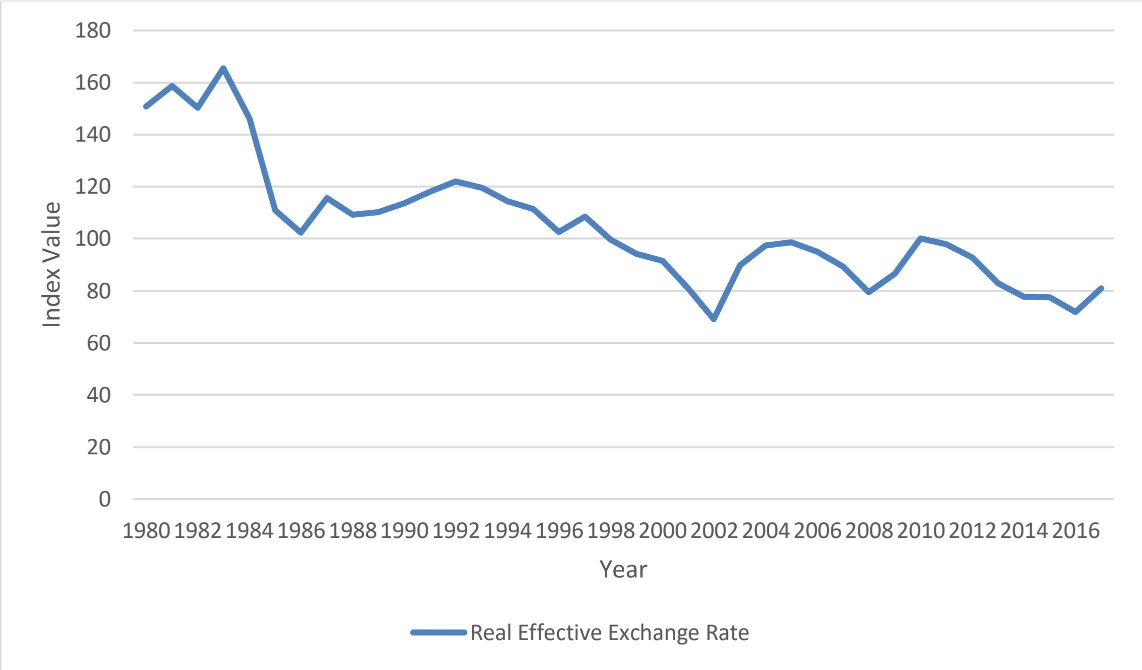
In the period 1994-’95 – the first two years of the Government of National Unity – South Africa’s international financial relations were normalised and steps were taken towards developing a forward market with less involvement from the Reserve Bank, and the progressive easing of exchange control (Van der Merwe, 1996). The rand was very volatile during this period and even though the rand eventually stabilised in the 1990s, Dewing (2015) states that the volatility would still have led to great losses of government funds and resources. This would have led to intervention by Reserve Bank to try to control the volatility of the rand – the more volatile the currency, the greater the risk the economy faces. According to Eun, Kılıç & Lai (2012), the commercial and financial rands were unified, and the dual exchange rate system again abolished.

A sixth period is that from 1995 to the present. Between March 1995 and January 2000 the country adopted a unitary exchange rate under the managed floating rand. Under this régime the spot exchange rate was determined by market forces under conditions where exchange rate control was exercised only over residents in respect of capital movements. (Mokoma, 2014). Since 1995 South Africa has been actively pursuing a floating exchange rate system as opposed to a fixed exchange rate, under which the rand is free to float and is determined by relative changes in the demand for and supply of currency, with intervention by the Reserve Bank sometimes being required (Mpofu, 2013; cited in Dewing, 2015). Intervention is sometimes required to minimise short run variability by adjusting the stock level of gold and foreign exchange reserves (Nattrass *et al*, 2002; cited in Mokoma, 2014). This was a result of the Reserve Bank's adoption of an inflation targeting régime. According to Mokoma (2014), the move to a free-floating exchange rate régime was due mainly to the fact that for inflation targeting to work well, there was a need for an independent monetary policy. However, Karoro *et al* (2009) believe that this market determined approach towards currency valuation has left the rand vulnerable to both domestic and external economic shocks.

Mohr *et al* (2008) suggest that with a free-floating currency, like the rand, there are three policy options available: 1) To do nothing – they believe in allowing the market forces of demand and supply to determine the exchange rate. 2) To intervene, by buying or selling foreign exchange. 3) To use the interest rate to influence the exchange rate. For example, they state that to avoid a depreciation of the rand the Reserve Bank may increase the interest rate relative to rates elsewhere in the world. With regards to option 1, the volatility of the exchange rate becomes an alarming factor as it may have adverse effects on the economy. Option 2 may be disruptive to the foreign exchange rate system and may be detrimental to the economy. Option 3 may be the best policy option available to influence the exchange rate for the greater good of the economy.

The various exchange rate régimes down the years are an indication of trial and error by the Reserve Bank in trying to find the most suitable exchange rate policy. Based on South Africa's history of a volatile rand, one would expect the Reserve Bank to implement a fixed exchange rate policy as opposed to a flexible one. This is because a currency that is left to be determined by market forces of demand and supply is riskier and hence leads to volatility. A fixed exchange rate brings stability and has a lower risk of volatility.

Figure 2.2 Real effective exchange rate in South Africa



Source: World Bank (2018)

As seen in Figure 2.2 the real effective exchange rate index value was 150.82 in 1980. This figure rose to 165.46 in 1983 – the highest index on record. The index value decreased significantly to 102.83 in 1986. It then gradually rose to 121.89 in 1992. In 1997-'98 the Asian financial crisis had an effect on the rand. According to Bhundia & Ricci (2006; cited in Dewing, 2015), the East Asian crisis resulted in a fall in demand for internationally traded commodities, causing the prices of South Africa's exported goods and services to fall, leading to a currency depreciation. This is evident as the real effective exchange rate during these years was 108.38 in 1997 and 99.68 in 1998. In an attempt to strengthen the rand, the Reserve Bank sold US dollars, which reduced the balance of South Africa's gold and foreign exchange reserves and helped to meet a heightened demand for US currency (Dewing, 2015).

The rand depreciated again in 2001. This came as a shock to many, as the economy seemed to be doing well at the time. In disbelief, the government appointed the Myburgh Commission to determine the cause of the rand's depreciation. According to Bhundia & Gottschalk (2003; cited in Dewing, 2015), the reasons behind the downfall of the rand were: 1) a decline in global economic activity, 2) contagion from events in Argentina, and 3) a weakening in the current account. The real effective exchange rate that year was 80.81. The years 2002 and 2003 seemed to have been better, as the real effective exchange rate improved. This improvement was attributable to the Reserve Bank's inflation targeting régime (Dewing, 2015). The Reserve Bank used high interest rates to combat inflation during this period, which resulted in an increase in foreign investments and led to a strengthening of the rand (Samson *et al*, 2003; cited in Dewing, 2015).

A global financial crisis struck in 2007 and '08, which dampened the rand. This was a time when economic activity in South Africa was low and foreign investments were low. However, according to Dewing (2015), South Africa was not affected as much as developed countries were. The real effective exchange rate was 89.34 in 2007 and 79.51 in 2008. In 2009, the rand appreciated well into 2010, which was attributable to the Fifa World Cup. The influx of foreign investments and an increase in economic activity led to a stronger rand and competitiveness ***vis*-à-*vis*** South Africa's main trading partners.

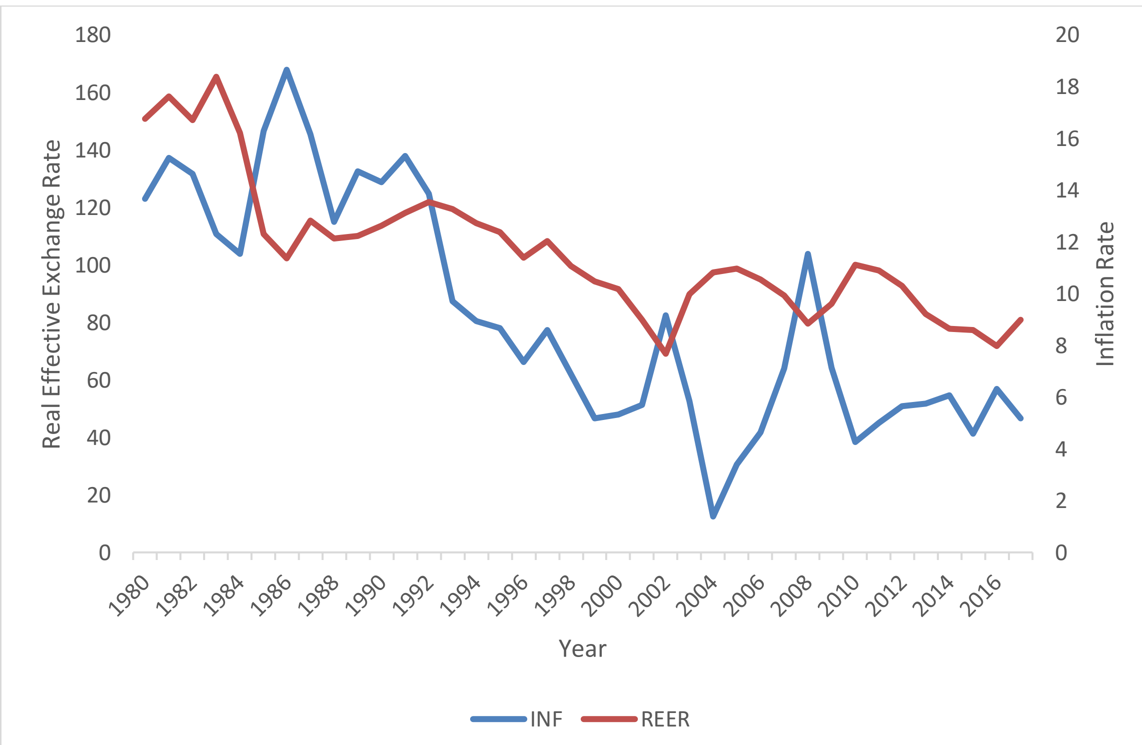
The real effective exchange rate (REER) has declined somewhat since 2011, as is evident in Figure 2.2. In 2012 it fell significantly to 92.72 and in 2013 to 82.95. Kumo, Rielander & Omilola (2014) state that this was attributable to an increasing deficit, capital outflows and labour unrest. In 2015, the rand depreciated by about 3.3% when Finance Minister Nhlanhla Nene was axed by then president Jacob Zuma. This saw the rand plummet to about R15/$1 (Cilliers, 2016). The REER has gradually increased since 2016, reaching 80.32 in 2017.

2.4 The relationship between inflation and exchange rate in South Africa

The literature indicates that there is a relationship between inflation and exchange rate. The Reserve Bank uses the repo rate to control inflation, which as a result affects the exchange rate. Variations in the inflation rate might lead to exchange rate fluctuations (Dewing, 2015). This is yet to be proved by the findings of this study. The evolution of both the inflation and exchange rate policies down the years has shown how transparent the Reserve Bank has been in achieving its objectives. Although some periods were better than others, one cannot deny the transition.

Through the periods mentioned, one may notice that the inflation targeting framework and the floating exchange system are interlinked through the influence of major events of the times. Some argue that the exchange rate is a determinant of inflation. Ncube & Ndou (2011) argue that the Reserve Bank has left the exchange rate to be determined by market forces in the inflation targeting era, making it more volatile. This is shown in Figure 2.2; this in essence has an effect on inflation. Schaling (2008) believes it to be public knowledge that a weaker exchange rate has a habit of increasing the CPI inflation rate as a result of greater wage inflation or greater domestic currency prices of imported final goods. However, there is a popular school of thought postulating that a depreciation boosts exports, which further boosts growth. The trade-off between the two variables becomes a key driver in determining future economic policies. Figure 2.3 depicts the relationship between inflation and exchange rate in South Africa from 1980 to 2017.

Figure 2.3 Annual inflation rate and real effective exchange rate in South Africa



Source: World Bank (2018)

Figure 2.3 indicates an inverse relationship between inflation and real effective exchange rate. Once the currency depreciates, inflation is seen to increase. In 1986, inflation was fairly high. However, the real effective exchange rate decreased to 102.28. As mentioned above, this was during the period when the Reserve Bank failed to implement a solid inflation-combating monetary policy; this is evident as the rand depreciated in the same year.

Figure 2.3 shows that throughout the Asian financial crisis of 1997-’98, both the inflation rate and the real effective exchange rate increased. This is a bit of a surprise, as one would have expected the opposite. However, in 2002 the relationship between the two variables resurfaces. This is shown by a significant increase in the inflation rate, matched by a sharp decrease in the real effective exchange rate. In 2004, the inflation rate decreased significantly to 1.39%, corresponding with a real effective exchange rate of 97.42. The negative relationship is seen again during the global financial crisis of 2008. In 2010, the real effective exchange rate was 100, corresponding with a low inflation rate of 4.26%. In 2016, inflation rose to 6.33% whereas the real effective exchange rate decreased to 71.80. Generally, Figure 2.3 shows a negative relationship between inflation and exchange rates.

2.5 Conclusion

The objective of this chapter was to analyse the trends of both inflation and exchange rates in South Africa to gain a better understanding of how both variables have behaved down the years. This gives an indication as to whether a relationship exists between inflation and exchange rates as well as the link between the monetary and exchange rate policies. Section 2.2 provided an overview of inflation in South Africa during the period 1980 to 2017. This section briefly provided the history and transition of inflation over the years. Key events were highlighted and briefly discussed. It is evident that major events like the global financial crisis and the currency crisis contributed a major role in the transformation of the country’s monetary policy.

Section 2.3 provided an overview of exchange rates in South Africa over the period 1980-2017. This section, too, highlighted the key events of this period and provided possible reasons for the trends observed. It is evident from this section that the events of the years 1986, 2001 and 2008 played a key role in the adjustments in the real effective exchange rate. Section 2.4 then attempted to show the link between inflation and exchange rates in South Africa, and Figure 2.3 indicates a negative relationship between the two variables. The next chapter will discuss the existing literature on the relationship between inflation and exchange rate.

Chapter three:
Literature review

3.1 Introduction

The literature has identified the relationship between exchange rate and inflation through a theory called the exchange rate pass-through effect. This theory explains and analyses how the exchange rate passes through into inflation, whether directly or indirectly. Hence it is of importance to highlight the relationship between the two variables. The prime lending rate is the percentage at which commercial banks loan money to each other and to the public. Through the lending of credit, inflation is affected, as the higher the interest that is paid back to the bank the lower inflation is, as people are spending less money. The lower the money circulating in the economy is, the lower inflation is. The Fisher equation further explains how interest rates and inflation are related. The relationship between unemployment and inflation is explained by the Phillips curve. The relationship is inverse and explains that a 1% rise in unemployment will result in a 1% decrease in inflation.

The purpose of this chapter is to provide an outline of the relevant literature on both exchange rate and inflation to gain a better understanding of the various schools of thought. Section 3.2 presents a review of literature on both exchange rate and inflation. It includes theories on both exchange rate and inflation. This will make it easier to specify the most suitable model for this study. Section 3.3 presents the relevant empirical literature on exchange rate and inflation. Lastly, the chapter will be concluded by Section 3.4.

3.2 Theoretical literature

This section will discuss the main theories of inflation and the theories of exchange rate. The exchange rate pass-through effect and the determinants of its elasticity are also examined, as well as the different monetary and exchange rate policies are briefly discussed.

3.2.1 Inflation theories

According to the demand-pull theory, inflation arises when the total demand for goods and services is larger than the total supply, such that the subsequent excess cannot be fulfilled by running down the current stock, redirecting surplus from the export market to the local market

(Ebiringa & Anyaogu, 2014). Increase in money supply more than output is one of the major causes of demand-pull inflation (Lado, 2015). That is the origin of the saying "too much money chasing few goods".

Gurley & Shaw (1960) state that the increase in the rate of money can be explained in two ways. Firstly, the growth of near-money substitutes can lessen the demand for money and increase the rate of money. Secondly, money held up due to inescapable controls (such as war), may start to be spent when controls are relaxed or removed, thereby increasing the turnover or the rate of money (Gurley & Shaw, 1960). This may lead to an increase in inflation, as there would be too much money circulating in the economy with no matching output. This may even cause hyperinflation – an excessive general increase in price levels.

According to the cost-push school, inflation occurs from a rise in cost of production, an increase in wages due to pressure from trade unions, and represents a socio-political view (Alpanda *et al*, 2010). The cost-push view attributes inflation to a host of non-monetary supply-orientated influences of shocks that increase costs and thus price (Ebiringa & Anyaogu, 2014). Wage-push inflation occurs when labour unions prosper in making money wages increase, triggering a rise in prices. Firms that enjoy monopoly power have also been found to use that power to increase prices, which causes a general increase in the price level (Lado, 2015). This is known as profit-push inflation.

The structuralist theory explains the long-run inflationary trend in developing countries in terms of structural inflexibilities, market imperfection and social tension, the relative inelasticity of food supply, foreign exchange, contract-protective measures, rise in demand for food, decreases in export earnings, the hoarding of import substitutes, industrialisation and political instabilities (Ezirim *et al*, 2012; cited in Ebiringa & Anyaogu, 2014). According to the structuralist view, inflation in less-developed countries (LDC) is an unavoidable result of their ambitious development programmes and is caused mainly by structural imbalances in such economies (Lado, 2015). According to (Dwivedi, 2009:551; cited in Lado, 2015) the structural imbalances in LDC economies are:

- Food scarcity: the inequality between demand for and supply of food
- Input imbalance: scarcity of capital and surplus labour, lack of fuel and oil

- Foreign exchange bottlenecks: inequality between exports and imports and balance of payments shortfalls
- Infrastructural bottlenecks: insufficient supply of electricity, transport and communication, and telecommunication
- Social and political restraints

The quantity theory of money states that changes in the general prices levels are determined by fluctuations in the amount of money in circulation (Totonchi, 2011). It explains how the aggregate price level is established through the interaction of money supply and money demand (Ireland, 2014). Ireland states further that it reveals what inflation truly is: a debasement of currency, which is the loss in the buying power of money caused through cautious policy actions taken by the central bank. David Ricardo (1772-1823), whom Totonchi (2001) regards as the most influential among classical economists, thought the disequilibrium effects that occur from a rise in the amount of money are short-lived and unimportant in long-run equilibrium analysis (Totonchi, 2011).

3.2.2 Exchange rate theories

Exchange rate is one of the simple economic tools utilised to rectify several economic misalignments facing countries (Ebiringa & Anyaogu, 2014). In simple terms, the exchange rate refers to the price of a local currency for a foreign currency. The two main theories of exchange rate will be discussed below.

