THE TERM STRUCTURE OF INTEREST RATES AND ECONOMIC ACTIVITY IN SOUTH AFRICA

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ABSTRACT

Many research papers have documented the positive relationship between the slope of the yield curve and future real economic activity in different countries and different time periods. One explanation of this link is based on monetary policy. The forecasting ability of the term spread on economic growth is based on the fact that interest rates reflect the expectations of investors about the future economic situation when deciding about their plans for consumption and investment.

This thesis examined the predictive ability of the term structure of interest rates on economic activity, and the effects of different monetary policy regimes on the predictive ability of the term spread. The South African experience offers a unique opportunity to examine this issue, as the country has experienced numerous monetary policy frameworks since the 1970s. The study employed the Generalised Method Moments technique, since it is considered to be more efficient than Ordinary Least Squares.

Results presented in this thesis established that the term structure successfully predicted real economic activity during the entire research period with the exception of the last sub-period (2000-2004) when using the multivariate model. In the periods of financial market liberalisation and interest rates deregulation the term structure was found to be a better predictor of economic activity in South Africa. These findings emphasise the importance of considering the prevailing economic environment in testing the term structure theory.

Keywords: Term structure; GMM; Monetary policy frameworks; South Africa

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CHAPTER ONE

INTRODUCTION

1.1 CONTEXT OF THE STUDY

Monetary policy plays an important part in attaining the macroeconomic policy objectives of relative domestic price stability, balance of payments equilibrium, high and stable employment and optimal long-run economic growth. In order to achieve these policy objectives many central banks influence certain variables, such as the monetary aggregates or total bank credit, as intermediate targets in their policy actions. Controlling inflation by setting monetary policy to target nominal variables has long been an aim of policy-makers. For such a strategy to succeed there must exist a variable that has some predictive value on inflation and economic activity. The history of targeting monetary aggregates has been one of limited success, at least in South Africa, in that the relationship between the monetary aggregates and nominal variables appears to have broken down in the 1990s. Prior to South Africa's adoption of an inflation targeting regime, there was a persistent excessive growth in the money supply, while at the same time there was a definite downward trend in inflation (Dos Santos and Schaling, 2000:3). It became apparent that the change in the money supply had become a less reliable indicator of underlying inflation and therefore, a less reliable anchor for monetary policy, a more reliable anchor for monetary policy was therefore required.

It is against this background that this thesis will study the predictive ability of the term structure of interest rates with respect to economic activity in South Africa. The term structure has received considerable attention in the United States and most developed economies like Canada (Estrella and Hardouvelis, 1991; and Harvey, 1997).

Economists believe that the term structure is driven by the expectations of participants in financial markets. As such, the term structure inherently contains information useful for discovering forecasts of market participants (Harvey, 1988; Estrella and Hardouvelis, 1991). The economic insight underlying the relation between the term structure of interest rates and economic activity is straightforward, as illustrated in Kim and Limpaphayom (1997:380).

If market participants expect rates to fall during economic contractions, they will wish to lock into current higher rates or increase capital gain prospects via longer term assets. Hence, economic expectations influence investor behaviour which, in turn, affects the term structure of interest rates. The latter therefore should contain information which can be used to forecast expected short-run fluctuations of future economic activity.

Although the literature on term structure is extensive, very few studies have been done in developing countries. For instance, with respect to South Africa, up to now there have been only two known studies done on the topic, namely, Nel (1996) and Moolman (2002). In Nel (1996) the period under investigation was the twenty years from 1974:1-1993:4. This was sub-divided into two periods of 1974:1-1983:4 and 1984:1-1993:1. The study used Johansen cointegration tests, and the year-to-year growth in the real GDP was taken to represent the fluctuations in economic activity. The study by Moolman (2002) was based on data from 1979:1 to 2001:3, and used the probit model to detect the turning points in the economic activity (or business cycle).

As noted by Strydom (2000:1), in the 1990s South Africa emerged from the era of trade and economic isolation into a world that was rapidly integrating in terms of trade, technological innovation and globally-driven production processes, amongst others. Within this environment the country was taking its place as an emerging market.

As such, its economic policies had to deal with economic disruptions that were closely related to developments in the outside world, but with financial institutions and markets that were relatively more sophisticated and better developed than such institutions in many other developing countries (other sub-Saharan countries). The Nel (1996) study did not cover these policy changes; hence there is a need for a new study that will capture them.

Further, the results of this study may complement the findings of the more recent study by Moolman (2002), by supporting the evidence that the yield curve may be used as an economic forecasting tool in South Africa.

The South African experience provides an excellent opportunity to assess the influence policy changes may have on the predictive ability of the term structure. South Africa has experienced a dramatic shift in economic policy framework. According to Strydom (2000), during the 1970s and the early 1980s, monetary policy in South Africa consisted mainly of direct controls. Monetary policy was conducted mainly through interest rate controls, liquid asset requirements, and cash reserve requirements. These measures were aimed at controlling the growth in monetary aggregates with a view to curbing inflation. However, the stringent controls of the said period gave little room for financial market development. Hence, it was undesirable to continue this monetary policy regime of direct controls.

