

**INFLATION THRESHOLD AND NONLINEARITY:  
IMPLICATIONS FOR INFLATION TARGETING IN  
SOUTH AFRICA**

by

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## **ABSTRACT**

Following many other central banks around the world, the South African Reserve Bank has adopted inflation targeting as its monetary policy framework. The aim of this is to achieve low levels of inflation in order to attain price stability thereby promoting growth. In South Africa, the chosen band to target is 3%–6%. This has been criticised by many trade unions who are calling for the abandonment of inflation targeting. Despite targeting 3%–6%, it is not known whether this is the optimal inflation range for South Africa. Therefore, the aim of this study is to determine the inflation threshold level for South Africa using quarterly data for the period 1983 to 2010.

The first section determines whether or not there is a long-run relationship between inflation and growth using the Johansen cointegration method. Exogeneity tests determine the causality between these variables. Vector error correction models are estimated if cointegration is found. The second part determines the threshold level of inflation using the method of conditional least squares. The inflation level that maximises the R-squared value and minimises the residual sum of squares gives an indication of the threshold level. The third part of the study determines whether or not inflation volatility has a significant impact on growth.

The first part established that there is long-run comovement between inflation and growth. The causality is bidirectional with both variables being endogenous. Findings regarding the threshold level show that the current inflation targeting band of 3%–6% may be extended up to 9.5%. In addition, the range of inflation from 5.5% to 6.5% promotes economic growth in South Africa. Finally, the evidence suggests that inflation volatility does not have a significant impact on economic growth and the focus of policy should be directed towards the level of inflation as has been the case.

## **DECLARATION**

Except for references specifically indicated in the text, and such help as has been acknowledged, this thesis is wholly my own work and has not been submitted to any other institution for degree purposes.

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Derwina Morar

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**ABBREVIATIONS AND ACRONYMS**

ADF	Augmented Dickey–Fuller
AIC	Akaike Information Criteria
APEC	Asia-Pacific Economic Cooperation
BRO	Baltics, Russia and other countries of the Former Soviet Union
CE	Cointegrating Equation
CEE	Central and Eastern Europe
CIS	Commonwealth Independent States
CPI	Consumer price inflation
CPIX	Consumer price inflation excluding mortgage payments
DLCPI	First difference of the log of CPI
DLGDP	First difference of the log of GDP
ECB	European Central Bank
FDI	Foreign direct investment
FPE	Final Prediction Error
GDP	Gross domestic product
GOVC	Government consumption
HQ	Hannan–Quinn Information criteria
IMF	International Monetary Fund
INF	Inflation rate
INV	Investment
KPSS	Kwiatkowski, Phillips, Schmidt and Shin
LCPI	Log of CPI
LGDP	Log of GDP
LM	Lagrange Multiplier
LR	Likelihood Ratio
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary least squares
POP	Population
PP	Phillips–Perron
RSS	Residual sum of squares
SARB	South African Reserve Bank

SDINF	Inflation uncertainty
SIC	Schwarz Information Criteria
Stats SA	Statistics South Africa
TFP	Total factor productivity
TOT	Terms of trade
UK	United Kingdom
USA	United States of America
VAR	Vector Autoregressive
VECM	Vector Error Correction Model

# CHAPTER ONE

## INTRODUCTION

### 1.1 CONTEXT OF RESEARCH

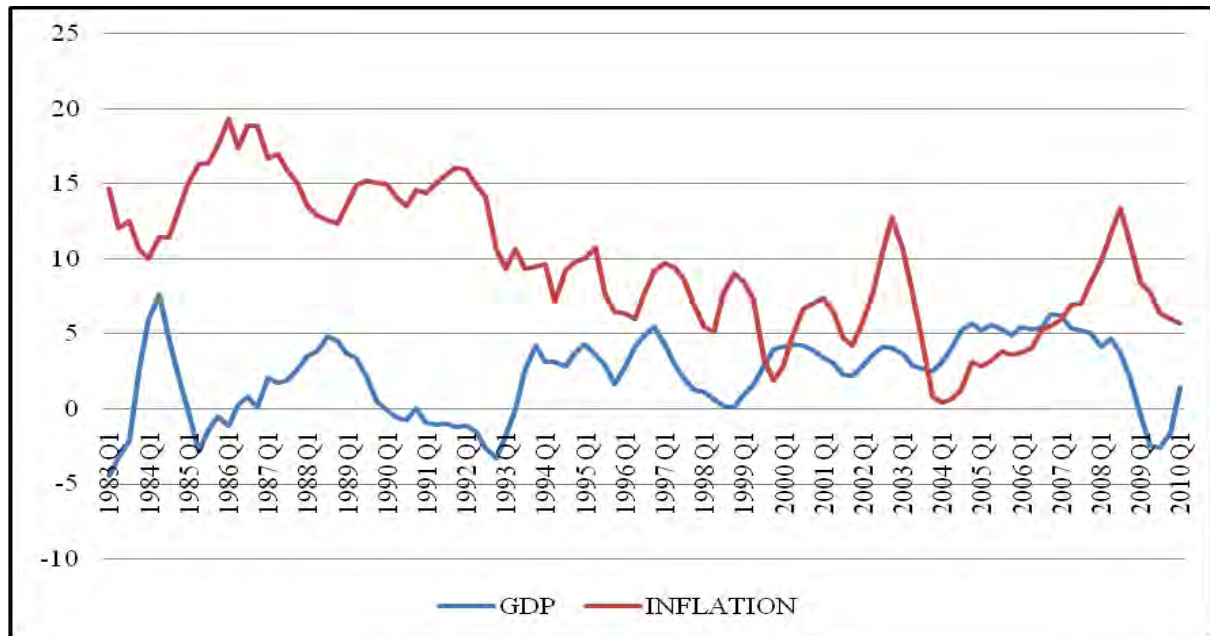
The inflation-growth relationship has been debated for some time (see Barro, 1995b; Bruno and Easterly, 1995; Judson and Orphanides, 1996; Ghosh and Phillips, 1998b; Gillman *et al.*, 2004). Inflation can have three possible effects on growth: a positive effect, a negative effect and no effect at all. It is generally agreed that high levels of inflation would have a negative impact on growth, but certain inflation thresholds could have a positive effect on growth (Faria and Carneiro, 2001; Ghosh and Phillips, 1998b). Empirical literature has explored this nonlinearity (for example, Barro, 1995b; Bruno and Easterly, 1995; Judson and Orphanides, 1996; Sarel, 1996; Ghosh and Phillips, 1998b; Khan and Senhadji, 2001; Burdekin *et al.*, 2004; Gillman *et al.*, 2004) and found that inflation is only harmful to an economy if it is beyond a certain threshold level. A country should then adopt a macroeconomic policy that achieves inflation levels within that band so as not to damage growth prospects within the economy.

Many central banks around the world, including the South African Reserve Bank (SARB) have adopted inflation targeting frameworks as their monetary policy stance in order to achieve low levels of inflation and attain price stability. SARB adopted an inflation targeting framework in 2000 aimed at achieving an inflation level of between 3% and 6% by the year 2002. This inflation range was set by the Minister of Finance in conjunction with the Reserve Bank (SARB, 2010: 4). This target has been criticised as being too narrow for a country with a history of double digit inflation (Mail and Guardian, 2009).

Figure 1.1 illustrates the behaviour of gross domestic product (GDP) growth rate and inflation rate in South Africa from 1983–2010. Peaks in inflation are followed by slowed growth approximately 12–18 months later. For example, the inflation peak in 1986 was followed by stunted growth in 1988. More recently, inflation has been trending upwards since 2004. This was followed by a tightening of monetary policy in an attempt to bring the inflation rate back to the set target band. By setting the inflation target at 3–6%, it presumes that inflation at that range would have a positive impact on economic growth. However, to

the best of our knowledge, no empirical study has been carried out to verify this. Hence, the need for the current study which attempts to fill this gap.

**Figure 1.1: The behaviour of GDP growth and inflation, 1983–2010**



Source: Plotted by author with data obtained from SARB and StatsSA

Growing empirical research investigates the inflation threshold rate or inflexion point at which the inflation-growth relationship is positive. However, most of the research has focused on groups of industrial and developing countries and there has been very little research on individual countries, including South Africa. In addition, none of the studies have reached a consensus as to the inflation thresholds for developing or industrial countries. Studies by Barro (1995b), Bruno and Easterly (1995), Judson and Orphanides (1996), Sarel (1996), Ghosh and Phillips (1998b) and Gillman *et al.* (2004) investigate the inflation threshold rate for groups of industrial and developing countries. Of all these studies, only Sarel (1996) included South Africa in the sample. Studies that have separated developing and industrial countries include Khan and Senhadji (2001) and Burdekin *et al.* (2004)<sup>1</sup>. Other studies such as those by Fischer (1993), Kalra and Sløk (1999) and Pollin and Zhu (2005) were conducted on developing countries only. South Africa was included in the study conducted by Pollin and Zhu (2005). Few studies focus on individual countries; examples

<sup>1</sup> Burdekin *et al.* (2004) included South Africa in their study.

include Singh and Kalirajan (2003), Ahmed and Mortaza (2005), Hussain (2005) and Mubarik (2005).

Studies conducted on a group of developing and industrial countries have mixed results. A majority of the studies analyse data from the 1960s to the 1990s (Barro, 1995b; Bruno and Easterly, 1995; Judson and Orphanides, 1996; Ghosh and Phillips, 1998b; Gillman *et al.*, 2004) with the exception of Sarel<sup>2</sup> (1996) whose study covered the period from 1970–1990. Barro (1995b), Judson and Orphanides (1996), Sarel (1996) and Gillman *et al.* (2004) found inflation threshold levels of 15%, 10%, 8% and 10% respectively. In contrast, a study by Ghosh and Phillips (1998b) was conducted on International Monetary Fund (IMF) member countries<sup>3</sup>, and they found a much lower inflation threshold of 2.5%. They added that, at inflation levels of 5% and 10%, the growth rate was equally good as at an inflation rate of 2.5%. Bruno and Easterly (1995) conducted an empirical analysis on industrial and developing countries and found an inflation threshold level of 40%. Thus with such a broad range of inflation rates from 2.5% to 40%, it is difficult for countries to settle on an inflation target.

Khan and Senhadji (2001) and Burdekin *et al.* (2004) separated the industrial and developing countries for the period 1960–1990. South Africa was included in the study by Burdekin *et al.* (2004). Khan and Senhadji (2001) found the optimum inflation band for industrial countries to be 1–3%. This was supported by the 3% inflation target found by Burdekin *et al.* (2004) for industrial countries. However, the results differed for developing countries. Khan and Senhadji (2001) found an inflation threshold band of 11–12% whereas Burdekin *et al.* (2004) found structural breaks in their model at 3%, 50% and 100%.

Regarding developing countries, most studies suggest a double digit inflation level ranging from 15–30% (see Fischer, 1993 and Pollin and Zhu, 2005). Fischer's (1993) study of developing countries from 1961–1988 found optimum inflation ranged from 15% to 30%. Similarly, Pollin and Zhu (2005) show that for the period 1961–2000, middle income countries, which includes South Africa, should target inflation from 14 to 16%, while lower income countries should have a slightly higher inflation target of 15–23%.

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<sup>2</sup> South Africa is included in this study.

<sup>3</sup> South Africa is an IMF member country.

Studies conducted to estimate the inflation threshold for individual countries are scarce. Some of the country-specific studies include Singh and Kalirajan (2003) for India, Ahmed and Mortaza (2005) for Bangladesh, Hussain (2005) and Mubarik (2005) for Pakistan. For India, Singh and Kalirajan (2003) were unable to determine an inflation threshold level; they suggested, however, that India broaden their current inflation band to 4–7% in order to account for imperfections in the economy and structural rigidities such as protective labour laws, directed credit policy, and government intervention in commodity markets. The results for Pakistan were conflicting, possibly due to the differing time periods. Mubarik (2005) estimated the inflation threshold at 9% from 1973–2000 whereas Hussain (2005) estimated an inflation band of 4–6% for the period 1973–2005. Ahmed and Mortaza's (2005) study on Bangladesh from 1980–2005 found that, above an inflation rate of 6%, there is a significant negative long-run relationship between inflation and growth, while below 6% there appears to be no significant effect on growth. All studies conducted on individual countries employ the method of conditional least squares as suggested by Khan and Senhadji (2001) to estimate the threshold inflation level.

Despite the growing interest in the inflation threshold level, few studies have included South Africa. In addition, these studies have included South Africa within a group of other countries under investigation. For instance, Sarel (1996) included South Africa in a group of developing and industrial countries and estimated an inflation threshold of 8%. Burdekin *et al.* (2004) grouped South Africa into their developing countries and found optimum inflation levels of 3%, 50% and 100%. Pollin and Zhu (2005) estimated a separate inflation band for middle income countries which included South Africa between 14% and 16%. The inconsistency in these results and the lack of empirical research in this area on South Africa calls for further studies. Furthermore, labour unions are putting pressure on the Reserve Bank to abandon inflation targeting altogether and to focus on job creation and economic growth; however this is without justification that the current inflation target is harming economic growth (Lourie, 2009). In particular, no study is known to have been conducted on the inflation threshold level of South Africa as an individual country, hence the need to fill this gap.

## **1.2 OBJECTIVES OF THE STUDY**

The main goal of the study is to determine the inflation band in South Africa that will produce optimum growth. More specifically, the following objectives will be pursued:

1. To determine whether there is a long-run relationship between price level and economic growth in South Africa.
2. To determine the nature of the causal relationship, if any, between price level and economic growth.
3. To determine if there is a threshold level of inflation for South Africa, above which the relationship between inflation and economic growth is negative.
4. To determine whether the inflation uncertainty has a greater impact on economic growth than the inflation rate.
5. Based on findings, propose policies for the Central Bank's inflation target.

## **1.3 METHODS OF THE STUDY**

The research objectives will be achieved by conducting a time series analysis of quarterly data from 1983Q1–2010Q1. All data will be obtained from SARB and StatsSA.

The first objective will be achieved using the Johansen test for cointegration, which will establish whether or not there is a long-run relationship between inflation and growth. If cointegration is found, weak exogeneity tests will be conducted to determine the causal relationship. Following this, the third objective will be explored using the method of conditional least squares, following Khan and Senhadji (2001), Ahmed and Mortaza (2005), Hussain (2005) and Mubarik (2005). Next, ordinary least squares regressions are estimated in order to determine the impact of the inflation rate and the inflation uncertainty on economic growth.

## **1.4 ORGANISATION OF THE STUDY**

The thesis is organised into six chapters as follows:

Chapter one introduces the study. It includes the context and objective of the study and motivates the research. Chapter two reviews the literature in the area – both theoretical and empirical. Chapter three provides an overview of the relationship between growth and inflation in South Africa and explains the inflation targeting framework used in South Africa. Chapter four presents the methodology of the study as well as describes the variables and

data used in the study. Chapter five presents and discusses the results. Finally, Chapter six concludes the study.

## **CHAPTER TWO**

# **THEORETICAL ISSUES AND SURVEY OF EMPIRICAL LITERATURE**

### **2.1 INTRODUCTION**

This chapter focuses on the theoretical and empirical literature regarding the relationship between inflation and growth as well as the threshold level of inflation. The second section describes the theoretical relationship between inflation and growth in the long-run and the short-run. Following this, there is a description of the costs of inflation. The next section considers the less studied area of inflation thresholds. The fifth section describes the relationship between inflation volatility and economic growth. The empirical literature follows. The empirical literature first focuses on the inflation-growth relationship followed by the empirical evidence on the inflation threshold. The empirical sections are divided into cross-country analyses, single-country analyses and studies conducted on South Africa. Finally, the last section concludes the chapter.

### **2.2 THE RELATIONSHIP BETWEEN INFLATION, GROWTH AND UNEMPLOYMENT**

Inflation is defined by Thirlwall (1974: xi) as a ‘rise in the general price level whatever its cause’. Inflation, according to Mishkin (2001: 11) is ‘a continual increase in the price level’. Dornbusch *et al.* (1999: 33) define inflation similarly as ‘the rate of change in prices’. Mohr (2005: 59) importantly points out that inflation is the ‘sustained increase in the general level of prices’ as opposed to a once-off increase. Generally there is no disagreement as to the meaning of inflation and it is clearly understood that it is the continuous ‘upward adjustment of prices’ (Curwen, 1976: 1). However, difficulties arise when determining the effect of inflation on unemployment and thus on a country’s economic growth and development.

Prior to the 1960s, little attention was paid to the effect of inflation on economic growth. With the birth of the Phillips curve, much attention was directed to the role that inflation plays on unemployment and therefore growth. The Phillips curve (Figure 2.1) shows that there is a trade-off between inflation and unemployment – that is, at high inflation there is

lower unemployment and therefore higher levels of economic growth (Phillips, 1958: 283). By implication, for an economy to grow, moderate to high inflation should be tolerated (Phillips, 1958: 283). Since then, this issue has generated a debate between structuralist and monetarist economics. Structuralists argue that inflation is needed for economic growth, whereas monetarists argue that inflation is harmful to economic growth (Mallik and Chowdhury, 2001: 123).

Phillips (1958: 283, 299) identifies three factors that explain the rate of change of money wage rates: the level of unemployment; the rate of change of unemployment; and the change in retail prices. Considering the level of unemployment, if the demand for labour is greater than the supply, then there are few unemployed in the market so employers are willing to pay higher wages to attract labour, and wage rates are bid up rapidly. In contrast, when the demand for labour is lower than the supply of labour, the wage rates fall very slowly because workers do not want to offer labour for less than the prevailing rate. This shows that there is a non-linear relationship between the rate of change of wage rates and unemployment. To relate this to growth, high inflation leads to low unemployment, which leads to greater productivity and hence higher growth.

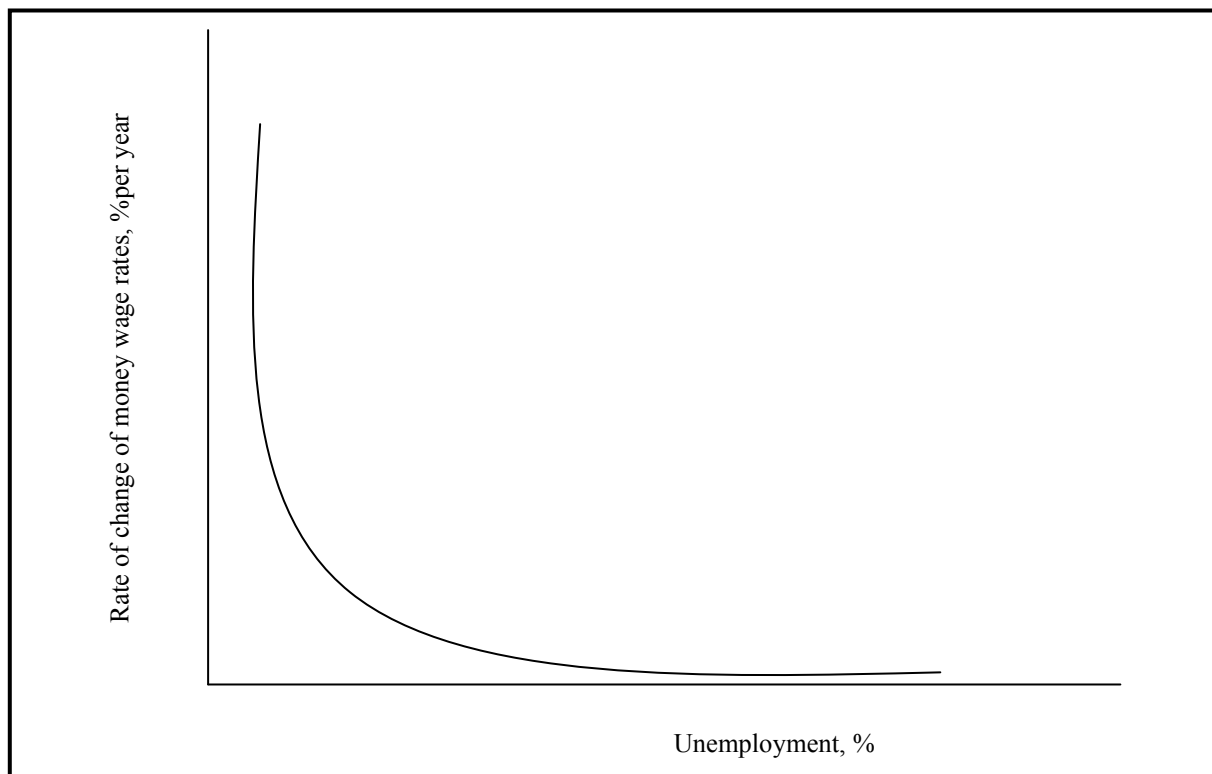
The second factor is the rate of change of unemployment. During an upward phase of the business cycle, the demand for labour increases and so unemployment decreases. Employers will offer higher wages than those in a year when unemployment was the same but the demand for labour was not increasing. Conversely, during a downward phase of the business cycle, the demand for labour will decrease, and the unemployment rate will increase. Employers will not be persuaded to offer higher wages as the labourers have less bargaining power than in a year when unemployment was the same but the demand for labour was not decreasing (Phillips, 1958: 283, 299).

The third factor is the change in retail prices, which are expressed through the cost of living adjustments. This effect is minimal except when there is a great increase in imports, which is reflected in retail prices. Anticipated increases in the retail prices will have a negligible effect because any cost of living adjustments taken on by the employers will be equivalent to the offers they are willing to make to recruit labourers when there is a high demand for labour. However, if the rise in prices is sudden, then the jump in retail prices is high, and the cost of living adjustment will be considerable for the employers. As higher wages are paid out, the

import and retail prices will rise further, therefore leading to a wage spiral which will continue till the prices of imports come down (Phillips, 1958: 283–284).

Therefore, Phillips proposes an inverse, nonlinear relationship between money wage rates and unemployment, which is popularly called the Phillips curve as shown in Figure 2.1 below. The higher the wage rates, the lower the unemployment. This can be related to inflation and economic growth. Rises in money wage rates results in increases in the inflation level. Lower unemployment leads to higher productivity and therefore higher growth, thus high inflation levels lead to high economic growth. In order for an economy to grow and reduce unemployment, a high inflation must be accepted.

**Figure 2.1: The Phillips curve, unemployment and the rate of change of money wage rates in the United Kingdom, 1861–1958**



*Source: Phillips, 1958*

Mundell (1963) and Tobin (1965) support the positive inflation-growth relationship postulated by Phillips (1958). This has become known as the Mundell–Tobin effect.

According to Mundell (1963: 280–283), wealth is divided between money and shares. Inflation causes a shift away from money towards savings in form of shares. This investment accelerates growth. A drop in inflation will cause a decrease in growth.

Tobin (1965) suggests a positive relationship between inflation and economic growth but suggests a different channel. The higher the inflation, the higher the growth rate due to increased capital stock. When there is price inflation, the public directs more money towards taxes and the government budget and away from savings. The government channels this into capital formation. This has an increasing effect on economic growth (Tobin, 1965: 681–682).

Therefore, according to the Mundell–Tobin effect, increases in inflation cause agents to adjust their portfolio balances. Since money and capital are substitutes, there will be shifts away from real money balances towards capital stock, thereby increasing economic activity. So a rise in the price level increases economic activity, as postulated by Phillips (1958).

A contrasting picture is that given by Fischer and Modigliani (1978) and Stockman (1981). Both authors identify a negative relationship between inflation and growth. According to Fischer and Modigliani (1978), inflation imposes costs on the economy which lead to wasted time and resources and therefore a decline in economic growth. Stockman (1981: 388) discusses an economy in which individuals divide their wealth between two assets, namely money and capital stock, and real money is spent on consumption and investment. At higher inflation levels, consumption decreases and investment increases as investment will have a higher return. However, with the low return on money, the net return is low. Therefore investment and capital stock are lowered. So economic growth declines due to lower consumption, lower investment and lower capital stock (Stockman, 1981: 391–392).

Therefore as can be seen, the theoretical positions on the relationship between inflation and growth is a controversial one. As Friedman (1973: 41) puts it, ‘historically, all possible combinations have occurred: inflation, with and without development; no inflation, with and without development.’

The Phillips curve has been developed further. Phelps (1967) and Friedman (1976) argue that the Phillips curve is vertical in the long-run at the natural rate of unemployment when the actual and expected rates of inflation are equal. In the long-run an economy will always move

back to the long-run Phillips curve because, through people's expectations, the actual rate of inflation will equal the expected rate. Lucas and Rapping (1969: 342–350) also support the vertical Phillips curve in the long-run. The positive relationship between inflation and unemployment only holds in the short-run.

Jones and Manuelli (1993) use a cash-in-advance model to determine how the rate of inflation affects the long-run growth of the economy. The effect of high inflation on growth depends on the model used. There are several possibilities: the first is an increase in the growth rate because, as depreciation rises, the tax paid on capital is reduced. The second effect is a decrease in the growth rate. As the money supply increases, so do the nominal interest rates. Tax credits on depreciation are reduced, resulting in an increase in the cost of capital. The third is dependent on the impact of inflation on the labour-leisure choice. Assuming cash goods and credit goods are substitutes for each other, increasing the price of cash goods will see consumption move away from cash goods and towards credit goods, causing the growth rate to first decrease then increase. If cash goods and credit goods are complements, price increases in cash goods will result in consumption of cash and credit goods both decreasing and therefore increase the demand for leisure goods. This will cause a drop in the growth rate (Jones and Manuelli, 1993: 22).

Ambler and Cardia (1998) use an endogenous growth model to explore the link between inflation and growth. The model shows that there is a negative relationship between inflation and growth for time series models in the short and long-run, and for cross-sectional studies in the long-run only (Ambler and Cardia, 1998: 90). In the long-run, monetary expansion brings about a negative relationship between inflation and growth. An increase in the rate of monetary expansion causes higher taxes on consumption. Therefore, consumers will direct their spending towards leisure activities instead of consumption. Employment in the steady state decreases. This causes a decrease in the growth rate (Ambler and Cardia, 1998: 102).

In South Africa in particular, Hodge (2002: 436–437) finds that there is no significant trade-off between price inflation and unemployment in the short-run, showing that the short-run Phillips curve does not hold for South Africa.

To date, the relationship between inflation and growth remains inconclusive. However, over time, it has been agreed that low and stable inflation promotes economic growth and that, at

high levels of inflation, uncertainties impose costs on the economy (Mubarik, 2005: 35). The following section will discuss these costs.

## **2.3 COSTS OF INFLATION**

There are two types of inflation that affect an economy – anticipated inflation and unanticipated inflation. Jackman *et al.* (1981: 171) define anticipated inflation as ‘a situation in which all increments in the general price index are (and have been) correctly foreseen by economic agents, and in which prices adjust perfectly flexibly.’ Despite knowing there will be an increase in prices, there are still costs associated with anticipated inflation (Briault, 1995: 33). Unanticipated inflation is the opposite situation to anticipated inflation. It is completely unexpected and; a general rise in the prices is not expected and therefore accommodated for by the general public, and so the prices do not adjust flexibly (Jackman *et al.*, 1981: 182–183). Therefore, unanticipated inflation is more costly than anticipated inflation as there is no time to make adjustments in order to cushion inflation (Moosa, 1997: 652). There are several channels and systems through which both types of inflation may harm economic activity; each of these will be discussed in turn.

### **2.3.1 UNCERTAINTY**

The inflation rate is positively related to the level of uncertainty in the economy. Higher inflation is associated with more variations in inflation, which ultimately lead to uncertainty (European Central Bank [ECB], 2008: 77). Uncertainty about the inflation rate creates confusion regarding buying, selling, borrowing and investing. For any of these, one needs to base decisions on current and future prices (Smal, 1998: 36). Uncertainty creates confusion about these prices, therefore discouraging investment and leading to a lower capital stock in a country (ECB, 2008: 77–78). Investors who are willing to invest will tend to enter into shorter-term contracts if there is more uncertainty about the inflation rate. There is a higher chance of correctly forecasting shorter-term prices than longer-term ones (Briault, 1995: 34; Moosa, 1997: 653). However, willing investors will expect to be compensated for their risk due to the increased uncertainty making investing more costly for borrowers. A higher risk premium leads to higher real rates, which further discourage investment and result in lower capital stock (Briault, 1995: 34; ECB, 2008: 78).

### **2.3.2 SHOE-LEATHER COSTS**

One of the earliest costs associated with inflation is the ‘shoe-leather’ cost. This is defined by Smal (1998: 37) as ‘the cost of wasted resources and opportunity, when going frequently to the bank to withdraw cash for their daily purchases.’ The costs associated with anticipated inflation arise due to interest not being earned on real money balances. Therefore by holding onto cash, the interest that would have been earned is forgone. Therefore every effort is made to minimise cash balances hence the need to make daily withdrawals for cash purchases (Smal, 1998: 37). Individuals will also try to ‘synchronise cash expenditures with the receipt of cash income’ (Briault, 1995: 33). Both businesses and individuals, in trying to protect their wealth, will waste time and resources, leading to reduced macroeconomic performance (ECB, 2008: 78). Financial institutions have since developed payment methods that do not involve cash, for example debit cards and credit cards. This has subsequently contributed to the development of a country’s financial sector (Smal, 1998: 37).

Menu costs are related to shoe-leather costs. As overall prices increase, businesses need to change their prices regularly to keep up with the changing inflation rate, continually gather information about the market, and make informed decisions about price changes (Briault, 1995: 36). This can be costly, especially in hyperinflationary situations when the prices are being changed very frequently (Smal, 1998: 37). Lately, menu costs have been reduced. The introduction of computer systems has made it less problematic and time consuming to adjust price codes (Moosa, 1997: 652).

### **2.3.3 REDISTRIBUTIONAL COSTS**

To protect their income from inflation, individuals will divert time and resources away from their usual productive activities into redistributing their income. This leads to inefficiencies in terms of resource allocation and a loss to economic activity. There are several channels through which redistribution occurs.

Income is redistributed from holders of money balances. Although every effort is made to eliminate cash balances it is not always possible to completely eliminate them. The purchasing power of any cash held, including bank deposits will be reduced by inflation, redistributing the wealth of any holders of money balances (Dowd, 1994: 1).

Income may also be redistributed between lenders and borrowers. Fully anticipated inflation is captured in the nominal interest rate and this has an impact on loan repayments. A rise in inflation will lower the real return of repayments to lenders, redistributing income from lenders to borrowers. A fall in inflation has the opposite effect; lenders will gain with a higher real return and in this instance income will be redistributed from borrowers to lenders. If borrowers make higher real repayments, they will be discouraged from taking out loans and hence making investments (Briault, 1995: 34). In addition, lenders are taxed on interest payments and borrowers may deduct interest payments. Therefore borrowers face a higher burden than lenders (Smal, 1998: 40).

