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INFLATION DYNAMICS IN SOUTH AFRICA

By

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at the

UNIVERSITY OF THE WITWATERSRAND

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DECLARATION

I, Temitope Lydia Leshoro declare that the research work reported in this dissertation is my own, except otherwise indicated and acknowledged. It is submitted for the degree of Doctor of Philosophy in the University of the Witwatersrand, Johannesburg. This thesis has not, either in whole or in part, been submitted for a degree or diploma to any other universities.



Signature of candidate Date: …8th FEBRUARY, 2016.

ABSTRACT

The design and implementation of the monetary policy in South Africa has been based on the idea of a trade-off between inflation and output growth. However, there is no consensus among empirical investigations on the existence of Phillips curve in the present times. While the South African Reserve Bank (SARB) has instrument independence, it does not have goal independence, which implies that there is coordination between the monetary policy and other macroeconomic policies. Thus, if the SARB objectives are in line with the other policy objectives, there should be a relationship between monetary variables and real variables. This therefore shows that in the long-run, monetary policy cannot single-handedly bring about both sustained economic growth and employment creation (SARB, 2014).

Thus this study explored inflation dynamics in South Africa by using the Hybrid new Keynesian Phillips curve (HNKPC) and the augmented Gordon's models. The study firstly estimated the Hybrid new Keynesian Phillips curve model with a view to determine whether Phillips curve exists and ascertain whether the backward-looking or forward-looking components drive inflation dynamics in South Africa using OLS and GMM estimation techniques. The results show that the Phillips curve does not exist in South Africa using various measures of demand-side variable. These findings are robust across estimation methodologies as well as different measurements of inflation expectations and data frequency. While the findings indicated that economic agents in South Africa are both rational and adaptive in predicting inflation, the results clearly showed the dominance of forward looking component over the backward looking element in driving inflation.

Secondly, given the focus of the South African monetary authority in maintaining stable inflation rates and the fact that monetary policy need to go hand-in-hand with other policies in order to ensure stable inflation and economic growth (Gruen, Pagan and Thompson, 1999), this study considered the expanded Gordon's model with a particular focus on how fiscal policy determines the inflation process in South Africa. The purpose of the Gordon's chapter is to verify the existence or non-existence of Phillips curve in an expanded model, within the context of an augmented "triangle" model while including the monetarist and fiscal side variables, thereby

checking whether the PC relationship of recent studies is robust to model specification. Thus, the augmented Gordon's model was estimated using a holistic approach of including the fiscalist, monetarist and the structuralist schools of thought, using the Vector autoregressive (VAR), vector error correction model (VECM) and innovation accounting techniques.

The results confirm the non-existence of PC whereby output growth maintained a negative relationship with inflation rate, signifying no trade-off despite the expanded specification, while the results from output-gap model are inconclusive. Further results showed that the demand-side, fiscal factors and some of the structural variables contribute more to the inflation dynamics in South Africa. Thus the changes in inflation rate are as a result of changes in output growth, government deficit, electricity price and exchange rate. The results confirmed that the Fiscal Theory of the Price Level (FTPL) applies to the South African economy, whereby not only monetary policies should be considered in controlling inflation, but also fiscal policies.

On the other hand, the importance of the determinants of inflation rate is not sufficient in observing the inflation dynamics in South Africa; therefore, this study concluded by investigating the level at which inflation becomes detrimental to output growth. In the context of the low levels of economic growth and high levels of unemployment in South Africa, the study analysed the output growth implications of the inflation targeting monetary policy of the South African Reserve Bank that targets an inflation band between three and six percent.

Using the Threshold Autoregressive (TAR) and the Sample Splitting Threshold Regression (SSTR) techniques, this study investigated the nonlinear inflation-growth nexus in South Africa with the purpose of identifying the inflation rate band that optimize output growth. The results showed that South Africa is able to accommodate a higher level of inflation beyond the current inflation target band by increasing the band to between seven and nine percent in order to enhance output growth. Our findings support the argument of studies that indicate that moderately higher inflation rate will not be harmful to the economy.

DEDICATION

I dedicate this Thesis to my husband, Selebogo Leshoro, my children (twins), Thato and Oreratile. I love you all, so much. God bless you.

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LIST OF ACRONYMS

2SLS	TWO-STAGE LEAST SQUARES
2SLS-IV	TWO-STAGE LEAST SQUARES INSTRUMENTAL VARIABLES
AD	AGGREGATE DEMAND
ADF	AUGMENTED DICKEY-FULLER
AIC	AKAIKE INFORMATION CRITERION
ARDL	AUTOREGRESSIVE DISTRIBUTED LAG
ARIMA	AUTO REGRESSIVE INTEGRATED MOVING AVERAGE
ARMA	AUTO REGRESSIVE MOVING AVERAGE
AS	AGGREGATE SUPPLY
BER	BUREAU FOR ECONOMIC RESEARCH
BIC	BAYESIAN INFORMATION CRITERIA
BoB	BANK OF BOSTWANA
CEA	COUNCIL OF ECONOMIC ADVISORS
CLS	CONDITIONAL LEAST SQUARES
COSATU	CONGRESS OF SOUTH AFRICAN TRADE UNIONS
CPI	CONSUMER PRICE INDEX
DF-GLS	DICKEY-FULLER GLS
DFE	DYNAMIC FIXED EFFECT
ECM	ERROR CORRECTION MODEL
ESTAR	EXPONENTIAL SMOOTH TRANSITION AUTOREGRESSIVE.
FIML	FULL INFORMATION MAXIMUM LIKELIHOOD
FMOLS	FULLY-MODIFIED ORDINARY LEAST SQUARES
FTPL	FISCAL THEORY OF PRICE LEVEL
GDP	GROSS DOMESTIC PRODUCT
GMM	GENERALIZED METHOD OF MOMENTS
HNKPC	HYBRID NEW KEYNESIAN PHILLIPS CURVE
HP	HODRICK-PRESCOTT
IFS	INTERNATIONAL FINANCIAL STATISTICS
IMF	INTERNATIONAL MONETARY FUND
IRF	IMPULSE RESPONSE FUNCTIONS
IT	INFLATION TARGET
IV	INSTRUMENTAL VARIABLES
LBVAR	LARGE BAYESIAN VECTOR AUTOREGRESSIVE
LR	LIKELIHOOD RATIO
LSTAR	LOGISTIC SMOOTH TRANSITION AUTOREGRESSIVE
MC	MARGINAL COST
MENA	MIDDLE-EAST AND NORTH AFRICAN
NAIRU	NON-ACCELERATING INFLATION RATE OF UNEMPLOYMENT
NKPC	NEW KEYNESIAN PHILLIPS CURVE
NLS	NONLINEAR LEAST SQUARES
OECD	ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT
OLS	ORDINARY LEAST SQUARES
PC	PHILLIPS CURVE
PMG	POOLED MEAN GROUP

PP	PHILLIPS-PERRON
RESET	REGRESSION ERROR SPECIFICATION TEST
RIE	REUTERS INFLATION EXPECTATIONS
RSS	RESIDUAL SUM OF SQUARES
SARB	SOUTH AFRICAN RESERVE BANK
SETAR	SELF-EXCITING THRESHOLD AUTOREGRESSIVE
SSR	SUM OF SQUARES RESIDUAL
SSTR	SAMPLE SPLITTING THRESHOLD REGRESSION
STAR	SMOOTH TRANSITION AUTOREGRESSIVE
STATSSA	STATISTICS SOUTH AFRICA
SVAR	STRUCTURAL VECTOR AUTOREGRESSIVE
TAR	THRESHOLD AUTOREGRESSIVE
TOT	TERMS OF TRADE
UNESCO	UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION
VAR	VECTOR AUTOREGRESSIVE
VECM	VECTOR ERROR CORRECTION MODEL
VD	VARIANCE DECOMPOSITION
WAMZ	WEST AFRICAN MONETARY ZONE

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The South African Reserve Bank (SARB) strives to achieve sustainable price stability as well as obtain and maintain a balanced economic growth. Although it also performs the function of financial stability, its main objective is to attain price stability. The Bank is able to realise this goal through its fundamental formulation and implementation of monetary policy, using mainly the repurchase rate (also known as the repo rate) as the monetary policy instrument. In its quest to achieve price stability and sustained economic growth, the SARB announced the formal adoption of the inflation targeting (IT) framework in February 2000, with the inflation target band of three to six percent set for 2002. This framework has been met with considerable opposition from the Congress of South African Trade Unions (COSATU) and studies such as Weeks (1999) and Hodge (2006) concluded that South Africa can still accommodate moderately higher inflation rate without adversely affecting economic growth.

The design and implementation of the monetary policy have been based on the idea of a trade-off between inflation and output growth (du Plessis and Burger, 2006). However, investigation has revealed empirical irregularities in the relationship between price inflation and output growth in many industrialized countries (Fuhrer and Moore, 1995a; Gali and Gertler, 1999; Rudd and Whelan, 2005)[1]. The possibility of the existence (or non-existence) of the Phillips curve and the importance of forward-looking, backward-looking or mixed price inflation[2] specifications have been considered in several studies (Hodge, 2002; and Fedderke and Schaling, 2005; Burger and Marinkov, 2006; Malikane, 2012).

Furthermore, the Hybrid new Keynesian Phillips curve (HNKPC) is chosen as the baseline model because it is the most widely accepted and commonly used model of the Phillips curve in

[1] Also see Batini, Jackson, and Nickell (2000) and Galı´, Gertler and Lo´pez-Salido (2001).

[2] Forward-looking PC is the new Keynesian PC which includes price expectations; the backward-looking PC is the traditional PC which considers the inclusion of only the inflation lag and the mixed PC is the Hybrid New Keynesian PC (HNKPC) which incorporates both the price expectations and lags.

modern macroeconomics, developed by Gali and Gertler, (1999). It is also used to observe the adaptive expectations in relation to the sticky-prices approach of Fischer (1977), Taylor (1980) and Calvo (1983). Thirdly, according to Nason and Smith (2005), HNKPC has significant implications for monetary policy in assisting how central banks should respond to events while inflation targeting is being maintained. Phillips curve (PC) is used to explain the determinants of inflation, for policy recommendations and inflation forecasting. Although, the HNKPC model is ideal in estimating the Phillips curve, Gruen, Pagan and Thompson (1999) stated that the Phillips curve alone cannot be used for the purposes of explaining inflation determinants and policy purposes except it is augmented to allow for the effects of additional variables such as, the demand and supply shocks, as well as institutional variables.

According to Gordon (1990), the "triangle" model of inflation depends solely on three components, namely, inflation inertia, demand shocks and supply shocks. Following from the study by Gali and Gertler (1999) who estimated the hybrid new Keynesian Phillips curve, other studies emerged in order to examine the effects of different additional variables on inflation dynamics in different countries (Akinboade, Niedermeier and Siebrits, 2002; Batini, Jackson and Nickell, 2005; Burger and Marinkov, 2006).

Furthermore, while SARB is free to choose any monetary policy instrument to achieve and to maintain the inflation target band, the targets are jointly set by the government and the Bank (Mboweni, 1999). This means that the Bank has instrument independence, but not goal independence, implying the coordination between the monetary policy and other macroeconomic policies. Thus, there should be a relationship between monetary variables and real variables, if the set target is in line with the other policy objectives.

This therefore confirms that in the long-run, monetary policy cannot single-handedly bring about both sustained economic growth and employment creation without the introduction of fiscal policies (SARB, 2014). Given the focus of the South African monetary authority in maintaining stable inflation rates and the fact that monetary policy need to go hand-in-hand with other policies in order to ensure stable inflation and economic growth (Gruen *et.al*, 1999), this study

will further consider the expanded Gordon's model to incorporate the effect of fiscal policy in determining inflation in South Africa. This study thus aims to explore inflation dynamics in South Africa. This is approached using the Hybrid new Keynesian Phillips curve (HNKPC) and the augmented Gordon's models.

On the other hand, the importance of the determinants of inflation rate is not sufficient in observing the inflation dynamics in South Africa, hence the study will also investigate the level at which inflation becomes detrimental to output growth. As economic theory proposes that some major economic variables are not only linearly related but they also exhibit non-linear behaviour therefore, the emerging studies have also shown that there is a possibility of a non-linear relationship between inflation and output growth. Fischer (1993) was first to identify such relationship. Thus, given the importance of examining the determinants of inflation and particularly its relationship with output growth, it is equally imperative to observe the level at which inflation becomes detrimental to output growth. This will assist policy makers to observe the inflation level that is detrimental to output growth since monetary and fiscal policies are deemed inseparable.

1.2 PROBLEM STATEMENT

Extensive review of PC literature in South Africa indicates that only one study (Malikane, 2013) explored the hybrid NKPC. The differences in the study by Malikane and the current study are that, while Malikane used consumer price index, inflation rate is used in this study. Malikane (2013) also used only output gap, as a demand side measure, quarterly data and one measure of inflation expectation (the rational expectations), while the current study uses two different measures of demand-side variables, annual and quarterly data, three different measures of inflation expectations and two different estimation techniques. Therefore the significant contribution of this study is to observe the sensitivity of the HNKPC model to different measures of inflation expectations and demand-side, data frequency and econometric techniques. Further contribution is in extending the Gordon's model to incorporate fiscal, monetary and structural factors, seeing that monetary policy cannot single-handedly combact inflation. None of the studies in South Africa estimated the triangular nested model of Gordon by explicitly including

all the three schools of thought, in determining inflation dynamics. Gordon's triangle model is not sufficient in capturing all the factors that could possibly cause changes in inflation as the model excludes the monetarist and the fiscal variables. Also, according to our knowledge, there is no study that considered the inclusion of the effect of the fiscal factors in determining inflation dynamics in South Africa; thereby considering the fiscal theory of price level (FTPL).

Finally, given the oppositions from unions and different conclusions from studies about the inflation target band of the country, this sudy will consider the appropriate inflation target band (or point) that will promote economic growth,

1.3 RESEARCH OBJECTIVE

The motivation for this study stems from the assessment of the monetary policy in South Africa based on the adoption of the inflation targeting framework. This is also due to the evidence of the challenge and importance of stable inflation in South Africa. The objective of this study is to explore the inflation dynamics in South Africa by observing its major determinants while at the same time assessing how it could either positively or negatively affect output growth. Based on the aim of this study, the following research questions will be answered:

1. Does Phillips curve exist in South Africa?
2. Are economic agents rational or adaptive in determining current inflation?
3. Is the fiscal theory of price level applicable to South Africa?
4. Is the current inflation target band beneficial to the South African economy?

The benefit of a country-specific study is that the variables that affect inflation or output growth can easily be determined for any individual country, unlike having to group different economies with different inflation and growth experiences. It also reveals more useful information that is specific to a particular country thereby making policy proposals less problematic (Phiri, 2013; Chimobi, 2010; Kremmer, Bick and Nautz, 2009).

1.4 OUTLINE OF THE STUDY

The thesis is structured as follows:

Chapter 1: Introduction

This chapter introduces the study, and also provides the background, motivations including the objectives.

Chapter 2: Theoretical review of inflation and output growth

The theory of the evolution of Phillips curve from the traditional model to the Gordon's model is discussed in this chapter. The conclusions of different schools of thought on the inflation-growth nexus are also explained.

Chapter 3: Sensitivity of the hybrid new Keynesian Phillips curve in South Africa.

This chapter estimates the output-based Philips curve in South Africa in order to investigate whether backward-looking, forward-looking or both components are present, while using output growth (and output-gap) to capture the demand-side. Three different measures of inflation expectations, namely survey, Hodrick-Prescott filter and the forecast using auto regressive integrated moving average (ARIMA) or auto regressive moving average (ARMA), is adopted. The use of different measures of expected inflation indicates which measure best explains inflation dynamics in South Africa. Different econometric techniques of Ordinary least squares (OLS) and Generalized Method of Moments (GMM) are also adopted. Further robustness of the results, apart from using different measures of demand-side and inflation expectations, is ascertained by using both annual and quarterly data series. Structural breaks are also included in order to account for possible policy shift. The objectives of this chapter is thus to determine whether Phillips curve exists in South Africa and to inform policy makers of how economic agents anticipate changes in inflation; whether they expect inflation to change based on the previous or future inflation rates. The reason is that if there is no existence of Phillips curve trade-off, monetary authorities can focus on targeting inflation without adversely affecting output and put to rest the current controversy surrounding the monetary policy in South Africa.

Chapter 4: An extended Gordon's triangle model for South Africa

The determinants of inflation dynamics in South Africa, using the concept of Gordon's model is estimated in this chapter. The "triangle" model of inflation depends on three components, which are, inflation inertia, demand shocks (which already existed in the traditional PC) and the supply shocks. This chapter however investigates the impact of the variables from different schools of thought of the fiscal, monetary and the structural factors. Vector autoregressive (VAR), vector error correction model (VECM) and innovation accounting techniques are employed to estimate the extended Gordon's model. The reason for the extended model is that the Gordon's triangle model is not sufficient to capture all the factors that could possibly cause changes in inflation as it excludes the monetarist and the fiscal variables. The importance of such extended model is to be able to observe the applicability of the different schools of thought to inflation dynamics in South Africa. Results obtained from this chapter will advise whether changes in inflation are caused by changes in fiscal, monetary or structural factors. This is important because it will make policy makers aware of the factors that drive inflation in the country and focus on these factors in order to combat inflation. This will thus assist policy makers to decide the best way to combat inflation after being cognisant of the factors that determine inflation as well as those that contribute more to inflation dynamics.

Chapter 5: The inflation-output growth threshold in South Africa

This chapter estimates the inflation-growth model in order to observe the inflation threshold and whether the adopted inflation target band is still appropriate for South Africa. Estimating the inflation threshold is important because not only will it assist monetary authorities to set the right target band; it will also give an indication when the economy is heating up. The econometric techniques used are the threshold autoregressive (TAR) model and the sample-splitting threshold regression (SSTR). It is important to note that, even though the inflation target framework is quite important in any economy, it is equally important to re-examine it periodically as the circumstances of any given country do not stay the same. The result obtained will give an indication of the appropriate inflation target band to be set by the monetary authorities. If threshold results are different from the current target band, it will be advisable that monetary

authorities consider changing the current band in order to fully benefit from the positive effects of inflation on output growth in South Africa.

Chapter 6: Conclusion

This chapter concludes the study with overall policy recommendations, while highlighting the limitations of the study and suggesting possible areas of further research.

CHAPTER 2

THEORETICAL REVIEW OF INFLATION AND OUTPUT GROWTH NEXUS

This chapter presents the progression of Phillips curve (PC) from the traditional model to the new Keynesian Phillips curve (NKPC), the hybrid new Keynesian Phillips curve (HNKPC) model, and further to the Gordon's triangle model. While the Phillips curve is the first step to understanding inflation dynamics, the extended model, which is a nested Gordon's triangle model, is a holistic approach[3]. This chapter also discusses the relationship between inflation and output growth, highlighting the different conclusions of different schools of thought.

2.1 TRADITIONAL TO HYBRID NEW KEYNESIAN PHILLIPS CURVE

In 1954, Phillips related the changes in income and output to changes in the price level (Lipsey and Scarth, 2011). The study rejected the dissimilarity between output and price changes that was formalized in the kinked aggregate supply (AS) curve. When an economy is below full-employment, fluctuations in aggregate demand (AD) will cause income to change, but at full employment level, fluctuations in aggregate demand (AD) will cause prices to change (Lipsey and Scarth, 2011). Also, the factor price explanation of the price Phillips curve is that increases in the factor prices will not cause huge increases in the price of goods. However, if AD increases, factor prices will increase and this will increase the price of goods. This means that according to Phillips (1958), the main driving force on the cost side is wages (Lipsey and Scarth, 2011). This therefore led to investigating the relationship between the rate of change of money wage and unemployment levels.

Although the trade-off between inflation and unemployment was reported by Phillips in 1958 after several authors had viewed the causation as running from unemployment to wage inflation, Irving Fisher initially statistically measured the correlation between the changes in price level

[3] The Gordon's model emphasized the importance of the supply shocks, as well as additional lags on the dependent and independent variables that was excluded from the HNKPC model. The additional lags on the independent variable (unemployment gap as used by Gordon) measure the rate-of-change effect of the independent variable on inflation.

and changes in the volume of employment in 1926 (Fisher, 1926; Fisher, 1973). Fisher found a remarkably high relationship between the changes in the rate of price and employment. It was not until 1958 that Phillips estimated the relationship between unemployment rate and percentage changes in money wage. This is because Phillips believed that changes in prices are related to the level of income; this is the price Phillips curve. The major success of the Phillips curve, using a two-variable model, was the uncommon empirical result which shows the notable stability of the theory that holds true for the periods before World War I (1861 -1913) and post-World War II (1948 – 1957) (Humphrey, 1985).

Even though the Phillips curve could not provide answers to the causes of nor proffer suitable remedies for inflation, it was however able to accommodate a wide variety of inflation theories. The wage Phillips curve, according to the Keynesian theory, shows that an increase in wages as a result of excess labour demand will shift the flat marginal cost (MC) curve of the firms upwards thereby increasing the price of the products, and inflation will ensue (Lipsey and Scarth, 2011). This theory therefore accommodates both the demand-pull and cost-push theorists. Its further success lies in the provision of a convincing justification for the inability of policy makers to achieve full employment alongside price stability. In order for the Phillips curve to be more useful to policy makers, the model was transformed from wage-change relationship to price-change relationship. This is because policy makers used the rates of change of prices instead of wages in specifying inflation targets.

Therefore, the model was changed to the relationship between inflation and unemployment. That was to further assist authorities to determine the level of unemployment that would result from any given inflation rate. In the early 1960s, the first report compiled by the Kennedy Council of Economic Advisors (CEA) showed that the unemployment target point of 4 percent was rational and cautious. At the same time, the report stated that the macroeconomic conditions of the late 1950s to 1960s resulted in output gap of between 4 and 10 percent. The report later built on Okun’s Law, where unemployment was linked to output gap (Okun, 1962). Subsequently the Phillips curve was measured in terms of the relationship between inflation rate and output gap in many studies.

However, in the early to mid-1960s, it was discovered that there was a possibility for a shift in the Phillips curve, as a result of the contradiction between the empirical studies of U.S. and that of the U.K (Lipsey and Scarth, 2011). As a result, additional variables were introduced to account for such movements; this is the second stage of Phillips curve analysis. The model was believed to lack the appropriate variables to be included. The major variable that was excluded from the trade-off equation was the expected inflation. This variable was later found to be the main cause of the shift in the short-run Phillips curve.

Later on, the inflation expectation variable was fully integrated into the Phillips curve equations in the late 1960s to mid-1970s (Humphrey, 1985; King, 2008). It was realised that there was a misspecification in the original Phillips curve. An innocuous assumption of the exclusion of expected inflation in the Phillips curve model was initially made in the 1950s. Although Phillips (1958) suggested that there was a possibility of a 'catch-up' effect because changes in wages responded to the inflation rate in the previous period, Lipsey (1960) however disputed this stand point, because there was no such empirical evidence in the period considered in the original paper by Phillips.

Moreover, the assumption not to include inflation expectations was appropriate during the period considered because the average inflation rate was close to zero. This was apart from the two World War periods. Meanwhile, the idea of the lack of emphasis on expected inflation in the Phillips curve model was not acceptable to the traditional monetary economists especially in the 1960s and 1970s when inflation began to increase (Lipsey and Scarth, 2011). Hence, the expectations-augmented Phillips curve was developed as a result of the fact that the inflation expectations term which was excluded from the original traditional Phillips curve rendered it incorrect.

Another important reason for the inclusion of inflation expectations is that since after World War II, consumers have been expecting increases in prices, thus by acting on it, prices rose. Therefore greater weight was placed on expectations by the monetary authorities to direct macroeconomic activities (King, 2008). In the early 1970s, the original Phillips curve was redefined in the

following ways: (1) the specification for excess demand variable was changed from the inverse function of unemployment rate, x (U), to the gap between the current or actual rates of unemployment and the natural rate of unemployment, $U - U_N$; this is the natural rate hypothesis; (2) the introduction of the inflation expectations variable, which produced the expectation-augmented equation; and (3) the inclusion of the expectations-generating mechanism, which are adaptive-expectations and error-learning mechanism.

There were, however, criticisms against the adaptive-expectations mechanism, in that it inaccurately represents price expectations formulation. This shortcoming resulted in the use of an alternative approach, the rational expectations approach, to Phillips curve. Under the rational expectations approach with the natural rate hypothesis, it was believed that there is no trade-off both in the short and the long runs. This is its distinction from the adaptive expectations natural rate Phillips curve. The inflation expectations variable entered the model with a unit coefficient. This shows that there is no inflation-unemployment trade-off in the long-run; although there could be a trade-off in the short run as a result of inflationary surprise (Humphrey, 1985; King, 2008). According to the new classical economists, who followed Friedman's approach, the short-run Phillips curve was found to be steep. Thus, they considered unemployment gap or real output gap a demand-side variable (Lipsey and Scarth, 2011).

Phelps (1978) and Friedman (1968) developed the natural rate of unemployment and implied that there exists a relationship between changes in unemployment rate, *u*, and the inflation rate, as shown:

$$\pi_t = \pi_t^e - aU_t = \pi_{t-1} - aU_t \qquad \ldots \{2.1\}$$

$$\Delta\pi_t = \pi_t - \pi_{t-1} = -aU_t$$

Where, π_t is the rate of inflation at period t; π_t^e is the rate of expected inflation in the same period; π_{t-1} is the rate of inflation in the previous period; U_t is the unemployment rate in period t and Δ denotes the change.

The accelerationist Phillips curve, which is the original Phillips curve framework, excluded the long-run trade-off between the two variables, inflation and unemployment rates. It focused on

the significance of expectations in the development of price-setting. In order to highlight the role of the Non-accelerating inflation rate of unemployment (NAIRU) in Phillips curve framework, the following equation was derived:

$$\Delta\pi_t = \pi_t - \pi_{t-1} = -a(U_t - U^*) \qquad \ldots \{2.2\}$$

Where U^* is the NAIRU; $U_t - U^*$ is the unemployment gap and π_t is the rate of inflation at period t. When the actual unemployment rate equals NAIRU, then the change in inflation rate will be zero. In the short-run Phillips curve, NAIRU was assumed to be zero in equation {2.2}.

According to Estrella and Mishkin (1999), the idea of the natural rate of unemployment results in the following expectations-augmented Phillips curve:

$$\pi_t = \pi_t^e - \beta(L)(u_t - \bar{u}_t) + \delta' z_t + \varepsilon_t \qquad \ldots \{2.3\}$$

where, π_t is the inflation rate from one-period lag to the current period (from t-1 to t); π_t^e is the inflation expectations from the previous period; L is the lag operator; β is the coefficient; u_t is current unemployment rate; $\bar{u}_t$ is the natural rate of unemployment; z_t primarily represents the supply shocks; ε_t is the disturbance term.

Nevertheless, the concept of NAIRU was seen to be flawed, with serious uncertain estimates in the early to mid-1990s when the rate of inflation in the US moved below the rate of NAIRU. Although inflation did not increase, it however actually dropped. The uncertain estimates confirm the unreliability of NAIRU in providing assistance to monetary policy makers. Another problem of uncertainty in NAIRU is the modelling, whereby the correct form of model specification is not known. NAIRU was seen as a short-run rather than a long-run concept of the natural rate of unemployment.

Subsequently, following the extension of the original Phillips curve through the inclusion of the expected inflation, the focus later shifted from wage inflation to price inflation. This made researchers to be concerned with changes in the mark-up prices over wages. Therefore, the price-change version of the Phillips curve later incorporated changes in other input prices. The new Keynesian Phillips Curve (NKPC), which incorporates the expected inflation, was later criticized

as it was found to be inconsistent with empirical studies (Fuhrer and Moore, 1995; Dufour, Khalaf and Kichian, 2006; Rudd and Whelan, 2007; and Hornstein, 2007).

The Keynesian theory was believed to lack good micro-foundations, because the Keynesian underpinnings believed in a complex economy, which is characterized by oligopolistic market structures. This is where firms are confronted with market rigidities with horizontal short-run marginal cost curves. In contrast, the new classical economists believed in an economy with monopolistic firms and consumers (Lipsey and Scarth, 2011). Other criticisms of NKPC include its inability to explain the dynamic behavior of output and inflation, as well as not generating enough inflation and output persistence in the presence of the price stickiness assumption (Lendvai, 2004).

According to the seminal work of Taylor (1980) and Calvo (1983), the price setting forward-looking firms were incorporated into the NKPC and Gali and Gertler (1999) combined NKPC with the backward-looking effect. Hence, the rejection of the NKPC resulted in the introduction of the "hybrid" NKPC. The assumption on which NKPC was based relates to agents facing high decision-making costs. In the hybrid NKPC, the agents used a simple rule-of-thumb to follow the optimizing agents, with a one-period time lag. Therefore, the hybrid NKPC includes both the past actual inflation terms, as well as the term for the inflation expectations.

The two models of traditional Phillips curve and the NKPC predict different dimensions of responses of economic variables, unemployment or output, to a shock in the monetary policy variable. However, the use of Phillips curve could be summed up in the following trinity of benefits; (1) to explain inflation through its determinants, (2) for policy recommendation, and (3) to forecast inflation (Stiglitz, 1997). According to Eller and Gordon (2003), the Phillips curve does not incorporate any variable that represents the supply shock; it is therefore not sufficient in providing the determinants of inflation.

However, this study starts by choosing the HNKPC as the baseline model, and this will be estimated in chapter 3, while progressing to empirically test the augmented Gordon's model. The

HNKPC is widely accepted and a commonly used model of the Phillips curve in modern macroeconomics. It is also important in observing the adaptive expectations in relation to the sticky-prices approach as well as its importance in assisting central banks with monetary policy of how to respond to events while inflation targeting is being maintained. The augmented Gordon's model will include the supply shock as well as other control variables in determining inflation.

2.2 THE GORDON'S TRIANGLE MODEL

It was initially widely believed that there is a negative relationship between inflation and unemployment in the Phillips curve model. This relationship turned out to be a strong positive one when the increased oil-prices were accompanied by increases in unemployment (McConnell and Brue, 2002; Ogbokor, 2005; Gordon, 2011). The two oil price shocks of 1973 – 1974 and 1979 – 1980 did not cause a subsequent fall in unemployment according to the Phillips curve trade-off theory; this change in the relationship was seen as a fail in the theory. Thus, following the breakdown of the PC after the 1970's, this model was divided into two forks, namely the 'right fork' and the 'left fork', according to Gordon (2011). These two paths have no possibility of converging as they have distinct paths. The right fork approach is where expectations are anchored on the forward-looking inflation behavior. It however does not incorporate the effect of changes in the supply shock nor inertia.

The left fork approach, also known as the mainstream or the triangle model[4], includes the effect of supply shocks and how they cause upward or downward shifts in the Phillips curve. This approach also considers the inclusion of the past inflation (also known as backward-looking inflation or inertia) instead of the inflation expectation behavior. Hence, the 'triangle' model, as first used in Gordon (1983), obtained its name from the mainstream specification of the inclusion of three sets of explanatory variables that represent the demand, supply and inertia.

[4] This is also termed the resurrection of the Keynesian economics or the extended Phillips curve.

The general triangle framework specification (Gordon, 1983, 2011) was originally:

$$p_t = a(L)p_{t-1} + b(L)D_t + c(L)z_t + e_t \qquad \ldots\{2.4\}$$

Where, the dependent variable, p_t, is the inflation rate. The three components are inertia, captured by the lags of the dependent variable, demand-side index, D_t, and the vector of supply shock variables, z_t; e_t is the serially uncorrelated error term. Lower cases are logarithms in differences and upper cases are logarithms in levels (Gordon, 1997 and 2013), L is the lag operator.

The major features of the triangle model include the supply shocks variables and the unusually long lags of the dependent variable, inflation rate. A "natural rate" of the demand variable is obtained when the sum of the coefficients on the lagged dependent variable equals unity. This natural rate is consistent with the constant inflation rate. By using the current and lagged values of unemployment gap (the proxy for demand-side factor) on inflation rate, a steady inflation is predicted. This is the case when the factors that represent the unemployment gap and the supply shock are zero. Therefore, the Gordon's triangular model is always estimated without a constant term and chapter 4 will provide the empirical investigation of the augmented Gordon's model.

2.3 THEORETICAL BACKGROUND OF THE EFFECT OF INFLATION ON OUTPUT GROWTH

Many theories give different explanations and conclusions on the effects of inflation rate on output growth. With early theories of inflation-growth nexus, this relationship was built on the observation of different cycles; whereby cycles of inflation were followed by cycles of deflation. While some theories proposed that the relationship is negative, others postulated that they exhibit positive relationship especially in the 1970s when low output growth rates were accompanied by high inflation rates. Yet other theories believed that there is no relationship between these variables. This section will outline the different explanations of the various theories regarding the inflation-growth nexus.

According to the Classical growth theory proposed by Adam Smith, a negative relationship was implicitly proposed through the negative impact of higher wages on the profit levels of the firms. Growth model and productions function, which are supply-side driven, were hypothesized. The production function is where output is determined by labour (L), capital (K) and land (T) inputs. Accordingly, the growth of these inputs also determines the output growth. Thus, the output growth (g_y) is determined by the population growth (g_L), investment growth (g_K), land growth (g_T) and the overall productivity growth (g_f) (Todaro and Smith, 2011).

Smith believed that this model is supply-driven and explained that savings determine investment, which in turn determines growth. The change in price inflation and its effect on output are not explicitly expressed in this theory. The increased inflation reduces the profit levels, thereby reducing savings and hence a decline in output growth. Likewise, the model developed by Stockman (1981) in the neo-classical theory, known as the *Stockman Effect* depicts an inverse relationship between inflation and output growth. This is because the model showedthat money is classified as a complement to capital. It explained that when inflation increases, the purchasing power of money balances is eroded, and the welfare of individuals also falls. Since money and capital are complementary goods, it is expected that capital accumulation will fall, hence the output growth declines.

According to the new growth theory, economic growth is dependent on the rate of return on capital which is initially affected by inflation. In this case, inflation is seen as a form of tax (Fama and Schwert, 1977). When inflation increases, the rate of return declines; this leads to a fall in the capital accumulation, thus output growth falls. This shows a negative relationship between inflation and output growth. This theory further explains growth on the premise of both human capital and physical capital, as well as the importance of savings (Todaro and Smith, 2011).

On the other hand, Mundell (1963) was one of the proponents of a positive inflation-growth nexus without using the excess demand for commodities. Tobin extended the model by Mundell and stated that an increase in inflation rate leads to an increase in the output growth, although

temporarily (Tarawalie *et.al*, 2012). Mundell's model relates inflation and growth through individual's wealth. Mundell argued that an increase in inflation expectations or inflation rate is believed to directly cause a decline in the rate of return on real money balances of individuals. In order for people to increase their savings and thus accumulate wealth, they switch to financial assets. This leads to an increased pressure on asset prices which consequently results in a fall in the real rate of interest (Tarawalie *et.al*, 2012). The increase in the savings leads to higher capital accumulation and hence increased output growth.

The Keynesian school of thought argued that there is a positive relationship between inflation and output. The same argument was put forth by what became known as *Tobin Effect*, under the neo-classical framework (Tobin, 1965). The Traditional Keynesian model based on the Aggregate Demand (*AD*) and Aggregate Supply (*AS*) framework explains the inflation-growth nexus. The upward-sloping AS curve is the major feature of this model whereby changes in the AD will lead to changes in both the prices and output in the short-run. The Keynesian school of thought is not based on the vertical AS curve otherwise; changes in demand will cause changes in prices only (Dornbusch, Fischer and Kearney, 1996). However, in the long-run, which is the steady state, this relationship turns to negative.

The initial positive relationship between inflation and output growth is normally due to 'time-inconsistency problem' (Dornbusch, et al, 1996). This is when producers each think that other producers' prices remain at the same level while only the prices of their products have increased; meanwhile, aggregate prices have actually increased. In this case, such producers continue to produce more, thereby increasing output, while prices also continue to increase. Another reason for the initial positive relationship between inflation rate and output growth as stated by Blanchard and Kiyotaki (1987) is that firms could decide to defer their supply of goods to a later date and at a price they agreed on with their consumers. Hence, even if prices increase later, the firms will still have to fulfil their agreement to supply more. Therefore, there exists a short-run trade-off between output and inflation rate, but not in the long-run. In the short-run, many factors are believed to affect inflation rate and output level; these include, price expectations, labour force, interest rates (such as discount rates), government expenditure (Gokal and Hanif, 2004).

The neo-Keynesian framework believed that inflation rate is rather determined by the actual level of output and the natural rate of employment (Gokal and Hanif, 2004). This theory is based on the concept of *potential or natural output level*. This is the level where an economy produces at its highest capacity level, while fully employing all its available resources in the production process. The natural output level corresponds to the *natural rate of unemployment*. According to this theory, it is believed that in the long-run the Philips curve is vertical. This shows that actual output is equal to its potential and unemployment rate is equal to the natural rate of unemployment. This occurs when inflation rate remains unchanged. One major setback regarding this theory is the inability to find the exact level of potential output and the natural rate of unemployment.

Lastly, Milton Friedman, as a proponent of the monetarist framework, postulated the neutrality of money and focused on the long-run supply of money. This theory proposed that there is no relationship between inflation and output growth. The quantity theory of money and the neutrality of money are the components of the long-run supply side. Superneutrality of money is when real variables, such as the real output growth, do not respond to changes in growth rate of money supply. Therefore, Friedman suggested that an increase in money supply (or its velocity) will cause inflation rate to increase at a higher rate than the rate of output growth. Thus reinforcing the fact that money supply does not affect output levels (or growth) but it rather affects inflation rate (Gokal and Hanif, 2004).

This theory therefore argues that inflation and output growth exhibits no relationship. The same believe is emphasized by Sidrauski (1967), who proposed that inflation has no effect on output growth, because money was seen as being ‘super neutral’. Given the theoretical foundation of the relationship between these variables, it is important to note that empirical studies have shifted to the possible non-linear relationship between the variables. Fischer (1993) was first to identify the possible threshold point for the inflation-growth nexus. Thus, chapter 5 is dedicated to identifying the threshold inflation rate.

2.4 CONCLUSION

Changes in monetary policy stance have a short-run impact on real variables, such as employment and output, in the economy; with a long-run impact on the general price levels. The short-run impact is sometimes referred to as the non-vertical short-run Phillips curve. The relationships of the trade-off between inflation and output as well as employment have received considerable attention in literature, without reaching any agreed conclusions (du Plessis and Burger, 2006; Mankiw, 2001). Nonetheless, Phillips curve has gone through much iteration, having being estimated in several ways particularly for the industrialized countries using various variables and methods.

The traditional way of estimating the Phillips curve was to measure a change in the price level as determined by the output gap or unemployment gap. Phillips (1958) estimated it as the correlation between the wage inflation and unemployment. Successive studies measured the Phillips curve by substituting price inflation for the wage rates and therefore investigating the relationship between the price inflation and unemployment (Ogbokor, 2005; Fair, 2000; King and Watson, 1994). Other measurements replaced unemployment with output thereby measuring the relationship between price inflation and output. Yet, other studies used output growth as a measure of demand-side variable (Lucas, 1973; Hodge, 2002; Roeger and Herz, 2012). Various theories reached different conclusions on the relationship between inflation and output. While the Keynesian argued that positive relationship exists; signifying a trade-off and hence the existence of PC, the neo classical believed that these variables are negatively related, and the monetarist proposed that there is no relationship between them.

However, the monetary policy debate has focused on the belief that Phillips curve exists in South Africa. The design and implementation of the monetary policy have thus been based on the idea of a trade-off between inflation and output growth (du Plessis and Burger, 2006). The need for estimating the PC is borne out of its benefits, which include, explaining inflation through its determinants and for the purpose of policy recommendation (Stiglitz, 1997). There is also a need to observe the possible nonlinear relationship exhibited between inflation and output growth.

CHAPTER 3

SENSITIVITY OF THE HYBRID NEW KEYNESIAN PHILLIPS CURVE IN SOUTH AFRICA[5].

As a first step to understanding the inflation process in South Africa, this chapter investigates the existence of Phillips curve (PC) in context. It further explores the nature of PC by explaining whether inflation is driven by a forward-looking or backward-looking process using the hybrid new Keynesian Phillips curve (HNKPC) while incorporating the important variables of inflation expectations and inflation inertia in estimating inflation dynamics. Moreover, this chapter examines the sensitivity of HNKPC estimates in South Africa to different variable measurements, data frequency and estimation techniques.

3.1 INTRODUCTION

The Phillips curve indicates the trade-off between unemployment rate and inflation rate. The curve depicts the various combinations of unemployment and inflation rates that can be chosen. This means that low levels of unemployment can be chosen as long as an economy is prepared to have high inflation rates and vice versa. Although the Phillips curve was popular in the 1970s, it became questionable when increased price levels, as a result of the two oil price shocks of 1973 – 1974 and 1979 – 1980 did not cause a subsequent fall in unemployment as theoretically expected (McConnell and Brue, 2002; Ogbokor, 2005).

