



**The relationship between inflation and unemployment  
in South Africa: 1994-2015**

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degree Master of Commerce in Economics**

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## Abstract

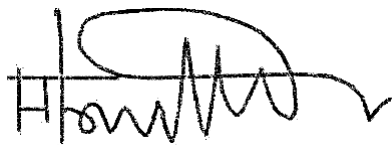
The nature of the relationship between inflation and unemployment has implications for the appropriate conduct of monetary policy. However, the question as to whether the traditional Phillips curve relationship holds true remains debatable despite advances in both theoretical and empirical evidence. This study revisits this debate for South Africa by examining data on unemployment, the repo interest rate and core CPI for the period from 1994Q1 to 2015Q4. This was in the light of recent developments in both theoretical and empirical Phillips curve literature. The research employed a hybrid version of the NKPC and various econometric techniques. The Augmented Dickey-Fuller test was used to examine the unit root properties of the data series. The Johansen cointegration technique was applied to test for cointegration among the variables. The research derived and estimated an error correction model for inflation. The model results demonstrated that the repo interest rate is statistically significant in explaining inflation. The VECM was derived and estimated to examine both short-run and long-run relationships among the variables. The results confirmed the existence of a positive but insignificant long-run relationship between unemployment and inflation. The study used the Granger causality test to ascertain the nature of causality among the variables. The research established the presence of unidirectional Granger causality running from core CPI to unemployment. Forecast error variance decomposition shows that large percentages of variations in each variable are attributable to each variable respectively. The empirical findings are helpful to the understanding of the Phillips curve relationship in South Africa and emerging economies in general.

**Keywords:** Phillips curve, inflation, unemployment, cointegration, error correction model

## Declaration and copyright

I, the undersigned Hemish Govera, hereby declare that this dissertation is my own original work and that it has not been submitted, and will not be presented at any other university for a similar or any other degree award.

Signature:

A handwritten signature in black ink, appearing to read 'Hemish Govera', written over a horizontal line.

Date: 2 October 2017



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I am eternally grateful to God Almighty for enabling me to complete this research.

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## List of abbreviations

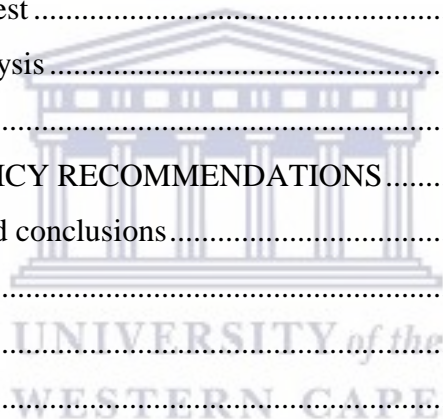
ADF	augmented Dickey-Fuller
AR	autoregressive
ARDL	autoregressive distributed lag
BLUE	best linear unbiased estimator
CPI	consumer price index
DOLS	dynamic ordinary least squares
ECM	error correction model
DSGE	dynamic stochastic general equilibrium
FEV	forecast error variance
GMM	generalised method of moments
IRF	impulse response function
LSTR	logistic smooth transition regression
MTAR	momentum threshold autoregressive model
NAIRU	non-accelerating inflation rate of unemployment
OLS	ordinary least squares
PC	Phillips curve
PP	Phillips-Perron
SARB	South African Reserve Bank
SVAR	structural vector autoregressive model
VAR	vector autoregressive model
VECM	vector error correction model

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# CHAPTER 1

## INTRODUCTION

### 1.1 Background and problem statement

Macroeconomic policy aims to promote economic growth and development, employment creation, improved living standards and equal distribution of income in the society. Achieving the stated macroeconomic goals would maximise a country's social welfare function (Afzal & Awais: 2012). In this context, monetary policy plays a crucial role as a macroeconomic policy tool.

However, there is no consensus on the appropriate conduct of monetary policy to achieve the twin goals of low inflation and low unemployment. Economists and policymakers do not satisfactorily understand the effect of monetary policy on employment creation (Reid & Du Rand: 2014). In the debate, one would normally come across two main contrasting perspectives on how monetary policy conduct influences employment. On the one hand, it is argued that an inverse relationship exists between inflation and unemployment which can be exploited to attain a low unemployment rate. This understanding has its roots in statistical findings by Phillips (1958) who found an inverse relationship between wage inflation and unemployment for England from 1888 to 1954. With subsequent research, the idea was extended to the general relationship between price inflation and unemployment.

The aforementioned findings shaped economic policy for over a decade. In the 1960s, the consensus was that monetary policy could be manipulated or exploited in favour of employment creation. In practice, that meant policy with an overly strict low inflation bias would stifle job creation and increase unemployment. But the traditional Phillips curve relationship broke down in the 1970s with concurrent high levels of both inflation and high unemployment, mainly in the US. Since then, various specifications and formulations of the model have been advanced to improve data fit and empirical application.

On the other hand, it is argued that the main mandate of monetary policy should be monetary and financial stability. From this viewpoint, price stability is regarded as an important precondition for the attainment of economic growth and consequently job creation. The argument justifies the use of inflation targeting as the main monetary policy control mechanism by central banks. Despite

this argument, it is generally accepted that monetary policy does not influence growth and employment in the long-run. In addition, Epstein (2007) argued that inflation targeting is a sub-optimal policy framework which does not consider the impact of monetary policy on unemployment, real wages, and growth.

In the South African context, one can briefly review the trends in the two variables during the period between 1994 and 2015. With the advent of democracy, the new government inherited a stagnant economy characterised by persistent high levels of both unemployment and inflation (Hodge: 2002). Over the period 1994-2015, the annual unemployment rate based on the narrow definition increased from an already high figure of 17% to 25%. The rate has averaged between 20% and 25% over the past 25 years (Vermeulen: 2015). However, the annual inflation rate generally fell over the same time period. With the exception of an 11% annual inflation rate in 2008, the rate has gone down to consistent single-digit figures since 1993. In the argument that low inflation promotes economic growth and subsequently employment creation, such price stability is thought to promote sustainable long-term economic growth and job creation. However, from the trends discussed above, price stability does not seem to help improve the unemployment outlook, which actually deteriorated during the period under study.

Notwithstanding the advances in literature, the kind of correlation between unemployment and inflation remains fiercely debated with few definite answers (Gali & Gertler: 1999). Be that as it may, Vermeulen (2015) contends that both positions discussed above have merit. This empirical study is an objective attempt to determine which of the two views has merit. The findings from the research have implications for optimal monetary policymaking for the country. Monetary policy as a macroeconomic policy tool should be relevant and adaptive to domestic macroeconomic challenges such as unemployment and income inequality. So, it is imperative that policymakers ascertain the optimal use of various policy instruments to maximise societal welfare. For the domestic economy, the question that begs an answer is whether the goals of low inflation and low unemployment are mutually compatible. If they are incompatible, the extent to which they can be optimally substituted one for the other needs to be ascertained and exploited in pursuit of low inflation and high employment. The policy implications are important for a country keen to address poverty, unemployment and income inequality.

## **1.2 Research objectives**

The research has these objectives:

- to review the trends in inflation and unemployment in South Africa over the period 1994 to 2015.
- to test whether the original Phillips curve trade-off relationship existed between unemployment and inflation in the South African economy over the period 1994 to 2015.
- to determine whether higher inflation could contribute to employment creation for South Africa.

## **1.3 Justification for the research**

Unemployment and inflation are key determinants of social and economic welfare in any country. The two constitute a vicious circle that explains the endemic nature of poverty in developing countries (Umaru & Zubairu: 2012). In this context, it becomes imperative to strive for both consistent price stability and low unemployment. In this regard, South Africa adopted inflation targeting in 2002. The understanding was that price stability would translate into opportunities for employment creation, economic growth and poverty alleviation (Mnyande: 2007). However, overall financial stability alone cannot guarantee the achievement of the ultimate macroeconomic objectives by itself (Mboweni: 2000). This is especially true as the country is grappling with high levels of poverty and unemployment despite maintaining single-digit inflation rates. So, the determination has to be made whether the low-inflation-focused monetary policy approach has social costs in terms of unemployment. This research intends to ascertain how monetary policy choices such as inflation targeting have affected other macroeconomic goals, particularly employment outcomes, in the country. This paper's contribution is to help determine whether inflation targeting is an efficient way of addressing social challenges especially the high unemployment the country faces. Monetary policymaking is considered able to strike a balance between price stabilisation and other competing developmental roles (Epstein: 2007).

## **1.4 Structure of the research**

The research is divided into six chapters; the introduction, stylised facts on inflation and unemployment in South Africa, the literature review, the methodology, research findings and the conclusion. Chapter 1 introduces the research. Chapter 2 outlines the stylised facts on inflation and unemployment in South Africa, focusing on the period 1994-2015. Chapter 3 presents an overview and describes the evolution of the Phillips curve theoretical and empirical literature. Chapter 4 discusses the theoretical model and develops the econometric model for the analysis which is run in Chapter 5. Chapter 5 presents the estimation results and discusses the results. Chapter 6 details the conclusions, the implications of the research findings and policy recommendations.



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## CHAPTER 2

### STYLISTED FACTS ON INFLATION AND UNEMPLOYMENT

#### 2.1 Introduction

There is substantial literature and data on inflation and unemployment pertaining to the domestic economy. Empirical observations as well as inferences have been generated on the two variables over the years. This chapter focuses on empirical facts and key properties of unemployment and inflation over the period 1994-2015. The first part of the chapter traces how the domestic monetary policy evolved over the same period. The second part presents stylised facts and recent developments in inflation and unemployment dynamics in the economy. The remainder of the chapter discusses the general interaction between the two variables. The last part is the conclusion.

#### 2.2 The evolution of monetary policy in South Africa

Over the recent years, domestic monetary policy has generally transitioned from direct control to market-related monetary policy measures. From the 1980s, the evolution of monetary policy can be classified into three broad monetary policy frameworks. First, following on the recommendations of the De Kock Commission, the central bank adopted explicit monetary growth targets in 1986. This monetary policy regime was in effect until 1998. In this monetary system, the Reserve Bank manipulated short-term interest rates to achieve pre-announced monetary targets. The bank discount rate was used to influence the overnight collateralised lending rates and, ultimately, market interest rates. The bank also conducted open-market operations to manipulate liquidity in the economy. In the 1990s, money supply targets became ineffective due to financial liberalisation and other structural developments which altered the monetary transmission mechanism (Casteleijn: 2000). As such, monetary targets were subsequently supplemented by the following indices; the exchange rate, balance of payments, output gap, asset prices, fiscal stance, and total credit extension and wage settlements.

Second, in 1998, the central bank signaled the intention to switch to a more eclectic monetary policy approach. A new monetary accommodation system was introduced in which liquidity was determined through daily tenders and repurchase transactions. The new system retained pre-announced M3 targets though with less emphasis. According to Vermeulen (2015), the monetary policy framework enjoyed significant success.



Lastly, a crucial development in monetary policymaking was the switch to the inflation targeting monetary policy regime<sup>1</sup>. The aim was to improve central bank policy transparency and accountability to help manage inflation expectations (Muellbauer & Aron: 2001). Both the South African Reserve Bank Act<sup>2</sup> and the Constitution of the Republic of South Africa<sup>3</sup> mandates the central bank to maintain financial stability as the primary or main strategic objective. Both acts emphasise currency protection to sustain economic growth (Mboweni: 2000). Under the inflation targeting regime, the central bank pursues one main monetary policy objective: to achieve and maintain domestic monetary and financial stability. In that regard, monetary policy is tasked with keeping inflation low and stable which is conducive to overall economic stability.

In the current inflation targeting monetary policy framework, the targeted economic variable is the headline CPI which is set by the government through the Cabinet (Kumo: 2015). Currently, the annual rate of inflation excluding interest payments on mortgages has to be maintained within a target band of 3% to 6%. It is believed that an inflation rate within this range is low enough to maintain greater monetary discipline and financial stability. To maintain the inflation rate within target, the Monetary Policy Committee (MPC) keeps track of the factors that influence inflation and manipulates (repo) interest rates. This monetary policy strategy assumes a causal relationship between inflation and the money supply. High inflation is thought to impede optimal growth and raise unemployment levels in the long-term. Hence, controlling money supply is regarded as an intermediate objective in achieving the ultimate goal of controlling inflation. To a great extent, the inflation-targeting regime in the country has been a success. According to Mnyande (2007), inflation targeting has successfully reduced both the inflation rate and inflation expectations to levels below those which would have occurred without inflation targeting. Mnyande (2007) further contends that monetary policy credibility has improved significantly due to inflation targeting.

### **2.3 An overview of inflation in South Africa**

In South Africa, inflation plays a crucial role in the economy (Madito & Khumalo: 2014). It is generally regarded as a monetary phenomenon closely linked to growth in money supply (Molentze: 2000). *Ceteris paribus*, rapid increases in money supply with no corresponding changes in output and in velocity of circulation results in inflation. In South Africa, money supply is

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<sup>1</sup> South Africa adopted inflation targeting in 2002

<sup>2</sup> South African Reserve Bank Act (No 90 of 1989; SARB Act)

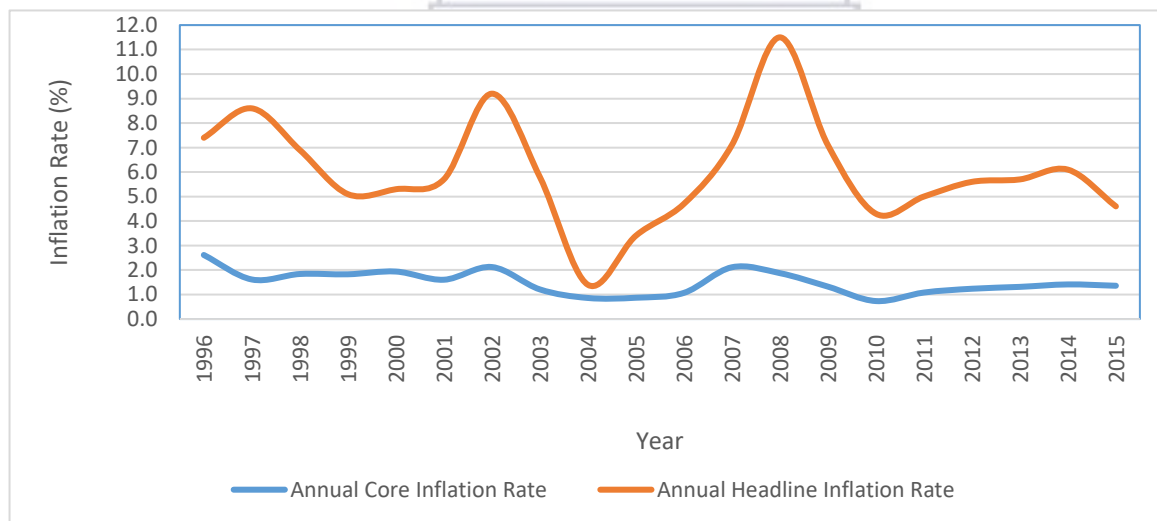
<sup>3</sup> The Constitution of the Republic of South Africa (Act 108 of 1996; Constitution)



associated with changes in the M3 money stock which is the broad definition of money supply. The transmission mechanism in the South African monetary system is similar to that of the main industrial economies (Mollentze: 2000). It is assumed that expansionary monetary policy stimulates the economy and *vice versa*. To aid our research, we need to discern key trends in the variables during the period under study. Figure 2.1 traces the evolution of both annual core and headline inflation in the period from 1994 to 2015.

The core inflation rate, as can be noted from the figure and as can be expected, was generally low and more stable than headline inflation for the whole period under review. Overall, the variable fell from 2.6% in 1997 to 1.4% in 2015. It averaged roughly 1.5% in the same period. There are no significant upswings or downswings in the variable in the whole period. Over the period under study, trends in the core inflation rate mirrored trends in headline inflation though at modest values. Despite notable peaks in 2002 and in 2008, headline inflation generally declined during the period under review. The variable fell from 8.6% in 1997 to end at 4.7% in 2015. It averaged 7.9% in the period under study.

Figure 2.1: Annual inflation rate in South Africa, 1994-2015



Source: Statistics South Africa (2016)

Notably, the annual headline inflation rate troughed at 1.4% in 2004 and peaked at 11.5% in 2008. The onset of the decline in inflation coincided with the attainment of multiracial democracy and

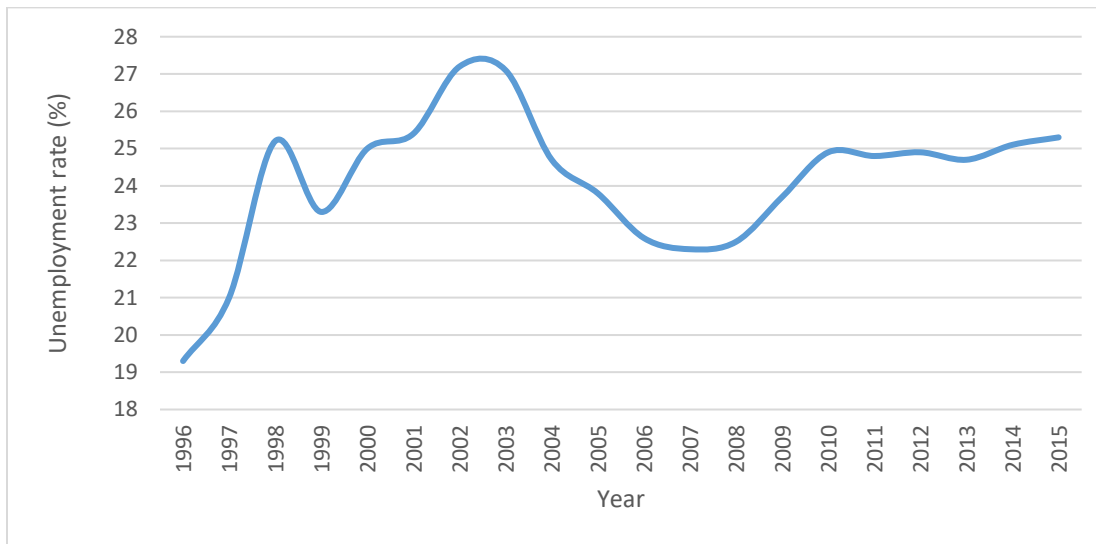
the reintegration of the domestic economy into international financial markets. Reintegration brought along pressure for the government to align the domestic inflation rate to that of its trading partners. That, partly, explains why monetary policy focus shifted to the defence of the domestic currency value in the late 1990s. The headline inflation rate increased from 5% in 1999 to 9.2% in 2002 before falling to reach its lowest figure of 1.4% in 2004. Thereafter, it increased rapidly to peak at 11.8% in 2008. The increase is linked to the 2006 financial crisis impact on the South African economy. Afterwards, the inflation rate consistently stayed close to 6% on average, mainly due to the central bank's monetary strategy to keep it within the target band of 3% to 6%. The only exception is the 2007-08 spike attributable to the financial crisis.

## **2.4 An overview of unemployment in South Africa**

The domestic economy is characterised by one of the worst labour market performances compared to other countries. In the country, unemployment is higher among the rural, female, uneducated, and young proportions of the population. Contributing to the high unemployment levels are structural factors. The South African economy is experiencing skills-biased technological changes and the production process is undergoing capital intensification. This increases the demand for skilled labour and reduces the demand for unskilled labour. Consequently, high unemployment persists especially among young African labour market participants (Kingdon & Knight: 2001).