Fixed income earners face a loss due to inflation. Individuals earning fixed incomes, for example, pension payments, will lose the value of these payments as inflation causes the income to be redistributed from the fixed income earners to the financial institutions. If the returns on retirement funds cannot keep up with the pace of inflation, there will be a loss in retirement income. Furthermore, lower income groups are less knowledgeable about the financial markets than wealthier groups and are also less able to afford hedging against inflation. Therefore redistributive costs are more likely to affect the lower income groups than the wealthier groups (Smal, 1998: 38).

Inflation is one of the factors that bring about wage negotiations. Labour unions fight for higher wages as the prices increase. However, by doing so they are pushing individuals into higher tax brackets (if those tax brackets are not fully indexed), forcing them to pay higher taxes. This is known as bracket creep or the fiscal drag phenomenon. The higher tax payments will be redistributed towards the government. This situation is avoidable if the tax brackets are revised often enough to keep up with the rising inflation and rising wages. However, this is not always easily effected; it can be costly in terms of time and resources (Smal, 1998: 38–39). Another option is to use index-linked contracts. However, this is also a costly option. In addition, it creates excess demand and therefore higher prices. So as much as index-linked contracts have fewer costs of inflation, they tend to bring about higher inflation levels (Briault, 1995: 37). Financial contracts will also be costly unless fully indexed (Briault, 1995: 34). To add to this, depreciation allowances are not indexed causing businesses to cater for this cost through profits. As a result businesses tend to invest in short-term inventories and capital (ECB, 2008: 78–79).

### **2.3.4 ECONOMIC COSTS**

Inflation has been shown to reduce economic activity and therefore growth in many ways. Individuals and businesses try to protect their wealth from inflation and in doing so waste time and resources. Therefore, inflation brings about inefficiencies that lead to the misallocation of resources and a general decline in macroeconomic performance (ECB, 2008: 77, 78).

Reduced savings lead to reduced investments, which in turn reduce growth level (Briault, 1995: 34). General uncertainty about future price levels discourages investment, leading to a lower capital stock in the economy (ECB, 2008: 78). Furthermore, the returns on investments are reduced by inflation, therefore investors will invest in short-term capital rather than making long-term investments. Investors would also rather invest in assets that can hedge against inflation (property, equity) rather than productive assets (plant and equipment). This may lead to an asset price bubble in inflation hedge assets. It also reduces the economy's production capacity therefore reducing economic growth (Smal, 1998: 41–42; ECB, 2008: 79).

Labour negotiations waste resources and push up nominal wages leading to unproductiveness and therefore lower growth. Inflation variability leads to shorter average contract lengths. Therefore resources are wasted in continual renegotiating of these contracts (Smal, 1998: 42–43).

Reduced competition, domestically and internationally reduces investment and therefore growth (Smal, 1998: 42–43). Higher inflation reduces competitiveness in the goods sector with trading partners, reducing trade and therefore causing an imbalance in the balance of payments account in the way of a current account deficit. Less investment will flow into the country in the goods sector and so deter the country's ability to reduce its current account deficit. In addition, with the reduced competition in international markets, profits in the traded goods sector will decline. Resources will move away from the traded goods sector and into the non-traded goods sector (Smal, 1998: 40).

Inflation understates the real value of depreciation. Therefore higher profits are declared resulting in higher tax paid on profits. This disadvantages companies wanting to make additional investments (Smal, 1998: 40; ECB, 2008: 78–79).

It is now generally agreed by economists that high inflation would have a negative impact on economic activity and that sustained growth is not achievable with high levels of inflation. There is also general agreement that inflation imposes many social and economic costs on an economy, both of which are difficult to quantify. Furthermore, as the economic situation changes, so do the effects of inflation as well as its costs (Smal, 1998: 33). Overall, inflation leads to inefficiencies in markets which waste resources that could otherwise be used in productive activities (Smal, 1998: 42–43). Therefore policymakers aim for low inflation. However a new argument arises over how low inflation should be.

#### **2.4 THE INFLATION THRESHOLD**

Targeting low inflation has been criticised because there are short-run costs associated with it. If, in the short-run, there is high inflation, this can bring about greater aggregate demand and therefore higher economic growth as shown by the Phillips curve. However this comes with higher prices. Persistent inflation in the long run will dampen economic growth. In the long-run, maintaining stable, low inflation leads to better growth (Motley, 1998: 15–16).

With general agreement that inflation is harmful to growth, many central banks aim for low inflation. However, it is not certain how ‘low’ inflation should be. High inflation could harm growth but, on the other hand, having a rate of inflation that is too low or an inflation rate of zero could inhibit economic growth. Therefore, central banks aim for a non-zero, low rate of inflation. Billi and Khan (2008) identify four reasons for keeping inflation low but above zero. The first is the measurement error. In measuring inflation, there is usually a measurement error, which tends to overstate the inflation rate. Therefore the true inflation rate will be closer to zero than thought. Secondly, nominal wages may have a downward rigidity. If employees refuse nominal wage cuts, then employers will not be able to cut their wages. If there is zero inflation and demand decreases, then firms will not be able to offer lower real wages and will be compelled to lay off workers. Therefore, if there is a small amount of inflation, real wages can be lowered without an effect on nominal wages. Thirdly, inflation should be kept at a sufficient rate above zero so as to avoid deflation. Although inflation is costly, deflation is thought to be even more costly. Asset values will fall while the value of debt will increase. The real cost of servicing debt will increase, increasing the burden on debtors. To make their payments, debtors will sell assets which will drop their prices even more. Therefore, the cost of debt will continue to increase while the asset values

will decrease. This leads into the fourth reason: the zero lower bound. As inflation drops, so do nominal interest rates. If inflation falls to zero then so will nominal interest rates, making it impossible for central banks to use the interest rate tool to implement monetary policy (Billi and Khan, 2008 : 5–11).

Cooley and Hansen (1991: 498–501) show that there are welfare gains from reducing moderate inflation to zero permanently. However, this also has costs associated with it in terms of lost revenue. The lost revenue in the study is substantial, and replacing it with either labour income tax or capital income tax is not always feasible. Temporary reductions of inflation to zero also have welfare and revenue costs.

Mundell (1965: 100) shows that the relationship between economic growth and inflation is non-linear. Deficit finance can be used to spur on economic growth but up to a certain maximum point. As the inflation rate approaches infinity, the limit of economic growth achievable reaches a maximum. An inflation rate of 50% sees an increase in economic growth of 1%. An inflation rate of  $\infty\%$  will only raise growth by 1.5%. Therefore this positive relationship between inflation and economic growth reaches a maximum at some point (Mundell, 1965: 102). By implication, the relationship between the two variables is non-linear.

Studies have been conducted on the non-linear relationship between inflation and growth. It has become clear that there is a threshold level of inflation, below which inflation may have no effect or even a positive effect on growth, and above which inflation has a negative effect on growth (Sarel, 1996: 199–200). Therefore by targeting inflation below the threshold level, an economy can avoid the negative effects of inflation and growth leading to a sustainable growth rate and lower unemployment in the long-run.

According to Tobin (1972: 1), the full employment level is the inflation threshold for a country. Below full employment, when there is excess labour supply, prices decline or become stagnant. The economy moves above full employment when there is an excess demand for labour and this situation sees price increases.

Harris *et al.* (2001: 12–13) provide an explanation for the nonlinearity between inflation and growth. At low rates of inflation, consumers mainly use money for purchases. Any credit

used is very little. Therefore, the demand for money is inelastic. As the inflation rate rises, it becomes more elastic. So when the inflation rate is low and the demand for money is inelastic, consumers are more likely to substitute consumption goods for leisure and money for a little credit. With a higher inflation rate and a more elastic demand for money, the substitution from goods to leisure decreases and the substitution from money to credit increases. Leisure increases at a decreasing rate, causing the growth rate to decrease by increasingly smaller amounts. Therefore at higher rates of inflation, there is a larger negative impact on growth than at lower rates.

Modelling a small open economy, Huybens and Smith (1998: 395) establish a relationship between inflation and growth at high and low steady state levels of inflation. At higher steady state levels of inflation, increasing the money growth rate will further increase inflation beyond a level that is conducive to capital formation and hence economic growth. With a lower steady state of inflation, increasing the money growth rate will also result in an increase in the steady state level of inflation; however this increase will be small enough to allow for capital formation.

However, the inflation threshold is unique to each country. According to Sepehri and Moshiri (2004: 192), the threshold level for developing countries is likely to differ to that of industrial countries. Countries differ in terms of their nature and structure of the economy. Therefore each country needs to determine the threshold unique to it. Cross-country studies can only provide a vague target within which to keep inflation in line. Single-country studies can provide the threshold level for those specific countries.

## **2.5 INFLATION, INFLATION UNCERTAINTY AND ECONOMIC GROWTH**

Inflation uncertainty is the ‘unpredictability of future inflation’ (Sweidan, 2004: 43). The effects of inflation and inflation uncertainty on economic growth are difficult to separate as they are closely correlated (Fischer, 1993: 4). The correlation between them is positive. Inflation uncertainty can either have a negative effect on economic growth or an insignificant effect, depending on its impact on the economy (Sweidan, 2004: 43).

It is important to identify the individual effects of inflation and inflation uncertainty on economic growth. If inflation is affecting the growth rate, then controlling it within the right levels can lead to a more stable environment. However, if it is the uncertainty that is affecting

the growth rate, then controlling for uncertainty may be a better option than focusing on keeping inflation within a band. If an inflation band is chosen, volatility within that range can hinder growth prospects (Judson and Orphanides, 1996: 2).

## **2.6 EMPIRICAL EVIDENCE ON THE INFLATION-GROWTH RELATIONSHIP**

There is a growing body of literature on the inflation-growth relationship. This section provides a brief overview of the literature, with a focus on single country analysis<sup>4</sup>.

The major focus of the studies has been to determine whether there is a significant relationship between inflation and growth. The most common method used is the Ordinary Least Squares (OLS) method (cf. Bhatia, 1960; Lucas, 1973; Hodge, 2006; Li, 2006). OLS is applied to pooled, cross-sectional as well as time series regressions; the R-squared value being used to indicate the strength of the relationship between inflation and growth.

The studies can also be divided into the variables included in the models. Bivariate models which regress growth on inflation are used by Bhatia (1960), Lucas (1973), Fischer (1983), Faria and Carneiro (2001), and Ahmed and Mortaza (2005), to name a few. Most of the studies however have used more comprehensive multivariate models, regressing economic growth onto inflation as well as a variety of explanatory variables<sup>5</sup>.

The inflation-growth literature shows strong evidence of a negative relationship between inflation and growth, regardless of the model or the control variables in the model. However, there have been studies that show a positive relationship between inflation and growth (Jung and Marshall, 1986) or no evidence of a relationship between the two (Bhatia, 1960).

This section reviews a few studies (cf. Bhatia, 1960; Lucas, 1973; Kormendi and Meguire, 1985; Jung and Marshall, 1986; Barro, 1995b; Bruno and Easterly, 1995, Andrés and Hernando, 1997; Li, 2006) to demonstrate the relationship between inflation and growth. They highlight the method, the variables and the nature of the relationship. The cross-country studies will be discussed first, followed by the single-country analysis and lastly the studies based on South Africa.

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<sup>4</sup> For a summary on the inflation-growth literature see table A1.

<sup>5</sup> See table A2a and A2b for details on variables of the multivariate models.

### **2.6.1 CROSS-COUNTRY ANALYSIS**

The first of the papers reviewed is Bhatia (1960). This study focuses on 5 developed countries, namely the United Kingdom (UK), Germany, Sweden, Canada and Japan<sup>6</sup>. Using a simple bivariate model of the inflation rate and the growth rate, the study finds no conclusive evidence as to the relationship between inflation and growth. This is due to conflicting results for each country for the differing time periods. The study is divided into two time periods. The long period is divided into price waves of 20–30 years and the short period is divided into price waves of 5–10 years. First, using OLS, a linear equation is fitted for the rate of growth and the rate of price change for long periods. The finding is an inverse relationship between inflation and growth for the UK, Germany and Japan, while a positive relationship is found for Sweden and Canada. However the only significant coefficients are those for Japan and Sweden. Second, an OLS regression is run for the shorter periods and while Germany and Japan still show an inverse relationship, and Sweden and Canada are found to have a positive relationship, the UK now shows a positive relationship. In this case only the coefficient for Germany is significant. Given the differing results and the insignificance of most results, no conclusive results can be drawn about the inflation-growth relationship (Bhatia, 1960: 108, 110, 113–114).

Lucas (1973) finds a positive relationship between inflation and growth. Like Bhatia (1960), Lucas (1973) also estimates a bivariate model using OLS. The study covers 18 developed and developing countries from 1951–1967. The results show that there is a ‘stable trade-off’ between inflation and growth (Lucas, 1973: 330–334). Fischer (1983) conducts a similar study to that of Lucas (1973). Again a bivariate model is estimated for 53 developed and developing countries<sup>7</sup>, covering the period from 1961–1981. Running cross-sectional and time-series regressions, this study finds a negative relationship between inflation and growth. This inverse relationship is supported by Kormendi and Meguire (1985) whose finding is also a negative relationship between inflation and growth. The study is based on 47 developed and developing countries, including South Africa for 1950–1977. Cross-sectional regressions are run on multivariate models which include real output, money supply, inflation rate, population growth, government spending, exports and investment as the explanatory variables.

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<sup>6</sup> The periods of study are as follows: UK: 1812–1912; Germany: 1865–1910; Sweden: 1865–1934; Canada: 1873–1938; Japan: 1881–1922.

So far all the studies analysed have been before the 1990s. However, more recent studies have still supported an inverse relationship between inflation and growth. Andrés and Hernando (1997) conducted a study on Organisation for Economic Co-operation and Development (OECD) countries from 1961 to 1996. Using OLS, per capita income is regressed on the rate of investment, the rate of human capital accumulation and the growth rate of population. With the exception of population growth, these control variables differ from those of Kormendi and Meguire (1985). However, the results are the same; an inverse relationship between inflation and growth.

Bhatia's (1960) study was focused on developed countries in Europe. Lucas (1973), Fischer (1983), Kormendi and Meguire (1985) and Andrés and Hernando (1997) have all grouped developed and developing countries together. However developing countries differ from developed in terms of their economic structure. Therefore other authors (see Jung and Marshall, 1986; Malla, 1997; Li, 2006) have gone on to separate developed and developing countries in their study. Jung and Marshall (1986) find a positive relationship between inflation and growth while Malla (1997) and Li (2006) support the inverse relationship. Jung and Marshall's study is conducted on 19 developed countries and 37 developing countries. South Africa is included in this study for the period 1951 to 1980. Using the growth rate as the dependent variable and the inflation rate as the independent variable, the study finds that 16 countries have a negative relationship on growth. However, Egypt and Uruguay support positive relationships between inflation and growth. Like Bhatia (1960), this study also finds no conclusive evidence for the relationship between inflation and growth for 38 countries.

As one of the objectives of this study is to determine whether or not there is a relationship between inflation and growth in South Africa, the review will now move onto single country analyses.

## **2.6.2 SINGLE COUNTRY ANALYSIS**

Authors have recognised the weaknesses of conducting studies on groups of countries. The structure of economies differs from country to country. To be more precise about the relationship in a country, a model specific to that country needs to be estimated. Authors have started to conduct these studies. An overview of these will be described in this section.

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<sup>7</sup> The developing countries include South Africa.

Smyth (1992; 1994) conducted studies on the United States of America (USA). Both studies find the same results despite differing variables, time periods and methods. Smyth (1992) regresses the growth rate on the inflation rate using OLS from 1955 to 1990. But in 1994, Smyth regresses the growth rate on the inflation rate as well as total private business sector hours, the ratio of employment in the services industry to the goods industry, and the price of energy to the price of business sector output, using a growth equation estimate from 1951 to 1992. Both studies find a negative relationship between inflation and growth, with higher inflation reducing output in the steady state. Sbordone and Kuttner (1994) also conduct a study on USA for a much longer time period, from 1947 to 1994. This study also supports the idea that inflation is harmful to growth.

The remaining studies on single countries are all conducted on developing countries. Faria and Carneiro (2001), Chowdhury and Siregar (2004), Gokal and Hanif (2004) and Ahmed and Mortaza (2005) all use bivariate models. Singh and Kalirajan (2003), Sweidan (2004) and Hussain (2005) use multiple regression models. Despite the differing methods, variables and time periods, all the studies find significant negative relationship between inflation and growth.

Faria and Carneiro (2001) show that there is a negative impact of inflation on growth in the short-run for Brazil from 1980 to 1995. There is no evidence of a long-run relationship between the two variables. Chowdhury and Siregar (2004) conduct their study on Indonesia from 1950 to 1997 and find a bidirectional relationship between inflation and growth: a shock to inflation has a stronger and more negative impact on economic growth than a shock to economic growth on inflation. For Fiji, Gokal and Hanif (2004) find a weak negative effect of inflation on growth from 1970 to 2003. Ahmed and Mortaza's (2005) study finds a stable long-run negative relationship between inflation and growth for Bangladesh from 1981 to 2005.

In a study on India, Singh and Kalirajan (2003) find that any increases in inflation are detrimental to growth. The study covers the period 1971 to 1998 and uses a cross-sectional regression. Sweidan (2004) finds a strong significant negative relationship for Jordan from 1976 to 2003, and Ahmed and Mortaza (2005) find the similar results for Pakistan.

In 2004, Mejia-Reyes conducted a study on the nonlinearities in the Mexican output-growth relationship using the smooth transition regression model. The findings shows that inflation consistently has a negative effect on growth in Mexico (Mejia-Reyes, 2004: 1–2, 12).

Despite earlier literature, there is strong empirical evidence for an inverse relationship between inflation and growth. The case for South Africa will now be considered.

### **2.6.3 EMPIRICAL LITERATURE ON SOUTH AFRICA**

South Africa has been included in several cross-sectional studies<sup>8</sup> and has been shown to have a negative relationship between inflation and growth in all the studies except Jung and Marshall (1986). Two single country studies will be reviewed to see if the cross-sectional studies have adequately captured the relationship for South Africa.

Nell (2000) conducted a study using quarterly data from 1960 to 1999. A vector autoregressive (VAR) model is used for real GDP growth, rate of change in terms of trade, rate of change in the money stock, inflation rate, and the nominal lending rate. The VAR model shows that inflation has an independent negative impact on growth. The authors suggest that inflation should be kept in single digits as mild inflation may be beneficial to growth. In addition, double digit inflation should be avoided so as to stay away from possible costs imposed on growth due to inflation.

Similarly, Hodge (2006) finds existence of a negative relationship. For the periods covering 1950 to 2002, an OLS regression is run with growth rate as the dependent variable and inflation rate, labour productivity, gross fixed investment, tax burden, and terms of trade as the explanatory variables. The results show that in the medium to long-term, there is a strong negative impact of inflation on growth.

Few studies have been conducted on South Africa as a single country. Therefore there is a need to conduct this study on South Africa and to determine the short-run as well as the long-run effects of inflation on growth.

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<sup>8</sup> See table A1.

## **2.7 EMPIRICAL EVIDENCE ON INFLATION THRESHOLDS**

This section provides an overview of the growing empirical literature on inflation thresholds. The focus is on studies conducted on single countries<sup>9</sup>.

The major focus of the empirical studies is to establish the threshold rate of inflation above which the effects of inflation are inimical to growth. In estimating the threshold level, authors use different methods, the most popular being spline estimation for cross-country analysis (cf. Fischer, 1993; Judson and Orphanides, 1996; Sarel, 1996; Ghosh and Phillips, 1998a; 1998b; Motley, 1998; Kalra and Sløk, 1999; Burdekin *et al.*, 2004; Gillman *et al.*, 2004) and the conditional least squares method for single-country analysis (cf. Khan and Senhadji, 2001; Sweidan, 2004; Ahmed and Mortaza, 2005; Hussain, 2005; Mubarik, 2005).

In addition to differing methods, studies are based on dissimilar models. There are those that focus on bivariate models which involve the GDP growth rate being regressed on the inflation rate (cf. Chowdhury and Siregar, 2004; Gokal and Hanif, 2004; Ahmed and Mortaza, 2005) as well as more comprehensive multivariate models which include explanatory or control variables aside from just the inflation rate<sup>10</sup>.

The results suggested by the literature are inconclusive as to the inflation threshold. To date, majority of the studies have been cross-sectional studies grouping developed and developing countries together and suggesting a threshold level applicable to all of the countries in the study. Recognising the limitation of this, more recent studies have found separate thresholds for developed and developing countries and some have furthered this limitation by conducting an analysis on single countries. In addition, while the majority of the studies are in agreement regarding a negative relationship between inflation and growth above the threshold, very few have found a positive relationship below the threshold (cf. Ghosh and Phillips, 1998b; Khan and Senhadji, 2001; Rousseau and Wachtel, 2002; Burdekin *et al.*, 2004; Sweidan, 2004).

This review will begin by analysing the cross-country studies by Barro (1995b), Bruno and Easterly (1995) and Sarel (1996) that have grouped together developed and developing studies in the estimation using the OLS method. Then the spline estimation technique based

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<sup>9</sup> See table A3 for a summary of the studies reviewed.

on cross-country studies (Judson and Orphanides, 1996) will be discussed. Following this, studies conducted by Khan and Senhadji, (2001) and Burdekin *et al.* (2004) demonstrate the effect of separating developed and developing countries. The remaining review will be on single-country studies as well as those on South Africa.

### **2.7.1 CROSS-COUNTRY ANALYSIS**

The first set of studies to be reviewed are those that have grouped together developed and developing countries. The well-known paper by Barro (1995b) assesses the impact of inflation from as far back as the 1960s. The data is divided into three decades: 78 countries from 1965 to 1975, 89 countries from 1975 to 1985 and 84 countries from 1986 to 1990. The wide range of explanatory variables included in this study are the inflation rate (calculated using the consumer price indices or the deflator for gross domestic product if the former is unavailable), inflation variability (computed using the standard deviation of the inflation rate), log of GDP, male schooling, female schooling, log of life expectancy, human capital, log of fertility rate, ratio of government consumption to GDP, ratio of public education spending to GDP, the black market premium, the rule-of-law index, the change in the terms of trade, the investment to GDP ratio, a democracy index and finally the democracy index squared. The rationale for the study is to provide additional empirical evidence for the relationship between inflation and growth, given the limited empirical work to support the theoretical claims that inflation is costly<sup>11</sup> (Barro, 1995b: 4, 24).

The regression equations are based on the neoclassical growth model and are regressed using the instrumental variables method. The instruments are mostly prior values of the regressed variables. The results reveal a linear relationship between inflation and growth with threshold effects at 15% and 40%. The negative effect of inflation on growth is only statistically significant when inflation is in excess of 40% (Barro, 1995b: 3–4, 8).

Bruno and Easterly (1995) also conducted a cross-sectional study on developed and developing countries<sup>12</sup>. Their study particularly considers the growth performance of

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<sup>10</sup> See table A4a and A4b for studies and details of variables.

<sup>11</sup> For arguments on the cost of inflation see Fischer and Modigliani (1978); Dowd (1994); Briault (1995); Moosa (1997); O'Reilly (1998); Smal (1998) and European Central Bank (2008).

<sup>12</sup> South Africa is included in this study.

countries with inflation crises, before, during and after the crises. They define an inflation crisis as a country experiencing inflation greater than 40%, as did Barro (1995b).

Using a non-parametric definition of high inflation crises<sup>13</sup>, this study reveals that the negative association between economic growth and inflation is only plausible past high inflation rates, in this case 40%. The costs of inflation become more apparent once the threshold level is breached (Bruno and Easterly, 1995: 20).

Sarel (1996) used an OLS regression and found an inflation threshold level of 8%<sup>14</sup>. Like Barro (1995b) and Bruno and Easterly (1995) Sarel tested for threshold effects in a group of 87 developed and developing countries from 1970–1990. The GDP growth rate is the dependent variable and the control variables consist of consumer price index (CPI), terms of trade, real exchange rates, government expenditures and investment as well. The inflation dummy that maximises the R-squared value and minimises the residual sum of squares (RSS) is used as the threshold inflation rate, in this case 8%. The relationship between the inflation rate and the growth rate is also non-linear. This is illustrated by the effects of inflation above and below the threshold level. Below the threshold, the effect that inflation has on growth is positive; however, this is not significant and is weak. Above 8%, there is a very powerful negative effect on growth (Sarel, 1996: 201–209).

Using the spline estimation technique<sup>15</sup>, Judson and Orphanides (1996) found a threshold level of 10% for 119 developed and developing countries which included South Africa from 1959 to 1992. The multivariate model estimate consisted of the inflation rate, investment as a share of GDP, investments share in income, capital accumulation and investment in human capital as the explanatory variables. The authors concluded that high inflation is detrimental to growth.

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<sup>13</sup> A country is defined as having a high inflation crisis when inflation is above some threshold level; 40% is chosen in this study. The country's growth performance is then calculated before, during and after the crisis (Bruno and Easterly, 1995:1, 6–7).

<sup>14</sup> Sarel's (1996) study includes South Africa as a developing country.

<sup>15</sup> The spline operator generates a piecewise linear regression line (Judson and Orphanides, 1996: 10). An *n*th order polynomial spline function is a piecewise function whose pieces are polynomial segments of degree at most *n* and which are joined together in a continuous fashion. So that the (*n*-1)th derivative is continuous (Poirier and Garber, 1974, 231). Also see Greene (1993, 322-324).

So far, the studies have grouped together developed countries and developing countries. This can be misleading as developing countries experience much higher inflation rates than developed countries. Developing countries also tend to grow at a much faster rate than developed and so have higher inflation levels. Studies<sup>16</sup> have divided their testing between developed and developing countries therefore enabling them to estimate separate threshold levels for the developing countries and the developed countries. This is well illustrated in Khan and Senhadji (2001) and Burdekin *et al.* (2004).

Khan and Senhadji (2001) use a technique similar to the spline estimation known as conditional least squares for 140 countries divided into developed and developing countries from 1960–1998. The conditional least squares method involves first estimating models using OLS yielding the RSS as a function of the threshold inflation rate,  $\pi^*$ . The value of  $\pi^*$  which minimises RSS is the threshold inflation rate (Khan and Senhadji, 2001: 3, 7).

Regressing the growth rate of GDP on the CPI growth rate, initial level of income, gross domestic investment as a share of GDP, population growth and the growth rate of terms of trade, Khan and Senhadji (2001: 9–12) found a threshold level of 1–3% for developed countries, 11–12% for developing countries and 11% for the full sample. This demonstrates that estimating a single threshold level for developed and developing countries is unreliable as the countries differ in terms of economic structure. Above all, the statistically significant thresholds estimates indicate there is a significant negative effect on growth due to inflation. Furthermore, below the thresholds of 1–3% for the developed countries and 11–12% for developing countries, there is a positive relationship between inflation and growth. This is only significant for developed countries. The method used by this study is employed in many single country analyses.

Burdekin *et al.* (2004) use spline estimation. The study uses GDP per capita as the dependent variable and only five explanatory variables: population growth rate, ratio of real government expenditure to GDP, black market exchange rate premium, terms of trade, and lastly the inflation rate. 21 developed countries are used for the study from 1965 to 1992 and 51 developing countries<sup>17</sup> from 1967 to 1992. Using spline estimation techniques and the generalised least squares method, nonlinear relationships are found for growth and inflation

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<sup>16</sup> See Burdekin *et al.* (2004), Pollin and Zhu (2005) and Li (2006).

<sup>17</sup> South Africa is included in this study.

in both groups. For developed countries, the threshold is estimated at 8% and 25%. Below 8%, the relationship between inflation and growth is negative but insignificant. Between 8% and 25%, there is a significant negative effect on growth. A 1% increase in inflation reduces growth by 0.3%. For developing countries, 3%, 50% and 102% are the values of inflation that maximise R-squared. However, at 102%, the breakpoint is not significant. Below 3% there is a strong positive relationship. Between 3% and 50% there is a significant negative effect. Between 50% and 102% the effect on growth is negative yet insignificant. The log of inflation was also used. The results did not differ much except for the 3% threshold level for developing countries rising to 10% (Burdekin *et al.*, 2004: 522, 524–526, 528). The vast differences between the thresholds for the developed and developing countries further demonstrate the disadvantage of grouping all the countries together. This could lead to misleading results and therefore incorrect policies being put in place.

Dividing the studies between developing countries and developed countries so far appears to be a better estimation method than grouping them together. However amongst the developing or developed countries there may still be vast differences between the countries and the structure of their economies. Because of this, single country analyses have gained popularity.

### **2.7.2 SINGLE COUNTRY ANALYSIS**

The literature on threshold levels for single countries, once scarce, is now becoming common, especially in the case of developing countries<sup>18</sup>. One of the earlier studies is by Kannan and Joshi (1998) for India. Following Sarel (1996), an OLS regression is used to estimate the threshold level from 1981/82–1995/96. The estimated threshold of 6% does not have any effect below it but has a negative relationship between inflation and growth above 6% (Kannan and Joshi, 1998: 2726–2728). Following the conditional least squares method of Khan and Senhadji (2001), Singh and Kalirajan's (2003) finding opposes that of Kannan and Joshi (1998). No threshold level was determined for India from 1971–1998; instead the study concluded that inflation negatively affects growth at all levels (Singh and Kalirajan, 2003: 383–387).

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<sup>18</sup>For threshold studies on individual developing countries see Kannan and Joshi (1998); Singh and Kalirajan (2003); Chowdhury and Siregar (2004); Gokal and Hanif (2004); Sweidan (2004); Ahmed and Mortaza (2005); Hussain (2005) and Mubarik (2005).

Chowdhury and Siregar's (2004) study focused on the threshold level for Indonesia. An OLS regression in the form of a quadratic specification<sup>19</sup> was estimated consisting of just two variables, GDP growth rate and the inflation rate. The period covered is from 1950–1997. The threshold level determined is 20.4% for Indonesia. If inflation rises above the threshold level, there is a negative effect on growth. Gokal and Hanif (2004) conducted a study on Fiji from 1970–2003. Like Chowdhury and Siregar (2004), the study includes just two variables, inflation and growth. Using a joint frequency distribution<sup>20</sup>, the inflation threshold rate estimate for Fiji is 5%. Inflation rates above 5% result in a significant drop in the growth rate.

Using the conditional least squares method of Khan and Senhadji (2001) and Singh and Kalirajan (2003), Sweidan (2004) found a 2% threshold level for Jordan. Sweidan (2004) uses a more comprehensive model, avoiding the bivariate models used by Chowdhury and Siregar (2004) and Gokal and Hanif (2004). Above 2%, the relationship between growth and inflation is negative. Below the threshold level, there is a strong positive relationship between inflation and growth which is highly significant.

Mejia-Reyes (2004) found an inflation threshold level of 8.3% for Mexico. The method used was the smooth transition regression model<sup>21</sup>, which included the growth rate of output as the dependent variable and the inflation rate, depreciation rate and the USA output growth rate as the explanatory variables (Mejia-Reyes, 2004: 12).