3.2.2.1 Absolute power parity

A common approach to exchange rates is the absolute power parity (APP) theory, which states that the price levels in different economies move towards equality in common currency terms (Akinboade *et al*, 2004). The approach comes from the law of one price, which states that any commodity in a unified market has a single price (Akinboade *et al*, 2004). So a normal good to two or more nations should cost consumers the same amount after the currency has been converted (Dewing, 2015). This eliminates the problem of products in different nations not being exactly the same, so it seems that the theory is still relevant regardless of products being somewhat different from one nation to the next (Dewing, 2015). The equation that demonstrates this theory is:

E = equilibrium exchange rate

P = price level in country A

P^* = price level in country B

(Van der Merwe & Mollentze, 2010; cited in Dewing, 2015).

As straightforward and efficient as this theory may be, it is nonetheless problematic. A problem that affects the significance of the absolute model is the existence of factors like transport costs and tariffs, which the model does not take into consideration (Pilbeam, 1998; cited in Dewing, 2015). When dealing with the import and export of goods, tariffs and transport costs are generally unavoidable. As mentioned above, this model unfortunately does not cater for these factors, which puts its very existence and relevance into question. Another problem that arises regarding the model is that "there are many non-traded goods included in the price index of countries that cannot be equated with international trade" (Van der Merwe & Mollentze, 2010; cited in Dewing, 2015). An example of this would be hiring a lawyer to defend a company in a civil case in South Africa; the rendering of this service to the client cannot be equated in another country, for instance China.

3.2.2.2 Purchasing power parity

Another common exchange rate theory is purchasing power parity (PPP), a common approach to price determination in an economy. It presumes that the standard equilibrium rate of exchange present between two inconvertible currencies is established by the ratios of their buying powers; therefore the rate of exchange has a tendency to be determined at the point of equality between the buying powers of the two currencies (Ebiringa & Anyaogu, 2014).

The PPP theory reasons that the movements of exchange rates display divergent rates of inflation between various nations (Lado, 2015). The theory states that the given terms of trade $\frac{eP_f}{p}$, when P_f (foreign price level) and/or P (local price level) changes, e (exchange rate) changes in such a way as to maintain $\frac{eP_f}{p}$ constant (Lado, 2015). In other words, the purchasing power parity theory states that the exchange rate between two nations can be explained by inflation differentials, and the equilibrium exchange rate should change to counterbalance these inflation differences (Dewing, 2015).

Due to the relative purchasing power parity model's highlighting changes in prices, as opposed to absolute prices, this makes it weaker than the absolute power parity theory (Daniels & VanHoose, 2002; cited in Dewing, 2015). For this reason, this model is at a disadvantage in relation to the absolute power parity theory. Again there are problems regarding the relevance of this model. However, Moon *et al* (2010) reason that the purchasing power parity is still relevant as it allows policy-makers, researchers, businesses and consumers all want to compare incomes and expenditure, frequently when prices are different or changing. These comparisons may be used as tools to analyse the success of economic policies.

According to Dewing (2015), both the absolute and relative purchasing power parity theories only examine changes in exchange rates that occur due to international dealings in goods and services. He states that they make no reference to financial flows and money stock changes, which he finds to be careless and inadequate. The lack of reference to the influence of interest rates and oil prices on the exchange rate in this model further highlights a problem.

3.2.3 Exchange rate pass-through

The exchange rate pass through is simply the effect the exchange rate has on inflation. Sek *et al* state that if the effect of the depreciation is fully shown in import prices the pass-through is completed, but incomplete when only part of the depreciation is shown in import prices. The existence of the complete exchange rate pass-through to inflation originates from the law of one price and the purchasing power parity (PPP) principle, assuming that the equilibrium price of a specific good in two markets cannot be different if expressed in the identical currency (Rahimov *et al*, 2017). According to Kataranova (2010), variations in the pass-through amount with ruble depreciation or appreciation is dependant on the competitive nature in the market. She states that when the currency is depreciating, sellers attempt to retain their market share by turning to the tactic of pricing to market and bear the effects of the changes in the exchange rate themselves, which results in a decrease in profit but is not reflected in their product prices.

According to Terra (1998), high imported inflation is experienced by open economies as a result of imported goods. A rise in imported goods leads to amplified pressure on the local currency, and a depreciation against trading currencies (Mpofu, 2011). Due to South Africa being a small economy, it faces this risk as it tends to rely on imports. Exchange rate fluctuations can affect local prices through their effect on total supply and demand. According to Vinh & Fujita (2007), exchange rates could influence prices paid by the local buyers of imported goods directly and that in an open small economy like South Africa; currency depreciation will result in greater import prices and *vice versa*.

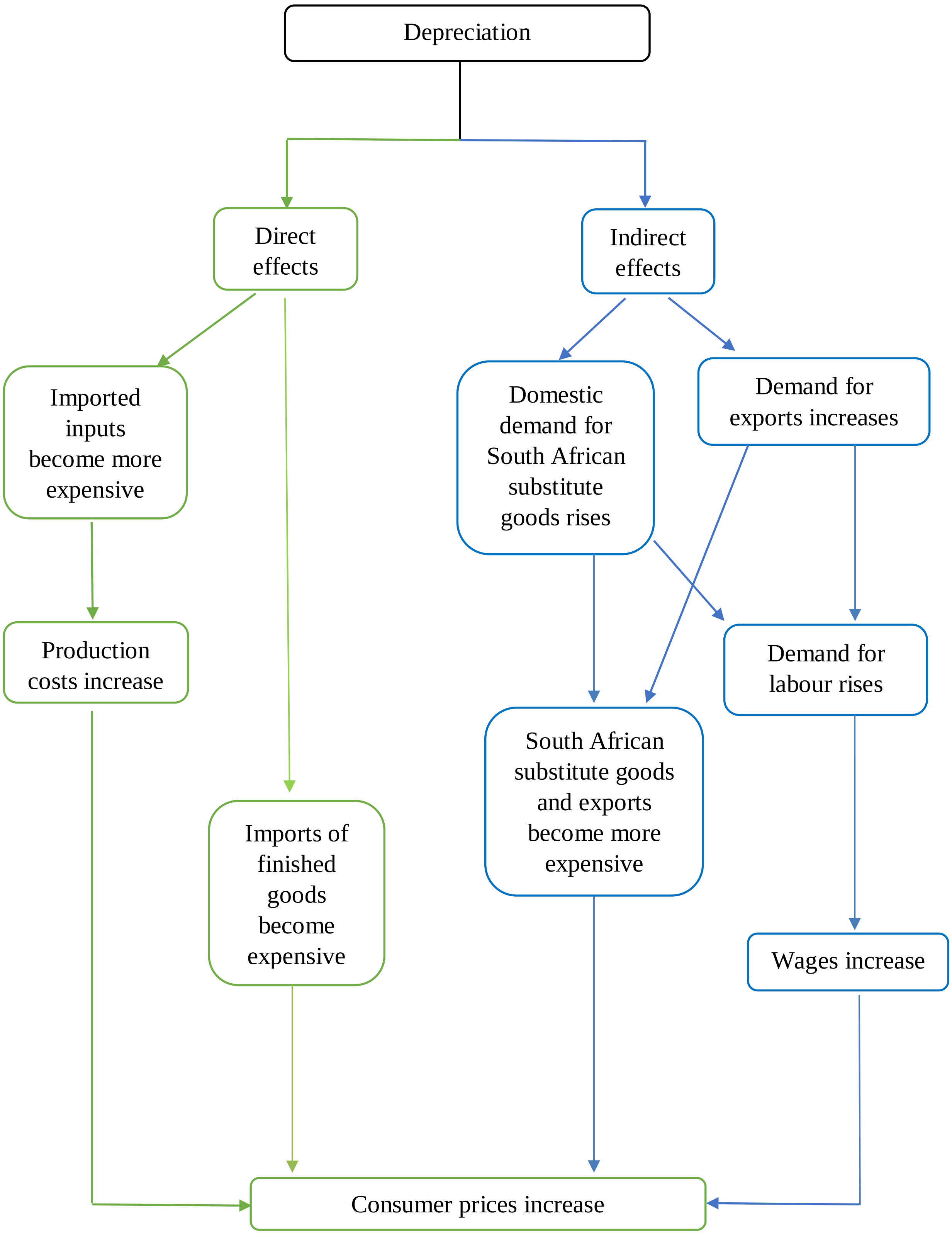
Marginal cost is increased through the potentially higher cost of imported inputs related with an exchange rate depreciation, which leads to higher prices of locally produced goods (Hyder & Shah, 2005). This then has a direct effect on inflation and poses a threat to the economy. The magnitude of the effect on inflation will depend on the margin of depreciation of the currency. Vinh & Fujita (2007) state that exchange rate variations may affect total demand and gross national product (GNP), which may also lead to an increase in input prices and drive up wage demands, due to workers looking for higher pay to keep up with real wages. They also state that a nominal increase in wages may drive up prices. This shows how exchange rate fluctuations lead to a ripple effect, and more or less how general prices react to these fluctuations.

According to Khodeir (2012), a change in exchange rate is one of the external factors that determine inflation in open markets. He states that the inflationary result of the exchange rate can be described by two channels, the direct and the indirect channel. The first, being the direct channel, is what he outlines as being linked to total demand, which refers to the effect of exchange rates on the import prices of the final consumption of domestic consumer goods, as stated above (Khodeir, 2012). Hufner & Schroder (2002) explain the direct channel of exchange pass-through to import prices by stating that if the foreign currency price of the imported good remains fixed and the exchange rate depreciates, the domestic-currency price of the imported good will also increase. They state further that the adjustment in import prices is most likely to result in adjustments in the producer and consumer prices of a country, provided producers raise their prices to match the rise in import prices. Failure to do so will most likely result in no translation in adjustments in consumer and producer prices, lessening the effect of the exchange rate pass-through on inflation.

The indirect channel, as described by Khodeir (2012), is linked to total supply, which refers to the effect of exchange rate on import prices of intermediate goods and capital. This then affects inflation indirectly due to the increase in import prices, as it will cost domestic producers more money to import goods. However, Hufner & Schroder (2002) are of the notion that the indirect channel refers to the international markets and competitiveness of goods.

They state that a depreciation of the exchange rate makes local products fairly cheaper for foreign buyers, so exports and total demand will increase and hence encourage a rise in the local price level. The result of exchange rate depreciation is a temporary increase in output and a permanent increase in the price level (Kahn, 1987; cited in Hufner & Schroder, 2002). This then leads to a larger increase in inflation than in output, which leaves the economy worse off. It may take longer for an economy to recover from a permanent increase in price levels and may result in a recession. To sum up the exchange rate pass-through effect, the following diagram will graphically represent the direct and indirect channels:

Figure 3.1: Pass-through from a depreciation of the South African rand to consumer prices



Source: Adapted from Savoie-Chabot and Khan (2015)

An increase in consumer prices in the long run occurs whether the exchange rate pass-through to import prices is done directly or indirectly. If there is a continuous increase in consumer prices via the exchange rate pass-through, this will have an effect on the consumer price basket, which will then increase inflation. However, the extent of this effect on inflation may not be complete, as the channel through which the exchange rate pass-through goes will determine the extent to which inflation is affected.

Taylor (2000) states that the extent of pass-through is also imperative for forecasting inflation and for deciding how much to tighten monetary policy in response to a rise in inflation that can be identified with an exchange rate change. According to Bailliu & Fujii (2004), new open-economy macroeconomics (NOEM) literature has looked into the extent to which exchange rate pass-through may depend on a nation's inflation performance or monetary policy. This work is based on Taylor (2000), who argues that a change to a low-inflation environment causes a decline in the anticipated persistence of price changes and cost, which results in a decrease in exchange rate pass-through (ERPT). Such studies highlight that the implementation of a more stable monetary policy may lead to a lowered ERPT.

López-Villavicencio & Mignon (2016) believe that the inflation targeting framework should contribute to lower inflation expectations and lower inflation. The thinking behind it is that implementing inflation targeting leads to credibility gains that are accountable for keeping low inflation expectations after an exchange rate appreciation. Reyes (2007) states that central banks respond to an exchange rate appreciation by raising the interest rate to prevent exchange rate changes from feeding into inflation under an inflation targeting régime. As a result, the exchange rate dynamics are affected, weakening the ERPT to inflation.

Despite the plentiful evidence of a declining role for ERPT in developed countries, the channel still plays a significant role for most emerging and developing countries (Taylor 2000; Frankel, 2012; cited in Rahimov *et al*, 2017). This is yet to be found to be true for South Africa, as it allows an opportunity to determine whether the exchange rate pass-through to inflation is complete or incomplete. Due to South Africa's adoption of an inflation-targeting régime, one would expect the ERPT to be incomplete, according to Taylor (2000) and Frankel (2012), but as stated, this is yet to be determined.

Devereux & Yetman (2002) have developed a model of pass-through in a price stickiness setup for importing companies and test the amount of pass-through empirically under volatile and high inflation situations to show the link between inflation and exchange rate (see Jooste & Jhaveri, 2014). The model shows that the exchange rate pass-through is higher when inflation is high. The model simply shows that some firms adjust prices instantly while other firms do not. Devereux & Yetman (2002) derive an equation for imported good prices similar to the neo-Keynesian Phillips curve by merging this equation with the recursive formulation of setting the import price index (Jooste & Jhaveri, 2014):

$$\pi_t = \eta(\lambda + \tau_t + q_t)\beta E_t \pi_{t+1} \tag{3.1}$$

where:

π_t is the inflation rate of imported goods, $q_t = s_t + p_t{}^* - p_{t-1}$ is the real exchange rate that is equal to the nominal exchange rate (s_t), amended for price differential between foreign prices (p_t), and τ_t is the distribution costs of firms. $\eta = \frac{(1-\beta\theta)(1-\theta)}{(\theta)}$. θ is the probability that firm prices will stay the same for any given period. β is the rate of discount and λ is the monopoly mark-up.

The perception of Equation 3.1 is that imported goods inflation will be higher when the real exchange rate is higher than its flexible price equilibrium – given as $(\lambda + \tau_t)$ (Jooste & Jhaveri, 2014). So the extent to which the exchange rate can diverge from flexible price equilibrium is dependent on the extent of price rigidity (Jooste & Jhaveri, 2014). In other words, the higher the θ the lower the η, which implies a decrease in the divergence of the exchange rate from its equilibrium (Jooste & Jhaveri, 2014). Equation 3.1 shows that there is a strong link between exchange rate and inflation, as the exchange rate pass-through to import prices is greater when inflation is high, as stated above.

3.2.4 Determinants of exchange rate pass-through elasticities

In the literature, there are a few determinants of exchange rate pass-through elasticities that are identified. This section will attempt to look at the elasticities affected by macroeconomic policies implemented domestically. This is imperative, as it assists policymakers in making informed decisions.

Razafimahefa (2012) states that on average, elasticities of pass-through are lower in nations with flexible exchange rate régimes than in those with fixed exchange rate régimes. This may be explained by the exchange rate volatility under a flexible rate régime. It is likely that the exchange rate pass-through elasticity in a fixed exchange rate régime is higher, as the exchange rate is fixed and so brings more stability. This allows a complete exchange rate pass-through to domestic prices, hence influencing inflation. Razafimahefa states further that higher-income nations show a lower exchange rate pass-through. The dynamic pass-through elasticities are highly linked with income per capita levels in nations with flexible exchange rate régimes (Razafimahefa, 2012). For example, income levels per capita are low in South Africa, so it is most likely that the exchange rate pass-through to domestic prices will be lower than that of a country like the United Kingdom.

According to Razafimahefa (2012), high inflation environments are related with a higher pass through in countries with flexible exchange rate régimes. This can be described by price setting in monopolistic competition. Firms set prices based on expectations. If they expect their costs to change in the future, they adjust their prices accordingly. If cost changes are frequent, firms must then adjust their prices more quickly and more often. So in a high inflation environment, the additional inflation brought on by the exchange rate is anticipated to raise price levels and costs persistently, so the exchange rate pass-through is higher Razafimahefa (2012).

Jooste & Jhaveri (2014) argue that the exchange rate pass-through is higher in perfectly competitive markets. They state that this is due to prices of firms' being set where their marginal revenue equals their marginal cost. However, Corsetti & Dedola (2002) argue that firms that are imperfectly competitive play a role in lowering the exchange rate pass-through because such firms are able to absorb exchange rate shocks as they already function at a mark-up over marginal cost. This is an example of incomplete exchange rate pass-through to import prices and may further be a result of menu costs or slow adjustment in price setting (Corsetti & Dedola, 2002).

3.2.5 Exchange rate régimes

There is a system in which the exchange rate operates which includes sets of rules, arrangements and institutions under which countries effect payments between themselves (Adeniji, 2013). This system sets the way different prices of a currency can be determined against one another. The system can only be either fixed or floating exchange rate.

The fixed exchange rate is the official exchange rate that the government sets and maintains (Adeniji, 2013). A price that is set will be established against a major world currency like the US dollar, euro or yen. However, the set price is generally determined against the US dollar. Adeniji (2013) states that the central bank, for example the Reserve Bank, buys and sells its own currency (rand) on the foreign exchange market in return for the currency to which it is fixed so to sustain the domestic exchange rate. In a nation that implements a fixed exchange rate régime; inflation may be compared more stable with a country that implements a floating exchange rate. This is due to the environment or rather the degree to which the exchange rate is controlled, which brings about stability. The more stable the exchange rate is, the more stationary inflation generally is.

The floating exchange rate is determined strictly by market forces and, according to Adeniji (2013), is often referred to “self-correcting”. He states further that the value of a currency will decline, if its demand is low, making imported goods costlier and increasing demand for domestic goods and services. This in essence will create jobs, causing an “auto-correction model” (Adeniji, 2013). However, the problem with a floating exchange rate régime is that because it is constantly changing, it causes currency volatility. For example, in South Africa the rand is volatile as already mentioned. As a result it may affect imported prices which then affect general prices, leading to inflation. For a country like South Africa that makes use of a floating exchange rate, inflation is expected to be non-stationary due to the rand’s volatility. However, due to the inflation targeting framework this has not been the case. In South Africa, the inflation rate has managed to remain between 3% and 6%. This is an example of how the central bank may also intervene to prevent high inflation and to ensure stability (Adeniji, 2013).

3.3 Empirical literature

The following section will provide empirical literature on studies undertaken on the relationship between exchange rate and inflation in South Africa, other parts of Africa, other developing countries and developed countries. In the literature, a variety of macroeconomic and financial variables is identified by previous researchers as determinants of inflation (Mokoma, 2014). The selection of the empirical literature was determined by the relevance of the study period, by variables used in the model and by categorising each study by region. This has allowed for a more detailed analysis between this study and other relevant studies.