Figure 2.2 below traces the evolution of unemployment as narrowly defined for the period 1994 to 2006. Considering actual figures, the unemployment rate has been persistently high. The rate averaged roughly 25% for the past 20 years without any noticeable decline (Vermeulen: 2015). Overall, the unemployment rate increased from 19.3% in 1994 to 25.3% in 2015. The unemployment rate increased rapidly from 19.3% in 1996 to 25.2% in 1998. This increase was briefly reversed in 1999 when it fell to 23.3%, after which a new sharp rise – up to 27.2% – took place in the period 1999-2002. After that it generally levelled at a stubbornly high average of 24% for the rest of the period under study.

Figure 2.2: Annual unemployment rate in South Africa, 1994–2015



Source: Statistics South Africa (2016)

Another key determinant of unemployment during the period under review is domestic labour market rigidities<sup>4</sup>. Whilst affirmative action initiatives aim to address historical economic imbalances, they inadvertently create new forms of restrictions on occupational mobility and employment opportunities (Mahlangu & Barreto: 2011). The same applies to 2011's proposed amendments to the labour laws.<sup>5</sup> The aim is to protect workers against exploitation. However, if passed, the legislation would contribute to labour market complexities, thereby discouraging employment. This is also true for the high level of labour union power in South Africa that also presents institutional barriers to labour mobility.

Macroeconomic and economic growth policies are also fundamental for employment growth. It has been asked whether South Africa has experienced jobless growth in recent years. Jobless growth refers to periods of economic growth during which absolute unemployment levels are either stagnant or falling. Jobless growth also refers to general economic growth that is accompanied by rising unemployment rates. To determine whether the domestic economy was able to generate new jobs at the pace required by the rapid increase in the size of the labour force between

<sup>4</sup> Examples include initiatives such as affirmative action (AA) and Broad-Based Black Economic Empowerment (BBBEE).

<sup>5</sup> Labour Relations Act (LRA), the Basic Conditions of Employment Act (BCEA) and Employment Equity Act (EEA).

1995 and 2015, three measures were computed and interpreted: the target growth rate, the actual growth rate and the employment absorption rate. The target growth rate is a measure of how fast employment would have had to expand so as to provide work for all the net entrants to the labour market between two periods. The actual growth rate captures the growth rate of the number of people employed between the two periods. The absorption rate traces the proportion of the new labour market entrants that gets employed during the period.

In the period 2008-2015, the target growth rate was roughly 29%. The actual growth rate was a low 8% with the employment absorption rate at 27%. The finding suggests that the absolute employment level was stagnant or falling with the increase in economic growth. Simply put, the economy did not generate enough jobs, as shown by the low employment absorption rates during the period under review. These calculations support the finding by Burger & Woolard (2005) that the economy has been unable to generate employment at a pace that keeps up with the growing labour force rate over the years. The calculations also support the findings by Borat & Hodge (2009) that the rate of job creation to be less than the growth of the labour force.

### **2.5 Inflation and unemployment dynamics: 1994-2015**

We can ascertain the nature of correlation between price inflation and unemployment by calculating the correlation coefficient measure ( $r$ ). In the study, we calculate this measure for the three variables and present the output in Table 2.1 below. The analysis computes five-year-period averages between 1996 and 2015 and an overall average for the whole period, from 1996 to 2015.

Table 2.1: Correlation between inflation and unemployment, 1996-2015

Year	Unemployment and headline inflation rate	Unemployment rate and core inflation rate
	Correlation coefficient ( $r$ )	Correlation coefficient ( $r$ )
1996-2000	-0.61	-0.53
2001-2005	0.80	0.71
2006-2010	-0.51	-0.78
2011-2015	-0.35	0.57
1996-2015	-0.26	-0.38

Table 2.1 presents data on the correlation coefficient between unemployment and inflation. The measure suggests a strong association between the two from 1996 to 2010. The relationship was strong and negative in the period 1996-2000 and turned strong and positive in the period 2001-05. The relationship reverted to strong negative in the five-year period 2006-10. In the period 2011-15, the relationship turned negative and weaker between headline inflation and unemployment. In the same period, the relationship between core inflation and employment was mild and positive. The interaction between unemployment and both core and headline inflation was mild and negative for the overall period under study. The relationship appears stronger for core inflation and unemployment compared to headline inflation.

The study also computed the correlation coefficient for the three series in the pre-inflation targeting and the post-inflation targeting periods. An average measure for the whole period under study was also computed. Table 2.2 presents the results. The measure for core inflation and unemployment was found to be -0.38. For the correlation between headline inflation and unemployment, the measure was -0.26. Both values suggest a generally mild and negative relationship during the period under study. When analysed with regard to each of the two periods, there was a stronger negative relationship between the variables in the pre-targeting period. The relationship turned weak though negative in the post-targeting period. We also see a mild tough consistent negative correlation between unemployment and both core and headline inflation for the overall period under study.

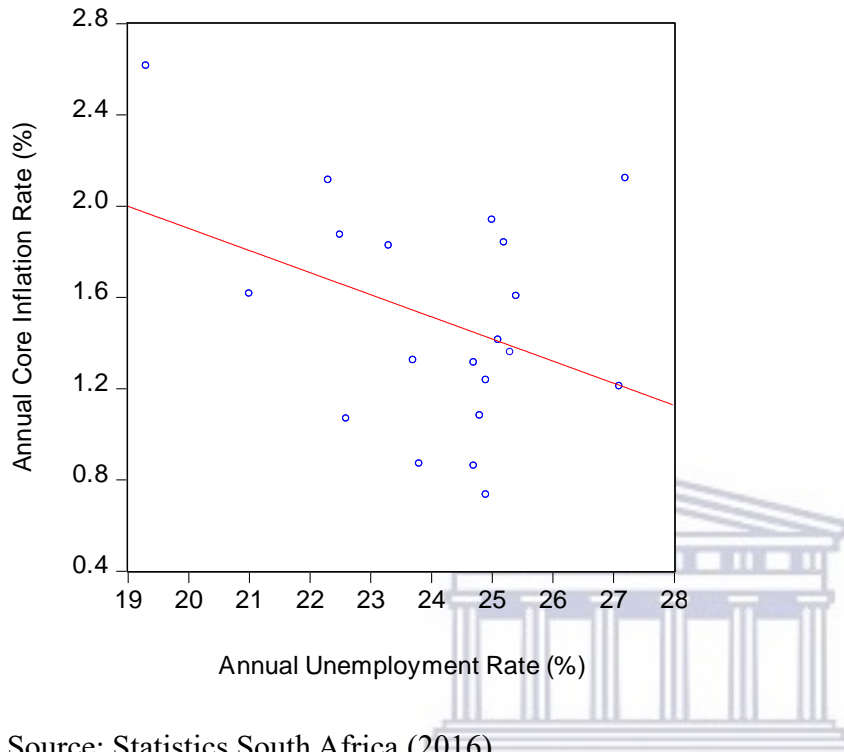
Table 2.2: Correlation between inflation and unemployment by period – pre-inflation targeting and post-inflation targeting

Year	Unemployment and headline inflation rate	Unemployment rate and core inflation rate
	Correlation coefficient (r)	Correlation coefficient (r)
1996-2002 (pre-targeting period)	-0.65	-0.61
2003-2015 (post-targeting period)	-0.10	-0.06
1996-2015 (overall)	-0.26	-0.38

The study proceeds to generate data plots to represent the relationships among the variables over time graphically. Plotting the data also helps discern how the two variables interact during the

period under study. Figure 2.3 displays a scatter plot of the core inflation and unemployment data for the period 1994-2015.

Figure 2.3: The relationship between core inflation and unemployment, 1994-2015

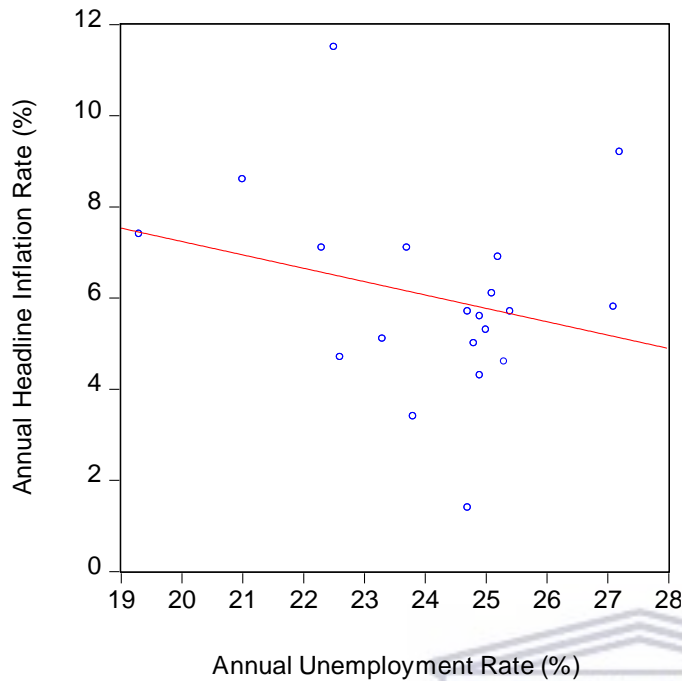


Source: Statistics South Africa (2016)

From the figure, we can fit a straight line through the data implying a linear correlation between the variables. The data points are not scattered about the line, suggesting that the relationship between the variables was mild. The fitted line slopes negatively, hinting at a negative association between the variables.

The scatter plot in Figure 2.4 presents the scatter plot for annual headline inflation and unemployment over the same period. The plot reveals a negative and mild linear relationship between the two variables. The relationship between unemployment and core inflation appears stronger compared with the unemployment and headline inflation. The finding implies that there is a trade-off relationship between the two. In theory, policymakers could target among several combinations of the two macroeconomic variables.

Figure 2.4: The relationship between headline inflation and unemployment, 1994-2015



Source: Statistics South Africa (2016)

## 2.6 Conclusion

To provide context to the research, this chapter detailed the developments in monetary policy during the period under study. Monetary policy in South Africa has generally evolved from direct control measures to market-related measures. An important development in the evolution of monetary policy was the switch to inflation targeting in 2002. The chapter also presented stylised facts on inflation and unemployment during the period 1994-2015. The analysis of historical inflation and unemployment information guides one in formulating crucial links between the two variables. During the period under review, trends in the variables hint at the existence of a negative relationship between them. This is corroborated by the negative coefficient of correlation between unemployment and both core and headline inflation for the period under review. Scatter plots of both core and headline and annual unemployment data for the same period suggests a negative though mild association between the two variables.



## CHAPTER 3

### LITERATURE REVIEW

#### 3.1 Introduction

This chapter traces the evolution of the Phillips curve theory through its history. The literature review section is organized as follows: the initial part of the chapter narrates the evolution of the Phillips curve theoretical literature. The section details the historical development of the Phillips curve theory. The remainder of the chapter discusses the empirical literature. That section is divided into three subsections with the first subsection reviewing the empirical literature on developed economies, the second discussing the empirical literature on emerging economies and the last subsection focusing on the domestic experience.

#### 3.2 Evolution of theoretical literature on the Phillips curve

Theoretical and empirical literature on the Phillips curve dates back to the 1950s. The literature has evolved with variations and formulations added over the years. The traditional Phillips curve relationship collapsed in the 1970s. Since then, completely new formulations have been advanced to fit empirical evidence.

##### 3.2.1 Phillips's basic correlation

Pioneering work on the Phillips curve relationship is largely attributed to Phillips (1958). He studied England's wage inflation and unemployment data for the period 1861 to 1957 and, through this study, discovered a negative relationship between the variables. Samuelson and Solow (1960) analysed the relationship between US price inflation and unemployment data for the period 1913-1957. The research found a similar negative relationship between the two variables. The model depicting this relationship was named the Phillips curve. The model made sharp predictions regarding inflation and unemployment trade-off within the Keynesian framework. The policy prescription was that monetary policy could be used to achieve appropriate pairs of socially desirable inflation-unemployment outcomes. Importantly, this implied that policymakers had a menu of policy choices. Governments could choose to keep inflation low at the expense of high unemployment. Conversely, expansionary monetary policy could be used to achieve low unemployment levels.



However, economic events in the US economy in the 1970s undermined the predictions and recommendations of the Phillips curve model. Oil shocks resulted in high inflation and, according to the Keynesian model, unemployment was supposed to fall. In fact, stagflation ensued and the period had the highest unemployment rates since the 1940s. The apparent prediction failure was one of the reasons why Lucas & Sargent (1978) among other economists, regarded the Keynesian model as unable to offer reliable guidance in formulating any type of policy. In light of the empirical shortcomings of the traditional PC model, neo-classical economists like Lucas, Sargent and Wallace, monetarists like Friedman and Cagan, and neo-Keynesians, like Fischer, Phelps and Taylor, proposed variations and additions to the traditional Phillips curve model.

### **3.2.2 Friedman's monetarist insight**

Friedman (1968), argued that the Phillips curve model was mis-specified. Friedman's approach provided a key theoretical insight that in labour markets, nominal wages are relatively high in relation to price inflation when excess demand for labour is large, and *vice versa*. Friedman reasoned that monetary policy can only influence unemployment temporarily. For instance, in pursuing the goal of low unemployment through monetary expansion, a lower interest rate would stimulate spending, raise labour productivity, and increase employment and output in the short-term. Friedman argued further that prices would rise before wages do, thus lowering real wages. This prompts demand for nominal wage increases by workers. Ultimately, increases in nominal wages and accumulated price increases would match. The real wage would increase such that unemployment is always at its natural rate or NAIRU<sup>6</sup>. NAIRU refers to an unemployment rate consistent with maintaining a stable inflation rate. Friedman concluded that the prediction of an exploitable inflation-unemployment trade-off would only hold temporarily, not permanently (Fuhrer, Kodrzycki, Little & Olivei: 2009).

### **3.2.3 Phelps's contribution**

Phelps (1967) used the adaptive expectations framework to derive the accelerationist Phillips curve model. The model posits that unemployment and inflation are independent in the long-run. Rather, the relationship between the unemployment rate ( $u$ ) and changes in the inflation rate ( $\pi$ ) is formulated as below:

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<sup>6</sup> Non-Accelerating Inflation Rate of Unemployment

$$\pi_t = \pi_t^e - au_t = \pi_{t-1}^e - au_t$$

$$\Delta\pi_t \equiv \pi_t - \pi_{t-1}^e - au_t$$

In the model, workers respond to real wages and real wages always adjust to keep labour demand and supply equal. Unemployment would always return to its natural rate associated with a certain real wage rate. Inflation expectations are formed adaptively,  $\pi_t^e = \pi_{t-1}$ . That means workers formulate future inflation expectations based on previous period inflation. If workers cannot correctly anticipate price increases, real wages will fall due to the unexpected increase in inflation. Firms' demand for labour will increase and consequently employment increases.

Incorporating adaptive expectations in the Phillips curve theory changed perceptions regarding the effectiveness of government actions in both the Keynesian and monetarist frameworks. Considering adaptive expectations, Keynesians view the role of money illusion as dominant with changes in nominal variables construed by economic agents as real despite there being no change in purchasing power. Monetarists assume that with adaptive expectations, people can be fooled by government actions but will eventually anticipate and adjust their economic behaviour accordingly, based on past experiences. For instance, with expansionary monetary policy, inflation would increase and unemployment would fall. With time and experience, workers would begin to notice the vicious circle between higher salaries and inflation. Ultimately, workers would anticipate that inflation drains their purchasing power, so monetary policy would have little effect on unemployment. Both Phelps and Friedman concluded that the government cannot permanently trade higher inflation for lower unemployment. With adaptive expectations, unemployment always tends to its natural rate in the long-run.

### 3.2.4 The “Lucas critique”

The “Lucas critique” factored in rational expectations in modelling inflation dynamics. The model assumes that economic agents have perfect information. Markets are assumed to be perfect and tend towards equilibrium. Under the stated assumptions, people come to know the model of the economy that the policymakers use, so policymakers cannot persistently fool them. If workers anticipated higher inflation, they would demand wage increases. Hence, for money supply to influence unemployment, the increase has to be unpredictable or more than expected. In the long-

term, the effect would be higher inflation but not lower unemployment. The Phillips curve relationship would break down as high unemployment and high inflation can co-exist in this case. A trade-off would only happen if the monetary policy action to increase inflation is not expected by the workers. The Lucas (1976) approach was widely criticised in the late 1970s for assuming that markets continuously clear and that there is perfect information. These assumptions are not empirically relevant (King & Watson: 1994).

### **3.2.5 Sargent and Wallace policy ineffectiveness proposition**

Neo-classical economists Sargent and Wallace (1975) argued the policy ineffectiveness proposition under which governments cannot intervene to influence real output. With rational expectations, monetary policy is ineffective in influencing employment in the economy. The reasoning is that if the monetary authorities expand money supply, economic agents would foresee the effects and revise wage and price expectations accordingly. The approach better explained why attempts to cure the stagflation in the 1970s using Keynesian prescriptions were to a large extent counterproductive and ineffectual.

### **3.2.6 The New Keynesian Phillips curve model (NKPC)**

Taylor (1980), Calvo (1983) and Fischer (1997), as discussed by Kiley (1997), argued that short-term inflation dynamics are better modelled through price rigidities within the NKPC framework. The NKPC model links price inertia, inflation, and changes in the real economy by relating inflation to capacity use or production costs. When prices are sticky, firms may adapt their production and employment levels in tandem with changes in monetary policy. In that way, the theory relates inflation, firms' expectations regarding future inflation, real marginal costs, and firms' marginal costs. Inflation rises through increases in real marginal costs which firms pass on to consumers translating into higher prices. Inflation also results when expectations regarding future inflation rise and firms raise current prices of output. The associated Phillips curve is negative in the short-run. Being micro-founded, NKPC was regarded as theoretically superior and hence was widely accepted. As a result, it became the "standard specification" in modelling unemployment and inflation dynamics (Du Plessis & Burger: 2006).

Despite a strong theoretical basis, many studies have shown that the NKPC predictions do not

conform to empirical evidence, raising serious questions about the model's use for practical policymaking. Ball (1991) disputed the NKPC implication that the Reserve Bank's commitment to a lower inflation target would raise output relative to potential and cause sudden disinflation. Empirically, disinflation usually occurs gradually, along with increased unemployment, slack growth, and recessions as in the US economic slowdown of the 1980s (Dennis: 2007). Estrella & Fuhrer (2002), as discussed by Dennis (2007), argued that empirical data does not show any links between real marginal costs, inflation and expectations. Notably, the NKPC cannot explain the hump-shaped response of US inflation to shocks. The NKPC incorrectly assumes that price stickiness translates into inflation stickiness, contrary to what has been observed empirically (Fuhrer & Moore: 1995). Mankiw (2001) concluded that the NKPC is inadequate and is not empirically valid, which renders it fundamentally flawed. The model can't explain the dynamic effects of monetary policy on inflation and output (Mankiw: 2001). Reid & Du Rand (2013) also criticised the NKPC for failure to model the dynamic impact of monetary policymaking on the economy.

In response to criticism, the NKPC was extended to hybrid specifications in which inflation outcomes depend on forward dynamics and backward dynamics (expected future inflation and lagged inflation). New hybrid specifications that brought together price rigidity and information rigidity improved empirical data fit. Christiano & Eichenbaum (2005) extended the Calvo model to give the standard specification of the hybrid Phillips curve. Building on the Calvo model, Christiano and Eichenbaum argued that firms that do not initially set their prices optimally would rely on lagged inflation to adjust their prices.