Economic reform received its first major impulse in 1977 with the appointment of the De Kock Commission with a mandate to evaluate monetary policy. It was through the recommendations of the De Kock Commission (1985) that South Africa moved from the monetary policy stance of direct controls to more liberal policies. The Commission’s final report, which was released in 1985, placed a great emphasis on the need for a market-oriented monetary policy and more effective instruments to achieve the goals of economic policy (Strydom, 2000:1).

Therefore, there was a change from non-market related controls towards market oriented policies. Another change as mentioned above is that in the 1990s South Africa emerged from the era of trade and economic isolation into a world that was rapidly integrating in terms of trade, technological innovation and globally-driven production processes. As such, there was a major transformation from a siege economy during apartheid to an economic framework which had to support a multi-party democracy after the first democratic elections in 1994 (Strydom, 2000:1).

It is believed that the different economic environments could affect the performance of the term structure as an economic growth predictor.

1.2 GOALS OF THE STUDY

The goal of this research is to establish whether the term structure has a predictive ability in determining economic activity in South Africa. To this end, two sub-objectives are pursued:

- Firstly, to empirically examine the relation between the term structure of interest rates and economic growth using the South African experience.
- Secondly, to investigate the effects of different monetary policy regimes on the ability of the term structure to predict economic activity.

1.3 METHODOLOGY

This research complements and extends the study of Nel (1996), by analysing the predictive ability of the term structure with regard to economic activity in South Africa. However, the study will depart from it by using the generalised method of moments (GMM), a method that is claimed to be highly efficient (Kim and Limpaphayom, 1997:384).The first step will be to conduct a literature review. The goals of the review will be to lay the groundwork with respect to:

- Theoretical and background information about the term structure of interest rates and economic activity.

- Potential problems that may arise in the calculation of the yield curve.
- How the yield curve can be used to determine the economy's future direction.

The period under investigation in this study is the past 34 years: from 1970:1 to 2004:4. The data used in this study are the 91-day Treasury bill rate, the long-term government bond, real Gross Domestic Product (GDP) growth obtained from the South African Reserve Bank (SARB), M3 (Broad Money Supply), and the All Share Index obtained from the Quoin Institute.

1.4 STRUCTURE OF THE RESEARCH

This research consists of six chapters. **Chapter one** is this brief introduction to the topic and it identifies the goals of the research and the research methodology, and then outlines the structure of the remaining chapters.

Chapter two deals with the theory of the term structure of interest rates, and a review of the previous literature. The aim of this chapter is to provide an exposition of the theory underpinning the term structure of interest rates, and the previous empirical findings on the term structure and its predictive ability of economic activity. This is important since such a review provides the background information about the term structure of interest rates and economic activity, the potential problems that may arise in the calculation of the yield curve, and how the yield curve can be used to determine the economy's future direction. This is to establish the reasons behind the choice of a specific model.

In **chapter three** the evolution of South African monetary policy is dealt with. Since one of the objectives of this research is to specify and test the relationship between the term structure of interest rates and growth in real economic activity in South Africa, it is essential that the phases of the monetary policy in South Africa are analysed.

Chapter four deals with the analytical framework. It gives an overview of the generalised method of moments, and the reasons why this study employs it and not other estimators such as ordinary least squares (OLS).

In chapter five the results of this research are presented and discussed.

Chapter six concludes the research.

CHAPTER TWO

THE THEORY AND EMPIRICAL FINDINGS ON THE TERM STRUCTURE OF INTEREST RATES

2.1 INTRODUCTION

The aim of this chapter is to provide an exposition of the theory underpinning the term structure of interest rates. This chapter also addresses the empirical findings of the previous literature on the term structure with regard to its predictive ability of economic activity, and the effects of monetary policy regimes on such predictive ability. This is important since such a review provides the background information about the topic, potential problems that may arise in the calculation of the yield curve, and how the yield curve can be used to determine the economy’s future direction.

2.2 THEORY OF THE TERM STRUCTURE OF INTEREST RATES

2.2.1 Introduction

The term structure of interest rates refers to the relationship between the yields of bonds with different terms to maturity. When interest rates of such bonds are plotted against their terms, it represents the yield curve.

The yield curve is also defined as the plot of yields on bonds with different terms to maturity with the same risk profile, liquidity and tax considerations and it describes the term structure of interest rates for particular types of bonds, such as long-term government bonds of 10 years and over (Mishkin, 2001:137).

Economists and investors believe that the shape of the yield curve reflects the market’s future expectation for interest rates and conditions for monetary policy. The yield curve can be classified as upward sloping, flat or downward sloping (Mishkin, 2001:137).