3.3.1 South Africa

Aron *et al* (2012) compared the exchange rate pass through with the monthly import price index in South Africa from 1980 to 2009. They state that there is an indication of slower pass-through under the inflation targeting framework, when impermanent shifts to foreign currency invoicing or improved hedging are taken into account after large exchange rate shocks in the period. Although the pass-through effect is slower under inflation targeting, there is a noticeable link between inflation and exchange rate.

Ncube & Ndou (2011) investigated the relationship between inflation, real interest rate, and exchange rate shocks in the South African inflation targeting framework using a Bayesian VAR sign restriction approach. They made use of monthly data covering the period January 2000 to January 2010. The results revealed that inflationary effects from exchange rate depreciation are reduced extensively through the tightenng of the monetary policy. The results also showed that under the flexible inflation targeting framework, giving more emphasis to the real effective exchange rate (REER) results in substantial real output growth.

Mpofu (2011) analysed the relationship between interest rate, exchange rate, money supply and oil price influence on inflation in South Africa over the period January 1999 to September 2010. He found that exchange rates and money supply have a strong positive relationship with inflation and states that they need to be managed. However, the results revealed that interest rates and oil price have a strong negative relationship with inflation. The negative relationship which was found to be true between oil price and inflation is not in line with economic theory and a larger number of observations may have produced a different outcome. This analysis is important, as this study aims to use the same variables for the regression model, including the unemployment rate.

Sibanda *et al* (2015) made use of the vector autoregressive (VAR) model to evaluate the effect of exchange rates and crude oil prices on inflation expectations in South Africa covering the period July 2002 to March 2013. The results showed a positive and significant relationship between exchange rates and inflation expectations. These results may be flawed as the use of the dependant variable inflation expectation does not give a true indication of the inflation rate.

Schaling (2008) assessed exchange rate volatility, inflation and competitiveness in South Africa over the period 1994-2006. The results showed that a depreciation of the exchange rate increases the inflation rate and that the exchange rate pass-through from nominal effective exchange rate and consumer price index is about 20%.

Parsley (2010) assessed the exchange rate pass-through to final goods and services and homogenous imports covering the period 1990-2009. The results showed a low pass-through to final consumer goods prices of between 14% and 27% in two years. He states that the decrease in exchange pass-through may be due to changes in the consumer price index, as opposed to fluctuations in the monetary environment or in the firms pricing behaviour.

In South Africa, a noticeable trend based on previous empirical literature emerges. Over the years, the exchange rate pass-through to consumer prices has lessened and minimised. Although minimised, the predominant result between exchange rate and inflation appears to be of a positive nature.

3.3.2 Other African countries

Audu & Amaegberi (2013) assessed the influence of exchange rate fluctuations on inflation targeting in Nigeria over the period 1970-2012. The findings revealed a negative and significant relationship between inflation and exchange rate. These findings are unusual, yet not uncommon.

Mohamed *et al* (2013) analysed the effect of changes on exchange rate on inflation in Egypt over the period 2003-2011. They utilised the VAR model and found a “weak” relationship between exchange rate and inflation. Due to the VAR model requiring a large parameter, the lack of a greater number of observations may explain the results obtained by these authors. This study encompasses the pre- and post-financial crisis periods, which appear to have weakened the Egyptian economy.

Khodeir (2012) investigated whether exchange rate movements had serious influence on inflationary expectations in Egypt over the period 1990-2008. He made use of the Granger-causality test and found a strong relationship between consumer price index (CPI) and exchange rate. In addition to the use of Granger Causality test, an ARDL model may have been used to capture the long run and short run relationships between exchange rate and CPI.

Ebiringa & Anyaogu (2014) investigated the relationships between interest rate, inflation and exchange rate in Nigeria over the period 1971-2010, making use of the autoregressive distributed lag approach (ARDL). The results revealed a significant short- and long-run positive relationship between exchange rate and inflation. These results seem to coincide with the economic status of Nigeria during that period.

Madesha *et al* (2013) assessed the relationship between inflation and exchange rate in Zimbabwe over the period 1980-2007. They made use of the Granger causality test, which revealed a long-run relationship between inflation and exchange rate. The causality results also revealed that the two variables Granger-cause each other. In other words, there is a bi-directional causal relationship between inflation and exchange rate. However, the use of the Granger causality test in this instance may not of been the best method of choice as it is very sensitive to timeframes.

Adeniji (2013) examined the effect of the volatility of the exchange rate on inflation in Nigeria using annual time series data from 1986 to 2012. He made use of the vector error corection model (VECM) framework and the Granger causality test. He concluded that there is a positive and significant relationship between inflation and the volatility of the exchange rate. The causality results showed a bi-directional relationship between the two variables.

Based on these African studies, it appears that a noticeable predominately positive relationship exists between exchange rate and inflation. In other African studies, a strong relationship between the variables emerges.

3.3.3 Other developing countries

Airaudo, Buffie & Zanna (2016) analysed the co-ordination of monetary and exchange rate policy in less developed countries like China, Brazil and Peru. They found that the exchange rate policy management significantly influences the efficiency of inflation targeting. They state that in a flexible exchange rate system, inflation targeting experiences a substantial risk of indeterminacy where macroeconomic variations can be driven by self-fulfilling anticipations.

Asad, Ahmad & Hussain (2012) examined the effect of real effective exchange rate on inflation in Pakistan over the period 1973-2007. Making use of the ordinary least squares (OLS) method, they found a strong and positive relationship between real effective exchange rate and inflation. The OLS method is outdated and therefore different findings may have been obtained using relevant and more accurate estimation methods, such as the ARDL model.

Monfared & Akin (2017) analysed the relationship between inflation and exchange rate in Iran over the period 1976-2012. They employed the Hendry method for the period 1976-2012 and quarterly data between 1997Q3 and 2011Q4 for the VAR model. They found a direct relationship between inflation and exchange rate. The results also revealed that a rise in foreign exchange rates increases inflation, indicating a positive relationship between the two variables. These results allow for policy analysis due to the VAR model's emphasis on forecasting.

Necsulescu & Serbanescu (2013) examined the effect of inflation on the exchange rate and on the average salary in Romania over the period 2000-2012. They found a negative relationship between exchange rate and inflation rate. They concluded that the annual average inflation rate had a strong influence on the average salary and on the exchange rate. Given the results, quarterly data may have been utilised to increase the number of observations to enhance the accuracy of the results.

Abdurehman & Hacilar (2016) assessed the relationship between inflation and exchange rate in Turkey over the period 2005-2014. An ordinary least squares (OLS) regression and the generalised autoregressive conditional heteroscedasticity (GARCH) model were employed. The results showed that purchasing power parity (PPP) does not exist in Turkey. The results also revealed no relationship between exchange rate and inflation. Once again, the obtainment of these results suggest that a more accurate method of estimation may have been used, as the OLS method is oudated.

Vinh & Fujita (2007) examined the effect of the real exhange rate on inflation and output in Vietnam using time series data over the period 1992-2005. They used a VAR model and the results showed that a real devaluation has a positive effect on inflation. Although it was a devaluation, the effects on inflation are similar to those of the effects of a depreciation on inflation. Once again, a larger number of observations would have provided a safety net in the obtainment of the results and may have produced different results.

Buyandelger (2015) carried out a study to analyse the impact of incomplete exchange rate pass-through effect on the Mongolian economy and its influence on monetary policy. Using a structural vector autoregression (SVAR) model he found that the exchange rate pass-through into inflation was 0.49% in the short run. Based on the results, it is important to note that the exchange rate pass-through to inflation is weak. This seems to be a prevalent condition in developing countries.

Looking at studies conducted in other devloping countries, it is rather difficult to reach a conclusion regarding the predominant relationship between exchange rate and inflation. However, authors have found that the exchange rate greatly infuences either inflation or inflation targeting.

3.3.4 Developed countries

Shalishali & Ho (2002) investigated the relationship between interest rate, inflation and exchange rate in Canada, the United Kingdom, Japan, Germany, France, The Netherlands, Switzerland and Sweden over the period 1972-1996. Using the international Fisher effect theory, they found that the theory held for several nations but not for others. The theory held when certain nations were identified as home countries, but not when they were viewed as foreign countries.

Sek *et al* (2012) empirically examined the relationship between the exchange rate and the inflation targeting framework in Norway, Sweden and the United Kingdom as well as Korea, the Philippines and Thailand. Using a multivariate generalised autoregressive conditional heteroscedasticity (GARCH) model, they found a significant correlation between exchange rate movements and both output and inflation. The effect of exchange rate on inflation was found to be weak and insignificant after the implementation of inflation targeting in all the countries.

Hufner & Schroder (2002) analysed the pass-through of exchange rate changes to consumer prices for the euro currency area (Germany, France, Italy, the Netherlands and Spain) by estimating vector error correction models (VECM). The study period they looked at was January 1982 to January 2001. They found by combining the national results using the weight of each nation's inflation rate in the harmonised index of consumer prices (HICP), on average 10% depreciation of the effective euro exchange rate results in an increase of 0.4 percentage points in the inflation rate after one year. The use of the VECM is commendable as it has pleasant interpretation with long and short run equations.

Savoie-Chabot & Khan (2015) analysed the exchange rate pass-through (ERPT) to consumer prices in Canada for the period 1995-2013. Their results suggest that at the time, the depreciation of the Canadian dollar provided a noticeable boost to Canadian inflation. This highlights the effect the exchange rate pass-through has on the monetary policy. This data-driven analysis has allowed the authors to arrive at a firm judgment of the effect of the ERPT.

Takhtamanova (2008) examined the changes in exchange rate pass-through for 14 OECD countries (Canada, Finland, Ireland, France, Italy, Japan, Netherlands, Denmark, New Zealand, Norway, Australia, Sweden, the United States and the United Kingdom) for the period 1980-2007. The study also compared the relationship between the real exchange rate growth and inflation over the periods 1980Q1-1989Q4 and 1990Q1-2007Q2. She found a weakening relationship between the variables and hypothesised that the decrease in the exchange rate pass-through is caused by a reduction in the proportion of flexible-price firms in the economy. The combined use of yearly and quarterly data is commendable, as it allows to capture events that transpired over the years more concisely.

Bailliu & Bouakez (2004) assessed the extent of exchange pass-through in industrialised economies (the United Kingdom, Japan, France and the United States) for the period 1973-2003. The results show that an appreciation or depreciation of the domestic currency is not passed through to domestic currency import prices across these countries. They state that the exchange rate pass-through to consumer prices has decreased over the years – a similar finding to that of Takhtamanova (2008). This indicates that the effect exchange rate has on inflation has weakened down the years.

In studies conducted on developed countries, there exists a predominately positive relationship between inflation and exchange rate. However, other authors have found that the relationship between the two variables is weakening.

3.4 Conclusion

In conclusion, absolute purchasing power parity is the idea that a normal good to two or more nations should cost consumers the same amount after the currency has been converted. The relative purchasing power parity is the notion that the movements of exchange rates reflect different rates of inflation between different nations (Lado, 2015). The exchange rate pass-through effect is the effect the exchange rate has on inflation and may be through either aggregate demand or aggregate supply. The pass-through may be complete or incomplete.

This chapter reviewed theoretical literature on exchange rates and inflation. It also reviewed relevant empirical literature on exchange rates and inflation across South Africa, other African countries, other developing countries and developed countries. The analysis of studies conducted in developed countries indicates that the exchange rate pass-through effect into inflation has weakened down the years. The South African studies have similar results to those conducted in other African countries, which show a positive relationship between inflation and exchange rate. Studies conducted in developing countries have produced different results from other regions, and no clear predominant relationship could be identified. The determinants of exchange rate pass-through elasticities were also briefly discussed. A predominantly positive relationship between exchange rate and inflation exists in countries around the world, whether developing or developed. The next chapter will present the methodology and estimation techniques this study seeks to employ in analysing the relationship between inflation and exchange rate.

Chapter four:
Research methodology

4.1 Introduction

This chapter aims to outline the methodology to be used in investigating the effect of exchange rates on inflation in South Africa. This chapter discusses the empirical model and the relevant data sources used. Section 4.2 will present the model specification and methodology of the study. The non-linear autoregressive distributed lag (NARDL) model mentioned in the model specification is a fairly new model and is crucial in determining the asymmetries between inflation and nominal effective exchange rate.

Section 4.3 describes the data indicates and relevant data sources used. Section 4.4 discusses the stationarity of the variables using various unit root tests. The Ng-Perron, DF-GLS and KSS unit root tests are discussed in detail in this section. In Section 4.5 a vector autoregressive (VAR) model is briefly discussed, to cater for potential endogeneity of the variables. Section 4.6 will then discuss the different diagnostic tests to be employed in the study. Section 4.7 will then conclude the chapter.

4.2 Model specification

This study will employ a non-linear autoregressive distributed lag (NARDL) model proposed by Shin, Yu & Greenwood-Nimmo (2014). It is the same as a normal ARDL model, but instead it shows how inflation will react when the exchange rate is depreciating and whether an appreciation will decrease inflation. One of the benefits of NARDL is that it allows one to capture asymmetries in the nominal effective exchange rate-inflation relation in both the long run and the short run (Lacheheb & Sirag, 2015). Another benefit is that it has the ability to combine I(0) and I(1) independent variables and to capture the hidden cointegration, which is not possible within the traditional methods (Nasr *et al*, 2018). In addition to this, it performs better in testing for cointegration relationships in small samples, "compared with alternative cointegration procedures" (Romilly *et al*, 2001; cited in Nasr *et al*, 2018).

For the purpose of this study, the NARDL model will be employed to investigate the possible existence of both short- and long-run asymmetries in the response of inflation to increases or decreases in the exchange rate. The model for the study is specified:

$$INF_t = \alpha_0 + \alpha_1 NEER_t^+ + \alpha_2 NEER_t^- + \alpha_3 PLR_t + \alpha_4 MS_t + \alpha_5 OP_t + \alpha_6 UN_t + \varepsilon_t \qquad (4.1)$$

where:

INF = inflation rate

NEER = nominal effective exchange rate

PLR = prime lending rate

MS = money supply

OP = oil price

UN = unemployment rate

In equation (4.1), $NEER_t^+$ and $NEER_t^-$, are partial sums of positive and negative changes in $NEER_t$:

$$NEER_t^+ = \sum_{i=1}^{t} \Delta NEER_i^+ = \sum_{i=1}^{t} \max(\Delta NEER_i, 0) \qquad (4.2)$$

and

$$NEER_t^- = \sum_{i=1}^{t} \Delta NEER_i^- = \sum_{i=1}^{t} \min(\Delta NEER_i, 0) \qquad (4.3)$$

The long-run relationship between nominal effective exchange rate and inflation increases is α_1 and α_2 captures the long-run relationship between nominal effective exchange rate and inflation reduction (Ibrahim, 2015). Equation (4.1) replicates asymmetric long-run nominal effective exchange rate pass-through to inflation.

A non-linear autoregressive distributed lag (NARDL) representation of equation (4.1) is:

$$\Delta INF_t = \alpha + \beta_0 INF_{t-1} + \beta_1 NEER_{t-1}^+ + \beta_2 NEER_{t-1}^- + \beta_3 PLR_{t-1} + \beta_4 MS_{t-1} + \beta_5 OP_{t-1} + \beta_6 UN_{t-1} + \sum_{i=1}^{p} \phi_i \Delta INF_{t-i} + \sum_{i=0}^{q} (\theta_i^+ \Delta NEER_{t-i}^+ + \theta_i^- \Delta NEER_{t-i}^-) + \sum_{i=0}^{r} \delta_i \Delta PLR_{t-i} + \sum_{i=0}^{s} \sigma_i \Delta MS_{t-i} + \sum_{i=0}^{u} \varphi_i \Delta OP_{t-i} + \sum_{i=0}^{v} \partial_i \Delta UN_{t-i} + u_t \qquad (4.4)$$

where:

p, q, r, s, u and v are lag orders and $\alpha_1 = -\beta_1/\beta_0$, $\alpha_2 = -\beta_2/\beta_0$, the long run effects of nominal effective exchange rate increase and nominal effective exchange rate decrease on inflation.

$\sum_{i=0}^{q} \theta_i^{+}$ measures the short-run influences of nominal effective exchange rate increases on inflation and $\sum_{i=0}^{q} \theta_i^{-}$ measures the short-run influences of nominal effective exchange rate decrease on inflation (Ibrahim, 2015). In essence, the short-run influences of nominal effective exchange rate changes on inflation are also captured.

4.3 Data analysis

Quarterly time series data on inflation and exchange rate covering the period 1994Q1-2017Q4 will be utilised to analyse the relationship between inflation and exchange rate in South Africa. The period is significant as it encompasses the periods before and since the global financial crisis as well as the era of full democracy in South Africa. It allows capturing the events that transpired and makes it possible to analyse how they affect the variables at hand. Data will be obtained from three main sources: the Reserve Bank, the World Bank and the Organisation for Economic Co-operation and Development (OECD). The data description is:

Inflation (**consumer price index**) shows the annual percentage change in the cost to the average consumer of obtaining a basket of goods and services that may be changed or fixed at specified intervals, such as yearly (World Bank, 2018). Inflation is expressed in percentage terms.

Nominal effective exchange rate is a weighted exchange rate of the rand measured against a basket of the currencies of South Africa's 20 major trading partners (SARB, 2018). Nominal effective exchange rate is expected to have an inverse relationship with inflation.

Prime lending rate refers to the interest rate that commercial banks charge creditworthy customers. Prime lending rate is expected to have an inverse relationship with inflation.

Money supply (**M3**) refers to the notes and coins in circulation; cheque, transmission and savings deposits; and call, short-, medium- and long-term deposits (Rossouw, 2007). Money supply is expected to have a positive relationship with inflation.

Oil price refers to the Brent crude oil price in US dollars. The oil price is expected to have a positive relationship with inflation.

Unemployment rate refers to the amount of unemployed people as a proportion of the labour force. Unemployment rate is expected to have an inverse relationship with inflation.

Table 4.1 presents a description of the variables used to estimate the regression equation, alongside their expected signs.

Table 4.1 Variable description and expected signs

Variables	**definition**	**unit of measurement**	**expected sign**
dependant variable			
INF	consumer price index	percentage	
independent variables			
NEER	nominal effective exchange rate	percentage	-
PLR	prime lending rate	percentage	-
MS	M3	percentage	+
OP	Brent crude oil price	US dollar	+
UN	unemployment rate	percentage	-

Source: Researcher's own computation

4.4 Unit root test

To test for stationarity, the Ng-Perron, DF-GLS and KSS tests will be employed. To detect the stationarity of the variables under study, the unit root test is used. There are two reasons the test is undertaken: Firstly, to prevent the spurious regression problem. Secondly, an assumption underlying the application of causality tests is that the time series should be stationary (Rotich, Cheruiyot, Korir & Yegon, 2014). A variable is stationary if its mean, variance and auto-covariance remain constant no matter at what point they are measured (Sajid & Sarfraz, 2008).