In addressing the criticisms levelled against the NKPC, Dennis (2006) developed a hybrid NKPC model drawing on both price rigidity and information rigidity. The model assumes that a proportion of firms can update prices while the rest of the firms cannot update their prices in each period. Of the firms that are able to update their prices, a random proportion set their prices optimally and the rest use lagged inflation data to index their prices. The proportion of firms that could update their prices depended on "menu costs" – costs borne by firms due to updating their prices – in such a way that the higher the menu costs, the greater the proportion of firms not changing prices during a specified time period. The firms updating their prices also depended in proportion on the costs the firms bear to obtain information needed to set their prices optimally. The higher the costs of this information, the greater the proportion of firms opting for indexation-based pricing. Generally,

hybrid models combining both sticky prices and information performed better when exposed to empirical micro-data analysis (Dennis: 2007).

### **3.2.7 The Gordon triangular model (GTM)**

Gordon (1990) proposed the GTM, which holds that the rate of inflation depends on inertia, supply and demand. The model differs from other models of inflation in that it does not factor the role of wages, employment rates and expectations in inflation determination. GTM directly relates inflation to the level and rate of change in de-trended real output. The model postulates that inflation depend on growth in nominal gross national product (GNP) in excess of potential real GDP. Residual instability in inflation is then attributed to supply shocks.

### **3.2.8 The sticky information Phillips curve (SIPC)**

Mankiw & Reis (2002) proposed the SIPC model. In contrast with the NKPC, the model is based on different microeconomic origins of nominal rigidity – sticky information rather than sticky prices. The model asserts that price inertia is better explained by information rigidity rather than price rigidity. Contrary to the NKPC, the SIPC assumes that information is not perfect or instantaneous. In the model, it is costly for firms to acquire information, so they end up rationing the information they possess. The model assumes that all update prices in each period based on their forecast of inflation. To forecast inflation, a fixed proportion of firms change the information as they receive the latest data, but the remaining share of firms cannot update the information. Under these conditions, production cost shocks pass through to aggregate prices over time due to the time lag before firms recognise that a shock has actually occurred.

### **3.2.9 The neo-classical theory**

The neo-classical approach currently dominates professional thinking about monetary policy (Palley: 2007). The associated Phillips curve has roots in the work of Phelps (1967), Friedman (1968) and Lucas (1976). Under the approach, both money and inflation are veils. Expected monetary policy is neutral in both the short and the long-runs. The associated Phillips curve is formulated below:

$$\pi = f(u-u^*) + \pi^e$$

Where  $\pi^e$  = expected inflation,  $u$  = unemployment rate,  $\pi$  = inflation rate and  $u^*$ = natural rate of

unemployment (NAIRU). In the model, monetary policy influences inflation through nominal interest rates, which then affects nominal demand. Monetary policy can affect unemployment in the short-run only if it is unanticipated. If it is anticipated, it can only affect inflation. In the long-run, monetary policy is fully anticipated, so it can only influence inflation.

In the model, an anticipated permanent increase in money supply results in a movement along the short-run Phillips curves which only raise inflation and lower unemployment. Workers are fooled by the rise in nominal wages and accept jobs, reducing unemployment. The fall in unemployment causes real wages to fall, raising the profit rate. This stimulates investment growth, capital stock accumulation and the growth rate. When workers realise that they were fooled, they operate on the original labour supply curve, which raises both unemployment and real wage rates. Profit rates fall due to previous period over-accumulation of capital stock. Investment falls and, along with it, the growth rate. In the end, the economy reverts to the initial equilibrium level, although with a higher inflation rate on a higher short-run Phillips curve. Ultimately, the vertical long-term Phillips curve holds, with monetary policy affecting only long-run inflation, with no change in unemployment.

Monetarists believe that “inflation is always and everywhere a monetary phenomenon”. The monetarist view is that inflation results from alterations in the supply of money. An increase in the rate of money supply increases the price level in the economy. So, inflation-unemployment trade-off is only temporary due to the neutrality of money in the long run. The associated long-run Phillips curve is steep and vertical, implying that inflation does not have any relationship with unemployment in the long-term. The notion of NAIRU is dismissed outright, as inflation is thought of as being determined by monetary policy, not by unemployment rates. This approach makes sharp predictions for monetary policy. It considers inflation as a “bad” and prescribes that monetary policy should be biased towards maintaining zero inflation rates. This prescription motivates why some world central banks have adopted or contemplate adopting inflation targets.

### **3.2.10 The neo-Keynesian theory**

The neo-Keynesian theory dominated economic theory and policymaking from the 1950s to the late 1970s. The Phillips curve specification under the approach is formulated as below:

$$\pi = f(u) + \lambda\pi^e \quad \text{and} \quad f' < 0, \quad 0 < \lambda < 1$$

Where  $\pi^e$  = expected inflation,  $u$  = unemployment rate,  $\pi$  = inflation rate and  $\lambda$  = coefficient of



inflation expectations which is assumed to be less than unity. The model assumes no natural rate of unemployment hence there is a permanent trade-off between inflation and unemployment.

In the short-run, expansionary monetary policy results in higher inflation and lower unemployment causing real wages to fall and profits to increase. This encourages investment and raises the wage rates. The long-run equilibrium is realised with a lower unemployment rate due to the positive effect of inflation on the demand for capital. In the model, the short-run effect of monetary policy on the real wage is negative and does not have an effect on the long-run growth rate. So the optimal monetary policy depends on societal preferences regarding unemployment and inflation.

### 3.2.11 The post-Keynesian theory

As discussed by Palley (2007), the post-Keynesian approach is based on different microeconomic foundations from the neo-classical and neo-Keynesian models and has its roots in the works of Tobin (1972). The dynamic equilibrium Phillips curve takes the form below:

$$\pi = f(u, \lambda \pi^e) \quad \text{and} \quad f_1 < 0, f_2 > 0, 0 < \lambda < 1, \pi = \pi^e$$

Where  $\pi^e$  = expected inflation,  $u$  = unemployment rate,  $\pi$  = inflation rate and  $\lambda$  = the degree of downward real wage resistance in sectors with unemployment. In the equation if  $\lambda = 1$ , inflation is fully incorporated into nominal wage settlements so it cannot help ease labour market adjustments.

The associated Phillips curve is negatively sloped, suggesting a permanent trade-off relationship in the long-run. This trade-off can be explained in terms of the nature of micro-foundations influencing the inflation rate. If the inflation is demand-pull driven, it helps ease adjustments in the labour market. If it is cost-push/conflict inflation, negative slope stems from the firms' price and workers' wage-setting behaviour. The model implies no natural rate of growth of unemployment. In the theory, the role of monetary policy is critical as it affects the real wage, growth rate, profit rate, inflation and unemployment rates.

### 3.3 Empirical literature review

The previous section chronicled the evolution of Phillips curve theories. The theories have been extensively tested empirically. Researchers employed various econometric models and techniques in both developing and developed countries, with mixed results. This section looks at the empirical research on developed and developing countries, with a separate section for the domestic economy.

### 3.3.1 Empirical evidence on developed economies

Researchers from different economic perspectives such as Gordon (1990), Gali & Gertler (1999), Niasken (2001), Rudd & Whelan (2006), Dennis (2006), Dupor, Kitamura & Tsugura (2006), Sala & Karanassou (2009) and Kitov & Kitov (2013) studied the Phillips curve in developed countries. The countries of study include Spain, Japan, France, Denmark, Austria, Finland, Belgium, Ireland, Greece, Italy, Portugal, the Netherlands, Germany, Sweden, the UK and the US.

Gordon (1990) tested the Gordon triangular model (GTM) on 1970-2006 US inflation and unemployment data. The study found an overall positive but weak correlation between the two variables. Gali & Gertler (1999) undertook a structural econometric analysis of inflation dynamics in the US for the period 1960-97. The study employed GMM estimation of the new hybrid Phillips curve and data on output gap and inflation rates. The finding was that future expected inflation had a predominant role in the inflation-unemployment relationship. The study concluded that neo-Keynesian firm theory-based models provided a good approximation of inflation dynamics.

Niasken (2001) used the autoregressive distributed lag model (ARDL) to study the Phillips curve relationship in the US economy from 1960 to 2001. The research found a negative short-run relationship. However, no evidence of long-run Phillips curve relationship was found. Niasken's findings were corroborated by Reichel (2004), who provided additional evidence that unemployment and inflation were not cointegrated. Reichel's study employed Niasken's ARDL version incorporated into the error correction model (ECM). Reichel analysed inflation and unemployment information for 15 European countries and in North America for the period between 1960-2001. The countries studied were Spain, Japan, France, Denmark, Austria, Finland, Belgium, Ireland, Greece, Italy, Portugal, the Netherlands, Germany, Sweden, the UK and the US. The researcher further famously remarked that the concept of the Phillips curve should be buried as it was totally useless as a policy guideline.

Rudd & Whelan (2006) gathered empirical estimates of the NKPC for the US in the period 1960-2000. The study found that the roles of expected future inflation and real marginal costs were small and insignificant. Furthermore, the study found that inflation was unresponsive to changes in real marginal costs. Rather, lagged inflation was found to be an important determinant of future inflation.



Dennis (2006) empirically tested a hybrid model of the NKPC using US data for the period 1982-2002. The research used likelihood methods to estimate a generalised Calvo-Phillips curve embedded within a dynamic stochastic general equilibrium (DSGE) model. The study found that about 60% of surveyed firms updated their prices every quarter, suggesting that menu costs were low. The study also found that most of those firms that changed their prices used indexation-based pricing, suggesting that information costs were high. The observed higher frequency of price adjustment in empirical micro-data provides a better description of inflation dynamics (Dennis: 2006).

Dupor, Kitamura & Tsugura (2006) worked on and tested empirically a hybrid model which combined elements of both information rigidity and price rigidity. In the model, it was assumed that some firms behave in a manner matching the Calvo price-rigidity model and some as in the Mankiw and Reis information rigidity model. The study used US data for the period 1960-2005. The research found that only about 15% of firms change their prices each quarter. Roughly 60% of the firms that change their prices make the determination using outdated information.

Sala & Karanassou (2009) studied the US economy in the period 1960-2005 using structural vector autoregression (SVAR) and generalised method of moments (GMM) models. The research found evidence of long-run inflation-unemployment trade-off in the US. Ribba (2015) used a structural vector autoregressive model (SVAR) to ascertain what drove US inflation and unemployment between 1960 and 2011. The research found no long-run association between the two.

Kitov & Kitov (2013) researched inflation, unemployment and labour force dynamics in Japan for the period 1980-2003. The research used the traditional Phillips curve approach to make long-term projections of the variables. The study found that increasing unemployment resulted in decreasing inflation, supporting the predictions of the Phillips curve in its original form.

### **3.3.2 Empirical evidence on emerging economies**

Various empirical studies were undertaken on unemployment and inflation dynamics in developing countries. From the empirical research reviewed, Furuoka (2007) looked at Malaysia, Umaru & Zubairu (2012) studied the Nigerian economy and Touny (2013) researched the Egyptian economy. Prasanna & Gopakumar (2011) studied the Phillips curve relationship in India, and Al-Zeaud & Al-Hosban (2015) studied the case of Jordan. Furuoka, Munir & Harvey (2013) looked at the

Philippines. Katria, Bhutto, Butt, Domki, Khawaja & Khalid (2013) studied 14 developing countries; Bangladesh, Russia, Nepal, Afghanistan, India, Bhutan, Maldives, Indonesia, South Africa, Sri Lanka, Iran, China, Myanmar and Pakistan.

Furuoka (2007) used the VECM to study inflation and unemployment dynamics in Malaysia for the period 1973-2004. The research confirmed the existence of a long-run trade-off relationship between the two variables. The study found a causal relationship between the two in Malaysia during the same period.

Umaru & Zubairu (2012) empirically researched the Phillips curve relationship in Nigeria from 1977 to 2009. The study used the Engle-Granger cointegration test as well as the ARCH and GARCH techniques for testing volatility. The research didn't find evidence of the Phillips curve relationship in Nigeria for that period.

Touny (2013) investigated the Phillips curve relationship in Egypt between 1974 and 2011 using the VECM. The research used inflation and unemployment data to test the expectations-augmented Phillips curve theory. The research aimed at ascertaining whether inflation containment policy could reduce unemployment in the long-run. The two variables were found to be cointegrated with a positive relationship between them.

Furuoka, Munir & Harvey (2013) sought to establish whether the Phillips curve relationship existed in the Philippines during the period 1980-2010. The study employed the dynamic ordinary least squares (DOLS) method and the Hodrick-Prescott filter. The research detected a long-run negative and causal correlation between unemployment and inflation in the period under review.

Katria, Bhutto, Butt, Domki, Khawaja & Khalid (2013) researched the nature of the Phillips curve relationship for the period 1980-2010 in 14 countries: Bangladesh, Russia, Nepal, Afghanistan, India, Bhutan, Maldives, Indonesia, South Africa, Sri Lanka, Iran, China, Myanmar and Pakistan. The study used the ordinary least squares method. The research adopted a debt servicing proxy, gross capital formation, real interest rates, inflation rates and unemployment rates as variables. The study found a negative correlation between inflation and unemployment rate in the countries studied. Therefore, the research concluded that the concept of the Phillips curve relationship was true.

Prasanna & Gopakumar (2011) empirically analysed inflation and economic growth in India

between 1972 and 2008. The study used the Phillips-Perron unit root test and the Engle-Granger two-step cointegration test. The analysis discovered a long-run negative relationship between inflation and GDP for the period under study.

Al-Zeaud & Al-Hosban (2015) studied the Jordanian economy empirically to learn whether the Phillips curve relationship existed in the period 1976-2013. The study employed the vector error correction model as well as linear and non-linear ordinary least squares methods. The research found strong empirical evidence of the Phillips curve in Jordan. The relationship between the two was found to be negative non-linear during the period under study.

### **3.3.3 Empirical evidence on South Africa**

The earliest studies on unemployment and inflation in South Africa date back to the 1960s. Du Plessis & Burger (2006) neatly presented the history of this research. The two grouped the empirical literature into two groups. One group comprises researchers who tried to fit non-linear specifications to the data. The group tried to identify phases of the business cycle during which the Phillips curve relationship could hold. This group includes researchers like Strebel (1976), Nell (2000), and Burger & Marinkov (2006). The second group researched the indirect effect through the wage equation determined in the wage-and-inflation system. This group did not consider the direct effect of demand in the inflation dynamics equations. Such researchers include Pretorius & Small (1994) and Fedderke & Schaling (2005).

Early research in South Africa was by Keynesian contributors like Gallaway, Koshal & Chapin (1970), Hume (1971), Truu (1975), Strydom & Steenkamp (1976) and Strebel (1976). The researchers followed Phillips's study closely and investigated the potential trade-off between inflation (nominal wages) and the unemployment rate. The early research generally found a modest and statistically significant trade-off between the two variables. The finding was in line with international theoretical and empirical experience of that time.

Krogh (1967) used the traditional PC approach to study the period 1948-65. The study found a small positive relationship at low levels of inflation. The relationship turned to strong negative at higher rates of inflation. Gallaway, Koshal & Chapin (1970) analysed the period 1948-63 using the distributed lag time series model with deterministic trend of the Phillips curve. The results

indicated a significant negative relationship that suggested a mild trade-off between the two variables. Hume (1971) studied the period 1946-75 using a nine-equation wage-price model. The study found a significant negative relationship, also suggesting a mild trade-off. Truu (1975) used the time series model of the PC and found a highly significant negative effect during the 1948-75 period.

As discussed by Du Plessis & Burger (2006), Strydom & Steenkamp (1976) studied the 1960-75 period using a time series model of the expectations-augmented Phillips curve. The results suggested that in a price equation the output gap is significant for the period 1960-70 but not for 1971-75. In the wage equation, the unemployment rate was significant over 1958-75. Strebel (1976) studied the period 1954-74 using both time series regression and analysis of variance (Anova). The research found that unemployment was significant during periods of rising inflation but not during periods of disinflation.

According to Du Plessis & Burger (2006), Levin & Horn (1987) used the Phillips curve graphs to study the period 1969-85 and found a weaker relationship in the 1970s. The study by Pretorius & Smal (1994) on the 1970-92 period used a time series model of the expectations-augmented Phillips curve. The research found that the output gap had an indirect effect via the wage equation. Nell (2000) researched the relationship between CPI and the output gap in the period 1971-93. The study used the time series model of non-linear expectations-augmented Phillips curve. The results highlighted a significant relationship during a period of accelerating inflation (1971-85) and also during downswings between 1986 and 1993.

Another study of the unemployment rate, employment growth and output gap was conducted by Hodge (2002) for the period 1970-2000. Hodge used the ECM and discovered that the relationships were either perverse or insignificant. Federer & Scaling (2005) used the VECM to study the relationship between GDP deflator and output gap. The researchers did not find any significant direct effect, but an indirect channel via the adjustment of unit labour costs to its long-run equilibrium.

Burger & Marinkov (2006) used the Gordon triangular model to study the relationship between output gap and CPI between 1976 and 2002 in the South Africa. The study was one of the first to estimate a version of the neo-Keynesian Phillips curve. It found no evidence of inflation-unemployment trade-off and also found little evidence of output gap effect.

Du Plessis & Burger (2006) researched the evidence of the NKPC in South Africa for the period 1975-2003. The research used the hybrid version of the model and the output gap and expected future inflation as variables. The conclusion was that NKPC is not a good approximation of South African inflation dynamics. The generalised method of moments econometric approach was found to be a better fit for South Africa.

Burger & Marinkov (2006) sought to establish whether the Gordon model of Phillips curve could be applied to the South African economy. The study used data on inflation gap and output gap for the period between 1976 and 2002. The research found no evidence of inflation and unemployment trade-off. Chicheke (2009) studied the relationship between monetary policy and unemployment in South Africa for the period 1980-2008 using the VECM. The dissertation found no long-run trade-off between the two.

Reid & Du Rand (2014) attempted to fit the SIPC to inflation and unemployment data on the South African economy for the period 1995-2010. The research used inflation expectations and output gap as variables. The study employed the Dickey-Fuller test, the Hedrick-Prescott filter application and the Kalman filter estimation. The research estimated a VAR model using the generalised least squares econometric procedure. The study could not determine whether the SIPC or the NKPC better approximated the domestic economy. The reason for that were various data and estimation issues encountered with the macroeconomic surveys that were conducted.

Phiri (2015) used the logistic smooth transition regression (LSTR) and the momentum threshold autoregressive (MTAR) models to examine the asymmetric effects in the domestic economy. The study looked at the period 1970-2014 to test the neo-classical, the neo-Keynesian and the hybrid neo-Keynesian Phillips curves. One of the findings was that marginal cost-based as well as output gap-based versions of the hybrid neo-Keynesian PC provided a good fit for South African data. The empirical results indicated that monetary policy in South Africa had an influence on the demand side of the economy through inflation inertia and inflation expectations while appearing to exhibit no significant effects on the supply side of the economy.

### **3.4 Conclusion**

The Phillips curve theoretical framework has evolved down the years. Pioneering the study, Phillips, Solow and Samuelson found a reasonably reliable correlation between unemployment and

inflation. The finding implied the existence of an exploitable trade-off which monetary policy could exploit. In contrast, Friedman and Phelps pointed out various mechanisms through which monetary policy only impacts unemployment in the short-run, and not in the long-run. The understanding was developed further, with Lucas, Sargent and Wallace incorporating rational expectations into the analysis. Sargent and Wallace deduced that monetary policy can only influence unemployment if it is unpredictable and if inflation responds instantaneously to market-clearing price changes. The most recent theoretical developments of the Phillips curve have focused on the analysis of market imperfections like price rigidities in the NKPC and information stickiness in the SIPC.