Although the traditional Phillips curve was criticized on the basis of theory and some empirical studies, it nonetheless gives a good empirical explanation of inflation during the post-war periods (Rudebusch and Svesson, 1999; Roeger and Herz, 2012). The New-Keynesian Phillips curve (NKPC) also known as the expectations-augmented Phillips curve considers the inclusion

[5] Leshoro, T. and Kollamparambil, U., 2016, 'Inflation or Output Targeting? Monetary Policy Appropriateness in South Africa, *PSL Quarterly Reviews,* 69(276), 77 – 104. This is a joint publication with my supervisor; my contribution is 80%.

of price expectation; this is the forward-looking inflation process. The forward-looking inflation expectations are theoretically essential in the estimation of the Phillips curve because the price inflation expectations precede the dynamics in the current rate of inflation (Bhanthumnavin; 2002). Also the NKPC is used in the theoretical analysis of monetary policy (Roeger and Herz, 2012).

However, this model has been criticized because of the inclusion of price expectation which was forced in the model. The reason is that it was believed that expected future prices are not important to empirically explain inflation or price behaviour (Fuhrer, 1997; Eller and Gordon, 2003[6]). It is however important to verify this argument because according to King (2008), consumers expected prices to increase after World War II, and by acting on it, prices rose. Therefore greater weight was placed on expectations by the monetary authorities to direct macroeconomic activities. Thus, it is important to include price expectations in the Phillips curve model.

On the other hand, the importance of forward-looking, backward-looking or mixed price inflation specification is currently being considered in several studies. The "old" or "traditional" Phillips curve specification includes only the lagged inflation variable; this is the backward-looking inflation. The Hybrid New-Keynesian Phillips Curve (HNKPC) which is the model with both the forward-looking (NKPC) and backward-looking components (traditional Phillips curve) is the mixed price inflation specification. The HNKPC was introduced by Gali and Gertler (1999). The consideration of the forward-looking Phillips curve is consistent with theory in that the understanding of the interaction between the past and future inflation values would affect its dynamic structure and this is important for policy making.

Also, monetary authorities need to understand how economic agents predict prices so that they are able to respond before the actual change in prices is realised. Thus, the movements in prices should not occur before remedial measures are applied. If economic agents are more backward-looking, then the policies to be adopted should be more forward-looking. If monetary authorities

[6] See also Eller and Gordon (2003), Rudd and Whelan (2006) and Rudd and Whelan (2007).

are as backward-looking as the economic agents, the latter will be able to anticipate the response of the monetary authorities. The decisions made by the economic agents will counterbalance the shock (Batini and Haldane, 1999:193).

Therefore, it is important for policy makers to determine whether inflation is backward-looking or forward-looking and be concerned with the possibility of the existence or non-existence of Phillips curve in South Africa. The objective of this chapter is thus to determine whether Phillips curve exists in South Africa and ascertain whether the backward-looking or forward-looking components determine inflation dynamics in South Africa. The reason is that if there is no existence of Phillips curve trade-off, monetary authorities can focus on targeting inflation without adversely affecting output and put to rest the current controversy surrounding the monetary policy in South Africa.

In order to achieve these goals, the study investigated three focus areas of sensitivity analysis of the South African HNKPC model to variable measurements, data frequency and estimation techniques. This is because different studies in South Africa and other country contexts have investigated the sensitivity of Phillips curve separately to various variable measurements, data frequency and estimation techniques. The choice of the HNKPC as the baseline model is because it is the most widely accepted and commonly used model of the Phillips curve in modern macroeconomics developed by Gali and Gertler (1999). It is also used to observe the adaptive expectations in relation to the sticky-prices approach of Fischer (1977), Taylor (1980) and Calvo (1983). Thirdly, according to Nason and Smith (2005), HNKPC has significant implications for monetary policy in assisting how central banks should respond to events while inflation targeting is being maintained.

The rest of the chapter proceeds as follows: the following section provides the stylized facts on inflation trend; section 3.3 explores the micro foundation of the Phillips curve. This is followed by the review of empirical literature in section 3.4. Data and methodology are presented in section 3.5, while the analysis of estimation and results are discussed in section 3.6. Section 3.7 concludes the chapter with policy recommendation.

3.2 HISTORY OF INFLATION DYNAMICS IN SOUTH AFRICA: 1960 –2014.

The consumer price index (CPI) which was introduced in 1917 measures the changes in the overall price levels of consumer goods and services, and it is a good indicator of economic and social welfare. The index initially considered only the large parts of the urban areas, but in 1997, the smaller urban areas were included. The CPI is made up of two important indexes, namely, the fixed-basket price index as well as the cost-of-living index. The fixed-basket price index measures the cost of purchasing a basket of consumer goods and services in a particular period, and the cost-of-living index measures the effects of the changes in prices on the level of welfare or the standard of living of consumers (StatsSA, 2013).

In the first half of the 1960s, inflation was reasonably low, whereby consumer and wholesale prices slowed down. In 1964, the food prices increased to about 8.8 percent after which it declined in the first three quarters of the following year. However in the last quarter of 1965, due to an increase in food prices, consumer prices increased sharply (SARB, 1965). With increases in food prices to 7.1 percent, mainly from higher prices for vegetables, as well as increases in housing to 4.8 percent, inflation rate rose significantly from late 1960s to the early 1970s, from an already high rate.

Further acceleration of the rate of inflation was seen from the 1970s through to the 1980s. The main reason for the increases was still attributed to sharp increase in the food prices. In the first three quarters of 1980, inflation increased to 8.6 percent, 13.3 percent and 16.3 percent in succession (SARB, 1980). The main contributors of the increase in the food prices were vegetables, meat, milk and milk products, fruits and sugar. Higher prices were also realised in motor vehicles, housing services and furniture, which also contributed to the surge in inflation rates. The prices in 1980 were, on average, 13.4 percent higher than in 1979. However, moving from the 1980s to the 1990s, particularly from 1989 to late 1990, inflation rates slowed down considerably.

Although the National Energy Council imposed domestic price increases of 8.5 percent on petrol and 9.8 percent on diesel in September 1990, the decline in international crude oil in November

1990 led to a decline in inflation. Also, in the first half of 1990, the country experienced cost-push inflation pressures as a result of a successful higher wage demand of more than 20 percent by the trade unions. From the beginning of 1995, inflation rates declined considerably due to the fall in food prices of vegetables, meat and fruits. Other contributors to the fall include stronger exchange rate value of the rand, increased domestic expenditure and inflationary pressures due to money supply and credit growth.

The periods after 1995 saw a significant decline in inflation rate, similar to the 1970s periods. In January 1997, the consumer price index which excludes interest rates on mortgage bonds, CPIX, was introduced, but was discontinued in 2009. Hence the CPI for all urban areas was announced and became the headline inflation measure as well as the inflation target measure (StatsSA, 2013). In the third quarter of 2000, inflation increased to 8.2 percent mainly as a result of increased prices of imported crude oil that began early 1999 as well as increased food prices due to the damage in agricultural products in early 2000. However, by excluding fuel and food prices from the CPIX, the inflation rate was marginally low at 6.7 percent in the same third quarter of 2000. On average inflation rate continued to subside considerably in the first half of the 2000s.

In January 2002, the consumer price indexes for the whole country as well as for the rural areas were introduced and the South African Reserve Bank (SARB) also adopted the inflation targeting (IT) framework, with the band of 3 to 6 percent. With the sustained large output gap, decline in food and fuel prices and the strengthening of the rand, the inflationary pressures declined, where it was as low as 3.2 percent in September 2010, before slightly increasing to 3.4 percent in the succeeding month. The Reserve Bank managed to achieve the IT goal and keep inflation within the target for an extended period. Although the inflation rate exceeded the target band in 2007 and in July and August 2013, it was moderately low in other periods. It increased to 5.7 percent year-on-year in 2013 and increased further to 5.8 percent in January 2014. Moreover, Statistics South Africa (StatsSA) recently reweighted and rebased the consumer price index (CPI). Table 3.1 below shows the different components of the consumer price index along with their new weights for the base year, 2012.

Table 3.1: Consumer Price Index: All urban areas*

Component	Weight (2012 = 100)
Food and non-alcoholic beverages	15.41
Alcoholic beverages and tobacco	5.43
Clothing and footwear	4.07
Housing and Utilities	24.52
Household contents, equipment and maintenance	4.79
Health	1.46
Transport and Communication	19.06
Recreation and culture	4.09
Education	2.95
Entertainments and others	18.22
All items index	**100.00**

*Based on 2010/2011 expenditure. The reweighting and rebasing of the CPI was carried out in February 2013
Source: StatsSA Statistical Release (2013).

3.3 MICRO FOUNDATION OF THE HNKP CURVE

The hybrid new Keynesian Phillips curve is a widely accepted model in modern macroeconomics and it is derived from the New Keynesian model. This model assumes that monopolistically-competitive firms are confronted with the short run price ridigity (Gali and Gertler, 1999; Basarac, Skrabic and Soric, 2011). The baseline model of the HNKPC relates inflation to its lag, its expectations and real marginal cost.

According to Lendvai (2004), given that the subsets of firms that produce differentiated goods in an economy use the input labour, the production function will be:

$$Y_t(i) = L_t(i) \quad \ldots \{3.1\}$$

Where $Y_t(i)$ is the goods produced by firm *i* and $L_t(i)$ is the labour employed by firm *i*, $i \in [0,1]$

The production function for the whole industry is:

$$L_t^d \cong zY_t \quad \ldots \{3.2\}$$

Where $Y_t \equiv \left(\int_0^1 Y_t(i)^{\frac{\varepsilon-1}{\varepsilon}} d_i \right)^{\frac{\varepsilon}{\varepsilon-1}}$ is the output produced in the industry;

$L_t^d \equiv \int_0^1 L_t(i) \; d_i$ is the labour employed by the industry;

ε_t is the price elasticity of demand and the elasticity of substitution between the differentiated goods for consumers, according to Dixit-Stiglitz (1977), $\varepsilon > 1$.

Therefore following Calvo (1983) and Gali and Gertler (1999), at any given period, each firm can either adjust its price or decide not to change its price but keep it fixed with a common probability. This probability is common across firms and it is constant over time. The probability that a firm will adjust its price is $1-\xi$, and the probability that it will keep its price fixed is ξ.

By introducing inflation inertia, that is, the past expectations of inflation, as suggested by Gali and Gertler (1999), two types of firms were assumed. These are firms that change and adjust their prices by considering the price expectation and the firms that follow the rule-of-thumb of backward-looking. The fractions of these firms are $1-\omega$ and ω respectively. According to Yun (1996), assuming that fixed prices are determined by the rate of inflation and the previous price levels, as shown below:

$$P_t^{fix}(i) = P_{t-1}(i)(1+\pi) \qquad \ldots \{3.3\}$$

Where $P_t^{fix}(i)$ is the fixed prices of firm *i*

π is the inflation rate

The aggregate price index, P_t, can then be expressed as an index of fixed prices P_t^{fix} and an index of adjusted prices P_t^{adj} as follows:

$$P_t = \left[\xi (P_t^{fix})^{1-\varepsilon} + (1-\xi)\left(P_t^{adj}\right)^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}} \qquad \ldots \{3.4\}$$

Furthermore, the adjusted price index can also be expressed as a weighted average of backward-looking prices, P^b, and forward-looking prices, P^f as:

$$P_t^{adj} = \left[\omega(P_t^b)^{1-\varepsilon} + (1-\omega)\left(P_t^f\right)^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}} \quad \ldots \{3.5\}$$

While the prices set by the forward-looking firms are to allow them maximize their share value, the backward-looking agents adjust their prices according to the rule-of-thumb. The share value of the forward-looking firms is determined by the present value of future profits which the firms pay to households in the form of dividends. Assuming that firms are not allowed to re-optimize, then the price set at a particular time will affect the firm's profits and dividends. Therefore, a forward-looking firm will re-adjust its price and set it to maximize the following:

$$E_t \sum_{k=o}^{\infty} \phi_{t+k} (\beta\xi)^k \left[P_t^f (1+\pi)^k - s_{t+k}^{mc}\right] \; Y_{t+k}(i) \quad \ldots \{3.6\}$$

And if the firm is allowed to re-optimize, equation 3.6 becomes:

$$E_t \sum_{k=o}^{\infty} \phi_{t+k} (\beta\xi)^k Y_{t+k}(i) \left[P_t^f (1+\pi)^k - \frac{\varepsilon}{\varepsilon - 1} s_{t+k}^{mc}\right] = 0 \quad \ldots \{3.7\}$$

Where ϕ_{t+k} is the marginal value of a currency unit to households, which is treated as exogenous by the firm; ξ^k is the probability of a firm re-optimizing the price that is set, with *k* representing the number of periods it fixes its prices; s^{mc} represents the nominal marginal cost in period t, β is the discount factor; other variable are as earlier defined.

The price set by the backward-looking firms is based on the average of the adjustment price set in the previous period updated by the inflation rate in the previous period. This is depicted as:

$$P_t^b(i) = P_{t-1}^{adj}(1+\pi_{t-1}) \quad \ldots \{3.8\}$$

This equation shows that P_t^b depends on the information known up until period t-1. However, it also incorporates the inertia, which is the past expectation about the future inflation and price level. Another useful feature of this rule of thumb is that it shows that information on future

inflation is included since the adjusted price index, P_t^{adj}, includes the forward-looking price setters (Gali and Gertler, 1999). This means that the forecast for current inflation is expressed in terms of past inflation.

Therefore, the hybrid Phillips curve which includes inflation inertia component is obtained by combining equations 3.4, 3.5, 3.7 and 3.8. These are the aggregate price index, the adjusted price index, the prices set by the forward-looking and backward-looking firms. The hybrid Phillips curve model is shown as:

$$\overline{\pi}_t = \gamma_b \overline{\pi}_{t-1} + \gamma_f E_t(\overline{\pi}_{t+1}) + \lambda_s \overline{s}_t \qquad \ldots \{3.9\}$$

Where,

$$\gamma_b \equiv \frac{w}{\varphi} = w\varphi^{-1},$$

$$\gamma_f \equiv \frac{\beta\xi}{\varphi} = \beta\xi\varphi^{-1},$$

$$\lambda_s \equiv \frac{(1-w)(1-\xi)(1-\beta\xi)}{\varphi} = (1-w)(1-\xi)(1-\beta\xi)\varphi^{-1} \text{ and}$$

$$\varphi \equiv \xi + w[1-\xi(1-\beta)]$$

Equation 3.9 is considered the hybrid PC which includes inflation inertia only if $\gamma_b > 0$, that is if $w > 0$. This means that the fraction of firms with the backward-looking prices introduced the inflation inertia.

A HNKPC model has inflation expectation and demand pressure variables. The demand pressure variable is measured using labour share (or real unit labour cost) as a proxy for the marginal cost in the Gali and Gertler (1999) model. However, Agenor and Bayraktar (2010) argued that the use of labour share, especially for the case of a developing country, for instance, South Africa, may result in unreliable inferences as a result of errors in the data. The errors arise from the fact that there are large numbers of individuals in the labour force who are involved in informal economy and are thus not captured in the data. They consequently proposed a model that replaces the labour share of Gali and Gertler's model with the output gap (Malikane, 2012).

They assumed that $\bar{s}_t = ky_t$; where y_t is the output gap. Thus the model becomes:

$$\bar{\pi}_t = \gamma_b \bar{\pi}_{t-1} + \gamma_f E_t(\bar{\pi}_{t+1}) + \beta y_t \quad \ldots\{3.10\}$$

where other variables are as earlier defined and $\beta = k\lambda_s$

This study will therefore estimate the Phillips curve model by incorporating the HNKPC model which includes the lagged inflation and inflation expectation.

The above model, equation 3.10, will be adopted; this is the output-based HNKPC model, using the output-gap as the demand-side variable. This model is more applicable to South Africa as a developing country, rather than the marginal cost-based HNKPC model, following Agenor and Bayraktar (2010). Also, according to Mehra (2004), output gap variable is relevant and theory-consistent when hybrid model is estimated along with the lagged inflation and/or the expected inflation. In addition, the output growth will be used in order to validate the result of the output-gap model, while also following Lucas (1973) and Hodge (2002).

Another reason for the use of output growth as a proxy is that output gap is believed to be ridden with error of measurement resulting from the inability to observe the potential output. The results obtained from the output growth model will therefore confirm the authenticity of the results of the output-gap model. These results will assist monetary authorities to determine if Phillips curve exists in South Africa and whether inflation dynamics are determined by the inflation lag and/or expected inflation. Hence, monetary authorities will be able to conclude whether inflation in South Africa is backward-looking or forward-looking.

3.4 EMPIRICAL LITERATURE REVIEW

This section will review various studies that estimated both the Phillips curve and the hybrid Phillips curve models. The seminal papers will firstly be reviewed, followed by studies on South Africa.

3.4.1 Implementation of the theory

Gali and Gertler (1999) used the single-equation generalized method of moments (GMM) to test the new Keynesian Phillips curve. The study investigated whether a good approximation of the dynamics of inflation for the United States of America could be obtained; using data spanning over the period 1960:Q1 to 1997:Q4. The real marginal cost instead of output gap was adopted because they argued that the real marginal cost is more theory-consistent than output gap, as the impact of the productivity gains is directly accounted for by marginal cost. They however included output gap, among other variables, as an instrumental variable.

Meanwhile, according to Mehra (2004), the irrelevance of the output gap arises when PC model is estimated, omitting the lagged inflation and/or the expected inflation. Also, the empirical work on the traditional Phillips curve emphasizes the importance of output gap, instead of marginal cost, as the appropriate measure of economic activity. Gali and Gertler's result showed that the real marginal cost was a good determinant of the US inflation. They further found that although backward-looking behaviour is statistically significant, it does not show enough quantitative importance. They therefore concluded that the new Keynesian Phillips curve with forward-looking behaviour gives a good description of inflation dynamics. Other papers that used GMM include Batini, Jackson, and Nickell (2000) and Gali, Gertler, and Lo´pez-Salido (2001).

Rudd and Whelan (2005) used the same US data as used by Galı´and Gertler (1999) to find if the new-Keynesian Phillips curve (NKPC) truly provides good description of inflation process. They also adopted GMM and an alternative approach of two-stage least squares (2SLS) due to the possible misspecification of equation in Gali and Gertler (1999) and bias of GMM estimation. Rudd and Whelan's model did little to improve upon the results obtained by Gali and Gertler, as

they also found that the inflation expectation variable has a statistically significantly higher magnitude compared to inflation lag.

Furthermore, Linde (2005) adopted the GMM, nonlinear least squares (NLLS) and full information maximum likelihood (FIML) for the New-Keynesian hybrid Phillips curve, using quarterly U.S. postwar data. It was argued that the use of a single equation estimation method is not informative when using NKPC in real world. However, Nason and Smith (2008) argued that although single-equation techniques do not use all the possible information in the economy, the results obtained from such are not affected by any misspecification about the rest of the economy and therefore, the results are still valid and reliable.

Linde's argument was that using limited information method, such as GMM, gives imprecise, unreliable and biased estimates. It is biased in small samples, such that the size of the bias tends to support backward-looking behaviour when indeed the true NKPC is forward-looking (Fuhrer and Moore, 1995a). However, Rudd and Whelan (2005) argued that GMM tends to give estimation results that support a forward-looking Phillips curve, even when the true specification is purely backward-looking.

Therefore, Linde used another technique of NLS, apart from GMM, for HNKPC, to validate the findings. Both real marginal costs and output-gap were used as the driving variables. The NLS results showed a robust result across the samples studied. Also, irrespective of the driving variable used (output gap or real marginal costs), the estimates have unexpected negative signs, as the expected sign was positive. Linde further found a mix in the result of whether inflation is backward-looking or forward-looking. In contrast to Gali and Gertler's (1999) findings, Linde (2005) concluded that the approximation of the U.S. inflation dynamics should not be a purely forward-looking NKPC. Rather, it should be a version with both the forward-looking and backward-looking components.

Furthermore, Olubusoye and Oyaromade (2008) modeled the inflation process in Nigeria using annual data from 1970 to 2003. They estimated a hybrid Phillips curve by adopting the error

correction mechanism framework and including both inflation expectation and inflation lag. Rather than using the Hodrick-Prescott (HP) filter approach to generate expected inflation, they used the first difference of the log of the current price level, believing this is consistent with the rational and adaptive expectation hypotheses. While inflation inertia and inflation expectation have short-run effects, the former showed a weak effect, and the latter had a positive and significant effect on inflation. Hence, the study concluded that the inflation dynamics in Nigeria is forward-looking.

Other studies that used the single equation model of the Ordinary Least Squares (OLS) include Moriyama (2008) for Sudan, and Ogbokor (2005) for Namibia. While the former study found a positive but insignificant effect of lag inflation on current inflation, the latter found that there is stagflation in Namibia. The results further showed that the Namibian economy does not portray the traditional Phillips curve notion of negative relationship between inflation and unemployment, while inflation is not significantly backward-looking in Sudan. Moriyama (2008) argued that there is a possibility of a bias in the result because the regression is based on a single-equation model and the possible contemporaneous interrelations among the variables were excluded. This is in line with Linde (2005), stating the possible bias and inconsistency in the NKPC results when single-equation techniques are used.

However, Loungani and Swagel (2001) used the VAR model to examine the interrelationship of variables including output gap to the current inflation. This study was carried out on 53 developing countries in Africa, Asia, the Mediterranean and South America. They used HP filter to calculate the potential output in order to obtain output gap. Their study focused on the effect of past inflation among other variables on current inflation. The results obtained for all the countries put together showed that inflation lag affects current inflation while output gap has a small effect on inflation. The VAR results showed that inflation in the African countries exhibits a backward-looking behaviour.

Basarac *et.al* (2011) estimated the hybrid Phillips curve for nine transition economies, using the dynamic fixed effect (DFE) and the Pooled Mean Group (PMG) approaches, while GMM was

used to test for robustness. The objective of their study was to explore the importance of backward-looking and forward-looking behaviours in setting the price and if output gap is a good indicator of inflationary pressure. They used the output gap as a proxy for real marginal cost variable. The data on expected inflation variable was obtained from the consumer surveys. The results obtained showed that inflation was backward-looking because it has higher magnitude and it is highly statistically significant. Similarly, the output gap was found to be positive and statistically significant for all the models. They therefore concluded that the HNKPC model with the output gap as an explanatory variable is consistent with theory in all the countries considered.

The review shows that various "driving" variables are considered, such as real marginal costs, output gap, output growth, lagged price inflation and price expectation in different studies. Despite the criticisms of output gap being theory inconsistent, it is confirmed this is only so when the lagged inflation and/or the expected inflation are excluded from the hybrid model.

3.4.2 Empirical literature on Inflation in South Africa.

Many studies have examined the applicability of the Phillips curve in South Africa, dating as far back as over four decades. Different conclusions were reached when using different measures of inflation. The different measures used ranged from Gross Domestic Product (GDP) deflator (Fedderke and Schaling, 2005[7]) to Consumer Price Index (CPI) and nominal wages (Hodge, 2002; and Burger and Marinkov, 2006)[8]. Early studies supported the then established theory of a significant trade-off between inflation rates or nominal wages and unemployment rates.

Other studies used real GDP growth as a proxy for unemployment rates, and a significant result of a trade-off between inflation and output growth was once again obtained. The main conclusion reached was that the policy makers should not make use of this trade-off as it harmed the economy by allowing inflation to increase in order to obtain higher growth and employment. Then difficulty arose in terms of finding the right specification of the Phillips curve model for South Africa, where the theory can match the South African experience. Some studies

[7] Also see Krogh (1967); Pretorius and Smal (1994).
[8] Also see Hume (1971); Truu (1975); Strebel (1976); Stydom and Steenkamp (1976) and Levine and Horn (1987); Nell (2000).

considered whether inflation is a necessary condition for faster economic growth (Nell, 2000; Burger and Marinkov, 2006) using the Phillips curve model.

In later studies (Nell, 2000; Hodge, 2002; Fedderke and Schaling, 2005)[9], different econometric techniques were used to estimate the Phillips curve in South Africa. Nell (2000) did not observe whether inflation is backward- or forward-looking butused non-linear price expectations to estimate whether inflation is harmful or beneficial to the economy. The economy's inflationary experience was divided into four inflationary periods.Inflation expectations and output gap were included as some of the explanatory variables. The study found a statistically significant negative output gap during the accelerating inflation period and a statistically insignificant positive output gap during the deflationary period. This confirms that a trade-off exists during the accelerating inflation period.

Furthermore, Hodge (2002) tested whether a trade-off exists between unemployment rate and inflation in South Africa, using the traditional PC. Annual data spanning over the period 1970 to 2000 was used, while adopting the single-equation of error correction model (ECM). The results showed that the unemployment gap variable was either statistically insignificant or depict unexpected signed during the period studied. The study however found a highly significant positive relationship between inflation and output growth. In addition, the variation in inflation was found to be from its lag, thus inflation was found to be backward-looking.

On the other hand, Fedderke and Schaling (2005) adopted a vector error correction model (VECM) of estimation to model the expectations augmented Phillips curve for South Africa using a pure NKPC model and quarterly data from 1963Q4 to 1998Q2. The inflation expectations was generated by using the adaptive expectations, rational expectations and the Hodrick-Prescott filter approach. The preferred measure was the HP-filter method of price expectation because of the severity of the smoothing of the price series. The results obtained showed that when price was used as the dependent variable, output gap has a significant negative

[9] See also Hodge (2006); Burger and Marinkov (2006).

sign, which shows that Phillips curve exists. However, when the unit labour cost is used as the dependent variable, an insignificant positive sign is obtained on the output gap variable.

Furthermore, in the panel study carried out by Malikane (2012), where South Africa was included as one of the emerging markets considered, the study investigated the negative sign of the output gap in the Phillips curve specification. It was found that even when the labour share is used as the demand-side variable, the same result of 'no existence of Phillips curve' was obtained. In the later study carried out by Malikane (2013), the findings of Malikane (2012) was validated using GMM and two-stage least squares (2SLS) techniques.

The results obtained in the study by Fedderke and Schaling (2005) showed that South African inflation is forward-looking, but only the augmented PC was estimated. This is in contrast with the findings of Hodge (2002) who concluded that inflation in South Africa is backward-looking. The study estimated the inflation process only with a backward-looking element. However, Malikane (2012) estimated the HNKPC model for emerging economies and found that the inflation process in these countries depicts a strong and significant backward-looking behaviour.

In conclusion, all the above reviewed studies depict a mix of results and conclusions. Using different econometric techniques, measurements and data frequency, different conclusions were reached on the existence of PC and whether inflation is forward-looking or backward-looking (Table 3.2).

Table 3.2: Summary of previous literature on Phillips curve.

Author	Study country and time frame	Model	Estimation technique	Measure of demand-side variable and Findings	BL or FL
Gali and Gertler (1999)	USA: 1960Q1 - 1997Q4	HNKPC	GMM	Real marginal cost	FL
Linde (2005)	USA: 1960Q1-1997Q4 and 1987Q3-1999Q4	HNKPC	GMM, NLS, FIML	Real marginal cost and output gap: Insignificantly negative	Mix
Rudd and Whelan (2005)	USA: 1960Q1-1997Q4	HNKPC	GMM and 2SLS	Output gap: Significant negative. Labour income share: Significant	FL

				positive.	
Olubusoye and Oyaromade (2008)	Nigeria: 1970 - 2003	HNKPC	ECM	Real GDP: Insignificant positive	FL
Moriyama (2008)	Sudan: 1995Q1 – 2007Q2	Traditional PC	OLS, SVAR and VECM	Real GDP growth: Insignificant positive	Insignificant BL
Ogbokor (2005)	Namibia: 1991 - 2005	Traditional PC	OLS	Unemployment: Positive	NA
Loungani and Swagel (2001)	53 developing countries	HNKPC	VAR	Output gap	BL
Basarac *et.al* (2011)	9 transition economies: 2002Q2 – 2009Q2	HNKPC	DFE, PMG and GMM	Output gap	BL
Gruen *et.al* (1999)	Australia: 1965Q1 – 1997Q4	NKPC	VAR	Unit labour cost: Significant negative; trade-off Unemployment rate: Significant positive; no trade-off	NA
Abbas and Sgro (2011)	Australia: 1959Q3 – 2009Q2	NKPC and HNKPC	OLS, 2SLS, and GMM	Output gap: Insignificant positive; no trade-off. Labour income share: Insignificant positive	FL
Nell (2000)	South Africa: 1960Q2 - 1999Q2	NKPC	VAR	Output gap: negative	NA
Hodge (2002)	South Africa: 1970 - 2000	Traditional PC	ECM	Unemployment gap: Insignificant negative; No trade-off. Output growth: Significant positive; trade off	BL
Fedderke and Schaling (2005)	South Africa: 1963Q4 – 1998Q2	NKPC	VECM	Unit labour cost and Output gap: negative	NA
Malikane (2012)	10 emerging markets 1990 - 2011	HNKPC	GMM and OLS	Output gap: Insignificant positive and negative	Significant BL and insignificant FL
Malikane (2013)	6 developed: 1975Q1 – 2012Q2 and 6 emerging markets: 1995Q1 – 2012Q2	HNKPC	GMM and 2SLS	Output gap: Positive	Mix

Authors'compilation

3.5 DATA AND METHODOLOGY

3.5.1 Model Specification

Following Agenor and Bayraktar (2010), this study considers equation 3.10 for estimation. All the analysis was carried out using Eviews 8 and 9. Robustness was tested by considering alternative measures of demand-side and inflation expectations variables, as well as different data periods and econometric techniques. The choice of output gap and output growth as the demand-side measures is consistent with earlier work in South Africa by Nell (2000), Fedderke and Schaling (2005), and Burger and Marinkov (2006). Unemployment gap was not used due to possible limitation of incomplete data on the unemployment rate in South Africa. Moreover it is more prone to data errors (Agenor and Bayraktar, 2010).

The estimated models are therefore:

Output growth: $\overline{\pi}_t = \gamma_b \overline{\pi}_t^b + \gamma_f \overline{\pi}_t^e + \lambda_y \overline{y}_t + \lambda_{IT} D_IT + \lambda_{FC} D_FC + \mu_t$ …{3.11}

$\quad\quad\quad

if there are larger values of inflation expectations and smaller values of lag inflation; then inflation is said to be forward-looking and vice versa (Gali and Gertler, 1999). The sign expected for the existence of Phillips curve trade-off for output growth is positive while the expected sign for output gap is negative. According to the Classical theory, there exists a negative relationship between inflation and output growth; however, based on the Keynesian theory, these variables are positively related. The positive relationship signifies the trade-off indicated by Phillips curve.

According to Batini, Jackson and Nickell (2005) the expected signs for output gap, not based on PC trade-off, can either be positive or negative. A positive sign of the output gap is an indication that inefficiencies increase at an increasing rate during the high levels of output. A positive output gap thus implies that demand and inflationary pressures are building up. However, a negative sign shows that inefficiencies in production increase at a decreasing rate. Thus, different theories concluded that the relationship between output and inflation can be positive, negative or non-existence. Nevertheless the null hypothesis of this study is that the Phillips curve exists against the alternative hypothesis there is no Phillips curve in South Africa. Thus, the hypothesis for the existence of Phillips curve is that the expected sign is negative and positive for output gap and output growth respectively.

Two time dummy variables are introduced to account for two major events during the period of the study; these are the adoption of inflation targeting to capture the change in the monetary policy by the South African Reserve Bank in 2000 (*D_IT*) and the global financial crisis that occurred between the period 2008-2011 (*D_FC)*. The two included dummies are as follows:

$$D_IT = \begin{cases} 1 & IT \quad from \quad 2000 \quad onwards \\ 0 & otherwise \end{cases} \qquad \ldots\{3.13\}$$

$$D_FC = \begin{cases} 1 & for \ 2008 \text{ to } 2011 \quad financial \text{ crisis} \\ 0 & otherwise \end{cases}$$

The demand-side variables, output growth and output gap based on the data period considered, are presented along with the inflation rate in in figure 3.1. This figure showed a steady decline in

all the three variables until the end of 2002. Inflation rate and output gap are seen to be moving in the same direction, but there is a clear negative trend between inflation and output growth.

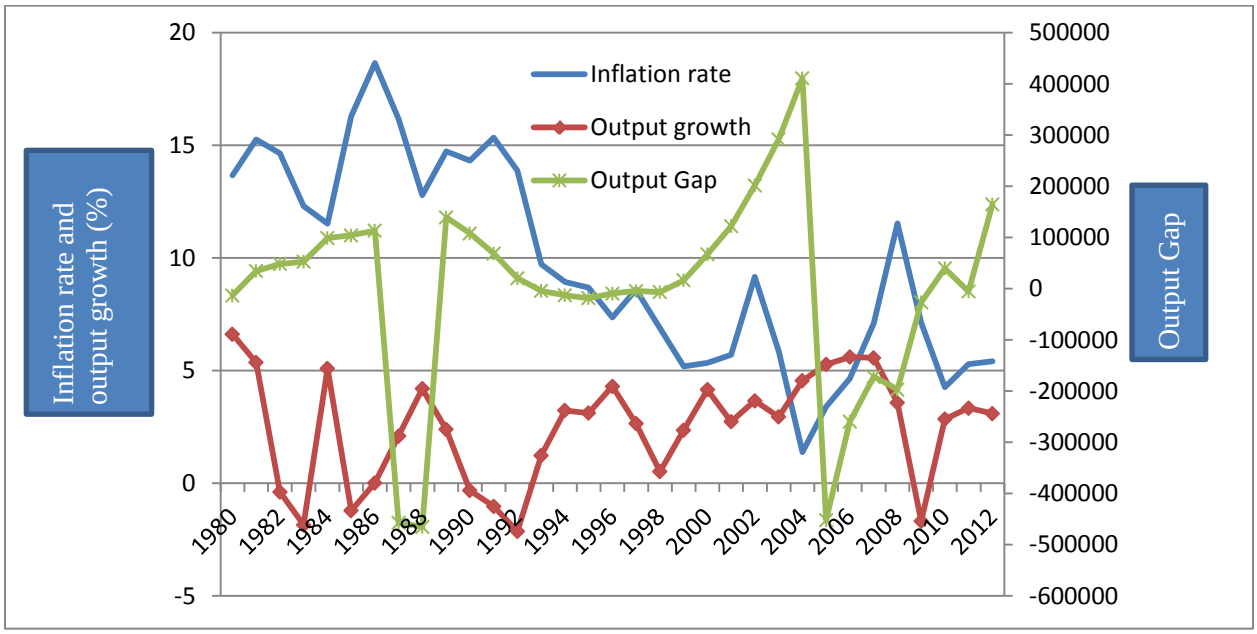

Figure 3.1: Quarterly Inflation rate, Output growth and Output Gap: 2000 to 2013.

Source: Author's calculation from IMF online database

The above output-based HNKPC models, equations 3.11 and 3.12, were estimated by firstly applying the ordinary least squares method, followed by the commonly-used technique of GMM. Annual data from 1980 to 2012 and quarterly data from 1980Q1 to 2013Q3 and 2000Q3 to 2013Q2 will be used. Only two models will be estimated under the annual series analysis. These are the models that use the Hodrick-Prescott (HP) filter as the measure of inflation expectation. Each of these two models were estimated with output growth and output gap interchangeably. The measures of inflation expectations using survey data and inflation forecast of auto regressive integrated moving average (ARIMA) technique are only available quarterly respectively from 2000Q3 to 2013Q2 and 1980Q1 to 2013Q3. The reason is that the use of ARIMA is only applicable for short-term periods such as daily, monthly and quarterly; it cannot be used for long-term periods like annual series.Hence these models will be estimated within the quarterly analysis.

The three different ways of measuring inflation expectations are presented in figure 3.2 below, using quarterly data starting from 2003Q3 to 2013Q2. This is because the survey data is only available during these periods as alluded to above, therefore the duration shown in figure 3.2 was considered in order to observe the movements in all the three types of inflation expectations. From these alternative inflation expectations measures, the inflation expectation of survey shows more variability than the inflation expectations based on Hodrick-Prescott filter and the ARIMA. The HP filter and ARIMA show severe smoothing. However, this study considered the three measures and examined the best measure of inflation expectations.

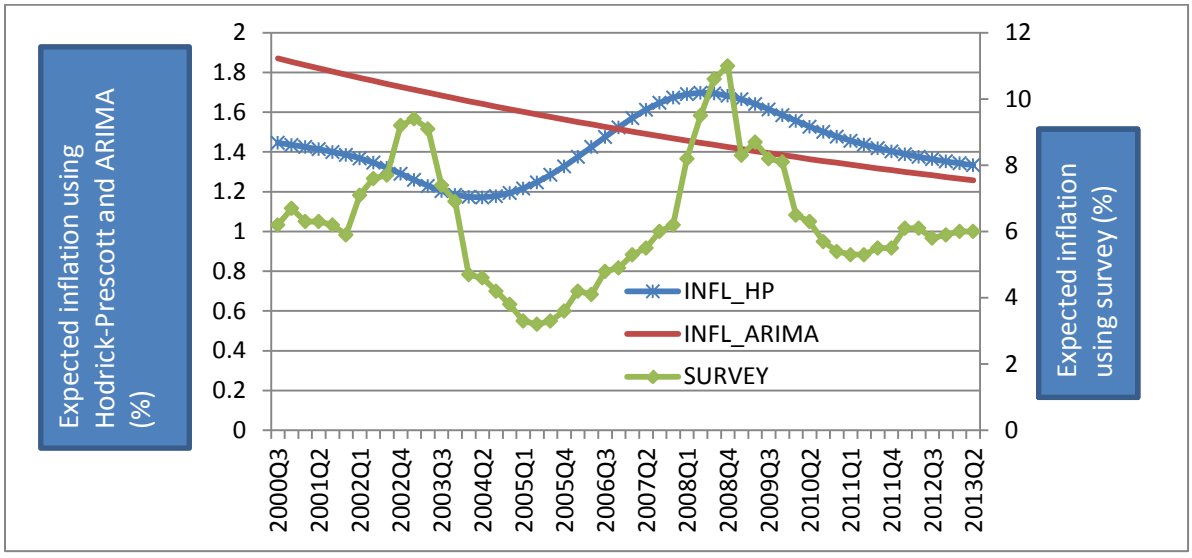

Figure 3.2: Three measures of inflation expectations (2000Q3 to 2013Q2).

Source: Author's calculation from IMF online database and South African Reserve Bank/Bureau for Economic Research (SARB/BER).

Furthermore, results obtained were compared between the two different measures of demand side; these are the output-growth and the output-gap variables. The other comparison was over the three different measures of expected inflation. Results of the two different data frequencies, annual and quarterly, were also compared. Lastly, the results of the GMM and the OLS techniques were compared. These comparisons are used to check the sensitivity of the hybrid NKPC model to different measurements, data frequency and techniques.

While three different measures of inflation expectations were regressed separately along-side the output gap, the same 3 different measures were regressed with the output growth. That was the case for both the annual data and quarterly data. This means that the output-based HNKPC model with both output growth and output gap were estimated with 3 different measures of inflation expectations, over the two data frequencies. However, since HP is the only available measure of expected inflation in the annual series, this implies that two models using the annual data and six models under the quarterly data series were estimated.

Thus, the models estimated over the two different techniques are as follows:

Annual series:

Model 1: $\bar{\pi}_t = \gamma_b \bar{\pi}_t^b + \gamma_f \bar{\pi}_t^e (HP) + \lambda_y y_{gap} + \lambda_{IT} D_IT + \lambda_{FC} D_FC + \mu_t$ … {3.14}

Model 2: $\bar{\pi}_t = \gamma_b \bar{\pi}_t^b + \gamma_f \bar{\pi}_t^e (HP) + \lambda_y \bar{y}_t + \lambda_{IT} D_IT + \lambda_{FC} D_FC + \varepsilon_t$ … {3.15}

Quarterly series:

Model 3: $\bar{\pi}_t = \gamma_b \bar{\pi}_t^b + \gamma_f \bar{\pi}_t^e (survey) + \lambda_y y_{gap} + \lambda_{IT} D_IT + \lambda_{FC} D_FC + \mu_t$ … {3.16}

Model 4: $\bar{\pi}_t = \gamma_b \bar{\pi}_t^b + \gamma_f \bar{\pi}_t^e (survey) + \lambda_y \bar{y}_t + \lambda_{IT} D_IT + \lambda_{FC} D_FC + \varepsilon_t$ … {3.17}

Model 5: $\bar{\pi}_t = \gamma_b \bar{\pi}_t^b + \gamma_f \bar{\pi}_t^e (HP) + \lambda_y y_{gap} + \lambda_{IT} D_IT + \lambda_{FC} D_FC + \mu_t$ … {3.18}

Model 6: $\bar{\pi}_t = \gamma_b \bar{\pi}_t^b + \gamma_f \bar{\pi}_t^e (HP) + \lambda_y \bar{y}_t + \lambda_{IT} D_IT + \lambda_{FC} D_FC + \varepsilon_t$ … {3.19}

Model 7: $\bar{\pi}_t = \gamma_b \bar{\pi}_t^b + \gamma_f \bar{\pi}_t^e (ARIMA) + \lambda_y y_{gap} + \lambda_{IT} D_IT + \lambda_{FC} D_FC + \mu_t$ … {3.20}

Model 8: $\bar{\pi}_t = \gamma_b \bar{\pi}_t^b + \gamma_f \bar{\pi}_t^e (ARIMA) + \lambda_y \bar{y}_t + \lambda_{IT} D_IT + \lambda_{FC} D_FC + \varepsilon_t$ … {3.21}

Data on inflation survey is only available from 2000Q3 to 2013Q2; hence equations 3.16 and 3.17 were estimated over these periods. The rest of the quarterly models (equations 3.18 to 3.21) were estimated over the period 1980Q1 to 2013Q3. The models on annual data series were estimated from 1980 to 2012 (these are equations 3.14 and 3.15).