4.4.1 First generation unit root tests

4.4.1.1 Ng-Perron

Ng and Perron (1995, 2001) built on detrended data y_t^* attained from the ADF-GLS test and changed the Phillips-Perron (PP) test (Arltova & Fedorova, 2016). The Ng-Perron test uses test statistics Z from the PP test that had been changed by Ng and Perron into its present formula:

$$\overline{MZ_{\emptyset}} = (T^{-1}y_t{}^{*} - s_{AR}{}^2)(2T^{-2}\sum_{t=1}^{T} y^{*}{}_{t-1})^{-1}, \quad (4.5)$$

$$\overline{MSB} = (T^{-2}\sum_{t-1}^{T}\frac{y_{t-1}{}^{*}}{s_{AR}{}^2})^{1/2}, \quad (4.6)$$

$$\overline{MZ_T} = \overline{MZ_{\emptyset}}.\overline{MSB}, \quad (4.7)$$

MP_T takes into account structural breaks, which is a modified version of the ERS point optimal statistic (Elliot *et al*, 1996, cited in Willem van den End, 2011).

Where $s_{AR}{}^2 = \left(\sum_{t=p+1}^{T}\varepsilon_t{}^2\right)((T-k)(1-\sum_{i=1}^{p}\hat{\beta}_i)^2)^{-1}$, and marked as M tests (Arltova & Fedorova, 2016).

The null hypothesis states that there is a unit root for the series; the alternative hypothesis states that there is no unit root for the series. If the p-value is less than the chosen level of significance the null hypothesis is rejected; if the p-value is greater than the chosen level of significance the null hypothesis is not rejected, meaning that the series is stationary.

4.4.1.2 DF-GLS

The DF-GLS possesses greater statistical properties than the ADF and PP test do. The DF-GLS test was proposed by Elliot, Rothenburg & Stock (ERS) in 1996 and modifies the Dickey-Fuller (DF) test statistic with the use of a generalised least squares rationale (Baum, 2000). They proved that their test possesses the best performance overall in working with small sample sizes and power, which suppresses the Dickey-Fuller test.

According to Baum (2000) there are variations of DF-GLS, and they are in two forms: detrending and GLS-demeaning. In terms of GLS detrending, the tested series is regressed on a linear trend and constant, and the residual series is utilised in a normal Dickey-Fuller regression (Baum, 2000). In terms of GLS demeaning, it is strictly a constant that appears in the first stage regression; the residual series is then utilised as the regressand in a Dickey-Fuller regression (Baum, 2000). The null hypothesis states that there is a unit root for the series and the alternative hypothesis that there is no unit root for the series. The DF-GLS test is the t-statistic on (p-1) in the augmented Dickey-Fuller regression using the GLS-detrended data $\tilde{y}_t$ (Wu, 2010):

$$\Delta\tilde{y}_t = (p-1)\tilde{y}_{t-q} + \sum_{j=1}^{k}\gamma_j\Delta\tilde{y}_{t-j} + e_t \quad (4.8)$$

The GLS-detrended series $\tilde{y}_t$ is defined as:

$$\tilde{y}_t = y_t - \hat{\psi}' Z_t \quad (4.9)$$

Where $\hat{\psi}$ minimises $S(\bar{\alpha}, \hat{\psi})$=$(y^{\bar{\alpha}} - \hat{\psi}' Z^{\bar{\alpha}})'(y^{\bar{\alpha}} - \hat{\psi}' Z^{\bar{\alpha}})$.

4.4.2 Second generation unit root tests

4.4.2.1 KSS

Kapetanios, Shin & Shell (KSS) proposed the KSS unit root test, which is a non-linear unit root test. The KSS test is based on detecting the presence of non-stationarity against a non-linear but globally stationary exponential smooth transition autoregressive (ESTAR) process (Chang *et al*, 2013). It is applied to test equation by adding the index of the transfer function to test nonlinear adjustment characteristics (Liu & He, 2010). KSS is given by the following ESTAR specification:

$$\Delta y_t = \gamma y_{t-1}\left[1 - \exp\left(-\theta {y^2}_{t-1}\right)\right] + \varepsilon_t \qquad (\theta \geq 0) \quad (4.10)$$

Where y_t is the demeaned or detrended time series of interest, while γ is the unknown parameter and ε_t is an i.i.d. error with constant variance and zero mean. $\left[1 - \exp\left(-\theta {y^2}_{t-1}\right)\right]$ is the exponential transition function adopted in the test to represent the nonlinear adjustment (Liu & He, 2010). The null hypothesis is $H_0: \theta = 0$, while the alternative hypothesis is $H_0: \theta > 0$. Under the null hypothesis, y_t follows a unit root process that is linear, while it is a nonlinear stationary ESTAR process under the alternative (Liu & He, 2010). Due to the null hypothesis $H_0: \theta = 0$ cannot be tested directly: KSS suggests reparametrising, computing a first order Taylor series estimate to specify Eq. (1) to attain the auxiliary regression given by:

$$\Delta y_t = \delta {y^3}_{t-1} + \varepsilon_t \quad (4.11)$$

Where the errors in Equation (4.11) are serially correlated, regression of Equation. (4.11) is expanded to:

$$\Delta y_t = \sum_{j=1}^{p} P_j \, \Delta y_{t-j} + \delta {y^3}_{t-1} + \varepsilon_t \quad (4.12)$$

In addition, the system of KSS equations with a Fourier function is:

$$\Delta y_t = \xi_t + \delta_t {y^3}_{t-1} + \sum_{j=1}^{p} P_j \, \Delta y_{t-j} + a_1 \sin(\frac{2\pi kt}{T}) + b_1 \cos(\frac{2\pi kt}{T}) + \varepsilon_t \qquad (4.13)$$

Where t=1,2…. T. The basis for choosing $[\sin(\frac{2\pi kt}{T}), \cos(\frac{2\pi kt}{T})$ due to a Fourier expression is capable of roughly absolutely integrable functions to any desired degree of accuracy (Chang *et al*, 2013). k is the frequency selected for the approximation and $[a_1, b_1]$ measures the amplitude and displacement of the frequency component (Chang *et al*, 2013).

4.5 Vector autoregressive

The vector autoregressive (VAR) model is suitable for the study as it caters for potential endogeneity. There could be bidirectional causality, so the VAR model is employed so that all variables are endogenous. Vector autoregressions (VARs) were introduced by Christopher Sims (1980). Papanicolas (2011) states that the VAR approach removed many restrictions that models impose and allowed the data to be modelled in an unrestricted reduced form, where variables are all treated as endogenous. This technique has become popular in economics in recent years.

The VAR model takes each variable by its own lagged values, including the current and past values of other lagged variables (Papanicolas, 2011). One of the advantages of VAR models is that they treat all variables as endogenous, thus there is no need to make specific which variables are exogenous or endogenous. A second advantage is that VAR models can be very useful for data description, as they offer a very rich structure (Brooks, 2008:291). However, one of the problems of VAR models is that they require an estimation of very large parameters. According to Gujarati & Porter (2009:778), the biggest challenge in dealing with the VAR model is choosing the appropriate lag length. They also state that the VAR model is likely suited for policy analysis due to its emphasis on forecasting.

The VAR model comes in three various forms, with each form placing different restrictions on the data being modelled: reduced form, recursive and structural. A reduced form VAR expresses each variable as a linear function of its own past values, the past values of all other variables being considered, and a serially uncorrelated error term (Papanicolas, 2011). This study will employ a reduced form vector autoregressive (VAR) model to capture long-run effects. The reduced form VAR equation is:

$$AX_t = \beta_0 + \beta_1 X_{t-1} + u_t \qquad (4.14)$$

where:

AX_t = a vector of six variables

u_t = residual term

These equations involve only one lag, but there could be more:

$$INF_t = \beta_{10} + \beta_{11}INF_{t-1} + \beta_{12}NEER_{t-1} + \beta_{13}PLR_{t-1} + \beta_{14}MS_{t-1} + \beta_{15}UN_{t-1} + \beta_{16}OP_{t-1} + u_t \quad (4.15)$$

$$NEER_t = \beta_{20} + \beta_{21}NEER_{t-1} + \beta_{22}INF_{t-1} + \beta_{23}PLR_{t-1} + \beta_{24}MS_{t-1} + \beta_{25}UN_{t-1} + \beta_{26}OP_{t-1} + u_t \quad (4.16)$$

$$PLR_t = \beta_{30} + \beta_{31}PLR_{t-1} + \beta_{32}INF_{t-1} + \beta_{33}NEER_{t-1} + \beta_{34}MS_{t-1} + \beta_{35}UN_{t-1} + \beta_{36}OP_{t-1} + u_t \quad (4.17)$$

$$MS_t = \beta_{40} + \beta_{41}MS_{t-1} + \beta_{42}INF_{t-1} + \beta_{43}NEER_{t-1} + \beta_{44}PLR_{t-1} + \beta_{45}UN_{t-1} + \beta_{46}OP_{t-1} + u_t \quad (4.18)$$

$$OP_t = \beta_{50} + \beta_{51}OP_{t-1} + \beta_{52}INF_{t-1} + \beta_{53}NEER_{t-1} + \beta_{54}PLR_{t-1} + \beta_{55}MS_{t-1} + \beta_{56}UN_{t-1} + u_t \quad (4.19)$$

$$UN_t = \beta_{60} + \beta_{61}UN_{t-1} + \beta_{62}INF_{t-1} + \beta_{63}NEER_{t-1} + \beta_{64}PLR_{t-1} + \beta_{65}MS_{t-1} + \beta_{66}OP_{t-1} + u_t \quad (4.20)$$

4.5.1 Lag order selection criteria

According to Holtz-Eakin *et al* (1988), one needs to decide about the optimal lag length when using the VAR model. Hušek (2009) suggests the use of information criteria for lag length selection. There are five pre-specified criteria: the Hannan-Quinn information criterion (HQ), the Schwarz information criterion (SIC), the Akaike information criterion (AIC), the sequential modified LR test statistic (LR) and the final prediction error (FPE). Each test is conducted at 5% level of significance. The best strategy is to select a lag order to condition on this estimate in constructing the impulse response function.

4.5.2 Impulse response function

According to Brooks (2014:362), the impulse response function traces out the responsiveness of the dependant variables in the VAR to shocks of each of the variables. It shows the effects of shocks on the adjustment path of the variables. The impulse response function in this study will apply Choleski's decomposition.

4.5.3 Granger causality test

The Granger causality test is based on the error correction model and was developed by Engle and Granger (1987). It enables us to explain the direction of the relationship. Gujarati & Porter (2009:653) state that "the Granger causality test assumes that the information relevant to the prediction of the particular variables is contained only in the time series data on these variables". So the argument is that if $y_1$causes y_2, lags of y_1 should be significant in the equation for y_2 (Brooks, 2008: 298). If this is the case, it is said that there is unidirectional causality from y_1 to y_2. According to Brooks (2008:298), if both sets of lags are significant, it is said that there is a bi-directional causality or bi-directional feedback. He also states that if y_1 is found to Granger-cause y_2 but not the other way around, it would be said that the variable y_2 is strongly exogenous. Lastly, Brooks (2008:298), states that if neither set of lags is statistically significant in the equation for the other variable, $y_1$and y_2 are said to be independent. The following Granger causality model will be employed to examine the relationship causality direction between inflation and exchange rate in South Africa:

$$INF_t = \mu_{10t} + \sum_{j=1}^{j} \alpha_{11}\, INF_{t-j} + \sum_{j=1}^{j} \alpha_{12}\, NEER_{t-j} + \sum_{j=1}^{j} \alpha_{13}\, PLR_{t-j} + \sum_{j=1}^{j} \alpha_{14}\, MS_{t-j} + \sum_{j=1}^{j} \alpha_{15}\, OP_{t-j} + \sum_{j=1}^{j} \alpha_{16}\, UN_{t-j} + e_{1t} \quad (4.21)$$

$$NEER_t = \mu_{20t} + \sum_{j=1}^{j} \alpha_{21}\, NEER_{t-j} + \sum_{j=1}^{j} \alpha_{22}\, INF_{t-j} + \sum_{j=1}^{j} \alpha_{23}\, PLR_{t-j} + \sum_{j=1}^{j} \alpha_{24}\, MS_{t-j} + \sum_{j=1}^{j} \alpha_{25}\, OP_{t-j} + \sum_{j=1}^{j} \alpha_{26}\, UN_{t-j} + e_{2t} \quad (4.22)$$

$$PLR_t = \mu_{30} + \sum_{j=1}^{j} \alpha_{31}\, PLR_{t-j} + \sum_{j=1}^{j} \alpha_{32}\, INF_{t-j} + \sum_{j=1}^{j} \alpha_{33}\, NEER_{t-j} + \sum_{j=1}^{j} \alpha_{34}\, MS_{t-j} + \sum_{j=1}^{j} \alpha_{35}\, OP_{t-j} + \sum_{j=1}^{j} \alpha_{36}\, UN_{t-j} + e_{3t} \quad (4.23)$$

$$MS_t = \mu_{40} + \sum_{j=1}^{j} \alpha_{41} MS_{t-j} + \sum_{j=1}^{j} \alpha_{42} INF_{t-j} + \sum_{j=1}^{j} \alpha_{43} NEER_{t-j} + \sum_{j=1}^{j} \alpha_{44} PLR_{t-j} + \sum_{j=1}^{j} \alpha_{45} OP_{t-j} + \sum_{j=1}^{j} \alpha_{46} UN_{t-j} + e_{4t} \quad (4.24)$$

$$OP_t = \mu_{50} + \sum_{j=1}^{j} \alpha_{51} OP_{t-j} + \sum_{j=1}^{j} \alpha_{52} INF_{t-j} + \sum_{j=1}^{j} \alpha_{53} NEER_{t-j} + \sum_{j=1}^{j} \alpha_{54} PLR_{t-j} + \sum_{j=1}^{j} \alpha_{55} MS_{t-j} + \sum_{j=1}^{j} \alpha_{56} UN_{t-j} + e_{5t} \quad (4.25)$$

$$UN_t = \mu_{60} + \sum_{j=1}^{j} \alpha_{61} UN_{t-j} + \sum_{j=1}^{j} \alpha_{62} INF_{t-j} + \sum_{j=1}^{j} \alpha_{63} NEER_{t-j} + \sum_{j=1}^{j} \alpha_{64} PLR_{t-j} + \sum_{j=1}^{j} \alpha_{65} MS_{t-j} + \sum_{j=1}^{j} \alpha_{66} OP_{t-j} + e_{6t} \quad (4.26)$$

4.5.4 Variance decomposition

Brooks (2014:337) states that variance decomposition provides the proportion of the movements in the dependant variables which are due to their own shocks as against shocks to the other variables. It shows which of the independent variables is stronger in explaining the variability in the dependant variables over time and so is important for analytical purposes.

4.5.5 AR root graph

To ensure the stability of the VAR model the AR root graph reports the inverse roots of the characteristic AR polynomial (Lutkepohl, 1991). If all roots have modulus less than one and lie inside the unit circle, the estimated VAR is stable.

4.6 Diagnostic tests

The following section will discuss the diagnostic tests conducted for this study. The normality test, serial correlation test, heteroscedasticity test and the Ramsey reset test will be conducted.

4.6.1 Normality test

To test whether the residuals are normally distributed, a normality test will be conducted. The main tests for the assessment of normality are the Lilliefors corrected K-S test, the Shapiro-Wilk test, the Kolmogorov-Smirnov (K-S) test, the Cramér-Von Mises test, the d'Agostino-Pearson omnibus test the Anderson-Darling test, the d'Agostino skewness test, the Anscombe-Glynn kurtosis test, and the Jarque-Bera test (Ghasemi & Zahediasi, 2012). The Jarque-Bera test will be employed to test for normality in this study. Adrino (2012) states that it uses the property of a normally distributed random variable. The first two moments of the mean and variance are characterised by the whole distribution. The null hypothesis is that the residuals are normally distributed, and the rejection of the null hypothesis would indicate that the residuals are either significantly skewed or leptokurtic (Gujarati, 2004:148).

The Jarque-Bera test is among the tests most commonly used by econometricians. It was proposed by Jarque and Bera in 1987. They gave skewness and kurtosis measures based on the Mahalanobis transformation (Domanski, 2010). Comparing how far the asymmetry and kurtosis measures diverge from values characteristic of the normal distribution is based on the Jarque-Bera test (Domanski, 2010).

H_0: Random elements are subject to the normal distribution

H_1: Random elements are not subject to the normal distribution

The Jarque-Bera test is based on the following statistic:

$$JB = \frac{N}{6}SK + \frac{N}{24}KU \qquad (4.27)$$

where:

N = sample size

SK = skewness

KU = kurtosis

The value of the J-B statistic would begin to increase, should skewness or kurtosis be higher than zero (Dewing, 2015).

4.6.2 Serial correlation test

This study will test for autocorrelation between the error terms. Correlation between members of series of observations ordered in time or space is defined as autocorrelation (Maurice & Buckland, 1971). One of the assumptions of the classical linear regression model (CLRM) is that serial correlation does not exist in the disturbances. So any signs of serial correlation would be in violation of one of the assumptions. Despite it now being an everyday practice to regard the terms of autocorrelation and serial correlation synonymously, a few authors prefer to differentiate the two terms (Gujarati & Porter, 2009:414). For the purposes of the study, the two terms will be used synonymously.

Serial correlation occurs for a number of reasons, some of which are:

1. Inertia
2. Specification bias: excluded variables
3. Cobweb phenomenon
4. Lags
5. Manipulation of data

The Breusch-Pagan-Godfrey serial correlation LM test will be used to test for serial correlation in the model. It allows for non-stochastic regressors, such as the lagged values of the regressand, higher-order autoregressive schemes and simple or high-order moving averages of white noise error terms (Gujarati & Porter, 2009:438). The LM test is:

$$LM = (n-q)R^2{}_{u^\wedge} \sim \chi^2{}_q \tag{4.28}$$

where q is the order number of an autoregressive process [AR(q) in the null hypothesis and requires the homoscedasticity assumption (Wooldridge, 2013). The null hypothesis states that the residuals are not serially correlated and the alternative hypothesis that the residuals are serially correlated. In other words, if the p-value is greater than the chosen level of significance there is no serial correlation.