In 2005, Sargsyan conducted a study on the inflation threshold in Armenia from 1996 to 2004. Following the method used by Khan and Senhadji (2001) the study finds a threshold rate of 4.5% annually. Above this level there are significant negative effects of inflation on growth. Below this level, the effect will not hinder growth and may promote it (Sargsyan, 2005: 3, 12, 15).

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<sup>19</sup>  $GDP_t = \beta_1 INF_t + \beta_2 INF_t^2 + \varepsilon_t$

<sup>20</sup> Joint frequency distribution refers to the number of times a given quantity occurs in a set of data (Business Dictionary, 2010).

<sup>21</sup> A smooth transition regression model is a flexible and intuitive framework which allows for modelling both regime dependent dynamics and regime switches, driven by a predetermined variable (the transition variable) which can be smooth or abrupt. Therefore the regimes are not necessarily associated to the business cycle but are defined by the transition variable. The transition variable and other variables have differentiated effects on output (Mejia-Reyes, 2004: 3).

The studies by Ahmed and Mortaza (2005), Hussain (2005) and Mubarik (2005) are similar in terms of the countries covered<sup>22</sup> and methods used<sup>23</sup>. Ahmed and Mortaza (2005) study the inflation threshold for Bangladesh from 1981 to 2005. Using the GDP growth rate and the inflation rate, the conditional least squares method estimates a threshold level of 6%. This is the same as that for India in Kannan and Joshi's study. India and Pakistan also have similar economic structures.

Hussain (2005) does not find a threshold level for Pakistan applying the conditional least squares method to a multivariate model. This is in contrast to Mubarik (2005) whose study finds a 9% threshold level for Pakistan. The differing results could be due to the time period covered<sup>24</sup> as well as the chosen variables<sup>25</sup>.

A similar study was conducted on Malaysia by Munir and Mansur (2009). The threshold is estimated using the conditional least squares method on a threshold autoregressive model<sup>26</sup>. The inflation threshold level is estimated to be 3.89%, above which there is a significant negative effect on growth. Below the threshold there is a significant positive effect on growth (Munir and Mansur, 2009: 5, 7, 9–11).

More recently, estimating the threshold effects for Ghana using annual data from 1960 to 2008, Frimpong and Oteng-Abayie (2010) found a threshold inflation rate of 11% which is slightly higher than Ghana's inflation target of 7–9%; a target which has consistently been missed (Frimpong and Oteng-Abayie, 2010: 225, 230). This emphasises the importance of a central bank targeting the right inflation band in order not to lose credibility as well as harm growth. The model followed the conditional least squares method of Khan and Senhadji (2001) (Frimpong and Oteng-Abayie, 2010: 228).

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<sup>22</sup> Ahmed and Mortaza's (2005) study is on Bangladesh, and both Hussain (2005) and Mubarik (2005) estimate thresholds for Pakistan. Bangladesh and Pakistan have similar economic structures.

<sup>23</sup> All studies use the conditional least squares method.

<sup>24</sup> Hussain's (2005) study covers 1973–2005. Mubarik's (2005) study covers 1973–2000.

<sup>25</sup> Both studies regress the GDP growth rate on the inflation rate, investment rate and the population growth rate. Hussain includes the additional variables of the ratio of M2 to GDP.

<sup>26</sup> An exogenously given variable known as the threshold variable is used to split the sample into two groups or regimes, which can or cannot be a regressor (Munir and Mansur, 2009: 5).

### 2.7.3 EMPIRICAL LITERATURE ON SOUTH AFRICA

As can be seen in Table 2.1, South Africa has only been included in cross-country studies. The cross country studies have a weakness in that they do not account for the different structures and characteristics of the economy included. Furthermore, there seems to be no conclusive threshold level for South Africa. Therefore single country analysis of inflation thresholds appears to give a better estimate. So far no single country analysis has been conducted on South Africa, hence the need for this study

**Table 2.1: Inflation threshold studies including South Africa**

Study	Threshold level	Effect below threshold	Effect above threshold
Barro (1995b)	15% and 40%	< 15%: not significant	15%-40%: negative and significant > 40%: negative and significant
Bruno and Easterly (1995)	40%	Positive, significant	Negative, significant
Judson and Orphanides (1996)	10%	Positive, insignificant	Negative, significant
Sarel (1996)	8%	Positive, insignificant	Negative, significant
Ghosh and Phillips (1998a)	2-3%	Positive, significant	Negative, significant
Ghosh and Phillips (1998b)	2-3%	Positive, significant	Negative, significant
Rousseau and Wachtel (2002)	6-8%, 13-25%	<6.8%: positive and significant	13-25%: positive, not significant >25%: negative, significant
Burdekin <i>et al.</i> (2004)	3%, 50% and 102%	<3%: positive, significant	>3%: negative, significant
Sepehri and Moshiri (2004)	4%	Positive, significant	Negative, significant
Pollin and Zhu (2005)	14-16% and 15-18%	Positive, significant	>18%: negative, significant
Li (2006)	14% and 38%	<14%: positive, significant	14-38%: negative, significant >38%: negative, significant
Rousseau and Yilmazkuday (2009)	4-19%	<4%: positive, significant	4-19%: negative, significant >19%: negative, significant

*Source: Compiled by author from studies reviewed*

### 2.8 CONCLUSION

This chapter explores issues regarding the relationship between inflation and growth. Firstly, theory has shown that there can be three possible relationships between inflation and growth; a positive relationship, a negative relationship or no relationship at all. The costs on growth due to inflation are discussed. This provides further evidence for a negative relationship between inflation and growth. According to theory, the negative effect on growth is thought

to happen at a particular inflation rate known as the inflation threshold. Beyond this inflection point, there is a negative relationship between inflation and growth. Below it, no relationship and in some cases a positive relationship. Inflation uncertainty may also have an effect on economic growth. Theory shows that inflation uncertainty may have a greater negative effect on growth than the level of inflation. If this is the case monetary policy should be directed towards controlling the inflation volatility with less emphasis on the inflation rate.

Empirical evidence provides support to the theoretical studies. The empirical literature is divided into three sections; cross-country analysis, single country analysis and studies on South Africa. In terms of the relationship between inflation and growth, empirical literature shows that there is a negative relationship between inflation and growth for the majority of the studies. This applies to South Africa as well. In terms of the inflation threshold level, empirical literature shows that inflation threshold levels exist for all but a few of the countries studied. Cross-country studies make it difficult to determine individual thresholds for specific countries. Single country analyses allow one to determine the exact threshold level for that country. South Africa has only been included in cross-country studies. Therefore there is a need for a single country analysis on the inflation threshold level for South Africa.

The next chapter considers the inflation-growth relationship with reference to South Africa. Together with this chapter, the next chapter lays the foundation for the empirical analysis.

## **CHAPTER THREE**

# **OVERVIEW OF SOUTH AFRICAN INFLATION AND ECONOMIC GROWTH**

### **3.1 INTRODUCTION**

The aim of this chapter is to provide an overview of monetary policy, in particular monetary policy in South Africa and its effect on inflation and growth. Section 3.2 discusses monetary policy in South Africa. Section 3.3 describes inflation targeting with particular reference to South Africa. Section 3.4 takes a first look at the relationship between economic growth, inflation and inflation uncertainty in South Africa. Lastly, section 3.5 provides a brief conclusion.

### **3.2 OBJECTIVES OF MONETARY POLICY IN SOUTH AFRICA**

Monetary policy in South Africa is conducted independently by SARB. The bank has a primary objective as well as an ultimate objective, as most central banks do. The primary objective has a shorter horizon and is used to achieve the long-term ultimate objective (Faure, 2006: 6).

The objectives of SARB are entrenched in the Constitution of the Republic of South Africa<sup>27</sup> as well as the South African Reserve Bank Act<sup>28</sup>. According to the constitution, ‘The primary object of the South African Reserve Bank is to protect the value of the currency in the interest of balanced and sustainable economic growth in the Republic.’

Therefore the primary objective is price stability and the ultimate objective is sustained economic growth. By implication, sustained economic growth cannot be achieved without keeping the price level stable. In doing so, stable financial conditions can be maintained (Casteleijn, 1999: 64; Mboweni, 2000: 1).

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<sup>27</sup> See the Third Amendment Act 26 of 1996.

<sup>28</sup> See Act 90 of 1989.

### **3.3 INFLATION TARGETING**

An inflation targeting framework is one where the central bank sets out to ‘target the rate of inflation directly’ (Faure, 2006: 9). Van der Merwe (2004:2) identifies three categories of inflation targeting: ‘eclectic inflation targeting’ is best suited to countries with a stable macroeconomic economy. With high credibility, transparency and accountability, these countries are able to focus on low levels of inflation as well as sustainable output. ‘Inflation targeting lite’ countries opt for a broader inflation band with the focus being on price stability. The country does not have enough credibility to pursue inflation targeting as its main objective. The last framework is ‘full-fledged inflation targeting’, which is followed by South Africa. This encompasses increasing credibility, transparency and accountability as well as using the primary goal of inflation targeting to achieve ultimate objectives (Van der Merwe, 2004: 2).

The SARB adopted a formal inflation targeting monetary policy framework in February 2000 (Mboweni, 2004: 3; Van der Merwe 2004: 1). The bank was to achieve an average annual rate of increase in the consumer price index excluding mortgage payments (CPIX) inflation of between 3% and 6%<sup>29</sup> by the year 2002<sup>30</sup>. In October 2001 it was decided that the inflation target was to remain unchanged for 2003, but for 2004 was to change to an annual average rate of 3%–5%. In October 2002, the 2005 target was revised to 3%–6% (Mboweni, 2002b: 2; Van der Merwe, 2004: 6). The average annual rate was revised to a continuous rate of 3%–6% from 2006 onwards. Therefore, the inflation rate was measured over a 12-month period with an inflation band of 3–6% for each month (Van der Merwe, 2004: 6).

Prior to formal inflation targeting, ‘informal’ inflation targeting was put in place. The goal was price stability; however, the time frame within which to achieve this target was not set. This goal was also an intermediate goal with the main focus being on money supply. Towards the end of the 1990s, an ‘eclectic’ or ‘pragmatic’ inflation targeting framework was adopted. In this case, the short-term interest rates were the focus point (Van der Merwe, 2004: 1).

The Reserve Bank has three measures of inflation: the headline consumer index, the core consumer price index, and the overall index which excludes the effects of changes in

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<sup>29</sup> A range of inflation allows some discretion to the central bank and also allows for cushioning when there are external shocks (Van der Merwe, 2004: 5).

mortgage costs (CPIX). The CPIX measure was chosen as the inflation rate to target (in metropolitan and other urban areas (Van der Merwe, 2004: 5) as it ensures the widest cover of consumer items. Cost of living expenses such as food prices, crude oil, and petrol costs are all included in the CPIX (Casteleijn, 2001: 7). In addition, this measure is the inflation measure most easily understood by the public (Van der Merwe, 2004: 5).

In October 2008, the Minister of Finance announced that the CPIX for all urban areas would be replaced by the CPI, which is more commonly known as the headline inflation measure. Inflation targeting is based on the CPI for all urban areas as from January 2009 (Kelly, 2008: 1).

International standards do not use interest rates on mortgage bonds but rather use a measure based on rental payments. To bring South Africa in line with international standards, the Headline CPI includes a measure of Owners' Equivalent Rent in place of interest rates on mortgage bonds. Therefore the Headline CPI addresses the needs which were addressed by the CPIX (Kelly, 2008: 1).

The benefits of inflation targeting include a clear and focused objective of monetary policy, making the central bank accountable for achieving this goal (Brash, 1994:173), an objective that will lead to higher economic growth and employment creation and that will give an indication of future inflation, which can then be used to influence wage and price settings (Faure, 2006: 9). While inflation targeting definitely has strong motives in support of it, it can also be problematic. Missing an inflation target can be harmful to a central bank's reputation. Often non-monetary factors are out of the bank's control (for example, food prices, oil prices) and can cause a rise in domestic prices. Inflation forecasting is exactly that, a forecast, and errors are possible, especially given the lag of monetary policy (Casteleijn, 1999: 69).

There are several reasons for the adoption of formal inflation targeting in South Africa. Firstly, it is credible and transparent (Mboweni, 2004: 2), making it understandable to the general public. There is one ultimate objective and, without intermediate objectives, it is an easier framework to understand (Van der Merwe, 2004: 1). Secondly it holds the independent central bank accountable. Thirdly there is a need to reduce the economic and social costs of

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<sup>30</sup> This target was determined by the government in consultation with SARB (Van der Merwe, 2004: 4)

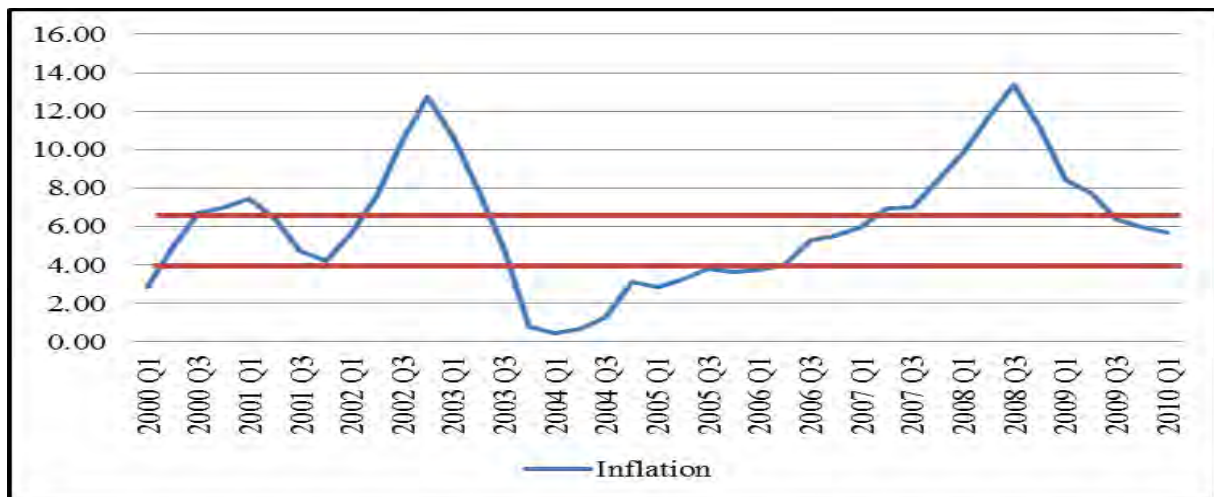
inflation. Inflation targeting aids the goals of macroeconomic stability, in particular, high sustainable growth and employment creation (Van der Merwe, 2004: 1).

The inflation targeting framework has come under heavy criticism, especially from the trade unions. Despite the Reserve Bank's defences of inflation targeting, the trade unions believe that it should be abandoned and instead, monetary policy should focus on job creation. The Reserve Bank is of the strong belief that low levels of inflation lead to sustained growth which in turn leads to job creation.

Inflation was as high as 15% in the 1980s and 1990s. It was brought down to single digits in December 1992 and to 5.2% in 1999. This was achieved under the informal inflation targeting monetary policy framework (Van der Merwe, 2004: 1). Due to its success, formal inflation targeting was adopted.

Figure 3.1 shows the inflation rate in South Africa since formal inflation targeting was adopted. The figure shows that there have been three breaches of the inflation band. Between 2000Q3 and 2002Q2, exogenous factors which were out of the control of the Reserve Bank were the main cause of the breach of the inflation band. These included steep rises in the cost of imported crude oil and a weakened rand. Food prices also played a part in the higher inflation levels. This upward shift in food prices was mainly due to adverse weather conditions. Between 2002Q2 and 2003Q3, exogenous factors were again behind the upper band of 6% inflation being breached. Factors cited by the Reserve Bank were a depreciation of the rand and increases in the prices of both oil and food. The latest breach of the inflation band occurred in 2007Q2 and lasted till 2009Q3. In 2007 and 2008, food and petrol prices were the main contributors to the high inflation levels (SARB, various issues).

**Figure 3.1: Inflation rate in South Africa, 2000–2010**

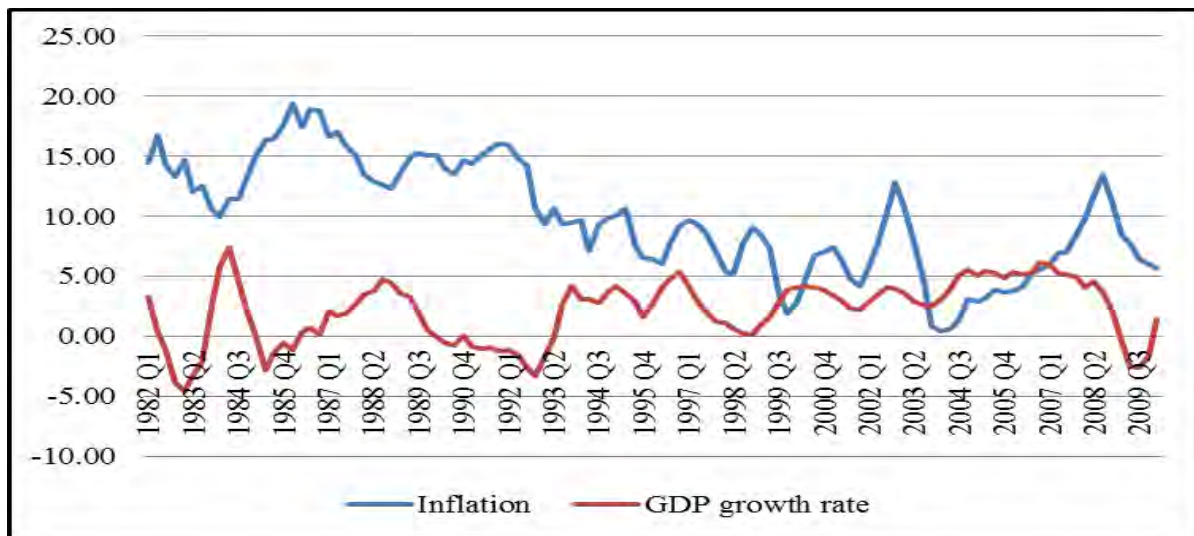


Source: Plotted by author with data obtained from StatsSA

### 3.4 ECONOMIC GROWTH, INFLATION AND INFLATION UNCERTAINTY IN SOUTH AFRICA

There is a clear inverse relationship between inflation and economic growth as illustrated in Figure 3.2. This is well illustrated between 1982 and 2000. From 2000 onwards when inflation targeting was implemented, there are fewer fluctuations in both the inflation rate as well as the GDP growth rate. This is in support of the inflation targeting objectives: a lower inflation rate will lead to a more sustained growth rate with fewer fluctuations. The graph also illustrates the lagged relationship between inflation and growth. Peaks in inflation are followed by troughs in growth. For example, the latest peak in 2008Q3 was followed by a trough in the GDP growth rate in 2009Q3.

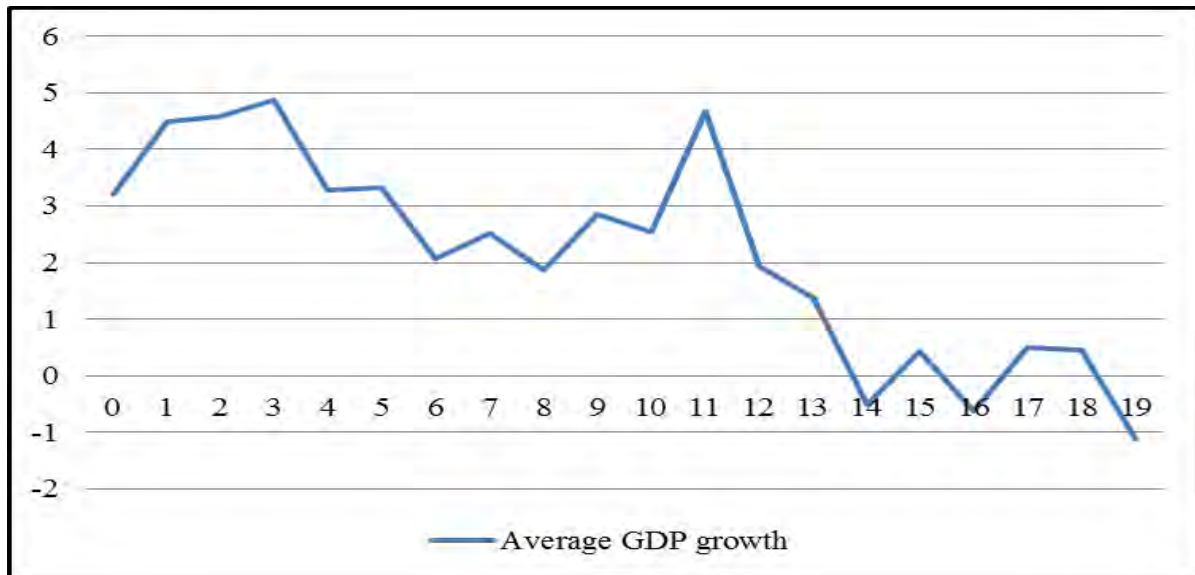
**Figure 3.2: Relationship between inflation and growth in South Africa, 1982–2010**



Source: Plotted by author with data obtained from SARB and StatsSA

To understand the historical nature of the relationship between inflation and economic growth in South Africa more accurately, the study follows the approach adopted by Mubarik (2005). (Also see Ahmed and Mortaza, 2005; Frimpong and Oteng-Abayie, 2010). The sample period of 1982–2010 is grouped into 19 observations. The range of inflation is chosen from the minimum and maximum inflation levels in the sample. Within this band, average GDP growth rates are calculated for each linear level of inflation. For example, if the inflation rate is 5% or less, it is assigned to level 5; if the inflation rate is greater than 5% but less than or equal to 10% it is assigned to level 10. Figure 3.3 shows that GDP growth and inflation have a positive relationship up until 3%. Thereafter it becomes negative. At 8% it becomes positive again and then returns to a negative relationship at 11%. This suggests that threshold levels may lie at 3% and 11%.

**Figure 3.3: Average GDP growth in South Africa, 1982–2010**



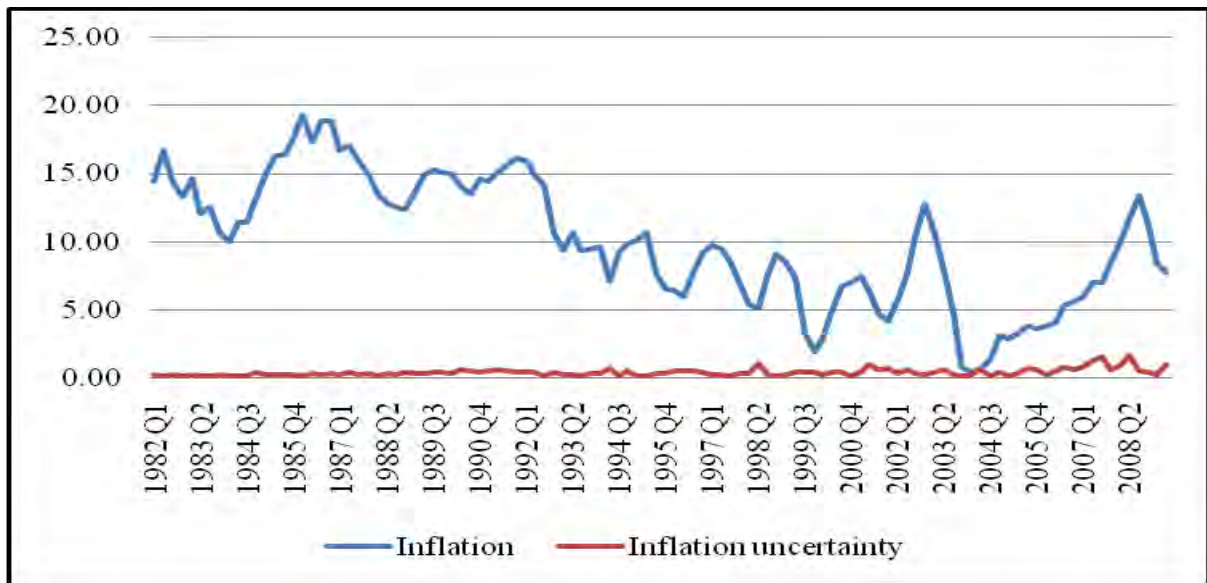
*Source: Plotted by author*

The greater the fluctuations in the inflation rate, the greater the inflation uncertainty. The relationship between inflation and inflation uncertainty in South Africa is illustrated in Figure 3.4. The rising inflation from 2004 onwards appears to have brought about more inflation uncertainty. This is even more noticeable in 2007 and 2008. From Figure 3.2 inflation has a negative impact on growth. However, inflation uncertainty may also have an impact on growth.

The relationship between inflation uncertainty and GDP growth in South Africa is also important; some authors (see Barro, 1995a; Judson and Orphanides, 1996) have shown that inflation uncertainty can have a negative association with growth as is illustrated in Figure 3.5. There does not appear to be any relationship between inflation uncertainty and growth. This suggests that inflation uncertainty does not have an effect on economic growth.

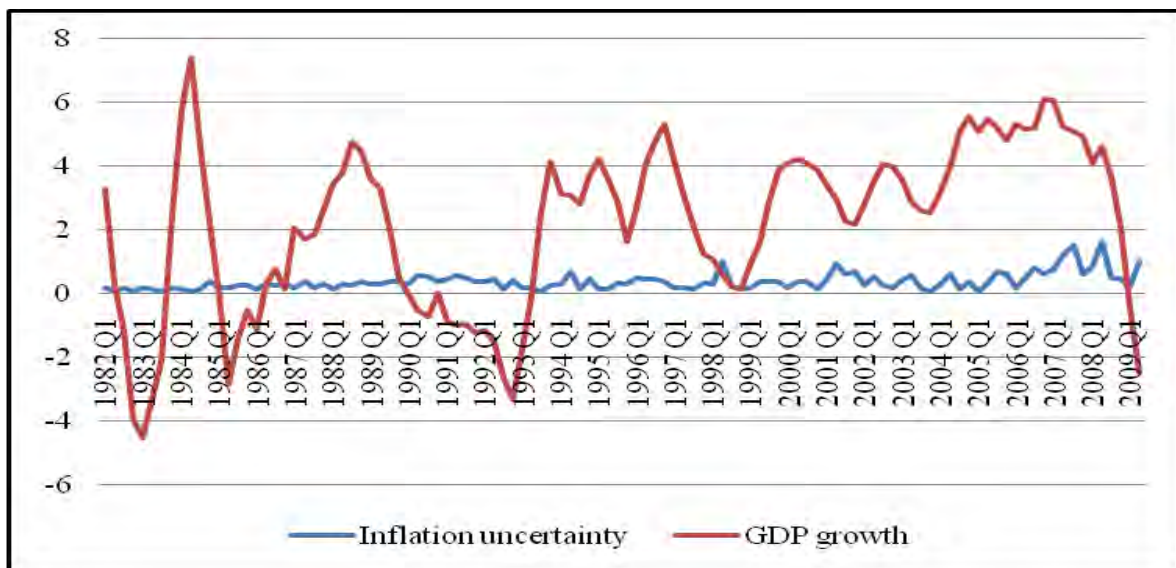
Considering the average of the variables by decade (Table 3.1), the inflation rate has seen a decreasing trend over the years. This has occurred alongside increasing GDP growth. Despite this, inflation uncertainty has been increasing. This suggests that lower levels of inflation are conducive to growth whereas higher inflation rates are harmful to economic growth. Inflation uncertainty does not appear to be related to GDP growth.

**Figure 3.4: The relationship between inflation and inflation uncertainty in South Africa, 1982–2009**



Source: Plotted by author with data obtained from SARB and StatsSA

**Figure 3.5: The relationship between inflation uncertainty and GDP growth in South Africa, 1982–2009**



Source: Plotted by author with data obtained from SARB and StatsSA

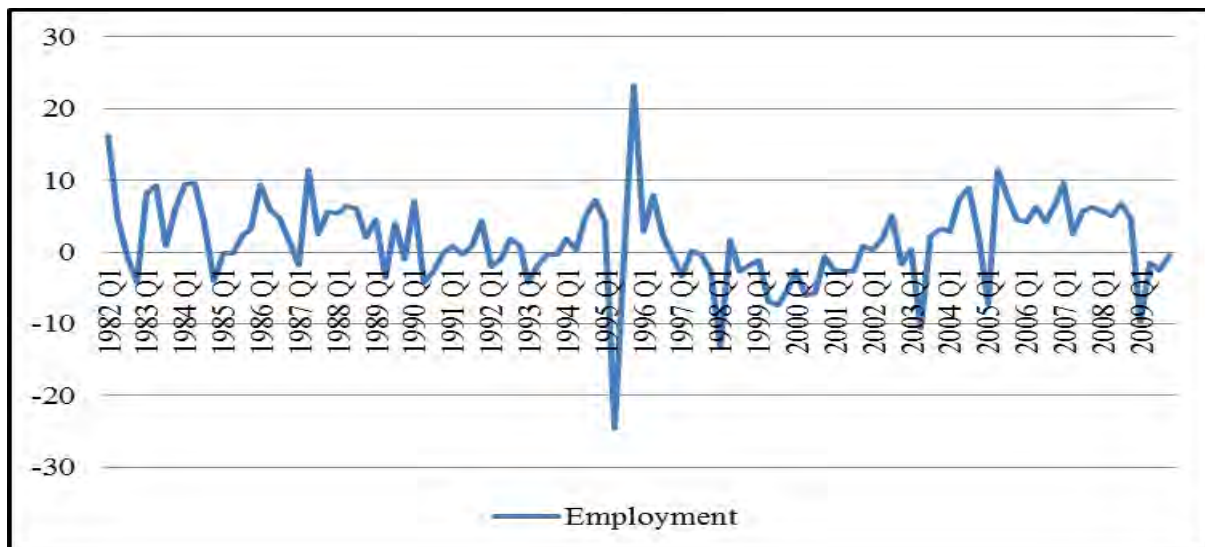
**Table 3.1: Average values of GDP growth, inflation and inflation uncertainty**

Period	GDP growth	Inflation	Inflation uncertainty
1980s	1.26	14.67	0.23
1990s	1.36	9.90	0.35
2000s	3.50	6.13	0.53
Full sample	2.11	9.88	0.37

Source: Compiled by author

Since the implementation of inflation targeting it is apparent from Figure 3.6 that employment has largely remained in the positive. It also shows that employment has also been less volatile since the implementation of inflation targeting. This suggests that low inflation levels promote job creation by increasing economic growth in the economy.

**Figure 3.6: Employment in South Africa, 1982–2009**



Source: Plotted by author with data from SARB

### 3.5 CONCLUSION

This chapter has provided an analysis of the inflation targeting framework in South Africa which is the current monetary policy framework. The main operational tool used in the South African framework is the repo rate. The main objective of monetary policy, which is conducted independently by the SARB, is price stability. Through the transmission mechanism, the repo rate ultimately affects consumer prices in South Africa. Since February

2000, the SARB has operated under a formal inflation targeting framework with the targeted inflation levels falling between 3% and 6%. This has been a largely successful policy despite criticisms from trade unions. Trade unions argue that job creation should be the main goal of monetary policy and not price stability. However, employment figures show that, since the implementation of the inflation targeting framework, employment figures have risen with a less volatile employment rate. This chapter has also illustrated the negative relationship between inflation and growth. This calls for further analysis of this relationship. Together with Chapter 2, this has laid down the framework for the empirical analysis which will be discussed in the next chapter.