When the yield curve is upward-sloping, the short-term interest rates, such as 91-day Treasury bill rate, are below the long-term rates, such as long-term government bond 10 years and over. When yield curves are flat, the short-term interest rates and long-term interest rates are the same. When the yield curves are downward-sloping, the long-term rates are below the short-term rates. Mishkin (2001:137) states that, besides explaining different shapes of the yield curves, a good theory of the term structure of interest rates must explain the following three important empirical observations about it:

- Interest rates on bonds of different maturities move together over time.
- When short-term interest rates are low, yield curves are more likely to have an upward slope; when short-term interest rates are high, yield curves are likely to slope forward and be inverted.
- Yield curves usually slope upward.

Economists have developed theories to explain the empirical observations about the shape of the yield curve; the three main theories being the expectations hypothesis, the segmented market theory and the liquidity premium theory (Mishkin, 1999:138). The fourth theory, the preferred habitat theory, is closely linked to the liquidity premium theory. The expectations hypothesis explains the first two facts about the yield curve, but not the third. The third fact is explained by the segmented market theory, and all the three facts are explained by the liquidity premium theory. These will be explained in more detail below.

2.2.1.1 Expectations hypothesis

The expectations hypothesis of the term structure states that the interest rate on a long-term bond will equal an average of the short-term interest rates that people expect to occur over the life of the long-term bond (Mishkin, 1999:138). For example, if people expect that short-term interest rates will be 10% on average over the coming five years, the prediction is that the interest rate on bonds with five years yield to maturity will also be 10%.

The key assumptions behind this hypothesis are that short-term and long-term securities can be treated as perfect substitutes, investors are risk neutral and the shape of the yield curve is determined by investors' expectations of future interest rates and future inflation (Michaelsen, 1965:445). To see how the assumption that securities with different maturities are perfect substitutes leads to the expectations hypothesis, the following two investment strategies are considered:

- Buy a one-year bond, hold it for one year, and reinvest the proceeds in another one-year bond, one year from now.
- Buy a two-year bond, hold it for two years.

According to the expectations hypothesis, both strategies should yield exactly the same result, since investors are indifferent to bonds of different maturities, and bonds are perfect substitutes. The interest rate on the two-year bond must equal the average of the two one-year interest rates. For example, assume the current interest rate on the one-year bond is 7% and an investor's expectation is that the interest rate on the one-year bond next year will be 10%. If the investor pursues the strategy of buying the two one-year bonds, the expected return over the two years will equal 8.5%, which is (7%+10%)/2. The investor will be willing to hold the two-year bond only if the expected return per year of the two-year bond is equal to or greater than 8.5%. In other words, the interest rate on the two-year bond must equal 8.5%, the average interest on the two one-year bonds.

Equation (2.1) represents the whole term structure of interest rates for bonds with longer maturity, where interest rate of i_{nt} on an *n*-period must equal:

$$i_{nt} = \frac{i_t + i^e_{t+1} + i^e_{t+2} + ... + i_{t+(n-1)}}{n} \quad \text{.. (2.1)}$$

Equation (2.1) states that the *n*-period interest equals the average of the one-period interest rates expected to occur over the *n*-period life of the bond. This is a restatement of the expectations theory in more precise terms.

The numerical example below might clarify what the expectations theory in equation (2.1)[1] is saying. If the one-year interest rate over the next five years is expected to be 5, 6, 7, 8 and 9% respectively, equation (2.1) indicates that the interest rate on the one-year bond would be 5.0%

For the two-year bond it would be:

$$\frac{5\% + 6\%}{2} = 5.5\%$$

For the three-year bond it would be:

$$\frac{5\% + 6\% + 7\%}{3} = 6.0\%$$

For the four-year bond it would be:

$$\frac{5\% + 6\% + 7\% + 8\%}{4} = 6.5\%$$

For the five-year bond it would be:

$$\frac{5\% + 6\% + 7\% + 8\% + 9\%}{5} = 7\%$$

It is evident that the rising trend in expected short-term interest rates produces an upward-sloping yield curve (positive yield curve) along which interest rates rise as maturity lengthens. It is also clear from the numerical example that when the yield curve is upward-sloping, the short-term interest rates are expected to rise in the future. In the event that long-term rates are currently above the short-term rates, the average of future short-term rates is expected to rise.

[1] The numerical example was adapted from Mishkin (2001:140)

When the yield curve slopes downward, the average of future short-term interest rates is expected to be below the current short-term rates, implying that short-term interest rates are expected to fall, on average, in the future. Only when the yield curve is flat does the expectations theory suggest that short-term interest rates are not expected to change, on average, in the future (Mishkin, 1999:141; Howells and Bain, 2002:197).

The expectations hypothesis explains why interest rates of different maturities tend to move together over time. Historically, an immediate increase in short-term interest rates tends to be higher in the future. As such, a rise in short-term interest rates will raise people's expectations of future short-term rates. In this theory long-term rates are the average of expected future short-term rates; therefore a rise in short-term rates will also raise long-term rates, causing short-term rates and long-term rates to move together over time. The expectations theory also explains why, when interest rates are low, yield curves are usually upward sloping, and when interest rates are high, yield curves are usually downward sloping. When short-term interest rates are low, economists and market participants generally expect them to rise to some normal level in the future, and the average of future expected short-term rates will be above current short-term rates, as such the yield curve would have a positive slope. On the other hand, if the short-term interest rates are high, the expectation will be that they will come down. Therefore long-term rates would drop below short-term rates because the average of expected future short-term rates would be below current short-term rates and the yield curve would slope downward and become inverted. The expectations hypothesis explains another important fact about the relationship between the short-term and long-term interest rates: interest rates are mean-reverting, that is, they tend to return to their normal levels if they are unusually high or low, and hover around that normal level.