4.6.3 Heteroscedasticity test

A vital assumption of the classical linear regression model is that the disturbances appearing in the population regression function are homoscedastic; meaning that they all have the same variance (Gujarati & Porter, 2009:365). The homoscedasticity assumption suggests that the variance of the errors is independent of any predictor or any linear combination of the predictor variables (Hayes & Cai, 2007). In essence, heteroscedasticity occurs when the variance of the error terms differs across observations.

Heteroscedasticity may take place in different forms. For example, if a model is misspecified due to a failure to include necessary interactions between independent variables, the variability in the errors may decrease or increase linearly as a function of one or more of the predictors, or variability may be larger for moderate values of one or more of the predictors (Hayes & Cai, 2007). The OLS regression estimator of the partial regression coefficients is unbiased and strongly consistent under heteroscedasticity, when the homoscedasticity assumption is violated. (White, 1980, cited in Hayes & Cai, 2007).

In this study, the autoregressive conditional heteroscedasticity (ARCH) test will be used to test for heteroscedasticity. The model was proposed by Engle (1982). It regresses the squared residuals on lagged squared residuals and a constant. The ARCH effect comes about when a time series exhibits autoregressive conditional heteroscedasticity (Wang *et al*, 2005). ARCH-type models have commonly been used to model the ARCH effect for economic and financial time series. It also allows one to model successive periods with high volatility and other periods with small volatility, which is why it will be suitable for the study, given the volatility of inflation and nominal effective exchange rate. The null hypothesis states that there is no ARCH effect; the alternative hypothesis is that there is an ARCH effect.

The ARCH formula is:

$$\hat{\varepsilon}_t^2 = \alpha_0 + \alpha_1 + \alpha_1 \hat{\varepsilon}_{t-1}^2 + \mu_1 \quad (4.29)$$

where:

$\hat{\varepsilon}_{t-1}^2$ = lagged squared residuals

α_0 = constant

μ_1 = error term

4.6.4 Ramsey RESET test

Ramsey (1969) developed the regression equation specification error (RESET) test. This is a general misspecification test aimed to check the inappropriate functional form of the model (Brooks, 2008; cited in Mokoma, 2014). The RESET test is based on the Lagrange multiplier principle and is normally performed with the use of the critical values of the F-distribution (Shukur & Mantalos, 2004). It is also used to test whether a regression model has been correctly specified in terms of the regressors that have been included (DeBenedictis & Giles, 1998; cited in Mokoma, 2014. The test is simple and straightforward. The Ramsey RESET test is used in this study to check the inappropriate functional form of the model. The RESET test statistic is given by:

$$\text{RESET}=\frac{(\hat{u}'\hat{u}-\hat{e}'\hat{e})/p^{*}}{\hat{e}'\hat{e}/(\hat{\imath}-k)} \text{ (Mokoma, 2014)} \tag{4.30}$$

The test above is an F-statistic for testing the following hypothesis:

$H_0: \emptyset_j = 0$ (the model is correctly specified)

$H_0: \emptyset_j \neq 0$ (the model is incorrectly specified)

If the Ramsey RESET test statistic is greater than 0.05, do not reject the null hypothesis; if it is less than 0.05, reject the null hypothesis. Accepting the null hypothesis would mean that the model is correctly specified.

4.7 Conclusion

In conclusion, this chapter discussed the methodology employed in this study. It also discussed in detail the data used, including data sources, variables and the methods used to analyse the data. The chapter identified the five independent variables that were selected based on previous studies and guided by relevant literature. A detailed review of the KSS, Ng-Perron and DF-GLS unit root tests are given. A detailed review of the NARDL model is given and a brief review of the VAR model is also given. Lastly, the diagnostic tests employed in this study were also discussed in detail. The following chapter will present the empirical results of the study.

Chapter five:
Empirical results & discussions

5.1 Introduction

This chapter presents and discusses the results of the study by providing an analysis of the empirical findings to examine the effect of the exchange rate on inflation in South Africa from 1994Q1 to 2017Q4. EViews software is used for this. To ensure the robustness of the results, both the linear and non-linear models will be estimated. This will highlight the differences in the results. Section 5.2 presents the descriptive statistics of each variable. Section 5.3 presents the correlating analysis. Section 5.4 presents the unit root test results and Section 5.5 presents the linear and non-linear models results. Section 5.6 presents the estimated VAR model results and Section 5.7 concludes the chapter.

5.2 Descriptive statistics

This following section presents the descriptive statistics for each variable employed in the model specification.

Table 5.1: Descriptive statistics

Variable	mean	median	maximum	minimum	standard deviation	skewness	kurtosis
INF	5.96	6.04	13.56	-1.76	2.83	-0.27	3.57
NEER	-1.27	-1.00	14.60	-17.20	5.53	-0.33	3.89
PLR	13.34	12.33	25.00	8.50	4.00	0.69	2.61
MS	12.47	12.41	25.06	0.75	5.90	0.24	2.05
OP	52.54	45.60	121.30	11.48	34.07	0.62	2.07
UN	23.98	24.50	29.30	16.90	2.75	-0.64	3.24

Source: Researcher's own computation

Based on Table 5.1, the mean and median values of inflation for the period 1994-2017 are 5.96% and 6.04%, respectively. The mean value is an indication of how the inflation rate over the 23-year period has managed to stay between 3% and 6%. The maximum value of inflation recorded over the period 1994-2017 is 13.56%, recorded in the last quarter of 2002. This was due to the currency crisis of 2001, the effects of which carried through into 2002. The minimum value is -1.76%, recorded in the first quarter of 2004. This is not a good indication, as inflation should not be negative: there needs to be a positive inflation rate to create stability within the economy. The standard deviation of inflation is 2.83%, indicating that the data points are spread over out a large range of values for the period 1994-2017. The skewness and kurtosis values are -0.27% and 3.57%, respectively.

Table 5.1 shows that the mean and median values of nominal effective exchange rate (NEER) for the period 1994-2017 are -1.27% and -1.00%, respectively. The mean value of nominal effective exchange rate is an indication that the rand has not performed well against the 20 trading partners, which indicates a weak rand over the years. The minimum value is -17.20%, recorded in the first quarter of 1998, at the height of the 1998 Asian financial crisis. The maximum value of 14.60% was recorded in the second quarter of 2009, a sign of recovery after the 2008 financial crisis. The standard deviation is 5.53%, which is an indication of the dispersed nature of the data points. The skewness and kurtosis values are -0.33% and 3.89%, respectively.

The descriptive statistic properties of prime lending rate show that the mean value is 13.34% and the median 12.33%. The mean of 13.34% indicates that the prime lending rate was relatively high over the period 1994-2017. The maximum value of prime lending rate is 25.00% and the minimum 8.50%. Both values were recorded in the third quarter of 1998 and from the third quarter of 2012 to the fourth quarter of 2013, respectively. The prime lending rate was high in 1998 due to the collapse of the credit market. The standard deviation is 4.00%. The skewness value of 0.69% shows that the data values of prime lending rate are slightly skewed left. The kurtosis value of 2.61% indicates that the data is light-tailed relative to a normal distribution.

Based on Table 5.1, the mean value of money supply for the period 1994-2017 is 12.47% and the median 12.41%. The mean value indicates that the percentage growth rate of money supply over the period was relatively high. The maximum value of money supply recorded over the period 1994-2017 is 25.06%, recorded in the third quarter of 2003. This was due to attempts to recover from the effects of the currency crisis of 2001. The minimum value of 0.75% was recorded in the first quarter of 2010. This was most likely due to the success of the 2010 Fifa World Cup, as there was an abundance of money circulating in the economy. The standard deviation of money supply is 5.90%, indicating that the data points are spread over out a large range of values for the period 1994-2017. The skewness value is 0.24% and kurtosis 2.05%.

Table 5.1 shows that the mean value of oil price for the period 1994-2017 is $52.54 and the median $45.60. The mean value is an indication of how oil prices have remained consistent through the 23 years. The maximum oil price value is $121.30, recorded in the second quarter of 2008. This was due to market instability in 2008/09. The minimum value of $11.48 was recorded in the first quarter of 1998, due to a decrease in demand for oil. The standard deviation is $34.07, an indication of the dispersed nature of the data points. The skewness value is $0.62 and kurtosis $2.07.

The descriptive statistic properties of unemployment rate show that the mean value is 23.98% and the median 24.50%. The mean value indicates that the unemployment rate over the period has managed to stay relatively stable and very high. The maximum value of unemployment rate is 29.30% and the minimum 16.90%. The maximum value was recorded in the first and second quarters of 2003, indicating that unemployment is a major problem in South Africa. The minimum value was recorded in 1995, the year after full democracy was achieved. South Africa managed to keep its unemployment rate relatively low that year. The standard deviation is 2.75%. The skewness value of -0.64% shows that the data values of unemployment rate are slightly skewed left. The kurtosis value of 3.24% indicates that the data is heavy-tailed relative to a normal distribution.

5.3 Correlating analysis

The correlating analysis is conducted to ascertain the strength of a relationship between two numerically measured variables. This section will present the correlating analysis results, shown in Table 5.2.

Table 5.2: Pairwise correlation

Correlation	INF	NEER	PLR	MS	OP	UN
INF	1.00					
NEER	0.02	1.00				
PLR	0.50***	-0.06	1.00			
MS	0.14	-0.17*	0.46***	1.00		
OP	-0.12	-0.02	-0.72***	-0.30***	1.00	
UN	-0.29***	0.15	-0.41***	-0.35***	0.18*	1.00

Note: asterisks ***, ** and * represent significance at 1%, 5% and 10% levels.

Source: Researcher's own computation

Based on Table 5.2, inflation and nominal effective exchange rate are positively correlated, which is not in line with *a priori* expectations. However, the relationship is insignificant. Prime lending rate is positively correlated with inflation, which is not in line with *a priori* expectations, and the nature of the relationship is significant at the 1% level. Money supply is positively correlated with inflation and is in line with *a priori* expectations. However, the nature of the relationship is insignificant. Oil price is negatively correlated with inflation and is not in line with *a priori* expectations. The nature of the relationship is insignificant. Unemployment rate is correlated negatively with inflation and is in line with *a priori* expectations. The nature of the relationship is significant at the 1% level.

The correlation of money supply and nominal effective exchange rate is revealed negative and significant at the 10% level. The correlation of money supply and prime lending rate is revealed positive and significant at the 1% level. The correlation of oil price and money supply is revealed negative and significant at the 1% level. The correlation of oil price and prime lending rate is revealed negative and significant at the 1% level. The correlation of unemployment rate and prime lending rate is revealed negative and significant at the 1% level. The correlation of oil price and money supply is revealed negative and significant at the 1% level. The correlation of unemployment rate and oil price is revealed positive and significant at the 10% level.

5.4 Unit root test

This section presents the results of the first- and second-generation unit root tests. The first-generation results are presented in tables 5.3 to 5.6, and the second-generation results in tables 5.7 and 5.8.

5.4.1 First generation unit root tests

The first-generation unit root tests were conducted at level and at first difference using both the intercept and intercept and trend options. This was to assure obtaining the most accurate results.

Table 5.3: DF-GLS & Ng-Perron unit root test results (a)

Variables	**Level**				
	Intercept				
	MZ_a	MZ_t	MSB	MPT	DF-GLS
INF	-8.58**	-2.01**	0.23*	3.08**	-1.85* [5]
NEER	-44.86***	-4.72***	0.10***	0.56***	-7.61*** [0]
PLR	-5.64	-1.61	0.28	4.54	-1.57 [1]
MS	-11.13**	-2.31**	0.20**	2.36**	-2.00** [4]
OP	-2.21	-0.98	0.44	10.54	-0.97 [2]
UN	-4.54	-1.36	0.30	5.66	-1.42 [0]

Notes: Optimal lag length of DF-GLS tests reported in brackets []. Asterisks ***, ** and * represent significance at 1%, 5% and 10% levels.

Source: Researcher's own computation

Table 5.3 shows that inflation is stationary at the 5% level using the Ng-Perron test but stationary at the 10% level using the DF-GLS unit root test. Nominal effective exchange rate is stationary at the 1% level using both the Ng-Perron and DF-GLS tests. It is apparent that prime lending rate is non-stationary at level. However, money supply is stationary at the 5% level as indicated above. Based on Table 5.3, both oil price and unemployment rate are non-stationary at level.

Table 5.4: DF-GLS & Ng-Perron unit root test results (b)

Variables	**Level**				
	intercept & trend				
	MZ_a	MZ_t	MSB	MPT	DF-GLS
INF	-25.86***	-3.59***	0.13***	3.52***	-2.78* [5]
NEER	-45.00***	-4.74***	0.10***	2.03***	-7.67*** [0]
PLR	-15.95*	-2.81*	0.17*	5.75*	-2.82* [1]
MS	-15.08*	-2.73*	0.18*	6.11*	-2.36 [4]
OP	-13.87	-2.57	0.18	6.89	-2.57 [1]
UN	-12.20	-2.47	0.20	7.46	-2.64 [0]

Notes: Optimal lag length of DF-GLS tests reported in brackets []. Asterisks ***, ** and * represent significance at 1%, 5% and 10% levels.

Source: Researcher's own computation

In Table 5.4, inflation is stationary at the 1% level using the Ng-Perron unit root test. However, it is stationary at the 10% level using the DF-GLS unit root test. Nominal effective exchange rate is stationary at the 1% level using both unit root tests. Based on Table 5.4, money supply is stationary at the 10% level using the Ng-Perron unit root test but non-stationary at level using the DF-GLS unit root test. Prime lending rate is significant at the 10% level using both the DF-GLS and Ng-Perron unit root tests. Oil price and unemployment rate are both non-stationary at level.

Table 5.5: DF-GLS & Ng-Perron unit root test results (c)

Variables	**first difference**				
	Intercept				
	MZ_a	MZ_t	MSB	MPT	DF-GLS
PLR	-40.06***	-4.47***	0.11***	0.61***	-6.43*** [0]
OP	-75.49***	-6.13***	0.08***	0.35***	-7.49*** [1]
UN	-46.37***	-4.79***	0.10***	0.57***	-10.79*** [0]

Notes: Optimal lag length of DF-GLS tests reported in brackets []. Asterisks ***, ** and * represent significance at 1%, 5% and 10% levels.

Source: Researcher's own computation

Based on Table 5.5, prime lending rate, oil price and unemployment rate are stationary at first difference at the 1% level.

Table 5.6: DF-GLS & Ng-Perron unit root test results (d)

Variables	first difference				
	intercept & trend				
	MZ_a	MZ_t	MSB	MPT	DF-GLS
NEER	-44.62***	-4.72***	0.10***	2.05***	-12.08*** [0]
PLR	-40.10***	-4.47***	0.11***	2.27***	-6.44*** [0]
MS	-24.09***	-3.47***	0.14**	3.78***	-3.88*** [3]
OP	-78.08***	-6.23***	0.07***	1.23***	-7.64*** [1]
UN	-46.39***	-4.80***	0.10***	2.02***	-10.77*** [0]

Notes: Optimal lag length of DF-GLS tests reported in brackets []. Asterisks ***, ** and * represent significance at 1%, 5% and 10% levels.

Source: Researcher's own computation

It is evident from Table 5.6 that nominal effective exchange rate, prime lending rate, money supply, oil price and unemployment rate are all stationary at first difference at the 1% level using both unit root tests. However, the MSB statistic indicates that money supply is stationary at first difference at the 5% level. Table 5.6 also shows that there are no I(2) variables.

5.4.2 Second generation unit root tests

In this section of the paper the findings of the KSS non-linear unit root tests performed with and without a Fourier function are presented. For control purposes, an analysis is begun by focusing on the KSS test performed without a Fourier function approximation as found in Table 5.7.

Table 5.7: KSS unit root test without a Fourier function

Variable	KSS stat	optimum lag	AIC	SC
INF	-4.17***	5	2.56	2.75
NEER	-3.21***	2	6.42	6.53
PLR	-1.98*	1	2.60	2.66
MS	-1.93*	5	4.13	4.32
OP	-2.28**	2	7.22	7.32
UN	-2.60**	4	3.20	3.37
critical values				
1%	-2.82			
5%	-2.22			
10%	-1.92			

Notes: asterisks ***, ** and * represent significance at 1%, 5% and 10% levels. The optimal lag lengths for the tests are based on minimisation of AIC and SC information criterion. Optimal frequency approximation, K*, is selected via a minimisation of the SSR. The critical values associated with KSS tests are derived from Kapetanios *et al* (2003). The table above is the researcher's own computation.

Based on Table 5.7, unemployment rate and oil price reject the null hypothesis and are significant at 5% level, in other words these variables are both non-linear-stationary. Prime lending rate and money supply are significant at 10% level; they both reject the null hypothesis and are non-linear-stationary. Inflation and nominal effective exchange rate reject the null hypothesis and are therefore both non-linear-stationary at 1% level.

Table 5.8: KSS unit root test with a Fourier function

Variable	KSS stat	optimum lag	K^*	SSR
INF	-3.94***	5	5	54.72
NEER	-1.94*	5	5	2904.42
PLR	-1.74	5	5	66.36
MS	-1.54	5	5	255.24
OP	-3.21***	5	5	6146.99
UN	-2.67**	5	5	109.40
critical values				
1%	-2.82			
5%	-2.22			
10%	-1.92			

Notes: asterisks ***, ** and * represent significance at 1%, 5% and 10% levels. The optimal lag lengths for the tests are based on minimisation of AIC and SC information criterion. Optimal frequency approximation, K*, is selected via a minimisation of the SSR. The critical values associated with KSS tests are derived from Kapetanios *et al* (2003). The table above is the researcher's own computation.

Based on Table 5.8, the unemployment rate is non-linear-stationary at 5% level, as the null hypothesis is rejected. Prime lending rate and money supply both fail to reject the null hypothesis. Inflation and oil price are non-linear-stationary at 1% level, as they reject the null hypothesis. The nominal effective exchange rate is non-linear-stationary at 10% level, as the null hypothesis is rejected.

Most of the variables are stationary using all the unit root tests discussed above. The results from all the unit root tests are comparable as they produce similar results despite the different properties of each unit root test. If a series is stationary it means that a shock to that series will last for a long period as the variable will return to its mean. However, if it is non-stationary it means that if there is a shock to the variable, it will not revert to the mean.

5.5 Autoregressive distributed lag models

This section will present the results of the linear autoregressive distributed lag (ARDL) and non-linear autoregressive distributed lag (NARDL) models.

5.5.1 Bounds test

The cointegration test is performed for the linear specification. The results of the bounds test are presented in Table 5.9.

Table 5.9: Bounds test for linear cointegration

Model specification	**F-statistic**	**upper bound**		**Conclusion**
Linear	6.56	10%	3.35	Cointegration
		5%	3.79	
		2.5%	4.18	
		1%	4.68	

Source: Researcher's own computation

Based on Table 5.9, it is evident that a long-run relationship exists in the linear model, as the F-statistic 6.56 is greater than the upper critical bound at 1%.