3.5.2 Data sources and variable descriptions

Annual and quarterly time-series data spanning over the period 1980 to 2013 were used to estimate the output-based hybrid new Keynesian Phillips cure (HNKPC) model. All the variables except survey were sourced from the database of the *International Monetary Fund/International Financial Statistics (IMF/IFS);* survey data were sourced from the *South African reserve Bank/Bureau for Economic Research (SARB/BER).* Dummies were also included in the study in order to capture any form of structural changes that occurred during the period considered. The two major structural changes considered are the adoption of the inflation targeting framework announced in 2000 and the financial crisis of 2008 to 2011. These variables are shown in table 3.3.

Table 3.3: Variables and definitions for the Hybrid NKPC model

Variable	Variable definition	Frequency
Inflation π_t	Inflation rate derived from the consumer price index (2005 prices)	1980 to 2012 and 1980Q1 to 2013Q3
Lagged inflation π_t^b	Lag of the inflation rate	1980 to 2012 and 1980Q1 to 2013Q3
Dummy1, D_IT	Dummy variable captures the implementation of the adoption of inflation targeting in 2000.	1980 to 2012 and 1980Q1 to 2013Q3
Dummy2, D_FC	Dummy variable captures the period of global financial crisis, 2008 to 2011.	1980 to 2012 and 1980Q1 to 2013Q3
Measures of Expected inflation variables π_t^e		
(i) Survey, π_t^e **(survey)**	i) Survey approach uses data from interviewing 4 groups of respondents.	(i) 2000Q3 to 2013Q2
(ii) Hodrick Prescott (HP) filter, π_t^e **(HP)**	ii) Hodrick Prescott (HP) filter approach	(ii) 1980 to 2012 and 1980Q1 to 2013Q3
(iii) ARIMA, π_t^e **(ARIMA)**	iii) ARIMA is obtained using the forecast approach.	(iii) 1980Q1 to 2013Q3

Demand-side variables		
(i) Output gap y_{gap}	i) The difference between the actual and potential output, using the Hodrick Prescott (HP) trend $\Delta y = y_{gap} = y_t^* - \hat{y}_t$	(i) 1980 to 2012 and 1980Q1 to 2013Q3
(ii) Output growth $\bar{y}$	ii) The growth of real GDP $\Delta\bar{y} = \left(\frac{y_t}{y_{t-1}}\right) - 1$	(ii) 1980 to 2012 and 1980Q1 to 2013Q3

Inflation expectation is important as a determinant of current inflation because it is used to forecast inflation as well as assess the inflation-credibility of the inflation targeting of the monetary authorities. Although, inflation expectations cannot be observed directly because its measurement poses some difficulties, inflation targeting is deemed successful when inflation expectations are rightly managed (Kershoff, 2000; Ueda, 2009). There are different ways of obtaining survey inflation expectations in South Africa. These are survey data by Bureau of Economic Research (BER) and the Reuters Inflation Expectations (RIE). The data on inflation expectations survey carried out by BER is available quarterly starting from the first quarter of 2000. The data from RIE is available monthly from December 1999 (Ehlers and Steinbach, 2007).

The survey on inflation expectations conducted by BER is published on behalf of the SARB. This survey is based on four groups of respondents; namely the households, the business sector, the financial sector and the trade union sector. Although these type of surveys are useful, they are however prone to biases. Such biases include forecasters not revealing their true forecasts, lack of sufficient incentives that would allow them make use of the available resources when answering the survey questionnaire and the lack of attaching weights to responses according to the number of respondents and who they are (Woodward, 1992; Thomas, 1999).

Although there is limited available data with small sample sizes on South African inflation expectations survey, there are other ways of measuring inflation expectations; and these are explained below. Other potential methods are the adaptive inflation expectations introduced by

Fisher (1930) and the rational inflation expectations developed by Muth (1961). The notion of adaptive expectations assumed that economic agents are not fully aware of the nature of the economy, but base their inflation predictions on the past forecast errors $(\overline{\pi}_t^b - \pi_{t-1}^e)$. These are the backward-looking agents. The criticism against the adaptive expectations hypothesis is that economic agents will always overestimate inflation during disinflationary periods and underestimate it during the inflationary periods. The reason is that they always base their expectations of future inflation on the past inflation levels. The adaptive expectation model is as follows:

$$\pi_t^e = \pi_{t-1}^e + \lambda(\overline{\pi}_t^b - \pi_{t-1}^e) \qquad \ldots \{3.22\}$$

where, λ is the adaptive coefficient; π^e is the expected current inflation; π_{t-1}^e is the inflation expected in the previous period; $\overline{\pi}_t^b$ (also written as π_{t-1}) is the actual inflation of the previous period.

Given the criticism against the adaptive expectations, the rational expectation rule was developed. The rational expectations hypothesis assumed that economic agents are rational enough to rightly observe the changes in economic policies. They are thereby able to continuously predict the accurate future inflation. The rational expectation is forward-looking, whereby economic agents are believed to fully understand how the economy functions. The rational expectation model is:

$$\pi_t = \pi_t^e + \mu_t \qquad \ldots \{3.23\}$$

where, π_t is the current inflation; π_t^e is the expected inflation in the current period; μ_t is the error term.

Another way to proxy expected inflation is through forecast as introduced by McCallum (1976) and used by several authors such as Roberts (1995), Aron and Muellbauer (2000) and Cooray (2002). The actual value of past inflation or its forecast can be used to proxy inflation expectation. However, Woodward (1992) warned against the use of the equation on past inflation to proxy expected inflation as it causes inaccurate results. One of the ways to forecast a variable is using the auto regressive integrated moving average (ARIMA) technique or auto regressive

moving average (ARMA) technique. An ARIMA process is made up of the number of lags of the dependent variable, *p-th order autoregressive* (AR) *process*, the order of integration, *I(d)*, and the lags of the error term, *q-th order moving average* (MA) *process*. Therefore, ARIMA is made up of 3 interacting processes, which becomes ARIMA(*p, d, q*).

Starting with a model without an independent variable:

$$\pi_t = \alpha + \mu_t \qquad \ldots \{3.24\}$$

By adding the *p-th* order autoregressive and the *q-th* order moving average processes, it becomes:

$$\pi_t = \alpha_0 + \beta_1\pi_{t-1} + \beta_{21}\pi_{t-2} + \beta_3\pi_{t-3} + ... + \beta_p\pi_{t-p} + \mu_t + \lambda_1\mu_{t-1} + \lambda_2\mu_{t-2} + ...\lambda_q\mu_{t-q} \qquad \ldots \{3.25\}$$

where, π is the inflation rate; α is the constant; and β and λ are the coefficients.

On the other hand, the Hodrick-Prescott filter approach as used by Fedderke and Schaling (2005), which incorporates both the price levels and the rate of change of prices, can also be used to proxy inflation expectations. The advantage of this approach lies in the severe smoothing of the prices as shown:

$$P_t^e = p_1^*.....p_n^* \min\left\{\sum_{t-1}^{n}\left(p_t - p_t^e\right)^2 + \lambda\sum_{t-1}^{n}\left(\Delta^2 p_{t+1}^2\right)\right\} \qquad \ldots \{3.26\}$$

Therefore this study considered the rational expectations approach using three different measures namely; survey, the forecast approach using ARIMA method and Hodrick-Prescott (HP) filter approach. This is to examine the measure of expected inflation that best explains the inflation dynamics in South Africa. Also, two different measures of demand-side component were used in order to observe the type of demand factor that applies to the South African economy. These variables are output growth, which is the growth rate of real GDP and the output gap, which is the difference between the actual output and the potential output.

3.5.3 Tests of Stationarity

Since the method of estimation is determined by the nature of the variables as well as their interrelationships, the variables were firstly tested for stationarity. Secondly the possible long-run relationship that could exist among them was examined using cointegration technique. The stationarity test was carried out using the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and the Dickey-Fuller GLS (DF-GLS) detrended. The results showed that, for the annual series, only inflation rate, lagged inflation and expected inflation measured by HP-filter were found to be integrated of order one, I(1). This means that these variables became stationary after the first difference. Output growth and output gap were integrated of order zero, I(0), that is, they were stationary at levels. Only HP-filter measure of inflation expectations is available annually. The stationarity test results for annual series are shown in table A3.1 of Appendix A and for quarterly series in table A3.2 of the Appendix.

The quarterly series were divided into two parts, because of the time period available for different variables, as earlier highlighted. The data on inflation expectations using survey is available from 2000Q3 to 2013Q2; and this is labelled 'a' in the table. The variables in this model were tested for stationarity and they were all found to be stationary at levels. This means they were integrated of order zero, I(0). The second part of the quarterly series with data spanning over the period 1980Q1 to 2013Q3 makes up the models for inflation expectations using HP-filter and ARIMA. This is labelled 'b' in the table. In these models, all the variables were also found to be stationary at levels; they were all integrated of order zero, I(0). Hence, there was no need to test for co-integration among the variables of the quarterly data series since they were all stationary at levels.

3.5.4 Estimation Methodology

Given the nature of the variables considered in this chapter, this study proceeds to estimate the output-based HNKPC model by firstly applying the ordinary least squares (OLS) technique. This is followed by the commonly-used technique of GMM. The annual data from 1980 to 2012 and quarterly data from1980Q1 to 2013Q3 and 2000Q3 to 2013Q2 were used. The adopted techniques are explained below.

3.5.4.1 Co-integration and Ordinary Least Squares (OLS) techniques

Fully-Modified ordinary least squares (FMOLS) approach to co-integration popularized by Phillips and Hansen (1990) is used to formally test the presence of the possible long-run co-integrating relationships among annual variables. These are the variables that are integrated of different orders. Some of the advantages of using this technique are that the FMOLS estimator employs a semi-parametric correction which eliminates the bias resulting from endogeneity. This technique performs better in small samples and also incorporates the corrections for possible serial correlation.

This study could not make use of the standard Johansen co-integration test because the backward-looking component of the HNKPC model could not be explicitly included in the model. Also due to the problem of restrictions, the study could not proceed to use the Vector Error Correction Model (VECM) method. The autoregressive distributed lag (ARDL) could also not be adopted as an approach to co-integration due to the problems of lag, although this technique allows for a mix of orders of integration. Hence, the best alternative approach to co-integration used in this chapter is the FMOLS.

The problems of endogeneity, which normally arises in co-integration and the problem of serial correlation which usually occurs in variables that have unit roots, are corrected for by FMOLS. Seeing that some of the variables included in the model are non-stationary, this technique will correct any problem of serial correlation that might arise. FMOLS does not depend on lag length, and the t-ratios obtained from FMOLS are asymptotically normally distributed and the results are robust[10].

Meanwhile, obtaining the long-run estimates is not sufficient, as this study aims to observe the relationships among these variables. Therefore, the OLS framework was used to determine these relationships for both data frequencies. In this framework, the first required step is to test the stationarity of each of the variables, thereby determining their order of integration, as carried out in the preceding section. This is followed by testing for co-integration, using the FMOLS. This

[10] For more details on FMOLS, see Borland and Ouliaris (1994); Roudet, Saxegaard and Tsangarides (2007); Liddle 2012.

applies if the variables are integrated of different orders, e.g. I(0), I(1) and in some cases I(2). Otherwise, if the variables are all stationary at levels, I(0); there is no need to test for cointegration. After establishing co-integration, the OLS models would be estimated. The values and the significance of the variables, particularly the demand-side variables, inflation lag and expected inflation, were observed.

OLS is the most basic and most commonly used technique, as it provides a measure of accuracy; it is easier to analyse and interpret and it is efficiently implemented. However, OLS is faced with many limitations such as increase in R-squared given increased number of independent variables. Thus, the adjusted R-squared is normally reported. Another limitation is its inability to address endogeneity problem; hence this study adopted the generalised method of moments.

3.5.4.2 Generalized Method of Moments (GMM)

A GMM technique, which was formalized by Hansen (1982), is commonly used in estimation models where complete information of the knowledge of the data distribution is not required. Moreover, the moment conditions (or instrumental variables) are valid and relevant when they are not correlated with the error term, but correlated with the included endogenous variables conditional on the exogenous variables. The GMM technique is more applicable to this study because firstly, complete information of the data distribution is not known and not required. Secondly, our HNKPC model, which also includes the lag of the dependent variable, is better estimated using this technique. In most economic models, one or more explanatory variables are found to be endogenous; hence, the two main reasons for the applicability of the GMM technique in this study is to correct for autocorrelation of the residuals in a standard OLS estimation and to address the possible problem of endogeneity.

In order to test whether the selected moments are relevant or not, the correlation between the moment conditions and each of the endogenous variables in the model are measured. The moment conditions are measured along with the exogenous explanatory variables in the original structural model. This is done by estimating the set of excluded exogenous variables on each of the endogenous variables in the model, using the least squares method. This is the first-stage

regression. Otherwise, the J-stat can be used to determine the endogeneity of the instruments used.

3.6 EMPIRICAL RESULTS

The variables of the quarterly data series were not tested for co-integration because they were all stationary at levels. This means they were all integrated of order zero, I(0) (Table A3.2, Appendix). Since the variables for the annual series were integrated of different orders (Table A3.1, Appendix), co-integration among the variables was tested, using the Fully-Modified Ordinary Least Squares (FMOLS) approach to co-integration. The co-integration test results generally showed that even though the variables were integrated of different orders, there is a stationary linear combination of these non-stationary variables because they have a long-run relationship (Table 3.4).

Table 3.4: Results of FMOLS Co-integration Test (1980 to 2012): Dependent variable - Inflation

Variables	**Model 1: Output gap**	**Model 2: Output growth**
	Coeff.	Coeff.
$\bar{\pi}_t^b$	0.36*** (0.10)	0.31*** (0.12)
$\bar{\pi}_t^e(HP)$	0.64*** (0.10)	0.71*** (0.13)
$\bar{y}_t$	____	-0.09 (0.09)
y_{gap}	-1.07E-06 (1.05E-06)	____
Phillips-Ouliaris test	Tau stat: -4.59***	Tau stat: -4.41**
Hansen Instability test	Lc stat: 1.97***	Lc stat: 1.64**

***1%, **5%, *10%
Model: Intercept with no additional deterministic trend; estimated in a non-differenced form.
Standard Error in parenthesis ( )
Null hypothesis: Series are not co-integrated.
Analysis: By author.

In order to test the variables for possible co-integration, the Phillips-Ouliaris test method as well as the Hansen instability[11] co-integration test of FMOLS was adopted and the results are as shown in the same table 3.4. If in a (nx1) vector time-series, with 0<r<n co-integrating vectors, then there will be n-r common I(1) stochastic trends. Thus, the above results show that the variables are co-integrated since the null hypothesis of 'no co-integration' was rejected by the two test methods at 5% level of significance. The OLS results are reported in section 3.6.1 below, followed by the GMM results in 3.6.2.

3.6.1 Ordinary Least Squares (OLS) result

After obtaining the levels of stationarity, the order of integration and the co-integrating relationship of the variables, the OLS is estimated for all the models (equations 3.14 to 3.21). The results obtained from the OLS technique shows that based on either the output gap-inflation nexus or output growth-inflation nexus; there is no trade-off between these variables (Table 3.5). Phillips curve does not exist in South Africa during the period of study because the demand side variables are either economically or statistically insignificant. While, output gap is statistically significant in model 3, it is not economically significant, which is contrary to the expected negative sign for the existence of Phillips curve. However, when it is rightly signed (models 1, 5 and 7), it is statistically insignificant. Output growth variable also depicts unexpected signs in most instances (models 2, 6 and 8) and all are statistically insignificant. When it shows the right and expected positive sign (model 4), it is also not statistically significant. Thus, this study concludes that Phillips curve does not exist in South Africa especially based on the output gap measure of demand-side.

Although, inflation dynamics in South Africa seem to be more significantly forward-looking, the result shows a mix in terms of the significance of both components. The forward-looking components are mainly statistically significant except in model 4, and the backward-looking variable is statistically significant in all the models, except in models 1, 2 and 3. Also, the magnitudes of the inflation expectations measures are larger compared to the inflation lag

[11] Phillips-Ouliaris test method is a single-equation cointegration test, also known as the residual-based cointegration test; while Hansen instability is a regression-based estimation of cointegration test.

variable. This shows that according to the OLS results, economic agents are more rational than adaptive in predicting inflation.

Table 3.5: OLS Inflation Estimation result: Dependent variable – Inflation rate.

Variables	**Annual Data: Cointegrated Regression**		**Quarterly Data: Stationary series**					
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**
$\overline{\pi}_t^b$	0.26 (1.43)	0.14 (0.71)	0.16 (1.02)	0.37** (2.44)	0.25*** (3.04)	0.24*** (2.75)	0.41*** (5.01)	0.39*** (4.66)
$\overline{\pi}_t^e(HP)$	0.74*** (3.88)	0.89*** (4.11)	—	—	0.74*** (8.29)	0.78*** (8.24)	—	—
$\overline{\pi}_t^e(survey)$	—	—	0.10* (1.83)	0.09 (1.44)	—	—	—	—
$\overline{\pi}_t^e(ARIMA)$	—	—	—	—	—	—	0.57*** (6.64)	0.61*** (6.61)
$\overline{y}_t$	—	-0.23 (-1.32)	—	0.09 (0.43)	—	-0.11 (-1.23)	—	-0.12 (-1.14)
$y_{gap(t)}$	-4.91E-07 (-0.26)	—	1.77E-05*** (2.79)	—	-1.98E-07 (-0.59)	—	-1.76E-07 (-0.49)	—
D_IT	-0.199 (-0.24)	0.50 (0.52)	0.63** (2.09)	0.37 (0.91)	0.14 (0.94)	0.23 (1.35)	0.07 (0.45)	0.16 (0.87)
D_FC	0.92 (0.68)	0.68 (0.51)	-0.10 (-0.37)	-0.26 (-0.82)	-0.32 (-1.19)	-0.39 (-1.40)	-0.12 (-0.42)	-0.18 (-0.61)
Adj R^2	0.79	0.81	0.30	0.19	0.57	0.57	0.52	0.52
DW-d stat	1.85	1.80	1.80	1.89	1.95	1.91	2.01	1.97

Figures in parentheses indicate t-statistics. ***1%, **5%, *10%.
Analysis: By author

The results show that the forward-looking component has larger magnitude compared to the smaller values of the coefficient of the backward-looking inflation component. The lag inflation is both economically and statistically highly significant in all the models except in models 1, 2 and 3 where it is not statistically significant but economically significant. This result supports the findings of Hodge (2002) who used ECM technique to estimate the traditional Phillips curve for South Africa. In addition, these results support the sensitivity of HNKPC model to different measurements of inflation expectation variables as HP-filter and ARIMA measures of expected inflation give better results in estimating the HNKPC model.

However, the model is not sensitive to data frequency because both quarterly and annual data series give consistent results. This model is also not sensitive to demand-side variable as the results show that Phillips curve does not exist when the demand-side variable output gap is used,

and the output growth variable was statistically insignificant in all the models, even though it is economically significant in only one model (model 4). All the models passed the battery of diagnostic tests, as shown in table 3.6.

Table 3.6: Results of the diagnostic tests of the OLS model

Diagnostic tests	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Normality Test (Jarque-Bera)	1.53 (0.47)	1.45 (0.48)	0.88 (0.64)	0.22 (0.89)	5.81 (0.05)	6.70 (0.03)	1.34 (0.51)	1.02 (0.60)
Serial Correlation LM Test[+] (F-statistic)	0.15 (0.86)	4.98 (0.11)	2.16 (0.13)	2.35 (0.11)	0.77 (0.47)	1.25 (0.29)	1.03 (0.36)	0.22 (0.80)
Heteroskedasticity Test[++] (F-statistic)	1.30 (0.29)	1.33 (0.28)	1.36 (0.26)	1.40 (0.24)	0.13 (0.98)	0.06 (0.99)	0.63 (0.68)	0.77 (0.57)
Ramsey RESET Test (F-statistic)	0.88 (0.39)	0.64 (0.52)	0.66 (0.51)	0.51 (0.61)	0.21 (0.83)	0.08 (0.94)	0.70 (0.48)	0.97 (0.33)

[+]Breusch-Godfrey; [++]Breusch-Pagan-Godfrey
Figures in parentheses indicate P-value.
Analysis: By author.

3.6.2 Generalized Method of Moments (GMM) results

Establishing valid and reliable results require that robustness checks be carried out. This can be tested by either using the same technique but changing the variables, or using a different technique altogether. This study therefore used a GMM technique to further affirm the authenticity of the OLS results above. Valid instruments for estimating the HNKPC model may not be easily identified, but studies have shown that the instruments that are used must be lagged. The reason is that the instruments have to be uncorrelated with the residual in the HNKPC model so that the results will be valid and be able to correct for the problem of serial correlation.

Therefore, this section discusses the GMM results obtained using the lag of some of the dependent and independent variables as instrumental variables. The instruments were chosen following Gali and Gertler (1999), Gali, Gertler, and Lo´pez-Salido (2005) and Nason and Smith (2008) whereby the variables are correlated with the endogenous variables conditional on the exogenous variables. These instruments have direct effect on inflation rate and they are still uncorrelated with the residuals in each model. These results are presented in table 3.7.

The results of the GMM technique confirm a non-existence of the Phillips curve in South Africa. While output growth is negative and statistically significant (model 2), when it carries the expected positive sign, it is statistically insignificant (models 4 and 6). This shows that the output growth variable does not have the expected sign for the existence of Phillips curve in all the models. It depicts an inverse relationship with inflation rates, instead of the expected positive relationship. This affirms that there is no trade-off between inflation and output growth. Along the same line, in models 1 and 3, output gap has the unexpected sign and is highly statistically significant. It has the expected negative sign in model 5, but this is not statistically significant at any acceptable level of significance. Hence, there is also no short-run trade-off between inflation and output gap.

The findings of this study are contrary to the results of Hodge (2002), where on one hand, it was found that there is a short-run trade-off between inflation and output growth. On the other hand, Hodge also found no existence of the trade-off between inflation and unemployment rate. The possible reason for dissimilarity in these results compared to Hodge's results could be due to different periods of studies considered. This chapter thus concludes that the Phillips curve does not exist in South Africa based on the relationships between inflation and the demand-side variables. This is because the demand-side variables have the unexpected sign although they are statistically significant, and if rightly signed, they are statistically insignificant. This study therefore concludes that the South African economy does not exhibit the existence of Phillips curve during the period of study based on both the output gap and output growth relationships with inflation.

Table 3.7: GMM inflation estimation results: Dependent variable – Inflation Rate.

Variables	**Annual Data: 1980 – 2012**		**Quarterly Data: 2000Q3 – 2013Q2**					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
γ_b	0.36*** (2.96)	0.05 (0.45)	0.22 (1.31)	0.40*** (3.78)	0.28** (2.02)	0.29** (2.35)	0.47*** (2.53)	0.45*** (5.61)
$\gamma_f\,(HP)$	0.62*** (4.98)	1.03*** (7.17)	—	—	0.70*** (4.71)	0.66*** (4.69)	—	—
$\gamma_f\,(survey)$	—	—	-0.01 (-0.10)	0.07 (0.45)	—	—	—	—
$\gamma_f\,(ARIMA)$	—	—	—	—	—	—	0.52*** (2.80)	0.53*** (5.99)

λ_y	—	-0.54** (-2.47)	—	0.13	—	0.20 (0.80)	—	-0.06 (-0.36)
$\lambda_{y\ gap}$	3.3E-06* (1.82)	—	2.4E-05** (2.41)	—	-1.7E-06 (-0.64)	—	2.97E-06 (0.85)	—
λ_{IT}	0.40 (0.44)	1.34* (1.87)	1.14** (2.33)	0.57 (0.50)	-0.29 (-0.86)	-0.73* (-1.69)	-0.75 (-0.61)	0.10 (0.21)
λ_{FC}	-1.20 (-0.83)	0.05 (0.04)	0.12 (0.12)	-0.84 (-1.21)	1.07 (0.77)	1.85 (1.26)	2.02 (0.55)	-0.28 (-0.28)
R^2	0.75	0.80	0.31	0.20	0.43	0.36	0.006	0.53
Adj R^2	0.72	0.77	0.25	0.12	0.41	0.34	-0.025	0.52

Figures in parentheses indicate t-statistics. ***1%, **5%, *10%
Instruments for GDP growth: Constant term, three lags of current inflation, expected inflation of HP-filter, survey and ARIMA, inflation lag and two lags of output growth.
Instruments for GDP gap: Constant term, two lags of current inflation, expected inflation of HP-filter, survey and ARIMA, inflation lag and output gap.
Analysis: By author.

Furthermore, the results obtained show that although both inflation expectation variables and lagged inflation variable are significant in many instances having different magnitudes[12] the results however show that the forward-looking component is predominant because it has larger values than the backward-looking variable. While previous studies on GMM gave mixed results, the GMM results obtained from this study showed that although both components of inflation expectations measures are statistically significant in South Africa, the forward-looking component clearly proves to be dominant.

In addition, the HP-filter measure of inflation expectation is highly statistically significant in models 1, 2, 5 and 6. The inflation expectation variable measured using the HP-filter has larger values compared to the smaller values of the inflation lag in the same models. This also applies to the statistical significance of ARIMA (models 7 and 8). Hence, inflation is forward-looking based on these models. However, inflation expectations measured using survey is not statistically significant in any of the models.

Although survey was expected to be the best measure of inflation expectations, the results however showed otherwise. Based on the sensitivity of the HNKPC model to the two different measurements, namely; inflation expectations and demand-side variables; the results show that

[12] Gali and Gertler (1999) explained their findings through the component that has the larger or smaller values.

HP-filter and ARIMA give better explanations of the HNKPC model. This could be attributed to the fact that they were directly obtained from the inflation rate series. The inflation expectation component of these variables is not only economically significant, having the expected signs; they are also highly statistically significant across all the models, with the exception of survey. This shows that HNKPC model is sensitive to different measures of inflation expectation variables.

However, this model is not sensitive to different measures of demand side. This is because whether output gap or output growth is used, there is no existence of Phillips curve trade-off in South Africa. These results also show that the HNKPC model is not sensitive to data frequency as no one model gives better results of inflation dynamics in South Africa over the periods of study. This study therefore could not affirm the findings of Fuhrer (1997) and Roberts (2001), who argued that the HNKPC model does not give the true inflation dynamics when using quarterly data. In addition, the two included dummies either have the unexpected sign or if rightly signed, they are statistically insignificant, except in model 6 where D_IT is both economically and statistically significant.

Each of the models was also tested for normality, endogeneity and weak instruments and the models passed this battery of diagnostic tests (Table 3.8). The diagnostic tests of the GMM results obtained confirm the validity of these results. The null hypothesis of the diagnostic tests could not be rejected. Hence the model is stable, with valid and relevant instruments used.

Table 3.8: Results of the diagnostic tests of the GMM model

Diagnostic tests	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**
Normality Test (Jarque-Bera)	2.17 (0.34)	2.93 (0.23)	0.02 (0.99)	0.24 (0.89)	0.03 (0.98)	0.19 (0.91)	0.40 (0.82)	0.29 (0.86)
Endogeneity Test (J-stat)	0.59 (0.99)	1.65 (0.89)	3.78 (0.58)	2.36 (0.80)	4.51 (0.48)	1.46 (0.92)	5.18 (0.39)	2.93 (0.57)
Weak Instrument test[+]	0.36	0.67	0.84	0.86	0.34	0.41	0.14	0.37

Figures in parentheses indicate P-value.
[+]Stock-Yogo.
Analysis: By author.

3.6.3 Summary

Based on all the above results, this study answers the research question of firstly, whether Phillips curve exists in South Africa and secondly, if it is backward-looking or forward-looking. This was done by exploring the sensitivity of the HNKPC model to different variable measurements, data frequency and estimation techniques. This model is not sensitive to different measures of demand-side variables; it is however sensitive to different measures of inflation expectations variables. While the former sensitivity result is in relation to the first research question, the latter relates to the second research question. The results also showed no sensitivity to different econometric techniques and data frequency.

The results clearly showed that Phillips curve does not exist in South Africa. This is because the demand-side measures, using both the output growth and output gap variables, were not rightly signed, as they did not depict the expected signs, and they are not statistically significant when rightly signed. The results therefore showed that irrespective of the measure of the demand-side variable used, the result did not change. This is contrary to earlier studies on South Africa which found significant trade-off between inflation and output growth.

Lastly, this study is not sensitive to different econometric techniques as they both give similar and consistent results. While the current findings indicate that economic agents in South Africa are both rational and adaptive in predicting inflation, the results clearly indicate the dominance of forward-looking variables over the backward-looking components in determining inflation. Previous studies found mixed results for inflation process in South Africa because they either considered a pure traditional or expectations augmented PC. Besides, each study used one econometric technique and hence could not observe if their results are conflicting or not. However, this study considered the hybrid NKPC, which includes both components of the backward- and forward-looking and more than one econometric technique was adopted. This study is also contrary to the mixed findings of Malikane (2013) who used the HNKPC for emerging markets while including South Africa.

3.7 CONCLUSION AND POLICY RECOMMENDATIONS.

This chapter explored the sensitivity of HNKPC model to various variable measurements, data frequency and estimation techniques by investigating the existence of Phillips curve in South Africa. The chapter estimated the output-based HNKPC model and further observed whether the backward-looking or the forward-looking factors determine inflation dynamics in South Africa. The motivation for this study was to inform monetary policy of the importance of inflation and how it affects output in South Africa. It is also important for policy makers to be concerned with whether inflation is determined by backward- or forward-looking components in South Africa because movements in prices should not occur before remedial measures are applied. This means that monetary authorities need to understand how economic agents predict prices so that they are able to respond before the actual change in prices is realised.

The results obtained confirmed that the Phillips curve trade-off does not exist in South Africa, as the demand-side variable measures either depicted unexpected relationship with inflation or not statistically significant. The study thus found that the HNKPC model is not sensitive to the different measures of demand-side variables. This means that irrespective of the variable used, output growth or output gap, Phillips curve trade-off does not exist in South Africa. The model is however sensitive to different measures of inflation expectations but not sensitive to data frequency and estimation techniques.

Given that there is no trade-off between inflation and output growth in South Africa, monetary authorities should give more attention to increasing output which will not significantly lead to an increase in inflation. The reason is that based on the findings of this study, policies that will encourage economic growth will not lead to increased inflation but such policies will rather encourage price stability, seeing that there is no significant positive relationship between these variables. Thus, monetary authorities could consider introducing policies with the purpose of improving output and the effect of such policies will not be inflationary.

Finally, this study concludes that economic agents are more forward-looking than backward-looking in South Africa. Economic policies in general and monetary policies in particular require

a forward-looking phenomenon, because movements in prices should not occur before remedial measures are applied (Keynes, 1923). However, since this study found no trade-off between inflation and the demand-side variables, and inflation is forward-looking, monetary authorities need to focus on remedial measures to combat possible increase in future inflation since economic agents predict changes in inflation using its expectations. They should also give attention to enhancing economic growth since this will not lead to increased inflation.

It is important to note that monetary policy cannot be formulated based entirely on the Phillips curve due to its inconsistency with empirical studies in terms of the trade-off between inflation rate and unemployment rate. An alternative to the PC, which could be considered for further research, is the Taylor policy rule. This policy rule can be observed for its applicability in formulating monetary policy, although this policy rule does not provide the right monetary policy to adopt (Chatterjee, 2002). This shows that there is a need to therefore explore other determinants of inflation dynamics in South Africa by extending the model. This is examined in the subsequent chapter.

APPENDIX TO CHAPTER 3

Table A3.1: Stationarity tests[#]: Annual Data (1980 – 2012)

	LEVELS			FIRST DIFFERENCE			
Variables	ADF	PP	DF-GLS	ADF	PP	DF-GLS	Decision
$\bar{\pi}$	-2.830	-2.786	-2.850	-2.492	-8.930***	-3.297**	I(1)
$\bar{\pi}_t^b$	-2.864	-2.769	-2.840	-4.614***	-7.907***	-6.110***	I(1)
$\bar{\pi}_t^e$ (HP)	-4.586***	-1.276	-1.535	-4.583***	-1.435	-4.007***	I(1)
$\bar{y}$	-4.526***	-4.548***	-3.928***	NA	NA	NA	I(0)
y_{gap}	-3.782**	-3.494*	-3.915***	NA	NA	NA	I(0)

[#]test equation of trend and intercept and intercept only.
Critical values: ADF and PP [1% -4.273; 5% -3.558; 10% -3.212]; DF-GLS [1% -3.770; 5% -3.190; 10% -2.890]
***1%, **5%, *10%

Table A3.2: Stationarity tests[#]: Quarterly Data (2000Q3 – 2013Q2; 1980Q – 2013Q3)

	LEVELS			
Variables	ADF	PP	DF-GLS	Decision
$\bar{\pi}$ (a)	-4.218***	-4.218***	-4.251***	I(0)
$\bar{\pi}$ (b)	-7.528***	-7.718***	-5.457***	
$\bar{\pi}_t^b$ (a)	-4.171***	-4.171***	-4.209***	I(0)
$\bar{\pi}_t^b$ (b)	-7.323***	-7.426	-6.305***	
$\bar{\pi}_t^e$ (b) (HP)	-3.316*	-1.347	-3.080**	I(0)
$\bar{\pi}_t^e$ (a) (Survey)	-2.980**	-2.097	-2.838***	I(0)
$\bar{\pi}_t^e$ (b) (ARIMA)	-10.60***	-10.85***	-6.692***	I(0)
$\bar{y}$ (a)	-3.570**	-3.295*	-3.523**	I(0)
$\bar{y}$ (b)	-6.142***	-6.164***	-2.725*	
y_{gap} (a)	-3.517**	-3.552**	-3.592**	I(0)
y_{gap} (b)	-9.113***	-60.77***	-9.188***	

[#]test equation of trend and intercept (T&I) and intercept (I) only.
(a) represents 2000Q3 – 2013Q2; and (b) represents 1980Q1 – 2013Q3
Critical values: ADF and PP (T&I) [1% -4.148; 5% -3.500; 10% -3.180]; DF-GLS [1% -3.766; 5% -3.187; 10% -2.887]
Critical values: ADF and PP (I) [1% -3.571; 5% -2.922; 10% -2.599]; DF-GLS [1% -2.613; 5% -1.948; 10% -1.613]
***1%, **5%, *10%

CHAPTER 4

AN EXTENDED GORDON'S TRIANGLE MODEL FOR SOUTH AFRICA.

This chapter progresses from the "Hybrid" New Keynesian Phillips Curve (HNKPC) model, where no evidence was found for the existence of Phillips curve (PC) in South Africa. This chapter explores the existence of the Phillips curve in the context of an extended (or augmented) 'triangle' model incorporating the demand-side factors along with the fiscalist, monetarist and the structuralist schools of thought. The reason for considering the extended model is to verify whether PC trade-off exists when other control variables are included. The extended model will facilitate the verification of the findings of the previous chapter, whether or not they are robust to model specification. The results obtained could also assist policy makers to be aware of other variables which may lead to changes in inflation.

4.1 INTRODUCTION

The major reason for the collapse of the PC was the omission of the supply shocks whereby the model only considered the inertia and the demand side effects (Gordon, 1990). This was because there was no oil price shock before the PC period in order to have considered the importance of the supply shock (Gordon, 2013)[13]. After the breakdown of the Phillips curve model as a result of the stagflation in the mid-1970s, the Gordon's triangle model, which was introduced in the 1980s, gained popularity (Gordon, 1984; Phelps, 1978; Gordon, 2013).

Gordon (2013) highlighted the major differences between the New Keynesian Phillips Curve (NKPC) approach and the mainstream triangle approach. The mainstream triangle approach has longer lags on the dependent variable, to capture inflation inertia. It also incorporates additional lags (instead of the levels) on the rates of change of unemployment gap or output gap to capture the demand-side component (Fisher, 1926; Phillips, 1958). It further explicitly includes the variables that represent the supply-side component. These variables include changes in the relative prices of food, non-food, energy, non-oil import prices, pressure from unions with regard

[13] See also Gordon (1990).

to wage changes resulting in strike actions and price control shocks (through its termination or imposition) (Gordon, 1977; Blinder, 1979, 1982).

Furthermore, Stiglitz (1997) highlighted that the trinity of the benefits of Phillips curve are its suitability for explaining the determinants of inflation, for policy purposes and forecasting inflation. But Gruen, *et.al* (1999) stated that the Phillips curve alone cannot be used for the three purposes except it is augmented to allow for the effects of additional variables. The additional variables are the demand and supply shocks, as well as institutional variables. According to Gordon (2011), the triangle model of inflation depends solely on three components, namely, inflation inertia, demand shocks and supply shocks.

Meanwhile, the Gordon's triangular model excluded the unemployment rate variable because this variable has a mix of cyclical component as well as the structural component. Gordon believed that by including such variable without decomposing it into different segments will complicate the model, hence its omission (Gordon, 1990; Perry 1970). Another omitted variable was wages; this was because it was believed that the objective of the Federal Reserve was to control inflation, as it is the case with the South African Reserve Bank (SARB), and not growth rates of wage.

Gordon also believed that the changes in wage rates will affect costs of production. This is because as employers increase the wages of their workers (with wages making up the greater part of production costs), the price of goods and services will increase only if employers wish to maintain their profit level (Rich and Rissmiller, 2000). The last and major variable which was purposely excluded from the triangular model of Gordon was the price expectations. The reason Gordon gave was that there is a difference between the speed of price adjustment and the speed of expectation formation. It was argued that the delay in price adjustment can be as a result of wages, price contracts and the time taken for the increased cost to be realised. But expectations can be formed logically and on time as long as there is full information about the aggregate price level (Gordon, 1990).

Therefore, this chapter proceeds as follows; the following section provides the theoretical framework which explains the theories of different schools of thoughts. Empirical studies on the determinants of inflation are reviewed in section 4.3. This is followed by the data and methodology in section 4.4. Results are presented and analyzed in section 4.5, while conclusion and policy recommendations are discussed in section 4.6.

4.2 THEORETICAL FRAMEWORK OF INFLATION DETERMINANTS

There are three different schools of thought regarding the factors that determine inflation; these are the monetarist, the fiscalist and the structuralist. The monetarists believed that too much money chasing too few goods is the reason behind inflation dynamics. They also believed that inflation is "*always and everywhere a monetary phenomenon*" (Friedman, 1966a). Thus, they concluded that monetary aggregates are the only variables that determine inflation. The monetarist argued that increases in the price level result from increases in the nominal money supply. The increase in the money supply could either be exogenously or endogenously determined. The exogenous increase in money supply includes new or issued money, while endogenous increase is through banking credit (Silva, 2008).

On the other hand, the fiscalists believed that fiscal variables, such as government expenditure, debts and taxes cause changes in inflation. While the standard monetarists believed that a central bank can achieve price stability as long as it is committed to this goal, however, the proponents of the fiscal doctrine disagreed. The fiscalists argued that an appropriate monetary policy is not sufficient to achieve price stability but also an equally appropriate fiscal policy (Woodford, 1994; Cochrane, 2000; and McCallum, 1998). They thus concluded that apart from monetary policies, fiscal policies also affect inflation. Due to the importance of the fiscal policy in determining price-level, Woodford (1994) called it the Fiscal Theory of the Price Level (FTPL)[14].

[14] For indepth discussion of the FTPL, refer to Woodford (1995); Cochrane (1998); Leeper (1991); and Sims (1994).

According to Sargent and Wallace (1981), the monetarist doctrine acknowledges that appropriately chosen levels of both the fiscal and monetary policies will help achieve price stability. However, they argued that despite this, the fiscal authorities will be forced to adopt the suitable fiscal policy if the central bank is tough enough. This argument was not embraced by the supporters of the FTPL. The proponents of the FTPL believed that central banks should rather convince the fiscal authorities to choose a suitable policy (Christiano and Fitzgerald, 2000). Thus, according to Sims (1994:399), "i*n a fiat-money economy, inflation is a fiscal phenomenon, even more fundamentally than it is a monetary phenomenon*", supporting the FTPL.

According to Javid and Arif (2014), a sustainable fiscal policy is achieved when the intertemporal budget constraint of government is obtained without having to adjust the policy of the price level. But, a monetary policy dominance or Ricardian regime is believed to occur when government adjusts the budget deficit in order to restrict the accumulation of debt without monetization of debt by the central bank. However, the fiscal policy is believed to be dominant or non-Ricardian regime, when the budget deficits are independent of real liabilities.

In addition, the main argument behind the FTPL is that government can influence the time path of inflation by using some fiscal policy instruments, without directly using monetary policy, to determine the changes in inflation rate. Thus, the fiscalists are of the opinion that fiscal policies are more important in determining the levels of prices, instead of the monetary policies. However, according to Leeper (1991), there are different regimes in which monetary and fiscal policies are active and passive. For instance, in the monetary dominant regime, the monetary policy determines the price level whereas fiscal policy is reactive. In this regime, the government must balance its intertemporal budget, while accepting the inflation rate set by the monetary policy (Komulainen and Pirttilä, 2000). The opposite is true when there is active fiscal policy and passive monetary policy; this is the fiscal dominant regime whereby the intertemporal budget constraint of the government determines the price level. In this regime, monetary policy reacts to the changes in the price level in order to balance the money demand equation (Komulainen and Pirttilä, 2000).