## **CHAPTER FOUR**

### **METHODOLOGY**

#### **4.1 INTRODUCTION**

This chapter describes the empirical methods used to explore the relationship between inflation and economic growth. It also discusses the proxies and data used in the study. There is overwhelming support from the empirical evidence to support a negative relationship between inflation and economic growth. However, the evidence in support of an inflation threshold level has mixed results. Cross-country studies have found evidence in support of a threshold level for South Africa however; there is no consensus as to the value of the threshold. Furthermore, these studies are not country specific, making it difficult to settle on a particular rate for each country. A long-run relationship between inflation and economic growth does not imply causality. So in addition, the chapter will explore the causality between inflation and growth in relation to South Africa. In terms of the volatility of inflation, there is a strong positive relationship between the inflation rate and the volatility of inflation. However, it is unclear as to whether it dampens economic growth.

The objective of this chapter is to adopt an empirical framework that will address the aforementioned issues in order to obtain robust results on the relationship between inflation and economic growth in South Africa. Specifically, this chapter will attempt to address the following issues:

1. To determine whether there is a long-run relationship between price level and economic growth in South Africa.
2. To determine the nature of the causal relationship, if any, between price level and economic growth.
3. To determine if there is a threshold level of inflation for South Africa, above which the relationship between inflation and economic growth is negative.
4. To determine whether the inflation uncertainty has a greater impact on economic growth than the inflation rate.
5. Based on the findings, propose policies for the Central Bank's inflation target.

The chapter is organised as follows: Section 4.2 discusses the method used to determine the long-run relationship between inflation and growth. Section 4.3 describes the threshold model which will determine whether or not there is a threshold level of inflation for South Africa as well as the volatility model. Section 4.4 defines the variables and data sources. Lastly, section 4.5 concludes.

## **4.2 LONG-RUN MODEL: JOHANSEN COINTEGRATION APPROACH**

### **4.2.1 TESTING FOR STATIONARITY/UNIT ROOT**

Most economic series are nonstationary and this can produce misleading regression results. Therefore it is important to test variables for stationarity. Variables that are not stationary can be differenced in order to make them stationary (Brooks, 2008: 318–319, 326).

There are several methods to test for stationarity. These include a visual plot of the data, unit root tests and stationarity tests. Two unit root tests and one stationarity test will be performed as well as an analysis of the visual plots of the data. The unit root tests are the augmented Dickey–Fuller (ADF) test and the Phillips–Perron (PP) test, and the stationarity test is the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test.

The ADF and PP test the null hypothesis that there is a unit root against the alternative that the series is stationary (has no unit root). Both these tests have been criticised for having low power if the unit root is close to the non-stationary boundary. Therefore the KPSS test for stationarity is used. This test reverses the null and alternative hypothesis of the unit root tests. Using the Lagrange Multiplier (LM) statistic, it tests the null hypothesis of stationarity versus the alternative of non-stationarity or presence of a unit root (Brooks, 2008: 327–331).

Variables should ideally be integrated of the same order, preferably  $I(1)$ . If all the variables are  $I(0)$ , there will be no problem of a spurious regression and a standard regression may be estimated (Brooks, 2008: 326).

### **4.2.2 COINTEGRATION AND THE VECTOR ERROR CORRECTION MODEL**

Although two variables appear not to be related in the short-run, there may be a long-run relationship between them. This can be tested by the method of cointegration. There are two

main methods of testing for cointegration: the residuals based approach such as the Engle–Granger approach and the maximum likelihood approach such as the Johansen (1990) method and Johansen and Juselius (1990) method. The latter methods will be used in this paper and based on a VAR system. The purpose of this test is to determine if there is a long-run relationship between log of CPI (LCPI) and log of GDP (LGDP). The vector error correction model (VECM) then estimates the long-run and short-run parameters of this relationship (Lütkepohl and Krätzig, 2004: 93–108; Brooks, 2008: 335–355).

Assume a vector  $X_t = [LGDP, LCPI]$ , where LGDP is the log of GDP and LCPI is the log of CPI, and assume that the vector has a VAR representation as follows:

$$X_t = z + \sum_{i=1}^p \Pi_i X_{t-i} + \varepsilon_t \quad \dots 4.1$$

where  $z$  is a  $(n \times 1)$  vector of deterministic variables,  $\varepsilon$  is a  $(n \times 1)$  vector of white noise error terms and  $\Pi_i$  is a  $(n \times n)$  matrix of coefficients. This VAR must now be turned into a VECM in order to use the Johansen method:

$$\Delta X_t = z + \sum_{i=1}^{p-1} B_i \Delta X_{t-i} + \Pi X_{t-1} + \varepsilon_t \quad \dots 4.2$$

where  $X_t$  is a vector of  $I(1)$  variables defined above,  $\Delta X_t$  are all  $I(0)$  variables,  $\Delta$  indicates the first difference operator,  $B_i$  is a  $(n \times n)$  coefficient matrix and  $\Pi$  is a  $(n \times n)$  matrix whose rank determines the number of cointegrating relationships. If  $\Pi = r$  then there are  $r$  possible stationary linear combinations and  $n \times r$  matrices of  $\alpha$  and  $\beta$  such that

$$\Pi = \alpha\beta' \quad \dots 4.3$$

where  $\alpha$  represents the speed of adjustment matrix and  $\beta$  is a matrix of long-run coefficients. The speed of adjustment matrix indicates the speed with which the system adjusts back to the long-run equilibrium from last period's deviations (Lütkepohl and Krätzig, 2004: 93–108; Brooks, 2008: 350–355).

Prior to running the cointegration test, the appropriate lag order needs to be selected as the Johansen test may be affected by the lag length used in the VECM. There are two ways to determine the appropriate lag length; that conform to *a priori* knowledge. The study uses the

information criteria, which include the sequential likelihood modified likelihood ratio (LR), Akaike information criteria (AIC), final prediction error (FPE), Schwarz information criteria (SIC) and the Hannan–Quinn information criteria (HQ). The information criteria may give conflicting lag lengths, therefore the appropriate lag length will be the one that eliminates serial correlation (Lütkepohl and Krätzig, 2004: 110–112; Brooks, 2008: 329).

The second issue when running a cointegration test is the choice of deterministic assumptions in the Johansen test for cointegration. EViews 6 provides 5 deterministic trend assumptions: Case 1 assumes no deterministic trend in the data, and no intercept or trend in the VAR and in the cointegrating equation (CE); Case 2 assumes no deterministic trend in the data, no intercept in the VAR, and an intercept in the CE; Case 3 assumes a linear deterministic trend in the data, and an intercept in the CE and VAR; Case 4 assumes a linear deterministic trend in the data, intercept and trend in the CE, and no trend in the VAR; and Case 5 allows for a quadratic deterministic trend in the data, intercept and trend in the CE, and linear trend in the VAR. If none of the visual plots show a trend in the series, and unit root tests do not show the presence of a trend, then Eviews 6 recommends Case 2. If the series has stochastic trends, then Case 3 is suggested. Case 4 is used if some of the series are trend stationary. Cases 1 and 5 are rarely used in practice. Therefore graphical plots, unit root tests and *a priori* knowledge is used to choose the best deterministic assumption (Eviews 6 Users Guide II, 2007: 364–366).

Once the appropriate lag length and deterministic trend assumption have been chosen, the number of cointegrating vectors can be determined. The Johansen method makes use of two LR test statistics to determine the rank of the  $\Pi$  matrix; the trace statistic and maximum eigenvalue:

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

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

where  $r$  is the number of cointegrating vectors under the null hypothesis and  $\hat{\lambda}_i$  represents the estimated value for the  $i$ th ordered eigenvalue from the  $\Pi$  matrix. The trace statistic tests the

null hypothesis that the number of cointegrating relations is  $r$  against the alternative of  $k$  cointegrating relations where  $k$  is the number of endogenous variables. The maximum eigenvalue tests the null hypothesis that there are  $r$  cointegrating vectors against an alternative of  $r+1$  (Lütkepohl and Krätzig, 2004: 112–116).

After identifying the number of cointegrating vectors, a VECM is estimated by specifying the number of cointegrating vectors and the trend assumption used in the cointegration step, and normalising the model on the true cointegrating relation(s). The VECM restricts the long-run behaviour of the endogenous variables to converge to their cointegrating relationships, while allowing for short-run adjustment dynamics (Lütkepohl and Krätzig, 2004: 112–116; Brooks, 2008: 350–355).

### 4.3 THRESHOLD MODEL AND VOLATILITY MODEL

Having established whether or not there is a long-run relationship between inflation and economic growth the next step is to determine: if there is a structural break in this relationship; the significance of the structural break if one exists; and the estimated effect of inflation on economic growth on either side of the structural break. In order to do so, following the studies of Sarel (1996), Khan and Senhadji (2001) and Ahmed and Mortaza (2005), the study estimates the following model using the method of conditional least squares:

$$GDP_t = \beta_0 + \beta_1(\pi_t) + \beta_2(EXTRA) + \beta_3(POP_t) + \beta_4(INV_t) + \beta_5(TOT_t) + \beta_6(GOVC_t) + U_t \quad \dots 4.6$$

where  $\pi_t$  is the rate of inflation

$\pi^*$  is the rate of inflation at which the structural break occurs

DD is a dummy variable where  $DD = 1$  if  $\pi > \pi^*$

$= 0$  otherwise

EXTRA =  $DD[\log(\pi) - \log(\pi^*)]$ , GDP is the GDP growth rate, POP is the population growth rate, INV is the growth rate of fixed capital formation, TOT is the change in terms of trade and GOVC is the growth rate of government consumption.

Using the method of conditional least squares, first, Equation 4.6 is estimated using OLS for a range of inflation levels. When the full range of inflation levels has been estimated using OLS, the optimal threshold level is the one that maximises the R-squared which implies that it is the one that minimises RSS. When inflation is low (below the structural break), EXTRA = 0 and the effect of inflation on growth is estimated by the coefficient of  $\pi_t$ . When inflation is high (above the structural break), the effect of inflation on growth is estimated as the sum of  $\beta_1 + \beta_2$ . EXTRA estimates the difference between the effects of inflation on growth on the two sides of the structural break (Sarel, 1996: 205–208; Khan and Senhadji, 2001: 4, 7; Ahmed and Mortaza, 2005: 14–15).

In order to determine if the volatility of inflation has an independent effect on growth, the following models are run:

$$GDP_t = \alpha_0 + \alpha_1(INF_t) + \alpha_2(INV_t) + \alpha_3(GDP_{t-1}) + \alpha_4(GDP_{t-2}) \quad \dots 4.7$$

$$GDP_t = \beta_0 + \beta_1(SDINF_t) + \beta_2(INV_t) + \beta_3(GDP_{t-1}) + \beta_4(GDP_{t-2}) \quad \dots 4.8$$

$$GDP_t = \gamma_0 + \gamma_1(INF_t) + \gamma_2(SDINF_t) + \gamma_3(INV_t) + \gamma_4(GDP_{t-1}) + \gamma_5(GDP_{t-2}) \quad \dots 4.9$$

where GDP is the GDP growth rate, INF is the inflation rate, SDINF is the inflation uncertainty and INV is the growth rate of gross fixed capital formation.

Equation 4.7 considers the effect of inflation on GDP growth. Equation 4.8 considers the effect of inflation uncertainty on GDP growth (Judson and Orphanides, 1996: 8). The regression is also run with both the inflation and inflation uncertainty (Equation 4.9). This determines the joint effect on growth as well as give an indication of the relationship between the two (Judson and Orphanides, 1996: 10; Sweidan, 2004: 60).

## 4.4 DEFINITIONS OF VARIABLES AND DATA SOURCES

### 4.4.1 MEASURING ECONOMIC GROWTH AND INFLATION

The two main measures of economic growth in the empirical literature are the growth rate of real GDP and the growth rate of real GDP *per capita*. As can be seen from Table A5, the growth rate of real GDP is the most commonly used variable and is also used in previous studies on South Africa (Nell, 2000; Hodge, 2006). The growth rate of GDP is also used in

the time series studies of Khan and Senhadji (2001), Sweidan (2004), Ahmed and Mortaza (2005), Hussain (2005) and Mubarik (2005). Therefore the growth rate of real GDP will be used.

In this study there is an expected negative impact of inflation on economic growth as well as the likelihood of a threshold level of inflation for South Africa. For the long-run model, CPI is used. For the threshold model, inflation is measured as the log percentage change in the CPI index. For the volatility model, inflation is measured as one plus the rate of change in the price level. The CPI index is rebased from 2008 to 2005 to keep it in the same base period as the other data.

Sarel (1996: 203), after plotting the actual inflation rate and the log of the inflation rate, shows that the level of inflation has a very skewed distribution with more weighting given to the extreme inflation observations. Therefore it is suggested that the log transformation of the inflation rate be used. The log of inflation is more normally distributed (Sarel, 1996: 203; Khan and Senhadji, 2001: 3–4). Hence the log of inflation is used in the threshold model.

However, a problem with using the log of inflation is that values will not exist for negative inflation rates. In addition, for inflation rates close to zero, the log of inflation approaches negative infinity. Therefore following Khan and Senhadji (2001: 6), the following specification allows for linear values of inflation below or equal to one and the log values for inflation rates greater than one:

$$f(\pi_t) = (\pi_t - 1)I(\pi_t \leq 1) + \log(\pi_t)I(\pi_t > 1)$$

The first term in the right hand side accounts for all terms greater than one. The second term disregards all terms equal to or less than one. Therefore all observations can be accounted for whether they are negative or not (Khan and Senhadji, 2001: 6). In this study, the specification was not needed as there were no negative inflation rates.

#### 4.4.2 CONTROL VARIABLES

Theory is vague as to which control variables should be used in a growth equation. As can be seen from tables A2a, A2b, A4a and A4b, there are many variables that have been used in the

empirical literature. Some of them are specific to particular countries, such as the study on agriculture in India by Kannan and Joshi (1998). Whereas Ahmed and Mortaza (2005) used a bivariate model with the inflation rate as the only dependent variable, Khan and Senhadji (2001), Sweidan (2004), Hussain (2005) and Mubarik (2005) all used multivariate models. The basis of the control variables will be based on these papers, as well as those of Nell (2000) and Hodge (2006), whose studies are both based on South Africa.

Altogether, these studies suggest a wide range of control variables as follows: the rate of investment, the growth rate of population, terms of trade, the interest rate, the initial level of income, labour, tax and the growth rate of money (cf. Nell, 2000; Khan and Senhadji, 2001; Sweidan, 2004; Ahmed and Mortaza, 2005; Hussain, 2005; Mubarik, 2005; Hodge, 2006). Another very common control variable in macroeconomic studies is government consumption (cf. Kormendi and Meguire, 1985; De Gregorio, 1992; 1993; Smyth, 1994; Barro, 1995b; Sarel, 1996; Alexander, 1997; Loungani and Sheets, 1997; Barro, 2001; Singh and Kalirajan, 2003; Burdekin *et al.*, 2004; Pollin and Zhu, 2005; Li, 2006; Vaona and Schiavo, 2007; Rousseau and Yilmazkuday, 2009). Levine and Renelt (1992) find that only the share of investment in GDP is correlated with growth. Sala-I-Martin (1997a; 1997b) runs regressions to determine the variables associated with growth; only the variables that are found to be significant in the study will be mentioned. They are investment in equipment, number of years of having an open economy, Confucianism, rule of law, Islam, political rights, dummy variables for Latin America and Sub-Saharan Africa, civil liberties, revolutions and coups, fraction of GDP in mining, standard deviation of the black market premium, primary exports in 1970, degree of capitalism, dummy variables for war, investment in non-equipment, absolute latitude, exchange rate distortions, Protestants, Buddhism, Catholicism and Spanish colony (Sala-I-Martin, 1997a:181–182). As these variables would result in a very onerous set of estimations, for this study, four variables have been chosen, namely the rate of investment, government consumption, terms of trade and the population growth rate. The measurement of the variables and the *a priori* expectations are discussed next.

#### 4.4.2.1 Investment

Investment is highly correlated with output growth; countries with higher investment rates tend to grow faster than those without (Sargsyan, 2005: 10). The expected effect of

investment on economic growth is positive (Hodge, 2006: 167). A statistically significant effect of investment on growth is found in Kannan and Joshi (1998: 2726). In this study, investment is measured as the growth rate of gross fixed capital formation.

#### 4.4.2.2 Government consumption

Government consumption stimulates aggregate demand, therefore promoting economic growth. In India, Singh and Kalirajan (2003: 383) found a positive relationship between government consumption expenditure and economic growth. The more involved the government is in infrastructure development and social sectors, the greater the positive impact towards economic growth. The effect of government consumption on growth may be negative if resources are wasted and government consumption crowds out private investment. In this study, the growth rate of government consumption is used.

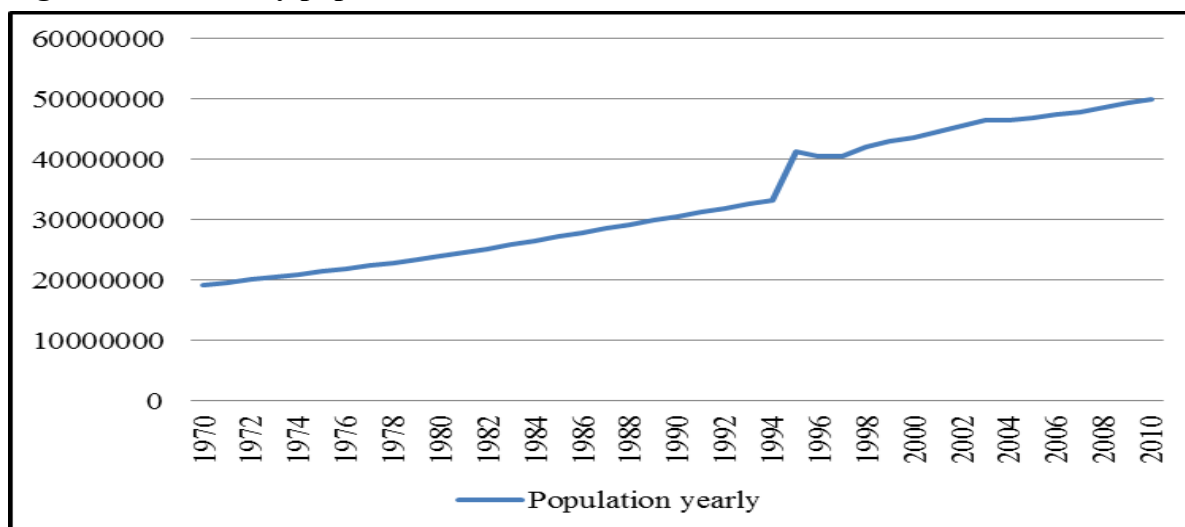
#### 4.4.2.3 Terms of trade

Terms of trade is included to account for any supply shocks. The supply shocks would otherwise bring about a negative correlation between inflation and growth (Sarel, 1996: 202). As the terms of trade improves, there is a more positive effect on growth (Hodge, 2006: 167). This occurs through any effects it may have on national income and absorption in the long-run (Singh and Kalirajan, 2003: 383). Sarel (1996: 206) found a positive relationship between terms of trade and economic growth. Hodge (2006: 168) shows that this positive relationship is highly significant. In this study, the growth rate of terms of trade is used.

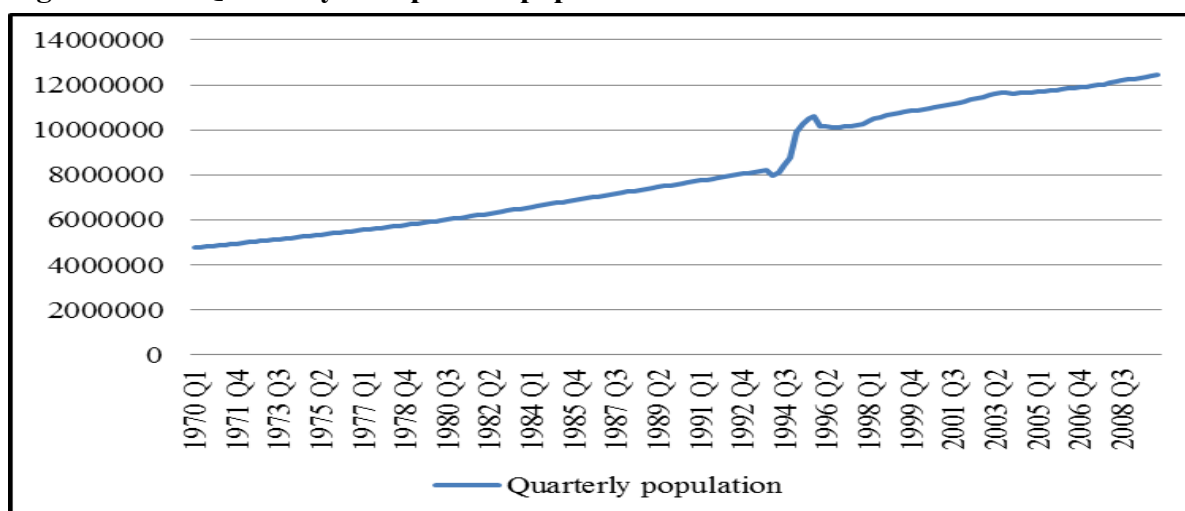
#### 4.4.2.4 Population

The growth rate of population is said to be partially correlated with economic growth (Singh and Kalirajan, 2003: 377). Population growth is shown to have a significant positive effect on GDP in Khan and Senhadji (2001: 11). In this study the growth rate of population is used.

Population data obtained from StatsSA website is yearly. As this study is based on quarterly data, the population data is interpolated. The interpolation method used in Eviews 6 is the *Quadratic: match sum* (Aziakpono, 2005: 163). In figures 4.1 and 4.2, the yearly and interpolated quarterly data, respectively, can be seen to follow the same pattern, therefore showing that the interpolated series reflects as far as possible the pattern of the original series.

**Figure 4.1: Yearly population data**

Source: Plotted by author with data from StatsSA

**Figure 4.2: Quarterly interpolated population data**

Source: Plotted by author with data from StatsSA

#### 4.4.2.5 Standard deviation of inflation

The standard deviation of inflation is included as a proxy for inflation uncertainty. The expected result is a negative effect on economic growth (Judson and Orphanides, 1996: 4–5). Following Judson and Orphanides (1996: 5), the standard deviation of inflation for each quarter is calculated as the standard deviation of the four monthly observations for that quarter.

#### **4.4.3 DATA SCOPE AND SOURCES**

Data on GDP, terms of trade, government consumption and investment are obtained from SARB. Data for CPI and population are obtained from StatsSA. The long-run model is estimated from 1981Q1 to 2010Q1. The threshold model and volatility model are divided into three periods. The first is the full period from 1983Q1 to 2010Q1; the second captures the period prior to inflation targeting and is from 1983Q1 to 1999Q4; the third period coincides with the inflation targeting framework from 2000Q1 to 2010Q1.

#### **4.5 CONCLUSION**

This chapter sets out the analytical framework which is used in addressing the questions regarding the long-run comovement of the relationship between LGDP and LCPI, threshold level of inflation for South Africa and the issue of the effect of volatility of inflation on growth. First, the analytical framework for long-run comovement (Johansen cointegration framework) is discussed. Then the analytical framework surrounding the threshold model is described. Next the volatility model is presented where the effect of the volatility of inflation on economic growth is explored. Lastly the proxies and data used in the study are discussed. In the next chapter, these frameworks are used for the empirical analysis.

## **CHAPTER FIVE**

### **RESULTS**

#### **5.1 INTRODUCTION**

In chapter 1, the following objectives were set out: 1. to determine whether there is a long-run relationship between price level and economic growth in South Africa; 2. to determine the nature of the causal relationship, if any, between price level and economic growth; 3. to determine if there is a threshold level of inflation for South Africa, above which the relationship between inflation and economic growth is negative; 4. to determine whether the inflation uncertainty has a greater impact on economic growth than the inflation rate; 5. based on the findings, propose policies for SARB's inflation target. Having reviewed the existing empirical literature and set out the analytical framework, the analytical framework is now applied to address the objectives.

This chapter is divided into six sections including this one. Section 5.2 discusses the stationarity and unit root tests. Section 5.3 applies the Johansen cointegration method which discusses the long-run relationship. Section 5.4 describes the threshold model. Following this, Section 5.5 discusses the volatility model. Lastly, Section 5.6 concludes.

#### **5.2 STATIONARITY AND UNIT ROOT RESULTS**

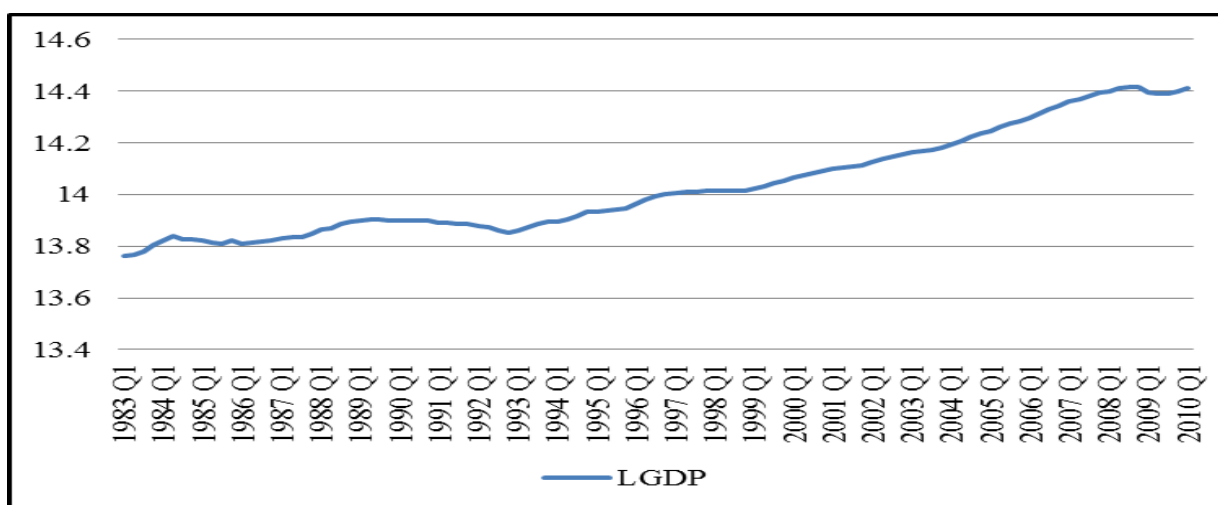
In the Johansen test for cointegration, the first step is to test for stationarity of the relevant series. A graphical plot of the data is an informal test for stationarity that will give a first indication as to the order of integration of the series. Figures 5.1 and 5.2 below plot the variables of LGDP and LCPI. Both variables appear to be trending upwards. Therefore it is clear from this graphical analysis that neither series are stationary. The first difference of LGDP (DLGDP) and LCPI (DLCPI) can be seen in Figures 5.3 and 5.4 respectively. It is clear that the first difference of both series is stationary. However, a formal method of testing must still be carried out.

The ADF and PP tests for unit roots and the KPSS test for stationarity are carried out. The null hypothesis for the unit root tests is for the presence of a unit root while the null

hypothesis for the KPSS test is that for stationarity. Table 5.1 reports the results of the tests. The tests were carried out under three assumptions; an intercept and trend, an intercept only and neither a trend or intercept. The test results show that in level terms, the variables are not stationary. Under first difference terms, however, they both become stationary.

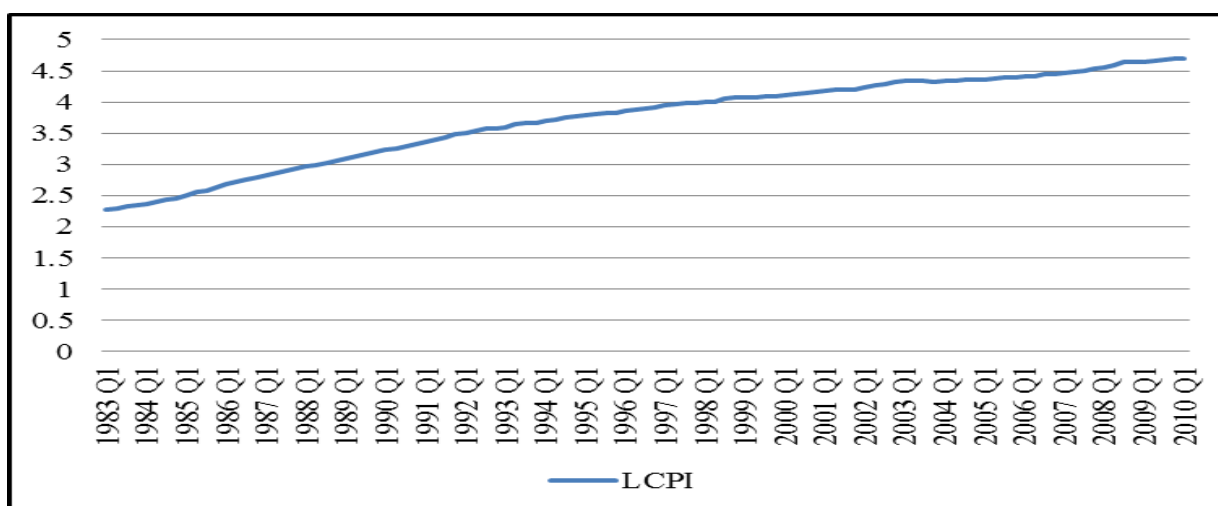
Given that the variables are both stationary in first difference terms or integrated of order 1, they can be tested for cointegration.