The results from reviewed empirical research are varied. A review of the literature indicates that the Phillips curve relationship is not well defined in developed countries. With the exception of Japan, various studies found no relationship between the two variables in various developed countries. Niasken (2001) and Reichel (2004) completely denied the existence of any inflation-unemployment trade-off. Niasken studied the US economy and Reichel expanded the analysis to other industrialised countries. Using cointegration techniques, none of them found any evidence of unemployment and inflation trade-off.

Empirical literature confirmed the existence of the Phillips curve relationship in developing countries for example Jordan, the Philippines and Malaysia. However, recent studies on the inflation/unemployment relationship in South Africa have not been conclusive. Variations of the Phillips curve theory such as the GMT, NKPC and the SIPC, although theoretically superior, have not been successful in explaining inflation dynamics in the South African context. Researchers generally found a modest though statistically significant negative relationship between the two variables especially in the 1960s (Reid & Du Rand: 2013). The relationship was less stable, as evidenced by the occurrence of stagflation in the 1970s. More recent studies generally found no significant relationship between the two variables since the 1970s. Most recently, studies in South Africa also did not find a long-run Phillips curve relationship. The empirical literature suggests that economists have not been able to determine the nature of the Phillips curve relationship for South Africa.

There are apparent limitations to reviewed research, which are both theoretical and empirical.



Despite fitting South African data reasonably, as found by Phiri (2015), NKPC models are generally unable to match the observable reality (Mankiw: 2001, Reid & Du Rand: 2013). Dennis (2006) argued that neo-Keynesian business cycles are inconsistent with both time series and micro-data on inflation and on the frequency of price changes. Also, the Calvo pricing model is inconsistent with both inflation data and micro-data on the frequency of price updates (Dennis: 2009). Du Plessis & Burger (2006) argue that despite extensive research undertaken to date, it is difficult to find a Phillips curve matching both theory and the South African empirical experience. Hodge (2002) summarised evidence from South African literature and concluded that there is little evidence of trade-off between the two variables. The literature review information has been summarised as a table in Appendix A.

Despite advances in theory and empirical research, the debate regarding how monetary policy influences labour market performance continues to be a central theme in macroeconomics. It is in the light of the lack of conclusive results in the South African context that this research seeks to contribute to the debate. This research takes a crucial step of estimating a VECM model using quarterly data. The study adopts core inflation data as a proxy for inflationary pressure. This is unlike previous studies that mainly incorporated headline inflation into the analysis. The core inflation measure is widely regarded as a better guide for both current and future policy than headline inflation rates. It is also less volatile, so it is regarded as representing the inflation that is most controllable by policy. The adoption of error correction modelling allows the research to trace the dynamic interactions between the variables. The methodology has been used successfully in studies in other developing countries, for example the Philippines, Malaysia, Egypt and Sudan. The approach overcomes the shortcomings of other methodologies that do not separate long-run and short-run dynamics in the analysis.

## CHAPTER 4

### METHODOLOGY

#### 4.1 Introduction

This chapter discusses the methodology used for the study. The first part details the theoretical model that informs the model estimation. The second part develops the empirical model to be estimated. It also explains the preliminary data analysis process, data manipulation techniques and statistical procedures to be applied to the data. The following section defines the variables and explains the data sources. The last section discusses the merits and limitations of the adopted methodology. Finally, the chapter closes with a conclusion.

#### 4.2 The theoretical model

From the theoretical literature reviewed in the last chapter, the NKPC is theoretically superior, making it attractive as the basis modelling. Hence, the study adopts a Fanelli (2005) hybrid formulation of the NKPC. In the model, the inflation rate depends on the expected future values of inflation rate, lagged inflation and a vector of driving variables. The model can be formulated in its structural form as:

$$\pi_t = \gamma_f E_t \pi_{t+1} + \gamma_b \pi_{t-1} + \lambda' x_t + u_t$$

where  $\pi_t$  is the inflation rate at time  $t$ ,  $E_t \pi_{t+1}$  is the expected value at time  $t$  of the inflation rate prevailing at time  $t+1$ ,  $x_t$  is the vector of explanatory variable(s),  $u_t$  is a disturbance term and  $\gamma_f$ ,  $\gamma_b$ , and  $\lambda$  are structural parameters with  $\lambda$  as a vector. In the model specification, we follow Stock and Watson (2001) and formulate the vector  $x_t$  to consist of the two driving variables; the unemployment rate and the repo interest rate. In the model, the *a priori* expectation is that;  $\gamma_f \geq 0$ ,  $\gamma_b \geq 0$ ,  $\lambda > 0$  and  $\gamma_f + \gamma_b \leq 1$ .

#### 4.3 The empirical model

The theoretical model described in the previous section guides the research in formulating the empirical model. The study employs the following econometric procedures; the Augmented Dickey-Fuller (ADF) unit root test, the Johansen cointegration test, the VAR model and the VECM. The study also develops the methodology for model diagnostic tests, the Granger causality test, impulse response function analysis and forecast error variance decomposition.



### 4.3.1 Unit root test

A crucial step in setting up an econometric model is determining the integration properties of the data series. As the norm in econometric research, unit root tests are used to determine stationarity properties of time series data. The tests help ascertain whether data is integrated and the order of integration. The need to run unit root tests is motivated by economic theory. Economic theory postulates that statistical modelling and inference using integrated variables could lead to non-standard distributions and perhaps spurious regression results. Importantly, checking the stationarity properties informs on the possibility of long-run cointegrating relationships among the variables.

In performing the unit root tests, the study uses the ADF test. According to Enders (2015), three different regression equations can be used to test for the presence of a unit root:

$$\Delta y_t = \gamma y_{t-1} + \sum_{i=2}^p \beta_i \Delta y_{t-i+1} + \varepsilon_t$$

$$\Delta y_t = a_0 + \gamma y_{t-1} + \sum_{i=2}^p \beta_i \Delta y_{t-i+1} + \varepsilon_t$$

$$\Delta y_t = a_0 + a_2 t + \gamma y_{t-1} + \sum_{i=2}^p \beta_i \Delta y_{t-i+1} + \varepsilon_t$$

The first equation is a pure random walk model, the second adds an intercept, and the third includes both a drift and a linear time trend. The difference in the three equations concerns the presence of the deterministic elements  $a_0$  and  $a_2 t$ . The ADF test involves estimating one or more of the equations above using OLS in order to obtain the estimated value of  $\gamma$  and the associated standard error.

The parameter of interest in all the three regression equations is  $\gamma$ . If  $\gamma = 0$ , then the  $\{y_t\}$  sequence contains a unit root. Comparing the resulting  $t$ -statistic with the appropriate value reported in the results allows determination whether to accept or reject the null hypothesis  $\gamma = 0$ . The decision rule is to reject the null hypothesis if calculated  $t$ -statistics are greater than the critical ADF  $t$ -statistics. Or, if the obtained  $p$ -value is less than the specified significance level. In doing the tests, caution is taken in case the data series is exponentially trending. In such a case the data series would be logged before differencing. Stationary differences of the log of the series would then be used and not just the differences of the series.

### 4.3.2 The VAR model

Once the order of integration has been ascertained, we proceed to formulate the VAR model. The first step in the process is choosing the optimal lag length. The lag length for our VAR( $p$ ) model is determined using the model selection criteria. The general approach is to fit VAR( $p$ ) models with orders  $p = 0, \dots, p_{max}$  and choose the value of  $p$  which minimises some model selection criteria. The most common information criteria are the Akaike (AIC), Schwarz-Bayesian (BIC) and Hannan-Quinn (HQ). The study computes the lag length for these criteria; the FPE, AIC, SC and HQ. The study chooses the lag length that minimises the Akaike information criteria (AIC):

$$AIC(p) = \ln |\tilde{\Sigma}(p)| + \frac{2}{T}pn^2$$

where  $T$  is the sample size,  $n$  is the number of variables and  $p$  is the number of lags. We rely on Liew (2004) who found that Akaike's information criterion (AIC) minimises the chance of under-estimation while maximising the chance of recovering the true lag length.

With the optimal lag length determined, the next step is formulating the VAR model. A standard VAR model can be estimated if all the variables are found to be stationary. In instances where the variables are integrated in the same order, the appropriate model to estimate is a VAR in differences. In the three variable cases under consideration, let  $y_1 = \log$  core CPI,  $y_2 =$  the unemployment rate and  $y_3 =$  the interest rate. An assumption is that the three variables at time  $t$  are  $y_{1t}$ ,  $y_{2t}$  and  $y_{3t}$  respectively. Let  $Y_t = (y_{1t}, y_{2t}, y_{3t})$  denote the  $(3 \times 1)$  vector of the series. A basic VAR( $p$ ) model takes the form:

$$Y_t = c + \Pi_1 Y_{t-1} + \Pi_2 Y_{t-2} + \dots + \Pi_p Y_{t-p} + \varepsilon_t \quad \varepsilon_t = N(0, \Sigma)$$

where  $\Pi_1, \dots, \Pi_p$  are  $(q \times q)$  autoregressive matrices and  $\Sigma$  is an  $(q \times q)$  variance-covariance matrix.

VAR modelling has an equation for each variable in the system. Hence, we let the time path of  $y_{1t}$  be affected by current and past values of both  $y_{2t}$  and  $y_{3t}$ . We also let the time path of  $y_{2t}$  be affected by contemporaneous and past values of both  $y_{1t}$  and  $y_{3t}$ . Similarly, we let the time path of  $y_{3t}$  be affected by contemporaneous and past values of both  $y_{1t}$  and  $y_{2t}$ . Assuming a VAR(1) model, we can write out the primitive structural VAR(SVAR) system:

$$y_{1t} = b_{10} - b_{12}y_{2t} - b_{13}y_{3t} + \phi_{11}y_{1t-1} + \phi_{12}y_{2t-1} + \phi_{13}y_{3t-1} + \varepsilon_{1t} \quad (4.1)$$

$$y_{2t} = b_{20} - b_{21}y_{1t} - b_{23}y_{3t} + \phi_{21}y_{1t-1} + \phi_{22}y_{2t-1} + \phi_{23}y_{3t-1} + \varepsilon_{2t} \quad (4.2)$$

$$y_{3t} = b_{30} - b_{31}y_{1t} - b_{32}y_{2t} + \phi_{31}y_{1t-1} + \phi_{32}y_{2t-1} + \phi_{33}y_{3t-1} + \varepsilon_{3t} \quad (4.3)$$

In the model, we assume that  $y_{2t}, y_{2t}$  and  $y_{3t}$  are stationary and  $\varepsilon_{1t}, \varepsilon_{2t}$  and  $\varepsilon_{3t}$  are uncorrelated white-noise disturbances with standard deviations of  $\sigma_1, \sigma_2$  and  $\sigma_3$ , respectively.

In the model, equations (4.1), (4.2) and (4.3) cannot be estimated using OLS. The estimates would suffer from simultaneous equation bias due to the regressors and the error terms being correlated. This is due to  $y_{1t}$  having contemporaneous effect on both  $y_{2t}$  and  $y_{3t}$ . At the same time,  $y_{2t}$  has contemporaneous effect on  $y_{1t}$  and  $y_{3t}$ . Lastly,  $y_{3t}$  has contemporaneous effect on both  $y_{1t}$  and  $y_{3t}$ . However, we can use matrix algebra to transform the equations into the compact form:

$$y_{1t} + b_{12}y_{2t} + b_{13}y_{3t} = b_{10} + \phi_{11}y_{1t-1} + \phi_{12}y_{2t-1} + \phi_{13}y_{3t-1} + \varepsilon_{1t} \quad (4.4)$$

$$y_{2t} + b_{21}y_{1t} + b_{23}y_{3t} = b_{20} + \phi_{21}y_{1t-1} + \phi_{22}y_{2t-1} + \phi_{23}y_{3t-1} + \varepsilon_{2t} \quad (4.5)$$

$$y_{3t} + b_{31}y_{1t} + b_{32}y_{2t} = b_{30} + \phi_{31}y_{1t-1} + \phi_{32}y_{2t-1} + \phi_{33}y_{3t-1} + \varepsilon_{3t} \quad (4.6)$$

The three equations can be represented in matrix form:

$$\begin{bmatrix} 1 & b_{12} & b_{13} \\ b_{21} & 1 & b_{23} \\ b_{31} & b_{32} & 1 \end{bmatrix} \begin{bmatrix} y_{1t} \\ y_{2t} \\ y_{3t} \end{bmatrix} = \begin{bmatrix} b_{10} \\ b_{20} \\ b_{30} \end{bmatrix} + \begin{bmatrix} \phi_{11} & \phi_{12} & \phi_{13} \\ \phi_{21} & \phi_{22} & \phi_{23} \\ \phi_{31} & \phi_{32} & \phi_{33} \end{bmatrix} \begin{bmatrix} y_{1t-1} \\ y_{2t-1} \\ y_{3t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix}$$

We can write out the matrices in reduced form:

$$AY_t = \Gamma_0 + \Gamma_1 Y_{t-1} + e_t \quad e_t \sim N(0, I) \quad (4.7)$$

where  $e_t$  are serially uncorrelated and independent of each other and:

$$A = \begin{bmatrix} 1 & b_{12} & b_{13} \\ b_{21} & 1 & b_{23} \\ b_{31} & b_{32} & 1 \end{bmatrix}, Y_t = \begin{bmatrix} y_{1t} \\ y_{2t} \\ y_{3t} \end{bmatrix}, \Gamma_0 = \begin{bmatrix} b_{10} \\ b_{20} \\ b_{30} \end{bmatrix}, \Gamma_1 = \begin{bmatrix} \phi_{11} & \phi_{12} & \phi_{13} \\ \phi_{21} & \phi_{22} & \phi_{23} \\ \phi_{31} & \phi_{32} & \phi_{33} \end{bmatrix} \text{ and } e_t = \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix}$$

We can premultiply by  $A^{-1}$  to obtain the reduced form VAR model:

$$Y_t = \beta_1 + \beta_2 Y_{t-1} + e_t \quad e_t \sim N(0, \Sigma_u) \quad (4.8)$$

where  $\beta_1 = A^{-1}\Gamma_0$ ,  $\beta_2 = A^{-1}\Gamma_1$  and  $e_t = A^{-1}\varepsilon_t$  and  $\Sigma_u = A^{-1}IA^{-1'} = A^{-1}A^{-1'}$ .

We can now present our general trivariate VAR( $p$ ) model in matrix form as:

$$\begin{bmatrix} y_{1t} \\ y_{2t} \\ y_{3t} \end{bmatrix} = \begin{bmatrix} \phi_{11}^1 & \phi_{12}^1 & \phi_{13}^1 \\ \phi_{21}^1 & \phi_{22}^1 & \phi_{23}^1 \\ \phi_{31}^1 & \phi_{32}^1 & \phi_{33}^1 \end{bmatrix} \begin{bmatrix} y_{1t-1} \\ y_{2t-1} \\ y_{3t-1} \end{bmatrix} + \dots + \begin{bmatrix} \phi_{11}^p & \phi_{12}^p & \phi_{13}^p \\ \phi_{21}^p & \phi_{22}^p & \phi_{23}^p \\ \phi_{31}^p & \phi_{32}^p & \phi_{33}^p \end{bmatrix} \begin{bmatrix} y_{1t-p} \\ y_{2t-p} \\ y_{3t-p} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix}$$

The right-hand side of the equations contains only predetermined variables and the error terms are assumed to be serially uncorrelated with constant variance. Where a reduced-form VAR is employed, each equation can effectively be estimated using OLS. Moreover, the OLS estimates are consistent and asymptotically efficient (Enders: 2015).

However, without imposing some restrictions on the SVAR, we run into the identification problem. We have nine unknowns (the elements of A) but only six equations to estimate them, making it impossible to identify the structural model from the estimated VAR. Therefore, we need to impose some restrictions to the SVAR. In the model, we address the problem by imposing identifying assumptions based on zero short-run restrictions (Cholesky identification). To identify the structural model from an estimated VAR, it is necessary to impose  $(\frac{n^2-n}{2})$  restrictions on the structural model (Enders: 2015). It follows that exact identification in our three-variable VAR requires three restrictions. We assume that  $A^{-1}$  in (4.7) to be lower triangular with:

$$Y_t = A^{-1}\Gamma_0 + A^{-1}\Gamma_1 Y_{t-1} + \tilde{A}e_t \quad (4.9)$$

and 
$$\tilde{A} = \begin{bmatrix} \tilde{a}_{11} & 0 & 0 \\ \tilde{a}_{21} & \tilde{a}_{22} & 0 \\ \tilde{a}_{13} & \tilde{a}_{23} & \tilde{a}_{33} \end{bmatrix}$$

Imposing the Cholesky identification restrictions and rewriting the model in matrix form:

$$\begin{bmatrix} y_{1t} \\ y_{2t} \\ y_{3t} \end{bmatrix} = \begin{bmatrix} \tilde{b}_{10} \\ \tilde{b}_{20} \\ \tilde{b}_{30} \end{bmatrix} + \begin{bmatrix} \tilde{\Phi}_{11} & \tilde{\Phi}_{12} & \tilde{\Phi}_{13} \\ \tilde{\Phi}_{21} & \tilde{\Phi}_{22} & \tilde{\Phi}_{23} \\ \tilde{\Phi}_{13} & \tilde{\Phi}_{23} & \tilde{\Phi}_{33} \end{bmatrix} \begin{bmatrix} y_{1t-1} \\ y_{2t-1} \\ y_{3t-1} \end{bmatrix} + \begin{bmatrix} \tilde{a}_{11} & 0 & 0 \\ \tilde{a}_{21} & \tilde{a}_{22} & 0 \\ \tilde{a}_{13} & \tilde{a}_{23} & \tilde{a}_{33} \end{bmatrix} \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix}$$

The restriction results in an identified system with six equations and six unknowns which we proceed to estimate.

### 4.3.3 Johansen cointegration test

Once the order of integration has been determined, it is necessary to test for cointegrating relationships among them. The test helps ascertain whether the non-stationary time series data

have long-run equilibrium relationship(s). Cointegrating relationship(s) forms the basis of the VECM specification.

To ascertain the presence and nature of cointegration, the study uses the Johansen cointegration test. The test is regarded as superior with desirable statistical properties (Sjö: 2008). Assuming that  $y$  is the vector of variables under consideration, the test can be formulated as:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + \dots + A_p y_{t-p} + \varepsilon_t$$

$$\Delta y_t = \pi y_{t-1} + \sum_{i=1}^{p-1} \pi \Delta y_{t-1} + \varepsilon_t$$

where  $\pi = -(I - \sum_i^p A_i)$  and  $\pi_i = -\sum_{i+1}^p A_j$ .

The test centres on the  $\pi$  matrix and the rank of  $\pi$  equals the number of cointegrating vectors.  $\pi$  is the long-run coefficient matrix. It follows that if  $\text{rank}(\pi) = 0$ , we have a null matrix with all variables being jointly non-stationary as in a VAR in first differences.  $\text{rank}(\pi) = 1$ , suggests the existence of a single cointegrating vector with  $\pi y_{t-1}$  as the error correction term. When the rank  $(\pi) = n$ , the vector process is stationary. If  $1 < \text{rank}(\pi) < n$ , then there are multiple cointegrating vectors.

The test uses two test statistics; trace and maximum eigenvalue. The procedure tests for the number of characteristic roots (eigenvalues) that are significantly different from unity. The trace test statistics are formulated as:

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

In the equation above,  $\hat{\lambda}_i$  are the estimated values of the characteristic roots (eigenvalues) and  $T$  are usable observations.  $r$  represents the number of cointegrating relationships. An individual eigenvalue is associated with a different cointegrating vector (eigenvectors).  $\lambda_{trace}$  is a joint test, where the null is that the number of cointegrating vectors is less than or equal to  $r$  against an unspecified alternative that there are more than  $r$  cointegrating vectors.