Furthermore, according to David and Leeper (2009), the dynamic impact of government purchases on the equilibrium, irrespective of the monetary-fiscal regime, is that increased government spending (through increased tax revenues, issue of new debts or money creation) will increase the demand for the goods sold by monopolistically competitive firms that produce intermediate goods. This will be followed by the firms increasing the labour demand in order to meet the increased demand of their goods. Meanwhile, the increased labour demand will cause the real wages and real marginal costs to increase; thus firms that can re-evaluate their pricing decision will increase their prices.

The choice of financing government debt is imperative to how the inflation time path is determined (Woodford, 1995; Kocherlakota and Phelan, 1999). According to Aiyagari and Gertler (1985) if the increases in debt are backed by current or expected seigniorage, then debt increases are inflationary. Sims (1994) nevertheless disagreed and concluded that the backing of government debt will only be inflationary if it was taken that the generated seigniorage is through the issue of money.

The link between inflation and fiscal policy is the heart of the FTPL, which explains the role of fiscal policy in determining the price level and inflation. The FTPL is based on the intertemporal budget constraint of the government, whereby it sources funds in the asset market through the issue of new debts, tax revenues or creation of money. We start by considering a closed economy where the government issues money and one-period nominal debt. Therefore the flow of budget constraint of the government is given by:

$$M_t + B_t = (1 + i_{t-1})(M_{t-1} + B_{t-1}) + P_t(g_t - \tau_t) - i_{t-1}M_{t-1} \qquad \ldots\{4.1\}$$

Where, M_t is the nominal end-of-period money balances; B_t is the is the nominal end-of-period for bonds; i_{t-1} is the nominal interest rates that borrowers and lenders agreed on at the end of period *t-1*; P_t is the price level, g_t is the real government spending, and τ_t is lump-sum taxes.

Also according to Leeper (1991) and Sims (1994), given that '*y*' endowment units of consumption goods are received by a representative consumer, with $g < y$ purchased by the government; the consumer optimization rule will be:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \left[\log(c_t) + \log(m_t)\right]$$
$$c + \frac{D_t}{P_t} + \frac{M_t}{P_t} + \tau_t = y + \frac{M_{t-1}}{P_t} + i_{t-1}\frac{D_{t-1}}{P_t} \qquad \ldots\{4.2\}$$

According to David and Leeper (2009), on the side of the firm, if a continuum of monopolistically competitive firms use labour to produce goods, their production of good *j* will be:

$$y_{jt} = ZN_{jt} \qquad \ldots\{4.3\}$$

Where Z is total technology, which is assumed to be constant and is common across all firms.

Total demand of consumers and government will result in the following demand curve for firm *j*:

$$y_{jt} = \left(\frac{p_{jt}}{P_t}\right)^{-\theta} Y_t \qquad \ldots\{4.4\}$$

Where Y_t is $C_t + G_t = Y_t$

As discussed in the previous chapter, following Calvo (1983), the fraction of firms that are permitted to adjust their price is $1-\xi$, and the fraction that are not allowed to adjust, but keep their prices fixed is ξ. If firms are permitted to adjust their prices at time *t*, a new optimal price, p_t^*, will be chosen in order to maximize the expected discounted sum of profits as follows:

$$E_t \sum_{i=o}^{\infty} \xi^i q_{t,t+i} \left[\left(\frac{p_t^*}{P_{t+1}}\right)^{1-\theta} - s_{t+k}^{mc}\left(\frac{p_t^*}{P_{t+1}}\right)^{-\theta}\right] Y_{t+i} \qquad \ldots\{4.5\}$$

Where s^{mc} is the real marginal cost

If government's real primary surplus, s, and nominal government debt, *D*, which respectively includes seigniorage revenue and interest are written as:

$$s_t = \tau_t - g_t + \left(\frac{i_t}{1+i_t}\right)\frac{M_t}{P_t}$$

$$D_t = (1+i_t)B_t + M_t, \qquad \ldots\{4.6\}$$

then the government uses money creation, debt and direct lump-sum taxes in order to finance its constant level of purchases each period subject to the following budget constraint:

$$\frac{D_t}{P_t} + \frac{M_t}{P_t} + \tau_t = g + \frac{M_{t-1}}{P_t} + i_{t-1}\frac{D_{t-1}}{P_t} \qquad \ldots\{4.7\}$$

$$\lim_{T\to\infty} D_T \Pi_{t=0}^{T-1}\left(\frac{1}{1+i_t}\right) = 0$$

Therefore according to Leeper (1991), the government intertemporal budget constraint can be written as:

$$\frac{D_t}{P_t} = \sum_{t=0}^{\infty} s_t i_t \qquad \ldots\{4.8\}$$

Where $i_{j,t} = \Pi_j^t \pi_{t+j+1}\left(\frac{1}{1+r_{j-1}}\right) \qquad j \geq 0; \;\; i_{0,0} = 1$

$s_t = \tau_t - g_t + \frac{M_t - M_{t-1}}{P_t}$; π is inflation rate.

The intertemporal budget constraint of equation {4.7} is equivalently the equation for the FTPL. This equation states that the present value of the future government surpluses including seigniorage must be equal to the real value of initial debt. This budget constraint does not have to hold in equilibrium and if equilibrium exists, it does not have to be unique. However, according to Leeper (1991), the joint stance of monetary policy and fiscal policy is imperative in order to determine the existence and uniqueness of the equilibrium. Therefore, according to the assumption of FTPL, the government should be *non-Ricardian*. While a Ricardian policy is when the government budget constraint is satisfied with equality, a non-Ricardian policy occurs when the intertemporal budget constraint equilibrium is rejected. This means that in equations {4.7} and {4.8}, the present value of future government surpluses should thus be chosen such that it is independent of the real value of government debt while also independent of the initial price level.

Furthermore, while the nominal interest rate set by the monetary authority is determined by the current inflation (equation {4.9}), the level of outstanding real government debt, *d*, is determined when fiscal authority adjusts the direct lump-sum taxes (equation {4.10}). Therefore:

$$R_t = \alpha_0 + \alpha\pi_t + \theta$$
$$\theta_t = \rho_1\theta_{t-1} + \varepsilon_{1t} \qquad |\rho_1| \le 1, \qquad \varepsilon_{1t} \approx N\left(0, \sigma_1^2\right) \qquad \text{...\{4.9\}}$$

$$\tau_t = \gamma_0 + \gamma d_{t-1} + \psi_t$$
$$\psi_t = \rho_2\psi_{t-1} + \varepsilon_{2t} \qquad |\rho_2| \le 1, \qquad \varepsilon_{2t} \approx N\left(0, \sigma_2^2\right) \qquad \text{…\{4.10\}}$$

By substituting the policy rules and the consumer optimization problem into the government budget constraint; that is substituting equations {4.9}, {4.10} and {4.2} into equation {4.7}, we obtain:

$$\varphi_1\tilde{\pi}_t + \tilde{b}_t + \varphi_2\tilde{\pi}_{t-1} - \left(\beta^{-1} - \gamma\right)\tilde{b}_{t-1} + \varphi_3\theta_t + \psi_t + \varphi_4\theta_{t-1} = 0 \qquad \text{…\{4.11\}}$$

Where, $\varphi_1 = \dfrac{c}{(R-1)}\left[\dfrac{1}{\beta\pi} - \dfrac{\alpha}{(R-1)}\right] + \dfrac{b}{\beta\pi}$; $\varphi_2 = \dfrac{\alpha}{\pi}\left[\dfrac{c}{(R-1)^2} - b\right]$; $\varphi_3 = -\dfrac{c}{(R-1)^2}$ and

$$\varphi_4 = \frac{\varphi_2}{\alpha}$$

However, Gordon (1983) originally specified the triangle framework as:

$$p_t = a(L)\,p_{t-1} + b(L)D_t + c(L)z_t + e_t \qquad \text{… \{4.12\}}$$

The dependent variable, p_t, is the inflation rate. The three components are inertia, captured by the lags of the dependent variable, demand-side index, D_t, and the vector of supply shock variables, z_t; e_t is the serially uncorrelated error term. Lower cases are logarithms in differences and upper cases are logarithms in level, L is the lag operator.

Therefore, based on the FTPL, the major fiscal policy instruments are government expenditure and tax rates. This is such that while taxes and price levels are negatively correlated; government spending is positively correlated with prices (Kocherlakota and Phelan, 1999; Christiano and

Fitzgerald, 2000)[15]. According to Woodford (1995) the fiscal policy can affect inflation rate if the government follows n*on-Ricardian* fiscal policies. This is when the government budget constraint does not hold with equality; that is government spending does not necessarily have to equal its revenue obtained through taxes. Thus, Kocherlakota and Phelan (1999) concluded that it is not possible to follow both the fiscal theory and the monetary theory simultaneously.

Lastly, the structuralist is the third school of thought. It is also known as the cost-push or supply-side component. This school argued that there are more variables affecting inflation far beyond monetary aggregates because inflation dynamics also result from structural maladjustments. Some of the structural variables are world oil-price increases, actions of the trade unions, monopoly power, imposition of indirect taxes, and depreciation of national currencies to mention a few (Struthers, 1981; Silva, 2008). The major disagreement between the structuralist and the monetarist comes from the factors that cause the changes in inflation.

Even though the structuralists agree that monetary aggregates affect inflation, they argued that these are not the only drivers of inflation. The structuralists believed that both the monetary policies and fiscal policies are not enough to control inflation without aggravating unemployment and causing growth stagnation (Silva, 2008). Another major difference is that while the monetarists believed that causality runs from money supply to inflation, the structuralists argued that causality is from price inflation to money supply. The structuralists further argued that money supply is not active, but passive as it is led by changes in inflation.

This school of thought concluded that the supply-side effects, which result from increased costs of production, affect inflation. The school pointed out the three major origins of inflationary pressures; namely the pressures from the imbalances between the industrial sector and the agricultural sector, the pressures from the foreign trade sector and the pressures from the public sector (Lim and Papi, 1997; Silva, 2008). Gordon's triangular model only includes the demand-side variables as well as the structural variables, while the fiscal and the monetary variables were excluded.

[15] See also Ramsey (1927); Sargent and Wallace (1981).

The major differences between the triangle approach and the NKPC approach include the long lags in the dependent variable, extra lags on the demand-side factor, and the supply shock variables. This chapter considers the nested-Gordon's triangle model, by extending the original model beyond the inclusion of the structural variables; this was done by incorporating monetary policy and fiscal policy variables from equation {4.11}. The extended Gordon's triangular model adopted in this study is therefore the combination of equations {4.11} and {4.12}. Equation {4.11} includes the monetary and fiscal variables, while equation {4.12} includes the demand-side and the supply shock variables. The model is specified in the methodology section below (Equation {4.13}).

4.3 LITERATURE REVIEW

Empirical studies on the determinants of inflation dynamics in various countries are reviewed in this section. These studies modelled inflation by incorporating and comparing some of the different schools of thoughts discussed above. Very few studies focused mainly on the mainstream triangular model without necessarily comparing the schools of thoughts. Studies that compared the different schools of thoughts focused on the monetarist and the structuralist, while excluding the fiscalist theory. The empirical review is followed by some of the gaps identified in the literature.

4.3.1 Empirical review of literature on the determinants of Inflation

Successive studies emerged following the study by Gali and Gertler (1999) who estimated the new Keynesian Phillips curve, as discussed in the previous chapter. These studies proceeded to examine the nested Phillips curve by including different and additional variables on inflation dynamic models in different countries. Batini, Jackson and Nickell (2005) estimated the new Keynesian Phillips curve for the United Kingdom (U.K.), by nesting the baseline Gali and Gertler's model while including the structural factor commodity prices as one of the instrument. Batini *et.al* (2005) found that the labour share and real import prices have significant effects on current inflation. The real oil prices were also found to have a major impact on the U.K. inflation.

Furthermore, some of the studies that considered the effect of supply shock variable, specifically oil price, on inflation dynamics include Berument and Tasci (2002), Hahn (2003), LeBlanc and Chinn (2004), Swanepoel (2006) and Wesso, Visser and Mollentze (2007). Hahn (2003) found that oil price, exchange rate and non-oil import prices contributed largely to changes in inflation in the Euro area. Meanwhile, the study by LeBlanc and Chinn (2004) investigated the effects of oil price on inflation in five countries, namely, France, Germany, Japan, United States and the United Kingdom. Their results showed that oil price does not have any major effect on inflation in Japan, United States and the United Kingdom. But France and Germany showed a significant impact of oil price in inflation.

Gruen *et.al* (1999) carried out a study by improving upon the Phillips curve, in Australia. They investigated the distinction between the short-run and long-run trade-offs between inflation and unemployment. They also observed the problem of time-varying NAIRU, with import prices and 'speed-limit' effects to explain price and unit labour costs movements. Although, they found that strong output growth is inflationary in the short-run, their study showed no trade-off in the long-run between inflation and unemployment.

Manera and Cologni (2005) investigated the effect of international oil prices on domestic inflation and overall economic activity for G-7 countries using impulse response function technique. They found that while the effect of a shock in oil prices leads to an increase in interest rates in Japan and Italy, it leads to a fall in interest rates in the other countries. The fall in interest rates in the other countries was seen as contradicting the fact that monetary policy is directed to fighting inflation as a result of a shock in oil price. Their study found that oil price affects the interest rate directly, and indirectly targeting inflation. They also found that in all the countries except Japan, the effect of a shock in oil price did not immediately lead to an increase in inflation at least in the first two quarters.

According to Gordon (2011), the triangle model is nested in the NKPC model. Gordon observed that very few studies have been carried out to examine and compare the NKPC model[16] and the inertia-bound triangular model. Gordon compared the two models in order to observe the model that gives a better empirical explanation of the postwar US inflation. The results obtained showed that the triangle approach with the combination of the inertia, demand-side and supply shock is the better model (Gordon, 2011). The comparison was based on the sum of squares residual (SSR) of the standard measure of goodness of fit.

The slope estimate of the NKPC was found to be biased towards zero because the model omitted the supply shock variables. The Gordon's triangle model outperformed the NKPC in terms of the rejection of the tests of exclusion and specification error due to the omission of supply shocks in the NKPC model. The triangle model showed that the inclusion of supply shock variables, with a long lag on the dependent variable (inflation) is important in specifying a Phillips curve model. Gordon therefore concluded that the NKPC model was an empirical failure as it applied to the US data.

Durevall and Ndung'u (1999) modeled a simple inflation dynamics for Kenya, using a single-equation error correction model (ECM). The study was to differentiate between the short-run and the long-run effects of each of the explanatory variables on inflation. They improved upon previous studies through data extension spanning over the period 1972:Q1 to 1996:Q4. They included, among other variables, the terms of trade (TOT) and maize-price inflation because maize is a staple crop in Kenya. Co-integrating vectors were found from using the Johasen maximum likelihood procedure and the model stability was tested using the recursive estimation.

Similar approach was adopted by Ocran (2007) to determine the long-run and short-run effects of some explanatory variables on inflation dynamics in Ghana. While the results obtained by Durevall and Ndung'u (1999) showed that maize price and money supply had short-run effects on inflation, Ocran (2007) found money growth, interest rates and exchange rates to be significant, also in the short-run. However, both studies found foreign price, exchange rate and

[16] The traditional PC model only considers the inertia and omits the supply shock variables. The NKPC omits inertia and the supply shocks, but includes the expected inflation, while the HNKPC omits only the supply shocks.

TOT affecting inflation in the long-run. These studies therefore showed that the inflation dynamics in Kenya and Ghana are caused by both the structural and monetary factors. Neither of these studies considered the inflation inertia.

In Mali, Diouf (2007) investigated the determinants of inflation using quarterly data ranging from 1979Q1 to 2006Q1 and adopted a single-equation model of error-correction mechanism. Using the co-integration techniques and general-to-specific methods of Ordinary Least Squares (OLS), the study tested the monetarist theory and the structuralist theory of inflation. According to Diouf, the monetarists' stance is that inflation is a monetary phenomenon whereby expansionary fiscal and monetary policies affect inflation. The structuralists believed that the supply-side effects, resulting from increased costs of production, affect inflation[17].

In addition, a variable of interest that was used to capture the supply-side constraint was cereal production; this was used as a proxy for rainfall. The result obtained showed that inflation in Mali is driven by both the demand and supply sides. The results further showed that while real income, exchange rates and the deposit rates all have positive effects on inflation in the short-run, increased discount rates have deflationary effect. The decrease in the supply-side was found to be inflationary, whereby a fall in the average national rainfall caused a significant rise in inflation. The hypothesized negative relationship was therefore obtained.

Furthermore, Kabundi (2012) used a single-equation error correction model (ECM) to determine the main drivers of inflation in Uganda using monthly data over the period January 1999 to October 2011. Kabundi considered the external factors, internal factors and accommodative policy in determining the inflation dynamics. The external factors included world food and world energy prices. The internal factors referred to domestic variables such as domestic non-food, food, and energy prices (this is also the supply-side constraint). The accommodative policies refer to the monetary aggregates.

[17] The monetarist theory focused on the monetary sector while the structuralist theory is the external sector. Fiscal policy is the same as the demand-side, according to Diouf (2007).

Like Diouf (2007), Kabundi's main addition to previous studies was the inclusion of the agricultural shock as measured by the production of cereal; this is the supply side effect. Kabundi (2012) highlighted some of the advantages of using a single-equation ECM over the structural vector autoregressive (SVAR) model. The advantages include the insensitiveness of ECM to the degree of freedom, as well as its ability to incorporate both the long-run equilibrium relationship and short-term dynamics of inflation process. However, the choice of technique depends on what the study aims to achieve. The results obtained showed that all the determinants of inflation namely, external and internal factors as well as the accommodative policy have lasting effects on inflation dynamics in Uganda. Another variable of interest was the inflation inertia, and this was also found to be significant.

Melitz (2002) estimated the reaction functions of the monetary and fiscal policy authorities on nineteen Organisation for Economic Co-Operation and Development (OECD) countries, using annual data spanning over the period 1960 to 1995. The study found that these two policies move in opposite directions. However, Favero and Monacelli (2003) found the evidence of a fiscal dominance in the US during the period 1960 to 1987, supporting Cochrane (1998) who argued that the fiscal theory of price level determination was dominant in the US from 1960. Meanwhile, other studies found that US economy was rather dominated by monetary policy regime (Creel and Sterdyniak, 2002; Coanzoneri, Cumby and Diba, 2001; and Bohn, 1998). Javid and Arif (2014) could not find a clear determinant of inflation process whether is it monetary or fiscal policy dominating for Pakistan over the period 1960 to 2009. While they found that the discount rate responded negatively to inflation rate, thus, confirming the fiscal policy regime; the monetary policy regime was also confirmed when they found an inverse relationship between money growth and inflation rate.

Meanwhile, the study by Akinboade, Niedermeier and Siebrits (2002) examined the determinants of inflation using the monetarist and the structuralist approaches. They concentrated on the extent and importance of the pass-through of changes in exchange rate and foreign prices on domestic inflation in South Africa. They adopted the structural vector autoregressive (SVAR) and the impulse response functions (IRF) approaches using quarterly data over the period

1970Q1 to 2000Q2. They also captured the effects of structural breaks of the debt standstill in 1985; 1987 global stock market crash and the Asian crisis in 1998. They found that the inflation dynamics in South Africa followed mainly the structuralist approach, with a limited effect of the monetarist approach. The coefficient of the money supply variable was found to be significant, with the correct hypothesized positive sign. The nominal interest rate had a negative effect on the domestic prices in the short run, whereby a sharp increase in the nominal interest rate causes a fall in inflation, up until the fifth quarter.

Swanepoel (2006) investigated the effects of international economic developments on the South African economy using graphs, correlation matrix and VAR. The study considered how different international economic conditions of oil price, exchange rate, and trade openness affect the local prices and economic growth. The result shows a correlation coefficient of about 0.3 between inflation and oil price. The study reported that the oil price shock of 2004 was considerably smaller than those experienced in 1973, 1979, 1990 and 1999. The percentage change in real rand price of oil in 1973 was 263.7; 1979 was 23.2; 1999 was 70.6 and 2004 was 11.1. The study also found that although there is a positive relationship between inflation rate and oil prices in South Africa, using the impulse-response function technique, this was not significant. The study however found a positive relationship between the annual changes in real rand oil price and economic growth. The study therefore suggested the validation of the results through the use of more rigorous econometric investigations.

Moreover, the study by Steinbach, Mathuloe and Smit (2009) estimated an open economy New Keynesian model for South Africa by observing the pass-through of changes in exchange rate to the prices of imported goods and ultimately to the consumer price index, using quarterly data. Several domestic and international macroeconomic time-series variables were also included. The results showed that there exists a positive relationship between inflation and GDP. The same positive relationship was observed by Alpanda, Kotze and Woglom (2010) for South Africa using Bayesian techniques. However, Gumata, Kabundi and Ndou (2013) explored different transmission mechanisms for South Africa, using Large Bayesian Vector Autoregressive (LBVAR), variance decomposition (VD) and impulse-response function (IRF) models and found

that although all the channels are relevant, the interest rate channel appeared to be the most important channel of transmission mechanism.

Along the same line as Diouf (2007), Adusei (2013) used a single-equation of ECM to observe whether the inflation dynamics in South Africa follow a monetarist or structuralist phenomenon. Adusei (2013) re-examined this relationship as investigated by Akinboade *et.al* (2002) but using a Fully Modified Ordinary Least Squares (FMOLS) and Granger causality test techniques. While Akinboade *et.al* (2002) used quarterly data, Adusei (2013) adopted annual time series data spanning over the period 1965 to 2006. The variables considered to capture the structural effects are the openness of South African economy and the size of government. This size of government was proxied by the ratio of government spending to gross domestic product (GDP). The variables that were used to examine the possible effect of the monetarist component are money supply and nominal interest rate. Adusei also incorporated the effects of the 1987 global stock market crash as well as the end of apartheid system in 1994 through the inclusion of dummy variables.

However, the study by Adusei found the presence of the effects of both schools of thoughts, namely the monetarist and the structuralist, in determining the inflation dynamics in South Africa. Some of the variables did not have the hypothesized signs, or were insignificant, especially in the long-run when the effects of the structural breaks were taken into account. The results showed that while increased trade openness worsens inflation, nominal interest rate was found not to be significant both in the short- and long-runs. GDP had a positive relationship and money supply was found to be negatively related to inflation. The causality test result showed that GDP Granger causes (or leads) inflation and on the other hand inflation Granger causes money supply. These however showed conflicting results to Akinboade *et.al* (2002).

The studies that examined whether the Gordon's triangular model is applicable to South Africa are by Burger and Marinkov (2006) and Malikane (2013). Burger and Marinkov examined the existence of Gordon's triangle through inflation inertia, output level effects and the rates of change effects. Malikane estimated the cost-based new Keynesian triangle Phillips curve using

the marginal cost variable for six developed and six emerging countries including South Africa. The purpose of Malikane's study was to observe the negative sign of the marginal cost variable, measured by output gap. Burger and Marinkov considered the split output gap in order to incorporate the non-linear Phillips curve.

While one of the split output gaps captured the period when the economy overheats, the other was for the period when the economy was weak. They used quarterly data over the period 1976Q1 and 2002Q2, adopting the error correction model (ECM). Malikane also adopted quarterly data from 1975Q1 to 2012Q2 for developed countries and from 1995Q1 to 2012Q2 for emerging economies, using GMM and 2SLS techniques. As suggested by Gordon (2013)[18], the inclusion of the current period excess demand and the lags (or the change) of excess demand, are necessary in the inflation model. Burger and Marinkov (2006) included both the lags and the changes in the level of output gap overtime, and not the current levels of output gap, in their model. They concluded that the triangular model was not applicable to South Africa because the existence of the model means that the inflation inertia, output level effects and the rates of change effects should be present.

The effect of the output level was not evident; this means that the demand-side does not have any effect on the inflation dynamics, whereas inflation inertia was significant and existing. However, Malikane found that the output gap variable, which captures the demand-side, is positively related to inflation. This is contrary to Burger and Marinkov's results but in line with the Adusei (2013) who also found a positive relationship between the demand-side and inflation. Malikane's results further showed that the supply shock variables are significant and important in the empirical validity of the marginal cost Phillips curve. Hence, the results gave reliable parameters of the Gordon's triangular PC model. The study therefore concluded that for the Phillips curve to exist, more inflation lags as well as the introduction of supply shock variables should be considered.

[18] See also Gordon (1977) and Gordon (1997).

Meanwhile, Burger and Marinkov (2006) found that the demand side, as shown by the output level, was not significant; while the supply side, captured by the unit labour cost and the terms of trade variables, were quite significant. The significant supply shock variables were also found in Malikane's study. The results obtained by Burger and Marinkov were the same as the findings of Akinboade, *et.al* (2002). Burger and Marinkov found that Gordon's triangle does not exist in South Africa. This is because inflation dynamics is not demand-driven, it is structural. Akinboade, *et.al* also found that inflation is largely determined by the structural variables. Burger and Marinkov performed a stability test and the model was found to be stable. Nevertheless, the study omitted testing for the possible effects of structural changes that could have affected the result, observing the length of the data used.

4.3.2 Literature Gap

The studies reviewed above observed the effects of different schools of thought earlier discussed in determining inflation dynamics in various countries. Very few of the studies focused on the Gordon's triangle model; depicting that the Gordon's model in itself is also not sufficient in explaining the inflation dynamics. But again, none of the studies in South Africa estimated the triangular nested model of Gordon by explicitly including all the three schools of thought, in determining inflation dynamics. Based on the reviewed literature, firstly, different studies reached different conclusions; hence conflicting results were obtained, in the case of South Africa. This therefore necessitates a further investigation on the drivers of inflation in South Africa, using various sets of explanatory variables.

Secondly, according to our knowledge, there is no study that considered the inclusion of the effect of the fiscal factors in determining inflation dynamics in South Africa; thereby considering the fiscal theory of price level. It is important to investigate whether fiscal variables, along with other factors contribute to inflation dynamics in South Africa. This is important because it will make policymakers aware of the factors that drive inflation in the country and focus on these factors in order to combat inflation. Thus, this study estimated the extended Gordon's triangle by exploring the group of factors that caused changes in inflation, not only considering the effects of supply-shock variables, but also by incorporating all the three different schools of thought. The

reason for the extended model is that the Gordon's triangle model is not sufficient to capture all the factors that could possibly cause changes in inflation as it excludes the monetarist and the fiscal variables.

The Gordon's triangular model considers the inflation inertia, demand-side and supply-side shocks. This means that the monetarist and the fiscal components are excluded in this model. However, since this chapter is a nested Gordon's triangular model, it therefore focused on the model that includes the demand-side variables, the fiscal variables, supply-shock (the structural) variables and the monetary variables and not follow strictly the variable definitions of Gordon. The importance of such extended model is to be able to observe the applicability of the different schools of thought to inflation dynamics in South Africa. This will thus assist policy makers to decide the best way to combat inflation after being cognisant of the factors that determine inflation as well as those that contribute more to inflation dynamics. Lastly, advanced econometric techniques and available current data series that were used, compared to previous studies, are additions to literature.

4.4 DATA AND METHODOLOGY

4.4.1 Model Specification

The extended Gordon's triangle model is a nested model based on equations {4.11} and {4.12} and it is specified as follows:

$$\bar{\pi}_t = f(DS_t, F_t, Z_t, M_t, D_IT, D_FC) \quad \ldots \{4.13\}$$

$$D_IT = \begin{cases} 1 & Inflation \quad t\arg eting \quad period \quad from \quad 2000 \\ 0 & otherwise \end{cases}$$

$$D_FC = \begin{cases} 1 & Financial \quad Crisis \quad in \quad 2008-2011 \\ 0 & otherwise \end{cases}$$

Where the dependent variable, $\bar{\pi}_t$, is the inflation rate obtained from the consumer price index (CPI); DS_t is the set of demand-side variables; F_t is the fiscal variable; Z_t, captures the supply shock variable components; these are also the structural variables. M_t is the monetary factor. The two dummy variables, D_IT and D_FC, are introduced in the model, as in chapter 3. While D_IT

captures the period of the adoption of inflation targeting framework, D_FC is dummy variable which is associated with the effects of the periods of the financial crisis. In order to test for robustness and thus confirm the consistency and reliability of the result, different sets of variables were used to proxy demand side, monetary policy and structural variables. Two sets of quarterly data were also adopted, making a total of four models (two models each per quarterly data series for output growth-inflation model and output gap-inflation model).

Quarterly data spanning over the period 2002Q1 to 2014Q2 and 1995Q4 to 2014Q1 were used, making 50 and 74 sufficiently long data points respectively. The demand-side variables are the output growth, $\bar{y}_t$; and the output gap, $y_{gap(t)}$. The variable that captures the fiscal component is the ratio of fiscal deficit to the gross domestic product (GDP), GD_t. The supply shock variables that were considered are the oil price (measured in local currency, Rand), $OILP_t$, the exchange rate[19], EXR_t and electricity prices, $ELECT_t$. The monetary variables are growth rate of money measured as the rate of growth of M2, MSG_t, short-term interest rates using money market rate, MMR_t and Treasury bill rate, TBR_t.

The parameters of fiscal variable, external or structural variables and money supply growth in equation 4.10 are theoretically expected to be positively related to inflation. That is, increases in fiscal deficit, oil price, exchange rate, electricity price and money supply are expected to generate inflationary pressures in the economy. The sign expected for the existence of Phillips curve for the output growth variable, y_t, is positive while the expected sign for output gap variable, $y_{gap(t)}$, is negative. These parameters are theoretically expected to have respectively positive and inverse relationships with inflation in order for Phillips curve trade-off to exist. This means that for instance, in order to have increases in output growth, the economy should be prepared to forgo decreased inflation and vice versa (Hodge, 2006).

[19] The nominal exchange rate was used in order to avoid the problem of collinearity. This is because the real exchange rate is deflated by the same inflation rate which is the dependent variable. Thus, in order to avoid inconsistency, inflation rate is maintained as the dependent variable as in chapter 3.

Likewise, a country willing to have lower inflation rate will also experience increases in output gap[20]. Inflation rate will decline, if output gap increases; thus, increased inefficiencies at an increasing rate will cause inflation rate to fall; this is the trade-off. The short-term interest rates are expected to be negatively related to inflation. The expected signs for the coefficients of the inflation target and financial crisis dummy variables are respectively negative and positive.

4.4.2 Variable descriptions and data sources

This chapter estimated the extended Gordon's triangle model for South Africa by considering the effects of demand-side, fiscal variables, structural variables and the monetary variables on inflation rate. The fiscal variable is the ratio of government deficit to GDP. The tax rates could not be included due to short span of the available data. Besides, the inclusion of deficit has incorporated the effects of government spending and revenues (taxes).The major source of government revenue in South African is via different types of taxes; namely, gross tax revenue, non-tax revenue and SACU transfer. But over the past fiscal years (2004/2005 to 2011/2012), government expenditure has been higher than total revenues. This implies that some expenses were financed through borrowing and hence there was a budget deficit (Budget Review, 2013). Further budget deficit was also experienced in the following fiscal years (Budget Review, 2016). Since the global financial crisis of 2008, revenue has not recovered and the budget deficit has been increasing. The budget deficit is also estimated to continue up until the 2015/2016 fiscal year (Budget Review, 2013).

The demand-side variables considered are output gap and output growth. Since increase in output gap is an indication of increased actual output (GDP) or lower potential GDP, output gap moves in the same direction as the actual output and in opposite direction as potential output. There are different ways of measuring output gap, but this study adopted the method used by Fedderke and Schaling (2005), using the Hodrick-Prescott (HP) filter to obtain the potential output. Although, there are problems associated with obtaining the potential output, hence this study used output growth as another measure of demand side variable in order to affirm the results that were obtained from output gap.

[20] Increased output gap means that inefficiency increases at an increasing rate.

The common belief according to the Classical school of thought is that there exists a negative relationship between inflation and output growth, whereby in order to have low inflation rate, high output growth is needed or vice versa (Gokal and Hanif, 2004). However, following the Keynesian idea of the Phillips curve trade-off, in order to reduce inflation rate and keep it at that level, some amount of output growth needed to be sacrificed (Hodge, 2006). In the PC trade-off theory, there exists a positive (and significant) relationship between inflation rate and output growth. Hence, in order to observe if the PC trade-off exists, the relationship between these variables should be positive, whereby as output growth increases, inflation rate is expected to also increase.

On the other hand, output gap can be either positive or negative and neither is ideal. This is because while a positive output gap shows that an economy operates at an inefficient rate by overworking its resources, a negative output gap on the other hand equally shows inefficiency of an economy by under-utilizing its resources (Jahan and Mahmud, 2013). The theoretical explanation of the relationship between inflation and output gap, without considering the trade-off, is that, a positive output gap indicates that demand and inflationary pressures are building up; that is increased output gap leads to an increase in inflation. Likewise a real output below its potential, negative output gap, is deflationary (Fuentes, Gredig and Larraín, 2007). This indicates a positive relationship between inflation and output gap. Meanwhile, based on the trade-off theory, output gap is expected to be negatively related to inflation.

In capturing the effects of monetary variables on inflation rate, this chapter considered the growth rate of money supply and interest rates. Given an increase in money supply, spending will increase, and this will translate into higher inflation rate. The short-term lending rate, repurchase rate (repo rate), set by the South African Reserve Bank (SARB) influences other types of interest rates. Thus, the repo rate is proxied by the money market rate and the Treasury bill rate; these variables have the same trend. The structural variables are oil-price and exchange rate.

The variable, oil price, is important in determining inflation dynamics as a result of the recent increases in the international oil prices, which tend to affect domestic prices. Increases in the international oil prices led to the transference of income to the exporting countries as a result of a shift in the terms of trade. This results in a fall in the real national income of the importing country, coupled with increased cost of production and transport costs. The effect of the increase in oil price further affects the real wage as a result of increased domestic prices. The magnitude of this effect depends on the degree of dependence and oil price elasticity of demand of the importing country (Nkomo, 2006).

Furthermore, the exchange rate variable is included as a structural variable in order to observe the exchange rate movement, following the structuralist's school of thought as earlier highlighted. Also, since exchange rate plays a major role in open economies, such as South Africa, it can thus be targeted by the Reserve Bank. A fall in exchange rate indicates a strong value of the Rand, which is an appreciation of the local currency. An appreciation of the Rand means that more foreign exchange can be bought with Rand, imports will be cheaper and hence the volume of imports will increase while exports will be more expensive and thus decline in volume.

The effect of a change in exchange rate on imports and exports can be explained using the cost-push and demand-pull inflation respectively. A decline in exchange rate (an appreciation of the Rand) will lead to an increase in imports, as a result of a fall in the cost of imports. This will cause the demand for dollars to increase since it is cheaper to buy from abroad. The fall in the cost of production leads to a decrease in the domestic inflation and vice versa as a result of cost-push inflation.

On the other hand, since South African exports are now more expensive, as a result of the appreciation of the Rand, there will be less demand for them. This results in decreased export earnings and income, thus leading to a decline in the net exports and a decline in aggregate demand which then leads to a fall in domestic prices; this is the demand-pull inflation. The opposite is true for the increase in exchange rate (a depreciation of Rand) which leads to

increased domestic prices. The trend in the selected fiscal, monetary and structural variables against inflation is not clear over the period considered (figure 4.1). While there is a co-movement between inflation and government deficit in some periods, the trend in other periods is quite unclear. The movement in inflation and money market is relatively clear, depicting negative and sometimes positive relationship. The trend in inflation and the demand-side variables is reported in the previous chapter.

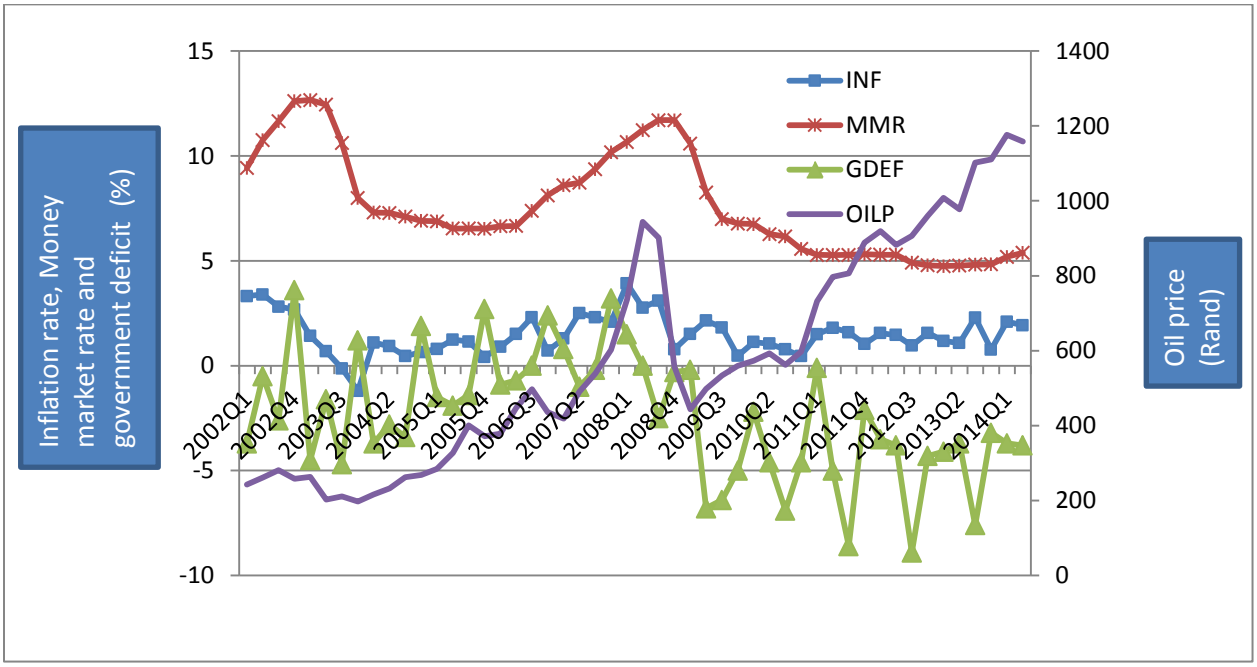

Figure 4.1: Quarterly inflation rate, fiscal, monetary and structural components: 2002 to 2014.

Source: Author's calculation from IMF and SARB online database.

The choice of output gap, money supply, interest rates and exchange rate are in line with previous studies on different countries (Chhibber, *et.al* 1989; Akinboade, *et.al*, 2002; Fatukasi, 2006; Wesso *et.al*, 2007; Olubusoye and Oyaromade, 2008; Adusei, 2013; Malikane, 2013). Furthermore, since empirical studies on inflation dynamics in South Africa ended in the early 2000s, this study therefore considered data extension, incorporating changes that could have occurred since then, for instance, the financial crisis of 2008. Table 4.1 presents the variables used in this study as well as their definitions and sources.

Table 4.1: Variables and their definitions for extended Gordon's triangular model

Variable	Variable definition	Source
Inflation, $\overline{\pi}_t$	Inflation rate derived from the consumer price index (2010 prices).	IMF/ IFS
Dummy variable, D_IT	Dummy variable captures the implementation of the adoption of inflation targeting in 2000.	
Dummy variable, D_FC	Dummy variable to capture the period of global financial crisis, 2008 to 2011.	
	Demand side variables	
Output growth, $\overline{y}_t$	Growth rate of real GDP (measured in %).	IMF/ IFS
Output gap y_{gap}	The difference between the actual, y_t^*, and potential output, $\hat{y}_t$, using the Hodrick Prescott (HP) trend $\Delta y = y_{gap} = y_t^* - \hat{y}_t$	Computed from GDP obtained from IMF/ IFS
	Fiscal variable	
Government deficit, *GD*	The ratio of national government deficit/surplus to GDP; this is the fiscal deficit/surplus as a percentage of GDP (measured in %).	SARB online database 2015
	Structural variables (External Shocks)	
Oil price, $OILP$	The price of crude oil per barrel (measured in local currency, Rand).	SARB online database 2015
Exchange Rate, *EXR*	Nominal effective exchange rate, (measured as a percentage change).	IMF/ IFS
Electricity price, ELECT	Electricity price index (2008 prices)	Quantec Quarterly
	Monetary variables	
Money supply growth, *MSG*	The rate of growth of money, M2 millions of Rands (measured in %).	IMF/ IFS
Interest rates, MMR and TBR	This is the short-term interest rate (measured in %)	IMF/ IFS

IMF/IFS is the International Financial Statistics of the International Monetary Fund; SARB is the South African Reserve Bank.

4.4.3 Estimation Methodology

According to Johansen and Juselius (1990) and Hjalmarsson and Osterholm (2007) economic time series are generally non-stationary processes, but in order to determine the applicable technique, the nature of the variables was examined by performing the stationarity test (Table A4.1 of Appendix A) and observing the order of integration. Since the variables are integrated of different orders, further test is to examine whether they move together in the long-run or not using the co-integration test. Hjalmarsson and Osterholm (2007) pointed out that although it is typically believed that Johansen methodology is used when all the variables in the system are integrated of order one I(1), having stationary variables is theoretically acceptable, and that hence Johansen (1995) stated that the pre-test of the variables in order to establish the order of integration is of little or no concern.