This implies that short-term interest rates will have more volatility than long-term rates: short-term rates represent an average of future short-term rates, hence this is the case (Mishkin, 1999:141). The shortcoming of the expectations hypothesis is that it fails to explain why the yield curve usually slopes upward: this is explained by the segmented market theory below.

2.2.1.2 The segmented market theory

This theory of the term structure assumes that credit markets are segmented, separated and distinct. Therefore the interest rate on each bond with a different maturity is determined by the supply of and demand for that bond, with no effects from expected returns on other bonds with other maturities (Mishkin, 1999:142). This theory holds that investors have specific investment preferences that are ultimately dictated by the nature of their liabilities (Howells and Bain, 1998:190)

A key assumption of the segmented market theory is that bonds of different maturities are not substitutes. Some lenders or borrowers prefer short-term bonds, while others prefer long-term ones. Investors and borrowers are concerned with specific maturities only. Interest rates are determined independently in separate markets with different maturities, without affecting other segments of the credit market. Investors or bond issuers only care about one segment of the bond market.

This theory explains why yield curves are usually upward-sloping, and states that investors are risk-averse, so they prefer the safety of short-term bonds. Long-term bonds will have higher yields as a result of their lower demand since investors prefer short-term bonds. It does not, not however, explain why interest rates tend to move together over time, and it also does not offer any insights into why yield curves slope upward when interest rates are very low and slope downward when interest rates are very high.

2.2.1.3 The liquidity premium theory

Since each of the above two theories explain empirical facts that the other cannot, a logical step is to combine them, which leads to the liquidity premium theory. This theory of the term structure states that the interest rate on a long-term bond will equal an average of short-term interest rates expected to occur over the life of the long-term bond, plus a premium that responds to supply and demand conditions for that bond (Mishkin, 1999:143). The liquidity premium theory modifies the expectations hypothesis by assuming that investors are risk-averse; therefore they will demand a premium for long-term bonds because of interest rate risk. It is assumed that investors require a liquidity premium to induce them to lock up their funds for longer-term maturity (Howells and Bain, 2002:324). That is, investors must be paid an extra return in the form of an interest rate premium to encourage them to invest in long-term securities and compensate them for the increased risk (Van Zyl, Botha and Skeritt, 2003:43)

The liquidity premium theory's main assumption is that bonds of different maturities are substitutes, but not perfect substitutes, which means that the expected return on one bond does influence the expected return on a bond of a different maturity. Liquidity premium theory also allows investors to prefer one bond maturity over another. Investors tend to prefer shorter-term bonds because these bonds bear less interest-rate risk. As such, if the investors were to hold bonds of longer maturities they must be offered a liquidity premium to induce them to do so. This will have the effect of modifying the expectations theory; hence to equation (2.1) above, a positive liquidity premium is added.

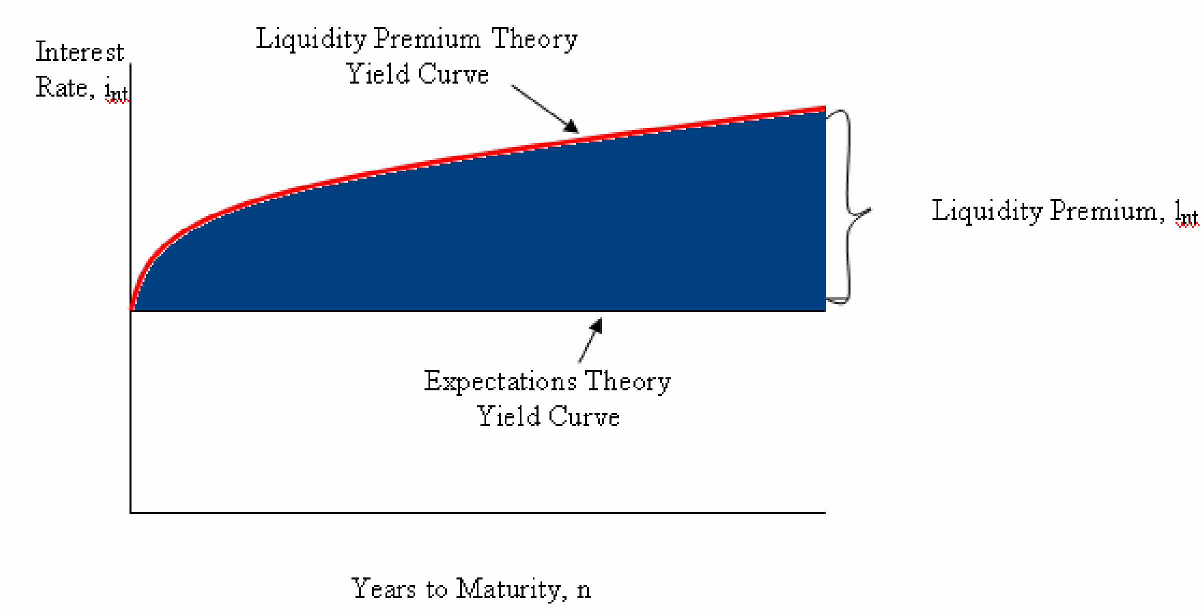
The liquidity premium theory is thus written as:

$$i_{nt} = \frac{i_t + i^e_{t+1} + i^e_{t+2} + \ldots + i^e_{t+(n-1)}}{n} + l_{nt} \quad \text{...... (2.2)}$$

where l_{nt} is the liquidity premium term for the *n*-period bond at time *t*, which is always positive and rises with the term to maturity of the bond, *n*.

Figure 2.1[2] below shows the relationship between the expectations hypothesis and liquidity premium theory. It is evident from the figure that because the liquidity premium is always positive and grows as the term to maturity increases, the yield curve implied by the liquidity premium theory is always above the yield curve implied by the expectations theory and has a steeper slope. The yield curve implied by the expectations theory is drawn under the scenario of unchanging future one-year interest rates.

Figure 2.1: The relationship between Liquidity Premium and Expectations Theories



Source: Mishkin (1999:144)

The numerical example below further clarifies what the liquidity premium theory in equation (2.2) is implying.

[2] Figure 2.1 was adapted from Mishkin (1999:144).

The assumption is that the one-year interest rate over the next five years is expected to be 5, 6, 7, 8 and 9% respectively, investors' preferences for holding short-term bonds means that the liquidity premiums for one- to five-year bonds are 0, 0.25, 0.5, 0,75, and 1.0% respectively. Equation (2.2) indicates that the interest rate on the one-year bond would be: 5%+0%=5%

For the two-year bond it would be:

$$\frac{5\% + 6\%}{2} + 0.25 = 5.75\%$$

For the three-year bond it would be:

$$\frac{5\% + 6\% + 7\%}{3} + 0.5 = 6.5\%$$

For the four-year bond it would be:

$$\frac{5\% + 6\% + 7\% + 8\%}{4} + 0.75 = 7.25\%$$

For the five-year bond it would be:

$$\frac{5\% + 6\% + 7\% + 8\% + 9\%}{5} + 1.0\% = 8\%$$

The comparison of the above to that of the expectations hypothesis shows that the liquidity premium theory produces yield curves that slope more steeply upward because of investors' preference for short-term bonds. It is also clear from the above numerical example that there is an increasing liquidity when the term to maturity is longer. Securities with longer maturities offer higher yields (Howells and Bain, 1998:133)

The combination of the expectations hypothesis and the segmented market theory explains the three facts about the term structure of interest rates. Therefore the liquidity premium theory and the preferred habitat theory explain all three empirical facts about the relationship between the short-term interest and the long-term interest rates.

2.2.1.4 The preferred habitat theory

According to Mishkin (1999:143) the liquidity premium theory is closely related to the preferred habitat theory, which takes a less direct approach to modifying the expectations hypothesis, but comes up with a similar conclusion.

This theory assumes that investors have a preference for bonds of one maturity over another, a particular bond maturity (preferred habitat) in which they prefer to invest (Howells and Bain, 2002:326). The investors are preferring bonds of one maturity over another; as such they will be willing to buy bonds that do not have the preferred maturity only if they can have a somewhat higher expected return. The investors are likely to prefer the habitat of short-term bonds over that of longer-term bonds; they will only hold longer-term bonds if they have a higher expected return. The above reasoning will lead to the same equation (2.2) implied by the liquidity premium theory with a term premium that rises with maturity.

2.3 Theoretical behaviour of the term structure and economic activity

Interest rates are strongly affected by changes in the business cycle and often move in the same direction that the business cycle is moving. According to Rose (2003:235), market interest rates tend to rise when the economy is expanding toward its peak or highest point, and fall when the economy is contracting toward the trough of a recession or its lowest point. Therefore an upward-sloping yield curve suggests that short-term interest rates are expected to rise, an inverted yield curve would imply short-term interest rates are expected to fall and a flat yield curve suggests that the short-term and long-term interest rates are the same, meaning that rates are not expected to change in the future. If the term structure of interest rates reflects in part the collective inflation expectations or recession, it is intuitive to believe that it must also reflect market participants' assessments of future real economic activity (Estrella and Hardouvelis, 1991:566).

In the US since the 1960s a yield curve inversion (as measured by the difference between the ten-year and three-month Treasury rates) have preceded every recession on record (Estrella, 2005:6). Since the interest rate cycle precedes the business cycle, it is assumed that a positively sloped yield curve is associated with economic expansion, hence growth in real economic activity.