The maximum eigenvalue test conducts separate tests on each eigenvalue. The null hypothesis is that the number of cointegrating vectors is  $r$  against the alternative of  $r + 1$ .

$$\lambda_{max}(r, r + 1) = -T \ln(1 - \hat{\lambda}_{r+1})$$

Hypothesis testing is conducted in a sequence:

$$H_0: r = 0 \text{ versus } H_1: 0 < r \leq n$$

$$H_0: r = 1 \text{ versus } H_1: 1 < r \leq n$$

$$H_0: r = 2 \text{ versus } H_1: 2 < r \leq n$$

$$H_0: r = n - 1 \text{ versus } H_1: r = n$$

Firstly, the test considers the null-hypothesis that there are no cointegrating relationships;  $H_0 : r = 0$  and  $\text{rank}(r) = 0$ . If this null is not rejected, it can be concluded that there are no cointegrating vectors. However, if the null hypothesis of no cointegration is rejected, the null that there is one cointegrating vector would be tested. The process is repeated with incremental ranks and only stops when the null cannot be rejected.

#### 4.3.4 The vector error correction model (VECM)

If cointegrating relationships are confirmed among the variables, then a multiple-equation ECM is estimated. To derive the VECM, we can start by illustrating the VAR model in a general form. We define the vector  $Y_t = (y_{1t}, y_{2t}, y_{3t})$  and allow all three variables in the vector to be potentially endogenous:

$$Y_t = A_1 Y_{t-1} + \dots + A_k Y_{t-k} + u_t \quad u_t \sim N(0, \Sigma) \quad (4.10)$$

Following Harris & Sollis (2003), equation (4.10) can be reformulated into a VECM of the form:

$$\Delta Y_t = \Gamma_1 \Delta Y_{t-1} + \dots + \Gamma_{k-1} \Delta Y_{t-k+1} + \Pi V_{t-1} + u_t$$

Where  $\Gamma_i = -(I - A_1 - \dots - A_i)$ ,  $(i = 1, \dots, k - 1)$  and  $\Pi = -(I - A_1 - \dots - A_k)$

The specification allows us to depict both short-run and long-run adjustment to changes in  $Y_t$  through the estimates of  $\Gamma_i$  and  $\Pi$ .  $\Pi$  is a  $3 \times 3$  matrix that informs on long-run relationships in the system. The matrix can be represented as  $(\Pi = \alpha\beta)$  where  $\alpha$  represents the speed of adjustment to disequilibrium and  $\beta$  is a matrix of long-run coefficients. The term  $\beta Y_{t-k}$  embedded in equation (4.10) represents up to  $(n - 1)$  cointegration relationships in the multivariate model. The term ensures that the  $Y_t$  converges with their long-run steady state solutions. Setting the lag length to 1 in equation (4.10) and presenting the model in full:

$$\begin{bmatrix} \Delta y_{1t} \\ \Delta y_{2t} \\ \Delta y_{3t} \end{bmatrix} = \Gamma_1 \begin{bmatrix} \Delta y_{1t-1} \\ \Delta y_{2t-1} \\ \Delta y_{3t-1} \end{bmatrix} + \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \\ \alpha_{31} & \alpha_{32} \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{12} & \beta_{13} \\ \beta_{21} & \beta_{22} & \beta_{23} \end{bmatrix} \begin{bmatrix} y_{1t-1} \\ y_{2t-1} \\ y_{3t-1} \end{bmatrix} \quad (4.11)$$

Two cointegrating relationships enter each of the equations in the system. The two cointegration vectors with associated speed-of-adjustment terms in the equations for  $\Delta y_{1t}$ ,  $\Delta y_{2t}$  and  $\Delta y_{3t}$  are respectively given by:

$$\alpha_{11}(\beta_{11}y_{1t-1} + \beta_{12}y_{2t-1} + \beta_{13}y_{3t-1}) + \alpha_{12}(\beta_{21}y_{1t-1} + \beta_{22}y_{2t-1} + \beta_{23}y_{3t-1})$$

$$\alpha_{21}(\beta_{11}y_{1t-1} + \beta_{12}y_{2t-1} + \beta_{13}y_{3t-1}) + \alpha_{22}(\beta_{21}y_{1t-1} + \beta_{22}y_{2t-1} + \beta_{23}y_{3t-1})$$

$$\alpha_{31}(\beta_{11}y_{1t-1} + \beta_{12}y_{2t-1} + \beta_{13}y_{3t-1}) + \alpha_{32}(\beta_{21}y_{1t-1} + \beta_{22}y_{2t-1} + \beta_{23}y_{3t-1})$$

The VECM specification allows for the two cointegrating relationships to enter into all three ECMs with differing speeds of adjustment. The specification allows for different speed-of-adjustment coefficients from equation to equation allowing for asymmetric adjustment in the variables. In the VECM,  $\alpha_{11}$  and  $\alpha_{12}$  represent the speed at which  $\Delta y_{1t}$ , the dependent variable in the first equation in the model, adjusts towards the first and second long-run cointegration relationship respectively. In the same way,  $\alpha_{21}$  and  $\alpha_{22}$  represent the speed at which  $\Delta y_{2t}$  adjusts to the two cointegration relationships. Lastly,  $\alpha_{31}$  and  $\alpha_{32}$  capture the speed at which  $\Delta y_{3t}$  responds to short-run disequilibrium in the two long-run cointegration relationships. An *a priori* assumption is that the adjustment coefficients are significant. Also that the absolute value of the adjustment parameters should be between 0 and 1 in order that the short-run deviations converges to a long-run equilibrium. The magnitude of the parameters capture how quickly equilibrium is achieved in one quarter. The closer to unity the terms are, the faster the adjustment process depicted in the model.

#### 4.4 Definition of variables and data sources

This study analyses the behaviour of two main variables, core inflation and unemployment. Yet, using an example of the Canadian economy, Smithin (1996) argued that monetary policy conduct is an obvious explanation for inflation and unemployment outcomes in an economy. Accordingly, the model adopts the repo rate as the proxy for monetary policy. Quarterly data on the variable was obtained from the SARB website. Furthermore, the study considers the unemployment rate measured as strictly defined. Quarterly unemployment data was obtained from the SARB website.



Further, the study adopted core inflation as an indicator for inflationary pressure. The variable is used to track underlying movement in average consumer prices. In contrast with headline inflation, core inflation is less volatile. This is because the measure excludes volatile components for instance food, non-alcoholic beverages, petrol and energy prices. Core inflation controls for the effect of temporary price shocks on inflation which could result from various factors. As such, the measure is regarded as a reliable indicator of underlying movements in consumer prices attributable to economic and monetary policy. Most importantly, core inflation is used by the SARB to inform policy (Du Plessis, Du Rand & Kotze: 2015). Monthly core CPI data was extracted from the Statistics South Africa website. Quarterly core inflation rates were then calculated as quarter-over-quarter changes in the underlying index.

#### 4.5 Granger causality test

The analysis also entails determining causal links among the variables included in the system. The study employs the Granger causality test to aid this determination. A variable X Granger causes Y if past values of X have explanatory power over current values of Y. In our VAR( $p$ ) model,  $y_{2t}$  and  $y_{3t}$  fail to Granger-cause  $y_{1t}$  if  $\phi_{12}^j = \phi_{13}^j = 0$  for all  $j$ :

$$\begin{bmatrix} y_{1t} \\ y_{2t} \\ y_{3t} \end{bmatrix} = \begin{bmatrix} b_{10} \\ b_{20} \\ b_{30} \end{bmatrix} + \begin{bmatrix} \phi_{11}^1 & 0 & 0 \\ \phi_{21}^1 & \phi_{22}^1 & \phi_{23}^1 \\ \phi_{31}^1 & \phi_{32}^1 & \phi_{33}^1 \end{bmatrix} \begin{bmatrix} y_{1t-1} \\ y_{2t-1} \\ y_{3t-1} \end{bmatrix} + \dots + \begin{bmatrix} \phi_{11}^p & 0 & 0 \\ \phi_{21}^p & \phi_{22}^p & \phi_{23}^p \\ \phi_{31}^p & \phi_{32}^p & \phi_{33}^p \end{bmatrix} \begin{bmatrix} y_{1t-p} \\ y_{2t-p} \\ y_{3t-p} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix}$$

Similarly,  $y_{1t}$  and  $y_{3t}$  fails to Granger-cause and  $y_{2t}$  if  $\phi_{21}^j = \phi_{23}^j = 0$  for all  $j$ :

$$\begin{bmatrix} y_{1t} \\ y_{2t} \\ y_{3t} \end{bmatrix} = \begin{bmatrix} b_{10} \\ b_{20} \\ b_{30} \end{bmatrix} + \begin{bmatrix} \phi_{11}^1 & \phi_{12}^1 & \phi_{13}^1 \\ 0 & \phi_{22}^1 & 0 \\ \phi_{31}^1 & \phi_{32}^1 & \phi_{33}^1 \end{bmatrix} \begin{bmatrix} y_{1t-1} \\ y_{2t-1} \\ y_{3t-1} \end{bmatrix} + \dots + \begin{bmatrix} \phi_{11}^p & \phi_{12}^p & \phi_{13}^p \\ 0 & \phi_{22}^p & 0 \\ \phi_{31}^p & \phi_{32}^p & \phi_{33}^p \end{bmatrix} \begin{bmatrix} y_{1t-p} \\ y_{2t-p} \\ y_{3t-p} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix}$$

Lastly,  $y_{1t}$  and  $y_{2t}$  fails to Granger-cause and  $y_{3t}$  if  $\phi_{31}^j = \phi_{32}^j = 0$  for all  $j$ :

$$\begin{bmatrix} y_{1t} \\ y_{2t} \\ y_{3t} \end{bmatrix} = \begin{bmatrix} b_{10} \\ b_{20} \\ b_{30} \end{bmatrix} + \begin{bmatrix} \phi_{11}^1 & \phi_{12}^1 & \phi_{13}^1 \\ \phi_{21}^1 & \phi_{22}^1 & \phi_{23}^1 \\ 0 & 0 & \phi_{33}^1 \end{bmatrix} \begin{bmatrix} y_{1t-1} \\ y_{2t-1} \\ y_{3t-1} \end{bmatrix} + \dots + \begin{bmatrix} \phi_{11}^p & \phi_{12}^p & \phi_{13}^p \\ \phi_{21}^p & \phi_{22}^p & \phi_{23}^p \\ 0 & 0 & \phi_{33}^p \end{bmatrix} \begin{bmatrix} y_{1t-p} \\ y_{2t-p} \\ y_{3t-p} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix}$$

At the 5% level of significance, we would conclude that Granger causality is present if the p-values for the tests are less than 0.05. If the p-values are not less than 0.05, then we would conclude that Granger causality is not present.

#### 4.6 Impulse response function analysis

In conducting statistical inference, the study generates impulse responses to trace out the responsiveness of the variables to shocks to each of the variables in the VAR. For each variable in each equation, a unit shock is applied to the error, and the effects upon the VAR system over time are traced. In our model, there are three variables, thus a total of  $n^2 = 3^2 = 9$  impact multipliers (orthogonalised impulse responses) are generated. In the VAR system in (4.8), the Cholesky decomposition requires all elements above the principal diagonal to be zero with:

$$\tilde{A} = \begin{bmatrix} \tilde{a}_{11} & 0 & 0 \\ \tilde{a}_{21} & \tilde{a}_{22} & 0 \\ \tilde{a}_{13} & \tilde{a}_{23} & \tilde{a}_{33} \end{bmatrix}$$

Imposing the restriction and presenting the three equations in the VAR in (4.8) one by one:

$$y_{1t} = \tilde{b}_{10} + \tilde{\Phi}_{11}y_{1t-1} + \tilde{\Phi}_{12}y_{2t-1} + \tilde{\Phi}_{13}y_{3t-1} + \tilde{a}_{11}\varepsilon_{1t}$$

$$y_{2t} = \tilde{b}_{20} + \tilde{\Phi}_{21}y_{1t-1} + \tilde{\Phi}_{22}y_{2t-1} + \tilde{\Phi}_{23}y_{3t-1} + \tilde{a}_{21}\varepsilon_{1t} + \tilde{a}_{22}\varepsilon_{2t}$$

$$y_{3t} = \tilde{b}_{30} + \tilde{\Phi}_{31}y_{1t-1} + \tilde{\Phi}_{32}y_{2t-1} + \tilde{\Phi}_{33}y_{3t-1} + \tilde{a}_{13}\varepsilon_{1t} + \tilde{a}_{23}\varepsilon_{2t} + \tilde{a}_{33}\varepsilon_{3t}$$

From the equations and according to the Cholesky decomposition:

$\varepsilon_{1t}$  affects all the variables contemporaneously.

$\varepsilon_{1t}$  and  $\varepsilon_{2t}$  affect contemporaneously  $y_{1t}$  and  $y_{2t}$ , but not  $y_{3t}$ .

$\varepsilon_{3t}$  affects contemporaneously only  $y_{3t}$ , but not  $y_{1t}$  and  $y_{2t}$ .

In conducting the impulse response analysis, the order of the variables matters. The variable placed on top is the most exogenous and is affected only by a shock to itself. Each variable contemporaneously affects all the variables ordered afterwards, but it is affected with a delay by them. As such, we order the variables as; the core CPI → the repo rate → unemployment.

## 4.7 Forecast error variance decomposition

In undertaking variance decomposition, we separate the variation in each endogenous variable into the component shocks of the VAR/VECM. The FEVD exercise provides valuable information about the relative importance of each innovation in affecting the other variables in the system. Essentially, we can deduce the portion of the variance in the forecast error in predicting  $y_{i,t+n}$  that is due to the structural shock  $\varepsilon_j$ . In general:

$$y_{t+n} = \mu + \sum_{i=0}^{\infty} \Phi_i \varepsilon_{t+n-i}$$

so that the n-period forecast error  $y_{t+n} - E y_{t+n}$  is given by:

$$y_{t+n} - E y_{t+n} = \sum_{i=0}^{n-1} \Phi_i \varepsilon_{t+n-i}$$

As typical in empirical research with time series data, each variable in the model is assumed to explain most of its forecast error variance at short horizons and smaller proportions at longer horizons.

## 4.8 Model diagnostics

Diagnostic tests are performed on the estimated statistical model to check for symptoms of misspecification. Model misspecification can be diagnosed through the presence of auto-correlation, residual non-normality, residual heteroscedasticity and parameter non-constancy. For the estimated structural model to be valid, the vector of shocks should show absence of correlation, heteroscedasticity and non-normality. In addition, model stability analysis helps check whether the estimated process is stationary and ergodic with time-invariant means, variances, and auto-covariances.

### 4.8.1 Residual normality test

The classical linear regression model assumes the normality of regression residuals. Under the assumption of normality, the errors  $u_t$  are independent of the explanatory variable(s) and are independently and identically distributed as normal,  $N \sim (0, s^2)$ . Violation of the assumption of residual normality could lead to incorrect inferential conclusions (Jarque & Bera: 1980). The study adopts the Jarque-Bera residual normality test to determine whether the residuals from the estimated model are normally distributed. The test measures the difference in kurtosis and in

skewness in the estimated model from that in a normal distribution (Jarque & Bera: 1980). For the test, the null and alternative hypotheses are set up as follows:

$H_0$ : The residuals in the estimated model are normally distributed

$H_1$ : The residuals in the estimated model are not normally distributed

The decision rule is to reject the null hypothesis if the p-value is less than or equal to the level of significance being tested at. Or, if the Jarque-Bera (JB) statistic is greater than the chi-square statistic. The JB test statistic is computed as:

$$JB = \frac{(N - k)}{6} \left[ s^2 + \frac{(K - 3)^2}{4} \right]$$

$N$  is the number of observations,  $k$  is the number of estimated parameters,  $S$  is the skewness of the variables and  $K$  the kurtosis of the variables.

#### 4.8.2 Serial autocorrelation test

Serial autocorrelation refers to correlation of a model signal or error with itself. In any estimated model, the concept may result from statistical issues such as omitted variables, non-linear relationships, measurement errors and model misspecification. Data manipulation techniques like averaging, interpolation and extrapolation can also result in serially correlated errors. Serial correlation is more prevalent in time series data as compared with cross-section data. The study employs the Breusch-Godfrey LM test to formally test for serial autocorrelation in the system residuals. An advantage of the test is that it can be used to check for serial correlation in higher-order  $AR(p)$  processes. In the test, the null hypothesis is that the coefficients for the lagged variables equal zero. The alternative hypothesis is that the coefficients are significantly different from zero. For  $n$  lagged variables, the null and alternative hypotheses are formulated as:

$$H_0: \rho_1 = \dots = \rho_n = 0$$

$$H_1: \rho_1 \neq \dots \neq \rho_n = 0$$

We reject the null hypothesis at 5% significance level the probability value of the F-statistic is less than 0.05.

### 4.8.3 Heteroscedasticity test

Heteroscedasticity occurs when the variance of the unobservable error ( $\mu$ ), conditional on independent variables, is not constant. A consequence of heteroscedasticity in modelling is that OLS estimators, though still unbiased, become inefficient, thus not BLUE any longer. In fact, the usual OLS t-statistic and confidence intervals would no longer be valid for statistical inference. The study adopts the Breusch-Pagan (BP) test for heteroscedasticity. The BP test essentially uses model residuals from the estimated model. The test regresses the residuals squared on all of the  $y$ s, and then use the  $R^2$  to form a Lagrange Multiplier (LM) statistic. The statistic is given as  $LM = nR^2$ , which is distributed  $\chi^2_k$ , provided that:

$$u_t = \rho_1 u_{t-1} + \dots + \rho_r u_{t-r} + v_t \quad v_t \sim N(0, \sigma^2)$$

The null hypothesis is that the model residuals have homoscedastic variances. The alternative hypothesis is that model residuals have heteroscedastic variances. The two hypotheses are formulated as:

$$H_0: \rho_1 = \dots = \rho_r = 0$$

$$H_1: \rho_1 \neq \dots \neq \rho_r = 0$$

We reject the null hypothesis at 5% level of significance if the probability value of the test statistic is less than 0.05.

### 4.8.4 Model stability analysis

In econometric modelling and after estimating an econometric model, it is crucial to validate that the estimated model is stable. This entails checking whether the estimated model parameters are stable across various subsamples in the series. A stable VAR( $p$ ) process is stationary and ergodic with time invariant means, variances, and autocovariances. The study considers the stability and stationarity of the VAR(1) model depicted in equation (4.8):

$$Y_t = \mu + AY_{t-1} + e_t$$

Substituting backward we obtain:

$$\begin{aligned} Y_t &= \mu + AY_{t-1} + e_t \\ &= \mu + A(\mu + AY_{t-2} + e_{t-1}) + e_t \end{aligned}$$

$$\begin{aligned}
&= (I + A)\mu + A^2Y_{t-2} + Ae_{t-1} + e_t \\
&\vdots \\
Y_t &= (I + A + \dots + A^j)\mu + A^jY_{t-j} + \sum_{i=0}^{j-1} A^i e_{t-i}
\end{aligned}$$

If all the eigenvalues of  $A$  are smaller than one in modulus then  $A^j = P\Lambda^jP^{-1} \rightarrow 0$ . The sequence  $A^i, i = 0, 1, \dots$  is absolutely summable. The infinity sum  $\sum_{i=0}^{j-1} A^i e_{t-i}$  and  $(I + A + \dots + A^j)\mu \rightarrow (I - A)^{-1}\mu$  and  $A^j \rightarrow 0$  as  $j$  approaches infinity. If the eigenvalues are smaller than one in modulus then  $Y_t$  has the following representation:

$$Y_t = (I - A)^{-1}\mu + \sum_{i=0}^{\infty} A^i e_{t-1-i}$$

The eigenvalues ( $\lambda$ ) of  $A$  satisfy the condition that  $\det(I - \lambda A) = 0$ . Therefore the eigenvalues correspond to the reciprocal of the roots of the determinant of  $A(z) = I - Az$ . In general, the stability condition for a VAR( $p$ ) requires that all the eigenvalues of  $A$  (the AR matrix of the companion form of  $Y_t$ ) are smaller than one in modulus. That means a VAR( $p$ ) is stable if  $\det(I - A_1z - A_2z^2 - \dots - A_pz^p) \neq 0$  for  $|z| \leq 1$ . For instance, a VAR(1) model is stable if  $\det(I - Az) \neq 0$  for  $|z| \leq 1$ . Equivalently, stability requires that all the eigenvalues of  $A$  are smaller than one in absolute value.