Hjalmarsson and Osterholm (2007) further stated that the single variable that is I(0) will reveal itself through the cointegrating vector; this shows that the inclusion of one I(0) variable along with other I(1) variables is acceptable in the cointegration model. Meanwhile in the study by Burger and Marinkov (2006), there was only one I(1) variable and therefore had to be excluded from the model. They indicated that at least two series of a higher order of integration can be included in the long-run as explanatory variables, using Johansen technique, provided that the combination of the two series is integrated of lower order. Therefore, since there is no other I(1) variable with which the I(1) variable that they obtained could break down to I(0), they excluded it. However, in this chapter, there is more than one I(1) variables, and the Johansen technique can be applied to all the variables and the study can proceed to the dynamic model if cointegration is found.

As carried out in the study by Fedderke and Schaling (2005), the variable integrated of order zero, I(0), was included directly in the dynamic (or error correction) model, along with the I(1) variables and the chosen dummy variables that captured structural economic changes. Thus, this study also included all the variables, as they are mixed orders of integration, along with the dummy variables, in the dynamic model. The method of co-integration and vector error correction model (VECM) will provide the long-run relationship along with the individual

effects and the short-run adjustment back to equilibrium of inflation rate. The estimation procedure is as follows: the VAR in its reduced-form is first estimated and the diagnostic tests are performed; this is followed by the test of cointegration and the identification of the cointegrating vectors. Thirdly, the vector error correction model will be estimated followed by the diagnostic tests.

4.4.3.1 Vector Autoregressive (VAR) technique

If the variables are non-stationary and not co-integrated, then the VAR can be written and estimated entirely in its first difference, but the first difference VAR is not applicable when the variables are non-stationary and co-integrated (Ender, 2004:287, 358). All the variables in a VAR system are assumed to be endogenous; where the system treats each variable as being determined by the other variables; this technique was proposed by Sims (1980). The purpose of a VAR is not to interpret the estimated parameters but to determine the logical association or the interrelationship between the variables (Enders, 2004:270). In a univariate autoregressive equation the lagged values of a variable explains its current value. However, in order to capture the dynamic nature of multiple time-series and obtain reliable policy analysis, a VAR is a more appropriate technique as it performs better than the single-equation technique.

The multivariate linear simultaneous VAR system, for output growth[21], is written as:

$$\bar{\pi}_t = \alpha_0 + \sum_{i=1}^{n1} \alpha_{1t} \bar{\pi}_{t-i} + \sum_{t=1}^{n2} \alpha_{2t} \bar{y}_{t-i} + \sum_{i=1}^{n3} \alpha_{3t} GD_{t-i} + \sum_{i=1}^{n4} \alpha_{4t} OILP_{t-i} + \sum_{i=1}^{n5} \alpha_{5t} ELECT_{t-i} + \sum_{i=1}^{n6} \alpha_{6t} MMR_{t-i} + \alpha_7 D_IT + \alpha_8 D_FC + \mu_t$$

$$\bar{y}_t = \alpha_0 + \sum_{i=1}^{n1} \alpha_{1t} \bar{\pi}_{t-i} + \sum_{t=1}^{n2} \alpha_{2t} \bar{y}_{t-i} + \sum_{i=1}^{n3} \alpha_{3t} GD_{t-i} + \sum_{i=1}^{n4} \alpha_{4t} OILP_{t-i} + \sum_{i=1}^{n5} \alpha_{5t} ELECT_{t-i} + \sum_{i=1}^{n6} \alpha_{6t} MMR_{t-i} + \alpha_7 D_IT + \alpha_8 D_FC + \mu_t$$

$$GD_t = \alpha_0 + \sum_{i=1}^{n1} \alpha_{1t} \bar{\pi}_{t-i} + \sum_{t=1}^{n2} \alpha_{2t} \bar{y}_{t-i} + \sum_{i=1}^{n3} \alpha_{3t} GD_{t-i} + \sum_{i=1}^{n4} \alpha_{4t} OILP_{t-i} + \sum_{i=1}^{n5} \alpha_{5t} ELECT_{t-i} + \sum_{i=1}^{n6} \alpha_{6t} MMR_{t-i} + \alpha_7 D_IT + \alpha_8 D_FC + \mu_t$$

$$OILP_t = \alpha_0 + \sum_{i=1}^{n1} \alpha_{1t} \bar{\pi}_{t-i} + \sum_{t=1}^{n2} \alpha_{2t} \bar{y}_{t-i} + \sum_{i=1}^{n3} \alpha_{3t} GD_{t-i} + \sum_{i=1}^{n4} \alpha_{4t} OILP_{t-i} + \sum_{i=1}^{n5} \alpha_{5t} ELECT_{t-i} + \sum_{i=1}^{n6} \alpha_{6t} MMR_{t-i} + \alpha_t D_IT + \alpha_8 D_FC + \mu_t$$

$$ELECT_t = \alpha_0 + \sum_{i=1}^{n1} \alpha_{1t} \bar{\pi}_{t-i} + \sum_{t=1}^{n2} \alpha_{2t} \bar{y}_{t-i} + \sum_{i=1}^{n3} \alpha_{3t} GD_{t-i} + \sum_{i=1}^{n4} \alpha_{4t} OILP_{t-i} + \sum_{i=1}^{n5} \alpha_{5t} ELECT_{t-i} + \sum_{i=1}^{n6} \alpha_{6t} MMR_{t-i} + \alpha_7 D_IT + \alpha_8 D_FC + \mu_t$$

$$MMR_t = \alpha_0 + \sum_{i=1}^{n1} \alpha_{1t} \bar{\pi}_{t-i} + \sum_{t=1}^{n2} \alpha_{2t} \bar{y}_{t-i} + \sum_{i=1}^{n3} \alpha_{3t} GD_{t-i} + \sum_{i=1}^{n4} \alpha_{4t} OILP_{t-i} + \sum_{i=1}^{n5} \alpha_{5t} ELECT_{t-i} + \sum_{i=1}^{n6} \alpha_{6t} MMR_{t-i} + \alpha_t D_IT + \alpha_8 D_FC + \mu_t$$

… {4.14}

[21] The same model can be used for output gap, where the demand-side variable, output gap, replaces the output growth. Since this is an extended model, the constant term is included, in order to capture the effect of all other variables that could possibly affect inflation rate.

It is important to note that the underlying critical values of a VAR change depending on the number of dummies included. However, the dummy variables, D_IT and D_FC, will also be included in the vector error correction model if cointegration exists. Each of the variables in the VAR system is endogenous, except for the constant term. The focus of this chapter is to explore the effects of each variable in the first model of equation 4.14 on inflation. Equation 4.14 can thus be written in its reduced-form as shown below:

$$\overline{W_t} = \alpha_0 + a(L)\,p_t + b(L)DS_t + c(L)F_t + d(L)Z_t + e(L)M_t + \varepsilon_t \qquad \ldots\{4.15\}$$

Where $\overline{W_t}$ is the vector of dependent variables; L is the lag operator; p_t is the vector of lagged inflation variable; DS_t is the vector of lagged demand-side variables; F_t is the vector of lagged fiscal variable; Z_t is the vector of lagged supply shock variables; M_t is the vector of lagged monetary variable; and ε_t is the vector of error terms.

A VAR requires that all the variables be stable[22] (stationary) in order to have reliable results. The lag length is first determined using the Akaike information criterion (AIC), and the stability test is performed. If the VAR is found not to be stationary, a differenced VAR can be estimated. The variables could be written and estimated entirely in its first difference, but Sims (1980) and Sims, Stock and Watson (1990) advised against estimating VAR in its differenced form. This is because such VAR will only invalidate the goal of the technique in determining the interdependence of each variable.

The diagnostic tests have to be satisfied in order to have reliable, stable and valid results. Stability of the VAR roots is the main diagnostic test that has to be passed before continuing the estimation. If the VAR is not stable (nonstationary), results such as the impulse response and the variance decomposition will be invalid. Other diagnostics tests included normality, autocorrelation and heteroskedasticity. The reason for adopting a VAR technique[23] in this

[22] The test for stationarity of a VAR is different from the stationarity tests for variables in single equation models. A VAR is said to be stationary, when all its roots lie within the unit circle; this is also known as the stability of a VAR.

[23] A factor-augmented vector autoregression (FAVAR), which uses numerous variables to capture both the unobserved variables and observed factors, is an alternative approach, but this study has a limited number of variables, hence VAR is still applicable, with valid and reliable results.

chapter is to observe the results that were obtained compared to the single equation model of the previous chapter.

4.4.3.2 Co-integration technique

This chapter adopts the Johansen co-integration approach for all the variables, given that there is at least one variable that is integrated of order one, I(1)[24]. Given a full rank, *n*, and a reduced rank, *r*, the maximum number of co-integrating equations that can be obtained is $r \leq (n-1)$. There were two common likelihood ratio (LR) test statistics of co-integration which were used to determine the number of co-integrating equation in the models considered. These test statistics, as proposed by Johansen (1988), are the trace statistic (λ_{trace}) and the maximum eigenvalues statistic (λ_{max}). Their respective test statistics are:

$$\lambda_{trace} = -T \sum_{i=r+1}^{n} \log(1-\hat{\lambda}_i) \quad \ldots \{4.16\}$$

$$\lambda_{\max} = -T \log(1-\hat{\lambda}_{r+1}) \quad \ldots \{4.17\}$$

The above two tests were conducted under a sequential null hypothesis of $r = 0$, then $r = 1$ and then $r = 2$ and so on. This continued until we failed to reject the null hypothesis, using the p-value. If the results of the two statistics are conflicting, the maximum eigenvalue result would then be chosen. This is because this statistic has a sharper alternative hypothesis and usually pins down the exact number of cointegrating vectors (Enders, 2004:354; Akanbi, 2012).

The use of Johansen technique is more appropriate because this is a multivariate simultaneous equation and not a single equation model. Besides, given a simultaneous model, there is a likelihood of more than one cointegrating vector and Johansen technique is the suitable technique to provide such result. Thus, the applicable technique is Johansen as it tests the cointegration among all the variables.

[24] The inclusion of stationary variables, I(0), in Johansen test of cointegration might increase the number of cointegrating vectors; otherwise, including all the variables (all I(0) and I(1) variables) is equally acceptable.

4.4.3.3 Vector Error Correction Mechanism (VECM)

According to Enders (2004:372), the variables that are cointegrated share the same stochastic trends and can therefore not drift far apart. These variables also have an error correction representation, such that each of the variables will respond to the deviation from the "long-run equilibrium". Therefore if cointegration was found, the study would proceed to estimate the vector error correction model (VECM) in order to obtain the adjustments of each variable to long-run equilibrium. This technique gives the short-run and long-run coefficients, as well as the rate of adjustment of the model back to equilibrium. After identifying the cointegrating vector and normalizing the co-integrating model, the inflation rate equation with the long-run and short-run coefficients can be written as:

$$\bar{\pi}_t = \beta_0 + \theta_0 ECT + \beta_{1t}\bar{y}_t + \beta_{2t}\mathrm{GD}_t + \beta_{3t}OILP_t + \beta_{4t}ELECT + \beta_{5t}MMR_t + \sum_{i=1}^{p}\beta_{it}\Delta\bar{\pi}_{t-i} + \sum_{i=1}^{p}\beta_{it}\Delta\bar{y}_{t-i} + \quad \ldots\{4.18\}$$

$$\sum_{i=1}^{p}\beta_{it}\Delta GD_{t-i} + \sum_{i=1}^{p}\beta_{it}\Delta OILP_{t-i} + \sum_{i=1}^{p}\beta_{it}\Delta ELECT_{t-i} + \sum_{i=1}^{p}\beta_{it}\Delta MMR_{t-i} + \beta_6 D_IT + \beta_7 D_FC_t + \mu_t$$

Where *p* is the maximum lag length selected in sub-section 4.4.3.1 above and the other variables are as earlier defined.

4.4.3.4 Impulse Response Function

The innovation accounting technique analyses the dynamic relationship among variables using the impulse response function (IRF) and the variance decomposition (VD) within the VAR system. While the IRF provides the interaction and the response between variables, the VD gives the contribution of each variable to the shock in other variables (Morales, 2003). However, this chapter only observed the innovation in inflation rate as a result of a shock in the demand-side variables, using VD. The impulse response function helps to trace the effect of one standard deviation shock in one variable on both the current and the future values of other variables in the system. The IRF observes the time path of a given variable, as a result of shocks in the independent variable. Also, an IRF determines how the dependent variable responds over a specified time period, to one-unit shock in the other variables.

IRF traces how one variable responds to a shock in another variable over time. This method is important and applicable for policy analysis because it assists policy makers to observe how inflation responds to shocks in different variables and the duration of the effects of the shocks.

Therefore, the results obtained from these methods will assist policy makers to observe the factors that have impact on inflation dynamics, according to the objective of this chapter.

4.5 ANALYSIS OF EMPIRICAL RESULTS

This section discusses the results obtained from the Johansen test of cointegration, VECM and the results of the innovation accounting technique.

4.5.1 Johansen Co-integration result

The lag length was tested for the VAR system (Tables A4.2 and A4.3 of Appendix A); maximum lag length of four was chosen, based on the Akaike Information Criteria (AIC), however, the VAR showed stability in its roots at different lags for the different models. The ordering of the variables was Cholesky triangular, whereby the first variable is the most endogenous, and this is the inflation rate variable. Other diagnostic tests were also carried out, and the null hypotheses were not rejected at the chosen lag length; thus, revealing a well-specified model.

Furthermore, the results of the Johansen test of cointegration showed that the null hypothesis of 'no co-integration' among all the variables was rejected (Table 4.2). This technique simply determines the number of the cointegrating vectors that exists among any variable. The results from both Max-eigenvalue and Trace tests of the Johansen technique are conflicting for a model with 'intercept and trend' in the cointegrating equation (Tables A4.6 of Appendix A).

Table 4.2: Co-integration test results.

2002Q1 to 2014Q2					
		Model 1		Model 2	
Null	Alternative	$\lambda_{\max}$ Statistic: output growth	λ_{trace} Statistic: output growth	$\lambda_{\max}$ Statistic: output gap	λ_{trace} Statistic: output gap
$r = 0$	$r \geq 1$	76.85***	187.96***	95.19***	186.78***
$r \leq 1$	$r \geq 2$	37.51	111.11***	33.47	91.60**
$r \leq 2$	$r \geq 3$	30.63	73.60***	26.03	58.13
$r \leq 3$	$r = 4$	19.63	42.97**	16.79	32.10
1995Q4 to 2014Q1					
		Model 3		**Model 4**	
Null	Alternative	$\lambda_{\max}$ Statistic: output growth	λ_{trace} Statistic: output growth	$\lambda_{\max}$ Statistic: output gap	λ_{trace} Statistic: output gap
$r = 0$	$r \geq 1$	44.99**	138.56***	55.30***	117.71***
$r \leq 1$	$r \geq 2$	32.44	93.58***	36.03	88.80***
$r \leq 2$	$r \geq 3$	26.74	61.14	32.21	63.88**
$r \leq 3$	$r = 4$	18.73	34.39	25.82	42.92

***1%, **5%
Analysis: By author.

Given the conflicting results, as earlier explained, the maximum eigenvalue test result was chosen. Hence the study proceeds to the VECM using one cointegrating equation. The result shows that all the variables move together in the long-run, as the null hypothesis of 'no cointegration' was rejected. Thus the conclusion is that although the variables are not all stationary at the same level, they have at least one long-run relationship.

4.5.2 Vector Error Correction Mechanism (VECM) result

The VECM was estimated based on one cointegrating equation of the maximum eigenvalue test. The inflation rate variable was identified by the long-run cointegrating vector; this is the equation of interest in this study. After normalizing, the following long-run result for inflation rate is obtained for the four models and thus presented below (Table 4.3).

Table 4.3: VECM results: Dependent variable: $\overline{\pi}_t$

Variables	Output growth-inflation model: 2002Q1 to 2014Q2 (Model 1)	Output gap-inflation model: 2002Q1 to 2014Q2. (Model 2)	Output growth-inflation model: 1995Q4 to 2014Q1 (Model 3)	Output gap-inflation model: 1995Q4 to 2014Q1 (Model 4)
$\overline{y}_t$	-1.270***	—	-0.35**	—
	(9.01)		(-2.94)	
y_{gap}	—	-3.27E-06	—	1.59E-06
		(-0.28)		(0.118)
OILP	-0.0012	—	0.003***	0.004
	(-1.92)		(5.03)	(1.57)
ELECT	0.019**	0.215***	—	—
	(2.18)	(7.96)		
EXR	—	0.031**	9.72E-07***	1.61E-06***
		(2.19)	(3.92)	(2.42)
GDEF	0.224***	2.108***	0.052**	0.12
	(5.38)	(12.39)	(2.16)	(1.39)
MSG	—	-0.966***	—	0.596***
		(-6.74)		(5.63)
MMR	0.084	—	—	—
	(1.93)			
TBR	—	—	0.052	—
			(1.49)	
Trend	-0.009	-0.18***	-0.046***	-0.069
	(-0.52)	(-4.30)	(-4.72)	(-1.96)
ECT	-0.634***	-0.214***	-1.948***	-0.41***
	(-3.573)	(-2.789)	(-4.333)	(-3.468)
Constant	2.194	-1.647	1.224	0.009

Figures in parentheses ( ) indicate t-statistics. ***1%, **5%.

Results of the VECM showing the short-run and long-run coefficients for all the four models are presented in tables A4.7a, A4.8a, A4.7b and A4.8b (Appendix A).

Analysis: By author

The expected sign for output growth is positive for the existence of Phillips curve, but the result showed a statistically significant negative sign in both inflation-output growth models (models 1 and 3). This means that, based on the inflation-output growth nexus, there is no trade-off in the Phillips curve in South Africa.

When oil price and electricity price are used as structural variables, and money market rate as the monetary policy variable (Model 1), a percentage increase in output growth will result in a statistically significant fall in inflation rate by over a hundred percent. The negative relationship thus shows a non-existence of the Phillips curve since there is no trade-off between the variables. The result of the negative sign is consistent with the results obtained in the previous chapter, affirming that Phillips curve does not exist in South Africa even when the model is extended to include supply shock variables.

Similarly, the negative relationship continues when a different set of structural and monetary variables, namely exchange rate, oil price and Treasury bill rate, are used as control variables (Model 3). In this model, given a one percent increase in output growth, inflation rate will decline by over thirty percent. On the other hand, in the output gap-inflation models (Models 2 and 4), while the output gap coefficient show negative sign for model 2, it is positively signed in model 4. The negative sign of output gap in previous chapter is removed in one of the two output gap-inflation models. However, both models are statistically insignificant.

The fiscal variable, government deficit, has the expected sign and is statistically significant in all the models, except model 4, where it is statistically insignificant. A percentage increase in the fiscal policy variable of government deficit will cause inflation rate to increase significantly. This means that increased government deficit is inflationary in South Africa and this is highly statistically significant. Likewise, all the structural variables are economically significant except oil price in models 1 and 4, where the unexpected sign was obtained in model 1, and rightly signed in model 4, but it is statistically insignificant in both models. Swanepoel (2006) also found that oil price is insignificant in the inflation rate determination in South Africa. Electricity

price and exchange rate have the expected signs and are highly statistically significant at the chosen significant levels, across the models.

However, oil price is both economically and statistically significant in model 3, with a small effect on inflation rate. Here, if international oil price increases by one rand there will be a trifling increase in inflation rate of about 0.3 percent. The effect of increased oil price has been significantly felt in South Africa over the past years; it however has a small direct effect on inflation rate. This could be due to the fact that increased oil price affects other major economic variables such as production cost, wages and so on, before its effect is felt on inflation rate. A small effect of oil price on inflation was also found for Japan, United States and United Kingdom in the study by LeBlanc and Chinn (2004). The reason for the insignificant oil price variable in this current study is that the domestic oil prices is not only made up of crude oil prices but also includes the fuel levies and taxes imposed from time to time. The reason for not using the fuel prices as a variable is because the tax and levies are expected to be captured in the fiscal variable.

Likewise, the effect of a change in exchange rate on inflation rate confirms, as earlier explained, the possible transmission mechanisms that exchange rate goes through before finally affecting inflation rate. This is seen in the effect of a percentage increase in exchange rate on inflation rate. When exchange rate increases by one percent, inflation rate will increase by no more than 3.1 percent across the models. Meanwhile, a unit increase in electricity prices will lead to an increase in inflation rate of slightly over two percent and twenty one percent respectively in models 1 and 2. Lastly, the monetary policy variable, money supply growth was economically and statistically significant only in model 4.The result of the effects of the interest rates is not as theoretically expected, and they are also not statistically significant at the chosen levels of significance (Models 1 and 3).

Although the results show that an increase in interest rates leads to an increase in inflation rate in South Africa, this is not statistically significant. This means that interest rate did not statistically determine inflation rate in South Africa during the periods considered. The same result was

found by Bonga-Bonga and Kabundi (2015), where they concluded that monetary policy instrument is ineffective in influencing the level of inflation rate in South Africa. This is because they found that either a contractionary monetary policy is unable to cause a decline in inflation rate or that there is a considerably long lag in the monetary policy affecting inflation rate.

Furthermore, the results of these specifications show that while Phillips curve does not exist in South Africa, based on the inflation-output growth model; fiscal policy variable and structural variables, namely government deficit, electricity price and exchange rate are highly economically and statistically significant determinants of inflation rate in South Africa. These results support the findings of Akinboade, *et.al* (2002) that structural variables are significant in the inflation dynamics of South Africa and Malikane (2013) showed that the supply shock variables are significant and important in the empirical validity of the Phillips curve, thus giving reliable parameters of the Gordon's PC model.

In addition, the error correction terms of the short-run model, which capture the speed of adjustment, are highly statistically significant and showed high adjustments towards the long-run equilibrium path (Table A4.9a, A4.10a, A4.9b, A4.10b of Appendix A). The negative sign shows that the variables will bring the system back to its long-run equilibrium path. The dummy variable, D_FC depicts the expected positive sign across all the models and is statistically significant except in Models 1 and 2. Lastly, the graph presented in figure 4.2 shows that the estimated cointegration relation of each model is found to be appropriate. This is because each of the graphs reverts to the equilibrium, which is zero.

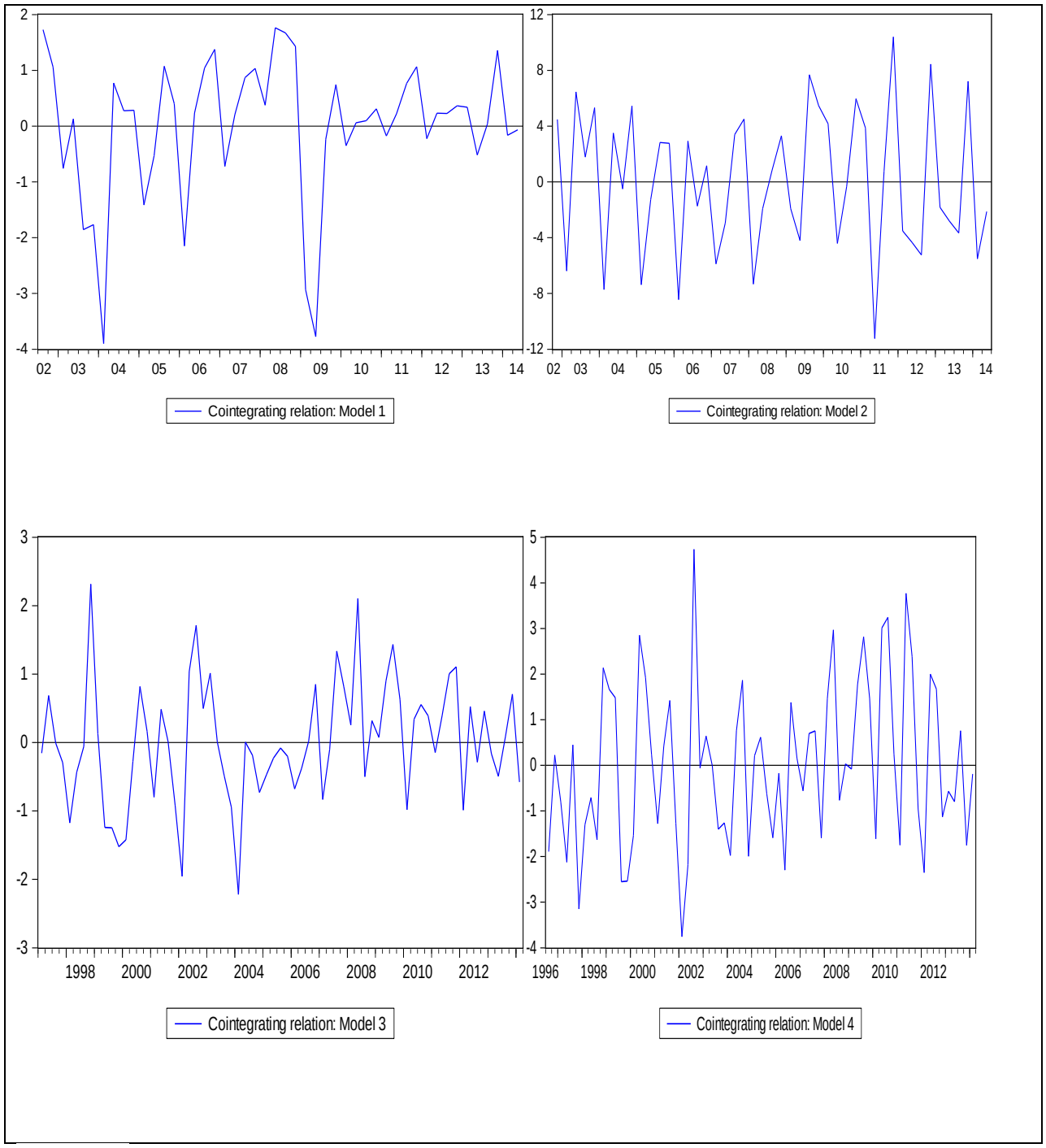

Figure 4.2: Cointegrating graphs for inflation rate models.

The diagnostic tests for each model were carried out and they failed to reject all the null hypotheses (Table 4.4).

Table 4.4: Diagnostic tests of inflation rate models – VECM.

H_0	H_1	Test	Statistic: Model 1	Statistic: Model 2	Statistic: Model 3	Statistic: Model 4
Error term is normally distributed	Error term is not normally distributed	JB-joint	11.09 (0.52)	5.60 (0.94)	6.38 (0.38)	11.24 (0.18)
Homoskedasticity	Heteroskedasticity	χ^2	336.30 (0.196)	587.02 (0.27)	1092.75 (0.49)	553.23 (0.19)
No serial correlation	Serial correlation	LM-test-χ^2 (lags 3 and 5)	41.79 (0.23)	46.17 (0.12)	35.15 (0.51)	46.62 (0.11)

Figures in parentheses indicate P-value.
Analysis: By Author

4.5.3 Impulse Response Function Result

The IRF explains the effects of one standard deviation shock in the other variables on inflation rate (model 1 of equation {4.11}). The IRF is derived from the estimated VECM result (Figure B4.3 of Appendix B). The impulse response function of inflation rate to a shock in the other variables was observed for a period of twelve quarters, which is over three years. Given a standard deviation shock in the output growth, the initial response of inflation is an increase from the first quarter to the second quarter. This is followed by a fall in inflation rate until the fourth quarter. Although, there is another increase up until the sixth quarter, the effect of the shock subsides and inflation stabilizes after the eleventh quarter, at a level lower than when it started. This means that a shock in output growth causes an immediate increase in inflation rate, but the shock dies out after two years. The intensity of the effect of the shock in output growth on inflation rate is minimal and the duration of this effect before decreasing, is considerably short.

Moreover, the increase in inflation as a result of a shock in the output growth is quite evident in the first two quarters before it stabilizes. This shows that in order for monetary authorities to curb inflation, output growth needs to be enhanced, as its negative effect on inflation is not perpetual but falls after the eleventh quarter. This result is consistent with the result obtained from the previous chapter whereby inflation and output growth are inversely related, and it was

concluded that increasing output growth will not have a detrimental effect on inflation. The variance decomposition also shows that despite the effects of other control variables, the demand-side variables highly contribute to the innovations in inflation rate (Table 4.5). During the period 2002 to 2014 and 1995 to 2014, these variables increased considerably within the first three quarters before gradually declining (Models 1 and 4). However, among all the variables in model 1, output growth variable had the highest contribution to innovations in inflation rate over the entire three years considered (Table A4.9, Appendix A). Among all the variables in models 2, 3 and 4, the demand-side variables, output growth and output gap, showed high contributions to inflation dynamics having the second highest contributions (Table A4.9, Appendix A). These results show and thus affirm the significance of demand-side to inflation dynamics in South Africa, over the data periods considered.

Table 4.5: 12-quarter contributions of the demand-side variables to the innovations in inflation rate.

Periods	Output growth-inflation model: 2002Q1 to 2014Q2 (Model 1)	Output gap-inflation model: 2002Q1 to 2014Q2 (Model 2)	Output growth-inflation model: 1995Q4 to 2014Q1 (Model 3)	Output gap-inflation model: 1995Q4 to 2014Q1 (Model 4)
1	0.000000	0.000000	0.000000	0.000000
2	6.121501	2.562753	12.92245	11.46145
3	6.408218	1.854497	11.30112	12.07632
4	5.650675	2.619171	10.90494	11.02748
5	4.723098	3.451513	10.21211	10.49168
6	4.750969	3.212454	12.38215	10.44517
7	4.293559	2.750468	13.04759	10.60282
8	4.183017	2.765246	15.08547	10.64265
9	4.028392	3.070123	16.36275	10.44442
10	4.024871	2.929029	18.69624	10.25724
11	3.903860	2.666750	19.20610	10.20914
12	3.888583	2.595050	19.82473	10.23121

Analysis: By author

4.5.4 Summary

This chapter estimated the extended Gordon's triangle model by including the supply shock variables while incorporating the variables from the three different schools of thought. Firstly, the results obtained affirmed that Phillips curve does not exist in South Africa during the period considered, as significantly negative relationship was obtained between inflation rate and output growth. The results further showed that the determinants of inflation dynamics in South Africa

are demand-side, fiscal and structural variables. Akinboade *et.*al (2002) and Burger and Marinkov (2006) also found that inflation dynamics in South Africa are more structural-driven, when they used different sets of variables.

Adusei (2013) found that inflation in South Africa follows the structuralist and monetarist approaches. This study further found that inflation in South Africa is demand-driven, which is contrary to the findings of Burger and Marinkov (2006). Their study concluded that Gordon's model does not exist in South Africa because they found that demand-side was insignificant. However, according to the findings of this current study, the demand-side variable using output growth is statistically significant in determining inflation in South Africa. Based on the variance decomposition results, both output growth and output gap variables showed relatively considerable contributions to inflation dynamics during the period considered. Therefore, based on these findings, monetary authorities have limited control over the external and structural variables, they can however, on the other hand, engage with the government to control the fiscal and demand-side variables in order to regulate inflation.

4.6 CONCLUSION AND POLICY RECOMMENDATIONS.

The objective of this chapter was to estimate an extended or nested Gordon's triangular model, in order to verify the existence of Phillips curve in an extended model and by incorporating all the three different schools of thought. This model was examined by combining the variables that capture the fiscal policy, supply-shock (or structural) and the monetary policy components, while also including the demand-side variables. Given the inconclusive results obtained in earlier studies about the major drivers of inflation in South Africa; the exclusion of two schools of thought from the Gordon's model and the inability of the Phillips curve model to include the major factors that determine inflation in the previous chapter; this chapter proceeded to estimate the extended Gordon's triangle model. The importance of inflation and correctly identifying its determinants are vital in South Africa as an inflation targeting economy.

The results obtained showed that the entire variables move together in the long-run, hence they are cointegrated. While output growth is negatively related to inflation rate in the long-run,

signifying a non-existence of the Phillips curve, the sign on output gap changed to positive, affirming no trade-off. This also shows that increased inflation will ensue as a result of a decline in output growth and increased output gap. This result corrobates with the findings of earlier studies like Malikane (2012) that extending the Phillips curve to include supply shocks removes the negative sign of the output gap. This also shows that the hybrid new Keynesian Phillips curve (HNKPC) of the previous chapter was under-specified, although, the short-run and long-run results of ECM and GMM in chapter 3 also showed that there was no trade-off, it is not a comprehensive model. The output growth maintains a negative relationship with inflation rate, as in chapter 3, indicating no trade-off despite the expanded specification in the current chapter. On the other hand, the sign on output gap changes to positive which further confirms the non-existence of Phillips curve.

Furthermore, the results show that the demand-side, fiscal factors and some of the structural variables contribute more to the inflation dynamics in South Africa. This means that the changes in inflation rate are as a result of changes in output growth, output gap, government deficit, electricity price and exchange rate. Even though, South Africa relies heavily on oil imports, the results obtained shows that the effect of a change in oil is not huge enough to drastically change inflation rate, supporting the findings of Swanepoel (2006). This shows that there are more variables that cause significant changes to inflation rate than oil price. Also, according to Nkomo (2006), the extent of the effect of oil price on inflation depends on the oil price elasticity of demand and the degree of dependency of the importing country.

The results also showed that the Fiscal Theory of the Price Level (FTPL) applies to the South African economy, whereby not only monetary policies should be considered in controlling inflation, but also fiscal policies. This finding also supports Woodford (1995) who concluded that fiscal policy can only affect inflation if the government is non-Ricardian, which means government spending is not equal to its revenue obtained from taxes. Since the South African government has been non-Ricardian, experiencing deficit for over the past decade, the FTPL applies to South African economy, and thus fiscal policy is applicable in determining inflation

rate. This is shown in the results whereby a change in government deficit is economically and highly statistically significant in determining inflation rate in South Africa.

This study therefore concludes that monetary authorities are faced with the challenge to curtail inflation resulting from changes in the demand-side, fiscal and structural factors. Based on these results, it is therefore suggested that monetary policy makers should be more concerned with the demand-side, fiscal variables as well as structural factors in controlling the price level, even though they have limited or no control over the structural variables in curbing inflation. The study also suggests that economic growth should be promoted by the policy makers in order to significantly reduce inflation.

In addition, in terms of the effect of government deficit on inflation, the government should re-assess its revenue and spending patterns in order to reduce the budget deficit. A review could be commissioned to ensure that revenue is well-spent and that it achieves the development outcomes that it was intended for, in order to avoid wastage and corruption. Finally, fiscal authorities should make sure that government departments do more with less. This can be done by efficiently spending public funds, while prioritising the allocation of resources to achieve major service deliveries. Government should further avoid over-spending which could lead to increased deficit and high inflation. Therefore, given the variables that contribute to inflation dynamics in South Africa, and the importance of price inflation, it is vital to explore the level of inflation above which it is detrimental to economic growth. This will be examined in the following chapter.

APPENDIX TO CHAPTER 4

NOTES

Stationarity Test

When the mean and variance of a time-series are constant over time, it is concluded that such series are stationarity. Most time-series data are non-stationary and estimating such without observing whether they have unit root or not can result in spurious regression results. Thus, it is important to test the stationarity of the series and avoid unreliable results.

The null hypothesis for testing the stationarity of a time-series variable states that the 'series has a unit root'. The following three methods of testing the stationarity of a series, namely Phillips-Perron (PP), Dickey-Fuller GLS (DF-GLS) detrended and Zivot-Andrew (ZA) are used. The ZA unit root test incorporates the possible effect of a structural break, which might lead to mistaken rejection or acceptance of the null hypothesis (unit root exists), when there is indeed the presence of unit root or not. The test equation of "Intercept and Trend" is adopted. The ADF test has been proved to have very low power (Odhiambo, 2010); hence PP, DF-GLS and Zivot-Andrew unit root tests are used. The stationarity test results are presented in tables A4.1a and A4.1b of Appendix A.

Appendix A: Tables

Table A4.1a: Stationarity test results[#]: Quarterly Data (2002Q1 – 2014Q2).

	LEVELS			FIRST DIFFERENCE		
Variables	PP	DF-GLS	ZA	PP	DF-GLS	Decision
$\overline{\pi}_t$	-1.964	-1.614	4.360	-9.957***	-3.721**	I(1)
$\overline{y}_t$	-3.214**	-3.022***	-4.340	—	—	I(0)
$y_{gap(t)}$	-2.133	-2.848***	-4.809*	—	—	I(0)
GD_t	-4.683***	-1.60*	-4.98**			I(0)
$OILP_t$	0.173	0.424	-4.413	-5.573***	-6.113***	I(1)
EXR_t	-6.202***	-4.167***	-8.649***	—	—	I(0)
$ELECT_t$	-1.702	-2.526	-3.607	-9.215***	-3.19**	I(1)
MMR_t	-2.137	-3.578**	4.508	-3.18*	-3.434**	I(1)
MSG_t	-6.234***	-0.684	-3.806	—	-2.750***	I(1)

[#]test equation of intercept and trend.
Test critical values: PP [1% -4.16; 5% -3.51; 10% -3.18]; DF-GLS [1% -3.77; 5% -3.19; 10% -2.89]; ZA [1% -5.34; 5% -4.93; 10% -4.58].
***1%, **5%, *10%

Table A4.1b: Stationarity test results[#]: Quarterly Data (1995Q4 – 2014Q1).

	LEVELS			FIRST DIFFERENCE		
Variables	PP	DF-GLS	ZA	PP	DF-GLS	Decision
$\overline{\pi}_t$	-1.924	-2.987*	-5.602***	-12.209***	-8.794***	I(1)
$\overline{y}_t$	-4.399***	-4.417***	-5.25**	—	—	I(0)
$y_{gap(t)}$	-2.745	-3.663**	-4.60	-4.463***	-4.29***	I(1)
GD_t	-6.247***	-2.41	-9.701***	—	—	I(0)
$OILP_t$	-1.853	-1.723	-3.352	-7.416***	-7.662***	I(1)
EXR_t	-7.805***	-4.281***	-5.09**	—	—	I(0)
MSG_t	7.394***	-2.131	-4.417	-21.491***	-10.504***	I(1)
TBRt	-2.772	-3.289**	-3.95	-6.435***	-5.904***	I(1)

[#]test equation of intercept and trend.
Test critical values: PP [1% -4.09; 5% -3.47; 10% -3.16]; DF-GLS [1% -3.69; 5% -3.13; 10% -2.83]; ZA [1% -5.57; 5% -5.08; 10% -4.82].
***1%, **5%, *10%

Table A4.2: Lag Order Selection for inflation-output growth model: 2002Q1 to 2014Q2

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-857.3008	NA	8.06e+08	37.53482	37.77334	37.62417
1	-525.4337	562.7311	2117.655	24.67103	26.34066*	25.29649
2	-472.8686	75.41957	1117.021	23.95081	27.05155	25.11236
3	-413.5862	69.59234	505.7539	22.93853	27.47038	24.63619
4	-335.5899	71.21403*	130.6534*	21.11261*	27.07557	23.34637*

* 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

Table A4.3: Lag Order Selection for inflation-output gap model: 2002Q1 to 2014Q2

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1144.345	NA	2.75e+14	50.27586	50.75290	50.45456
1	-920.4833	369.8580	7.97e+10	42.10797	44.01612*	42.82278
2	-878.6668	58.17959	6.83e+10	41.85508	45.19434	43.10598
3	-829.3156	55.78826	4.92e+10	41.27459	46.04496	43.06160
4	-752.4151	66.87006*	1.41e+10*	39.49631*	45.69779	41.81942*

* 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

Table A4.4: Stability of the VAR for inflation-output growth (2002Q1 to 2014Q2)

Endogenous variables: $\overline{\pi}_t$ $\overline{y}_t$ ELECT OILP GDEF MMR
Exogenous variables: C D_FC
Lag specification: 1 2

Root	Modulus
0.982214	0.982214
0.694030 - 0.281322i	0.748879
0.694030 + 0.281322i	0.748879
-0.332661 - 0.600963i	0.686891
-0.332661 + 0.600963i	0.686891
0.173168 - 0.615885i	0.639767
0.173168 + 0.615885i	0.639767
-0.107043 - 0.510306i	0.521412
-0.107043 + 0.510306i	0.521412
-0.511985 - 0.047000i	0.514138
-0.511985 + 0.047000i	0.514138
0.501826	0.501826

No root lies outside the unit circle.
VAR satisfies the stability condition.

Table A4.5: Stability of the VAR for inflation-output gap (2002Q1 to 2014Q2)

Endogenous variables: $\overline{\pi}_t$ y_{gap} ELECT EXR GDEF MSG
Exogenous variables: C D_FC
Lag specification: 1 2

Root	Modulus
0.995378	0.995378
0.806003 - 0.261098i	0.847238
0.806003 + 0.261098i	0.847238
0.001467 - 0.787736i	0.787737
0.001467 + 0.787736i	0.787737
0.571148	0.571148
-0.502739	0.502739
-0.261438 - 0.403449i	0.480750
-0.261438 + 0.403449i	0.480750
0.396048	0.396048
0.006947 - 0.236200i	0.236302
0.006947 + 0.236200i	0.236302
0.995378	0.995378
0.806003 - 0.261098i	0.847238

No root lies outside the unit circle.
VAR satisfies the stability condition.