5.5.2 Diagnostic tests

Before estimating the linear ARDL model and making inferences, diagnostic tests are first performed to assess the adequacy of the dynamic model. Table 5.10 presents the results of the relevant diagnostic tests.

Table 5.10: Diagnostic results (a)

Test	**Statistic**	**Probability**
normality test	0.93	0.62
serial correlation LM test	1.22	0.30
ARCH heteroscedasticity test	0.00	0.94
Ramsey RESET test	0.22	0.63

Source: Researcher's own computation

In Table 5.10, the p-value 0.62 of the normality test reveals that the residuals are normally distributed and are symmetric. There is also no serial correlation in the estimated model, as the p-value 0.30 is greater than 0.10. This means the residuals are not serially correlated. Based on Table 5.10, there is no heteroscedasticity in the estimated model as the p-value 0.94 is greater than 0.10. This indicates that the residuals are homoscedastic. Based on the p-value 0.63 of the Ramsey RESET test, the model is correctly specified and stable. The model passes all the diagnostic tests and so can be used for further analysis.

5.5.3 Long- and short-run models

The linear model is estimated here, and the results are shown in Table 5.11.

Table 5.11: ARDL estimations

Dependant variable: INF							
long-run coefficient estimates							
constant	**NEER**	**PLR**	**MS**	**LOG_OP**	**UN**	R^2	
-7.94	-0.53 (-3.47)***	0.44 (2.02)**	-0.07 (-1.02)	1.83 (1.70)*	0.05 (0.35)	0.93	
short-run coefficient estimates							
lag order	ΔINF	$\Delta NEER$	ΔPLR	ΔMS	ΔLOG_OP	ΔUN	**ECT**
0	0.35 (4.42)***	-0.02 (-1.40)	0.48 (4.21)***	-0.03 (-0.80)	1.86 (2.89)***	0.01 (0.35)	-0.24 (-5.81)***
1		0.01 (0.67)	0.21 (1.72)*	-0.13 (-2.25)**			
2		0.06 (3.77)***		0.06 (1.39)			

Notes: asterisks ***, ** and * represent significance at 1%, 5% and 10% levels. Number inside parentheses is the value of the t-ratio.

Source: Researcher's own computation

Based on Table 5.11, 93% of the variation in inflation is explained by nominal effective exchange rate, prime lending rate, money supply, oil prices and unemployment rate. In the long run there is a negative relationship between nominal effective exchange rate and inflation, which confirms *a priori* expectations. An appreciation in the exchange rate results in a decrease in inflation. This implies that a depreciation in the exchange rate results in an increase in inflation. This result is in line with the findings of Schaling (2008) and Audu & Amaegberi (2013), as they found the same result to be true in South Africa and Nigeria, respectively. Nominal effective exchange rate is also significant at 1% level.

In the long run there is a positive relationship between prime lending rate and inflation, which is not in line with *a priori* expectations, as this result indicates that a higher prime lending rate has a positive effect on inflation. Prime lending rate is significant at 5% level. These results are in line with Audu & Amaegberi (2013) and Khumalo *et al* (2017), who also found a positive relationship between interest rate and inflation in Nigeria and Swaziland, respectively.

In the long run, there is a negative and insignificant relationship between money supply and inflation which is not in line with *a priori* expectations. This result indicates that an increase in M3 money supply has a negative effect on inflation. This is most likely due to the ongoing recession. In a different but related study, Amassoma *et al* (2018) reached similar conclusions in Nigeria. They found that money supply does not considerably influence inflation in the long run.

In the long run, there is a positive and significant relationship between the Brent crude oil price and inflation at the 10% level, which is in line with *a priori* expectations. As this result indicates that an increase in the Brent crude oil price has a positive effect on inflation.

In the long run, there is a positive but insignificant relationship between unemployment rate and inflation, which is not in line with *a priori* expectations. This result indicates that an increase in the unemployment rate has a positive effect on inflation. This shows that the Phillips curve theory does not hold in the South African context, as several studies have proved (Burger & Marinkov, 2006; Chicheke, 2009).

The error correction term carries an expected negative sign, which is highly significant, indicating that inflation, nominal effective exchange rate, prime lending rate, money supply, oil prices and unemployment rate are cointegrated. The absolute value of the coefficient of the error correction term indicates that about 24% of the disequilibrium in inflation is offset by short-run adjustment in each quarter. In the short run, there is a negative insignificant relationship between nominal effective exchange rate and inflation. The result is in line with *a priori* expectations. There is a positive significant relationship between prime lending rate and inflation in the short run. This result is not in line with *a priori* expectations. Money supply and inflation have a negative but insignificant relationship in the short run. The result is not in line with *a priori* expectations. Oil price and inflation have a positive significant relationship in the short run, which is in line with *a priori* expectations. Unemployment rate and inflation have a positive but insignificant relationship in the short run, which is not in line with *a priori* expectations.

5.5.4 Bounds test

The cointegration test is performed for the non-linear specification. The results of the bounds test are presented in Table 5.12.

Table 5.12: Bounds test for non-linear cointegration

Model specification	**F-statistic**	**upper bound**		**Conclusion**
non-linear	9.97	10%	3.23	Cointegration
		5%	3.61	
		2.5%	3.99	
		1%	4.43	

Source: Researcher's own computation

Based on Table 5.12, it is evident that a long-run relationship exists in the linear model, as the F-statistic 9.97 is greater than the upper critical bound at 1%.

5.5.5 Diagnostic tests

Before estimating the non-linear ARDL model and making inferences, diagnostic tests are first performed to assess the adequacy of the dynamic model as done previously. Table 5.13 presents the results of the relevant diagnostic tests.

Table 5.13: Diagnostic results (b)

Test	Statistic	Probability
normality test	0.30	0.85
serial correlation LM test	0.20	0.81
ARCH heteroscedasticity test	1.05	0.30
Ramsey RESET test	0.15	0.69

Source: Researcher's own computation

In Table 5.13, the p-value 0.85 of the normality test reveals that the residuals are normally distributed and that they are symmetrical. There is also no serial correlation present in the estimated model, as the p-value 0.81 is greater than 0.10. This means that the residuals are not serially correlated. Based on table 5.13, there is no heteroscedasticity present in the model as the p-value 0.30 is greater than 0.10. This indicates that the residuals are homoscedastic. Based on the p-value 0.69 of the Ramsey RESET test, the model is correctly specified and stable, as 0.69 is greater than 0.10. The model passes all the diagnostic tests and so can be used for further analysis.

5.5.6 Long- and short-run models

The non-linear model shown in Equation 4.4 is estimated here and the results are shown in Table 5.14. The model allows the assessment of the inflation dynamic and its response to prime lending rate, money supply, oil price, unemployment rate and positive and negative changes in nominal effective exchange rate.

Table 5.14: NARDL estimations

Dependant variable: INF								
long-run coefficient estimates								
constant	**NEER_POS**	**NEER_NEG**	**PLR**	**MS**	**LOG_OP**	**UN**	R^2	
-8.29	-0.50 (-3.53)***	-0.50 (-3.60)***	0.40 (2.02)**	-0.08 (-1.28)	1.78 (1.71)*	0.04 (0.28)	0.93	
short-run coefficient estimates								
lag order	ΔINF	$\Delta NEER\_POS$	$\Delta NEER\_NEG$	ΔPLR	ΔMS	ΔLOG_OP	ΔUN	**ECT**
0	0.30 (3.73)***	-0.04 (-1.67)*	-0.04 (-1.41)	0.48 (4.21)***	-0.02 (-1.26)	1.92 (2.95)***	0.01 (0.29)	-0.27 (-6.20)***
1		-0.02 (-0.84)	0.05 (1.50)	0.34 (2.72)***				
2		0.11 (4.46)***						

Notes: asterisks ***, ** and * represent significance at 1%, 5% and 10% levels. Number inside parentheses is the value of the t-ratio.

Source: Researcher's own computation

Table 5.14 shows that 93% of the variation in inflation is explained by the nominal effective exchange rate, prime lending rate, money supply, oil prices and unemployment rate. In the long run, there is a negative relationship between an appreciation in nominal effective exchange rate (NEER_POS) and inflation; the relationship is significant at the 1% level. This result is in line with *a priori* expectations. These results are in line with Schaling (2008) and Audu & Amaegberi (2013), as mentioned previously. There is a negative relationship between a depreciation in nominal effective exchange rate (NEER_NEG) and inflation; the relationship is significant at 1% level. However, this result is not in line with *a priori* expectations, as this result implies that a depreciation of the nominal effective exchange rate decreases inflation. There are no asymmetries present; in other words an increase or a decrease in the nominal effective exchange rate will have a negative effect on inflation.

In the long run there is a positive relationship between prime lending rate and inflation, which is not in line with *a priori* expectations, as this result indicates that a higher prime lending rate has a positive effect on inflation. These results are in line with those obtained in the linear model. Prime lending rate is significant at 5% level.

In the long run, there is a negative relationship between money supply and inflation, which is not in line with *a priori* expectations, as this result indicates that an increase in M3 money supply has a negative effect on inflation. However, money supply is insignificant.

In the long run, there is a positive relationship between Brent crude oil price and inflation, which is in line with *a priori* expectations, as this result indicates that an increase in the Brent crude oil price has a positive effect on inflation, and oil price is significant at 10% level.

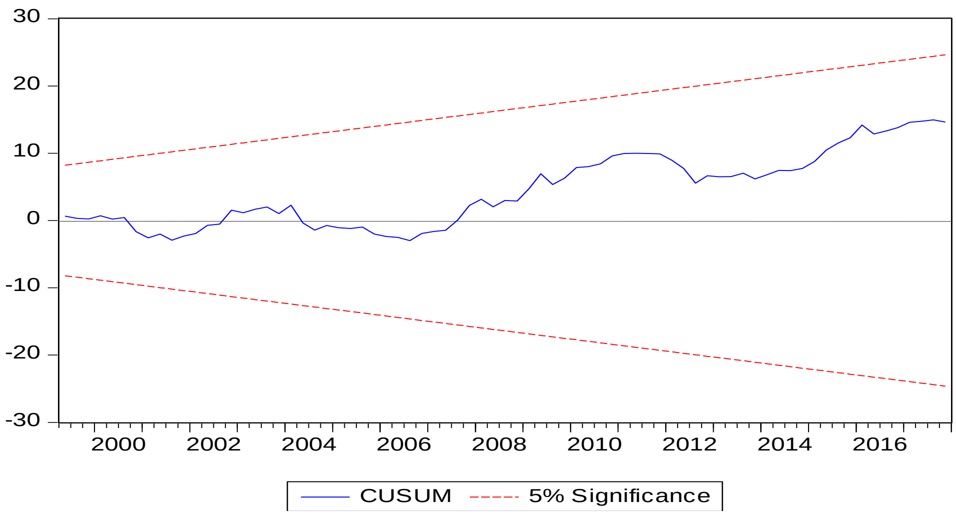
In the long run, there is a positive relationship between unemployment rate and inflation, which is not in line with *a priori* expectations, as this result indicates that an increase in the unemployment rate has a positive effect on inflation, and unemployment rate is insignificant. These results are similar to those obtained in the linear model and reaffirm that the Phillips curve does not hold in South Africa.

The error correction term carries an expected negative sign, which is highly significant, indicating that inflation, nominal effective exchange rate, prime lending rate, money supply, oil prices and unemployment rate are cointegrated. The absolute value of the coefficient of the error correction term indicates that about 27% of the disequilibrium in inflation is offset by short-run adjustment in each quarter. In the short run, there is a positive and significant relationship between changes in inflation, prime lending rate, oil price, and inflation at lag order zero. There is a positive and insignificant relationship between unemployment rate and inflation at lag order zero. There is a negative and significant relationship between an appreciation of the nominal effective exchange rate and inflation at lag order zero. There is a negative and insignificant relationship between a depreciation of the nominal effective exchange rate and inflation in the short run. This indicates that all the controlled variables except money supply, unemployment rate and a depreciation of the nominal effective exchange rate influence inflation significantly in the short run. After catering for any possible non-linearities, the results still show that a depreciation in the exchange rate decreases inflation.

5.5.7 CUSUM and CUSUM of squares

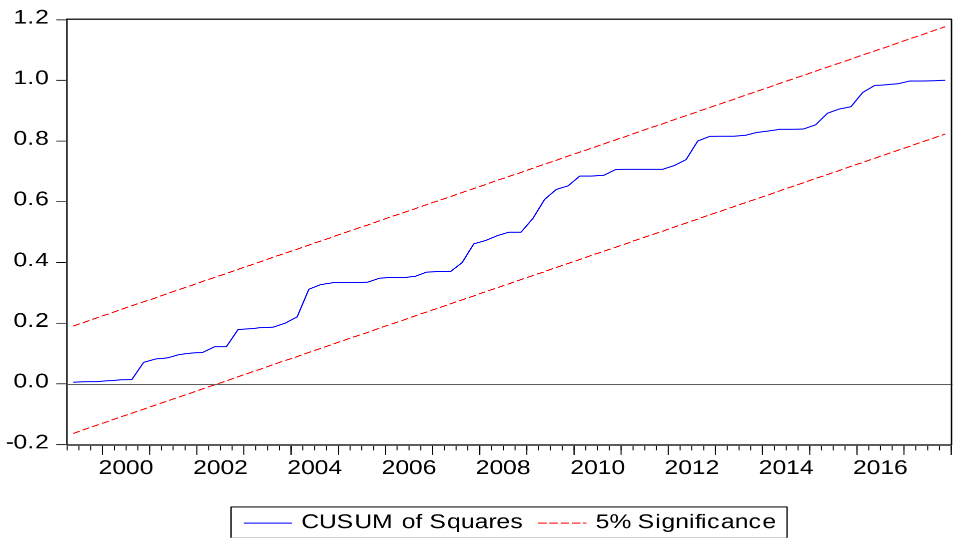
The stability of the model is tested by conducting CUSUM and CUSUM of squares tests as shown in Figures 5.1 and 5.2.

Figure 5.1 CUSUM test



Source: Researcher's own computation

Figure 5.2 CUSUM of squares test



Source: Researcher's own computation

Figures 5.1 and 5.2 show that both tests reveal the stability of the model coefficients since the estimated model lies within the 5% significance line for CUSUM and CUSUM of squares tests.

5.6 Vector autoregressive

This section will present the estimated VAR model results.

5.6.1 Lag order selection criteria

Table 5.15 VAR lag order selection criteria

Lag	logL	LR	FPE	AIC	SC	HQ
0	-966.52	NA	206.38	22.35	22.52	22.42
1	-742.16	412.62	2.72	18.02	19.21*	18.50*
2	-696.74	77.26	2.21	17.81	20.02	18.70
3	-666.13	47.85	2.58	17.93	21.16	19.23
4	-632.04	48.58	2.85	17.97	22.22	19.69
5	-575.43	72.87*	1.96*	17.50*	22.77	19.62
6	-548.94	30.45	2.83	17.72	24.01	20.25
7	-513.61	35.73	3.59	17.73	25.05	20.68
8	-476.73	32.21	4.86	17.71	26.05	21.07

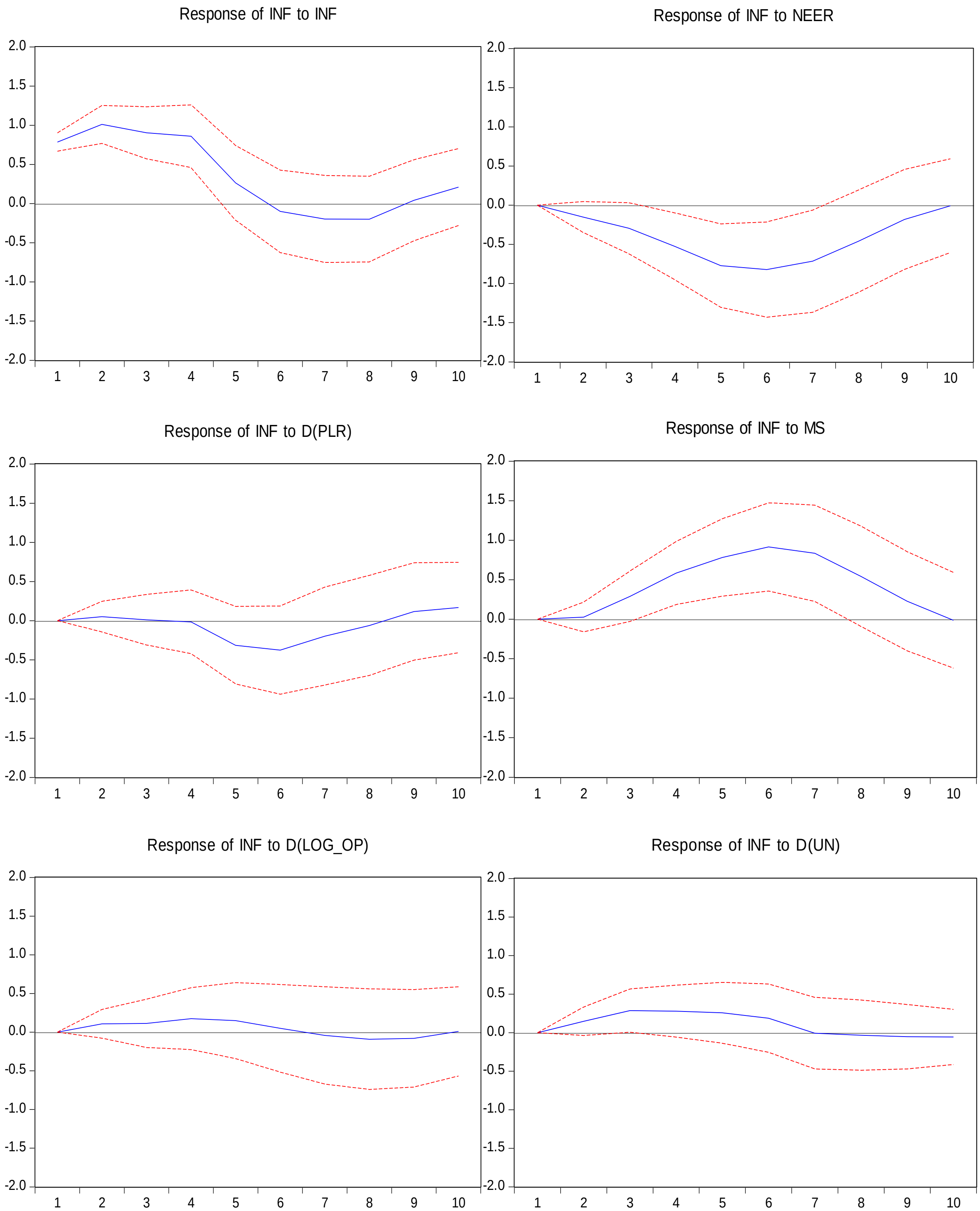
Notes: * indicates lag order selected by the criterion.