It has been stated above that this research set out to investigate the predictive ability of the term structure of interest rates on economic activity; therefore it is important to explain how the predictive ability of the term structure of interest rates is related to monetary policy.

2.3.1 Relationship between term spread predictions and monetary policy

There are different views on the appropriateness or effectiveness of alternative monetary policy instruments and transmission mechanisms. However a tightening of monetary policy usually means a rise in short-term interest rates, typically intended to lead to a reduction in inflationary pressures. The expectations are that when those inflationary pressures subside, policy easing will follow. Expected future short-term rates are important determinants of current long-term rates. Thus, long-term rates tend to respond to a contractionary monetary policy by increasing, although given that a policy reversal is expected, they tend not to increase by the same magnitude as short-term rates.

Central banks normally operate on the short end of the yield curve, and are able to influence the short-term interest rates directly. If the South African Reserve Bank (SARB) increases short-term interest rate (REPO rate), the spread between the short-term interest rates and long-term interest rates declines. This signifies that markets expect inflation to decline in the future and short-term interest rates to revert to normality. Contractionary monetary policy will induce less spending in some parts of the economy; this will lead to a decline in economic activity, hence a decline in future output growth.

An explanation of the predictive power of the yield curve for future output growth is that monetary policy tightening both slows down the economy and flattens (or even inverts) the yield curve. Monetary policy is therefore an important determinant of the shape and predictive power of the yield curve.

However, monetary policy is not likely to be the single determinant of the predictive nature of the term spread, since private-sector expectations are incorporated in the interest rates, and those expectations are based on some concept of the structure of the economy. As such the yield curve is able to forecast the evolution of the economy because the movements of both the short-term and long-term interest rates respond to the same cause, that is, current monetary policy.

2.4 EMPIRICAL FINDINGS ON THE YIELD CURVE AND ECONOMIC ACTIVITY

A number of studies provide empirical evidence that the term structure has predictive power on economic activity. According to Martinez-Serna and Navarro-Arribas (2003:3), the use of interest rates as predictors of the business cycle dates back to Burn and Mitchell, who included them in a list of useful variables to forecast real economic activity. Later, Kessel (1965) provided evidence, for the first time, about the co-movement between the term structure and the business cycle, and that the slope of the yield curve is associated with economic downturns or recoveries.

Recall that the main two objectives of this study are to test the ability of the term structure of interest rates to predict economic activity, and to test the effects of changes of monetary policy regimes on the predictive ability of the yield curve on economic activity.

The literature review focuses on studies that provide evidence on the information content of the yield curve with regard to economic activity and the effects of regime changes on the predictive ability of the term structure of interest rates. Much of the research on term structure has been based on formal statistical models, such as linear regressions and non-linear statistical equations.

The measures of real economic activity for which predictive power have been found include GNP and GDP growth, growth in industrial production, consumption, and investment. To predict these series, analysts have relied on relatively standard regression equations, taking care to deal with some important econometric issues. When the objective is to predict turning points, the methodology used is probit or logit equation (Estrella and Hardvouvelis, 1991:562), in which the forecasted variable assumes the values one and zero, for instance in predicting recession (the economy is either in a recession or it is not). The next sub-section reviews evidence on the yield curve's ability to predict real economic activity.

2.4.1 Predicting real economic activity

There is a substantial amount of evidence that suggests that there is a relationship between the slope of the yield curve and real economic activity. Estrella and Hardouvelis (1991), focusing on the United States of America data, established a positive relationship between the term structure of interest rates and economic activity. They showed that the term structure of interest rates can predict cumulative changes in GNP for up to sixteen quarters, and successive marginal changes in real GNP to seven quarters into the future. Estrella and Hardouvelis (1991) use an econometric model, whereby GNP series was regressed on the yield curve represented by the term spread between the 10-year government bond rate and the 3-months Treasury bill rate. They found that a steeper yield curve implies faster economic growth in the future, while a flatter yield curve implies economy will grow more slowly in the future.

Another objective of Estrella and Hardouvelis (1991) was to find out if the slope of the yield curve reflects the changes in monetary policy or if it reflects the influence of other factors such as interest rate expectations. To address this issue they added to the regression the current level of the short-term rate and tested to see if the term spread continued to have statistically significant coefficients at forecasting horizons. They showed that the information on the slope of the yield curve is mostly about other variables, not the current or expected monetary policy since the predictive power of the yield curve remained relatively unchanged. They argue that this feature of the term spread makes it provide useful information for the central banks in their efforts to stabilize output and employment.

Chen (1991), using U.S. data from 1954-1988, presents evidence that the term structure of interest rates can predict future growth rates of GNP up to five quarters ahead. He used a simple econometric model to regress GNP data on the yield spread represented by the difference between the average 10-year government bond yield and the one-month Treasury bill rate. Chen ran in-sample forecasts using quarterly data for periods up to eight quarters ahead. His study indicates a relationship between the term structure and the future level of economic activity: the steeper yield curve implies faster economic growth in the future whilst the flatter curve is associated with a slower growth in real output. Chen also observed that lower Treasury bill rates may reflect lower expected inflation, and lower inflation expectation may in turn reflect information indicating higher future growth. He observed further that the term structure is an important determinant of future stock returns, thus corroborating the results of Estrella and Hardouvelis (1991).