#### 4.9 Merits and limitations of the methodology

The adopted theoretical model, the NKPC, is theoretically superior. However, empirically, the models have not had much success in explaining inflation dynamics. For the empirical model, VECMs have several attractive features for empirical research. One advantage is simplicity. This is due to linearity, lack of structural assumptions (coefficient restrictions), and the common assumption that each variable in each equation appears with the same number of lags (Magee: 2013).

VARs do not require any structural modelling specification. With VARs, the main requirement is prior knowledge of the list of variables that influence each other. The researcher then only has to choose the variables to model and the number of lags ( $p$ ). VARs can then be written and analysed as one algebraic equation, even though they represent a system of  $m$  equations.

An additional merit is that VECM allows simultaneous modelling of both long-run model and short-run dynamics among cointegrated variables. Stock and Watson (2001) surmised that VARs are powerful tools which provide a coherent and credible approach to data description, forecasting, structural inference and policy analysis. Importantly, one can also evaluate the dynamic effect of random shocks to the system using IRFs and FEVD.

However, the simplicity of the models comes at a cost. One drawback is that being atheoretical, the models do not help the researcher determine the nature of causality in the estimated system (Mohamed, Skima, Saafi & Farhat: 2014). To address this, the research developed the empirical model from an SVAR. The research also conducts Granger causality tests to isolate the direction of causality among the variables in the system.

Moreover, VAR models treat the endogenous variables as functions of lagged values of themselves and other variables. As a result, the models often suffer the curse of high dimensionality due to inclusion of endogenous variables and the high amount of lags usually used (Van Lill: 2015). Sangasoongsong & Bukkapatnam (2012) referred to this as the over-parameterisation problem. The inclusion of many lags means a prohibitively large number of parameters has to be estimated. In addition, the huge number of regressors in the models are usually highly correlated (Magee: 2013). According to Magee (2013), this leads to estimates and impulse response functions (IRFs) with high standard errors. In the study, this shortcoming is remedied by choosing the appropriate lag length using the AIC criteria. Another technique adopted is causal ordering of the variables, and imposing restrictions the shocks using Cholesky decomposition.

#### **4.10 Conclusion**

The objective of the research was to investigate the empirical relationship between the inflation rate and unemployment in the South African economy. However, it is argued that monetary policy conduct is an obvious explanation for inflation and unemployment outcomes in an economy. Hence, the model incorporates the repo interest rate as proxy for monetary policy. From the literature reviewed, the NKPC is theoretically superior and is adopted for the econometric model. The study adopts a Fanelli (2005) hybrid formulation of the NKPC aided the determination of the variables to include in the empirical model; inflation expectations, lagged inflation and a vector of driving variables. Following Stock and Watson (2001), we incorporate the interest rate and unemployment rate to constitute the vector of driving variables.



The research employs the ADF unit root test to determine the stationarity properties of the series. If the variables are found to be stationary, a VAR model will be estimated. The Johansen cointegration test will be used to detect the presence of cointegration among the variables. If all the variables are found to be non-stationary and cointegrated the study moves on to estimate the ECM and the VECM. The study then proceeds with statistical inference. This includes analysing causal impacts through Granger causality tests, impulse response function analysis and forecast error variance decomposition. Finally, model diagnostic tests are run on the estimated model.



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## CHAPTER 5

### RESEARCH FINDINGS

#### 5.1 Introduction

This chapter estimates the econometric model and presents the research findings. In conducting the empirical research, the study employs several descriptive and econometric techniques. In the chapter, start by deriving summary statistics and undertaking graphical analysis of the data series. What follows are ADF unit root and the Johansen cointegration tests. We then estimate an ECM for core CPI. In addition, the study estimates the VECM developed in the last chapter. In the last part of the chapter, we run the Granger-causality test and carry out impulse response analysis and forecast error variance decomposition. Lastly, we perform model diagnostic tests and conclude the chapter.

#### 5.2 Summary statistics

The empirical analysis starts by deriving summary statistics of the data series. For each individual series, we derive the following statistics; the mean and the standard deviation, and identify the extreme values. Table 5.1 reports the summary statistics. In the table, we express the variables in logarithms where LCPI is the log of core CPI, LUER represents log of the unemployment rate and LRR is the log of the repo rate.

Table 5.1. Summary statistics

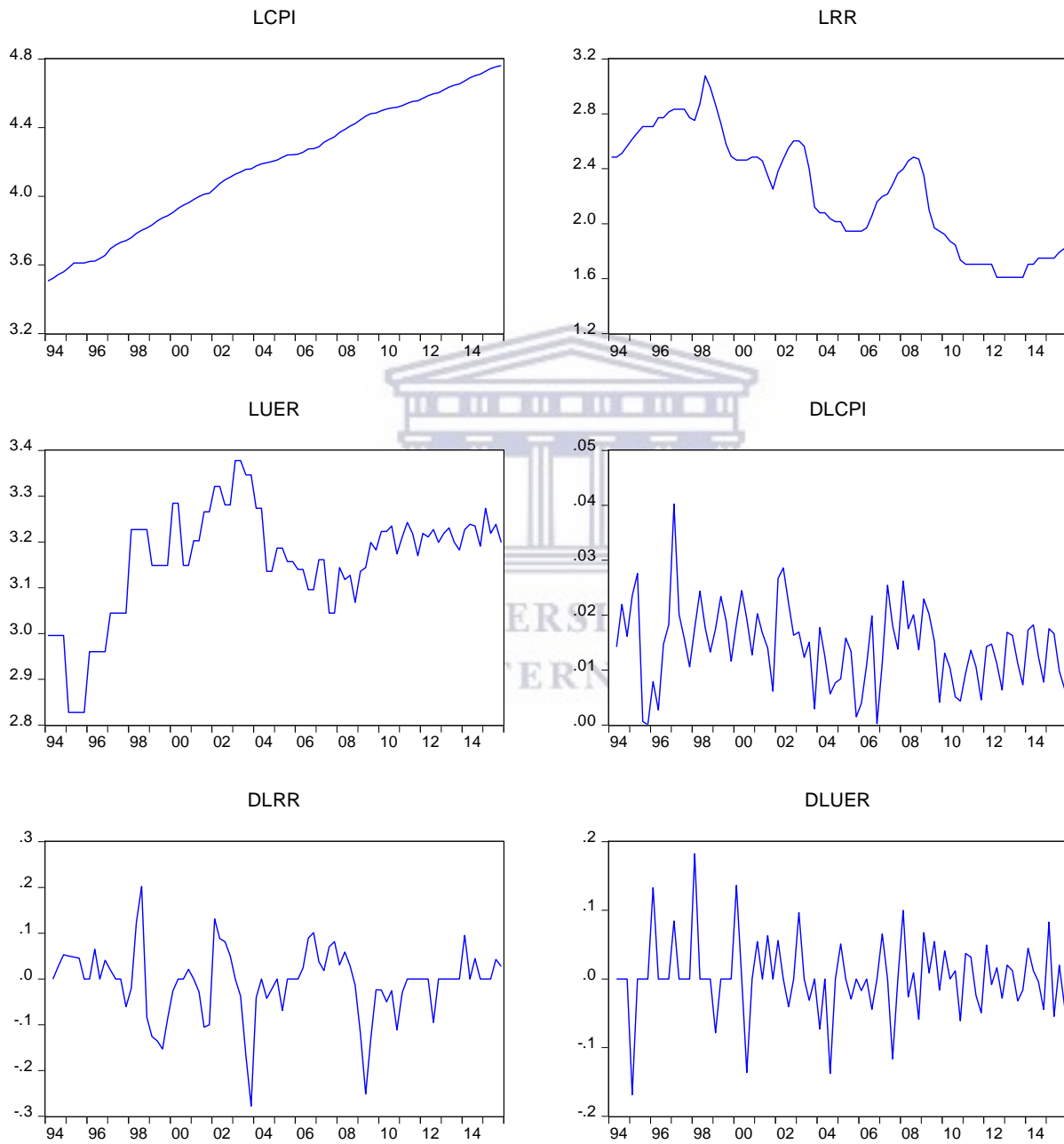
Variable	Mean	Standard deviation	Min	Max
LCPI	4.177	0.371	3.507	4.761
LRR	2.242	0.413	1.609	3.077
LUER	3.159	0.120	2.827	3.378

From the table, we can note that the extreme values of all the variables are roughly close to the mean, thus exhibiting little variation or spread. The same fact can also be ascertained from the relatively low standard deviations. Thus, we conclude that we do not have high magnitude variations in the data on the macroeconomic variables under study.

We then proceed with graphical analysis of the data. Plotting the series helps us ascertain the

behaviour of the variables visually over the time period under study. The exercise helps determine whether or not the series are subject to permanent changes in their logarithmic levels. Figure 5.1 plots the log unemployment rate (LUER), the log repo rate (LRR) and log core CPI (LCPI) over the period 1994Q1 to 2015Q4.

Figure 5.1: Time plots of the variables



Source: Statistics South Africa (2016)

From the figure, it is evident that the series in logarithmic levels deviate from their mean values with unequal variances during the whole period, hinting at non-stationarity. The graphs also hints at the order of integration in that the differenced series appear to be stationary. We can, over and above that, deduce that first differencing the original series reduces the level of non-stationarity and likely induces stationarity. Taking into consideration data trends, the repo interest rate is generally falling during the period under review. However, both core CPI and the unemployment rate exhibit a general upward trend over the same period. The two series generally moved together, suggesting that the macroeconomic variables shared similar shocks or disturbances. That characteristic hints at a cointegrating relationship between them. Cointegration requires that the series in the data set be integrated of the same order. In the next section, the study employs the ADF unit root test to formally determine the integration properties of the data.

### 5.3 Unit root test

To statistically determine the stationarity properties of the data, the research applied the ADF unit root test. In the test, we reject the null hypothesis of unit root at the 5% level of significance if the absolute value of the ADF statistic is greater than the associated critical value. The results for the three series under study are presented in Table 5.2.

Table 5.2: Unit root test results

Series	ADF-statistic		Order of integration
	Levels	First differences	
LCPI	-2.365	-3.332	I(1)
LRR	-1.510	-5.392	I(1)
LUER	-2.353	-10.03	I(1)

Notes: The test includes a constant and the sample period spans 1994 (1) to 2015 (4). LINF is log core CPI, LUER is the log unemployment rate and LRR is the log repo rate. The critical values are -2.900 and -3.511 for 5% and 1% respectively.

As the results in the table show, for all the three variables in logarithmic levels, the ADF statistics are less than the critical value of 2.900 in absolute value. As such, we fail to reject the null hypothesis of non-stationarity at 5% significance level. The ADF statistics for all series in first differences are greater than the critical value of 2.900 in absolute value. So it follows that we reject the null hypothesis of non-stationarity in the differenced series at 5% level of significance.

According to the ADF unit root test, the series are I(1).

Since the series are I(1), the data would require differencing to induce stationarity before model estimation can be done. Ignoring this characteristic of the data would likely result in model misspecification and spurious regression results. However, as discussed in the methodology chapter, the concept of cointegration allows for the possibility that linear combinations of the non-stationary series could be stationary. With cointegration, an equilibrium relationship could exist among integrated variables such that they do not drift too far apart over the long-run. For this reason, the study proceeds with the formal Johansen cointegration test.

### 5.4 Cointegration test

The Johansen cointegration test procedure and its corresponding test statistics essentially amount to identifying the number of stationary linear combinations among the variables. The cointegration equation(s) thus obtained represents the long-run equilibrium relationship(s) in the system. For the test, we include the log of core CPI (LCPI), the log repo rate (LRR) and the log unemployment rate (LUER). We first select the optimal model specification using the AIC. Table 5.3 displays the results.

Table 5.3: Optimal model specification results

Data trend	None	None	Linear	Linear	Quadratic
	No intercept No trend	Intercept No trend	Intercept No trend	Intercept Trend	Intercept Trend
Number of CE(s) = 0	-12.42	-12.42	-12.69	-12.69	-12.65
Number of CE(s) = 1	-12.72	-12.74	-12.84*	-12.82	-12.80
Number of CE(s) = 2	-12.71	-12.76	-12.79	-12.79	-12.79
Number of CE(s) = 3	-12.58	-12.69	-12.69	-12.70	-12.70

CE – denotes “cointegrating equation”

\* indicates the optimal model selected by the AIC

From the summary presented in the table, Model 3 with one cointegrating vector is suggested as the best model. The model allows for an intercept but no trend in both the CE and the VECM specification. Table 5.4 displays the Johansen cointegration test results.

Table 5.4: Johansen cointegration test (trace statistic) results

Eigenvalue	Trace statistic	5% critical value	p-value	Number of cointegrating equations
0.256	36.24	29.80	0.001	None*
0.085	10.86	15.49	0.221	At most 1
0.037	3.227	3.841	0.072	At most 2

The trace test indicates 1 cointegrating equation at the 0.05 level  
 \*denotes rejection of the hypothesis at the 0.05 level

The Johansen cointegration test results provide evidence that the three variables are cointegrated. The trace test indicates that there is one cointegrating relationship among the three variables at 5% level of significance. In the test, when testing the null hypothesis that the rank is 0, the  $p$ -value for the trace statistic is less than 5%. As such, we reject that null hypothesis and assume the existence of at least one cointegrating relationship in the system. We then move on to test the null hypothesis that the rank of the matrix is 1. For the null hypothesis that there is at least one cointegrating relationship, the  $p$ -value for the trace statistic is greater than 0.05. In this case we fail to reject the null hypothesis and conclude that there is one cointegrating relationship in the system. Cointegration implies that the three series do not drift far apart from each other but maintain an equilibrium relationship over time. Table 5.5 presents the cointegrating equation normalised on the log of core CPI (LCPI).

Table 5.5: Normalised cointegrating coefficients (cointegrating equation)

	LCPI	LRR	LUER	Constant
Cointegration coefficients	1.000	1.115	-0.141	-6.552
Standard error		(0.114)	0.385	
t-statistics		[9.759]	[-0.368]	

We can reverse the signs due to the normalisation process and express the cointegrating equation as:

$$\text{LCPI} = 6.552 + 0.141 \text{ LUER} - 1.115 \text{ LRR}$$

The cointegration equation suggests a positive though insignificant long-run relationship between core CPI and unemployment. The effect of the unemployment variable on log core CPI is insignificant as evidenced by the low associated t-statistic. The equation also depicts a significant and direct inverse long-run relationship between core CPI and the repo rate. The finding implies that a *ceteris paribus* increase in the repo rate reduces the core CPI. The implication is that a stable, negative long-run association existed between core CPI and the repo rate in the period under study. Cointegration among the macroeconomic variables implies that the ECM is a viable approach in describing both the short-run and long-run relationships in the system.

### 5.5 The ECM for inflation

Now that we have established that cointegration exists among the variables, we can proceed to estimate a single ECM for core CPI. In the model, changes in the relevant variables represent short-run elasticities. The coefficient on the error correction term represents the speed of adjustment back to the long-run equilibrium relationship. The error correction term is the bridge that links short-run deviations to the long-run equilibrium. The term captures how quickly the variables converge to long-run equilibrium. A large value of the coefficient in absolute terms would suggest a rapid speed of adjustment in each quarter. Holding other variables in the system constant, the term should be negative and statistically significant in order to restore the system to the long-run equilibrium.

An important aspect of empirical research with error correction modelling is optimal lag selection. One reason is that statistical inference using the model depends on the correct model specification. In the study, we conduct a rigorous optimal lag selection exercise to decide the appropriate number of lags ( $p$ ) to include in the model. In undertaking the exercise, the study adopted the default maximum lag length of eight lags. From the exercise, we choose the lag length of the VAR in logarithmic levels that minimise the AIC. Table 5.6 presents the results.

Table 5.6: The optimal lag selection results

Lag	LR	FPE	AIC	SC	HQ
0	N/A	2.97	-1.91	-1.821	-1.875
1	840.2	5.88	-12.74	-12.38	-12.6



2	45.64	3.95*	-13.14*	-12.51*	-12.89*
3	11.34	4.22	-13.08	-12.18	-12.72
4	13.37	4.35	-13.05	-11.89	-12.59
5	19.30*	4.06	-13.13	-11.70	-12.55
6	6.265	4.641	-13.01	-11.31	-12.32
7	15.20	4.54	-13.04	-11.08	-12.25
8	7.973	5.031	-12.96	-10.73	-12.07

Note: \*indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

Considering the results displayed in the table, the AIC suggests an optimal lag length of two lags. Interestingly, three additional criteria – the FPE, the SC and the HQ – also suggest the same lag length. However, for the cointegration test, the ECM and the VECM specification, we follow Magee (2013) and adopt a single lag. Magee (2013) argued that estimation with differenced data should be with one less lag than there were in the original VAR in levels used for lag length selection. On that account, we adopt a single lag and estimate the ECM for core CPI. In the model estimation, percentage changes in core CPI are regarded as the “dependent” variable. We then estimate the ECM in terms of the other variables in logarithmic differences. Table 5.7 present the ECM estimates.

Table 5.7: The ECM estimates

Dependant variable	DLCPI				
	Variable	Coefficient	Standard error	t-statistic	p-value
ECT		0.006	0.004	1.627	0.108
DLCPI(-1)		0.251	0.114	2.202	0.031*
DLRR(-1)		0.005	0.010	0.464	0.644
DLUER(-1)		0.004	0.014	0.321	0.750
Constant		0.011	0.002	5.915	0.000*
R-squared			0.144		
Adj.R-squared			0.102		
F-statistic			3.406		
p-value			0.013		

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\* denotes significance at 5% level

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In interpreting the estimated model results, the short-run lagged estimate for LRR suggests that a 10% increase in the variable during the current quarter generates a statistically significant 2.5% increase in LCPI in the following quarter. The short-run lagged impact of the LRR is positive though statistically insignificant at the 5% significance level. The same applies to the short-run lagged impact of the unemployment variable. This suggests no short-run causality from both variables to core CPI. The estimated error correction coefficient of 0.006 is small, positive and statistically insignificant. This signals that in case of any disturbance in the system, divergence from equilibrium will occur and the system would become unstable. The  $R^2$  of 14% is low, hinting at the model's low explanatory power. The model's F-statistic is 3.406 and the associated probability value is 0.01 hence the model is statistically significant.

## 5.6 The VECM

Vector error correction modelling allows for short-run dynamic disequilibrium among the variables whilst allowing them to converge to their long-run equilibrium relationship. The study proceeds to estimate the VECM and Table 5.8 presents the model estimates.