**Figure 5.1: Plot of LGDP, 1983–2010**

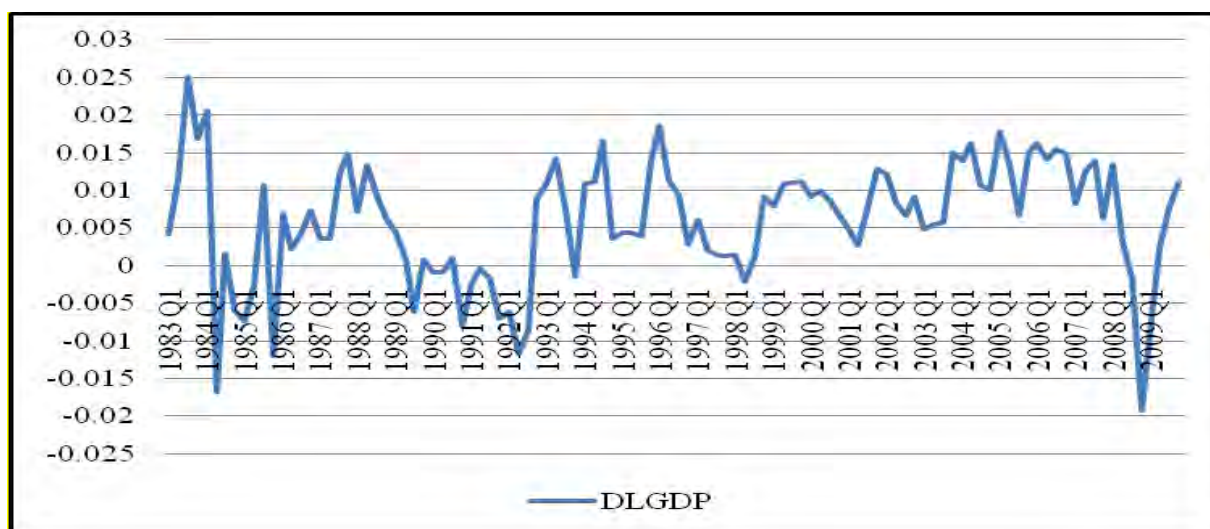


Source: Plotted by author with data from SARB

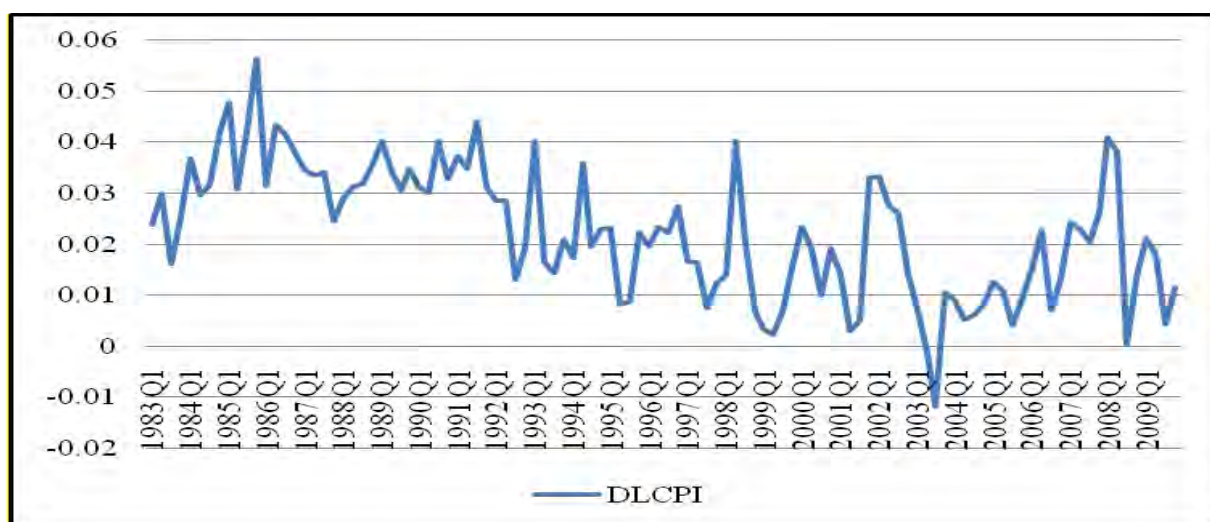
**Figure 5.2: Plot of LCPI, 1983–2010**



Source: Plotted by author with data from StatsSA

**Figure 5.3: Plot of DLGDP, 1983–2010**

Source: Plotted by author with data from SARB

**Figure 5.4: Plot of DLCPI, 1983–2010**

Source: Plotted by author with data from StatSA

Table 5.1: Unit root and stationarity tests

		LGDP						LCPI					
		ADF		PP		KPSS		ADF		PP		KPSS	
		T statistic	Result	Adjusted T statistic	Result	LM stat	Result	T statistic	Result	Adjusted T statistic	Result	LM stat	Result
<i>Level</i>	<i>None</i>	2.968		4.349				2.957		4.322			
	<i>Intercept</i>	1.405		1.506		1.182 <sup>a</sup>		1.365		1.445		1.185 <sup>a</sup>	
	<i>Intercept and trend</i>	-1.905		-1.231		0.299 <sup>a</sup>		-1.949		-1.265		0.299 <sup>a</sup>	
<i>First difference</i>	<i>None</i>	-3.861	I(1)	-4.849	I(1)			-3.900 <sup>a</sup>	I(1)	-4.906 <sup>a</sup>	I(1)		
	<i>Intercept</i>	-5.789	I(1)	-5.789	I(1)	0.438 <sup>c</sup>		-5.838 <sup>a</sup>	I(1)	-5.838 <sup>a</sup>	I(1)	0.419 <sup>c</sup>	
	<i>Intercept and trend</i>	-6.223	I(1)	-6.289	I(1)	0.055	I(1)	-6.251 <sup>a</sup>	I(1)	-6.316 <sup>a</sup>	I(1)	0.054	I(1)

Notes: The ADF test is based on critical t statistics as computed by MacKinnon (1991, 1996), and the KPSS tests are based on critical values computed by KPSS (1992). <sup>a, b</sup> and <sup>c</sup> denote rejection at 1, 5 and 10% respectively of the hypothesis for a unit root for the ADF and KPSS tests. The spectral estimation method used is the Bartlett kernel for the KPSS test.

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### 5.3 COINTEGRATION

The Johansen test for cointegration is conducted to determine whether there is a long-run relationship between LGDP and LCPI. Before conducting the cointegration test, the deterministic trend assumption and lag length need to be determined. The unit root tests were not significant for a trend and constant or for a constant alone, therefore assumption two is used, which does not include a trend or constant. The information criteria are used to determine the lag length order. Table 5.2 shows that all the information criteria suggested lag length two. However, at two lags, the diagnostic checks did not produce good results. Therefore, the Johansen cointegration model is estimated at lag length 3, which is the lag length that reduces serial correlation (see Table 5.3). Table 5.4 shows the results for the long-run model. Table 5.5 shows the cointegration test results. First considering the trace test, the null hypothesis of no cointegrating vectors is rejected at the 5% level of significance. The null hypothesis of at most one cointegrating vector cannot be rejected. It is therefore concluded that there is one cointegrating vector, and hence one cointegrating relationship using the trace test. Next, considering the maximum eigenvalue test, the null hypothesis of no cointegrating vectors is rejected at the 10% level. The null hypothesis of at least one cointegrating vector cannot be rejected, therefore concluding that there is one cointegrating relationship between LCPI and LGDP. Therefore, the Johansen cointegration test suggests that there is one cointegrating vector between LGDP and LCP.

The next step is to specify a VECM which distinguishes between the long-run and short-run movements between LGDP and LCPI. The model was normalised on LGDP in order to determine the long-run and short-run effects of LCPI on LGDP. The results for the VECM are reported in Table 5.4. The  $\alpha$  coefficient shows the short run adjustment which can be interpreted to mean that approximately 52% of the deviations from the long-run equilibrium for LGDP will be corrected each quarter. The  $\beta$  coefficient shows the effect of LCPI on LGDP in the long-run. A 1% increase in LCPI causes a 14.28% decrease in LGDP. This shows that there is a negative relationship between inflation and growth in the long-run. Nell (2000) finds that single-digit inflation may be beneficial to growth, whereas double-digit inflation may be harmful to growth. Hodge (2006) finds that, in the long-term, inflation is harmful to growth. The findings of this study are consistent with those of Nell (2000) and Hodge (2006).

Table 5.4 also reports the results for the weak exogeneity tests. As both variables are significant, the null of weak exogeneity is rejected and therefore it can be concluded that both LGDP and LCPI are endogenous as expected. Hence both variables are determined within the model.

The final step is to check for diagnostic checks. As can be seen in Table 5.4, the null of no serial correlation could not be rejected. Therefore there is no serial correlation present in the residuals.

**Table 5.2: Information criteria**

Lag	LR	FPE	AIC	SC	HQ
0	NA	0	-16.4	-16.35	-16.38
1	1148.05	0	-27.15	-27	-27.09
2	83.03*	2.68e-15*	-27.88*	-27.63*	-27.78*
3	1.61	0	-27.82	-27.47	-27.68
4	9.08	0	-27.84	-27.39	-27.66
5	1.57	0	-27.78	-27.24	-27.56
6	1.94	0	-27.73	-27.08	-27.47
7	4.76	0	-27.7	-26.96	-27.40
8	4.68	0	-27.68	-26.84	-27.34

Notes: LR: Sequential modified LR test statistic (each test at 5% level); FPE: Final prediction error; AIC: Akaike information criteria; SC: Schwarz information criteria; HQ: Hannan–Quinn information criteria. \* indicates the lag order selected by the information criteria

**Table 5.3: Serial correlation tests**

Lags	LM Stat	Probability
1	5.57	0.23
2	9.99	0.04
3	2.10	0.72

Notes: LM stat: Lagrange multiplier statistic

**Table 5.4: Results of estimations**

Cointegration				VECM				Weak Exogeneity		Diagnostics
Trace	Max	Lag length	Assumption	$\alpha$	$\beta$	Intercept	R-squared	LGDP	LCPI	Serial Correlation
1	1	3	2	-0.52 [-2.26]	-14.28 [-197.82]	23.68	0.33	4.02 (0.05)	3.87 (0.05)	2.10 (0.72)

Notes: T-statistics are shown in [ ] and P-values in ( )

**Table 5.5: Cointegration test results**

Obs	k	A	Trace		Max	
			r<0	r<1	r<0	r<1
113	3	2	21.33 (-0.05)	0.04 (-0.24)	15.92 (-0.05)	5.42 (-0.24)

Notes: Probability values are shown below in ( )

#### 5.4 THRESHOLD MODEL

For this model, the data is estimated in three subsamples. The first is for the full period from 1983Q1 to 2010Q1. The second period considers the period prior to the implementation of inflation targeting and ranges from 1983Q1 to 1999Q4. The last period considers data since the inflation targeting framework was introduced, covering the period from 2000Q1 to 2010Q1. The inflation levels for the full period range from 2% to 19%. For the period before

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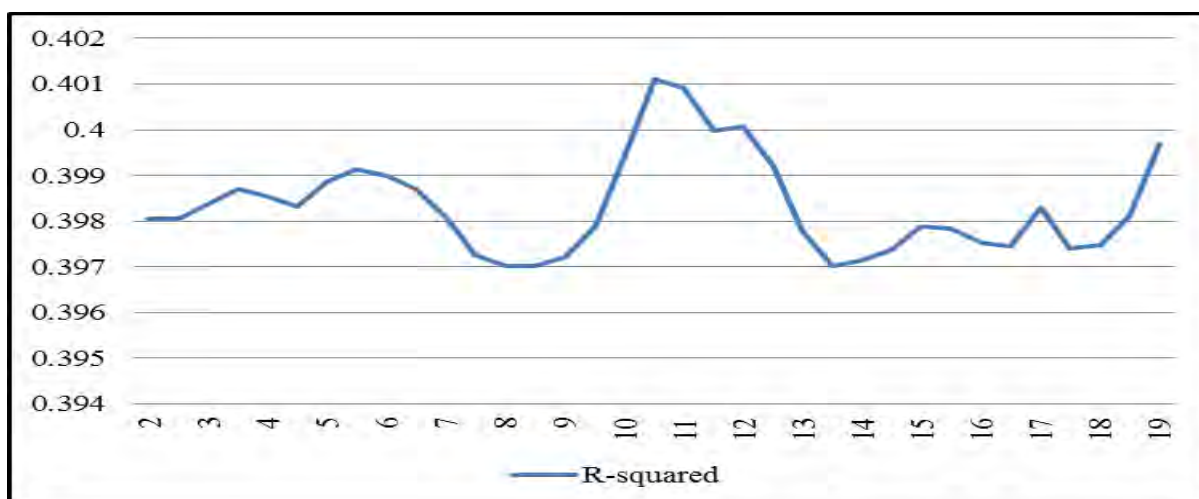
inflation targeting was introduced, the inflation levels range from 9.5% to 19% and from 2% to 12.5% for the inflation targeting period.

Below the structural break, when the inflation rate is low,  $EXTRA = 0$ , and the effect of inflation on growth is estimated by the coefficient of the log of inflation. When the inflation rate is high and above the structural break, effect of inflation on growth is measured by the sum of the log of inflation and the EXTRA coefficients.

#### **5.4.1 MULTIVARIATE THRESHOLD MODEL: 1983–2010**

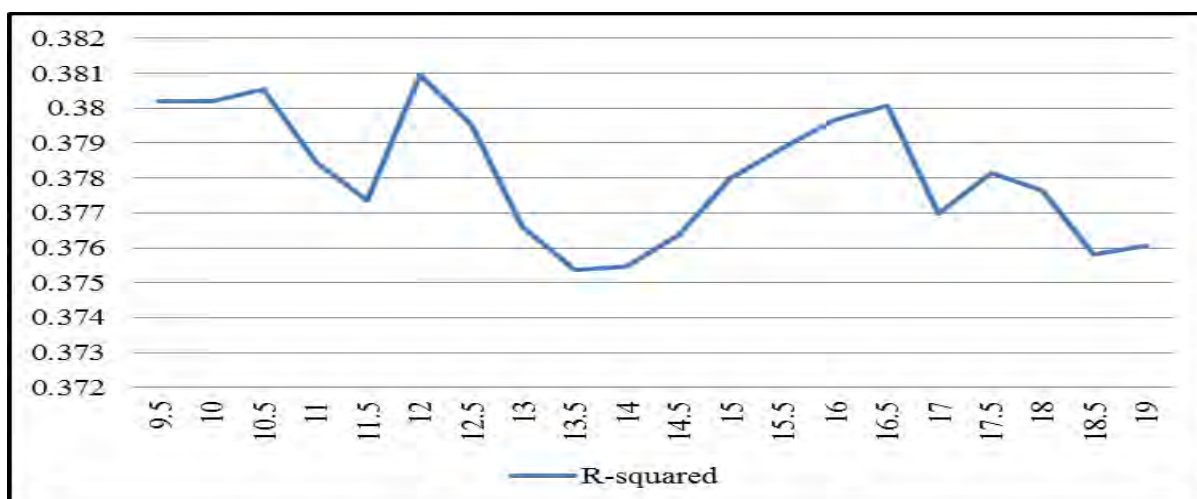
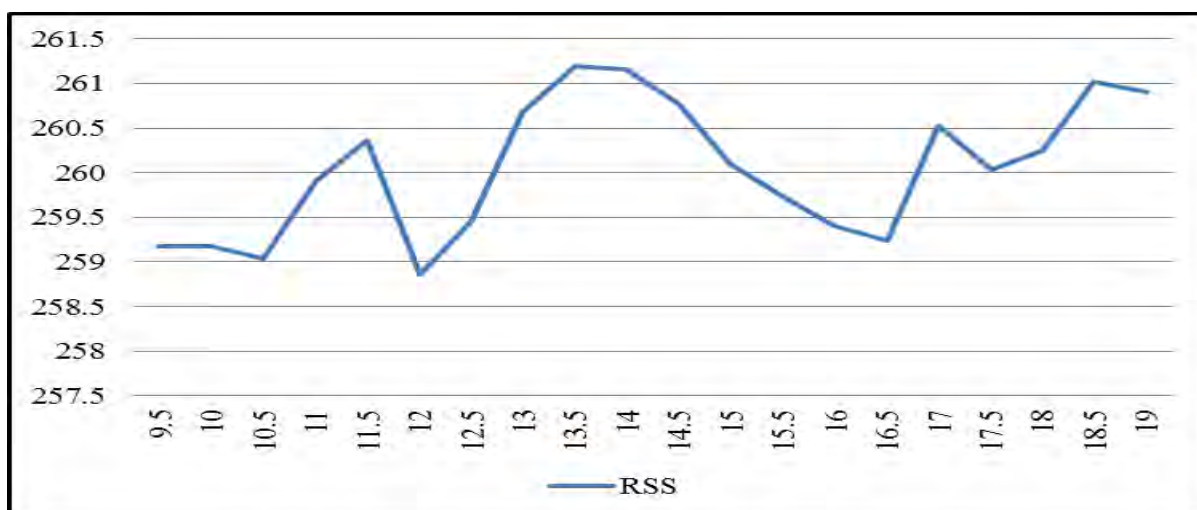
The structural breakpoint occurs at an inflation rate equal to 10.5% as illustrated in Figures 5.5 and 5.6. This breakpoint is significant as the log of inflation is statistically significant at 10.5%.

Between 2% and 3% inflation levels, there is a positive yet insignificant effect on growth. Between 3.5% and 7.5%, this effect is negative yet insignificant. Beyond 8%, the negative effect on growth becomes significant with it being highly significant at the 1% level from inflation levels of 9.5% onwards. Next, considering the relationship between the growth rate and the dummy of the inflation rate (EXTRA), between 2% and 8%, there is a negative and insignificant relationship. This relationship becomes positive yet insignificant between 8.5% and 13.5%. From 14% to 19% it then again becomes negative and insignificant. The sum of the log of inflation and the EXTRA coefficient is negative beyond 10.5% and increases at an exponential rate. The first panel in Table 5.6 (N/A) demonstrates the impact of ignoring a structural break. The effect of inflation on economic growth is thought to be the same throughout the inflation spectrum. This is misleading as can be seen in the large figures for the sum of the log of inflation and the extra coefficient.

**Figure 5.5: Multivariate model, R-squared, 1983–2010****Figure 5.6: Multivariate model, RSS, 1983–2010**

#### 5.4.2 MULTIVARIATE THRESHOLD MODEL: 1983–1999

For the period prior to inflation targeting, the estimated value of R-squared (minimum RSS) shows three maxima (minima) at 10.5%, 12% and 16.5%. This is illustrated in Figures 5.7 and 5.8. By considering the probability values of the log of inflation coefficients, it can be seen that none of the threshold levels are significant.

**Figure 5.7: Multivariate model, R-squared, 1983–1999****Figure 5.8: Multivariate model, RSS, 1983–1999**

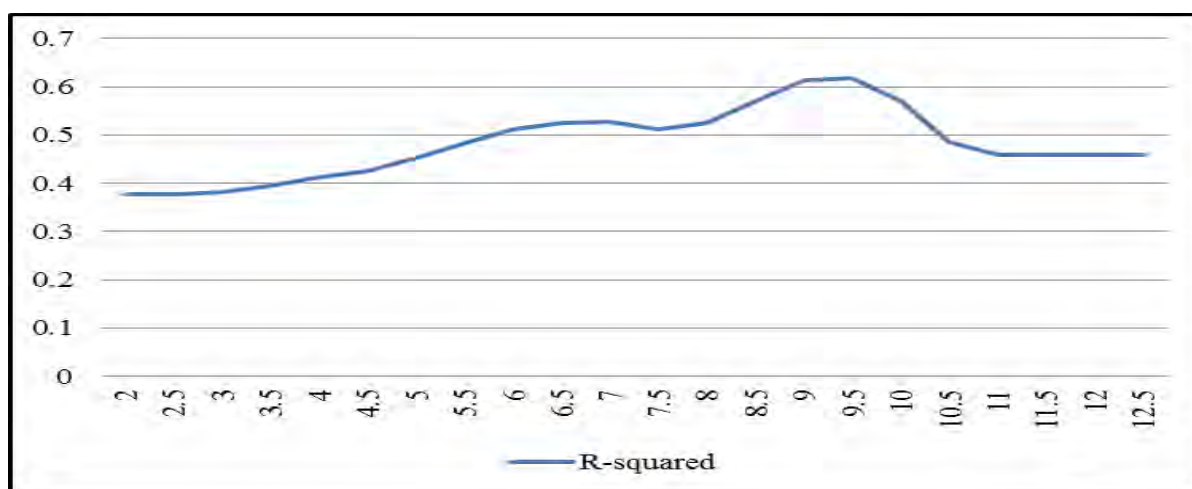
For this period, suggesting a threshold level is difficult because, although all the coefficients of inflation are negative, none of them are significant. In addition, all except for 19% of the EXTRA values are positive. The sum of the log of inflation and the EXTRA coefficient is positive for all values except 19%. This dataset covers the period prior to inflation targeting when inflation levels were high. This may be the reason behind the inconclusive results.

### 5.4.3 MULTIVARIATE THRESHOLD MODEL: 2000–2010

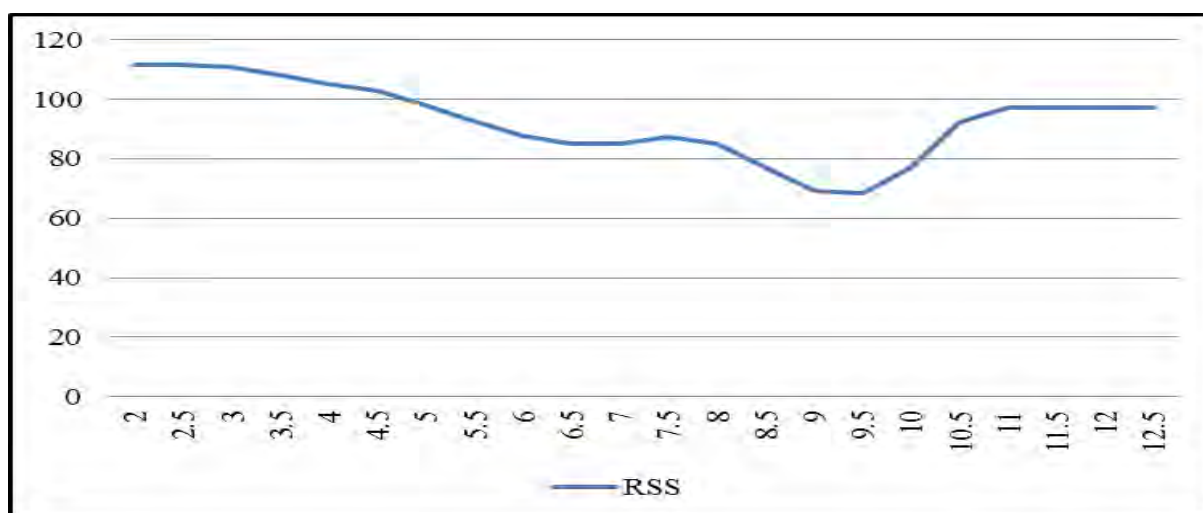
For the inflation targeting period, as can be seen in Figures 5.9 and 5.10, the maximum value of R-squared (minimum RSS) is 9.5%. Again this threshold level is not significant

Below 9.5%, the coefficients of the log of inflation are positive. These values are significant from 5.5% to 6.5% suggesting that this range of inflation is good for growth. From 9.5% onwards they become negative. The EXTRA value is also negative and highly significant beyond 9.5%. The sum of the log of inflation and extra increases in absolute value exponentially and has a negative sign. Therefore the recommended value of inflation for this period is 9.5%. Up until 9.5%, inflation is tolerable and may be good for growth. Again from the first panel (N/A) it can be seen that not including a threshold value can be misleading.

**Figure 5.9: Multivariate model, R-squared, 2000–2010**



**Figure 5.10: Multivariate model, RSS, 2000–2010**

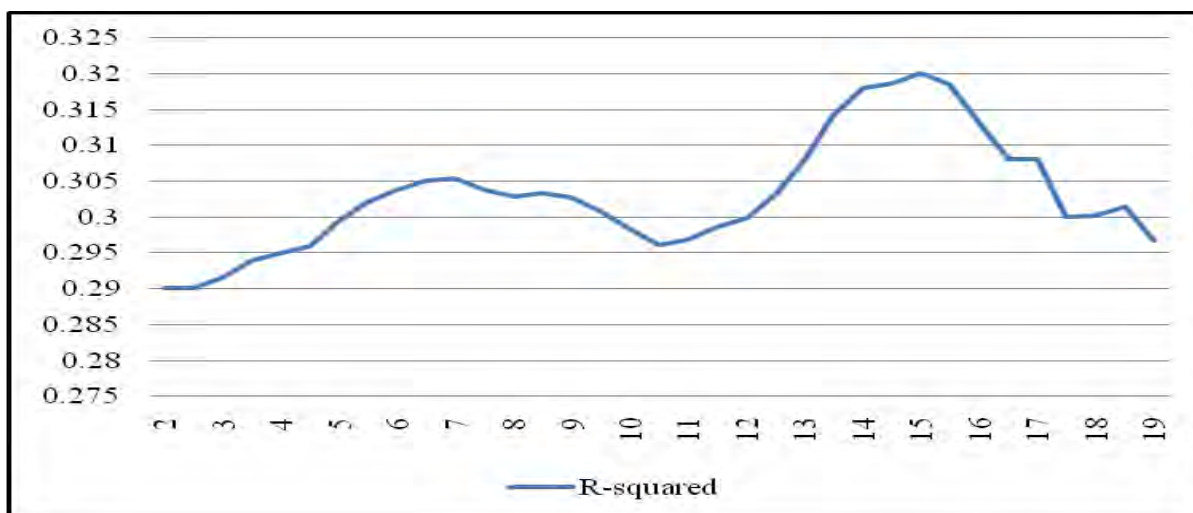


The regression was run as a trivariate model without the control variables. The level of inflation and the EXTRA coefficient were regressed on the GDP.

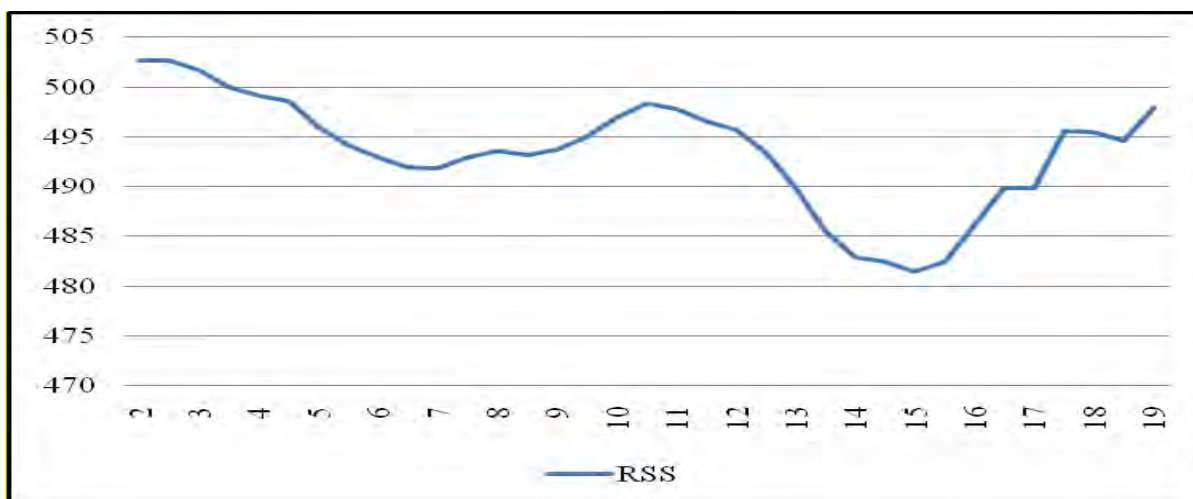
#### 5.4.4 TRIVARIATE THRESHOLD MODEL: 1983-2010

For the full sample period, R-squared is maximised and RSS minimised at 7% and 15%. This is illustrated in Figures 5.11 and 5.12. While 7% is not significant, 15% is significant. From 2% to 5% the coefficients of the log of inflation are positive and insignificant. From 5.5% to 8.5%, the coefficients are negative and insignificant. From 9% to 19%, the coefficients are negative and significant, becoming highly significant at 10.5%. Considering the EXTRA coefficient, it is negative and insignificant from 2% to 4%. It is negative and significant from 5% to 9.5%. From 10% to 11.5%, it remains negative but becomes insignificant. From 12% to 18.5% it is negative and significant. At 19% it is negative and insignificant. The sum of the log of inflation and the EXTRA coefficient are all negative.

**Figure 5.11: Trivariate model, R-squared, 1983–2010**



**Figure 5.12: Trivariate model, RSS, 1983–2010**

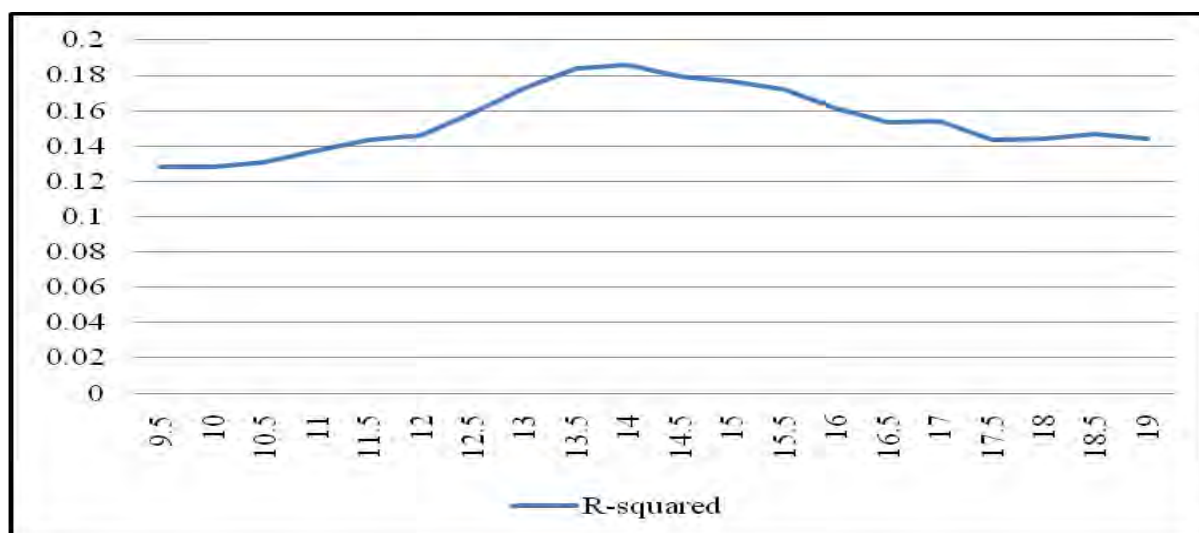


### 5.4.5 TRIVARIATE THRESHOLD MODEL: 1983-1999

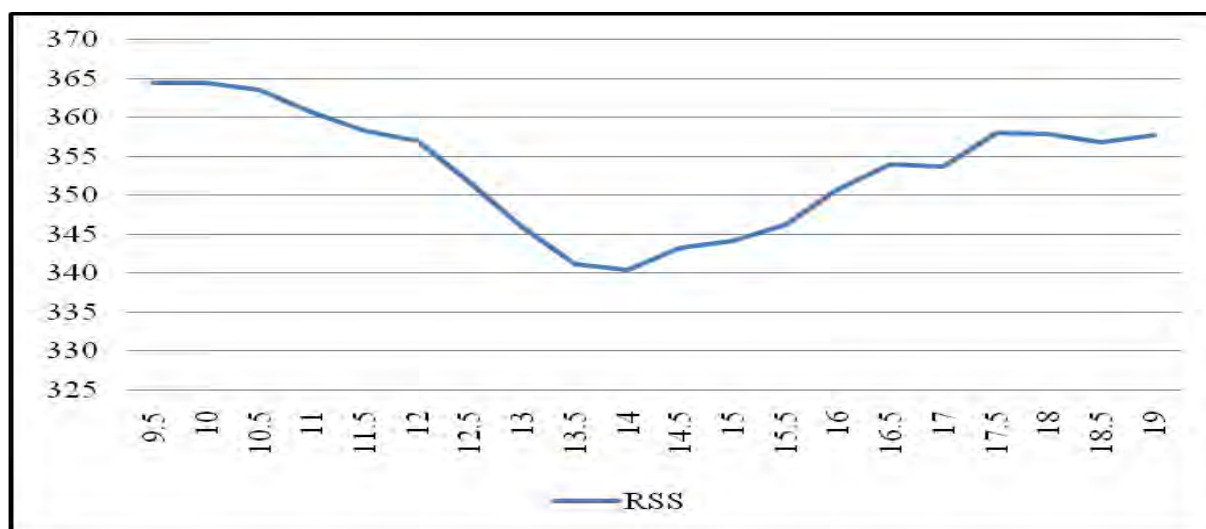
For the period prior to inflation targeting (1983–1999), R-squared is maximised (RSS minimised) at 14% (See Figures 5.13 and 5.14). 14% is not significant.