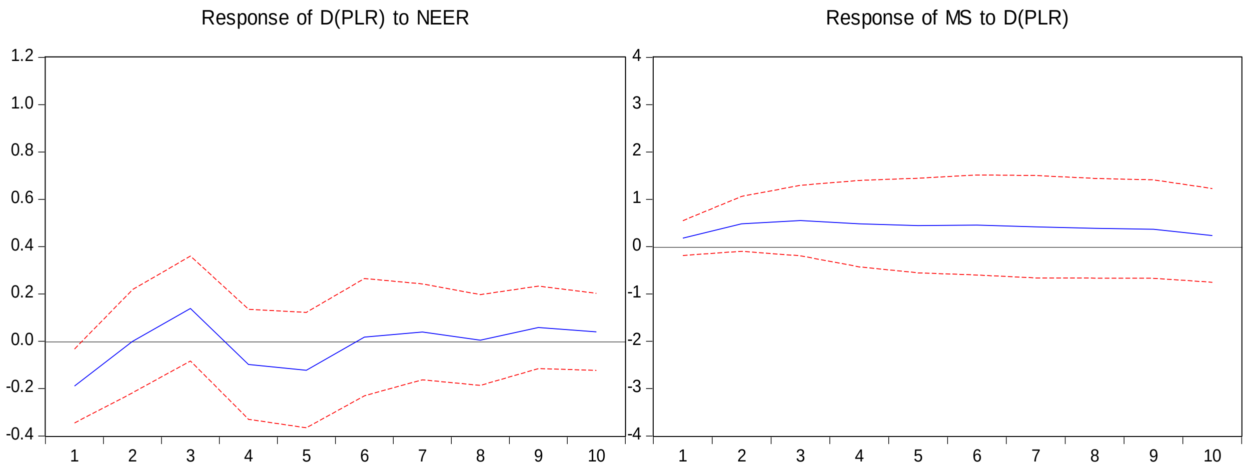
Source: Researcher’s own computation

Based on Table 5.15, the sequential modified LR test statistic (LR), final prediction error (FPE) and Akaike information criterion (AIC) consistently suggest that the best lag length for the model is five. So the study will follow the suggestion of the LR, FPE and AIC.

5.6.2 Impulse response function

Figure 5.3 Impulse response function





Source: Researcher's own computation

Figure 5.3 above represents the estimated impulse response function of inflation to the independent variables. The results reveal that inflation responds negatively to a shock to the nominal effective exchange rate for the first five periods; its response then increases towards equilibrium but remaining negative from the sixth period to the 10th period. This indicates a negative relationship between inflation and nominal effective exchange rate. This result is in line with economic theory and the results of the ARDL models. The results reveal that inflation responds positively to a shock to the prime lending rate in the first two periods, but decreases back to equilibrium in the third period. It then responds negatively from the fourth period up to the eighth period. It then responds positively in the ninth and 10th periods. This result is in line with economic theory, as there is a hint of a negative relationship after the fourth period.

The results reveal that inflation does not respond to a shock in money supply at equilibrium in the first period, but responds positively up to the sixth period. It then responds negatively from the seventh period up to the 10th period. This result is in line with economic theory as it implies that a shock to M3 money supply will result in an increase in inflation. The results reveal that inflation responds positively to a shock in the oil price for the first six periods; it then responds negatively in the seventh period up to the ninth period. The effect of the shock then dies out at the 10th period. This result is in line with economic theory as it implies that a shock to the Brent crude oil price will result in an increase in inflation. The results also show that inflation responds positively to a shock in the unemployment rate up to the sixth period. The effect of the shock then dies out after the seventh period. This result is not in line with economic theory, as

Vermeulen (2017) argues that inflation-targeting central banks, like the South African Reserve Bank, are consequently criticised for their attempts to keep inflation low – attempts which he believes contribute to higher unemployment.

Figure 5.3 reveals that prime lending rate responds negatively to a shock to the nominal effective exchange rate in the first two periods. It then responds positively in the second and third periods. It then responds negatively in the fourth and fifth periods, then reacts positively from the sixth to the 10th period. This result is in line with economic theory, even though the relationship is not stable. Figure 5.3 also reveals that money supply responds positively to a shock to the prime lending rate for 10 periods. The effect of the shock is relatively constant. This result is not in line with economic theory.

5.6.3 Granger causality test

Table 5.16 Granger causality/block exogeneity Wald tests

Dependant variable: INF		
Excluded	Chi-square	Probability
NEER	12.47	0.02
dependant variable: D(PLR)		
Excluded	Chi-square	Probability
MS	16.83	0.00
dependant variable: MS		
Excluded	Chi-square	Probability
INF	15.82	0.00
dependant variable: D(LOG_OP)		
Excluded	Chi-square	Probability
D(UN)	15.01	0.01
dependant variable: D(UN)		
Excluded	Chi-square	Probability
INF	26.06	0.00
D(PLR)	11.23	0.04
D(LOG_OP)	14.90	0.01

Source: Researcher's own computation

Based on Table 5.16, there is unidirectional causality running from nominal effective exchange rate to inflation. Nominal effective exchange rate Granger-causes inflation at 5% level. This result is in line with economic theory, as it implies that inflation is caused by changes in nominal effective exchange rate. It is evident that money supply Granger-causes prime lending rate at 1% level. This result is in line with economic theory, as this implies that prime lending rate is caused by changes in money supply. Inflation Granger-causes money supply at 1% level. This result is not in line with economic theory. Unemployment rate Granger-causes oil price at 5% level. This result is not in line with economic theory. Inflation Granger-causes unemployment rate at 1% level. This result is not in line with economic theory. Prime lending rate Granger-causes unemployment rate at 5% level. This result is not in line with economic theory. Lastly, oil price Granger-causes unemployment rate at 5% level. This result is in line with economic theory as this implies that unemployment rate is influenced by changes in oil price. The remaining variables show no causality.

5.6.4 Variance decomposition

Table 5.17 Variance decomposition of inflation

Variance decomposition of INF							
period	S.E.	INF	NEER	D(PLR)	MS	D(lOG_OP)	D(UN)
1	0.78	100.00	0.00	0.00	0.00	0.00	0.00
2	1.30	96.50	1.34	0.17	0.02	0.67	1.27
3	1.66	88.29	3.96	0.16	2.98	0.86	3.71
4	2.06	75.18	9.13	0.16	9.96	1.28	4.26
5	2.38	57.15	17.22	1.05	18.88	1.34	4.33
6	2.72	44.16	22.38	1.86	26.69	1.07	3.81
7	2.94	38.07	24.95	1.72	31.05	0.93	3.24
8	3.04	36.20	25.73	1.62	32.39	0.96	3.06
9	3.05	35.80	25.78	1.81	32.50	1.02	3.05
10	3.07	35.99	25.58	2.08	32.25	1.01	3.06

Source: Researcher's own computation

Based on Table 5.17, the variance shows that 35.99% in inflation is explained by itself in the 10th period. The other variables account for the remaining 64.01%, with money supply and nominal effective exchange rate explaining a larger significance of 32.25% and 25.58%, respectively. The other variables also explain smaller error variance, prime lending rate 2.08%, oil price 1.01% and unemployment rate 3.06%.

Table 5.18: Variance decomposition of nominal effective exchange rate

Variance decomposition of NEER							
period	S.E.	INF	NEER	D(PLR)	MS	D(lOG_OP)	D(UN)
1	5.49	7.35	92.64	0.00	0.00	0.00	0.00
2	5.79	7.26	87.88	3.48	0.92	0.04	0.40
3	5.93	7.09	84.45	3.72	4.19	0.05	0.46
4	6.10	6.75	80.98	3.53	8.14	0.06	0.52
5	6.13	6.95	80.05	3.64	8.25	0.50	0.58
6	6.44	6.58	73.33	5.17	7.50	0.50	6.88
7	6.48	6.55	72.63	5.15	8.10	0.65	6.90
8	6.57	6.54	70.76	5.00	9.94	0.63	7.10
9	6.60	6.50	70.37	4.97	10.35	0.65	7.14
10	6.62	6.61	69.91	5.10	10.54	0.68	7.13

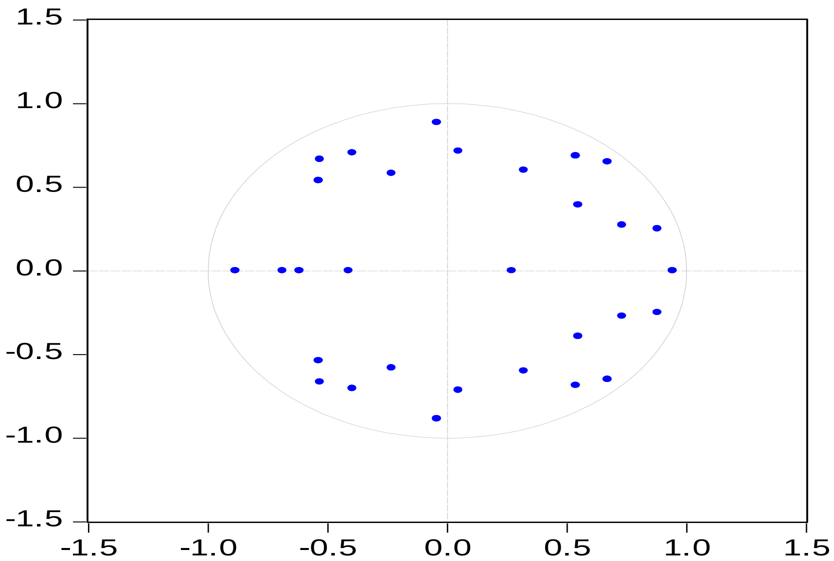
Source: Researcher's own computation

Table 5.18 presents the results of the variance decomposition of nominal effective exchange rate. It shows that 69.91% of variation in nominal effective exchange rate is explained by itself in the 10th period. The other variables account for the remaining 30.09% where money supply explains 10.54%. The remaining variables have a smaller variation, with inflation rate, prime lending rate and unemployment rate accounting for 6.61%, 5.10% and 7.13% of forecast error variance in the

10th period respectively. Money supply accounted for the most forecast error variance in the 10th period.

5.6.5 AR root graph

Figure 5.4 Inverse roots of AR characteristic polynomial



Source: Researcher's own computation

Figure 5.4 shows that all the reported inverse roots of the AR polynomial have roots with modulus which are less than one and they lie within the unit circle. Therefore, the estimated VAR is stable and stationary.

5.7 Conclusion

The purpose of this chapter was to present and discuss the results of the study by providing an analysis of the empirical findings to examine the effect of the exchange rate on inflation in South Africa from 1994Q1 to 2017Q4. In relation to stationarity, the controlled variables were found to be both stationary and non-stationary using the above-mentioned unit root tests. None were to be found to be I(2) variables. Cointegration tests were conducted and found that long-run relationships exist in both the linear and non-linear models. No heteroscedasticity, no serial correlation, normally distributed residuals and correctly specified models were all found to be true for both linear and non-linear models.

Most of the controlled variables were found to be positively correlated to inflation except oil price and unemployment rate. The linear model results show that there is a negative and significant relationship between nominal effective exchange rate and inflation. This implies that an appreciation in the exchange rate decreases inflation. Based on the non-linear model results, there are no asymmetries between inflation and nominal effective exchange rate. In simple terms, an increase or a decrease in the nominal effective exchange rate has a negative effect on inflation in South Africa. Both the linear and non-linear models produce similar results, indicating the accuracy of the results. The estimated VAR model results reveal that there is unidirectional causality running from the nominal effective exchange rate to the inflation rate. They also reveal a negative relationship between inflation and nominal effective exchange rate. The same result was found to be true for both linear and non-linear ARDL models. The next chapter will conclude the study and provide policy recommendations based on the findings of the study. It will also highlight areas for future research.

Chapter six:

Conclusion and recommendations

6.1 Introduction

This study examined the effect of the exchange rate on inflation in South Africa for the period 1994Q1 to 2017Q4 with the application of the non-linear autoregressive distributed lag (NARDL) model. The vector autoregressive (VAR) model was also employed to cater for potential endogeneity. The study tested the stationarity of the variables using the DF-GLS, Ng-Perron and KSS unit root tests. After testing for unit roots and finding that the variables have different orders of integration, the ARDL model was used. In the section that follows, a summary of each chapter will be provided. Section 6.3 provides the policy recommendations and Section 6.4 the limitations of the study. Lastly, Section 6.5 will highlight areas of future research.

6.2 Summary

Chapter one provided a brief background to the study and presented the problem statement, the problem being the volatility of the exchange rate and the adverse effects those fluctuations may have on inflation. So the aim of the study was to analyse the effect the exchange rate has on inflation in South Africa. Two research questions were then identified: 1) what effect does depreciation have on inflation? 2) what effect does an appreciation have on inflation? The significance of the study was to assist the South African Reserve Bank in making the necessary adjustments to monetary policy so as to achieve price stability.

Chapter two presented an overview of the trends in exchange rate and inflation in South Africa for the period 1980-2017. The chapter briefly provided the history and transition of inflation down the years. Key events that transpired were highlighted and briefly discussed. The three monetary policy régimes introduced since 1980 were discussed in detail. The different exchange rate systems over that period were also presented and discussed. Events that transpired in the years 1985, 2001 and 2008 were found to have played a major role in changes to the real effective exchange rate. In 1985 the South African government declared a state of emergency and reinstated the dual exchange rate system, previously in use but abolished in 1983. In 2001, according to Bhundia & Gottschalk (2003), global economic activity decreased and a deterioration in the current account was observed. In 2008, the global financial crisis caused a decline in economic activity and low foreign investment. An exploration of the difference between inflation and real effective exchange rate was conducted through graphic representation; a negative relationship between the two variables was observed.

Chapter three identified the existing literature in relation to exchange rate and inflation. Four theories of inflation were identified and briefly discussed: 1) cost-push inflation, 2) demand-pull inflation, 3) the structuralist theory of money and 4) the quantity theory of money. However, the main focus was on exchange rate theories, specifically the exchange rate pass-through effect. This refers to the effect exchange rate has on inflation, whether directly or indirectly. The direct effect occurs when there is a depreciation and import inputs become more expensive, so increasing production costs, leading to a rise in consumer prices. The indirect effect occurs when there is a depreciaion and the demand for exports rises, leading to an increase in labour costs, followed by a rise in wages, leading to an increase in consumer prices.

Empirical literature indicated that the exchange rate pass-through to inflation in South Africa has lessened down the years, as shown by empirical evidence presented in Chapter three. There is predominantly a positive and strong relationship between inflation and exchange rate in other African countries. It was difficult to reach a conclusion regarding the predominant relationship between inflation and exchange rate in other developing countries, as some authors found a positive relationship, others a negative one and yet others no relationship between the two variables. However, exchange rate was found to influence inflation significantly. Lastly, the empirical literature identified a predominantly positive relationship between inflation and exchange rate in developed countries.

Chapter four presented the methodology employed in the study and provided the data description. The unit root tests employed in the study were discussed in detail. The NARDL model was discussed in detail, as this was the main model employed in this study, with the focus on determining whether asymmetries exist between inflation and exchange rate. The normality, heteroscedasticity, serial correlation and Ramsey RESET tests were all discussed in detail. The VAR model was briefly discussed.

Chapter five presented the empirical results of the study. The unit root test results found both I(0) and I(1) variables, but none were found to be I(2). The estimated linear and non-linear models passed the diagnostic tests. Long-run relationships were found to exist in both the linear and non-linear models. An appreciation in the exchange rate was found to decrease the inflation rate. However, an exchange rate depreciation was also found to lower the inflation rate. No asymmetries were found between exchange rate and inflation. A positive relationship was found between prime lending rate and inflation, which was not in line with economic theory. A positive relationship was found between oil price and inflation. A positive relationship was also found between the unemployment rate and inflation. This result also is not in line with economic theory. Finally, a negative relationship was found between money supply and inflation – again not in line with economic theory. The estimated VAR model results revealed unidirectional causality running from the nominal effective exchange rate to the inflation rate. A negative relationship between exchange rate and inflation was also found for the estimated VAR model, as observed through the impulse response function.

6.3 Recommendations

Given the results of the study, efforts geared towards decreasing inflation should focus not only on exchange rate policies but equally on those variables that are intertwined with them.

The study recommends that regulators or policymakers should arrive at means of evaluating exchange rate volatility. This could then lessen the effect the volatility of the exchange rate can have on inflation. The very dynamic of determining the exchange rate in terms of demand and supply is one of the causes of exchange rate volatility, so using a fixed exchange rate policy may help control inflation in South Africa. It has benefits such as providing greater certainty for importers and exporters, which in turn would increase foreign investment and help the South African government keep inflation low. However, a fixed exchange rate régime is very expensive to maintain at the present time, as it requires the central bank to intervene in foreign exchange markets. Also, efforts to increase the value of the rand will help reduce the inflation rate significantly.

South Africa's lending rates should be made more flexible so as to control the demand for money (Audu & Amaegberi, 2013). With the demand for money under control, aggregate demand will then be affected, which in turn will help manage inflation, given the relationship between the prime lending rate and the inflation rate, as established by the study. Alternatively, policymakers could reduce the prime lending rate, which would decrease inflation, even though financial institutions will lend more money to consumers, meaning more money circulating in the economy. Given the relationship between the inflation rate and M3 money supply in South Africa, inflation will still decrease.

The negotiation of better oil prices could also be a measure taken by the South African government to curb inflation. If the price of Brent crude oil were to decrease, the cost of petrol would be lower. Cheaper petrol would then lead to lower consumer prices; hence the inflation rate would decrease.

6.4 Limitations of the study

The study was faced with limitations. One that stands out is the restricted data on unemployment from the Reserve Bank's website. This limited the number of observations to 96, as the data goes back only as far as 1994. Data on M3 money supply and oil prices are not provided on a quarterly basis. As a result, averages of both variables had to be used for the estimation of both the NARDL and VAR models. This is limiting, as the averages do not give a true indication of the data.

This investigation focuses on identifying quantitative factors that affect inflation in South Africa. That said, non-quantifiable factors like politics and social changes are not included in the model (Dewing, 2015). This is a limitation, as it is difficult to quantify such factors.

The study also encountered a limitation in the form of time constraints. As a result, robustness checks could not be conducted. This also limited the depth this study could reach, so further research will need to be conducted.