Table A4.6: Summary of cointegration tests

Sample: 2002Q1 2014Q2					
Included observations: 48					
Series: $\overline{\pi}_t$ $\overline{y}_t$ ELECT OILP GDEF MMR					
Lags interval: 1 to 1					
Selected (0.05 level*) Number of Cointegrating Relations by Model					
Data Trend:	None	None	Linear	**Linear**	Quadratic
Test Type	No Intercept	Intercept	Intercept	**Intercept**	Intercept
	No Trend	No Trend	No Trend	**Trend**	Trend
Trace	4	5	4	**4**	3
Max-Eig	4	4	3	**1**	2

Sample: 2002Q1 2014Q2					
Included observations: 47					
Series: $\overline{\pi}_t$ y_{gap} ELECT EXR GDEF MSG					
Lags interval: 1 to 2					
Selected (0.05 level*) Number of Cointegrating Relations by Model					
Data Trend:	None	None	Linear	**Linear**	Quadratic
Test Type	No Intercept	Intercept	Intercept	**Intercept**	Intercept
	No Trend	No Trend	No Trend	**Trend**	Trend
Trace	2	2	2	**2**	2
Max-Eig	2	2	1	**1**	1

Sample: 1995Q4 2014Q1					
Included observations: 69					
Series: $\overline{\pi}_t$ $\overline{y}_t$ EXR OILP GDEF TBR					
Lags interval: 1 to 4					
Selected (0.05 level*) Number of Cointegrating Relations by Model					
Data Trend:	None	None	Linear	**Linear**	Quadratic
Test Type	No Intercept	Intercept	Intercept	**Intercept**	Intercept
	No Trend	No Trend	No Trend	**Trend**	Trend
Trace	3	5	3	**2**	1
Max-Eig	1	1	1	**1**	0

Sample: 1995Q4 2014Q1					
Included observations: 71					
Series: $\overline{\pi}_t$ y_{gap} EXR OILP GDEF MSG					
Lags interval: 1 to 2					
Selected (0.05 level*) Number of Cointegrating Relations by Model					
Data Trend:	None	None	Linear	**Linear**	Quadratic
Test Type	No Intercept	Intercept	Intercept	**Intercept**	Intercept
	No Trend	No Trend	No Trend	**Trend**	Trend
Trace	5	5	4	**3**	3
Max-Eig	2	3	3	**1**	1

Table A4.7a: Vector error correction model (VECM) result of output growth (2002Q1 to 2014Q2).

Vector Error Correction Estimates
Sample (adjusted): 2002Q3 2014Q2
Included observations: 48 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
$\overline{\pi}_t$ (-1)	1.000000
$\overline{y}_t$ (-1)	1.270086 (0.14095) [9.01082]
ELECT(-1)	-0.019327 (0.00887) [-2.17792]
OILP(-1)	0.001233 (0.00064) [1.92021]
GDEF(-1)	-0.224564 (0.04177) [-5.37594]
MMR(-1)	-0.083765 (0.04349) [-1.92621]
@TREND(02Q1)	0.009379 (0.01798) [0.52168]
C	-2.193692

Error Correction:	D($\overline{\pi}_t$)	D($\overline{y}_t$)	D(ELECT)	D(OILP)	D(GDEF)	D(MMR)
CointEq1	-0.634132 (0.17748) [-3.57296]	-0.435237 (0.13494) [-3.22532]	2.013473 (0.92942) [2.16637]	0.000000 (0.00000) [NA]	2.019350 (0.82562) [2.44586]	0.000000 (0.00000) [NA]
D($\overline{\pi}_t$ (-1))	-0.105054 (0.15698) [-0.66923]	0.165663 (0.09447) [1.75361]	-1.188987 (0.60608) [-1.96176]	27.91256 (15.0606) [1.85336]	-1.499772 (0.53991) [-2.77780]	-0.063330 (0.09085) [-0.69708]
D($\overline{y}_t$(-1))	0.603990 (0.27457) [2.19976]	-0.064367 (0.16524) [-0.38954]	-1.432472 (1.06010) [-1.35126]	58.91569 (26.3424) [2.23653]	-1.056404 (0.94436) [-1.11864]	-0.029407 (0.15891) [-0.18506]
D(ELECT(-1))	-0.073038 (0.03960) [-1.84418]	0.053190 (0.02383) [2.23168]	-0.554856 (0.15291) [-3.62865]	-2.290883 (3.79966) [-0.60292]	0.267301 (0.13622) [1.96234]	-0.012062 (0.02292) [-0.52623]
D(OILP(-1))	0.002209 (0.00231) [0.95745]	0.003910 (0.00139) [2.81567]	-0.004754 (0.00891) [-0.53363]	0.349056 (0.22136) [1.57688]	-0.002899 (0.00794) [-0.36529]	0.000957 (0.00134) [0.71667]

D(GDEF(-1))	-0.006592	-0.048008	-0.192768	0.535800	-0.232904	0.050852
	(0.04250)	(0.02557)	(0.16407)	(4.07709)	(0.14616)	(0.02459)
	[-0.15512]	[-1.87722]	[-1.17488]	[0.13142]	[-1.59347]	[2.06762]
D(MMR(-1))	0.292878	0.012562	-2.617727	24.58006	-1.756273	0.287161
	(0.29330)	(0.17651)	(1.13240)	(28.1391)	(1.00877)	(0.16975)
	[0.99857]	[0.07117]	[-2.31166]	[0.87352]	[-1.74100]	[1.69172]
C	0.006211	-0.144619	1.538305	14.54773	-0.052819	-0.027337
	(0.15053)	(0.09059)	(0.58118)	(14.4419)	(0.51773)	(0.08712)
	[0.04126]	[-1.59644]	[2.64684]	[1.00733]	[-0.10202]	[-0.31379]
D_FC	0.243907	-0.111538	2.375575	17.24808	-1.866197	-0.181971
	(0.24768)	(0.14905)	(0.95628)	(23.7625)	(0.85187)	(0.14334)
	[0.98477]	[-0.74830]	[2.48419]	[0.72585]	[-2.19070]	[-1.26947]
R-squared	0.420748	0.452329	0.428621	0.278458	0.525474	0.698895
Adj. R-squared	0.301927	0.339986	0.311415	0.130449	0.428135	0.637130
Sum sq. resids	22.06990	7.992917	328.9910	203143.2	261.0764	7.392285
S.E. equation	0.752260	0.452710	2.904422	72.17201	2.587328	0.435369
F-statistic	3.541026	4.026328	3.656994	1.881363	5.398404	11.31538
Log likelihood	-49.46138	-25.08556	-114.3050	-268.5202	-108.7557	-23.21071
Akaike AIC	2.435891	1.420232	5.137706	11.56334	4.906489	1.342113
Schwarz SC	2.786741	1.771082	5.488557	11.91419	5.257339	1.692963
Mean dependent	-0.030502	-0.022071	1.634070	18.67542	-0.068750	-0.111945
S.D. dependent	0.900363	0.557242	3.500105	77.39651	3.421407	0.722739

Determinant resid covariance (dof adj.)	804.0846
Determinant resid covariance	231.3353
Log likelihood	-543.9075
Akaike information criterion	25.20448
Schwarz criterion	27.58246

Table A4.8a: Vector error correction model (VECM) result of output gap (2002Q1 to 2014Q2)

Vector Error Correction Estimates
Sample (adjusted): 2002Q4 2014Q2
Included observations: 47 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
$\overline{\pi}_t$ (-1)	1.000000
y_{gap} (-1)	3.27E-06
	(1.2E-05)
	[0.27506]
ELECT(-1)	-0.215104
	(0.02704)
	[-7.95608]
EXR(-1)	-0.030816
	(0.01410)
	[-2.18524]
GDEF(-1)	-2.108173
	(0.17009)

	[-12.3946]					
MSG(-1)	0.965926 (0.14339) [6.73632]					
@TREND(02Q1)	0.180297 (0.04191) [4.30222]					
C	1.646512					

Error Correction:	D($\overline{\pi}_t$)	D(y_{gap})	D(ELECT)	D(EXR)	D(GDEF)	D(MSG)
CointEq1	-0.213750 (0.07664) [-2.78904]	0.000000 (0.00000) [NA]	-0.527338 (0.25603) [-2.05967]	1.216379 (0.49820) [2.44156]	1.177310 (0.13578) [8.67087]	0.000000 (0.00000) [NA]
D($\overline{\pi}_t$ (-1))	-0.233723 (0.17781) [-1.31447]	5727.040 (1854.36) [3.08841]	0.512667 (0.58761) [0.87247]	-0.699889 (1.19664) [-0.58488]	-0.799357 (0.30428) [-2.62704]	-0.104770 (0.42706) [-0.24533]
D($\overline{\pi}_t$ (-2))	-0.164471 (0.18416) [-0.89309]	4840.144 (1920.61) [2.52011]	1.092653 (0.60860) [1.79536]	-0.172077 (1.23939) [-0.13884]	0.098483 (0.31515) [0.31250]	0.936145 (0.44232) [2.11646]
D(y_{gap}(-1))	2.81E-05 (1.6E-05) [1.80313]	0.417266 (0.16265) [2.56549]	2.20E-05 (5.2E-05) [0.42670]	-0.000165 (0.00010) [-1.57452]	2.05E-05 (2.7E-05) [0.76744]	-1.05E-05 (3.7E-05) [-0.28024]
D(y_{gap}(-2))	-2.51E-05 (1.6E-05) [-1.58869]	-0.077810 (0.16464) [-0.47261]	-3.76E-05 (5.2E-05) [-0.72054]	-9.84E-05 (0.00011) [-0.92609]	5.91E-05 (2.7E-05) [2.18806]	5.99E-05 (3.8E-05) [1.58008]
D(ELECT(-1))	-0.080278 (0.05035) [-1.59446]	389.7131 (525.082) [0.74219]	-0.451143 (0.16639) [-2.71141]	-0.639908 (0.33884) [-1.88852]	0.244909 (0.08616) [2.84248]	0.215211 (0.12093) [1.77968]
D(ELECT(-2))	0.062123 (0.05499) [1.12963]	-1.611963 (573.534) [-0.00281]	0.046991 (0.18174) [0.25856]	-0.522053 (0.37011) [-1.41054]	0.039218 (0.09411) [0.41672]	-0.029508 (0.13208) [-0.22340]
D(EXR(-1))	-0.002296 (0.02727) [-0.08418]	564.0354 (284.449) [1.98290]	0.118607 (0.09014) [1.31587]	0.026339 (0.18356) [0.14349]	-0.109754 (0.04668) [-2.35145]	0.049508 (0.06551) [0.75574]
D(EXR(-2))	0.010088 (0.02578) [0.39122]	155.4778 (268.912) [0.57817]	-0.022842 (0.08521) [-0.26806]	-0.016739 (0.17353) [-0.09646]	-0.013194 (0.04413) [-0.29901]	0.110011 (0.06193) [1.77638]
D(GDEF(-1))	-0.230428 (0.11564) [-1.99256]	917.4115 (1206.06) [0.76067]	-1.211122 (0.38217) [-3.16903]	1.501472 (0.77829) [1.92920]	0.955242 (0.19790) [4.82686]	-0.578842 (0.27776) [-2.08400]
D(GDEF(-2))	-0.060176 (0.06222) [-0.96713]	913.5256 (648.909) [1.40779]	-0.633175 (0.20562) [-3.07928]	0.585218 (0.41875) [1.39754]	0.567171 (0.10648) [5.32662]	-0.360064 (0.14944) [-2.40937]
D(MSG(-1))	0.144123 (0.08581) [1.67957]	1252.018 (894.912) [1.39904]	0.366392 (0.28358) [1.29203]	-6.78E-06 (0.57750) [-1.2e-05]	-0.656478 (0.14685) [-4.47054]	-0.486441 (0.20610) [-2.36024]
D(MSG(-2))	0.056454	248.4405	-0.115870	0.069277	-0.160006	-0.342506

	(0.06318)	(658.920)	(0.20880)	(0.42521)	(0.10812)	(0.15175)
	[0.89352]	[0.37704]	[-0.55494]	[0.16293]	[-1.47987]	[-2.25705]
C	-0.061082	392.9489	1.373379	1.401616	0.031359	-0.106848
	(0.16834)	(1755.68)	(0.55634)	(1.13296)	(0.28809)	(0.40433)
	[-0.36284]	[0.22382]	[2.46862]	[1.23713]	[0.10885]	[-0.26426]
D_FC	0.142763	-1502.992	2.831719	0.621674	-1.532968	-0.618846
	(0.28644)	(2987.30)	(0.94661)	(1.92774)	(0.49018)	(0.68798)
	[0.49840]	[-0.50313]	[2.99143]	[0.32249]	[-3.12733]	[-0.89952]
R-squared	0.499490	0.555390	0.641072	0.375676	0.898538	0.721684
Adj. R-squared	0.280517	0.360873	0.484040	0.102534	0.854148	0.599920
Sum sq. resids	18.91582	2.06E+09	206.5846	856.7492	55.39531	109.1192
S.E. equation	0.768843	8018.299	2.540821	5.174303	1.315714	1.846612
F-statistic	2.281057	2.855224	4.082447	1.375388	20.24200	5.926936
Log likelihood	-45.30161	-480.1621	-101.4833	-134.9106	-70.55227	-86.48401
Akaike AIC	2.566026	21.07073	4.956738	6.379173	3.640522	4.318469
Schwarz SC	3.156499	21.66120	5.547210	6.969645	4.230995	4.908941
Mean dependent	-0.018825	-288.4669	1.644058	-0.400851	-0.025532	-0.061026
S.D. dependent	0.906416	10029.71	3.537253	5.461889	3.445127	2.919459

Determinant resid covariance (dof adj.)	1.23E+10
Determinant resid covariance	1.23E+09
Log likelihood	-894.0379
Akaike information criterion	42.17182
Schwarz criterion	45.99021

Table A4.7b: Vector error correction model (VECM) robustness result of output growth (1995Q4 to 2014Q1)

Vector Error Correction Estimates
Sample (adjusted): 1997Q1 2014Q1
Included observations: 69 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
$\overline{\pi}_t$ (-1)	1.000000
$\overline{y}_t$ (-1)	0.352466 (0.12005) [2.93594]
EXR(-1)	-9.72E-07 (2.5E-07) [-3.92218]
OILP(-1)	-0.002760 (0.00055) [-5.02828]
GDEF(-1)	-0.051772 (0.02401) [-2.15584]
TBR(-1)	-0.051645 (0.03466) [-1.49023]

@TREND(95Q4)	0.046320 (0.00982) [4.71827]					
C	-1.224060					

Error Correction:	D($\overline{\pi}_t$)	D($\overline{y}_t$)	D(EXR)	D(OILP)	D(GDEF)	D(TBR)
CointEq1	-1.948309 (0.44966) [-4.33282]	0.000000 (0.00000) [NA]	0.000000 (0.00000) [NA]	0.000000 (0.00000) [NA]	-2.903360 (1.03340) [-2.80952]	-0.646334 (0.80408) [-0.80382]
D($\overline{\pi}_t$ (-1))	0.772255 (0.43941) [1.75746]	-0.162306 (0.24484) [-0.66291]	147678.0 (169711.) [0.87017]	11.39339 (28.2179) [0.40376]	1.997648 (0.87734) [2.27695]	0.596262 (0.65209) [0.91439]
D($\overline{\pi}_t$ (-2))	0.592896 (0.30795) [1.92528]	-0.118627 (0.17159) [-0.69134]	104876.2 (118938.) [0.88177]	8.009426 (19.7758) [0.40501]	1.281711 (0.61486) [2.08456]	0.444936 (0.45700) [0.97360]
D($\overline{\pi}_t$ (-3))	0.352838 (0.21371) [1.65102]	-0.049948 (0.11908) [-0.41946]	107332.8 (82538.8) [1.30039]	17.58202 (13.7237) [1.28114]	0.741302 (0.42669) [1.73733]	0.091606 (0.31714) [0.28885]
D($\overline{\pi}_t$ (-4))	0.228411 (0.15169) [1.50581]	-0.081428 (0.08452) [-0.96343]	-11368.04 (58584.6) [-0.19404]	3.941869 (9.74086) [0.40467]	0.221676 (0.30286) [0.73195]	0.344855 (0.22510) [1.53199]
D($\overline{y}_t$(-1))	-0.062193 (0.32627) [-0.19062]	-0.312630 (0.18179) [-1.71969]	-265848.9 (126012.) [-2.10972]	26.81683 (20.9520) [1.27992]	-0.351857 (0.65143) [-0.54013]	-0.139556 (0.48418) [-0.28823]
D($\overline{y}_t$(-2))	-0.808804 (0.33642) [-2.40412]	-0.056696 (0.18745) [-0.30246]	-451243.4 (129934.) [-3.47287]	-22.47023 (21.6041) [-1.04009]	-0.203324 (0.67170) [-0.30270]	-0.549122 (0.49925) [-1.09989]
D($\overline{y}_t$(-3))	-0.467381 (0.30945) [-1.51036]	0.031030 (0.17242) [0.17996]	-135894.9 (119516.) [-1.13704]	-2.607972 (19.8720) [-0.13124]	-0.150176 (0.61785) [-0.24306]	-0.388731 (0.45922) [-0.84650]
D($\overline{y}_t$(-4))	-0.378717 (0.26881) [-1.40888]	0.095111 (0.14978) [0.63502]	-224050.7 (103819.) [-2.15809]	-36.73390 (17.2620) [-2.12803]	-0.575951 (0.53670) [-1.07313]	-0.260659 (0.39891) [-0.65343]
D(EXR (-1))	-1.67E-06 (6.8E-07) [-2.44261]	4.32E-07 (3.8E-07) [1.13739]	-1.118889 (0.26355) [-4.24553]	-5.82E-05 (4.4E-05) [-1.32787]	-3.92E-06 (1.4E-06) [-2.87682]	-6.27E-07 (1.0E-06) [-0.61889]
D(EXR (-2))	-6.50E-07 (6.8E-07) [-0.95131]	2.19E-07 (3.8E-07) [0.57444]	-0.396765 (0.26369) [-1.50465]	-6.78E-05 (4.4E-05) [-1.54604]	-3.44E-06 (1.4E-06) [-2.52009]	-2.33E-07 (1.0E-06) [-0.22984]
D(EXR (-3))	2.32E-07 (5.4E-07) [0.42815]	-2.30E-07 (3.0E-07) [-0.76123]	-0.008473 (0.20956) [-0.04043]	-7.24E-05 (3.5E-05) [-2.07786]	-2.36E-06 (1.1E-06) [-2.17573]	2.58E-07 (8.1E-07) [0.32013]
D(EXR(-4))	6.73E-07 (4.3E-07) [1.58201]	6.15E-08 (2.4E-07) [0.25934]	-0.119472 (0.16428) [-0.72725]	-2.94E-05 (2.7E-05) [-1.07761]	-1.10E-06 (8.5E-07) [-1.29092]	6.09E-07 (6.3E-07) [0.96467]

D(OILP(-1))	0.001512	0.001567	1641.536	0.619627	0.005443	0.002448
	(0.00268)	(0.00149)	(1034.60)	(0.17202)	(0.00535)	(0.00398)
	[0.56432]	[1.04982]	[1.58664]	[3.60201]	[1.01775]	[0.61577]
D(OILP(-2))	-0.005140	-0.002672	-843.7331	-0.719997	-0.000284	0.002054
	(0.00292)	(0.00163)	(1127.88)	(0.18753)	(0.00583)	(0.00433)
	[-1.76023]	[-1.64212]	[-0.74807]	[-3.83931]	[-0.04875]	[0.47398]
D(OILP(-3))	-0.001967	0.000186	-182.1117	0.489616	0.007334	0.000259
	(0.00319)	(0.00178)	(1233.95)	(0.20517)	(0.00638)	(0.00474)
	[-0.61562]	[0.10443]	[-0.14758]	[2.38641]	[1.14965]	[0.05470]
D(OILP(-4))	0.001026	-0.003464	73.20506	-0.201809	6.25E-05	-0.001694
	(0.00264)	(0.00147)	(1020.79)	(0.16973)	(0.00528)	(0.00392)
	[0.38816]	[-2.35190]	[0.07171]	[-1.18902]	[0.01185]	[-0.43199]
D(GDEF(-1))	0.004116	0.008247	26093.33	9.036686	-1.274491	-0.098980
	(0.09262)	(0.05161)	(35772.5)	(5.94790)	(0.18493)	(0.13745)
	[0.04444]	[0.15979]	[0.72942]	[1.51931]	[-6.89178]	[-0.72012]
D(GDEF(-2))	0.038829	-0.003732	14088.73	3.121221	-1.241734	-0.049590
	(0.09894)	(0.05513)	(38214.0)	(6.35384)	(0.19755)	(0.14683)
	[0.39243]	[-0.06770]	[0.36868]	[0.49123]	[-6.28566]	[-0.33773]
D(GDEF(-3))	0.067550	-0.005670	40912.19	7.895856	-1.161129	0.007310
	(0.09191)	(0.05121)	(35498.8)	(5.90238)	(0.18351)	(0.13640)
	[0.73494]	[-0.11072]	[1.15250]	[1.33774]	[-6.32720]	[0.05359]
D(GDEF(-4))	0.019817	-0.038400	27771.25	-0.191592	-0.271830	0.002113
	(0.08817)	(0.04913)	(34053.9)	(5.66215)	(0.17604)	(0.13085)
	[0.22476]	[-0.78162]	[0.81551]	[-0.03384]	[-1.54410]	[0.01615]
D(TBR(-1))	0.250605	-0.111050	-61316.03	-13.13866	0.032940	0.190645
	(0.14762)	(0.08225)	(57012.4)	(9.47945)	(0.29473)	(0.21906)
	[1.69768]	[-1.35015]	[-1.07549]	[-1.38602]	[0.11176]	[0.87028]
D(TBR(-2))	0.008110	0.019967	-221.3248	-4.186850	0.449990	-0.115360
	(0.16205)	(0.09029)	(62586.4)	(10.4062)	(0.32355)	(0.24048)
	[0.05005]	[0.22114]	[-0.00354]	[-0.40234]	[1.39081]	[-0.47971]
D(TBR(-3))	0.012060	-0.123076	14748.71	-13.65513	0.085323	0.154863
	(0.15391)	(0.08576)	(59444.7)	(9.88387)	(0.30730)	(0.22841)
	[0.07836]	[-1.43513]	[0.24811]	[-1.38156]	[0.27765]	[0.67801]
D(TBR(-4))	0.055484	0.033840	34458.89	5.915184	0.192411	-0.236479
	(0.15049)	(0.08385)	(58123.7)	(9.66424)	(0.30048)	(0.22333)
	[0.36868]	[0.40356]	[0.59285]	[0.61207]	[0.64035]	[-1.05887]
C	-0.442703	0.024571	-112354.7	-3.186151	0.994518	-0.377887
	(0.24724)	(0.13776)	(95490.5)	(15.8772)	(0.49365)	(0.36691)
	[-1.79056]	[0.17836]	[-1.17661]	[-0.20067]	[2.01464]	[-1.02992]
D_FC	1.219677	-0.305497	200076.4	-6.007499	-0.181038	0.177351
	(0.40363)	(0.22490)	(155889.)	(25.9197)	(0.80588)	(0.59898)
	[3.02179]	[-1.35838]	[1.28345]	[-0.23177]	[-0.22465]	[0.29609]
D_IT	0.316778	0.068849	65775.49	17.33525	-1.125619	0.168957
	(0.28744)	(0.16016)	(111015.)	(18.4585)	(0.57390)	(0.42656)
	[1.10206]	[0.42988]	[0.59249]	[0.93914]	[-1.96134]	[0.39609]
R-squared	0.611136	0.523864	0.680581	0.629952	0.886456	0.301231
Adj. R-squared	0.355054	0.210312	0.470232	0.386262	0.811683	-0.158934
Sum sq. resids	25.99609	8.070861	3.88E+12	107203.3	103.6315	57.24964
S.E. equation	0.796273	0.443678	307537.5	51.13427	1.589842	1.181665
F-statistic	2.386490	1.670738	3.235485	2.585051	11.85530	0.654614

Log likelihood	-64.22923	-23.87506	-951.8566	-351.4257	-111.9391	-91.46612
Akaike AIC	2.673311	1.503625	28.40164	10.99785	4.056206	3.462786
Schwarz SC	3.579905	2.410219	29.30824	11.90444	4.962800	4.369380
Mean dependent	-0.003508	-0.015996	7390.812	15.46845	-0.027536	-0.143478
S.D. dependent	0.991518	0.499275	422527.8	65.27102	3.663608	1.097653

Determinant resid covariance (dof adj.)	1.52E+13
Determinant resid covariance	6.71E+11
Log likelihood	-1529.414
Akaike information criterion	49.40330
Schwarz criterion	55.06952

Table A4.8b: Vector error correction model (VECM) robustness result of output gap (1995Q4 to 2014Q1)

Vector Error Correction Estimates
Sample (adjusted): 1996Q3 2014Q1
Included observations: 71 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
$\overline{\pi}_t$ (-1)	1.000000
y_{gap} (-1)	-1.59E-06 (1.3E-05) [-0.11782]
EXR(-1)	-1.61E-06 (6.6E-07) [-2.42071]
OILP(-1)	-0.003932 (0.00250) [-1.57147]
GDEF(-1)	-0.119719 (0.08632) [-1.38694]
MSG(-1)	-0.596030 (0.10587) [-5.63004]
@TREND(95Q4)	0.068635 (0.03496) [1.96332]
C	-0.009435

Error Correction:	$D(\overline{\pi}_t)$	$D(y_{gap})$	D(EXR)	D(OILP)	D(GDEF)	D(MSG)
CointEq1	-0.417366 (0.12036) [-3.46756]	0.000000 (0.00000) [NA]	0.000000 (0.00000) [NA]	-0.328982 (6.80812) [-0.04832]	-0.763098 (0.43997) [-1.73445]	1.362852 (0.30914) [4.40852]
$D(\overline{\pi}_t$ (-1))	-0.064749 (0.13823) [-0.46842]	414.7557 (1125.24) [0.36859]	-36995.35 (56470.2) [-0.65513]	8.130843 (8.61658) [0.94363]	0.037850 (0.48397) [0.07821]	-1.346008 (0.34450) [-3.90715]

D($\overline{\pi}_t$ (-2))	0.054800	950.5779	-18160.84	2.154882	0.526488	-0.943048
	(0.13329)	(1085.09)	(54455.1)	(8.30910)	(0.46670)	(0.33221)
	[0.41112]	[0.87604]	[-0.33350]	[0.25934]	[1.12811]	[-2.83875]
D(y_{gap} (-1))	5.10E-05	0.465873	-9.092821	0.003585	-2.27E-05	-7.24E-06
	(1.8E-05)	(0.14461)	(7.25744)	(0.00111)	(6.2E-05)	(4.4E-05)
	[2.87363]	[3.22149]	[-1.25290]	[3.23736]	[-0.36438]	[-0.16363]
D(y_{gap} (-2))	-1.12E-05	-0.043665	-3.709466	-0.001762	3.77E-05	2.02E-05
	(1.6E-05)	(0.12983)	(6.51554)	(0.00099)	(5.6E-05)	(4.0E-05)
	[-0.70381]	[-0.33633]	[-0.56933]	[-1.77251]	[0.67530]	[0.50807]
D(EXR(-1))	-1.92E-07	0.000100	-0.880135	-5.53E-05	-2.63E-06	1.98E-06
	(4.2E-07)	(0.00341)	(0.17115)	(2.6E-05)	(1.5E-06)	(1.0E-06)
	[-0.45836]	[0.02931]	[-5.14248]	[-2.11583]	[-1.79177]	[1.90040]
D(EXR(-2))	2.26E-07	0.001057	-0.312593	-3.20E-05	-1.35E-06	-5.45E-08
	(3.9E-07)	(0.00318)	(0.15949)	(2.4E-05)	(1.4E-06)	(9.7E-07)
	[0.57957]	[0.33269]	[-1.95999]	[-1.31497]	[-0.98682]	[-0.05605]
D(OILP(-1))	-0.001698	53.15185	1455.598	0.417783	0.011536	0.002370
	(0.00221)	(18.0294)	(904.800)	(0.13806)	(0.00775)	(0.00552)
	[-0.76650]	[2.94807]	[1.60875]	[3.02610]	[1.48761]	[0.42942]
D(OILP(-2))	-0.006553	-27.49738	-285.7065	-0.621582	-0.002492	0.011031
	(0.00230)	(18.7258)	(939.752)	(0.14339)	(0.00805)	(0.00573)
	[-2.84861]	[-1.46842]	[-0.30402]	[-4.33481]	[-0.30935]	[1.92419]
D(GDEF(-1))	0.085080	225.9746	2595.595	4.508052	-0.523538	-0.255486
	(0.03490)	(284.145)	(14259.8)	(2.17584)	(0.12221)	(0.08699)
	[2.43748]	[0.79528]	[0.18202]	[2.07186]	[-4.28389]	[-2.93688]
D(GDEF(-2))	0.049536	283.1645	-13274.67	-0.319820	-0.340587	-0.312021
	(0.03254)	(264.885)	(13293.2)	(2.02836)	(0.11393)	(0.08110)
	[1.52235]	[1.06901]	[-0.99860]	[-0.15767]	[-2.98951]	[-3.84755]
D(MSG(-1))	-0.167381	898.3811	-6645.518	3.168362	0.174310	-0.092094
	(0.05910)	(481.127)	(24145.3)	(3.68424)	(0.20693)	(0.14730)
	[-2.83203]	[1.86724]	[-0.27523]	[0.85998]	[0.84235]	[-0.62522]
D(MSG(-2))	-0.100117	-29.86138	-13716.60	-2.562014	0.063821	-0.175872
	(0.04905)	(399.269)	(20037.2)	(3.05741)	(0.17173)	(0.12224)
	[-2.04125]	[-0.07479]	[-0.68456]	[-0.83797]	[0.37164]	[-1.43877]
C	-0.427931	-523.5838	-40988.92	6.753811	0.071649	0.712010
	(0.25315)	(2060.80)	(103421.)	(15.7806)	(0.88635)	(0.63092)
	[-1.69040]	[-0.25407]	[-0.39633]	[0.42798]	[0.08084]	[1.12852]
D_FC	0.576968	-1911.327	3415.549	11.26658	0.318126	-2.207773
	(0.29416)	(2394.60)	(120173.)	(18.3367)	(1.02992)	(0.73312)
	[1.96142]	[-0.79818]	[0.02842]	[0.61443]	[0.30888]	[-3.01148]
D_IT	0.494620	339.2245	34381.80	11.45959	-0.281178	-0.582222
	(0.27821)	(2264.78)	(113658.)	(17.3426)	(0.97408)	(0.69337)
	[1.77786]	[0.14978]	[0.30250]	[0.66078]	[-0.28866]	[-0.83969]
R-squared	0.421649	0.501673	0.469732	0.480685	0.487202	0.651720
Adj. R-squared	0.263917	0.365765	0.325114	0.339053	0.347348	0.556735
Sum sq. resids	38.71956	2.57E+09	6.46E+12	150456.7	474.6538	240.5013
S.E. equation	0.839042	6830.252	342775.0	52.30274	2.937698	2.091112
F-statistic	2.673200	3.691282	3.248078	3.393911	3.483649	6.861267
Log likelihood	-79.21975	-718.5471	-996.5627	-372.6303	-168.1913	-144.0563
Akaike AIC	2.682246	20.69147	28.52289	10.94733	5.188487	4.508627
Schwarz SC	3.192146	21.20137	29.03279	11.45723	5.698387	5.018527

Mean dependent	0.001401	-363.2096	7012.817	15.41984	0.045070	-0.022964
S.D. dependent	0.977959	8576.532	417247.6	64.33409	3.636356	3.140838

Determinant resid covariance (dof adj.)	1.76E+23
Determinant resid covariance	3.80E+22
Log likelihood	-2450.415
Akaike information criterion	71.92717
Schwarz criterion	75.20965

Table A4.9: Variance decomposition of inflation rate

2002Q1 to 2014Q2: Inflation-output growth (Model 1)							
Period	S.E.	$\overline{\pi}_t$	$\overline{y}_t$	ELECT	OILP	GDEF	MMR
1	0.750742	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.979813	90.72774	6.121501	0.706174	1.518906	0.163365	0.762310
3	1.288525	87.17580	6.408218	1.585795	2.235336	1.410302	1.184553
4	1.504590	88.57745	5.650675	1.388680	2.151186	1.286932	0.945077
5	1.722192	89.10130	4.723098	1.194804	2.343954	1.637183	0.999663
6	1.872083	89.08346	4.750969	1.150329	2.327527	1.741067	0.946650
7	2.035179	89.32889	4.293559	1.149728	2.357216	1.919541	0.951061
8	2.168431	89.63543	4.183017	1.137499	2.323796	1.830872	0.889385
9	2.309609	89.63246	4.028392	1.074751	2.398872	1.920183	0.945343
10	2.434728	89.67591	4.024871	1.079266	2.407402	1.894559	0.917988
11	2.566086	89.71928	3.903860	1.043146	2.439829	1.954604	0.939278
12	2.682335	89.76837	3.888583	1.058371	2.447555	1.918676	0.918449
2002Q1 to 2014Q2: Inflation-output gap (Model 2)							
Period	S.E.	$\overline{\pi}_t$	y_{gap}	ELECT	EXR	GDEF	MSG
1	0.768843	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000
2	1.063835	88.88893	2.562753	3.313496	1.193176	3.108722	0.932921
3	1.266991	86.77720	1.854497	3.492036	1.935921	5.279901	0.660440
4	1.448691	88.07663	2.619171	2.671256	1.654556	4.216484	0.761899
5	1.637592	88.74303	3.451513	2.480991	1.318071	3.404525	0.601874
6	1.811581	88.41357	3.212454	2.109010	1.095213	4.554378	0.615371
7	1.957854	88.87015	2.750468	1.806463	1.251943	4.792849	0.528127
8	2.078266	89.39332	2.765246	1.612810	1.265162	4.430845	0.532618
9	2.185447	89.52847	3.070123	1.677722	1.159759	4.081269	0.482660
10	2.310320	89.63878	2.929029	1.510136	1.045157	4.380020	0.496878
11	2.427419	89.84316	2.666750	1.381585	1.108735	4.545649	0.454120
12	2.525241	90.08083	2.595050	1.286749	1.174932	4.416916	0.445522
1995Q4 to 2014Q1: Inflation-output growth (Model 3)							
Period	S.E.	$\overline{\pi}_t$	$\overline{y}_t$	EXR	OILP	GDEF	TBR
1	0.796273	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000
2	1.023533	72.92031	12.92245	0.881493	3.423715	4.800871	5.051161
3	1.119552	61.02805	11.30112	7.346816	11.64422	4.429127	4.250658
4	1.142098	59.11625	10.90494	7.562591	13.60735	4.438002	4.370858
5	1.199654	53.86475	10.21211	8.643827	18.99780	4.214455	4.067065

6	1.281290	47.21982	12.38215	7.735776	24.12375	4.366563	4.171946
7	1.322720	46.65639	13.04759	7.346088	24.65549	4.260986	4.033453
8	1.354131	44.51857	15.08547	7.029870	25.01333	4.072426	4.280333
9	1.393015	42.06847	16.36275	6.646629	26.19893	4.400599	4.322621
10	1.423311	40.31092	18.69624	6.597263	25.70057	4.409923	4.285083
11	1.440295	39.96156	19.20610	6.591060	25.22548	4.471495	4.544316
12	1.452412	39.29791	19.82473	7.172742	24.81612	4.413714	4.474793
1995Q4 to 2014Q1: Inflation-output gap (Model 4)							
Period	S.E.	$\overline{\pi}_t$	y_{gap}	EXR	OILP	GDEF	MSG
1	0.839042	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000
2	1.075742	82.89996	11.46145	2.381753	0.113990	0.981690	2.161159
3	1.277104	72.36825	12.07632	4.848560	0.735288	0.738187	9.233402
4	1.407405	68.99130	11.02748	5.661223	0.639629	2.154793	11.52557
5	1.498211	69.09162	10.49168	6.454512	0.659037	2.637951	10.66520
6	1.596994	69.61804	10.44517	6.426715	0.692715	2.323875	10.49348
7	1.709710	69.22405	10.60282	6.366416	0.605160	2.027826	11.17372
8	1.801354	68.76757	10.64265	6.515143	0.574137	2.040716	11.45978
9	1.879531	68.79205	10.44442	6.788207	0.536665	2.030066	11.40859
10	1.959141	68.86205	10.25724	6.975850	0.495253	1.907426	11.50218
11	2.040868	68.80507	10.20914	7.047794	0.460175	1.810613	11.66721
12	2.117299	68.74486	10.23121	7.100273	0.427644	1.765822	11.73018

Appendix B: Figures

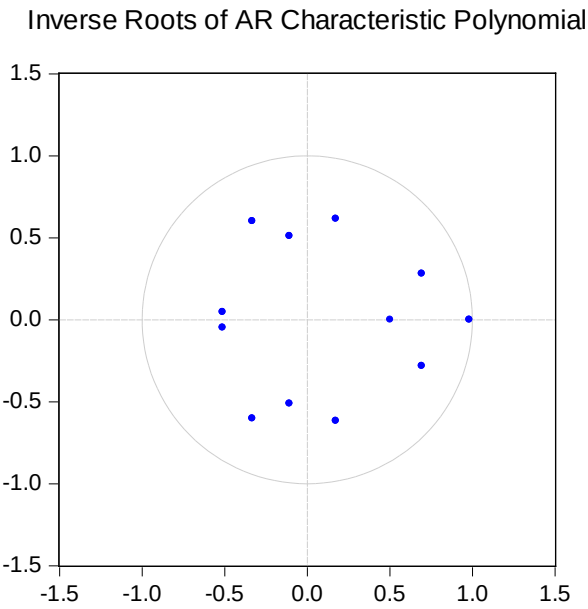

Figure B4.1: Stability of VAR for output growth.

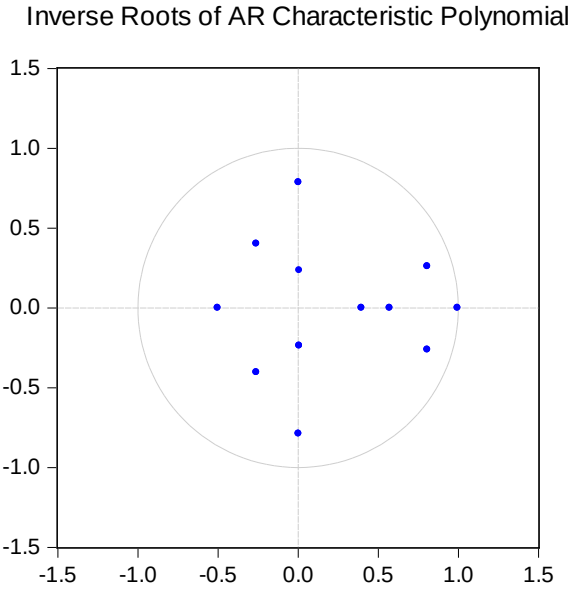

Figure B4.2: Stability of VAR for output gap.

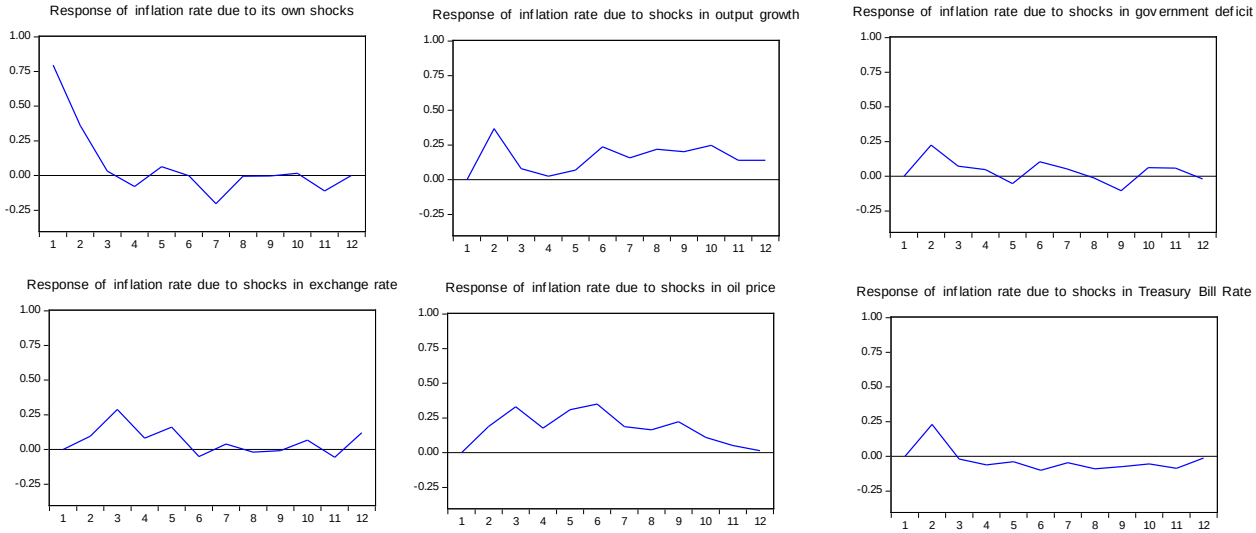

Figure B4.3: Response of Inflation Rate to one standard deviation shock over a 12-quarter period.

CHAPTER 5

THE INFLATION-OUTPUT GROWTH THRESHOLD IN SOUTH AFRICA[25].

Following from the previous chapters which concluded that there is no evidence of the existence of Phillips curve (PC) trade-off in South Africa, when the effects of the demand-side variables on inflation rate were examined; the current chapter observes the effect of inflation rate on output growth. The nonlinearity of inflation-output growth model is explored in order to observe whether an inflexion point, which is the point or band where inflation becomes detrimental to output growth, exists between them. The inflation threshold is important in assisting monetary policy makers to set the right inflation target band as well as give an indication of when the economy is heating up.