The log of inflation is positive but not significant from 9.5% to 14%. Thereafter it becomes negative although not significant up until 16.5%. From 17% to 19% it is negative and significant. The coefficient of EXTRA is negative and not significant from 9.5% to 12.5%. Then it is negative and significant from 13% to 15.5%. It remains negative but becomes insignificant from 16% up until 19%. For the sum of the log of inflation and EXTRA, the coefficients are negative for the entire sample.

**Figure 5.13: Trivariate model, R-squared, 1983–1999**



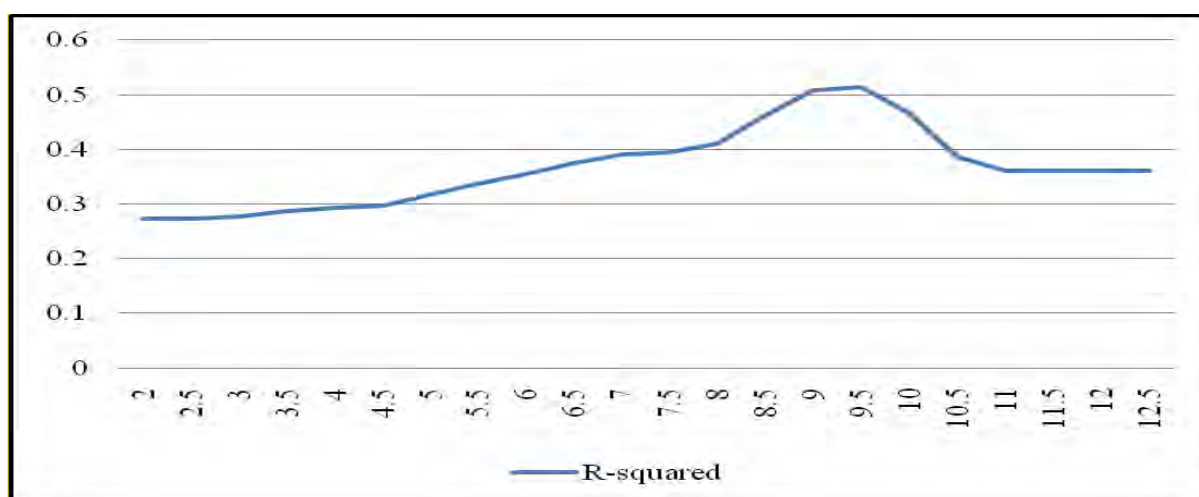
**Figure 5.14: Trivariate model, RSS, 1983–1999**



#### 5.4.6 TRIVARIATE THRESHOLD MODEL: 2000-2010

The results for the inflation targeting period maximise R-squared (minimise RSS) at 9.5% (see Figures 5.15 and 5.16). This value is significant. From 2% to 6%, the log of inflation is positive and insignificant. It becomes negative from 6.5% to 9% but this remains insignificant. At 9.5% the negative coefficient becomes significant up until 12.5%. The EXTRA coefficient is negative and insignificant from 2% to 4.5%. For the remainder of the inflation rates (5% to 12.5%), it is negative and significant. The sum of the log of inflation and the EXTRA coefficient is negative throughout the sample.

**Figure 5.15: Trivariate model, R-squared, 2000–2010**



**Figure 5.16: Trivariate model, RSS, 2000–2010**

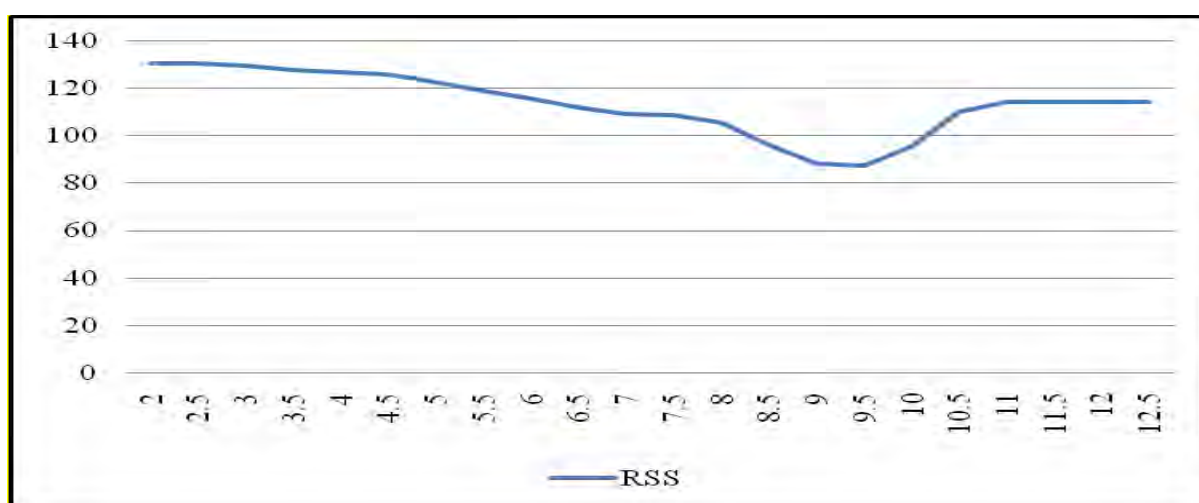


Table 5.6 summarises the findings of the threshold model. From Table 5.6, it can be seen that three threshold values are significant; 10.5% (multivariate model, 1983–2010); 15%

(trivariate model, 1983-2010) and 9.5% (trivariate model, 2000–2010). Prior to inflation targeting, inflation levels were very high. This may be the reason behind the high 15% threshold value. Currently South Africa targets inflation between 3% and 6%. The threshold of 9.5% suggests that South Africa may tolerate a higher inflation of up to 9.5% without harming growth. Beyond 9.5%, the effect on inflation is negative and significant. Considering the multivariate model for the inflation targeting period, there is a positive and significant effect on economic growth between 5.5% and 6.5%. This suggests that targeting inflation within this band will be favourable for higher economic growth.

**Table 5.6: Summary of threshold findings**

Period	Log of inflation			EXTRA			Log of inflation + EXTRA		Max R-squared/Min RSS
	Inflation range	Sign	Significance	Inflation range	Sign	Significance	Inflation range	Sign	
Multivariate 1983-2010	2-3%	Positive	Insignificant	2-8%	Negative	Insignificant	2-19%	Negative	10.5% significant
	3.5-7.5%	Negative	Insignificant	8.5-13.5%	Positive	Insignificant			
	8-19%	Negative	Significant	14-19%	Negative	Insignificant			
Multivariate 1983-1999	9.5%-18.5%	Negative	Insignificant	9.5-18.5%	Positive	Insignificant	9.5%-18.5%	Positive	10.5% not significant
	19%	Positive	Insignificant	19%	Negative	Insignificant	19%	Negative	12% not significant
									16.5% not significant
Multivariate 2000-2010	2-5%	Positive	Insignificant	2-3.5%	Negative	Insignificant	2-12.5%	Negative	9.5% not significant
	5.5%-6.5%	Positive	Significant	4-12.5%	Negative	Significant			
	7-9%	Positive	Insignificant						
	9.5-12.5%	Negative	Insignificant						
Trivariate 1983-2010	2-5%	Positive	Insignificant	2-4.5%	Negative	Insignificant	2-19%	Negative	7% not significant
	5.5-8.5%	Negative	Insignificant	5-9.5%	Negative	Significant			
	9-19%	Negative	Significant	10-11.5%	Negative	Insignificant			
				12-18.5%	Negative	Significant			
				19%	Negative	Insignificant			
Trivariate 1983-1999	9.5-14%	Positive	Insignificant	9.5-12.5%	Negative	Insignificant	9.5-19%	Negative	14% not significant
	14.5-16.5%	Negative	Insignificant	13-15.5%	Negative	Significant			
	17-19%	Negative	Significant	16-19%	Negative	Insignificant			
Trivariate 2000-2010	2-6%	Positive	Insignificant	2-4.5%	Negative	Insignificant	2-12.5%	Negative	9.5% significant
	6.5-9%	Negative	Insignificant	5-12.5%	Negative	Significant			
	9.5-12.5%	Negative	Significant						

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## 5.5 INFLATION UNCERTAINTY MODEL

It has been shown by some authors (see Fischer, 1993 and Barro, 1995a) that the inflation uncertainty can have an impact on inflation. However, inflation and inflation uncertainty are closely related (Fischer, 1993). Therefore to test for the effect of inflation uncertainty, three models are estimated; the first one only includes inflation, the second one only includes inflation uncertainty, and lastly the third one includes both inflation and inflation uncertainty. Table 5.7 shows the results for the volatility model. The three columns represent the estimates for the three samples: the full sample, prior to inflation targeting, and the inflation targeting period. The first panel includes only the level of inflation. In all three samples, inflation has a negative and significant effect on growth. For the inflation targeting period, the significance is 5% whereas for the other two samples it is lower at 10%. This result is consistent with the result found in Judson and Orphanides (1996).

The second panel replaces the level of inflation with the uncertainty of inflation. There is a negative but insignificant relationship between uncertainty and growth. This is against the findings of Judson and Orphanides (1996) who found that the uncertainty of inflation has a significant negative effect on growth. This suggests that the policy focus should be on the level of inflation, as it has been, and not on the uncertainty of inflation. A possible explanation for this is that, as shown in Figures 3.4 and 3.5, inflation in South Africa has not been very volatile. However, comparison of RSS values of the first and second panel suggests that the fit obtained using the inflation uncertainty as an indicator of growth is as good a fit as using just the inflation level.

The third panel includes both the level of inflation and the uncertainty of inflation in the regression. Due to the positive correlation between inflation and inflation uncertainty, the individual coefficients are smaller than the first two panels. In this case, only the level of inflation for the inflation targeting period is negative and significant. This further supports the earlier view that policy should focus on the level of inflation. Again, the reason behind this result may be that inflation has not been very volatile in South Africa. Comparison of the RSS values of the first panel with the first and second panels suggests that the fit obtained using inflation and inflation volatility as indicators is just as good as using inflation only or inflation uncertainty only.

**Table 5.7: Inflation uncertainty**

Variable	Inflation		
	1983Q1–2010Q1	1983Q1–1999Q4	2000Q1–2010Q1
Inflation	-0.056 [-1.663] (-0.099)	-0.173 [-1.787] (-0.079)	-0.062 [-2.089] (-0.044)
Investment	0.053 [3.557] (-0.001)	0.056 [2.976] (-0.004)	0.007 [0.188] (-0.852)
R <sup>2</sup>	0.888	0.860	0.926
DW	2.087	2.243	2.107
RSS	81.043	60.219	13.251
Variable	Volatility		
	1983Q1–2010Q1	1983Q1–1999Q4	2000Q1–2010Q1
Volatility	-0.189 [-0.576] (-0.566)	-0.822 [-1.068] (-0.290)	-0.184 [-0.612] (-0.545)
Investment	0.049 [3.279] (-0.001)	0.049 [2.664] (-0.010)	0.011 [0.307] (-0.761)
R <sup>2</sup>	0.885	0.855	0.917
DW	2.075	2.187	2.092
RSS	82.951	62.177	14.790
Variable	Volatility and Inflation		
	1983Q1–2010Q1	1983Q1–1999Q4	2000Q1–2010Q1
Inflation	-0.070 [-1.639] (-0.104)	-0.158 [-1.441] (-0.155)	-0.075 [-2.068] (-0.047)
Volatility	0.215 [0.526] (-0.6)	-0.257 [-0.300] (-0.765)	0.219 [0.631] (-0.533)
Investment	0.052 [3.516] (-0.001)	0.056 [2.963] (-0.004)	0.006 [0.166] (-0.869)
R <sup>2</sup>	0.888	0.860	0.927
DW	2.102	2.233	2.136
RSS	80.823	60.130	13.093

Notes: The dependent variable in all regressions is GDP growth. Investment is the growth of gross fixed capital formation. Inflation is one plus the rate of change in the price level. Volatility is the standard deviation of monthly intra-quarter inflation. T-statistics are shown below the parameter in [ ] and probability values below that in ( ). RSS is the residual sum squared.

## **5.6 CONCLUSION**

This chapter presents and discusses the results with regard to various issues surrounding the relationship between inflation and growth.

The Johansen cointegration approach was estimated next to determine whether or not there is a long-run relationship between inflation and growth. The results from the bivariate cointegration show that there is cointegration between inflation and growth. The results suggest a significant negative long-run relationship between price level and economic growth.

Three threshold levels are estimated for South Africa; 10.5%, 15% and 9.5%. This paper suggests that the inflation targeting band of 3%-6% may be extended to 9.5% without deterring growth. In addition, between 5.5% and 6.5%, there is a positive relationship between inflation and economic growth. Targeting within this region will not only reap the benefits of a low inflation target but also promote growth.

Lastly the volatility model shows that the level of inflation in South Africa has a bigger impact on growth than the uncertainty of inflation. Although the uncertainty of inflation should be kept low, more emphasis should be placed on the level of inflation in South Africa when policies are being implemented.

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## **CHAPTER SIX**

### **SUMMARY OF FINDINGS, POLICY RECOMMENDATIONS AND AREAS FOR FURTHER RESEARCH**

#### **6.1 SUMMARY OF THE STUDY AND CONCLUSIONS**

The study analysed the relationship between inflation and growth in the South African context. This was done in order to determine the threshold level of inflation for South Africa, with a view to giving policy recommendations. In particular, four main issues were addressed in this study, namely: whether there is a long-run relationship between price level and growth in South Africa; the nature of the relationship if one is found, the threshold level of inflation for South Africa and the impact of inflation uncertainty on growth in terms of South Africa. The ultimate goal was to determine whether the current inflation targeting band of 3%–6% for South Africa is correctly situated or whether it needs any adjustment, either downwards or upwards.

The first step in the study was to review the existing literature. Here, the major theories on the relationship between inflation and growth were outlined. Theories are not in agreement as to the effect of inflation on growth. Those in support of a negative relationship believe that inflation imposes costs on an economy thereby reducing growth. A summary of these costs is considered. Theoretical literature on the inflation threshold was reviewed. The relationship between inflation and economic growth is non-linear. At high levels of inflation, inflation is detrimental to growth. Therefore policies are aimed at achieving low inflation levels. However, there is a certain threshold level below which inflation does not harm growth and may even have a positive effect on growth. Following this, the inflation uncertainty theory was considered. It is not just the level of inflation that may affect growth; the volatility or uncertainty of inflation may also harm growth. Next empirical literature for developed countries, developing countries and South Africa were reviewed. The general finding in this literature is that the relationship between inflation and growth is not only negative but has a nonlinear relationship. Therefore there exists a threshold level of inflation beyond which inflation has a significant negative impact on growth.

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Chapter 3 reviewed the economic performance of the South African economy. In particular, the inflation targeting framework was reviewed, which is the current monetary policy framework used by SARB. It also provided a first glance at the relationship between inflation, inflation uncertainty and growth in South Africa.

In order to address the objectives, four sets of empirical analyses were carried out. Firstly, the long-run relationship was examined using the Johansen framework. Prior to conducting the Johansen cointegration test, the variables were tested to determine their order of integration using the ADF, PP and KPSS tests. The variables were both found to be integrated of order one or first difference stationary. Variables need to be first difference stationary in order to conduct the Johansen test for cointegration. The Johansen test found that there was a significant cointegrating vector between inflation and growth therefore establishing that there is a significant long-run relationship between the two series.

The next step in the analyses was to determine the causality between inflation and growth using the weak exogeneity test. It was found that there is bi-directional causality between inflation and growth and that both variables are endogenous. The long-run results suggest a significant negative relationship.

Having established a long-run relationship between inflation and growth, the threshold level of inflation was tested for. The conditional least squares method was used whereby the regression is estimated using OLS for each level of inflation. The value that maximises R-squared and minimises RSS is the optimal level of inflation. The results for the different samples were mixed. This may be because of the varied levels of inflation within each sample. Significant threshold levels were 10.5% for the multivariate model for the full sample, 15% for the trivariate model for the full sample and 9.5% for the trivariate model for the inflation targeting period. The other models suggested various inflation thresholds; however, these were not significant. Between 5.5% and 6.5% there is a statistically significant positive effect on economic growth.

Lastly, the effect of inflation uncertainty on growth was determined. The results of this analysis showed that inflation uncertainty did not have a significant impact on growth. The level of inflation has a stronger influence on growth. The relationship between inflation and growth is shown to be negative which is in support of the VECM results found earlier.

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Therefore, overall, these results show that there is a significant negative impact of inflation on economic growth in the long-run. Inflation uncertainty does not have a significant impact on economic growth. Inflation levels up to 9.5% may be tolerated by the South African economy without being detrimental to growth.

## **6.2 POLICY IMPLICATIONS**

The results of this study have important implications for policy. With regards to monetary policy, the focus should be on the level of inflation as has been the case and not on the uncertainty of inflation. The uncertainty of inflation in South Africa, did not have a significant impact on economic growth. The inflation level is positively related to inflation uncertainty. Therefore, maintaining inflation within a narrow band will keep volatility low enough so that it does not have an impact on growth. The findings show that inflation has a significant negative impact on economic growth in the long-run and therefore suggest that by following an inflation targeting framework, the economy will benefit in the long-run despite the short-run costs associated with such a framework.

Currently, the inflation target is between 3% and 6%. This level of inflation is in line with that of South Africa's major trading partners. The target was set by SARB in conjunction with the Minister of Finance. Since no study has been conducted on the inflation threshold level in South Africa, this study has important policy implications. The findings in this study do not disapprove of the current inflation band. However, the results suggest that a wider band can be tolerated. Inflation levels up to 9.5% will not harm growth. This is in line with findings that developing countries should tolerate higher inflation levels than developed countries. More importantly, inflation levels between 5.5% and 6.5% may even have a positive impact on economic growth.

## **6.3 AREAS FOR FURTHER RESEARCH**

Few studies have been conducted on African countries. Those that have included South Africa have done so in cross-country studies. The downside of such studies is that it is difficult to determine the inflation threshold for individual countries and hence makes policy proposals problematic. Most African countries are plagued with employment problems. By

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targeting the inflation level that optimises economic growth, more jobs can be created in the long-run.

Therefore a recommendation for further research is to conduct the analysis on individual countries in Africa perhaps in certain regional areas such as the Southern Africa Customs Union area or Southern African Development Community region. A cross-country study may also be conducted to illustrate the downside of this analysis.

## APPENDIX

**Table A1: Summary of studies on the inflation-growth relationship**

Study	Country cover	Period cover	Estimation Method	Summary of findings
Bhatia (1960)	5 developed United Kingdom, Germany, Sweden, Canada, Japan	United Kingdom: 1812–1912 Germany: 1865–1910 Sweden: 1865–1934 Canada: 1873–1938 Japan: 1881–1932	Ordinary least squares	No definite conclusion
Lucas (1973)	18 developed and developing	1951–1967	Ordinary least squares for individual countries	Existence of a significant stable trade-off
Fischer (1983)	53 including South Africa	1961–1981	Ordinary least squares cross section and time series regressions	Negative relationship
Kormendi and Meguire (1985)	47 developed and developing, including South Africa	1950–1977	Ordinary least squares cross sectional regression	Negative relationship between inflation and growth
Jung and Marshall (1986)	19 developed, 37 developing, including South Africa	South Africa: 1951– 1980	Granger causality tests F test to test the sign of the sum of inflation coefficients	16 countries have a negative relationship between inflation and growth Egypt and Uruguay have a positive relationship 38 countries are neutral
De Gregorio (1992)	12 developing	1951–1985	Generalised least squares	Significant negative relationship between growth and the inflation rate
Smyth (1992)	United States of America	1955–1990	Ordinary least squares	Significant negative relationship
De Gregorio (1993)	12 developing	1950–1985	Ordinary least squares on panel data with random effects White's robust correction for standard errors	Inflation negatively affects long-run growth

Study	Country cover	Period cover	Estimation Method	Summary of findings
Fischer (1993)	32 developed and developing	1965–1990	Generalised least squares cross-sectional regressions Panel regressions	Inflation negatively affects growth
Levine and Zervos (1993)	102 developed and developing	1960–1989	Ordinary least squares Extreme bounds analysis	Inflation has a negative impact on long-run growth but not significant
Stanners (1993)	44 advanced 9 developed and developing, including South Africa	Advanced: 1908–1988 Developed and developing: 1948–1986	Curve fitting in a quadratic equation ( $y=a+bx+cx^2$ ) Time series plot for individual countries	44: inflation not correlated with growth 12 advanced: not correlated with growth 9 developed: not correlated with growth
Sbordone and Kuttner (1994)	United States of America	1947–1994	Simple correlation Granger causality tests Instrumental variables	Negative relationship
Smyth (1994)	United States of America	1951–1992	Ordinary least squares growth equation estimate	Inflation reduces output in the steady state
Barro (1995a)	78, 89 or 84 All developed and developing, including South Africa	78: 1965–1975 89: 1875–1985 84: 1985–1990	Regressions equations Instrumental variables	Negative linear relationship
Bruno and Easterly (1995)	127 developed and developing, including South Africa	1961–1992	Ordinary least squares pooled time series and cross-section time regressions	Negative relationship in countries with discrete high inflation crises
Bruno and Easterly (1996)	26 developing	1961–1992	Ordinary least squares	No evidence of a long-run relationship between inflation and growth for annual inflation rates less than 40%
Fischer <i>et al.</i> (1996)	26 transition	1989–1994	Plot of data Fixed effects model	Negative correlation between inflation and growth

Study	Country cover	Period cover	Estimation Method	Summary of findings
Judson and Orphanides (1996)	119 developed and developing, including 22 OECD <sup>31</sup> and South Africa	1959–1992	Ordinary least squares panel regressions	A highly significant negative relationship exists between inflation and growth
Alexander (1997)	11 developed OECD <sup>32</sup>	1966–1988	Pooled or combined time series and cross section regressions Ordinary least squares	Negative relationship between inflation and growth
Andrés and Hernando (1997)	OECD	1961–1992	Instrumental variables Ordinary least squares Granger causality tests	Effect of inflation on growth is negative and significant
Ghosh (1997)	15 transition	1960–1996	Analysis of various charts	Negative relationship between inflation and growth
Loungani and Sheets (1997)	25 transition	1991–1994	Ordinary least squares	Inflation has a negative effect on growth
Malla (1997)	11 developed OECD 8 developing Asian	OECD: 1966–1988 Asian: 1979–1995	Pooled or combined time series or cross sectional form Ordinary least squares	Strong negative relationship between inflation and growth for both samples
Ghosh and Phillips (1998a)	145 IMF <sup>33</sup> member countries Developed and developing	1960–1996	Joint frequency distribution Panel regression Ordinary least squares Two-stage least squares	Negative relationship between inflation and growth which is statistically significant, regardless of any outliers
Ghosh and Phillips (1998b)	145 IMF member countries Developed and developing	1960–1996	Joint frequency distribution Multivariate regressions Ordinary least squares	Negative relationship between inflation and growth

<sup>31</sup> OECD: Organisation for Economic Co-operation and Development

<sup>32</sup> OECD: Organisation for Economic Co-operation and Development

<sup>33</sup> IMF: International Monetary Fund

Study	Country cover	Period cover	Estimation Method	Summary of findings
Motley (1998)	78 developed and developing	1960–1990	Cross section and time series regressions Ordinary least squares	30-year cross-section and short sample cross-section: negative relationship between inflation and growth
Nell (2000)	South Africa	1960–1999	Vector autoregressive model	Inflation has an independent negative impact on growth
Barro (2001)	78, 89 or 84 All developed and developing, including South Africa	78: 1965–1975 89: 1875–1985 84: 1985–1990	Three stage least squares Instrumental variables	Significant negative effect on growth
Faria and Carneiro (2001)	Brazil	Jan 1980–Jul 1995	Vector autoregressive model	Inflation has no long-run effects on real output, but it can have short-run impacts
Gylfason and Herbertsson (2001)	170, 145 developed and developing	1960–1992	Random effects panel model	Negative relationship between inflation and growth in the long run
Harris <i>et al.</i> (2001)	Full: 41 OECD <sup>34</sup> : 29 APEC <sup>35</sup> : 18	1961–1997	Spline function Instrumental variables	Negative non-linear relationship between inflation and growth for all groups Results are sensitive to the method used
Mallik and Chowdhury (2001)	4 developing	Bangladesh: 1874–1997 India: 1961–1997 Pakistan: 1957–1997 Sri Lanka: 1966–1997	Johansen cointegration and vector error correction models	Relationship between inflation and growth rates is positive
Singh and Kalirajan (2003)	India	1971–1998	Cross-sectional regression	Increase in inflation from any level has a negative effect on growth
Chowdhury and Siregar (2004)	Indonesia	1950–1997	Bivariate vector autoregressive model Granger causality tests Impulse response analysis	Bi-directional relationship between economic growth and inflation

<sup>34</sup> OECD: Organisation for Economic Co-operation and Development

<sup>35</sup> APEC: Asia-Pacific Economic Cooperation

Study	Country cover	Period cover	Estimation Method	Summary of findings
Gillman <i>et al.</i> (2004)	41 20 OECD 18 APEC	1961–1997	Panel ordinary least squares with fixed effects Instrumental variables	Negative relationship for full sample
Gokal and Hanif (2004)	Fiji	1970–2003	Correlation matrix Granger causality	Weak negative relationship
Mejia-Reyes (2004)	Mexico		Smooth transition regression model	Inflation always has a negative effect on growth
Sepehri and Moshiri (2004)	92 developed and developing, including South Africa OECD <sup>36</sup> : 24 Upper-middle income: 14 (South Africa) Lower-middle income: 26 Low income: 28	1960–1996	Ordinary least squares panel regressions	Effect of inflation on growth depends on the development of the country Linearity and non-linearity also depend on the development of the country
Sweidan (2004)	Jordan	1976–2003	Ordinary least squares multiple regression model	Relation between inflation and economic growth is strongly negative and statistically significant
Ahmed and Mortaza (2005)	Bangladesh	1981–2005	Engle–Granger two stage cointegration Johansen test for cointegration Error correction model	Stable long-run significant negative relationship
Hussain (2005)	Pakistan	1973–2005	Scatter diagrams	Cointegrated relationship between inflation and growth
Hodge (2006)	South Africa	Long-term: 1950–2002 Short-term: 1970–2003	Ordinary least squares linear regression	In the medium to long-term, inflation has a strong negative effect on growth

<sup>36</sup> OECD: Organisation for Economic Co-operation and Development

Study	Country cover	Period cover	Estimation Method	Summary of findings
Li (2006)	Growth equation: 27 developed, 90 developing, including South Africa  Growth accounting equation: 27 developed, 63 developing, including South Africa	Growth equation: 1961–2004  Growth accounting equation: developed: 1961–2004, developing: 1961–1990	Linear regressions: ordinary least squares and ordinary least squares with fixed effects	Negative relationship between inflation and growth
Rousseau and Yilmazkuday (2009)	84 developed and developing, including South Africa	1960–2004	Analysis of three-dimensional graphs Ordinary least squares with fixed effects	Significant negative relationship between inflation and growth
Yilmaz (2009)	Turkey	1988–2007	Vector autoregressive model	Long-run relationship between inflation and growth Bi-directional causality In the short-run, inflation negatively affects growth

*Source: Compiled by author*

Table A2a: Inflation-growth multivariate models

Study	Explanatory variables in alphabetical order																								
	BANK DENSITY	BANK DEPOSIT RATES	BLACK MARKET	BUDGET SURPLUS	CAPITAL ACCUM	DEMOCRACY	DEPRECIATION	DIVIDEND RATE	DROUGHT	EDUCATION	EMPLOYMENT	ENERGY PRICE	EXPORTS/IMPORTS	FERILITY	FIN SECTOR DEPTH	FISCAL BALANCE	FOREIGN INVESTMENT	GDP	GDP DEFLATOR	GDP PER CAPITA	GOVT CONSUMPTION	HEALTH	HUMAN CAPITAL	INCOME	INF RATE
NO OF TIMES VARIABLE USED	1	1	4	2	5	1	1	1	2	7	2	1	8	2	1	5	2	7	2	1	10	1	5	9	29
Kormendi and Meguire (1985)													•					•			•				•
De Gregorio (1992)																		•			•				•
De Gregorio (1993)																	•	•			•				•
Fischer (1993)			•	•																					•
Levine and Zervos (1993)																							•		•
Sbordone and Kuttner (1994)																			•						•
Smyth (1994)											•	•													•
Barro (1995a)			•			•				•				•							•	•			•
Bruno and Easterly (1995)										•															•
Bruno and Easterly (1996)										•															•
Fischer <i>et al.</i> (1996)																•								•	•
Judson and Orphanides (1996)					•																		•	•	•
Alexander (1997)					•								•								•				•
Andrés and Hernando (1997)																						•			•
Ghosh (1997)																								•	•
Loungani and Sheets (1997)																•									•
Malla (1997)					•						•	•									•				•