Table 5.8: Summary VECM estimates

	<b>D(LCPI)</b>	<b>D(RR)</b>	<b>D(UER)</b>
Error correction coefficient	0.006	-0.123*	0.063*
Standard error	(0.004)	(0.031)	(0.027)
t-statistics	[1.627]	[-3.987]	[2.286]
R-squared	0.144	0.420	0.116
Adj.R-squared	0.102	0.391	0.072
Alkaike AIC	-7.045	-2.761	-2.996
Schwarz SBC	-6.903	-2.618	-2.854

\* denotes significance at 5% level

From the table, the coefficient of the error correction term of LRR is negative and statistically significant at 5% level. The speed of adjustment to convergence is 12%. Thus, the repo rate is adjusted by 12% of past quarter deviation from equilibrium in the short-run. The sign and significance of the term confirms the stability of the system. The relatively low value of 12% is indicative of a slow speed of adjustment towards equilibrium. The coefficients on the error

correction terms of both core inflation and unemployment have positive signs. That means that any disturbance in the system would result in divergence from equilibrium.

### 5.7 Weak exogeneity test

In a cointegrated system, a variable is weakly exogenous if it does not respond to the discrepancy from the long-run equilibrium. The study tests for weak exogeneity by imposing constraints on the elements of the loading matrix ( $\alpha$ ). In this exercise, we test the null hypothesis that the  $\alpha$  element of a corresponding variable  $\beta$  from a cointegrating vector is not significantly different from zero. We proceed to test whether LCPI, LRR and LUER are weakly exogenous in the estimated VECM. Table 5.9 below shows the Chi-square values and the associated p-values of the test statistics.

Table 5.9: Weak exogeneity test results

Variable	Chi-square	p-value for the test statistic
LCPI	2.426	0.119
LRR	12.67	0.000*
LUER	3.959	0.047*

\*denotes rejection of the null at 5% level of significance

From the test output, the weak exogeneity hypothesis is rejected for both unemployment and the repo interest rate variables. This implies that both variables adjust over time to restore the long-run equilibrium following external shocks that could lead to deviation of the system from its long-run equilibrium. However, we could not reject the null hypothesis for weak exogeneity for the core CPI variable. The implication is that in specifying a parsimonious model, system error correction terms can be included in the equations of both the repo rate and the unemployment rate.

### 5.8 Granger causality test

The determination of the nature of relationship among the variables in the model also entails determining causal links among them, if any. The study employs the Granger causality test to aid this determination. The test allows us to statistically detect the cause and effect interaction among the variables in the system. Table 5.10 displays the results.

Table 5.10: VECM Granger causality test results

Null hypothesis	df	Chi-sq	p-value	Decision
LRR does not Granger cause LINF	1	0.216	0.642	Do not reject
LUER does not Granger cause LINF	1	0.103	0.750	Do not reject
LINF does not Granger cause LRR	1	1.280	0.258	Do not reject
LUER does not Granger cause LRR	1	0.421	0.516	Do not reject
LINF does not Granger cause LUER	1	7.842	0.005*	Reject
LRR does not Granger cause LUER	1	0.010	0.921	Do not reject

Note: \* denotes significance at 5% level. LINF is log core CPI, LUER is the log unemployment rate and LRR is the log repo rate

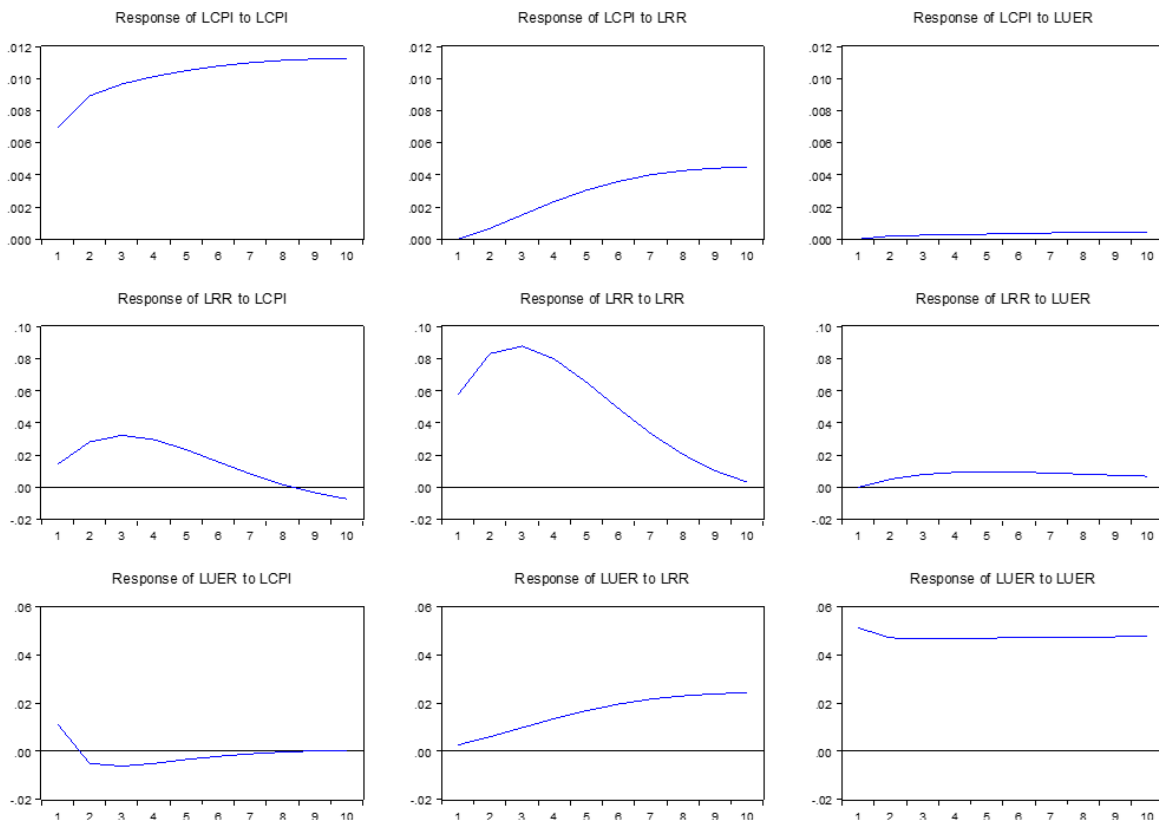
In the estimated model, unidirectional Granger causality runs from core CPI to unemployment. The finding is based on the fact that the null hypothesis that core CPI does not Granger cause unemployment is rejected at 5% level of significance. Therefore, we conclude that past values of inflation can be used to predict future unemployment levels. However, the study found no causal links between core CPI and the repo rate. The same applies to the causal interaction between the repo rate and unemployment.

### 5.9 Impulse response function analysis (IRF)

In this part, we study the impulse response relationship among the variables under study. Figure 5.2 below traces the generalised impulse responses of the three variables in question to both a unitary shock in their own values and the rest of the variables over a 10-quarter period. The figure displays the impulse response functions with a separate graph for each endogenous variable and response pair.

From the IRFs, the response of core CPI to a one-standard-deviation (SD) innovation in the repo rate is positive. The response gradually increases for the rest of the period under study. The response of unemployment to the same innovation in the repo rate is also positive and gradually increases for the entire forecast period. The same shock affects the variable itself positively and the effect remains constant for the whole period. The effect of a one-SD innovation in log CPI on the unemployment rate variable, though positive, is negligible for the whole forecast period.

Figure: 5.2: Impulse response functions



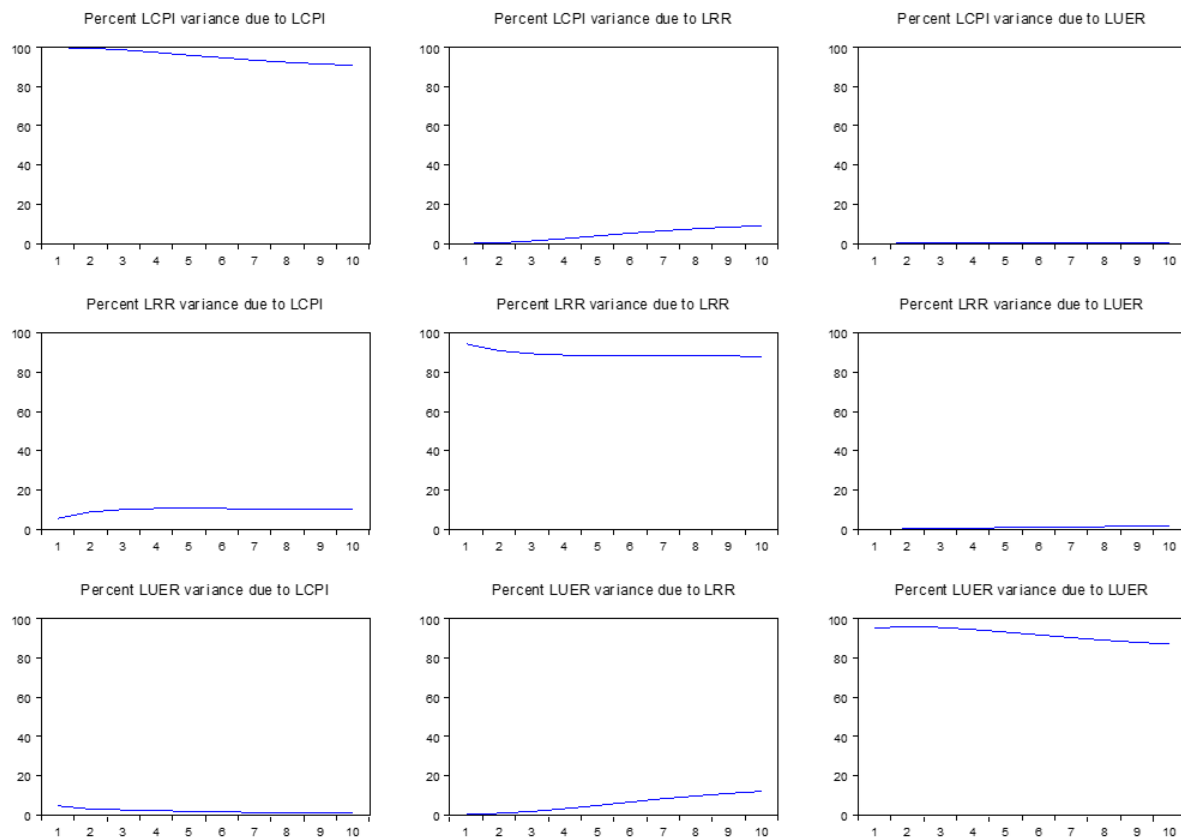
The effect of one SD deviation in repo rate on core CPI is positive and hump-shaped for the first three quarters. The effect starts falling from the fourth quarter. It falls gradually to turn negative in the eighth quarter. The same effect on the unemployment rate is positive and sustained for the whole period under study. However, the same shock affects the variable itself positively with the effect hump shaped for three quarters and thereafter falling gradually towards zero at the end of the forecast period. The response of unemployment to a one-SD innovation in core CPI is positive on impact and then falls below zero after one quarter and gradually increases back to zero as the forecast horizon increases to completely die down in the eighth quarter. The immediate effect of a one-SD innovation shock in unemployment to both inflation and the repo rate is positive and rises slightly over time.

### 5.10 Forecast error variance decomposition (FEVD)

The study performs a FEVD exercise to further assess the ability of the estimated model to correctly identify the shocks driving the dynamics of the system. Figure 5.3 reports the variance

decomposition (VDC) of each variable over the 10-quarter forecast period.

Figure 5.3: Forecast error variance decomposition



The results suggest that, after 10 quarters, a unitary shock in core CPI explains about 20% of the accumulated forecast error variance of the repo rate and about 3% of that of unemployment. The accumulated percentage variance of core inflation due to itself remains above 90% after 10 quarters. A unitary shock in the repo rate explains roughly 12% of the accumulated variance in core CPI and roughly 8% of the accumulated variance in the unemployment rate. From the results, it is apparent that the repo rate accounts for a greater share of its own fluctuations at about 80% at the end of the 10 quarters. Finally, a unitary innovation in the unemployment rate explains almost none of the variance in the inflation variable. However, the same shock explains about 2% of the variance in the repo rate with most of the variance of over 95% being explained by the shock to the variable itself.

## 5.11 Model diagnostics

In empirical research, model specification involves several choices, such as the variables to include, the functional form connecting the variables, and the nature of the interaction among the variables, if any. However, economic theory normally can't offer a tight specification of the dynamic relationships in economic data. That inevitably causes uncertainty as to whether the estimated model is correctly specified. This fact motivated the study to conduct the following diagnostic tests; residual normality, serial correlation and the heteroscedasticity test. We also graph the roots of polynomial characteristics to determine whether the estimated model satisfies the stability condition. Ideally, the roots should not lie outside the unit circle. Through the tests, we can evaluate the quality of the estimated model along a number of dimensions; residual normality, serial correlation, homoscedasticity and parameter consistency.

### 5.11.1 Residual normality test

The study employs the Jarque-Bera normality test to ascertain whether the model residuals are normally distributed. The null hypothesis assumes normal distribution which is tested against the alternative hypothesis of non-normal distribution. We evaluate the decision by comparing the calculated p-value with the specified significance level. In our case, the null hypothesis is rejected if the calculated probability value is less than the 5% critical value. Table 5.11 presents the Jarque-Bera normality test results.

Table 5.11: Jarque-Bera normality test results

Null hypothesis	Jarque-Bera statistic	p-value	Decision
Residuals are normally distributed	5.979	0.051	Do not reject the null hypothesis

The test output shows the calculated p-value as 0.051 which is greater than 0.05. Accordingly, we do not reject the null hypothesis of normally distributed residuals at 5% significance level. The conclusion is that model residuals follow a normal distribution.

### 5.11.2 Serial autocorrelation test

To further assess the validity of the estimated model, the study proceeds to check for evidence of



serially correlated disturbances using the Breusch-Godfrey LM test. The null hypothesis of no serial correlation is tested against the alternative hypothesis of serially correlated errors. The test results are presented in Table 5.12.

Table 5.12: Breusch-Godfrey LM test results

<b>Null hypothesis</b>	<b>F-statistic</b>	<b>p-value</b>	<b>Decision</b>
Residuals are not autocorrelated	2.096	0.130	Do not reject the null hypothesis

The calculated probability value is 0.130 which is higher than the 5% critical value. Accordingly, we do not reject the null and conclude that the specified model residuals are not serially correlated.

### 5.11.3 Heteroscedasticity test

In the Breusch-Pagan (BP) test, the null assumption is that the model errors have homoscedastic variances. The alternative hypothesis is heteroscedastic variance in the model residuals. From the test, lower p-values compared with a predetermined significance level indicates heteroscedastic error variances. The Breusch-Pagan test results are displayed in Table 5.13.

Table 5.13: Breusch-Pagan heteroscedasticity test results

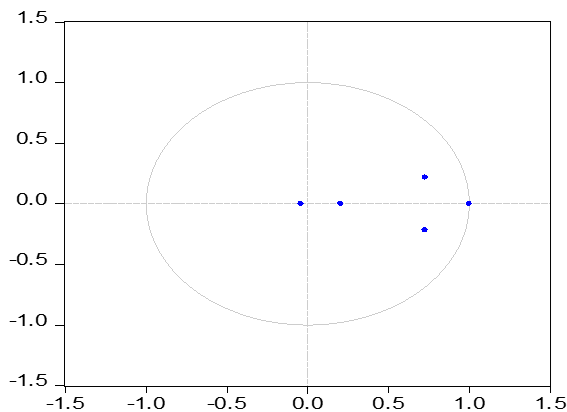
<b>Null hypothesis</b>	<b>F-statistic</b>	<b>p-value</b>	<b>Decision</b>
Residuals are homoscedastic	1.911	0.100	Do not reject the null hypothesis

The calculated probability value of 0.100 is more than the 5% critical value hence we cannot reject the assumption of homoscedasticity. The test results suggest that model residuals have the desired statistical property of homoscedastic variances.

### 5.11.4 Model stability analysis

In econometric modelling and after fitting an econometric model, it is crucial to check the estimated model stability. An estimated VECM is covariance-stationary if all eigenvalues of the coefficient matrix lie inside the unit circle. We graph the inverse roots of the AR characteristic polynomial in Figure 5.4 to determine the estimated model stability.

Figure 5.4: Inverse roots of AR characteristic polynomial



From the graph, the roots of polynomial characteristics do not lie outside the unit circle. Hence, we can conclude that the estimated model satisfies the stability condition. The model diagnostic tests results suggest that the estimated model is correctly specified and the statistical inference thus performed is valid.

### 5.12 Conclusion

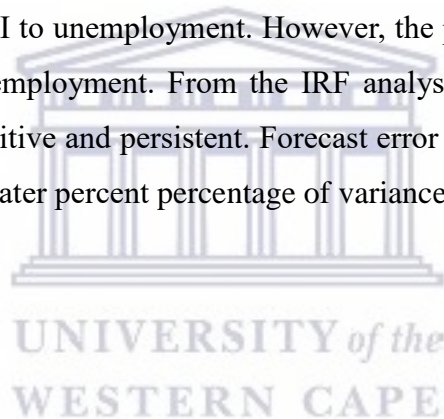
The aim of the chapter was to ascertain statistically the short-run, long-run and causal links between inflation and unemployment in South Africa between 1994 and 2015. The research identified, developed and estimated a model for the relationships based on the ECM and the VECM. The results obtained are in most respects plausible given the advantages of the approach over other standard techniques of estimating the same correlations.

The research adopted a hybrid version of the NKPC. The empirical model utilised quarterly data on unemployment, core CPI and the repo interest rate as variables. The three series were found to be  $I(1)$  with statistical evidence of a single cointegration equation. A significant and negative relationship was found between core CPI and the repo interest rate. In addition, the cointegrating equation implied the existence of a positive though statistically insignificant relationship between unemployment and core CPI.

The estimated ECM for core CPI had a positive and insignificant error correction term. In terms of the NKPC model, the estimation results show a weak role of expectations as captured by an insignificant error correction term. However, inflation persistence as approximated by lagged

inflation had the correct sign and was highly significant. From the estimation output, the NKPC is not a good approximation of inflation dynamics in South Africa. VECM estimation results show the error-correction term for the repo rate being negative and statistically significant. That means the burden of adjustment to long-run equilibrium relies on the repo rate, with a convergence rate of 12.3% a quarter.

In addition, the study discovered unidirectional Granger causality from core inflation to unemployment. However, the research found no evidence of Granger causality among the other variables. The research also did not find evidence of causality from either the repo interest rate or the unemployment rate to core CPI. In the short-run, the study found lagged core CPI to be the core driver of core CPI. However, the research found no evidence of short-run causality between the repo rate and both unemployment and core CPI. Rather, lagged repo rate was significant in explaining future values of the repo rate. Finally, the study confirmed the existence of short-run causality running from core CPI to unemployment. However, the paper found no short-run causality from the repo rate to unemployment. From the IRF analysis, unemployment responds to monetary policy shock was positive and persistent. Forecast error variance decomposition shows each variable contributing a greater percent percentage of variance in each respective variable.