5.1 INTRODUCTION

Inflation targeting (IT) framework is the heart of the new Keynesian monetary policy. The main characteristics of the framework include an official announcement of a numeric inflation target; design of monetary policy to achieve this goal, transparency and accountability. This framework has been widely accepted by many industrialized countries and emerging economies. It is perceived as a way of curbing the consequences of high inflation rate which generally leads to inefficient allocation of resources as well as low productivity growth. The number of countries that adopted inflation targeting has increased since its inception in 1990 led by New Zealand and many countries of the world have now adopted this framework, such that by 1993, five countries formally targeted inflation and by 1998, it increased to ten countries.

There are over twenty countries that currently adhere to inflation targetingframework, starting with New Zealand in 1990 and Albania in 2009 (Mishkin, 2001; Pétursson, 2004; Roger, 2010; Jahan, 2012). While some countries like Finland, Spain and Slovak Republic adopted the framework but it was abandoned when they adopted the euro as the domestic currency

[25] Leshoro, T. and Kollamparambil, U., 2016, 'Estimating a growth-maximising inflation targeting band for South Africa', International Journal of Economic Policy in Emerging Economies (IJEPEE), in press. This is a joint publication with my supervisor; my contribution is 80%.

(Roger, 2010; Jahan, 2012). On the other hand, Botswana described its policy as an objective rather than a target; hence they introduced medium-term inflation objective of 3 to 6 percent in 2002, which is measured over a three-year rolling period (BoB, 2015). However, Ghana informally adopted the framework in 2002 and formally in 2007 with the target horizon of 18 to 24 months period (Hammond, 2012).

The objective of many economies, including South Africa is to achieve low and stable prices alongside high and stable output levels. South Africa was the first African country to officially adopt the inflation targeting framework (Pétursson, 2004). The South African monetary policy system underwent a change through the formal adoption of inflation targeting in February 2000. The single digit inflation target band was set by the government, after consultation with the South African Reserve Bank (SARB), at three to six percent, to be achieved by 2002 and this band has been targeted since the IT adoption (Hammond, 2012) [26].

The target band was decided upon by using the calendar year average rate of increase in the CPIX for 2002 as well as for the subsequent year. A multi-year target approach was therefore adopted by using an average annual inflation rate increase of three to six percent in 2002 and 2003 and three to five percent for 2004 and 2005. When the monetary authorities realised that the three to five percent band would not be achieved due to a sharp depreciation in the rand value, they increased the band to three to six percent in 2005 (Van der Merwe, 2004).

However, in late 2003, the Minister of Finance announced that the SARB will do away with the calendar-year average because it caused difficulties in the implementation of the inflation targeting framework and thus led to inconsistencies in the monetary policy. The SARB therefore simply applied a continuous target of three to six percent from 2006 (SARB, 2016). In September 2003, the inflation rate moved into and remained within the set target band till 2007. After that period, the upper target band of six percent was breached occasionally, for instance from 2008 to late 2009 as a result of the global crisis as well as 2013 and 2014 due to increase in food and petrol prices (IMF, 2008: 11; SARB, 2014; SARB, 2015).

[26] Different target measures, such as the CPIX, which is the consumer price index for metropolitan and other urban areas, excluding the mortgage bond interest, and later the headline CPI were used since the introduction of the target band.

Furthermore inflation rate is one of the major economic variables and its effect on the economic activity of any country has received considerable attention in the macroeconomic paradigm. Its importance comes as a result of its determinacy of the stability of an economy. Hence, with the relationship between inflation and a country's economic activity, a sustainable economic growth can be achieved by properly manipulating both the monetary policy and the fiscal policy. Nevertheless, there is no conclusion reached concerning the relationship between inflation and economic growth.

While some studies found negative relationship between these variables (Vaona, 2012; Ocran, 2007; Hodge, 2006; Fischer, 1993) others concluded that positive relationship exists between them (Mallik and Chowdhury, 2001) and yet others found no relationship (Erbaykal and Okuyan, 2008; Faria and Carneiro, 2001). However, a growing number of literature has recently focused on the non-linearity of the inflation-growth nexus, as well as inflation-finance relationship (Sarel, 1996; Ghosh and Phillips, 1998; Khan and Senhadji, 2001; Rousseau and Wachtel, 2002; Burdekin *et.al*, 2004; Pollin and Zhu, 2005; Omay and Kan, 2010; Phiri, 2010; Leshoro, 2012).

Seeing the importance of curbing inflation in South Africa coupled with the fact that no conclusion was reached on the relationship between inflation and output growth, it is imperative to further observe the relationship between these variables. It is equally important to empirically determine the level at which the effect of inflation rate becomes detrimental on output growth in South Africa. The threshold result will inform particularly the monetary policy committee of the SARB of the level or band at which inflation target should be set; which should be slightly lower than inflation threshold. Doguwa (2012) suggested that inflation target should be set lower than the level of the inflation threshold, as there is quite a distinction between these two concepts. While inflation threshold is the turning point whereby inflation changes from positive to negative or vice versa, inflation target is the monetary policy goal that monetary authorities announce and thus use applicable policy tools to direct its policy to achieve such goal.

Therefore, the result obtained from the threshold will give an indication of what the inflation target level or band should be. It is important to note that, even though the inflation target framework is quite important in any economy, it is equally important to re-examine it

periodically because the circumstances of any given country do not stay the same. Since the adoption of the inflation target band, the SARB has not changed the band, even during the periods where the upper target was breached. If threshold results obtained are different from the current target band, it will be advisable that monetary authorities consider changing the current band in order to fully benefit from the positive effect of inflation on output growth in South Africa.

The rest of this chapter is organised as follows: stylized facts on the trend in South African economic growth is presented in section 5.2, followed by the discussion on growth theories in section 5.3, to identify the variables that will be included in the output growth model. Section 5.4 reviews empirical studies on inflation threshold, while data and methodology are presented in section 5.5. This is followed by the analysis of results in section 5.6. Conclusion and policy recommendations are presented in section 5.7.

5.2 TREND IN THE ECONOMIC ACTIVITY OF SOUTH AFRICA: 1990 – 2014

This section discusses the trends in the economic growth. It is important to observe the movement in this variable in order to know how the economy performed over time.

After three consecutive years of decline in the growth rate of real gross domestic product (GDP), there was a positive outlook in 1993. There were decreases of 0.5 percent, 0.4 percent and 2.1 percent in real GDP in the years 1990, 1991 and 1992 respectively (Central Statistical Service, 1993). Real GDP increased by 1.3 percent in 1993 compared to the previous year. The country experienced the first positive annual growth rate since 1989 when it grew by 2.3 percent in 1993. . The reason for the increased GDP in that year was mainly due to increases in agricultural yields. If the agricultural sector contribution was to be excluded, real GDP only increased by 0.3 percent compared to the previous year (Central Statistical Service, 1993).

The following year also experienced a greater increase in the real GDP by 2.7 percent (Central Statistical Service, 1994). Higher growth of 3.3 percent was further recorded in 1995. This was the highest rate since 1988 when the real GDP growth was 4.2 percent. The

manufacturing, trade and transport sectors contributed 7.6 percent, 6.1 percent and 4.7 percent respectively to the increased growth, while agricultural and mining sectors experienced a decline in production. There was an increase in growth of three percent in the third quarter of 1995 and the last quarter had a marginal decline of 2.7 percent. The decline in the fourth quarter was mainly attributed to the decrease in the manufacturing sector by 2.8 percent, although other sectors recorded increased positive rates.

Furthermore, there was a decline of 3.2 percent in 1996 in the growth rate and a further decline of 1.7 percent in 1997 (Central Statistical Service, 1997). This fall was ascribed to a sharp fall in the agricultural sector contribution. The average annual growth rate of this sector declined from 29.1 percent in 1996 to -1 percent in 1997. In the last two quarters of 1997, there was a confirmed economic activity slowdown whereby the economy only grew by 0.3 percent. The reason for the low economic growth in the last quarter was the low contributions of the major sectors that constitute about 60 percent of the total GDP. These sectors are agriculture with -0.2 percent, manufacturing with -0.5 percent, trade with -0.4 percent and general government with -0.4 percent.

Meanwhile, there were trifling increases in the real GDP, with 1999 seeing an annual increase of 1.7 percent. The four quarters recorded gradual increases in real GDP of respectively 1.1 percent, 2.1 percent, 3.2 percent and 3.6 percent. The increase in the economic activity was due to the increased contributions from the following sectors; transport and communication, which increased by 0.6 percent, and finance and real estate recording an increase of 0.5 percent (Statistics South Africa, 1999). However, in 2000, the real growth rate increased by over 3 percent compared to 1999. The main contributors to the increase in the economic activity were finance, real estate and business services (0.8 percent), manufacturing (0.7 percent), transport and communication (0.6 percent) and wholesale and retail trade, hotels and restaurants (0.6 percent). While the contribution from agricultural sector was quite low at 0.1 percent, mining sector recorded a negative growth of -0.1 percent and general government also had a negative growth of -0.2 percent (StatsSA, 2000).

In years 2001 and 2002, economic activity increased further by 2.8 percent and 3.0 respectively. The fourth quarter of 2002 had real GDP increase by 2.4 percent compared to the increase in the third quarter of 2.9 percent. The real GDP for 2002 increased due to the

contributions from the manufacturing as well as finance, real estate and business services industries with 0.7 percent each. This was followed by the contributions from transport and communication with 0.6 percent and wholesale and retail trade, hotels and restaurants with 0.3 percent. Once again agricultural sector had low contribution of 0.2 percent, with general government contributing 0.1 percent. The mining sector did not contribute anything to economic activity during this period. This was because the mining sector recorded a decrease of 0.1 percent in the last quarter as a result of a decrease in the production of gold and metal ores (StatsSA, 2002).

The country continued to experience increased positive growths in the early to the late 2000s, where real GDP growth increased by 3.7 percent in 2004, 5.1 percent in the following year, and a further 5.4 percent in 2006. The economic growth rate of the last quarter of 2006 increased by 5.6 percent compared to the 4.5 percent increase in the third quarter. The major contributors in all these years were transport and communication, finance, real estate and business services and wholesale and retail trade, hotels and restaurants.

However, in the last quarter of 2008, there was a decline in economic activity. Real GDP decreased by 1.8 percent. The fall in economic activity in that quarter was attributed to the major decline in manufacturing sector by 3.5 percent, electricity, gas and water declined by 0.1 percent. Wholesale and retail trade, hotels and restaurants industry and the mining sectors each contributed zero percent. The other sectors had quite low positive contributions and their contributions were outweighed by the fall in the other sectors that recorded negative contributions. These sectors were finance, real estate and business services as well as general government having a contribution of 0.6 percent each; agriculture with 0.5 percent, construction with 0.4 percent and transport and communication with 0.2 percent (StatsSA, 2008). In year 2008, the real GDP fell by 3.1 percent, compared to 5.1 percent in 2007. Mining recorded a negative contribution of -0.3 percent, with electricity and gas having zero percent contribution. This was the advent of the global financial crisis.

The real GDP further decreased by 1.8 percent in 2009. The negative contributions of the following sectors, manufacturing with -1.8 percent, mining having -0.4 percent, wholesale, retail, motor trade and accommodation with -0.3 percent, led to the decline in economic activity. After 2009, the economy started regaining momentum and real GDP growth

increasing, even though it had been volatile. It increased gradually by 3.1 percent in 2011 compared to 2010 which increased by 2.8 percent. Although, there was a fall in the growth rate in 2013, it was a positive growth, whereby it increased by 1.9 percent.

Furthermore, the real GDP growth for the third quarter of 2014 increased by 1.4 percent compared to the second quarter, which increased by 0.6 percent. The sectors that contributed to the increased economic activity were finance, real estate and business services as well as the wholesale, retail and motor trade; catering and accommodation with 0.5 percent each, general government with 0.3 percent, agriculture, forestry and fishing industry and the transport, and communication each having 0.2 percent (StatsSA, 2013; StatsSA, 2014).

The increased production of field crops and animal products contributed to the growth in the agricultural sector. The increased activities in the financial markets constituted the growth in the finance, real estate and business sector. Meanwhile, there was a negative contribution of -3.4 percent from the manufacturing industry, as a result of lower production in the basic iron and steel, non-ferrous metal products, petroleum, chemical products, rubber and plastic products, wood and wood products and paper (StatsSA, 2014). The country rebased the national account estimates at constant prices in 2014, changing the base year from 2005 to 2010. The rebasing is historically done every five years.

5.3 A BRIEF DISCUSSION OF GROWTH THEORIES

Economic growth is the sustained increase in the real national income and output over a period of time brought about by the productive capacity of an economy (Hardwick, Khan and Langmead, 1990:406; Todaro and Smith, 2009:821). The three prime important determinants of economic growth of any economy are: (1) population growth which translates to the growth in the labour force; (2) accumulation of capital (capital growth rate) and (3) technological process. There are however, different theorists who believed that economic growth are determined by many other factors. These are the classical, the neoclassical and the endogenous growth (or new growth) theories. The neoclassical and the endogenous growth theories emerged from the classical model.

The classical economists include Adam Smith (1776), David Ricardo (1817), Thomas Malthus (1798) and Joseph Schumpeter (1934). These economists provided many of the determinants of economic growth that appear in the later models. Some of the determinants include the accumulation of human and physical capital, the interaction between the growth rate of population and income per capita as well as the technological progress. Ramsey (1928) introduced the intertemporal utility function which only became widely used in the 1960s, but it is as important as the Cobb-Douglas production function. Ramsey's approach was widely applicable to other theories far beyond growth theory, such as consumption theory, the theory of business cycle and asset pricing.

Furthermore, Harrod (1939) and Domar (1946) theories, which became the Harrod-Domar growth model, placed emphasis on labour and capital as the two factors of production that are not substitutable; the non-substitutability became the major drawback of this theory. Other assumptions of this model include closed economy, whereby government and foreign trade are excluded (Edgmand, 1987:358; Hardwick, *et.al*, 1990:408). Harod-Domar growth model is a basic model which stresses the importance of savings and investment in determining economic growth. In its simplest terms, the model states that increase in capital-output ratio (investment) resulting from the abstention from consumption will result in economic growth (Ray, 1998:51, 55). According to the model, savings and investment are functions of income and are equal at equilibrium as follows (Todaro and Smith, 2003:113 – 114)[27]:

$$\frac{Y_t - Y_{t-1}}{Y_t} = \frac{s}{k}$$

$$\frac{\Delta Y_t}{Y_t} = \frac{s}{k} \qquad \ldots\{5.1\}$$

The expression, $\frac{\Delta Y_t}{Y_t}$, is the growth rate of output (or the warranted growth rate) which is equal to the capital output ratio, $\frac{s}{k}$ (Hardwick, *et.al*, 1990).

Another growth model of Solow (1956) and Swan (1956) modified the Harrod-Domar growth model by allowing for capital-labour substitution (Todaro and Smith, 2009:147). The Solow-

[27] The derivation of the model is shown in the appendix.

Swan Neoclassical growth model is based on the premise of conditional convergence, whereby the lower the starting level of per capita GDP, the faster the growth rate will increase in relation to the long-run (Barro and Sala-i-Martin, 2004: 17). This model also assumes that savings and investment are equal at equilibrium (Edgmand, 1987:361 – 362). The model further postulates a particular type of Cobb-Douglas production function with three driving forces as follows:

$$Y = Ae^{rt}K^{\alpha}N^{1-\alpha} \qquad (0 < \alpha < 1) \qquad ...\{5.2\}$$

Where, Y is output; K is the capital stock, N is the number workers employed (labour) and Ae^{rt} represents technology, whereby A is a positive constant, *r* is technological rate and *t* is time.

The output growth model derived from the production function is:

$$y = r + \alpha k + (1-\alpha)n \qquad \ldots\{5.3\}$$

Where *r, k* and *n* respectively represent technology, capital and labour and all these factors are positively related to the growth rate of output, *y*.

Some of the characteristics of the Cobb-Douglas production function of the basic neoclassical model include constant returns to scale and the diminishing returns to the factors of production. Given these characteristics, the Solow-Swan model also predicts that if technological improvement ceases, per capital growth will stop. Cass (1965) and Koopmans (1965) completed the neoclassical growth model and including the Ramsey's consumer optimization function in the neoclassical model. This therefore provides richer transitional dynamics, while maintaining the conditional convergence. The model also believed that the long-run per capita growth rate depends on the technological progress (Barro and Sala-i-Martin, 2004:18).

The dissatisfaction with the traditional growth theory (the basic neoclassical growth model) in explaining the sources of economic growth in the long-run led to the development of the endogenous growth theory. While the endogenous growth models are structurally similar in some instances with the neoclassical model, their underlying assumptions and conclusions are different (Todaro and Smith, 2009: 152). The endogenous growth model that is similar to the Harrod-Domar model is expressed as:

$$Y=AK \qquad \ldots\{5.4\}$$

This model shows that A represents all the factors that affect technology and K is both human and physical capital.

However, this formula excludes the diminishing returns to capital. The assumption is that investing in both human and physical capital will bring about improved productivity that will exceed private gains. This in turn offsets the diminishing returns, which results in sustained long-term growth; this was excluded in the traditional neoclassical growth theory. Although the endogenous growth model further stresses the importance of savings and technology, it differs from the traditional growth model by stating that the national growth rates of each country will remain constant and differ across the countries depending on the level of the national savings rates and technology (Todaro and Smith, 2009: 152). Romer (1986), one of the proponents of the endogenous growth model, emphasised the following as the determinants of economic growth; technological spillovers, which occur when the productivity gains of one firm or industry leads to the productivity gains of another firm or industry, investment in human capital (education), infrastructure and research and development (R&D) (Sala-i-Martin, 1997; Barro and Sala-i-Martin, 2004:20; Todaro and Smith, 2009: 153).

Lastly, new developments in the endogenous growth theory of Romer (1986) and Lucas (1988) stressed the importance of international trade in fostering economic growth and development. Theoretically, it was believed that there exists a positive relationship between trade and economic growth. This theory postulated that an economy can experience increased economic growth with less trade barriers through the following: developing nations increasing its absorption (or higher degree of openness) of technology developed in advanced countries, increased R&D benefits, more specialisation and efficiency in producing intermediate inputs, which leads to increase in the production of new products and services (Salvatore, 2014: 324).

Other means through which trade openness can enhance economic growth are to encourage increased economies of scale in production by encouraging domestic producers to efficiently use their resources in order to meet foreign demand and reduce price distortions (Salvatore, 2014: 323, 324). In general, although trade cannot be expected to be the “engine of growth”,

it still contributes significantly to the economic growth of many developing nations through the comparative advantage of Heckscher-Ohlin theorem[28] (Salvatore, 2014: 323).

5.4 LITERATURE REVIEW

Given the various theories of growth discussed above, this section reviews the empirical inflation-output growth nexus followed by gaps identified in the literature.

5.4.1 Empirical review of inflation threshold

The relationship between these variables is observed in terms of the non-linearity that exists between them. Fischer (1993) was among the first to identify the possible inflexion or threshold point for the inflation-growth nexus. This is the point where the relationship between inflation and output growth variables changes from positive at low levels of inflation rate to negative at high levels of inflation rate or vice versa. Economic theory proposes that some major economic variables exhibit a non-linear behavior and it is important to examine such variables in order to observe their level of non-linearity (Enders, 2004: 387).

Fischer (1993) and Bruno and Easterly (1995, 1998) are the proponents of the nonlinear relationship between inflation and growth where their empirical studies focused on identifying such nonlinearities by observing the effects of inflation on economic welfare. Bruno and Easterly used a spline regression function on a panel of twenty-six countries, using annual data spanning over the period 1961 to 1992. They found inflation threshold band of twenty to thirty percent and concluded that inflation rate within this band is favourable. Once inflation rate increases to a high of forty percent, it becomes detrimental to economic growth. Their study thus confirmed the nonlinearity of inflation-growth nexus, whereby inflation rate higher than a threshold of forty percent negatively affects growth.

They however concluded that there exists some form of ambiguity between inflation and output growth at low levels of inflation rate. This is because inconsistent and inconclusive

[28] The Heckscher-Ohlin Theorem states that "*a nation will export the commodity whose production requires the intensive use of the nation's relatively abundant and cheap factor and import the commodity whose production requires the intensive use of the nation's relatively scarce and expensive factor"* (Salvatore, 2014: 112)

result was obtained for the relationship between inflation and output growth for inflation rate below the threshold point of forty percent. These studies however failed to obtain a threshold point at which economic growth could be maximized. Barro (1995) found a negative relationship between inflation and output growth using instrumental variables (IV) technique. The study was carried out on a panel of a hundred countries over the period 1960 to 1990. The results showed that the real GDP per capital will fall by 0.2 percent per year given an increase in average inflation rate of ten percentage points.

In determining whether inflation is detrimental to growth and the level therein, the following studies found the existence of a non-linear relationship between inflation and output growth. Sarel (1996) explored the effect of non-linear inflation-growth nexus, using a fixed-effect ordinary least squares (OLS) technique. Annual data spanning over the period 1970 to 1990 was adopted for a panel of eighty-seven countries. The study found the existence of a structural break with the inflation threshold obtained at eight percent level. The results also showed a significant and robust negative impact of inflation rate on growth at inflation levels higher than eight percent.

Furthermore, Khan and Senhadji (2001) used a conditional least squares (CLS) method to investigate the relationship between inflation and investment as a share of gross domestic product (GDP) along with other variables. This is a commonly-used technique whereby the explanatory power is determined when the residual sum of squares (RSS) is minimized or the coefficient of determination (Adjusted R-squared) is maximized conditional on a particular threshold level. Their study was based on over a hundred and forty industrialized and developing countries using annual data from 1960 to 1998. Li (2006) also studied the relationship between output growth and inflation rate, using the ordinary least squares fixed-effect technique. The study considered ninety developing and twenty eight industrialized countries with data spanning over the period 1961 to 2004.

The result obtained by Khan and Senhadji (2001) showed the inflexion band of between one to three percent for industrialized countries; it was high at eleven to twelve percent for developing countries. On the other hand, Li (2006) found two threshold points for developing countries; these are fourteen percent and thirty eight percent. The first point (fourteen percent) was relatively close to the findings of Khan and Senhadji, but the difference in the

result found for the industrialised countries was quite vast, whereby Li (2006) found twenty four percent as the threshold. The reason for the dissimilarity in results could be the difference in the number of countries considered as well as the time period.

Pollin and Zhu (2005) introduced non-linearity in two ways while estimating a cross-country non-linear inflation threshold model over eighty countries grouped under Organisation for Economic Co-operation and Development (OECD), middle income (including South Africa), non-OECD high income and low income countries. They followed Bruno-Easterly framework by firstly excluding all observations with inflation rate higher than 40 percent from their data set. This is because they accepted the findings of Bruno and Easterly (1995) of high inflation producing negative effect on growth. Secondly, they used a quadratic function approach whereby the squared term of inflation variable enters the growth model; this is also a widely-used method of non-linear estimation. Using data spanning over the period 1961 – 2000, their results showed that the inflation threshold for middle-income countries and low-income countries is between fourteen and sixteen percent and between fifteen and twenty three percent band respectively.

In addition, Ghazouani (2012) investigated the non-linear relationship between inflation and growth on 19 Middle-East and North African (MENA) countries. A dynamic panel threshold model was estimated using a Generalized Method of Moments (GMM) technique. The results obtained showed that the turning point of inflation is ten percent above which a significant negative effect on growth occurs. Tarawalie *et.al* (2012) estimated the inflation threshold levels for the West African Monetary Zone (WAMZ) countries (Gambia, Guinea, Ghana, Liberia, Nigeria and Sierra Leone) using the conditional least squares method of Khan and Senhadji (2001). The inflation threshold found was in the range of ten percent for all the countries, although different data sample[29] range was used due to the problems of data availability in these countries.

Moreover, there are country-specific studies that focused on the non-linear relationship between output growth and inflation rate (Sweidan, 2004; Frimpong and Oteng-Abayie,

[29] Data sample from 1970 to 2010 was used for Ghana, Nigeria and Sierra Leone, while the other three countries were based on data from 1980 – 2010.

2010; Salami and Kelikume, 2010; Bassey and Onwioduokit, 2011; and Doguwa, 2012; Phiri, 2013). But these studies did not reach any conclusive result. In a country-specific study, Doguwa (2012) estimated the inflation threshold model for Nigeria, using quarterly data over the period 2005 to 2012. Three techniques were adopted to estimate the nonlinear relationship between real GDP growth and inflation rate.

These techniques are the fixed-effect OLS method of Sarel (1996), the conditional least squares of Khan and Senhadji (2001), and the sequential estimation procedure of Drukker, Gomis-Porqueras and Hernandez-Verme (2005), which selects the model that minimizes the Bayesian Information Criteria (BIC). While, the fixed-effect technique of Sarel was found to be inconsistent, the other two techniques put together suggested two threshold points of ten and a half percent and twelve percent. Meanwhile, the threshold band obtained by Salami and Kelikume (2010) was between seven and eight percent, while Bassey and Onwioduokit (2011) found a threshold of eighteen percent, but was insignificant. The results obtained in these studies differ significantly for the same country, Nigeria.

Furthermore, Jayaraman, Chen and Bhatt (2013) estimated the inflation threshold level of growth for Fiji. The study found that the inflation threshold beyond which output growth will decrease in Fiji is 3.6 percent, although the Reserve Bank has capped it at 0.5 percent. They used the nonlinear least squares (NLS) method on annual data from 1970 to 2008 and real GDP per labour was used in place of output growth.

Phiri (2013) estimated the non-linear inflation-growth nexus for Zambia using Hansen's (2000) sequential estimation procedure of threshold autoregressive (TAR) and Khan and Senhadji's (2001) CLS techniques.Although, this study observed the causal relationships among the variables considered, it was not used to observe the determining variable in order to avoid the problem of endogeneity. The study adopted quarterly data over the period 1998 to 2011. Obtained results showed that 22.5 percent is the level at which the positive effect of inflation on growth is maximized. The study further indicated that the effect of inflation on economic growth will be negative at any inflation level higher than 22.5 percent. The study therefore concluded that Zambia is able to accommodate moderately high inflation rate in order to experience more economic growth.

Phiri (2010) examined the relationship between inflation-finance and Leshoro (2012) investigated the inflation-growth threshold in South Africa. Phiri used real GDP growth and inflation along with other financial variables to test the inflation inflexion point that is unfavourable for finance-growth activity in South Africa. The study by Phiri used the conditional least squares (CLS) technique and two-stage least squares instrumental variables (2SLS-IV) technique for robustness while adopting quarterly data spanning over 2000 to 2010. The threshold point of eight percent was obtained. This is quite different from the results obtained in the cross-country studies.

Along the same line, Leshoro (2012) estimated the non-linear inflation-growth model, using quarterly data from 1980 to 2010. The conditional least squares (CLS) technique of Khan and Senhadji (2001) was adopted and two-stage least squares instrumental variables (2SLS-IV) method was used for robustness check in addition to using Granger causality test to determine the causal relationship between inflation and GDP growth. The study found an inflation threshold level of four percent. The study further showed that at an inflation rate of four percent and less, economic growth is positively affected, while it is adversely affected when inflation rate is above the threshold of four percent.

Meanwhile, Adusei (2012) re-estimated the inflation-growth nexus in order to examine the inflation level at which it is detrimental to growth. The same technique as Phiri (2010) and annual data from 1965 to 2010 were adopted. The results obtained showed that inflation threshold is seven percent such that holding inflation rate below this level could promote growth in the country. The threshold levels obtained from these studies for South Africa are quite different.

5.4.2 Literature Gap

The previous studies on South Africa used single techniques that only provide inflation threshold point or level and not a band; meanwhile inflation threshold can either be a point or band. This study therefore used more applicable techniques of threshold autoregressive (TAR) and sample splitting threshold regression (SSTR) to obtain the inflation threshold band and for the robustness of results. A band is more applicable in the case of South Africa

because the SARB adopted an inflation targeting framework of three to six percent band and not a single point.

In addition, the control variables that were considered in this study are quite different and more applicable to growth determinants in South Africa than in previous studies. For instance, Phiri (2010) focused on the inflation threshold of finance-growth nexus, thus using financial variables, such as equity, financial market activity proxied by bank credits, exchange rate and capital accumulation, Leshoro (2012) only used physical capital and terms of trade as the control variables, while Adusei (2012) included only financial development and economic openness. Thus, this study estimated the inflation-growth nexus using the growth applicable determinants. Lastly, this study started by checking whether threshold exists at all in the first place, which was also omitted in the previous studies on South Africa. Before a threshold analysis is carried out, a test for non-linearity required to be done and not assumed.

In conclusion, the monetary policy debate around the targeting of inflation rate within a specified band and the argument of the Congress of South African Trade Unions (Cosatu) that the use of repo rate has negatively affected employment and hence the economy at large, prompted the focus of this study. Also, based on the findings of Michie and Padayachee (1998), Weeks (1999) and Hodge (2006), the authors argued that moderately higher inflation rate will not be harmful to the economy; instead, policies accommodating such will cause higher growth and lower unemployment rate. They further argued that there exists non-linear relationship between these variables whereby a positive relationship exists below a certain threshold and in the medium to long term, there is a negative relationship.

However, the aim of this study is to provide an inflation band beyond which the economic growth is inversely affected, while giving an indication of when the economy is over-heating. The level of inflation that monetary authorities should consider targeting was thus suggested. It is imperative for any economy to periodically re-examine its target band because any economy's circumstances change. The result obtained from this study will therefore assist policy makers to properly set the inflation target band, in such a way that is not detrimental to economic growth in South Africa and the economy at large.

5.5 DATA AND METHODOLOGY

5.5.1 Model Specification

The following output growth model was estimated:

$$\Delta y_t = \alpha_0 + \alpha_{1t}\bar{\pi}_t + \beta_{it}Z_t + \mu_t \quad \ldots\{5.5\}$$

Where Δy_t is the growth rate of real Gross Domestic Product (GDP), $\bar{\pi}_t$ is the inflation rate and Z_t is the vector of control variables, α_0 and α_1 are respectively the constant and inflation coefficient, β_i is the vector coefficient which ranges from 1 to 4. Since this chapter aims to obtain the threshold target band of inflation in the output growth model, the choice of variables are guided by the growth theories highlighted above.

Therefore, the expanded growth model to be estimated is as follows:

$$\Delta y_t = \underset{+/-}{\alpha_0 + \alpha_1\bar{\pi}_t} + \underset{+}{\beta_{2t}INV_t} + \underset{+}{\beta_{3t}OPEN_t} + \underset{+}{\beta_{4t}INFRA_t} + \underset{+}{\beta_{5t}HC_TE_t} + \mu_t \quad \ldots\{5.6\}$$

Where INV is investment, which is measured as the ratio of gross fixed capital formation to GDP, following Harod-Domar growth model for physical capital; OPEN represents the trade-openness, used as a proxy for research and development, which captures the transfer of knowledge and efficiency gains as used by Pattillo, Poirson and Ricci (2002). This is also in line with the Romer (1986) and Lucas (1988) endogenous growth theory which proposed that an economy can experience increased economic growth with less trade barriers through increased R&D benefits; INFRA is an index of electricity consumption per 100 people and telephone subscription per 100 people, to capture infrastructure; HC is human capital which is proxied by the rate of enrolment in tertiary education. Other variables are as earlier defined. The theoretically expected signs are shown below each variable. Annual data ranging from 1969 to 2014 will be used[30]. A bivariate atheoretical model will also be estimated, using post inflation targeting regime quarterly data from 2001Q1 to 2014Q2. This estimation will be used to confirm the robustness of the result obtained from the annual data.

[30] The missing data points in some of the variables were calculated using linear interpolation method.

5.5.2 Variable descriptions and data sources

The inflation-growth threshold was estimated in this chapter, in order to observe the level above which inflation is detrimental to economic growth. The definitions and sources of the variables that were used are presented in table 5.1 below.

Table 5.1: Variables and their definitions for inflation-growth threshold model.

Variables	Variable definition	Source
Output growth, $\Delta \bar{y}_t$	Growth rate of real GDP (2010 prices) (measured in %).	WDI
Inflation, $\bar{\pi}_t$	Inflation rate derived from the consumer price index (2010 prices) (measured in %).	WDI
Investment, *INV*	Ratio of gross fixed capital formation to GDP (measured in %).	WDI
Trade openness, *OPEN*	Trade openness is ratio of the sum of exports and imports to GDP (measured in %).	WDI
Infrastructure, *INFRA*	Index of electricity consumption (per 100 people) and fixed telephone subscription (per 100 people).	WDI
Human Capital, *HC_TE*	Rate of enrolment in tertiary education.	UNESCO IS

WDI is the World Development Index database; UNESCO IS is the United Nations Educational, Scientific and Cultural Organization Institute for Statistics, Education statistics database.

5.5.3 Preliminary Estimations

It is important to test the variables for stationarity as most economic variables are non-stationary and hence result in misleading results. If different orders of integration are found, the model will be tested for cointegration. The third preliminary test is to observe if there is a possibility of endogeneity by examining the direction of causality between inflation and GDP growth as done by previous studies, using the Granger causality technique (Mubarik, 2005; Juhasz, 2008; Phiri, 2013). The fourth and final test is the regression error specification test (RESET), which examined whether the model is nonlinear before further observing the turning point. Based on the preliminary results, the applicable techniques were thus observed to estimate the threshold level.

5.5.3.1 Stationary and cointegration tests results

The nature of the variables and their interrelationships will determine the techniques used. The correlation among the variables was observed and the result shows low correlation among the explanatory variables (Table A5.1 of Appendix). The variables are first tested for stationarity using Phillips-Perron (PP), Dickey-Fuller GLS (DF-GLS) detrended and Zivot-Andrews tests and hence their orders of integration were observed. The results showed that only real GDP growth, investment and rate of tertiary enrollment were stationary at levels (Table A5.2 of Appendix).

Since the variables are integrated of different orders, it is important to examine the possible long-run relationship that could exist among them, using the cointegration tests of Hansen Parameter instability, Park Added Variables and Phillips-Ouliaris of Fully-modified ordinary least squares (FMOLS). The FMOLS estimator uses a semi-parametric correction which eliminates the bias resulting from endogeneity. This technique performs better in small samples and also incorporates the corrections for possible serial correlation. FMOLS does not depend on lag length, and the t-ratios obtained from FMOLS are asymptotically normally distributed and the results are robust.

The results showed that the null hypothesis of cointegration was rejected at 5% and 1% levels of significance using the Hansen Parameter instability test and Park Added Variables test respectively (Table A5.3 of Appendix). The Phillips-Ouliaris test however indicates that the null of cointegration cannot be rejected at 5% level of significance. If there is no cointegration, causality can still be tested, however, if cointegration is observed, causality has to exist but the direction of causality needs to be tested. The study therefore proceeds to use Granger causality test to observe the direction of causality.

5.5.3.2 Granger causality test result

It is always unclear with economic data to determine which variable is dependent and which ones are independent, but the use of Granger causality technique normally assists in understanding the interrelationships among economic variables (Enders, 2004: 239, 311). If causality is not observed, in the presence of endogeneity, the results obtained will be biased. This causality technique shows that any relationship that may be discovered between inflation rate and output growth goes beyond correlation and that there is definitely a causal

relationship (Phiri, 2013). According to Fischer (1993) and Khan and Senhadji (2001), the seriousness of the biasedness in the result of the inflation-growth regression model depends on whether causality mainly runs from inflation rate to output growth or vice versa.

If causality runs from inflation to growth, the endogeneity problem will be resolved, but if it runs from growth to inflation, the coefficient estimates may be biased. However, Fischer (1993) concluded that causality runs predominantly from inflation to growth thus avoiding the simultaneity bias. The simple Granger causality test could not be used as this is applicable to stationary variables (Enders, 2004: 358). However, the Granger causality employed within a VAR analysis can be used to determine the interrelationship between these variables (Enders, 2004: 239, 283).

Therefore, the study first tested for the stationarity in the VAR and it was stable as all the roots lie within the unit circle (Table A5.4a, Appendix). The VAR Granger causality results obtained showed that inflation Granger causes GDP growth and failed to reject the null hypothesis that GDP growth does not Granger cause inflation (Table A5.4b, Appendix). Thus the results are not biased as there is clear uni-directional causality from inflation rate to GDP growth.

5.5.3.3 Regression Error Specification Test (RESET) result

Before a nonlinear technique can be applied, it is important to check whether the model exhibits a nonlinear behavior (Luukkonen, Saikkonen and Terasvirta, 1988; and Enders, 2004: 406). The RESET technique was used to test whether the model is linear or nonlinear before proceeding to estimate the nonlinear model, if nonlinearity is found, in order to obtain the threshold band. There are a number of procedures to test for nonlinearity but no particular test performs better in pinning down the proper form of nonlinearity (Enders, 2004: 406).

Therefore, this study used the RESET technique. The importance of this procedure is that besides its ease of use, it does not involve estimating large number of parameters (Enders, 2004: 408). This technique also portrays a realistic power in detecting nonlinearity, where the null hypothesis of linearity is tested against the alternative of nonlinearity. In order to perform the RESET, an auxiliary regression, whereby the residuals on the vector of variables

in the original regression is regressed on other variables, has to be estimated. The following equation shows the best-fitting linear model from where the series of residuals is obtained:

$$\Delta\bar{y}_t = \alpha_0 + \alpha_{1t}\bar{\pi}_t + \alpha_{2t}Z_t + AR(1) + AR(2) + ... + AR(p) + MA(1) + MA(2) + ... + MA(q) + \varepsilon_t \quad \ldots\{5.7\}$$

A best-fitting model is obtained based on the orders of the partial autocorrelation and moving average, while including other exogenous variables. Therefore, the auxiliary model is:

$$e_t = \alpha_0 + \alpha_{1t}\bar{\pi}_t + \beta_{it}Z_t + AR(1) + AR(2) + ... + AR(p) + MA(1) + MA(2) + ... + MA(q) + \delta_{1t}\Delta\hat{y}_{1t}^2 + \delta_{2t}\Delta\hat{y}_{2t}^3 + \delta_{3t}\Delta\hat{y}_{3t}^4$$

$$e_t = \varphi_0 z_t + \sum_{h=2}^{H} \delta_{it}\Delta\hat{y}_t^h \qquad for \quad H \geq 2 \qquad \ldots\{5.8\}$$

Where *z* is the vector of all the variables contained in equation 5.6; the value of H is normally selected as 3 or 4.

If the model is linear, the regression will have little explanatory power, whereby the F-value will be small and insignificant. Secondly, the model will be accepted as linear if the null hypothesis of linearity is not rejected using the Wald test. If the null hypothesis is however rejected, it means the F-statistics obtained using the Wald test is significant, the regression model is non-linear and thus the study will proceed to observe the threshold band. The individual t-statistics cannot be used even if the individual coefficients are statistically significant because the regressors are possibly correlated since the autoregressive and moving average are included (Enders, 2004: 416).

In estimating the model to test for linearity, the partial correlation shows an autoregressive order of 2, and the order of moving average of 2. This means that equation {5.7} is regressed as ARMA(2,2) and is thus the best-fitting linear model. In order to observe the nonlinearity of the variable, the next step is to obtain the auxiliary model of equation {5.8}. The results show that firstly the explanatory power of the model, F-value, is not small and it is highly significant across all levels of significance (Table A5.5, Appendix). Secondly, based on the joint test of the significance of the nonlinear variables, using the Wald test, the null hypothesis of linearity was rejected (Table 5.2).

Table 5.2: Non-linearity result: Wald test

Test Statistic	Value	df	Probability
F-statistic	6.115	(3, 32)	0.002
Chi-square	18.346	3	0.0004

Null Hypothesis: Model is linear

Analysis: By Author

Hence the study concludes that the inflation-growth model is non-linear and the study thus proceeds to estimate the nonlinear model using the two applicable techniques in order to establish robustness of the results.

5.5.4 Estimation Methodology

The threshold autoregressive technique and sample-splitting threshold regression technique were used and these are discussed below.

5.5.4.1 Threshold Autoregressive (TAR) Technique

A TAR model is a non-linear time-series model proposed by Tong and Lim (1980). It is used to describe how the conditional mean of a time series behaves. A simple TAR model can be estimated using an ordinary least squares technique. This technique gives reliable results of the dynamic structure of economic time series as it best captures asymmetries, jump phenomena and limit cycles of the series (Tsay, 1989; Li, 2006). The autoregressive nature of such technique is that it addresses the possible problem of endogeneity. An appropriate functional form of the model can be obtained using the Terasvirta's test.

The Terasvirta's test is used to determine whether the TAR model is a logistic smooth transition autoregressive model (LSTAR) or an exponential smooth transition autoregressive model (ESTAR). However, there is no test to determine the superior model among TAR or smooth transition autoregressive (STAR) models (Enders, 2004: 412, 416)[31]. According to Tsay (1989), Hansen (1997) and Enders (2004:400, 412), STAR model simply shows that the autoregressive parameters change slowly and it is continuous around the threshold. It is equally applicable to use a TAR as it captures the jump phenomena at the threshold.

[31] See Enders (2004: 400 – 422) for in-depth understanding of the differences in the STAR, (including LSTAR and ESTAR) and TAR models.