Estrella and Mishkin (1997) provide evidence that in France, Germany, Italy, the United Kingdom and the United States the spread between the 10-year government bond yield and the 3-month Treasury bill rate is able to predict real GDP growth up to between four and eight quarters ahead.

Mishkin (1990) looked at the information in the longer maturity term structure by examining U.S. data. The empirical analysis was based on the monthly data from 1953 to 1987 for inflation rates and interest rates on one - through five-year Treasury bonds. This study was subdivided into the pre-October 1979 period and post-October 1979 period, because the relationship of nominal interest rates and inflation shifted dramatically with the monetary regime change of October 1979[3]. Mishkin regressed the change in the inflation rate on the slope of the term structure. The evidence indicates that there is substantial information in the longer maturity term structure about future inflation: the slope of the yield spread has a great deal of predictive power for future changes in inflation. He observed that at longer maturities the term structure of nominal interest rates contains very little information about the term structure of real interest rates. The evidence in Mishkin (1990) indicates that for maturities of six months or less, the term structure contains no information about the future path of inflation, but contains information about the term structure of real interest rates. Mishkin (1990) indicates further that, at longer maturities, the term structure of interest rates can be used to assess future inflationary pressures: when the slope of the yield curve steepens, it is an indication that the inflation rate will rise in the future and when the slope flattens, it is an indication that the inflation rate will fall.

The results of this study indicated that there is a great deal of information in the longer maturity term structure about the future path of inflation. The results for the two sub-periods indicate the same conclusion, that is, the term structure for maturities greater than a year contains a great deal of predictive power for the changes in future inflation. The results were stronger for the pre-October 1979 period than the post-October 1979 period.

[3] The Federal Reserve implemented a new policy of targeting monetary aggregates rather than interest rates.

Davis and Fagan (1997) examined the predictive power of the yield curve on real output growth in the European Union countries and found statistical significance in all except Spain, France and Italy. The data employed in this study is quarterly, with samples beginning at various dates in the 1970s (depending on data availability) and ending at 1992:4. Inflation is measured by the CPI and output by GDP (or, where this is not available at a quarterly frequency in some countries, by industrial production). The slope of the yield curve is measured by the difference between the yield on long-term domestic government bonds in the secondary market and short-term money-market interest rates. They used a relatively straightforward bivariate model in order to assess whether there is a correlation between yield spreads and future inflation and output growth or other measures of economic activity.

Davis and Fagan (1997) and Alonso, Ayuso and Martinez-Pages (2001) show that there is little information content pertaining to the predictive ability of the term spread in Spain. Alonso et al. (2001) explored the predictive ability of various financial indicators for output growth and they found poor information content.

Engsted (1995), using thirteen OECD countries' figures from 1962 to 1993, presented evidence that long-term interest rates, to a large extent, reflect expected future inflation. Cointegration techniques were applied to examine the time-series properties of interest rates and inflation rates, and VAR methodology was applied to examine the predictive power of the spread (Engsted, 1995:42).

The recent study by Martinez-Serna and Navarro-Arribas (2003) analysed the relationship between the term structure of interest rates and expected economic growth by testing the model of Harvey (1998) with the Spanish data from January 1993 to December 2001. Harvey's model has been tested in several countries using ex post consumption or output growth as proxies for expected consumption growth.

They employed the Consumer Confidence Indicator (CCI) and the Economic Sentiment Indicator (ESI), drawn up by the European Commission, as dependent variables representing expectations about the future economic situation. The different combinations of interest rates were used as independent variables. For the interest maturities, they used the term spread between the 10-year long rates and the 3-month short rate. They specified two versions of the model: a simplified one in which the only variable is the term spread, and a complete one which also includes the real short rate. A positive and statistically significant relationship between the term spread and these two indicators (CCI and ESI) was found. The results indicated that the Spanish term structure of interest rates contains useful information to predict the expected economic growth. These results were contrary to those obtained by Davis and Fagan (1997) and Alonso et al. (2001).

Harvey (1997) carried out a study on the relation between the term structure of interest rates and Canadian economic growth. The period under investigation was 37 years from 1958:1 to 1995:4. In this study three sets of comparisons were presented: firstly, the predictive power of the three-year yield spread was contrasted with the longer maturity 10-year yield spread. Secondly, the information in the Canadian term structure relevant for economic growth was contrasted with the information in the U.S. term structure relevant for forecasting U.S. economic growth. Thirdly, some sub-period analysis was presented to assess the stability of the relations between term structure and economic activity. The short-term yield is the compounded annual rate for the Bank of Canada ninety-day Treasury bill.

Two long-term rates were considered: the government of Canada 10-year-and-over bond yield and the government of Canada one-to-three-year bond yield. Most of the analysis in Harvey (1997) concentrated on the government of Canada one-to-three-year bond yield. He showed that the term structure of interest rates in Canada contain important information about economic growth.