6.5 Areas of future research

Even though exchange rate was found to influence inflation in South Africa significantly, there is a need also to examine the volatility of the exchange rate. That said, the rate at which exchange rate volatility affects economic growth is another area that requires further research, especially in South Africa. The relationship between inflation and exchange rate needs further research in South Africa, as non-quantifiable factors were not included in the estimated models, as mentioned above.

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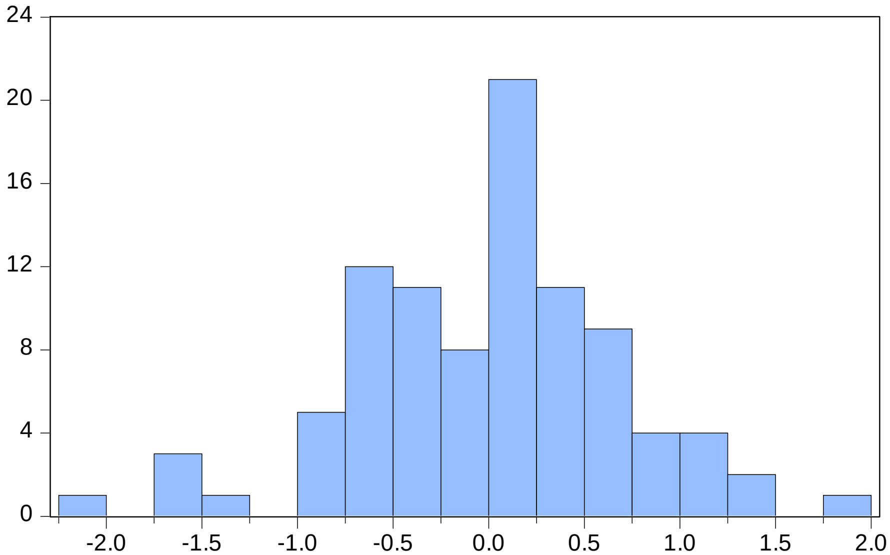
Appendices

Appendix A



Series: Residuals	
Sample 1994Q4 2017Q4	
Observations 93	
Mean	7.65e-16
Median	0.068443
Maximum	1.924624
Minimum	-2.004737
Std. Dev.	0.712224
Skewness	-0.143719
Kurtosis	3.397190
Jarque-Bera	0.931474
Probability	0.627672

Appendix B

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.222038	Prob. F(2,74)	0.3005
Obs*R-squared	2.973404	Prob. Chi-Square(2)	0.2261

Test Equation:
Dependent Variable: RESID
Method: ARDL
Date: 11/01/18   Time: 10:32
Sample: 1994Q4 2017Q4
Included observations: 93
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INF(-1)	0.126181	0.126108	1.000580	0.3203
INF(-2)	-0.093078	0.108017	-0.861696	0.3916
NEER	0.004920	0.019678	0.250032	0.8033
NEER(-1)	0.001129	0.017161	0.065776	0.9477
NEER(-2)	0.008345	0.018195	0.458654	0.6478
NEER(-3)	0.009059	0.017492	0.517879	0.6061
PLR	0.050430	0.118727	0.424758	0.6722
PLR(-1)	-0.142868	0.206724	-0.691102	0.4917
PLR(-2)	0.078899	0.140008	0.563536	0.5748
MS	-0.012424	0.045366	-0.273854	0.7850
MS(-1)	-0.003577	0.063081	-0.056707	0.9549
MS(-2)	0.031687	0.063459	0.499324	0.6190
MS(-3)	-0.019285	0.047958	-0.402111	0.6888
LOG_OP	-0.138221	0.648601	-0.213107	0.8318
LOG_OP(-1)	0.057748	0.653105	0.088421	0.9298
UN	0.005093	0.035478	0.143552	0.8862

C	0.238659	2.049957	0.116422	0.9076
RESID(-1)	-0.232706	0.182277	-1.276662	0.2057
RESID(-2)	-0.172998	0.137867	-1.254811	0.2135

R-squared	0.031972	Mean dependent var	7.65E-16
Adjusted R-squared	-0.203494	S.D. dependent var	0.712224
S.E. of regression	0.781337	Akaike info criterion	2.524448
Sum squared resid	45.17612	Schwarz criterion	3.041861
Log likelihood	-98.38685	Hannan-Quinn criter.	2.733365
F-statistic	0.135782	Durbin-Watson stat	1.918982
Prob(F-statistic)	0.999989		

Appendix C

Heteroskedasticity Test: ARCH

F-statistic	0.004654	Prob. F(1,90)	0.9458
Obs*R-squared	0.004758	Prob. Chi-Square(1)	0.9450

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 11/01/18 Time: 10:38
Sample (adjusted): 1995Q1 2017Q4
Included observations: 92 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.499904	0.098211	5.090100	0.0000
RESID^2(-1)	0.007205	0.105612	0.068223	0.9458

R-squared	0.000052	Mean dependent var	0.503558
Adjusted R-squared	-0.011059	S.D. dependent var	0.785251
S.E. of regression	0.789582	Akaike info criterion	2.386872
Sum squared resid	56.10951	Schwarz criterion	2.441693
Log likelihood	-107.7961	Hannan-Quinn criter.	2.408998
F-statistic	0.004654	Durbin-Watson stat	1.993680
Prob(F-statistic)	0.945759		

Appendix D

Ramsey RESET Test
Equation: UNTITLED
Specification: INF INF(-1) INF(-2) NEER NEER(-1) NEER(-2) NEER(-3)
PLR PLR(-1) PLR(-2) MS MS(-1) MS(-2) MS(-3) LOG_OP LOG_OP(-1)
UN C
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	0.469951	75	0.6398
F-statistic	0.220854	(1, 75)	0.6398

F-test summary:

	Sum of Sq.	df	Mean

			Squares
Test SSR	0.137021	1	0.137021
Restricted SSR	46.66820	76	0.614055
Unrestricted SSR	46.53118	75	0.620416

Unrestricted Test Equation:
Dependent Variable: INF
Method: ARDL
Date: 11/01/18 Time: 10:39
Sample: 1994Q4 2017Q4
Included observations: 93
Maximum dependent lags: 3 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (3 lags, automatic):
Fixed regressors: C

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
INF(-1)	1.055111	0.132378	7.970424	0.0000
INF(-2)	-0.332479	0.089700	-3.706576	0.0004
NEER	-0.028110	0.019624	-1.432406	0.1562
NEER(-1)	-0.032428	0.017252	-1.879719	0.0640
NEER(-2)	-0.011967	0.017087	-0.700355	0.4859
NEER(-3)	-0.059884	0.017449	-3.432035	0.0010
PLR	0.457943	0.126655	3.615681	0.0005
PLR(-1)	-0.146237	0.184333	-0.793328	0.4301
PLR(-2)	-0.205563	0.125384	-1.639475	0.1053
MS	-0.032048	0.045302	-0.707436	0.4815
MS(-1)	-0.053532	0.061736	-0.867115	0.3886
MS(-2)	0.128043	0.062729	2.041206	0.0447
MS(-3)	-0.064119	0.046494	-1.379097	0.1720
LOG_OP	1.824619	0.653399	2.792504	0.0066
LOG_OP(-1)	-1.376954	0.660343	-2.085209	0.0405
UN	0.010828	0.035790	0.302539	0.7631
C	-1.802523	2.095883	-0.860030	0.3925
FITTED^2	0.004011	0.008536	0.469951	0.6398

R-squared	0.936827	Mean dependent var	5.882952
Adjusted R-squared	0.922508	S.D. dependent var	2.829520
S.E. of regression	0.787665	Akaike info criterion	2.532497
Sum squared resid	46.53118	Schwarz criterion	3.022677
Log likelihood	-99.76111	Hannan-Quinn criter.	2.730418
F-statistic	65.42458	Durbin-Watson stat	2.138606
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection.

Appendix E

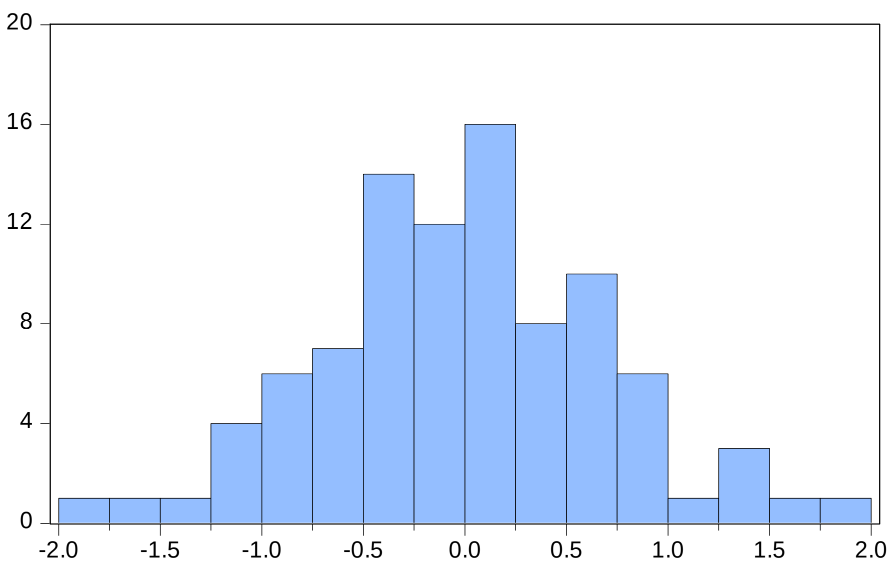
ARDL Cointegrating And Long Run Form
Dependent Variable: INF
Selected Model: ARDL(2, 3, 2, 3, 1, 0)
Date: 11/01/18 Time: 11:02
Sample: 1994Q1 2017Q4
Included observations: 93

Cointegrating Form				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(INF)	0.351620	0.079508	4.422425	0.0000
D(NEER)	-0.027419	0.019469	-1.408370	0.1631
D(NEER(-1))	0.011526	0.016974	0.679028	0.4992
D(NEER(-2))	0.062377	0.016538	3.771836	0.0003
D(PLR)	0.482756	0.114533	4.214983	0.0001
D(PLR(-1))	0.212989	0.123745	1.721195	0.0893
D(MS)	-0.035873	0.044336	-0.809124	0.4210
D(MS(-1))	-0.135892	0.060153	-2.259100	0.0267
D(MS(-2))	0.064552	0.046246	1.395857	0.1668
D(LOG_OP)	1.865672	0.644205	2.896083	0.0049
D(UN)	0.012663	0.035393	0.357796	0.7215
CointEq(-1)	-0.249511	0.042918	-5.813683	0.0000

Cointeq = INF - (-0.5384*NEER + 0.4490*PLR -0.0790*MS + 1.8303 *LOG_OP + 0.0508*UN -7.9435)

Long Run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
NEER	-0.538372	0.154792	-3.478038	0.0008
PLR	0.449046	0.221424	2.027992	0.0461
MS	-0.078967	0.076773	-1.028579	0.3069
LOG_OP	1.830277	1.074193	1.703862	0.0925
UN	0.050753	0.142334	0.356578	0.7224
C	-7.943472	8.118832	-0.978401	0.3310

Appendix F



Series: Residuals
Sample 1995Q1 2017Q4
Observations 92

Mean	-1.36e-15
Median	0.002301
Maximum	1.934280
Minimum	-1.924445
Std. Dev.	0.710777
Skewness	0.008060
Kurtosis	3.280583
Jarque-Bera	0.302782
Probability	0.859512

Appendix G

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.201604	Prob. F(2,73)	0.8179
Obs*R-squared	0.505360	Prob. Chi-Square(2)	0.7767

Test Equation:
Dependent Variable: RESID
Method: ARDL
Date: 11/01/18 Time: 10:51
Sample: 1995Q1 2017Q4
Included observations: 92
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INF(-1)	-0.022723	0.136289	-0.166730	0.8680
INF(-2)	0.023838	0.115050	0.207195	0.8364
NEER_POS	-0.001568	0.031588	-0.049645	0.9605
NEER_POS(-1)	0.005077	0.038615	0.131487	0.8958
NEER_POS(-2)	-0.003121	0.031791	-0.098172	0.9221
NEER_POS(-3)	-0.001072	0.028090	-0.038152	0.9697
NEER_NEG	0.001640	0.030016	0.054632	0.9566
NEER_NEG(-1)	-0.003183	0.043347	-0.073423	0.9417
NEER_NEG(-2)	0.001085	0.037833	0.028680	0.9772
PLR	0.005968	0.122777	0.048610	0.9614
PLR(-1)	0.022879	0.224189	0.102053	0.9190
PLR(-2)	-0.029703	0.151972	-0.195448	0.8456
MS	-0.001698	0.019439	-0.087345	0.9306
LOG_OP	-0.027778	0.664113	-0.041828	0.9668
LOG_OP(-1)	0.046369	0.670702	0.069134	0.9451
UN	0.000556	0.042633	0.013033	0.9896
C	-0.034654	2.054798	-0.016865	0.9866
RESID(-1)	0.050382	0.190945	0.263856	0.7926
RESID(-2)	-0.071042	0.137225	-0.517705	0.6062

R-squared	0.005493	Mean dependent var	-1.36E-15
Adjusted R-squared	-0.239728	S.D. dependent var	0.710777
S.E. of regression	0.791401	Akaike info criterion	2.551690
Sum squared resid	45.72101	Schwarz criterion	3.072494
Log likelihood	-98.37773	Hannan-Quinn criter.	2.761891
F-statistic	0.022400	Durbin-Watson stat	1.971626
Prob(F-statistic)	1.000000		

Appendix H

Heteroskedasticity Test: ARCH

F-statistic	1.053519	Prob. F(1,89)	0.3075
Obs*R-squared	1.064591	Prob. Chi-Square(1)	0.3022

Test Equation:
Dependent Variable: RESID^2

Method: Least Squares
Date: 11/01/18   Time: 10:51
Sample (adjusted): 1995Q2 2017Q4
Included observations: 91 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.448779	0.095978	4.675843	0.0000
RESID^2(-1)	0.108251	0.105466	1.026411	0.3075

R-squared	0.011699	Mean dependent var	0.503404
Adjusted R-squared	0.000594	S.D. dependent var	0.762153
S.E. of regression	0.761927	Akaike info criterion	2.315801
Sum squared resid	51.66741	Schwarz criterion	2.370984
Log likelihood	-103.3689	Hannan-Quinn criter.	2.338064
F-statistic	1.053519	Durbin-Watson stat	1.941897
Prob(F-statistic)	0.307480		

Appendix I

Ramsey RESET Test
Equation: NARDL01
Specification: INF INF(-1) INF(-2) NEER_POS NEER_POS(-1)
NEER_POS(-2) NEER_POS(-3) NEER_NEG NEER_NEG(-1)
NEER_NEG(-2) PLR PLR(-1) PLR(-2) MS LOG_OP LOG_OP(-1) UN C

Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	0.399542	74	0.6906
F-statistic	0.159634	(1, 74)	0.6906

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	0.098961	1	0.098961
Restricted SSR	45.97354	75	0.612981
Unrestricted SSR	45.87458	74	0.619927

Unrestricted Test Equation:
Dependent Variable: INF
Method: ARDL
Date: 11/01/18   Time: 10:52
Sample: 1995Q1 2017Q4
Included observations: 92
Maximum dependent lags: 3 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (3 lags, automatic):
Fixed regressors: C

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
INF(-1)	0.986448	0.130706	7.547061	0.0000
INF(-2)	-0.290053	0.089384	-3.245027	0.0018
NEER_POS	-0.052149	0.030521	-1.708652	0.0917

NEER_POS(-1)	-0.006406	0.037386	-0.171350	0.8644
NEER_POS(-2)	0.025819	0.031251	0.826182	0.4114
NEER_POS(-3)	-0.108609	0.026530	-4.093785	0.0001
NEER_NEG	-0.039802	0.030117	-1.321586	0.1904
NEER_NEG(-1)	-0.047635	0.042328	-1.125394	0.2641
NEER_NEG(-2)	-0.053973	0.035599	-1.516136	0.1337
PLR	0.462761	0.129284	3.579418	0.0006
PLR(-1)	-0.015203	0.188550	-0.080632	0.9360
PLR(-2)	-0.341436	0.129913	-2.628186	0.0104
MS	-0.023846	0.018875	-1.263356	0.2104
LOG_OP	1.876174	0.668517	2.806472	0.0064
LOG_OP(-1)	-1.402604	0.665965	-2.106122	0.0386
UN	0.009712	0.042706	0.227413	0.8207
C	-2.066748	2.125685	-0.972274	0.3341
FITTED^2	0.003465	0.008672	0.399542	0.6906

R-squared	0.936380	Mean dependent var	5.840389
Adjusted R-squared	0.921764	S.D. dependent var	2.814930
S.E. of regression	0.787354	Akaike info criterion	2.533304
Sum squared resid	45.87458	Schwarz criterion	3.026697
Log likelihood	-98.53198	Hannan-Quinn criter.	2.732442
F-statistic	64.06773	Durbin-Watson stat	1.942853
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection.

Appendix J

ARDL Cointegrating And Long Run Form
Dependent Variable: INF
Selected Model: ARDL(2, 3, 2, 2, 0, 1, 0)
Date: 11/19/18 Time: 11:43
Sample: 1994Q1 2017Q4
Included observations: 92

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(INF)	0.304365	0.081432	3.737636	0.0004
D(NEER_POS)	-0.049426	0.029583	-1.670771	0.0989
D(NEER_POS(-1))	-0.026303	0.031052	-0.847069	0.3997
D(NEER_POS(-2))	0.111930	0.025053	4.467634	0.0000
D(NEER_NEG)	-0.041860	0.029507	-1.418672	0.1601
D(NEER_NEG(-1))	0.053110	0.035334	1.503104	0.1370
D(PLR)	0.485686	0.115204	4.215885	0.0001
D(PLR(-1))	0.348868	0.127853	2.728672	0.0079
D(MS)	-0.023758	0.018768	-1.265897	0.2095
D(LOG_OP)	1.927102	0.652566	2.953116	0.0042
D(UN)	0.012189	0.042016	0.290100	0.7725
CointEq(-1)	-0.279872	0.045113	-6.203820	0.0000

Cointeq = INF - (-0.5070*NEER_POS -0.5067*NEER_NEG + 0.4021*PLR -0.0849*MS + 1.7873*LOG_OP + 0.0436*UN -8.2968)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
NEER_POS	-0.506963	0.143353	-3.536461	0.0007
NEER_NEG	-0.506719	0.140614	-3.603611	0.0006
PLR	0.402123	0.198454	2.026279	0.0463
MS	-0.084889	0.066085	-1.284543	0.2029
LOG_OP	1.787315	1.041639	1.715868	0.0903
UN	0.043552	0.151059	0.288311	0.7739
C	-8.296801	7.030521	-1.180112	0.2417