Table A2a continued

	BANK DENSITY	BANK DEPOSIT RATES	BLACK MARKET	BUDGET SURPLUS	CAPITAL ACCUM	DEMOCRACY	DEPRECIATION	DIVIDEND RATE	DROUGHT	EDUCATION	EMPLOYMENT	ENERGY PRICE	EXPORTS/IMPORTS	FERTILITY	FIN SECTOR DEPTH	FISCAL BALANCE	FOREIGN INVESTMENT	GDP	GDP DEFLATOR	GDP PER CAPITA	GOVT CONSUMPTION	HEALTH	HUMAN CAPITAL	INCOME	INF RATE
NO OF TIMES VARIABLE USED	1	1	4	2	5	1	1	1	2	7	2	1	8	2	1	5	2	7	2	1	10	1	5	9	29
Ghosh and Phillips (1998a)			•						•				•			•							•	•	•
Ghosh and Phillips (1998b)			•						•				•			•							•	•	•
Motley (1998)																									•
Nell (2000)																									•
Barro (2001)											•			•							•				•
Gylfason and Herbetsson (2001)										•			•					•							•
Harris <i>et al.</i> (2001)																			•	•					
Singh and Kalirajan (2003)	•	•						•								•		•		•				•	•
Gillman <i>et al.</i> (2004)																		•	•						•
Mejía-Reyes (2004)							•																		•
Sepehri and Moshiri (2004)				•						•			•												•
Sweidan (2004)					•																				•
Hussain (2005)																								•	•
Hodge (2006)																									•
Li (2006)					•								•								•			•	•
Rousseau and Yilmazkuday (2009)										•								•			•				•
Yilmaz (2009)																									•

Table A2b: Inflation-growth multivariate models

Study	Explanatory variables in alphabetical order																								
	INTEREST RATE	INVESTMENT	INV: PVT SECTOR	INV: PBL SECTOR	LABOUR	LITERACY	MONEY	OPENESS	POLITICAL INSTABILITY	POPULATION	PVT BUS HOURS	PBL CONSUMPTION	PRODUCTIVITY	RAINFALL	REFORM INDEX	REVENUE	RULE OF LAW	SAVINGS	TAX	TERMS OF TRADE	TFP	TOTAL OUTLAY	USA OUTPUT GROWTH	WAR	W/SALE PRICE
NO OF TIMES VARIABLE USED	3	20	1	1	3	3	6	2	1	8	1	2	1	1	1	3	2	1	1	7	1	1	1	2	1
Kormendi and Meguire (1985)		•					•			•															
De Gregorio (1992)		•				•																			
De Gregorio (1993)		•				•	•																		
Fischer (1993)																					•				
Levine and Zervos (1993)									•																
Sbordone and Kuttner (1994)	•												•												
Smyth (1994)											•														
Barro (1995a)		•															•								
Bruno and Easterly (1995)		•								•															
Bruno and Easterly (1996)		•								•															
Fischer <i>et al.</i> (1996)																									
Judson and Orphanides (1996)		•																							
Alexander (1997)					•																				
Andrés and Hernando (1997)		•								•															
Ghosh (1997)		•																			•				
Loungani and Sheets (1997)															•										
Malla (1997)																									

Table A2b continued

Ghosh and Phillips (1998a)	•				•		•								•
Ghosh and Phillips (1998b)	•					•		•							•
Motley (1998)	•				•										
Nell (2000)	•				•									•	
Barro (2001)	•				•				•					•	
Gylfason and Herbetsson (2001)	•				•										
Harris <i>et al.</i> (2001)	•														
Singh and Kalirajan (2003)	•		•	•	•			•		•		•		•	•
Gillman <i>et al.</i> (2004)	•				•										
Mejia-Reyes (2004)														•	
Sepehri and Moshiri (2004)	•							•							
Sewidan (2004)					•										
Hussain (2005)	•				•			•							
Hodge (2006)	•			•								•		•	
Li (2006)	•			•										•	•
Rousseau and Yilmazkuday (2009)														•	
Yilmaz (2009)															

Source: Compiled by author

**Table A3: Summary of studies on the inflation threshold**

Study	Country cover	Period cover	Estimation method	Summary of findings
Fischer (1993)	32 developing	1965–1990	Spline function	Nonlinear relationship Threshold: 15 and 40% Moderate inflation are sustainable provided inflation is below 30%
Barro (1995b)	78, 89 or 84 All developed and developing, including South Africa	1965–1975 1975–1985 1985–1990	Three stage least squares Instrumental variables	Nonlinear relationship Threshold: 15 and 40%
Bruno and Easterly (1995)	127 developed and developing, including South Africa	1961–1992	Pooled cross section time series regression	Threshold: 40% Beyond 40%, no association between inflation and growth
Clark <i>et al.</i> (1996)	United States of America	1964–1990	Nonlinear least squares	Evidence of significant asymmetry in the USA output-inflation relationship
Judson and Orphanides (1996)	142 developed and developing including South Africa	1959–1992	Spline estimates	Above 10%, the relationship between inflation and growth is insignificant High inflation is detrimental to growth
Sarel (1996)	87 developed and developing, including South Africa	1970–1990	Ordinary least squares	Threshold of 8% Below 8%, positive relationship between inflation and growth but is weak and insignificant Above 8%, significant and powerful negative effect of inflation on growth When inflation doubles, growth declines by 1.7%
Ghosh (1997)	15 transition	1960–1996	Chart analysis Classification tree	GDP growth is generally higher when inflation lies between 3 and 10% Below 3%, growth is slower Above 10%, negative relationship

Study	Country cover	Period cover	Estimation method	Summary of findings
Christoffersen and Doyle (1998)	22 transition (CEE and BRO) <sup>37</sup>	1990–1997	Ordinary least squares	Threshold of 13% No evidence of significant output gains of reducing inflation below the threshold level Above threshold, significant output losses Doubling inflation above the threshold reduces growth by 0.2%
Ghosh and Phillips (1998a)	145 IMF <sup>38</sup> member countries Developed and developing	1960–1996	Joint frequency distribution Spline technique	Nonlinear relationship between inflation and growth at very low levels of inflation (2–3%), relationship is positive
Ghosh and Phillips (1998b)	145 IMF member countries, including South Africa Developed and developing	1960–1996	Spline estimation Decision tree technique	Nonlinear relationship between inflation and growth Threshold: 2–3% Below threshold, positive relationship Above threshold, negative relationship
Kannan and Joshi (1998)	India	1981/82–1995/96	Ordinary least squares	Threshold of 6% Below threshold, negligible effect on growth Above threshold, negative relationship between inflation and growth Increasing inflation by 1% above the threshold level reduces growth by 0.5% p.a.
Motley (1998)	78 developed and developing	1960–1990	Spline estimation	Threshold: 5%
Kalra and Sløk (1999)	4 transition (Asian)	1993–1998	Ordinary least squares	No threshold found Adding the Asian transition countries to the non-Asian transition countries of Christoffersen and Doyle (1998) finds an inflation threshold of 8%

<sup>37</sup> CEE: Central and Eastern Europe; BRO: Baltics, Russia and other countries of the Former Soviet Union

<sup>38</sup> IMF: International Monetary Fund

Study	Country cover	Period cover	Estimation method	Summary of findings
Khan and Senhadji (2001)	140 developed/ developing	1960–1998	Conditional least squares	Full sample: threshold of 11%, significant. Below 11%, no significant effect on growth. Above 11%, significant negative effect on growth  Developed countries: threshold between 1–3% Developing countries: threshold between 11–12% Below thresholds, positive effect on growth, only significant for developed countries Above threshold levels, negative relationship between inflation and growth
Gylfason and Herbertsson (2001)	170, 145 developed and developing	1960–1992	Random effects panel model	Long-run average inflation in excess of 10–20% p.a. impedes economic growth over the long term
Khan (2002)	140 industrial and developing countries	1960–1998	Conditional least squares	Industrial countries: 1% Developing countries: 11% Both are significant
Rousseau and Wachtel (2002)	84 developed and developing including South Africa	1960–1995	Rolling panel regression	Financial depth has a positive effect on growth when inflation is below 13 and 25% Positive effect is significant when inflation is below the threshold of 6–8%
Singh and Kalirajan (2003)	India	1971–1998	Ordinary least squares	No threshold level Inflation has a negative effect at all levels
Tsionas and Christopoulos (2003)	15 developed (Europe)	1961–1999	Hansen's (1999) fixed bootstrap method Two-stage least squares	Threshold of 4.3% Nonlinear significant relationship between inflation and growth Inflation increases of 1% has a reduction in growth of 0.33%

Study	Country cover	Period cover	Estimation method	Summary of findings
Burdekin <i>et al.</i> (2004)	21 developed 51 developing, including South Africa	Developed: 1965–1992 Developing: 1967–1992	Spline estimation Generalised least squares	<p>Industrial: threshold of 8% and 25% Below 8%, negative effect on growth but not significant Between 8% and 25%, negative and significant relationship between inflation and growth If inflation increases by 1%, growth decreases by 0.3% In the short-run, inflation rise of 1% decreases growth by 0.15%</p> <p>Developing: 3%, 50% (both significant) and 102% (not significant) Below 3%, positive and significant effect on growth Between 3% and 50%, negative and significant effect on growth. Increasing inflation by 1% reduces growth by 0.083% Between 50% and 102%, negative effect on growth but not significant Over 102%, negative and significant effect on growth Using the log of inflation: developing threshold rises from 3% to 10% All results show nonlinearity between inflation and growth</p>
Chowdhury and Siregar (2004)	Indonesia	1950–1997	Ordinary least squares estimation on a quadratic specification	<p>Threshold: 20.4% Above threshold there is a decrease in economic growth</p>

Study	Country cover	Period cover	Estimation method	Summary of findings
Gillman <i>et al.</i> (2004)	41 20 OECD <sup>39</sup> 18 APEC <sup>40</sup>	1961–1997	Spline estimation Instrumental variables	Nonlinear relationship
Gokal and Hanif (2004)	Fiji	1970–2003	Joint frequency distribution	Inflation rise above 5% drops mean and medium growth
Mejia-Reyes (2004)	Mexico		Smooth transition regression model	Threshold value corresponds to an annualised inflation rate equal to 8.3%
Sepehri and Moshiri (2004)	92 developed and developing, including South Africa OECD: 24 Upper-middle income: 14 (South Africa) Lower-middle income: 26 Low income: 28	1960–1996	Spline estimation	OECD: no threshold Upper-middle income: 4% Lower-middle income: 15% Low income: 21%
Sweidan (2004)	Jordan	1970–2000	Conditional least squares	Threshold: 2% Below 2%, relationship is strong, significant and positive Above 2%, relationship is negative and significant
Ahmed and Mortaza (2005)	Bangladesh	1981–2005	Conditional least squares	Threshold: 6% Below threshold, no effect Above threshold, significant negative effect
Hussain (2005)	Pakistan	1973–2005	Conditional least squares	No threshold level of inflation
Mubarik (2005)	Pakistan	1973–2000	Conditional least squares	Threshold of 9% Below threshold, insignificant relationship Above threshold, significant negative relationship. Inflation increases of 1% cause growth to decline by 0.08%

<sup>39</sup> OECD: Organisation for Economic Co-operation and Development

<sup>40</sup> APEC: Asia-Pacific Economic Cooperation

Study	Country cover	Period cover	Estimation method	Summary of findings
Pollin and Zhu (2005)	80 divided into OECD <sup>41</sup> , middle income countries, which includes South Africa and low income countries	1961–2000	Pooled ordinary least squares Between effects Fixed effects Random effects	Full sample: threshold of 15–18% Above threshold, negative relationship Below threshold level, 1% increase in inflation increases growth by 0.1–0.15% OECD: no reliable results Middle income: 14–16% Low-income countries: 15–23%
Sargsyan (2005)	Armenia	1996–2004	Conditional least squares	Threshold: 4.5% p.a. Above 4.5%, inflation has a negative effect on growth
Li (2006)	90 developing countries and 28 developed countries including South Africa	Growth equation: 1961–2004  Growth accounting equation: developed: 1961–2004, developing: 1961–1990	Nonlinear fixed effects	Full sample: 14 and 38% Developed: 24% Developing: 14 and 38%
Malesevic (2007)	8 transition economies	1990–2003	Spline technique	Threshold: 18–20% Above the threshold there is a negative effect on growth Between 8 and 18% the effect is not significant Below 8% there is a positive effect on growth

<sup>41</sup> OECD: Organisation for Economic Co-operation and Development

Study	Country cover	Period cover	Estimation method	Summary of findings
Vaona and Schiavo (2007)	167 developed and developing	1960–1999	Nonparametric estimator Semiparametric instrumental variable estimator	All countries: Nonlinear relationship between inflation and growth Threshold of 12% Above threshold, negative relationship Below threshold, no significant effect on growth Developed: 12% Developing: no clear result
Munir and Mansur (2009)	Malaysia	1970–2005	Conditional least squares	Threshold: 3.89% Above: negative relationship Below: significant positive relationship
Rousseau and Yilmazkuday (2009)	84 developed and developing, including South Africa	1960–2004	Instrumental variables (two-stage least squares) Trilateral graphical approach	Threshold: between 4 and 19%
Pypko (2009)	6 CIS <sup>42</sup> countries	2001–2008	Conditional least squares	Threshold: 8% Non-linear inflation-growth relationship
Frimpong and Oteng-Abayie (2010)	Ghana	1960–2008	Conditional least squares	Threshold: 11%

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<sup>42</sup> CIS: Commonwealth Independent States

Table A4a: Inflation threshold multivariate models

Study	Explanatory variables in alphabetical order																										
	AGRICULTURE	BANK DENSITY	BANK DEPOSIT RATES	BANK LENDING RATES	BLACK MARKET	BUDGET SURPLUS	CAPITAL ACCUM	DEPRECIATION RATE	DIVIDEND RATE	DROUGHT	EDUCATION	EXCHANGE RATE	EXPORTS/IMPORTS	FDI	FERTILITY RATE	FIN DEVELOPMENT	FIN SECTOR DEPTH	FISCAL BALANCE	GDP	GDP DEFLATOR	GDP PER CAPITA	GDP GAP	GOVT CONSUMPTION	HEALTH	HUMAN CAPITAL	INCOME	INFLATION RATE
NO OF TIMES VARIABLE USED	1	1	1	1	4	3	5	1	1	2	8	1	8	1	1	1	2	4	7	1	1	1	9	2	3	7	33
Fischer (1993)					•	•																					•
Barro (1995b)											•				•								•				•
Bruno and Easterly (1995)											•																•
Judson and Orphanides (1996)							•																		•		•
Sarel (1996)												•											•				•
Ghosh (1997)																										•	•
Christoffersen and Doyle (1998)													•														•
Ghosh and Phillips (1998a)					•					•			•					•							•	•	•
Ghosh and Phillips (1998b)					•					•			•					•							•	•	•
Kannan and Joshi (1998)	•																										•
Kalra and Sløk (1999)																											•
Khan and Senhadji (2001)																										•	•
Gylfason and Herbetsson (2001)											•		•						•								•
Khan (2002)																										•	•
Rousseau and Wachtel (2002)											•						•		•								•
Singh and Kalirajan (2003)		•	•	•					•									•	•			•				•	•



Table A4b: Inflation threshold multivariate models

Study	Explanatory variables in alphabetical order																					
	INF VOLATILITY	INVESTMENT	INV: PVT SECTOR	INV: PBL SECTOR	INV: INCOME	LABOUR	LITERACY RATE	MONEY STOCK	NATURAL DISASTER	OPENNESS	POPULATION	PBL CONSUMPTION	RAINFALL INDEX	REVENUE	SAVINGS	TERMS OF TRADE	TFP	TOTAL OUTLAY	TRANSITION REFORM	USA OUTPUT	WAR	W/SALE PRICE
NO OF TIMES VARIABLE USED	1	20	1	2	1	1	1	5	1	4	13	2	1	3	1	14	2	1	2	1	5	1
Fischer (1993)																•						
Barro (1995b)		•								•						•						
Bruno and Easterly (1995)		•									•											
Judson and Orphanides (1996)		•			•																	
Sarel (1996)		•									•					•						
Ghosh (1997)		•														•						
Christoffersen and Doyle (1998)											•								•		•	
Ghosh and Phillips (1998a)		•										•		•							•	
Ghosh and Phillips (1998b)												•		•							•	
Kannan and Joshi (1998)		•														•						
Kalra and Sløk (1999)																						
Khan and Senhadji (2001)				•							•					•						
Gylfason and Herbertsson (2001)		•								•												
Khan (2002)		•									•					•						
Rousseau and Wachtel (2002)																						
Singh and Kalirajan (2003)			•	•			•				•		•	•	•	•		•				•

Table A4b continued

Tsionas and Christopoulos (2003)	•					•	
Burdekin <i>et al.</i> (2004)				•		•	
Gillman <i>et al.</i> (2004)	•		•				
Mejia-Reyes (2004)							•
Sepehri and Moshiri (2004)	•				•		
Sweidan (2004)			•				
Hussain (2005)	•		•		•		
Mubarik (2005)	•				•		
Pollin and Zhu (2005)	•			•		•	•
Sargsyan (2005)	•						•
Li (2006)	•	•				•	•
Vaona and Schiavo (2007)	•				•	•	
Munir and Mansur (2009)			•				
Rousseau and Yilmazkuday (2009)					•		
Pypko (2009)	•				•	•	
Frimpong and Oteng-Abayie (2010)	•	•	•			•	
Malesevic (2007)	•				•		•

Source: Compiled by author

Table A5: Choice of dependent variable

STUDY	DEPENDENT VARIABLES	STUDY	DEPENDENT VARIABLES
	GROWTH RATE OF REAL GDP		GROWTH RATE OF REAL GDP
	GROWTH RATE OF REAL PER CAPITA GDP		GROWTH RATE OF REAL PER CAPITA GDP
Bhatia (1960)	•	Kannan and Joshi (1998)	•
Lucas (1973)	•	Motley (1998)	•
Fischer (1983)	•	Kalra and Sløk (1999)	•
Kormendi and Meguire (1985)	•	Nell (2000)	•
Jung and Marshall (1986)	•	Barro (2001)	•
De Gregorio (1992)	•	Faria and Carneiro (2001)	•
Smyth (1992)	•	Gylfason and Herbertsson (2001)	•
De Gregorio (1993)	•	Harris <i>et al.</i> (2001)	•
Fischer (1993)	•	Mallik and Chowdhury (2001)	•
Levine and Zervos (1993)	•	Rousseau and Wachtel (2002)	•
Stanners (1993)	•	Singh and Kalirajan (2003)	•
Sbordone and Kuttner (1994)	•	Tsionas and Christopoulos (2003)	•
Smyth (1994)	•	Burdekin <i>et al.</i> (2004)	•
Barro (1995a)	•	Chowdhury and Siregar (2004)	•
Barro (1995b)	•	Gillman <i>et al.</i> (2004)	•
Bruno and Easterly (1995)	•	Gokal and Hanif (2004)	•
Bruno and Easterly (1996)	•	Mejia-Reyes (2004)	•
Clark <i>et al.</i> (1996)	•	Sepehri and Moshiri (2004)	•
Fischer <i>et al.</i> (1996)	•	Sweidan (2004)	•
Judson and Orphanides (1996)	•	Ahmed and Mortaza (2005)	•
Sarel (1996)	•	Hussain (2005)	•
Alexander (1997)	•	Mubarik (2005)	•

**Table A5** continued

Andrés and Hernando (1997)	•	Pollin and Zhu (2005)	•
Ghosh (1997)	•	Hodge (2006)	•
Loungani and Sheets (1997)	•	Li (2006)	•
Malla (1997)	•	Vaona and Schiavo (2007)	•
Christoffersen and Doyle (1998)	•	Rousseau and Yilmazkuday (2009)	•
Ghosh and Phillips (1998a)	•	Yilmaz (2009)	•
Ghosh and Phillips (1998b)	•		

Source: Compiled by author

**Table A6: Multivariate threshold model**

1983Q1–2010Q1							
Threshold Value	Variable	Coefficient	T statistic	Probability	Log Inf + Extra	R-squared	RSS
N/A	Constant	7.525	6.342	0.000		0.397	426.957
	Log Inf	-2.132	-4.222	0.000			
	Gov Con	-0.023	-0.499	0.619			
	Inv	0.076	2.929	0.004			
	Pop	-0.047	-0.892	0.375			
	TOT	-0.094	-2.343	0.021			
2%	Constant	-12.508	-0.263	0.793	-2.241	0.398	426.213
	Log Inf	27.040	0.391	0.697			
	Gov Con	-0.023	-0.498	0.619			
	Inv	0.072	2.627	0.010			
	Pop	-0.045	-0.843	0.401			
	TOT	-0.095	-2.364	0.020			
	Extra 2	-29.281	-0.422	0.674			
2.5%	Constant	4.249	0.541	0.590	-2.241	0.398	426.213
	Log Inf	1.621	0.182	0.856			
	Gov Con	-0.023	-0.498	0.619			
	Inv	0.072	2.627	0.010			
	Pop	-0.045	-0.843	0.401			
	TOT	-0.095	-2.364	0.020			
	Extra 2.5	-3.862	-0.422	0.674			
3%	Constant	4.983	0.916	0.362	-2.270	0.398	425.999
	Log Inf	0.347	0.067	0.947			
	Gov Con	-0.023	-0.496	0.621			
	Inv	0.071	2.572	0.012			
	Pop	-0.044	-0.834	0.406			
	TOT	-0.096	-2.374	0.019			

	Extra 3	-2.617	-0.479	0.633			
3.5%	Constant	5.237	1.181	0.240	-2.318	0.399	425.760
	Log Inf	-0.132	-0.035	0.972			
	Gov Con	-0.023	-0.495	0.622			
	Inv	0.070	2.459	0.016			
	Pop	-0.044	-0.819	0.414			
	TOT	-0.097	-2.390	0.019			
	Extra 3.5	-2.186	-0.536	0.594			
4%	Constant	5.679	1.488	0.140	-2.334	0.399	425.874
	Log Inf	-0.648	-0.219	0.827			
	Gov Con	-0.023	-0.499	0.619			
	Inv	0.069	2.374	0.020			
	Pop	-0.044	-0.814	0.418			
	TOT	-0.097	-2.388	0.019			
	Extra 4	-1.687	-0.509	0.612			
4.5%	Constant	6.020	1.772	0.079	-2.339	0.398	426.024
	Log Inf	-1.004	-0.411	0.682			
	Gov Con	-0.024	-0.500	0.618			
	Inv	0.069	2.326	0.022			
	Pop	-0.043	-0.811	0.419			
	TOT	-0.097	-2.381	0.019			
	Extra 4.5	-1.335	-0.473	0.638			
5%	Constant	5.911	1.906	0.060	-2.408	0.399	425.632
	Log Inf	-0.986	-0.471	0.639			
	Gov Con	-0.023	-0.498	0.620			
	Inv	0.067	2.227	0.028			
	Pop	-0.042	-0.790	0.432			
	TOT	-0.098	-2.400	0.018			
	Extra 5	-1.421	-0.563	0.574			
5.5%	Constant	5.948	2.071	0.041	-2.469	0.399	425.440
	Log Inf	-1.058	-0.572	0.569			
	Gov Con	-0.023	-0.495	0.622			
	Inv	0.066	2.146	0.034			
	Pop	-0.042	-0.776	0.439			
	TOT	-0.099	-2.409	0.018			
	Extra 5.5	-1.411	-0.603	0.548			
6%	Constant	6.139	2.303	0.023	-2.497	0.399	425.549
	Log Inf	-1.221	-0.741	0.461			
	Gov Con	-0.023	-0.495	0.622			
	Inv	0.066	2.105	0.038			
	Pop	-0.042	-0.775	0.440			
	TOT	-0.098	-2.404	0.018			
	Extra 6	-1.276	-0.581	0.563			
6.5%	Constant	6.358	2.573	0.012	-2.504	0.399	425.746
	Log Inf	-1.389	-0.944	0.347			
	Gov Con	-0.023	-0.490	0.625			

	Inv	0.066	2.100	0.038			
	Pop	-0.042	-0.778	0.439			
	TOT	-0.098	-2.394	0.019			
	Extra 6.5	-1.115	-0.539	0.591			
7%	Constant	6.686	2.898	0.005	-2.455	0.398	426.204
	Log Inf	-1.611	-1.213	0.228			
	Gov Con	-0.023	-0.497	0.620			
	Inv	0.068	2.141	0.035			
	Pop	-0.043	-0.793	0.430			
	TOT	-0.096	-2.371	0.020			
	Extra 7	-0.843	-0.424	0.672			
7.5%	Constant	7.142	3.289	0.001	-2.310	0.397	426.771
	Log Inf	-1.899	-1.562	0.121			
	Gov Con	-0.024	-0.501	0.618			
	Inv	0.072	2.239	0.027			
	Pop	-0.045	-0.831	0.408			
	TOT	-0.095	-2.340	0.021			
	Extra 7.5	-0.410	-0.211	0.833			
8%	Constant	7.482	3.619	0.001	-2.156	0.397	426.954
	Log Inf	-2.106	-1.860	0.066			
	Gov Con	-0.023	-0.497	0.620			
	Inv	0.075	2.315	0.023			
	Pop	-0.047	-0.866	0.389			
	TOT	-0.094	-2.325	0.022			
	Extra 8	-0.050	-0.026	0.980			
8.5%	Constant	7.607	3.884	0.000	-2.077	0.397	426.945
	Log Inf	-2.181	-2.078	0.040			
	Gov Con	-0.023	-0.491	0.624			
	Inv	0.077	2.345	0.021			
	Pop	-0.048	-0.881	0.380			
	TOT	-0.093	-2.326	0.022			
	Extra 8.5	0.103	0.053	0.958			
9%	Constant	7.795	4.204	0.000	-1.915	0.397	426.805
	Log Inf	-2.290	-2.357	0.020			
	Gov Con	-0.022	-0.475	0.636			
	Inv	0.079	2.411	0.018			
	Pop	-0.049	-0.907	0.366			
	TOT	-0.093	-2.328	0.022			
	Extra 9	0.375	0.190	0.850			
9.5%	Constant	8.022	4.561	0.000	-1.655	0.398	426.340
	Log Inf	-2.419	-2.682	0.009			
	Gov Con	-0.021	-0.446	0.657			
	Inv	0.084	2.523	0.013			
	Pop	-0.051	-0.942	0.348			
	TOT	-0.094	-2.337	0.021			
	Extra 9.5	0.763	0.384	0.702			

10%	Constant	8.285	4.918	0.000	-1.259	0.399	425.263
	Log Inf	-2.567	-3.022	0.003			
	Gov Con	-0.019	-0.401	0.689			
	Inv	0.089	2.672	0.009			
	Pop	-0.053	-0.983	0.328			
	TOT	-0.095	-2.360	0.020			
	Extra 10	1.308	0.637	0.525			
10.5%	Constant	8.447	5.209	0.000	-0.861	0.401	424.052
	Log Inf	-2.656	-3.297	0.001			
	Gov Con	-0.017	-0.355	0.724			
	Inv	0.093	2.788	0.006			
	Pop	-0.054	-1.006	0.317			
	TOT	-0.095	-2.382	0.019			
	Extra 10.5	1.796	0.836	0.405			
11%	Constant	8.370	5.311	0.000	-0.732	0.401	424.186
	Log Inf	-2.611	-3.371	0.001			
	Gov Con	-0.016	-0.337	0.737			
	Inv	0.094	2.753	0.007			
	Pop	-0.053	-0.987	0.326			
	TOT	-0.095	-2.380	0.019			
	Extra 11	1.878	0.816	0.416			
11.5%	Constant	8.210	5.362	0.000	-0.757	0.400	424.853
	Log Inf	-2.520	-3.387	0.001			
	Gov Con	-0.016	-0.337	0.737			
	Inv	0.092	2.655	0.009			
	Pop	-0.051	-0.956	0.342			
	TOT	-0.095	-2.364	0.020			
	Extra 11.5	1.763	0.711	0.479			
12%	Constant	8.167	5.502	0.000	-0.537	0.400	424.779
	Log Inf	-2.496	-3.498	0.001			
	Gov Con	-0.016	-0.334	0.739			
	Inv	0.093	2.630	0.010			
	Pop	-0.050	-0.936	0.351			
	TOT	-0.095	-2.360	0.020			
	Extra 12	1.959	0.723	0.471			
12.5%	Constant	8.016	5.587	0.000	-0.592	0.399	425.390
	Log Inf	-2.411	-3.541	0.001			
	Gov Con	-0.017	-0.351	0.726			
	Inv	0.091	2.518	0.013			
	Pop	-0.048	-0.912	0.364			
	TOT	-0.094	-2.356	0.020			
	Extra 12.5	1.820	0.613	0.541			
13%	Constant	7.787	5.587	0.000	-1.086	0.398	426.406
	Log Inf	-2.282	-3.493	0.001			
	Gov Con	-0.019	-0.397	0.692			
	Inv	0.085	2.309	0.023			

	Pop	-0.048	-0.902	0.369			
	TOT	-0.094	-2.344	0.021			
	Extra 13	1.196	0.363	0.717			
13.5%	Constant	7.546	5.585	0.000	-2.022	0.397	426.952
	Log Inf	-2.144	-3.438	0.001			
	Gov Con	-0.023	-0.470	0.639			
	Inv	0.076	2.068	0.041			
	Pop	-0.047	-0.888	0.377			
	TOT	-0.094	-2.330	0.022			
	Extra 13.5	0.122	0.034	0.973			
14%	Constant	7.439	5.661	0.000	-2.717	0.397	426.855
	Log Inf	-2.083	-3.485	0.001			
	Gov Con	-0.026	-0.520	0.604			
	Inv	0.072	1.937	0.056			
	Pop	-0.047	-0.874	0.384			
	TOT	-0.093	-2.314	0.023			
	Extra 14	-0.634	-0.156	0.877			
14.5%	Constant	7.411	5.811	0.000	-3.196	0.397	426.696
	Log Inf	-2.067	-3.625	0.001			
	Gov Con	-0.027	-0.549	0.584			
	Inv	0.069	1.898	0.061			
	Pop	-0.046	-0.861	0.391			
	TOT	-0.093	-2.302	0.023			
	Extra 14.5	-1.129	-0.249	0.804			
15%	Constant	7.389	5.951	0.000	-4.035	0.398	426.327
	Log Inf	-2.053	-3.758	0.000			
	Gov Con	-0.030	-0.599	0.551			
	Inv	0.066	1.810	0.073			
	Pop	-0.045	-0.838	0.404			
	TOT	-0.092	-2.284	0.024			
	Extra 15	-1.982	-0.388	0.699			
15.5%	Constant	7.418	6.053	0.000	-4.268	0.398	426.374
	Log Inf	-2.070	-3.874	0.000			
	Gov Con	-0.029	-0.590	0.556			
	Inv	0.067	1.880	0.063			
	Pop	-0.045	-0.835	0.406			
	TOT	-0.092	-2.286	0.024			
	Extra 15.5	-2.198	-0.373	0.710			
16%	Constant	7.459	6.155	0.000	-4.100	0.398	426.584
	Log Inf	-2.093	-3.998	0.000			
	Gov Con	-0.028	-0.561	0.576			
	Inv	0.069	2.042	0.044			
	Pop	-0.045	-0.845	0.400			
	TOT	-0.093	-2.304	0.023			
	Extra 16	-2.007	-0.299	0.766			
16.5%	Constant	7.478	6.210	0.000	-4.296	0.397	426.640