According to Tsay (1989), an arranged autoregression has to be estimated in order to obtain the threshold by sorting the series in an ascending order. Chan (1993) however demonstrates that a super-consistent threshold value can be obtained by excluding the highest and lowest fifteen percent of the values from the series. This is so that equal and adequate number of observations on either side of the threshold can be obtained. Therefore, each value within the middle observation, that is, within the seventy percent band, was in turn tested for possible threshold value. This means that the threshold will lie within the seventy percent band of the middle observations. The consistent estimate of the threshold, where its true value is observed, is obtained at the regression with the smallest sum of squared residuals (SSR) and/or the highest adjusted R-squared (Chan, 1993; Enders, 2004: 413).

The TAR model for estimating the inflation-growth threshold is thus shown as:

$$\Delta\bar{y}_t = \phi_0 + \phi_{1t} D_t(\bar{\pi}_t - \bar{\pi}_t^{\#}) + \sum_{i=0}^{n} \phi_{2t} Z_{t-i} + \sum_{i=0}^{p} \phi_{3t} \bar{\pi}_{t-i} + \sum_{i=1}^{q} \phi_{4t} \Delta\bar{y}_{t-i} + \mu_t$$

$$D_t = \begin{cases} 1 & if\ \bar{\pi}_t > \pi_t^{\#} \\ 0 & if\ \bar{\pi}_t \leq \pi_t^{\#} \end{cases} \qquad \ldots\{5.9\}$$

Where, D is the dummy variable which sets the threshold level; and other variables are as earlier defined. Equation 5.9 is an autoregressive model whereby output growth is expressed in terms of its own lags, the explanatory variables and their lags. The bivariate atheoretical TAR model follows from equation 5.9 except that it excludes the control variables. This is shown as:

$$\Delta\bar{y}_t = \phi_0 + \phi_{1t} D_t(\bar{\pi}_t - \bar{\pi}_t^{\#}) + \sum_{i=0}^{n} \phi_{2t} \bar{\pi}_{t-i} + \sum_{i=1}^{p} \phi_{3t} \Delta\bar{y}_{t-i} + \mu_t$$

$$D_t = \begin{cases} 1 & if\ \bar{\pi}_t > \pi_t^{\#} \\ 0 & if\ \bar{\pi}_t \leq \pi_t^{\#} \end{cases} \qquad \ldots\{5.10\}$$

5.5.4.2 Sample Splitting Threshold Regression (SSTR) Technique

A sample splitting threshold method is a non-linear time-series technique proposed by Hansen (1999). Unlike a TAR or self-exciting TAR (SETAR)[32] technique where ordered autoregressive model is observed and thereby estimating the model using the values within the seventy percent middle observation, the SSTR technique simply chooses possible

[32] SETAR is used to observe the threshold in single variable models (Tsay, 1989; Potter, 1995; Li, 2006).

threshold values. The threshold variable is assumed to be continuously distributed; while allowing the regression parameters to be different based on the value of the threshold, $\pi_t^{\#}$. This method works by automatically selecting the model that gives the minimum sum of squares residuals, thus obtaining the consistent estimate of the threshold. The threshold regression models are as follows:

$$\begin{cases} \Delta y_t = \alpha_0 + \alpha_1 \pi_t + \alpha_2 Z_t + e_{1t} & if \quad \pi_t > \pi_t^{\#} \\ \Delta y_t = \alpha_3 + \alpha_4 \pi_t + \alpha_5 Z_t + e_{2t} & if \quad \pi_t \leq \pi_t^{\#} \end{cases} \qquad \ldots \{5.11\}$$

where $\pi_t^{\#}$ is the threshold variable which is used in splitting the sample into regimes (Hansen, 2000). Although each model is linear in each regime, the possible regime switching shows that the whole model sequence is nonlinear (Enders, 2004:393).

Thus, equation 5.11 can be written in a single equation as:

$$\Delta \bar{y}_t = \theta_0 + \theta_1 \pi_t * I(\bar{\pi}_t > \pi_t^{\#}) + \theta_2 \pi_t * I(\bar{\pi}_t \leq \pi_t^{\#}) + \theta_{3t} Z_t + \varepsilon_t$$

where I is a dummy variable defined as:

$$I_t = \begin{cases} 1 & if \ \bar{\pi}_t > \pi_t^{\#} \\ 0 & if \ \bar{\pi}_t \leq \pi_t^{\#} \end{cases} \qquad \ldots \{5.12\}$$

5.6 ANALYSIS OF EMPIRICAL RESULTS

After observing the nature of the series through the stationarity test, cointegration tests, and the RESET technique which showed that the model is nonlinear; this section presents the TAR and SSTR results.

5.6.1 Threshold Autoregressive (TAR) result

The result of the multivariate TAR model shows that the relationship between inflation rate and the growth rate of GDP changed from negative, in the low levels of inflation, to positive in the medium level of inflation, implying a U-shaped curve. This relationship changed back to negative, at higher levels of inflation, implying an inverted U-shaped curve. The result shows that the inflation-output growth nexus is significantly non-linear from seven percent, as the relationship between the two variables changed (Table 5.3). This is also the model with

the highest adjusted R-squared and lowest residual sum of squares (RSS); and this is the point where the threshold is obtained (Table A5.6 of Appendix).

Table 5.3: Multivariate TAR results (Dependent variable: Real GDP growth).

Variables	**Threshold values**				
	$\pi_t^{\#} = 6\%$	$\pi_t^{\#} = 7\%$	$\pi_t^{\#} = 9\%$	$\pi_t^{\#} = 11\%$	$\pi_t^{\#} = 12\%$
$\overline{\pi}_t$	-0.705*	0.638**	0.446*	0.397*	-0.369*
	(0.35)	(0.29)	(0.24)	(0.22)	(0.22)
D* $\pi_t^{\#}$	0.461	0.408	0.205	0.150	0.107
	(0.38)	(0.32)	(0.28)	(0.31)	(0.34)
INV_t	-0.203	0.203	0.197	-0.179	-0.180
	(0.23)	(0.23)	(0.24)	(0.24)	(0.24)
$INFRA_t$	3.095**	3.287**	3.205**	3.115**	3.084**
	(1.34)	(1.35)	(1.37)	(1.37)	(1.37)
$OPEN_t$	0.249***	0.249***	0.255***	0.262***	0.262***
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)
HC_TE_t	0.109	0.113	0.120	0.118	0.112
	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)
$\Delta\overline{y}_{t-1}$	0.264	0.267	0.259	0.258	0.266
	(0.17)	(0.17)	(0.18)	(0.18)	(0.18)
$\overline{\pi}_{t-1}$	0.115	0.121	0.126	0.145	0.151
	(0.20)	(0.200)	(0.20)	(0.20)	(0.21)
INV_{t-1}	0.083	0.089	0.085	0.085	0.083
	(0.21)	(0.21)	(0.22)	(0.22)	(0.22)
$INFRA_{t-1}$	-3.605**	-3.760***	-3.671**	-3.541**	-3.521**
	(1.41)	(0.41)	(1.44)	(1.43)	(1.43)
$OPEN_{t-1}$	-0.207**	-0.208***	-0.216***	-0.221**	-0.221***
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)
HC_TE_{t-1}	-0.063	-0.059	-0.050	-0.0579	-0.062
	(0.13)	(0.13)	(0.14)	(0.14)	(0.14)
C	5.091	4.787	3.832	3.043	2.906
	(3.31)	(3.14)	(3.10)	(2.85)	(2.84)
RSS	95.28	94.80	98.07	98.94	99.36
Adj R^2	0.416	0.419	0.399	0.393	0.391

SE in parentheses (); * 10%, **5%, ***1%.
Analysis: By author

The result obtained from the multivariate TAR technique further shows that inflation rate of seven percent is beneficial to GDP growth, below which it has an adverse effect. Although the RSS and R-squared increased beyond the seven percent, the inflation-output growth relationship remained positive and statistically significant up until eleven percent before it changed to a significant negative relationship. Thus, inflation rate should ideally be kept within the range of seven to eleven percent where it is positively related to output growth, in order for the country to have enhanced economic growth. If inflation rate falls below this range or increases beyond it, it will be harmful to output growth. All the other control variables have the expected signs and their effects are highly statistically significant on

output growth. Only the ratio of investment to GDP and the rate of tertiary enrollment are not statistically significant, although they have the expected sign. This shows that other explanatory variables can be encouraged in order to boost output growth.

In addition, the result obtained from the bivariate atheoretical model shows that inflation rate of nine percent enhances output growth. This is the point where RSS is the lowest and adjusted R-squared is the highest at 11.81 and 0.35 respectively (Table A5.7 of the Appendix). The inflation rate of nine percent of the bivariate atheoretical model falls within the range where inflation is positively related to output growth in the multivariate growth model. Inflation rate continued to be positively related to output growth up until ten percent in the bivariate atheoretical model, although with a higher RSS and lower adjusted R-squared. Inflation became negatively related and statistically significant to output growth beyond ten percent. The models passed a battery of diagnostic tests, depicting reliable results (Table 5.4).

Table 5.4: Diagnostic Tests for threshold value: TAR

Diagnostic tests	**Statistics: multivariate model**	**Statistics: atheoretical bivariate model**
Normality Test (Jarque-Bera)	0.715 (0.699)	3.729 (0.155)
Serial Correlation LM Test^{+} (F-statistic)	3.408 (0.182)	0.814 (0.665)
Heteroskedasticity Test^{++} (F-statistic)	9.791 (0.634)	4.261 (0.641)
Ramsey RESET Test (F-statistic)	0.676 (0.411)	1.892 (0.163)

These tests were carried out at seven percent (multivariate) and nine percent (bivariate) inflation rates as these are the turning points.
$^{+}$Breusch-Godfrey; $^{++}$Breusch-Pagan-Godfrey
Figures in parentheses () indicate p-value.
Analysis: By Author

5.6.2 Sample Splitting Threshold Result

The threshold values obtained depicts a negative relationship between output growth and inflation rate at lower and higher levels of inflation, while it shows a positive relationship at medium level. This is similar to the results obtained in the TAR estimation. The relationship between these variables changed from negative to positive and back to negative over the three regimes (Table 5.5).

Table 5.5: Sample-Splitting threshold regression result

Variables	**Regime 1** $\pi_t^{\#} <$ **7.13**	**Regime 2** $7.13 \leq \pi_t^{\#} < 11.64$	**Regime 3** $11.64 \leq \pi_t^{\#}$
$\overline{\pi}_t$	-0.73***	1.29*	-0.73***
	(0.26)	(0.67)	(0.21)
INV_t	0.19	-0.18	0.45***
	(0.44)	(0.16)	(0.14)
$INFRA_t$	0.23	-0.35	0.66*
	(0.96)	(0.47)	(0.33)
$OPEN_t$	0.04	0.12**	0.46***
	(0.09)	(0.05)	(0.06)
HC_TE_t	0.13	0.43***	0.29***
	(0.49)	(0.16)	(0.11)
CONST	1.33	2.44	-3.29
	(8.55)	(2.36)	(6.16)
Adj R^2 0.47			
F-stat 3.36			
DW 2.08			
RSS 75.16			

SE in parentheses (); Regime 1: 18 observations; Regime 2: 13 observations; Regime 3: 15 observations.
* 10%, **5%, ***1%.
Analysis: By author

The high and low inflation regimes are separated by the threshold band 7.13 and 11.64 percent. This result is in line with the result obtained from the TAR technique with the thresholds of seven percent and nine percent, as they fall within the SSTR threshold band. The control variables, openness and tertiary enrollment, have the expected signs and are statistically significant, the other variables, investment and infrastructure, are not rightly signed and are statistically insignificant. Inflation rate has positive effect on output growth within the second regime, thus if for instance, inflation rate increases to as high as ten percent, it is still favourable to output growth. However, when inflation rate is below or above the threshold band of $7.13 \leq \pi_t < 11.64$, it is detrimental to output growth; hence inflation should be encouraged within this band.

The diagnostic tests for the threshold band was also carried out and the model failed to reject all the null hypothesis (Table 5.6). This shows that the result of the regime within the band of $7.13 \leq \pi_t < 11.64$ percent is reliable and valid. The CUSUM of squares result further affirms the stability of the model (Figure 5.1).

Table 5.6: Diagnostic Tests for threshold value: Sample Splitting technique

Diagnostic tests	Statistics
Normality Test (Jarque-Bera)	0.868 (0.648)
Serial Correlation LM Test[+] (F-statistic)	0.692 (0.707)
Heteroskedasticity Test[++] (F-statistic)	17.496 (0.421)

[+]Breusch-Godfrey; [++]Breusch-Pagan-Godfrey
Figures in parentheses indicate P-value.
Analysis: By Author

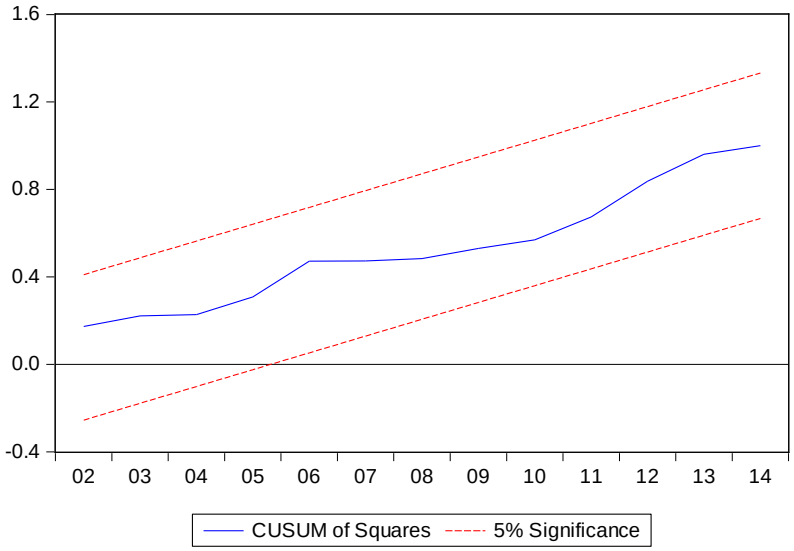

Figure 5.1: Stability test

5.6.3 Summary

This chapter examined the threshold level of inflation rate beyond which it is detrimental to output growth in South Africa. The threshold was estimated using threshold autoregressive method and sample splitting threshold regression technique. The model was however first tested for nonlinearity before proceeding to estimate the nonlinear model. The results obtained from these techniques are in agreement in terms of the inflation threshold band; thus obtaining the level at which inflation improves output growth. While the sample-splitting technique showed that inflation is positively related to output growth within the seven and eleven percent band, the results of the TAR technique, for both the multivariate theoretical and bivariate atheoretical models, showed that inflation enhances output growth at seven percent and nine percent respectively.

In general, both models and techniques selected inflation threshold levels of between seven percent and eleven percent. This shows that the inflation threshold below and beyond this range will be harmful to growth. The inflation threshold values that were chosen by these techniques fall outside the inflation target band of three to six percent of the SARB. In addition, the result obtained in this study is close to the findings of Khan and Senhadji (2001) where the threshold band of eleven to twelve percent was found, but contrary to the result of Li (2006) where two threshold points of fourteen and thirty eight percent were obtained for developing countries. Other control variables had the expected signs and are statistically significant in many instances.

5.7 CONCLUSION AND POLICY RECOMMENDATIONS.

This study investigated the nonlinear inflation-output growth nexus in South Africa with the purpose of identifying the band of inflation that optimises growth using two different techniques of TAR and sample splitting threshold regression. While the sample splitting technique showed that inflation is positively related to output growth within the band seven and eleven percent, the results of the TAR technique for both the multivariate theoretical and bivariate atheoretical models, showed that inflation enhances output growth at seven percent and nine percent respectively. This result was also found to be valid and robust across all the models. The results obtained are in line with some of the earlier studies on South African inflation threshold whereby inflation threshold points of seven percent and eight percent were obtained by Phiri (2010) and Adusei (2012) respectively.

The results of this study show that South Africa is able to accommodate moderately higher inflation rates in order to experience more economic growth. According to Doguwa (2012) any inflation point below the threshold band obtained is detrimental to output growth; hence inflation rate should rather be kept within this band, but slightly below the upper band. Thus, monetary authorities in South Africa can still accommodate a higher level of inflation beyond the current inflation target band of three percent to six percent by increasing the target band to between seven and nine percent in order to enhance output growth. The policy implications of the model is that there is scope to revise the inflation target band set by the SARB from its current level to higher levels. The findings support the argument of the Congress of South African Trade Unions (COSATU) that the use of repo rate has negatively affected

employment and the economy at large because the inflation target band set by SARB of between three percent and six percent lies far below the threshold band obtained in this study.

APPENDIX TO CHAPTER 5

Appendix A: Tables

Table A5.1: Correlation matrix

	Δy_t	π_t	INV_t	$INFRA_t$	$OPEN_t$	HC_t
$\Delta \bar{y}_t$	1.000	-0.391	0.743	-0.178	0.310	-0.062
$\bar{\pi}_t$	-0.391	1.000	-0.456	0.012	-0.080	0.596
INV_t	0.743	-0.456	1.000	-0.159	0.247	-0.191
$INFRA_t$	-0.178	0.012	-0.159	1.000	-0.115	-0.325
$OPEN_t$	0.311	-0.079	0.247	-0.115	1.000	-0.093
HC_TE_t	-0.062	0.596	-0.191	-0.325	-0.093	1.000

Table A5.2: Stationarity test results[#]: Annual Data (1969 – 2014).

Variables	**LEVELS**			**FIRST DIFFERENCE**		
	PP	**DF-GLS**	**ZA**	**PP**	**DF-GLS**	**Decision**
$\Delta \bar{y}_t$	-4.43***	-4.52***	5.46**	—	—	I(0)
$\bar{\pi}_t$	-3.32*	-1.99	-3.03	-7.73***	-6.44***	I(1)
INV_t	-3.01	-4.57***	-5.89***	—	—	I(0)
$OPEN_t$	-1.93	-2.11	-3.91	-7.37***	-6.63***	I(1)
$INFRA_t$	0.21	-1.00	-2.35	-4.96***	-4.53***	I(1)
HC_TE_t	-4.36***	-3.25**	-5.54**	—	—	I(0)

[#]test equation of intercept and trend.
Test critical values: PP [1% -4.18; 5% -3.51; 10% -3.18]; DF-GLS [1% -3.77; 5% -3.19; 10% -2.89]; ZA [1% -5.57; 5% -5.08; 10% -4.82].
***1%, **5%

Table A5.3: Cointegration Result

Tests	Stats		
Hansen Instability	Lc stat:	1.296	(0.01)
Park Added Variables	Chi-square:	30.644	(0.000)
Phillips-Ouliaris	z-stat:	-31.641	(0.07)

Null Hypothesis: Series are cointegrated; p-value in parentheses ()

Table A5.4a: VAR Root test

Roots of Characteristic Polynomial	
Endogenous variables: Δy_t π_t	
Exogenous variables: C	
Root	Modulus
0.802613	0.802613
0.538022	0.538022
No root lies outside the unit circle.	
VAR satisfies the stability condition.	

Table A5.4b: VAR Granger causality result

VAR Granger Causality/Block Exogeneity Wald Tests			
Sample: 2001Q1 2014Q2			
Included observations: 53			
Dependent variable: π_t			
Excluded	Chi-sq	df	Prob.
Δy_t	0.005495	1	0.9409
All	0.005495	1	0.9409
Dependent variable: Δy_t			
Excluded	Chi-sq	df	Prob.
π_t	13.78323	1	0.0002
All	13.78323	1	0.0002

Table A5.5: RESET result

Variable	**Coeff.**	**t-Stat**
$\overline{\pi}_t$	0.046	0.892
INV_t	0.308***	3.943
$INFRA_t$	1.141***	3.827
$OPEN_t$	0.011	0.407
HC_TE_t	0.189**	2.441
C	1.786	1.192
FITTED Δy_t ^2	1.145***	3.297
FITTED Δy_t ^3	-0.381***	-2.702
FITTED Δy_t ^4	0.033	2.262
AR(1)	1.629***	11.835
AR(2)	-0.940***	-9.410
MA(1)	-1.990	-0.006
MA(2)	0.999	0.003
SIGMASQ	0.516	0.006
Adj R-squared 0.58		
RSS 23.72		
DW stat 2.02		
F-stat 5.70		
Prob (F-stat) 0.00		

***1%, **5%

Table A5.6: TAR result

Variable	Coeff	t-Statistic	Prob.	RSS	Adj R^2
$\overline{\pi}_t$	-0.658124	-0.563265	0.5772	99.41	0.390
D3* π_t^3	0.354095	0.288689	0.7747		
INV_t	-0.192795	-0.808931	0.4245		
$INFRA_t$	3.044211	2.225384	0.0332		
$OPEN_t$	0.253149	3.042292	0.0047		
HC_TE_t	0.104410	0.734926	0.4677		
$\Delta\overline{y}_{t-1}$	0.264354	1.476822	0.1495		
$\overline{\pi}_{t-1}$	0.127040	0.598822	0.5535		
INV_{t-1}	0.082416	0.378633	0.7075		
$INFRA_{t-1}$	-3.519300	-2.455022	0.0197		
$OPEN_{t-1}$	-0.213111	-2.522875	0.0168		
HC_TE_{t-1}	-0.065671	-0.478758	0.6354		
C	3.971925	0.853472	0.3997		
$\overline{\pi}_t$	-0.660054	-0.945297	0.3516	98.92	0.394
D4* $\overline{\pi}_t^4$	0.367152	0.495160	0.6239		
INV_t	-0.192687	-0.810521	0.4236		
$INFRA_t$	3.031963	2.221552	0.0335		
$OPEN_t$	0.253156	3.063721	0.0044		
HC_TE_t	0.102509	0.723232	0.4748		
Δy_{t-1}	0.259966	1.457695	0.1547		
$\overline{\pi}_{t-1}$	0.122740	0.590214	0.5592		
INV_{t-1}	0.079873	0.367833	0.7154		
$INFRA_{t-1}$	-3.523766	-2.464261	0.0193		
$OPEN_{t-1}$	-0.212577	-2.533651	0.0164		
HC_TE_{t-1}	-0.066071	-0.482983	0.6324		
C	4.333330	1.072474	0.2915		
π_t	-0.723605	-1.543187	0.1326	97.16	0.404
D5* π_t^5	0.454787	0.909783	0.3697		
INV_t	-0.198624	-0.842746	0.4056		
$INFRA_t$	2.995401	2.213189	0.0341		
$OPEN_t$	0.252774	3.090970	0.0041		
HC_TE_t	0.106062	0.755099	0.4557		
Δy_{t-1}	0.257675	1.465086	0.1527		
$\overline{\pi}_{t-1}$	0.113999	0.557726	0.5809		
INV_{t-1}	0.082455	0.383642	0.7038		
$INFRA_{t-1}$	-3.491170	-2.462960	0.0193		
$OPEN_{t-1}$	-0.210641	-2.535930	0.0163		
HC_TE_{t-1}	-0.063785	-0.470358	0.6413		
C	4.904554	1.375442	0.1785		
π_t	-0.705458	-1.993688	0.0548		

D6* π_t^6	0.460908	1.214419	0.2335	95.28	0.416
INV_t	-0.202787	-0.868632	0.3915		
$INFRA_t$	3.094930	2.311168	0.0274		
$OPEN_t$	0.248911	3.068532	0.0044		
HC_TE_t	0.109094	0.784053	0.4388		
Δy_{t-1}	0.263730	1.518934	0.1386		
$\overline{\pi}_{t-1}$	0.115204	0.572633	0.5709		
INV_{t-1}	0.082862	0.389347	0.6996		
$INFRA_{t-1}$	-3.605040	-2.565465	0.0152		
$OPEN_{t-1}$	-0.206873	-2.510839	0.0173		
HC_TE_{t-1}	-0.062615	-0.466237	0.6442		
C	5.090851	1.536517	0.1342		
π_t	0.638303	2.170592	0.0375	**94.80**	**0.419**
D7* π_t^7	0.408330	1.282800	0.2088		
INV_t	0.202579	0.870017	0.3908		
$INFRA_t$	3.287194	2.439428	0.0204		
$OPEN_t$	0.248991	3.078272	0.0042		
HC_TE_t	0.112785	0.812024	0.4228		
Δy_{t-1}	0.266910	1.541895	0.1329		
$\overline{\pi}_{t-1}$	0.121032	0.604908	0.5495		
INV_{t-1}	0.088696	0.417819	0.6789		
$INFRA_{t-1}$	-3.760400	-2.662207	0.0120		
$OPEN_{t-1}$	-0.208063	-2.535178	0.0163		
HC_TE_{t-1}	-0.058738	-0.438159	0.6642		
C	4.787337	1.525068	0.1371		
π_t	0.531429	2.018589	0.0520	96.61	0.408
D8* π_t^8	0.302844	1.007774	0.3211		
INV_t	-0.199840	-0.850269	0.4015		
$INFRA_t$	3.282939	2.401851	0.0223		
$OPEN_t$	0.252374	3.094791	0.0041		
HC_TE_t	0.117451	0.834898	0.4100		
Δy_{t-1}	0.262485	1.500397	0.1433		
$\overline{\pi}_{t-1}$	0.122248	0.604233	0.5499		
INV_{t-1}	0.086551	0.403900	0.6890		
$INFRA_{t-1}$	-3.750153	-2.619271	0.0134		
$OPEN_{t-1}$	-0.213321	-2.580972	0.0146		
HC_TE_{t-1}	-0.050409	-0.370304	0.7136		
C	4.324873	1.379334	0.1774		
π_t	0.446222	1.885961	0.0684	98.07	0.399
D9* π_t^9	0.205224	0.722187	0.4754		
INV_t	0.196634	0.830504	0.4124		
$INFRA_t$	3.205222	2.332716	0.0261		
$OPEN_t$	0.255161	3.108114	0.0039		

HC_TE_t	0.119771	0.838839	0.4078		
Δy_{t-1}	0.259076	1.464659	0.1528		
$\overline{\pi}_{t-1}$	0.125657	0.615195	0.5428		
INV_{t-1}	0.085049	0.393911	0.6963		
$INFRA_{t-1}$	-3.671285	-2.550350	0.0157		
$OPEN_{t-1}$	-0.216258	-2.598402	0.0140		
HC_TE_{t-1}	-0.049713	-0.359766	0.7214		
C	3.831786	1.236066	0.2254		
π_t	0.416410	1.820732	0.0780		
D10* π_t^{10}	0.171348	0.586391	0.5617	98.61	0.395
INV_t	-0.188324	-0.792898	0.4337		
$INFRA_t$	3.151994	2.297492	0.0283		
$OPEN_t$	0.258961	3.139899	0.0036		
HC_TE_t	0.120297	0.834283	0.4103		
Δy_{t-1}	0.257442	1.445009	0.1582		
$\overline{\pi}_{t-1}$	0.136184	0.668622	0.5085		
INV_{t-1}	0.085717	0.395919	0.6948		
$INFRA_{t-1}$	-3.599714	-2.509414	0.0173		
$OPEN_{t-1}$	-0.218862	-2.618606	0.0134		
HC_TE_{t-1}	-0.055624	-0.403546	0.6892		
C	3.412488	1.153116	0.2574		
π_t	0.397461	1.770239	0.0862	98.94	0.393
D11* π_t^{11}	0.150098	0.485754	0.6305		
INV_t	-0.178676	-0.745595	0.4614		
$INFRA_t$	3.114948	2.274069	0.0298		
$OPEN_t$	0.262432	3.141869	0.0036		
HC_TE_t	0.117988	0.815843	0.4206		
Δy_{t-1}	0.257786	1.439469	0.1597		
$\overline{\pi}_{t-1}$	0.145435	0.714186	0.4803		
INV_{t-1}	0.084612	0.390146	0.6990		
$INFRA_{t-1}$	-3.540754	-2.474553	0.0188		
$OPEN_{t-1}$	-0.220887	-2.624868	0.0132		
HC_TE_{t-1}	-0.057874	-0.419496	0.6777		
C	3.042988	1.067732	0.2936		
π_t	-0.369086	-1.690967	0.1006	99.36	0.391
D12* π_t^{12}	0.107090	0.318343	0.7523		
INV_t	-0.179907	-0.743706	0.4625		
$INFRA_t$	3.084437	2.251120	0.0314		
$OPEN_t$	0.261592	3.095385	0.0041		
HC_TE_t	0.112277	0.777638	0.4425		
Δy_{t-1}	0.265633	1.490890	0.1458		
$\overline{\pi}_{t-1}$	0.150864	0.735022	0.4677		

INV_{t-1}	0.082539	0.379426	0.7069		
$INFRA_{t-1}$	-3.521007	-2.456862	0.0196		
$OPEN_{t-1}$	-0.220501	-2.598531	0.0140		
HC_TE_{t-1}	-0.061991	-0.449768	0.6559		
C	2.906344	1.022504	0.3142		
π_t	-0.336326	-1.577172	0.1246	99.65	0.389
D13* π_t^{13}	0.034943	0.090931	0.9281		
INV_t	-0.189899	-0.786691	0.4373		
$INFRA_t$	3.060292	2.233338	0.0326		
$OPEN_t$	0.257633	3.037555	0.0047		
HC_TE_t	0.105586	0.736858	0.4666		
Δy_{t-1}	0.271698	1.531209	0.1355		
$\overline{\pi}_{t-1}$	0.147451	0.707794	0.4842		
INV_{t-1}	0.085144	0.391098	0.6983		
$INFRA_{t-1}$	-3.516582	-2.450092	0.0199		
$OPEN_{t-1}$	-0.217636	-2.549068	0.0158		
HC_TE_{t-1}	-0.064996	-0.470033	0.6415		
C	2.897246	1.016902	0.3168		

Table A5.7: TAR result: bivariate atheoretical model

Variable	Coeff.	t-Statistic	RSS	Adj R^2
$\overline{\pi}_t$	-0.264**	-2.506	12.29	0.33
D3* π_t^3	0.104	1.154		
Δy_{t-1}	0.366**	2.455		
$\overline{\pi}_{t-1}$	0.279**	2.221		
Δy_{t-2}	0.186	1.127		
$\overline{\pi}_{t-2}$	-0.123*	-1.685		
C	0.624	2.018		
$\overline{\pi}_t$	-0.250**	-2.657	12.20	0.33
D4* π_t^4	0.099	1.291		
Δy_{t-1}	0.360**	2.423		
$\overline{\pi}_{t-1}$	0.273**	2.189		
Δy_{t-2}	0.188	1.147		
$\overline{\pi}_{t-2}$	-0.117	-1.617		
C	0.637**	2.063		
$\overline{\pi}_t$	-0.239***	-2.743	12.07	0.34
D5* π_t^5	0.102	1.463		
Δy_{t-1}	0.360**	2.432		
$\overline{\pi}_{t-1}$	0.267**	2.161		

Δy_{t-2}	0.188	1.157		
$\overline{\pi}_{t-2}$	-0.112	-1.566		
C	0.642**	2.098		
$\overline{\pi}_t$	-0.226***	-2.710	12.06	0.34
D6* π_t^6	0.102	1.490		
Δy_{t-1}	0.356**	2.408		
$\overline{\pi}_{t-1}$	0.263**	2.132		
Δy_{t-2}	0.183	1.133		
$\overline{\pi}_{t-2}$	-0.109	-1.528		
C	0.640**	2.096		
$\overline{\pi}_t$	-0.222***	-2.721	11.96	0.34
D7* π_t^7	0.122	1.609		
Δy_{t-1}	0.354**	2.402		
$\overline{\pi}_{t-1}$	0.262**	2.125		
Δy_{t-2}	0.181	1.125		
$\overline{\pi}_{t-2}$	-0.107	-1.501		
C	0.640**	2.112		
$\overline{\pi}_t$	-0.215**	-2.675	11.95	0.34
D8* π_t^8	0.148	1.624		
Δy_{t-1}	0.357**	2.422		
$\overline{\pi}_{t-1}$	0.253**	2.052		
Δy_{t-2}	0.170	1.061		
$\overline{\pi}_{t-2}$	-0.099	-1.384		
C	0.631**	2.089		
$\overline{\pi}_t$	0.219***	2.735	**11.81**	**0.35**
D9* π_t^9	0.206*	1.791		
Δy_{t-1}	0.336**	2.283		
$\overline{\pi}_{t-1}$	0.253**	2.070		
Δy_{t-2}	0.157	0.987		
$\overline{\pi}_{t-2}$	-0.096	-1.347		
C	0.667**	2.200		
$\overline{\pi}_t$	0.220***	2.673	12.07	0.34
D10* π_t^{10}	0.234	1.466		
Δy_{t-1}	0.321**	2.123		
$\overline{\pi}_{t-1}$	0.268**	2.166		
Δy_{t-2}	0.136	0.848		
$\overline{\pi}_{t-2}$	-0.105	1.461		
C	0.688**	2.188		

$\overline{\pi}_t$	-0.208**	2.475	12.42	0.32
D11* π_t^{11}	0.210	0.902		
Δy_{t-1}	0.340**	2.221		
$\overline{\pi}_{t-1}$	0.273**	2.166		
Δy_{t-2}	0.130	0.791		
$\overline{\pi}_{t-2}$	-0.112	1.531		
C	0.638**	1.989		
$\overline{\pi}_t$	-0.205**	-2.403	12.51	0.31
D12* π_t^{12}	0.266	0.708		
Δy_{t-1}	0.345**	2.252		
$\overline{\pi}_{t-1}$	0.276**	2.170		
Δy_{t-2}	0.131	0.796		
$\overline{\pi}_{t-2}$	-0.114	-1.562		
C	0.619*	1.919		
$\overline{\pi}_t$	-0.205**	-2.403	12.51	0.31
D13* π_t^{13}	0.699	0.708		
Δy_{t-1}	0.345**	2.252		
$\overline{\pi}_{t-1}$	0.276**	2.170		
Δy_{t-2}	0.131	0.796		
$\overline{\pi}_{t-2}$	-0.114	-1.562		
C	0.619*	1.9193		

* 10%, **5%, ***10%

Appendix B: Derivation of Harrod-Domar growth model

Savings, S, is a proportion of income, Y, and investment, I, is a change in capital stock, K. Savings function and investment function can therefore be written as:

Savings function: $S = sY$ … (4B.1)

Investment function: $I = \Delta K$ … (4B.2)

Meanwhile, output-capital ratio is a function of the capital stock, K, and national income, Y, such that $\frac{K}{Y} = k$ or $\frac{\Delta K}{\Delta Y} = k$ which can also be written as: $\Delta K = k\Delta Y$ … (4B.3)Therefore, at equilibrium, savings equals investment, shown as:

$S = I$ … (4B.4)

This means that from equations 4B.1 and 4B.3, equation 4B.4 can also be written as:

$S = sY = k\Delta Y = \Delta K = I$ or simply as

$sY = k\Delta Y$ … (4B.5)

By first dividing both sides by Y and then by *k*, equation 5.1 (in chapter 5) is obtained.

CHAPTER 6

CONCLUSION

This study explored the dynamics of inflation in South Africa. The motivation stems from the assessment of monetary policy in South Africa based on the adoption of inflation targeting framework in 2002. This framework has been met with considerable opposition from the Congress of South African Trade Unions (COSATU) and studies such as Weeks (1999) and Hodge (2006) argued that South Africa can still accommodate moderately higher inflation rate without adversely affecting economic growth. This study therefore investigated the underlying forces of inflation by observing the four research questions:

1. Does Phillips curve exist in South Africa?
2. Are economic agents rational or adaptive in determining current inflation?
3. Is the fiscal theory of price level applicable to South Africa?
4. Is the current inflation threshold band beneficial to the South African economy?

In attempting to answer the first two research questions of whether Phillips curve exists in South Africa and if economic agents are rational or adaptive in their inflation expectations, the study estimated the hybrid new Keynesian Phillips curve (HNKPC). This model was estimated by testing its sensitivity to different variable measurements, data frequency and estimation techniques. The different variable measurements used are the output growth and output gap as proxies for the demand-side variable and three different measures of inflation expectations; namely survey, Hodrick-Prescott (HP) filter and auto regressive integrated moving average (ARIMA).

The choice of output gap and output growth as demand-side measures is consistent with earlier work in South Africa by Nell (2000), Fedderke and Schaling (2005), and Burger and Marinkov (2006). This model could not use unemployment gap due to possible limitation of incomplete data on the unemployment rate in South Africa, and it is thus more prone to data errors (Agenor and Bayraktar, 2010). Annual and quarterly data as well as two different econometric techniques of ordinary least squares and a single-equation generalized method of moments were used to further observe the sensitivity of the HNKPC.

The result obtained showed that Phillips curve does not exist in South Africa, as output growth was found to be significantly negatively related to inflation rate, and output gap had a significant positive relationship with inflation rate across all the models, data frequency and estimation techniques. The model was found not to be sensitive to different measures of demand side variables as the results consistently support no evidence of Phillips curve in South Africa. It was also not sensitive to data frequency and estimation techniques. It was however sensitive to different inflation expectations measures whereby HP-filter and ARIMA gave better explanations of the HNKPC model. The model also shows that economic agents are more forward-looking than backward-looking.

However, the HNKPC model is not all-inclusive as it excludes some major factors, such as supply-shock (structural) variables. Observing the effects of supply-shock variables on inflation rate are quite important, especially as a result of the two oil-price shocks and this was included in the Gordon's model. Nevertheless, the Gordon's model does not include the possible effects of other factors like monetary and fiscal variables on inflation rate. Thus, this study proceeded to estimate the augmented (or extended) Gordon's model and observed the effects of various factors on inflation rate. This was based on different schools of thoughts, while also observing whether Phillips curve exists or not when the model was extended.

Further importance of this model was to observe the applicability of the different schools of thought to inflation dynamics in South Africa. While monetary authorities focus on using monetary policies to curb high inflation, fiscal policies are equally important as argued by the proponents of the fiscal theory of price level (or the fiscalists). Therefore, the augmented Gordon's model was estimated in order to observe the variables that significantly affect inflation rate in South Africa in an extended model and thereby answering the research question of whether the fiscal theory of price level is applicable to South Africa. This was investigated using two different periods of quarterly data series and different demand-side, monetary, structural and fiscal variables for robustness of result. The vector autoregressive (VAR), vector error correction model (VECM) and innovation accounting techniques were used. The simultaneous equation model used is more reliable than the single-equation model of the HNKPC.

The results obtained affirmed that despite the extended model, there is still no existence of Phillips curve trade-off in South Africa. It was therefore concluded that monetary authorities should focus on targeting inflation without adversely affecting output and put to rest the current controversy surrounding the monetary policy in South Africa. Further results showed that while inflation rate is demand-driven in South Africa, other major determinants are the structural and fiscal variables, which showed that the fiscal theory of price level is applicable to South Africa. Based on these findings and considering the fact that monetary authorities have limited control over the external and structural variables, they can, on the other hand, engage with the government so as to effectively control the fiscal and demand-side variables in regulating inflation. This is due to the increase in debt levels and budget deficit over the past fiscal years (2004/2005 to 2011/2012) and since the global financial crisis of 2008. Also, the budget deficit is estimated to continue up until the 2015/2016 fiscal year (Budget Review, 2013).

On the other hand, the importance of the determinants of inflation rate is not sufficient in observing the inflation dynamics in South Africa, hence the study went further to investigate the level at which inflation becomes detrimental to output growth, thereby providing answer to the last research question. The study firstly observed whether the relationship between inflation rate and output growth is nonlinear, seeing that literature has gone beyond examining the linear relationship between these variables. Since nonlinearity was found, the study then estimated their nonlinear relationship, applying the two techniques of threshold auto regression (TAR) and sample-splitting threshold regression (SSTR), and the inflation threshold target band rather than a target point was obtained.

The threshold points obtained in previous studies by Phiri (2010) and Adusei (2012) on South Africa fall within the target band of seven to eleven percent as obtained in this current study. Since the threshold results obtained are different from the adopted current target band of three to six percent, it was therefore suggested that monetary authorities could consider changing or reviewing the current band in order for the economy to fully benefit from the positive effect of inflation on output growth in South Africa. The positive effect of inflation rate on output growth depicted within this bandwidth showed that South Africa can still accommodate moderately higher inflation target band and this will not be detrimental to

economic growth. However, inflation rate outside the suggested target band is unfavourable to output growth.

The overall suggested policy is that monetary authorities should continue monitoring and striving to curb inflation. This is based on the obtained result that there is no trade-off between inflation rate and output growth. It is also therefore imperative to focus attention on managing or adjusting the fiscal and demand-side variables, so as not to excessively and negatively affect inflation rate. This is because as the results showed, monetary policy cannot single-handedly bring about higher economic growth without the introduction of fiscal policies, as the fiscal variable significantly determines economic growth. It is also important to note that the current inflation target band is rigid and could be revised upwards.

The major limitation of this study is the lack of reliable data on unemployment rate, which could have assisted us in the estimation of the inflation-unemployment threshold in order to explore the possible interrelationship between the monetary and fiscal policies. Another limitation is that monetary policy cannot be formulated based entirely on the Phillips curve due to its inconsistency with empirical studies in terms of the trade-off between inflation rate and unemployment rate. Areas of further research include investigating the effects of disaggregated government expenditures or an alternative measure of fiscal policy on inflation rate in order to observe the fiscal variables that contribute more to inflation dynamics in South Africa. An alternative to the PC is the Taylor policy rule, which can be observed for its applicability in formulating monetary policy, although this policy rule did not provide the right monetary policy to adopt (Chatterjee, 2002).

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