## CHAPTER 6

### CONCLUSIONS AND POLICY RECOMMENDATIONS

#### 6.1 Summary of the study and conclusions

Macroeconomic policy aims to promote economic growth, employment creation and price stability. However, there is considerable debate on how inflation and unemployment interact in an economy. Views regarding the nature of the relationship between the two cannot be separated from views regarding optimal monetary policymaking. While it is generally accepted that monetary policy affects unemployment, real income, and economic growth, there are disagreements as to how the policy should be optimally conducted to achieve the twin goals of price stability and low unemployment. This research revisited the debate by examining the relationship between inflation and unemployment in the domestic economy. This is accomplished in the light of recent developments in both theoretical and empirical Phillips curve literature. Notably, South African monetary policy makers do not explicitly consider employment creation as part of their mandate. This is despite the persistent high unemployment levels in the country. Rather, domestic monetary policy is inflation-targeting-based and in the regime, employment creation is considered a derivative of monetary policy. Whether this is the best approach in the local economy is debatable.

The main objective of the research was to test if the original Phillips curve relationship existed between the two variables over the period 1994-2015. The intention was to shed light on whether price stability guarantees employment growth through stable economic growth in the country or, on the contrary, if higher inflation could contribute to job creation. To aid this determination, the study reviewed several theoretical and empirical studies. The literature review chapter discussed the Phillips curve literature in general and went on to focus on the domestic experience. The section reviewed both the theoretical and empirical literature to ascertain gaps in past research. The research identified the NKPC as an attractive theoretical model. The study estimated an empirical model comprising unit root test and cointegration test. A single ECM for inflation was estimated along with a system VECM. To the best of our knowledge, the study is the first attempt at disentangling the nature of the relationship between core CPI and unemployment in South Africa. Reviewed studies instead focused mainly on the interaction between unemployment and headline inflation and/or other macroeconomic variables.

The research contributes to the empirical literature through econometric application of a hybrid version of the NKPC model via vector error correction modelling. In our formulation of the model, inflation depends on both expected and lagged inflation, the repo interest rate and unemployment. From the model estimation output, the relationship between inflation and unemployment was positive though insignificant during the period under review. The estimation results suggested that no traditional Phillips curve relationship existed in the domestic economy between 1994 and 2015. In terms of the NKPC model, the estimation results implied that the model does not approximate inflation dynamics that well in the South African context. The empirical findings contrast with conclusions made by Phillips and other researchers who found a significant trade-off between the two variables. Previous studies as summarised by Hodge (2002) also found little evidence of trade-off between inflation and growth (or employment) in the country. Recent studies on the inflation-unemployment relationship for South Africa have generally been inconclusive. Variations of the Phillips curve such as the GMT, NKPC and the SIPC, though theoretically superior, have not been successful in explaining inflation dynamics in the South African context.

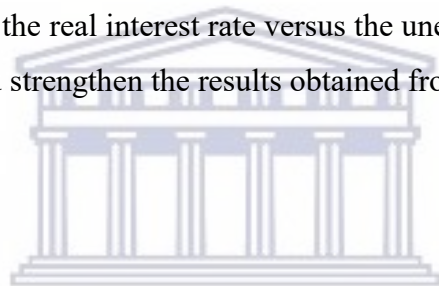
It is important that policymakers pay attention to the nature of the association between the two variables in formulating fiscal and monetary policies. The Phillips curve model remains an important part of the conception of how the two important economic variables interact in an economy. However, the research findings generated some doubts as to whether it can be a useful policy guide in South Africa. The research ascertained that no trade-off exists between inflation and unemployment that policymakers can exploit. The research findings imply that authorities cannot exploit the Phillips curve relationship by either pegging unemployment or stabilising the rate of inflation. Implicitly, unemployment can be reduced without generating any inflationary pressure on the economy. The finding could in part explain why the economy is grappling with persistent high levels of unemployment despite maintaining consistent single-digit inflation figures. Taking into account the research findings, the study recommends that policymakers adopt sound macroeconomic policies to promote employment creation. In addition, targeted job market can be adopted to address the problem of skills mismatch. In this context, domestic monetary policy could be expanded to consider employment creation explicitly, along with inflation control.

## **6.2 Limitations of the study**

A limitation of the study is that the adopted theoretical model, hybrid NKPC model does not consider institutional rigidities in the economy. The domestic labour market is characterised by high unionisation and a small informal sector. At the same time, oligopolies and state-owned firms play a significant role in the South African economy. These structural characteristics present high entry barriers to both labour and product markets and the impact on unemployment remains inconclusive.

## **6.3 Future Research**

There is scope to take into account the Taylor Rule as applied to South Africa and determine whether the setting of the repurchase rate by the SARB has had any direct or indirect impact on unemployment. Some researchers may be interested in seeing what the results look like for a simple Phillips Curve model of the real interest rate versus the unemployment rate. Incorporating such an additional model would strengthen the results obtained from this study.



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## 8. Appendix

Appendix A: Literature review summary table

Phillips curve theoretical development and evidence from developed countries						
Author (s)	Title	Country (ies) studied	Period of study	Methodology	Variables	Finding(s)
Phillips (1958)	The Relation Between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1861-1957	England	1861-1957	<ul style="list-style-type: none"> <li>Phillips Curve</li> </ul>	<ul style="list-style-type: none"> <li>Wages</li> <li>unemployment</li> </ul>	<ul style="list-style-type: none"> <li>The study found a negative correlation between unemployment and growth rate in nominal wages</li> </ul>
Samuelson and Solow (1960)	Analytical Aspect of Anti-Inflation Policy	U.S	1913-57	<ul style="list-style-type: none"> <li>Phillips Curve</li> </ul>	<ul style="list-style-type: none"> <li>price inflation</li> <li>unemployment</li> </ul>	<ul style="list-style-type: none"> <li>The study found a negative correlation between unemployment and price inflation.</li> </ul>
Reichel (2003)	On the death of the Phillips Curve: Further Evidence	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, Portugal, Spain, Sweden, UK, US	1960-2001	<ul style="list-style-type: none"> <li>Niskanen's ARDL version incorporated into an error correction model (ECM)</li> </ul>	<ul style="list-style-type: none"> <li>price inflation</li> <li>unemployment</li> </ul>	<ul style="list-style-type: none"> <li>The study found in support of Niaskanen findings that unemployment rates and inflation rates are not cointegrated.</li> </ul>
Gali and Gertler (1999)	Inflation dynamics: A structural econometric analysis	US	1960-97	<ul style="list-style-type: none"> <li>New-Keynesian Phillips Curve (NKPC)</li> </ul>	<ul style="list-style-type: none"> <li>real marginal cost as a proxy for the output gap</li> <li>inflation</li> </ul>	<ul style="list-style-type: none"> <li>The study found a predominant role for future expected inflation.</li> </ul>

Ribba (2015)	What Drives US Inflation and Unemployment in the Long-Run	US	1960-2011	<ul style="list-style-type: none"> <li>• Structural VAR approach</li> </ul>	<ul style="list-style-type: none"> <li>• the inflation rate</li> <li>• the rate of unemployment</li> <li>• a broad monetary aggregate</li> <li>• short-term interest rate</li> </ul>	<ul style="list-style-type: none"> <li>• The study found no long-run relation between inflation and unemployment</li> </ul>
Niasken (2002)	On the death of the Phillips Curve	US	1960-2001	<ul style="list-style-type: none"> <li>• Autoregressive distributed lag model (ARDL)</li> </ul>	<ul style="list-style-type: none"> <li>• inflation</li> <li>• unemployment</li> </ul>	<ul style="list-style-type: none"> <li>• The study found no evidence of a Phillips curve showing a tradeoff between unemployment and inflation in the long-run.</li> <li>• The study also discovered a negative short-run relationship between unemployment and the inflation rate. The study also found that a strong positive relationship between the unemployment rate and the inflation rate lagged one or two years</li> </ul>
Zhang, Osborne and Kim (2007)	The New- Keynesian Phillips Curve: From Sticky Inflation to Sticky Prices	US	1960-2005	<ul style="list-style-type: none"> <li>• Generalised Method of Moments (GMM)</li> <li>• NKPC</li> </ul>	<ul style="list-style-type: none"> <li>• Annualised quarterly growth rate of the GDP deflator</li> <li>• real potential GDP</li> </ul>	<ul style="list-style-type: none"> <li>• The study found that forward-looking behaviour plays a smaller role during the high and volatile inflation regime of the 1970s than over recent decades</li> </ul>
Kitov and Kitov (2013)	Inflation, unemployment, and labor force. Phillips curves and long-term projections for Japan	Japan	1980-2003	<ul style="list-style-type: none"> <li>• Phillips Curve</li> </ul>	<ul style="list-style-type: none"> <li>• CPI</li> <li>• GDP deflator</li> <li>• Unemployment</li> </ul>	<ul style="list-style-type: none"> <li>• The study found a negative relationship between inflation and unemployment with increase in unemployment, resulting in decreasing inflation</li> </ul>
Sala and Karanassou (2009)	The US Inflation-Unemployment Tradeoff: Methodological Issues	US	1960-2005	<ul style="list-style-type: none"> <li>• Structural VAR (SVAR)</li> <li>• Generalised Method of</li> </ul>	<ul style="list-style-type: none"> <li>• Money supply as proxy for output</li> <li>• Interest rates as proxy for</li> </ul>	<ul style="list-style-type: none"> <li>• The study found evidence on the long-run inflation-unemployment tradeoff in the US.</li> </ul>

	and Further Evidence			Moments (GMM)	inflation	
<b>Empirical evidence from developing countries</b>						
Author (s)	Title	Country (ies) studied	Period of study	Methodology	Variables	Finding(s)
Touny (2013)	Investigating the Long-Run Trade-Off between Inflation and Unemployment in Egypt	Egypt	1974-2011	<ul style="list-style-type: none"> <li>Vector Error Correction Model (VECM)</li> </ul>	<ul style="list-style-type: none"> <li>Inflation</li> <li>lagged inflation</li> <li>unemployment gap</li> </ul>	<ul style="list-style-type: none"> <li>The study found a positive relationship between changes in inflation rate and unemployment gap in the long run</li> </ul>
Furuoka (2007)	Does the "Phillips Curve" Really Exist? New- Empirical Evidence from Malaysia	Malaysia	1973-2004	<ul style="list-style-type: none"> <li>Vector Error Correction Model (VECM)</li> </ul>	<ul style="list-style-type: none"> <li>Unemployment</li> <li>Inflation rate</li> </ul>	<ul style="list-style-type: none"> <li>The study found the existence of a long-run and trade-off relationship</li> <li>The study also found a causal relationship between the unemployment rate and the inflation rate in Malaysia</li> </ul>
Prasanna and Gopakumar (2013)	Inflation and Economic Growth in India – An Empirical Analysis	India	1972-2008	<ul style="list-style-type: none"> <li>VECM</li> </ul>	<ul style="list-style-type: none"> <li>Inflation</li> <li>Output</li> </ul>	<ul style="list-style-type: none"> <li>The study found that there is a long-run negative relationship between inflation and GDP growth rate in India</li> </ul>
Umaru and Zubairu (2012)	An Empirical Analysis of the Relationship between Unemployment and Inflation in Nigeria from 1977-2009	Nigeria	1977-2009	<ul style="list-style-type: none"> <li>VECM</li> </ul>	<ul style="list-style-type: none"> <li>Inflation</li> <li>Unemployment</li> </ul>	<ul style="list-style-type: none"> <li>The study found that there is a long-run relationship between unemployment and inflation in Nigeria</li> </ul>
Furuoka, Munir and Harvey (2013)	Does the Phillips Curve Exist in Philippines?	Philippines	1980-2010	<ul style="list-style-type: none"> <li>Dynamic Ordinary Least Squares (DOLS)</li> </ul>	<ul style="list-style-type: none"> <li>Inflation</li> <li>Unemployment</li> </ul>	<ul style="list-style-type: none"> <li>The study detected a long-run negative and a causal relationship between inflation and unemployment rate</li> </ul>

Al-Zeaud and Al-Hosban (2015)	Does the Phillips curve really exist: An empirical evidence from Jordan	Jordan	1976-2013	<ul style="list-style-type: none"> <li>• Co-integration tests</li> <li>• VECM</li> <li>• linear and non-linear OLS</li> </ul>	<ul style="list-style-type: none"> <li>• Inflation</li> <li>• Unemployment</li> </ul>	<ul style="list-style-type: none"> <li>• The study found a strong empirical existence of Phillips Curve in the Jordanian economy.</li> <li>• The study also found a negative and non-linear relationship between unemployment and inflation</li> </ul>
Katria, Bhutto, Butt, Domki and Khawaja Javeria Khalid (2013)	Trade-off between inflation and unemployment	Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka Republic of China, Russia, Indonesia, Iran, Myanmar and South Africa	1980 -2010	<ul style="list-style-type: none"> <li>• OLS</li> </ul>	<ul style="list-style-type: none"> <li>• Inflation rate</li> <li>• Unemployment rate</li> <li>• Real interest rate</li> <li>• Debt servicing proxy</li> <li>• Gross capital formation</li> <li>• Combined effect of gross capital formation and real interest rate</li> </ul>	<ul style="list-style-type: none"> <li>• The study found that there is a negative relationship between inflation and unemployment rate in the countries that were studied and concluded that the concept of Phillips curve holds true</li> </ul>

### Empirical evidence from South Africa

Author (s)	Title	Country (ies) studied	Period of Study	Methodology	Variables	Finding(s)
Krogh (1967)	Growth and inflation	South Africa	1948-1965	<ul style="list-style-type: none"> <li>• Phillips curve gap</li> </ul>	<ul style="list-style-type: none"> <li>• Inflation</li> <li>• Unemployment</li> </ul>	<ul style="list-style-type: none"> <li>• The study found small positive relationship at low levels of inflation which turns to a strong negative relationship at higher rates of inflation</li> </ul>
Gallaway, Koshal and Chapin (1970)	The Relationship between the rate of change in money wage rates and unemployment levels in South Africa	South Africa	1948-1963	<ul style="list-style-type: none"> <li>• Distributed lag time series model with deterministic trend of Phillips curve</li> </ul>	<ul style="list-style-type: none"> <li>• Nominal wages in private manufacturing and construction</li> <li>• Unemployment rate</li> </ul>	<ul style="list-style-type: none"> <li>• The study found a significant negative relationship, suggesting a mild tradeoff between inflation and unemployment</li> </ul>
Hume (1971)	A study of inflation in South Africa	South Africa	1946-1966	<ul style="list-style-type: none"> <li>• Nine-equation</li> </ul>	<ul style="list-style-type: none"> <li>• Inflation</li> <li>• Unemployment rate</li> </ul>	<ul style="list-style-type: none"> <li>• The study found a significant negative relationship,</li> </ul>

				wage-price model		suggesting a mild tradeoff between the variables
Truu (1975)	Inflation in the South African economy	South Africa	1948-1975	<ul style="list-style-type: none"> <li>Time series model</li> <li>Phillips curve</li> </ul>	<ul style="list-style-type: none"> <li>Unemployment rate</li> <li>Inflation</li> </ul>	<ul style="list-style-type: none"> <li>The study found a highly significant negative effect between the two</li> </ul>
Pretorius and Smal (1994)	A macro-economic examination of the price formation process in the South African economy.	South Africa	1970-1992	<ul style="list-style-type: none"> <li>Time series model of the expectations augmented Phillips curve</li> </ul>	<ul style="list-style-type: none"> <li>GDP deflator</li> <li>Output gap</li> <li>Inflation rate</li> </ul>	<ul style="list-style-type: none"> <li>The study found that output gap has an indirect effect via the wage equation</li> </ul>
Nell (2000)	Is low inflation a precondition for faster growth? The case of South Africa	South Africa	1971-1993	<ul style="list-style-type: none"> <li>Time series model of non-linear expectations</li> <li>Augmented Phillips curve</li> </ul>	<ul style="list-style-type: none"> <li>GDP deflator</li> <li>Output gap</li> </ul>	<ul style="list-style-type: none"> <li>The study found that generally output gap is statistically significant for the accelerating inflation period, but not for the deflationary period</li> <li>The study also found that the negative output gap is statistically significant in the accelerating inflation period, while the positive output gap is statistically insignificant</li> </ul>
Hodge (2002)	Inflation versus unemployment in South Africa: Is there a trade off?	South Africa	1970-2000	<ul style="list-style-type: none"> <li>Error correction model of the Phillips curve</li> </ul>	<ul style="list-style-type: none"> <li>Inflation</li> <li>Unemployment rate</li> <li>Employment growth</li> <li>Output gap</li> </ul>	<ul style="list-style-type: none"> <li>The study found no evidence of a relationship between inflation and either unemployment, employment or the jobless rate</li> </ul>
Fedderke and Schaling (2005)	Long run determination of inflation in South Africa	South Africa	1960- 1999	<ul style="list-style-type: none"> <li>VECM</li> </ul>	<ul style="list-style-type: none"> <li>GDP deflator</li> <li>Output gap</li> <li>Price expectations</li> <li>Labour unit cost</li> <li>Real exchange rate</li> </ul>	<ul style="list-style-type: none"> <li>The study found no significant direct effect, but an indirect channel via the adjustment of unit labour costs to its long-run equilibrium</li> </ul>
Burger and Marinkov (2006)	The South African Phillips Curve: How applicable is the Gordon model	South Africa	1976-2002	<ul style="list-style-type: none"> <li>Gordon triangular model</li> </ul>	<ul style="list-style-type: none"> <li>Inflation gap</li> <li>Output gap</li> </ul>	<ul style="list-style-type: none"> <li>The study found no evidence of inflation-unemployment tradeoff</li> </ul>



Reid and Du Rand (2014)	A sticky information Phillips curve for South Africa	South Africa	1995-2010	<ul style="list-style-type: none"> <li>• VAR</li> <li>• Generalised Least Squares</li> </ul>	<ul style="list-style-type: none"> <li>• Current output gap</li> <li>• Previous expectations of current period inflation output gap growth values</li> </ul>	<ul style="list-style-type: none"> <li>• The study found no conclusion on which between the SIPC and the NKPC fits the South African data better</li> </ul>
Du Plessis and Burger (2006)	A New-Keynesian Phillips Curve for South Africa	South Africa	1975-2003	<ul style="list-style-type: none"> <li>• Hybrid NKPC</li> </ul>	<ul style="list-style-type: none"> <li>• Output gap</li> <li>• Expected future inflation</li> </ul>	<ul style="list-style-type: none"> <li>• The study found that NKPC does not explain inflation dynamics in the SA context.</li> <li>• The research suggested that the generalised method of moments econometric approach works best for SA</li> </ul>
Chicheke (2009)	Monetary policy, inflation, unemployment and the Phillips curve in South Africa	South Africa	1998-2008	<ul style="list-style-type: none"> <li>• VECM</li> </ul>	<ul style="list-style-type: none"> <li>• Inflation rate</li> <li>• Unemployment rate</li> </ul>	<ul style="list-style-type: none"> <li>• The study found that there is no long-run trade-off between unemployment and inflation</li> </ul>
Phiri (2015)	Examining asymmetric effects in the South African Philips curve: Evidence from logistic smooth transition regression (LSTR) models	South Africa	1970-2014	<ul style="list-style-type: none"> <li>• Logistic smooth transition regression (LSTR) econometric model</li> <li>• New-Classical PC</li> <li>• New-Keynesian PC</li> <li>• the Hybrid New-Keynesian PC</li> <li>• The momentum threshold autoregressive (MTAR) model</li> </ul>	<ul style="list-style-type: none"> <li>• Inflation</li> <li>• Unemployment rates</li> </ul>	<ul style="list-style-type: none"> <li>• The study found that marginal-cost-based as well as the output-gap-based versions of the Hybrid New-Keynesian PC provide a good fit for South African data.</li> <li>• The empirical results indicate that monetary policy in South Africa has an influence on the demand side of the economy through inflation inertia and inflation expectations while appearing to exhibit no significant effects on the supply side of the economy</li> </ul>



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