	Log Inf	-2.104	-4.066	0.000			
	Gov Con	-0.027	-0.552	0.582			
	Inv	0.070	2.148	0.034			
	Pop	-0.045	-0.851	0.397			
	TOT	-0.093	-2.318	0.023			
	Extra 16.5	-2.192	-0.275	0.784			
17%	Constant	7.461	6.223	0.000	-6.699	0.398	426.035
	Log Inf	-2.094	-4.077	0.000			
	Gov Con	-0.029	-0.597	0.552			
	Inv	0.067	2.134	0.035			
	Pop	-0.045	-0.835	0.406			
	TOT	-0.093	-2.321	0.022			
	Extra 17	-4.606	-0.470	0.640			
17.5%	Constant	7.496	6.261	0.000	-5.380	0.397	426.675
	Log Inf	-2.115	-4.132	0.000			
	Gov Con	-0.026	-0.543	0.589			
	Inv	0.072	2.370	0.020			
	Pop	-0.046	-0.860	0.392			
	TOT	-0.093	-2.324	0.022			
	Extra 17.5	-3.266	-0.260	0.796			
18%	Constant	7.496	6.267	0.000	-7.292	0.397	426.629
	Log Inf	-2.115	-4.138	0.000			
	Gov Con	-0.026	-0.542	0.589			
	Inv	0.071	2.378	0.019			
	Pop	-0.046	-0.859	0.392			
	TOT	-0.093	-2.329	0.022			
	Extra 18	-5.178	-0.280	0.780			
18.5%	Constant	7.489	6.272	0.000	-16.407	0.398	426.183
	Log Inf	-2.110	-4.142	0.000			
	Gov Con	-0.026	-0.542	0.589			
	Inv	0.070	2.357	0.020			
	Pop	-0.045	-0.851	0.397			
	TOT	-0.094	-2.347	0.021			
	Extra 18.5	-14.296	-0.430	0.668			
19%	Constant	7.509	6.311	0.000	-58.522	0.400	425.059
	Log Inf	-2.121	-4.186	0.000			
	Gov Con	-0.020	-0.428	0.670			
	Inv	0.069	2.522	0.013			
	Pop	-0.046	-0.861	0.392			
	TOT	-0.097	-2.407	0.018			
	Extra 19	-56.401	-0.675	0.501			

## 1983Q1-1999Q4

Threshold Value	Variable	Coefficient	T statistic	Probability	Log Inf + Extra	R-squared	RSS
N/A	Constant	2.082	0.444	0.659		0.375	261.289

	Log Inf	0.058	0.032	0.974			
	Gov Con	0.030	0.515	0.608			
	Inv	0.150	3.980	0.000			
	Pop	-0.081	-1.461	0.149			
	TOT	-0.091	-2.011	0.049			
9.5%	Constant	251.806	0.711	0.480	0.555	0.380	259.177
	Log Inf	-110.958	-0.705	0.484			
	Gov Con	0.033	0.562	0.576			
	Inv	0.156	4.020	0.000			
	Pop	-0.082	-1.467	0.148			
	TOT	-0.091	-2.004	0.050			
	EXTRA_9_5	111.514	0.705	0.484			
10%	Constant	56.227	0.731	0.468	0.555	0.380	259.177
	Log Inf	-23.535	-0.702	0.485			
	Gov Con	0.033	0.562	0.576			
	Inv	0.156	4.020	0.000			
	Pop	-0.082	-1.467	0.148			
	TOT	-0.091	-2.004	0.050			
	EXTRA_10	24.091	0.705	0.484			
10.5%	Constant	31.705	0.774	0.442	0.839	0.381	259.039
	Log Inf	-12.649	-0.721	0.474			
	Gov Con	0.034	0.572	0.570			
	Inv	0.159	3.990	0.000			
	Pop	-0.082	-1.459	0.150			
	TOT	-0.089	-1.956	0.055			
	EXTRA_10_5	13.488	0.728	0.470			
11%	Constant	18.049	0.634	0.528	0.953	0.378	259.909
	Log Inf	-6.710	-0.558	0.579			
	Gov Con	0.034	0.581	0.563			
	Inv	0.161	3.786	0.000			
	Pop	-0.081	-1.444	0.154			
	TOT	-0.086	-1.854	0.069			
	EXTRA_11	7.662	0.569	0.571			
11.5%	Constant	11.587	0.553	0.582	0.973	0.377	260.362
	Log Inf	-3.929	-0.449	0.655			
	Gov Con	0.034	0.578	0.565			
	Inv	0.161	3.579	0.001			
	Pop	-0.081	-1.436	0.156			
	TOT	-0.084	-1.778	0.081			
	EXTRA_11_5	4.902	0.466	0.643			
12%	Constant	14.085	0.851	0.398	1.917	0.381	258.864
	Log Inf	-4.933	-0.721	0.474			
	Gov Con	0.034	0.580	0.564			
	Inv	0.172	3.622	0.001			
	Pop	-0.079	-1.416	0.162			
	TOT	-0.079	-1.655	0.103			

	EXTRA_12	6.850	0.756	0.453			
12.5%	Constant	10.263	0.771	0.444	1.979	0.380	259.451
	Log Inf	-3.316	-0.610	0.544			
	Gov Con	0.033	0.566	0.573			
	Inv	0.171	3.451	0.001			
	Pop	-0.080	-1.421	0.160			
	TOT	-0.081	-1.704	0.093			
	EXTRA_12_5	5.295	0.657	0.513			
13%	Constant	5.911	0.529	0.599	1.379	0.377	260.679
	Log Inf	-1.510	-0.334	0.740			
	Gov Con	0.033	0.554	0.581			
	Inv	0.163	3.175	0.002			
	Pop	-0.082	-1.458	0.150			
	TOT	-0.085	-1.794	0.078			
	EXTRA_13	2.889	0.378	0.707			
13.5%	Constant	3.213	0.352	0.726	0.620	0.375	261.199
	Log Inf	-0.402	-0.110	0.913			
	Gov Con	0.032	0.529	0.599			
	Inv	0.155	3.047	0.003			
	Pop	-0.082	-1.457	0.150			
	TOT	-0.089	-1.911	0.061			
	EXTRA_13_5	1.022	0.145	0.885			
14%	Constant	3.144	0.403	0.688	0.814	0.375	261.163
	Log Inf	-0.372	-0.120	0.905			
	Gov Con	0.033	0.537	0.593			
	Inv	0.156	3.082	0.003			
	Pop	-0.083	-1.460	0.150			
	TOT	-0.089	-1.939	0.057			
	EXTRA_14	1.186	0.171	0.865			
14.5%	Constant	3.722	0.558	0.579	1.756	0.376	260.771
	Log Inf	-0.601	-0.230	0.819			
	Gov Con	0.036	0.585	0.561			
	Inv	0.161	3.232	0.002			
	Pop	-0.085	-1.489	0.142			
	TOT	-0.089	-1.937	0.057			
	EXTRA_14_5	2.358	0.348	0.729			
15%	Constant	3.911	0.668	0.507	3.019	0.378	260.101
	Log Inf	-0.672	-0.296	0.768			
	Gov Con	0.041	0.656	0.514			
	Inv	0.168	3.301	0.002			
	Pop	-0.088	-1.533	0.131			
	TOT	-0.088	-1.942	0.057			
	EXTRA_15	3.690	0.528	0.600			
15.5%	Constant	3.797	0.690	0.493	3.990	0.379	259.734
	Log Inf	-0.622	-0.293	0.770			
	Gov Con	0.041	0.670	0.505			

	Inv	0.169	3.412	0.001			
	Pop	-0.089	-1.553	0.126			
	TOT	-0.088	-1.947	0.056			
	EXTRA_15_5	4.612	0.604	0.548			
16%	Constant	3.547	0.682	0.498	4.934	0.380	259.403
	Log Inf	-0.517	-0.259	0.796			
	Gov Con	0.040	0.663	0.510			
	Inv	0.169	3.564	0.001			
	Pop	-0.090	-1.564	0.123			
	TOT	-0.088	-1.937	0.057			
	EXTRA_16	5.451	0.666	0.508			
16.5%	Constant	3.267	0.652	0.517	6.072	0.380	259.238
	Log Inf	-0.404	-0.211	0.834			
	Gov Con	0.040	0.666	0.508			
	Inv	0.168	3.647	0.001			
	Pop	-0.089	-1.565	0.123			
	TOT	-0.087	-1.921	0.060			
	EXTRA_16_5	6.476	0.695	0.490			
17%	Constant	2.662	0.541	0.590	4.538	0.377	260.530
	Log Inf	-0.167	-0.089	0.930			
	Gov Con	0.036	0.592	0.556			
	Inv	0.160	3.569	0.001			
	Pop	-0.086	-1.505	0.138			
	TOT	-0.089	-1.940	0.057			
	EXTRA_17	4.705	0.422	0.675			
17.5%	Constant	2.686	0.554	0.582	7.336	0.378	260.035
	Log Inf	-0.175	-0.095	0.925			
	Gov Con	0.037	0.614	0.542			
	Inv	0.161	3.745	0.000			
	Pop	-0.086	-1.521	0.134			
	TOT	-0.089	-1.947	0.056			
	EXTRA_17_5	7.511	0.542	0.590			
18%	Constant	2.613	0.540	0.591	9.838	0.378	260.255
	Log Inf	-0.146	-0.079	0.937			
	Gov Con	0.035	0.587	0.560			
	Inv	0.160	3.733	0.000			
	Pop	-0.086	-1.512	0.136			
	TOT	-0.088	-1.939	0.057			
	EXTRA_18	9.984	0.492	0.624			
18.5%	Constant	2.340	0.484	0.630	9.059	0.376	261.020
	Log Inf	-0.040	-0.022	0.983			
	Gov Con	0.031	0.526	0.601			
	Inv	0.155	3.656	0.001			
	Pop	-0.083	-1.471	0.146			
	TOT	-0.089	-1.936	0.057			
	EXTRA_18_5	9.099	0.251	0.803			

19%	Constant	1.871	0.391	0.697	-26.390	0.376	260.909
	Log Inf	0.135	0.074	0.941			
	Gov Con	0.033	0.554	0.582			
	Inv	0.146	3.659	0.001			
	Pop	-0.080	-1.415	0.162			
	TOT	-0.094	-2.012	0.049			
	EXTRA_19	-26.525	-0.298	0.767			

2000Q1-2010Q1							
Threshold Value	Variable	Coefficient	T statistic	Probability	Log Inf + Extra	R-squared	RSS
N/A	Constant	8.338	4.459	0.000		0.346	117.321
	Log Inf	-2.066	-2.147	0.039			
	Gov Con	-0.137	-1.634	0.111			
	Inv	-0.057	-0.739	0.465			
	Pop	-0.465	-0.831	0.412			
	TOT	0.025	0.256	0.799			
2%	Constant	-51.398	-1.127	0.268	-2.545	0.377	111.675
	Log Inf	85.012	1.280	0.209			
	Gov Con	-0.134	-1.616	0.115			
	Inv	-0.076	-0.972	0.338			
	Pop	-0.365	-0.653	0.518			
	TOT	0.005	0.046	0.963			
	Extra 2	-87.557	-1.311	0.199			
2.5%	Constant	-1.289	-0.170	0.866	-2.545	0.377	111.675
	Log Inf	9.003	1.060	0.297			
	Gov Con	-0.134	-1.616	0.115			
	Inv	-0.076	-0.972	0.338			
	Pop	-0.365	-0.653	0.518			
	TOT	0.005	0.046	0.963			
	Extra 2.5	-11.548	-1.311	0.199			
3%	Constant	1.215	0.227	0.822	-2.675	0.382	110.797
	Log Inf	4.912	0.978	0.335			
	Gov Con	-0.131	-1.581	0.123			
	Inv	-0.076	-0.976	0.336			
	Pop	-0.355	-0.638	0.528			
	TOT	-0.005	-0.053	0.958			
	Extra 3	-7.586	-1.415	0.166			
3.5%	Constant	1.355	0.297	0.768	-2.988	0.396	108.410
	Log Inf	4.062	1.074	0.291			
	Gov Con	-0.124	-1.516	0.139			
	Inv	-0.080	-1.042	0.305			
	Pop	-0.321	-0.580	0.566			
	TOT	-0.029	-0.291	0.773			

	Extra 3.5	-7.050	-1.672	0.104			
4%	Constant	1.060	0.258	0.798	-3.307	0.413	105.312
	Log Inf	3.761	1.213	0.234			
	Gov Con	-0.121	-1.502	0.142			
	Inv	-0.095	-1.228	0.228			
	Pop	-0.259	-0.473	0.639			
	TOT	-0.053	-0.519	0.607			
	Extra 4	-7.068	-1.969	0.057			
4.5%	Constant	1.007	0.265	0.793	-3.601	0.426	102.921
	Log Inf	3.348	1.266	0.214			
	Gov Con	-0.120	-1.495	0.144			
	Inv	-0.109	-1.401	0.170			
	Pop	-0.184	-0.336	0.739			
	TOT	-0.069	-0.674	0.505			
	Extra 4.5	-6.949	-2.181	0.036			
5%	Constant	0.431	0.122	0.903	-4.216	0.453	98.143
	Log Inf	3.402	1.478	0.149			
	Gov Con	-0.112	-1.424	0.164			
	Inv	-0.121	-1.590	0.121			
	Pop	-0.072	-0.132	0.896			
	TOT	-0.094	-0.919	0.364			
	Extra 5	-7.618	-2.578	0.015			
5.5%	Constant	-0.017	-0.005	0.996	-5.206	0.483	92.787
	Log Inf	3.475	1.702	0.098			
	Gov Con	-0.096	-1.250	0.220			
	Inv	-0.124	-1.683	0.102			
	Pop	-0.021	-0.040	0.968			
	TOT	-0.131	-1.275	0.211			
	Extra 5.5	-8.681	-2.998	0.005			
6%	Constant	-0.008	-0.003	0.998	-6.335	0.511	87.680
	Log Inf	3.314	1.844	0.074			
	Gov Con	-0.079	-1.041	0.305			
	Inv	-0.122	-1.718	0.095			
	Pop	-0.048	-0.096	0.924			
	TOT	-0.163	-1.591	0.121			
	Extra 6	-9.649	-3.390	0.002			
6.5%	Constant	0.597	0.222	0.826	-7.414	0.526	84.983
	Log Inf	2.759	1.749	0.089			
	Gov Con	-0.059	-0.785	0.438			
	Inv	-0.114	-1.653	0.108			
	Pop	-0.054	-0.108	0.915			
	TOT	-0.177	-1.743	0.090			
	Extra 6.5	-10.173	-3.597	0.001			
7%	Constant	1.679	0.684	0.499	-8.382	0.526	84.946
	Log Inf	1.919	1.386	0.175			
	Gov Con	-0.065	-0.867	0.392			

	Inv	-0.104	-1.522	0.137			
	Pop	-0.023	-0.045	0.964			
	TOT	-0.157	-1.591	0.121			
	Extra 7	-10.301	-3.600	0.001			
7.5%	Constant	3.017	1.332	0.192	-9.194	0.512	87.510
	Log Inf	1.052	0.845	0.404			
	Gov Con	-0.075	-0.994	0.327			
	Inv	-0.090	-1.309	0.199			
	Pop	-0.107	-0.214	0.832			
	TOT	-0.125	-1.297	0.203			
	Extra 7.5	-10.246	-3.403	0.002			
8%	Constant	3.490	1.653	0.108	-11.277	0.524	85.315
	Log Inf	0.730	0.639	0.527			
	Gov Con	-0.081	-1.092	0.282			
	Inv	-0.084	-1.242	0.223			
	Pop	-0.131	-0.267	0.791			
	TOT	-0.115	-1.231	0.227			
	Extra 8	-12.008	-3.571	0.001			
8.5%	Constant	3.774	2.003	0.053	-15.133	0.569	77.270
	Log Inf	0.513	0.512	0.612			
	Gov Con	-0.080	-1.135	0.264			
	Inv	-0.072	-1.121	0.270			
	Pop	-0.137	-0.293	0.772			
	TOT	-0.116	-1.323	0.195			
	Extra 8.5	-15.646	-4.198	0.000			
9%	Constant	4.424	2.656	0.012	-19.762	0.614	69.283
	Log Inf	0.157	0.178	0.860			
	Gov Con	-0.088	-1.336	0.190			
	Inv	-0.068	-1.115	0.273			
	Pop	-0.243	-0.554	0.583			
	TOT	-0.098	-1.215	0.233			
	Extra 9	-19.918	-4.855	0.000			
9.5%	Constant	5.627	3.626	0.001	-24.033	0.618	68.597
	Log Inf	-0.449	-0.551	0.585			
	Gov Con	-0.094	-1.440	0.159			
	Inv	-0.059	-0.979	0.334			
	Pop	-0.458	-1.055	0.299			
	TOT	-0.064	-0.815	0.421			
	Extra 9.5	-23.584	-4.914	0.000			
10%	Constant	6.448	4.023	0.000	-27.910	0.570	77.183
	Log Inf	-0.858	-1.019	0.316			
	Gov Con	-0.093	-1.342	0.189			
	Inv	-0.063	-0.983	0.332			
	Pop	-0.571	-1.239	0.224			
	TOT	-0.034	-0.417	0.679			
	Extra 10	-27.052	-4.205	0.000			

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10.5%	Constant	7.172	4.154	0.000	-28.900	0.485	92.338
	Log Inf	-1.291	-1.430	0.162			
	Gov Con	-0.097	-1.263	0.215			
	Inv	-0.061	-0.869	0.391			
	Pop	-0.581	-1.150	0.258			
	TOT	-0.021	-0.238	0.814			
	Extra 10.5	-27.609	-3.033	0.005			
11%	Constant	7.397	4.200	0.000	-33.936	0.459	97.072
	Log Inf	-1.419	-1.542	0.132			
	Gov Con	-0.097	-1.235	0.225			
	Inv	-0.063	-0.870	0.390			
	Pop	-0.583	-1.124	0.269			
	TOT	-0.013	-0.139	0.890			
	Extra 11	-32.516	-2.663	0.012			
11.5%	Constant	7.397	4.200	0.000	-47.768	0.459	97.072
	Log Inf	-1.419	-1.542	0.132			
	Gov Con	-0.097	-1.235	0.225			
	Inv	-0.063	-0.870	0.390			
	Pop	-0.583	-1.124	0.269			
	TOT	-0.013	-0.139	0.890			
	Extra 11.5	-46.349	-2.663	0.012			
12%	Constant	7.397	4.200	0.000	-79.620	0.459	97.072
	Log Inf	-1.419	-1.542	0.132			
	Gov Con	-0.097	-1.235	0.225			
	Inv	-0.063	-0.870	0.390			
	Pop	-0.583	-1.124	0.269			
	TOT	-0.013	-0.139	0.890			
	Extra 12	-78.201	-2.663	0.012			
12.5%	Constant	7.397	4.200	0.000	-230.850	0.459	97.072
	Log Inf	-1.419	-1.542	0.132			
	Gov Con	-0.097	-1.235	0.225			
	Inv	-0.063	-0.870	0.390			
	Pop	-0.583	-1.124	0.269			
	TOT	-0.013	-0.139	0.890			
	Extra 12.5	-229.431	-2.663	0.012			

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**Table A7: Trivariate threshold model**

1983Q1–2010Q1							
Threshold Value	Variable	Coefficient	T statistic	Probability	Log Inf + Extra	R-squared	RSS
N/A	Log Inf	-3.083	-6.462	0.000		0.281	509.309
2%	Log Inf	79.447	1.142	0.256	-3.315	0.290	502.638
	Extra 2	-82.762	-1.186	0.238			
2.5%	Log Inf	7.600	0.843	0.401	-3.315	0.290	502.638
	Extra 2.5	-10.915	-1.186	0.238			
3%	Log Inf	3.556	0.679	0.499	-3.360	0.292	501.635
	Extra 3	-6.916	-1.273	0.206			
3.5%	Log Inf	2.098	0.564	0.574	-3.447	0.294	500.001
	Extra 3.5	-5.545	-1.405	0.163			
4%	Log Inf	1.063	0.371	0.711	-3.507	0.295	499.156
	Extra 4	-4.570	-1.468	0.145			
4.5%	Log Inf	0.381	0.163	0.871	-3.556	0.296	498.530
	Extra 4.5	-3.937	-1.514	0.133			
5%	Log Inf	0.165	0.083	0.934	-3.663	0.299	496.096
	Extra 5	-3.828	-1.680	0.096			
5.5%	Log Inf	-0.059	-0.034	0.973	-3.790	0.302	494.162
	Extra 5.5	-3.731	-1.803	0.074			
6%	Log Inf	-0.325	-0.211	0.834	-3.904	0.304	492.971
	Extra 6	-3.579	-1.874	0.064			
6.5%	Log Inf	-0.571	-0.413	0.681	-4.012	0.305	491.978
	Extra 6.5	-3.441	-1.932	0.056			
7%	Log Inf	-0.817	-0.649	0.518	-4.118	0.305	491.803
	Extra 7	-3.301	-1.942	0.055			
7.5%	Log Inf	-1.096	-0.945	0.347	-4.196	0.304	492.952
	Extra 7.5	-3.100	-1.875	0.064			
8%	Log Inf	-1.293	-1.194	0.235	-4.313	0.303	493.618
	Extra 8	-3.020	-1.836	0.069			
8.5%	Log Inf	-1.423	-1.409	0.162	-4.467	0.303	493.223
	Extra 8.5	-3.044	-1.859	0.066			
9%	Log Inf	-1.593	-1.692	0.094	-4.575	0.303	493.702
	Extra 9	-2.983	-1.831	0.070			
9.5%	Log Inf	-1.782	-2.021	0.046	-4.642	0.301	495.026
	Extra 9.5	-2.860	-1.749	0.083			
10%	Log Inf	-1.961	-2.346	0.021	-4.694	0.298	496.889
	Extra 10	-2.732	-1.628	0.107			
10.5%	Log Inf	-2.106	-2.642	0.010	-4.767	0.296	498.377
	Extra 10.5	-2.661	-1.525	0.130			
11%	Log Inf	-2.146	-2.811	0.006	-5.023	0.297	497.796
	Extra 11	-2.877	-1.566	0.120			
11.5%	Log Inf	-2.169	-2.975	0.004	-5.366	0.299	496.587
	Extra	-3.197	-1.648	0.102			

11.5							
12%	Log Inf	-2.210	-3.169	0.002	-5.728	0.300	495.746
	Extra 12	-3.518	-1.703	0.092			
12.5%	Log Inf	-2.219	-3.344	0.001	-6.287	0.303	493.364
	Extra 12.5	-4.068	-1.851	0.067			
13%	Log Inf	-2.207	-3.468	0.001	-7.086	0.308	489.975
	Extra 13	-4.880	-2.045	0.043			
13.5%	Log Inf	-2.194	-3.602	0.001	-8.149	0.314	485.532
	Extra 13.5	-5.954	-2.278	0.025			
14%	Log Inf	-2.225	-3.789	0.000	-9.263	0.318	482.915
	Extra 14	-7.037	-2.407	0.018			
14.5%	Log Inf	-2.313	-4.099	0.000	-10.297	0.319	482.462
	Extra 14.5	-7.984	-2.429	0.017			
15%	Log Inf	-2.404	-4.446	0.000	-11.613	0.320	481.420
	Extra 15	-9.209	-2.478	0.015			
15.5%	Log Inf	-2.476	-4.676	0.000	-13.175	0.319	482.487
	Extra 15.5	-10.699	-2.427	0.017			
16%	Log Inf	-2.587	-4.995	0.000	-14.497	0.313	486.253
	Extra 16	-11.909	-2.242	0.027			
16.5%	Log Inf	-2.684	-5.274	0.000	-16.163	0.308	489.855
	Extra 16.5	-13.479	-2.052	0.043			
17%	Log Inf	-2.729	-5.449	0.000	-19.977	0.308	489.861
	Extra 17	-17.248	-2.051	0.043			
17.5%	Log Inf	-2.822	-5.680	0.000	-22.167	0.300	495.648
	Extra 17.5	-19.345	-1.709	0.090			
18%	Log Inf	-2.829	-5.709	0.000	-31.640	0.300	495.531
	Extra 18	-28.811	-1.717	0.089			
18.5%	Log Inf	-2.839	-5.771	0.000	-57.521	0.302	494.570
	Extra 18.5	-54.682	-1.777	0.078			
19%	Log Inf	-2.949	-6.122	0.000	-131.093	0.297	497.906
	Extra 19	-128.144	-1.558	0.122			

## 1983Q1–1999Q4

Threshold Value	Variable	Coefficient	T statistic	Probability	Log Inf + Extra	R-squared	RSS
N/A	Log Inf	-5.024	-3.103	0.003		0.127	364.927
9.5%	Log Inf	45.252	0.257	0.798	-5.166	0.128	364.470
	Extra 9.5	-50.419	-0.286	0.776			
10%	Log Inf	5.726	0.152	0.880	-5.166	0.128	364.470
	Extra 10	-10.892	-0.286	0.776			
10.5%	Log Inf	4.661	0.241	0.810	-5.420	0.131	363.515

	Extra 10.5	-10.081	-0.503	0.617			
11%	Log Inf	5.768	0.462	0.646	-5.978	0.137	360.708
	Extra 11	-11.746	-0.872	0.386			
11.5%	Log Inf	4.265	0.495	0.622	-6.429	0.143	358.293
	Extra 11.5	-10.695	-1.097	0.277			
12%	Log Inf	2.643	0.403	0.689	-6.887	0.146	356.950
	Extra 12	-9.530	-1.205	0.233			
12.5%	Log Inf	2.609	0.505	0.615	-7.762	0.159	351.833
	Extra 12.5	-10.371	-1.555	0.125			
13%	Log Inf	2.578	0.596	0.553	-9.006	0.173	345.910
	Extra 13	-11.584	-1.890	0.063			
13.5%	Log Inf	1.992	0.544	0.588	-10.234	0.184	341.224
	Extra 13.5	-12.227	-2.125	0.037			
14%	Log Inf	1.036	0.322	0.748	-11.347	0.186	340.394
	Extra 14	-12.383	-2.164	0.034			
14.5%	Log Inf	-0.311	-0.111	0.912	-11.886	0.179	343.230
	Extra 14.5	-11.575	-2.027	0.047			
15%	Log Inf	-1.259	-0.508	0.613	-12.701	0.177	344.193
	Extra 15	-11.442	-1.979	0.052			
15.5%	Log Inf	-1.848	-0.795	0.430	-14.003	0.172	346.265
	Extra 15.5	-12.155	-1.872	0.066			
16%	Log Inf	-2.650	-1.223	0.226	-14.603	0.161	350.673
	Extra 16	-11.953	-1.625	0.109			
16.5%	Log Inf	-3.237	-1.585	0.118	-15.487	0.154	353.976
	Extra 16.5	-12.250	-1.418	0.161			
17%	Log Inf	-3.441	-1.767	0.082	-18.739	0.154	353.663
	Extra 17	-15.298	-1.439	0.155			
17.5%	Log Inf	-3.954	-2.103	0.039	-19.378	0.144	358.093
	Extra 17.5	-15.424	-1.114	0.270			
18%	Log Inf	-3.973	-2.132	0.037	-27.031	0.144	357.889
	Extra 18	-23.058	-1.131	0.262			
18.5%	Log Inf	-3.988	-2.186	0.032	-48.703	0.147	356.809
	Extra 18.5	-44.715	-1.216	0.228			
19%	Log Inf	-4.441	-2.621	0.011	-109.765	0.144	357.778
	Extra 19	-105.324	-1.140	0.259			

## 2000Q1-2010Q1

Threshold Value	Variable	Coefficient	T statistic	Probability	Log Inf + Extra	R- squared	RSS
N/A	Log Inf	-2.727	-3.561	0.001		0.245	135.379

2%	Log Inf	75.258	1.156	0.255	-3.307	0.273	130.450
	Extra 2	-78.565	-1.198	0.238			
2.5%	Log Inf	7.054	0.860	0.395	-3.307	0.273	130.450
	Extra 2.5	-10.362	-1.198	0.238			
3%	Log Inf	3.369	0.713	0.480	-3.438	0.278	129.553
	Extra 3	-6.808	-1.307	0.199			
3.5%	Log Inf	2.179	0.645	0.523	-3.717	0.287	127.909
	Extra 3.5	-5.896	-1.490	0.145			
4%	Log Inf	1.231	0.475	0.638	-3.937	0.293	126.888
	Extra 4	-5.168	-1.595	0.119			
4.5%	Log Inf	0.556	0.265	0.792	-4.125	0.297	126.041
	Extra 4.5	-4.681	-1.678	0.102			
5%	Log Inf	0.449	0.254	0.801	-4.583	0.316	122.686
	Extra 5	-5.032	-1.983	0.055			
5.5%	Log Inf	0.362	0.235	0.815	-5.225	0.336	119.094
	Extra 5.5	-5.587	-2.279	0.028			
6%	Log Inf	0.178	0.132	0.896	-5.940	0.354	115.807
	Extra 6	-6.119	-2.534	0.016			
6.5%	Log Inf	-0.047	-0.040	0.969	-6.755	0.374	112.241
	Extra 6.5	-6.708	-2.799	0.008			
7%	Log Inf	-0.281	-0.262	0.794	-7.771	0.391	109.243
	Extra 7	-7.490	-3.015	0.005			
7.5%	Log Inf	-0.589	-0.597	0.554	-8.848	0.394	108.665
	Extra 7.5	-8.259	-3.056	0.004			
8%	Log Inf	-0.702	-0.759	0.452	-10.857	0.411	105.643
	Extra 8	-10.156	-3.270	0.002			
8.5%	Log Inf	-0.697	-0.835	0.409	-14.638	0.463	96.351
	Extra 8.5	-13.941	-3.923	0.000			
9%	Log Inf	-0.910	-1.221	0.230	-19.415	0.508	88.315
	Extra 9	-18.505	-4.500	0.000			
9.5%	Log Inf	-1.360	-1.968	0.056	-24.087	0.514	87.244
	Extra 9.5	-22.727	-4.579	0.000			
10%	Log Inf	-1.752	-2.513	0.016	-28.039	0.467	95.656
	Extra 10	-26.287	-3.972	0.000			
10.5%	Log Inf	-2.127	-2.918	0.006	-29.134	0.386	110.147
	Extra 10.5	-27.007	-2.950	0.005			
11%	Log Inf	-2.245	-3.046	0.004	-34.272	0.361	114.557
	Extra 11	-32.027	-2.628	0.012			
11.5%	Log Inf	-2.245	-3.046	0.004	-47.896	0.361	114.557
	Extra 11.5	-45.652	-2.628	0.012			
12%	Log Inf	-2.245	-3.046	0.004	-79.269	0.361	114.557
	Extra 12	-77.024	-2.628	0.012			
12.5%	Log Inf	-2.245	-3.046	0.004	-228.223	0.361	114.557
	Extra 12.5	-225.978	-2.628	0.012			

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