The yield curve predictions of economic growth were based upon an asset-pricing framework that linked bond yields to expected economic growth. It was further found that the Canadian term structure is able to forecast the part of Canadian economic growth that is unrelated to U.S. economic growth.

Robertson (1992) searched for the evidence on the ability of the term spread to forecast inflation using U.K. data from 1955 to 1975. He observed evidence that supports the view that there is some equilibrium relationship between the term structure of interest rates at maturities of up to about four years. He also found that the term structure of interest rates is set by market participants acting to reflect their views on future inflation. As such the term structure can provide information about future inflation, and thus be used as a guide to setting monetary policy (Robertson, 1992:1091). Using GDP deflator as a measure of inflation, and U.K. Government bonds as a measure of the yield spread, cointegration techniques were applied to examine the time-series properties of interest rates and inflation rates.

Nel (1996) found favourable evidence of the predictive ability of the term structure of interest rates for South Africa. The period under investigation in this study was the twenty years from 1974:1-1993:4. This was subdivided into the period of approximately 10 years prior to the gradual implementation of the new monetary control measures in South Africa during the 1980s, and the period thereafter. In this study only one measure of the slope of the yield curve was computed, that is, the difference between the rates on long-term government bonds 10-years-and-over and the 3-month Treasury bill. Both rates were quarterly averages, and Nel used a simple econometric model to regress the annual growth in real GDP on the yield curve. He concluded that the slope of the yield curve is positively related to the growth in real GDP in South Africa, which suggests that the term structure does contain information about economic activity.

The more recent study of the term structure of interest rate in South Africa is Moolman (2002). In this work the probit model was used to evaluate the term structure as a predictor of turning points in the South African business cycle. The use of the probit model is consistent with Estrella and Mishkin (1997). Quarterly data for the period 1979:1-2001:3 was used in the empirical analysis. Consistent with Nel (1996), the yield spread was defined as the yield difference between 10-year bonds and 3-month banker's acceptances. Moolman (2002) indicated that the term structure successfully predicts the turning points of the business cycle.

Other papers, as well as those reviewed in this thesis[4], show that the link between the term spread and real economic activity is not exclusive to the United States. Thus Lowe (1992) and Fisher and Felmingham (1998) found favourable evidence for Australia, Artus and Kaabi (1993) for France, and Clinton (1994) and Cozier and Tkacz (1994) for Canada. Plosser and Rouwenhorst (1994) provide evidence for the United States, the United Kingdom and Germany.

So far we have reviewed studies that mainly tested the ability of the term spread to predict economic activity, even though some studies tested the effects of monetary policy changes in the predictive ability of the term structure. The next section is devoted to those previous studies that tested the effects of monetary policy changes on the predictive ability of the term spread.

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[4] Table 2.1 on the empirical evidence about the predictive ability of the yield curve for economic activity tabulates the studies reviewed in this thesis and the results of each study.

2.4.2 The effects of monetary policy changes on the predictive ability of the term spread

Alles (2001) investigated the empirical relation between the term spread and the level of future economic activity within the 1976 to 1993 period using Australian data, following the methodology used in Estrella and Hardouvelis (1991). Regressions were carried out to test the explanatory power of the yield curve with respect to GDP growth over a quarter ahead, the marginal growth and the cumulative growth. During the sample period covered the Australian financial markets were deregulated, hence it was relevant to examine whether predictive power of the term structure also underwent any structural changes. To examine this issue Alles carried out Chow tests for structural stability on the regression models in the periods before and after the deregulation of the financial markets.

In testing the ability of the yield spread to predict real versus nominal GDP growth, the explanatory power of regression in which GDP growth one quarter and two quarters ahead was measured in real and nominal terms. The signs of the regression coefficients were all positive, implying that a positive slope of the yield curve forecasts an increase in economic activity.

Alles also examined the effect of the financial markets deregulation on the predictive power of the term structure. Theoretically one would expect predictability of the regression models to improve in the deregulated period, when the interest rates begin to reflect market conditions more closely. The predictability of the YR5-DAY180 spread improves marginally, while that of the YR10-DAY180 spread improves to a greater extent.

Turnovsky (1989) analysed the term structure of interest rates within a complete stochastic macroeconomic model using U.S. figures. He analysed in detail the effects of various monetary and fiscal policies on the term structure. To carry out this task he contrasted the effects of temporary versus permanent, and unanticipated versus anticipated, disturbances on the one hand, and the responses of long versus short, and real versus nominal rates, on the other.

Turnovsky (1989) observed that the response of the term structure is highly sensitive to the nature of the prevailing policy shocks in the economy. Turnovsky (1989:336) further shows that whereas an unanticipated temporary monetary expansion tends to have a greater effect on nominal rates, an unanticipated permanent monetary expansion has a greater effect on real rates.

Although little purpose would be served by reviewing the impacts of changes in fiscal policy, since the objective of this research is on the impact of monetary policy on the predictive ability of the term structure, they are worth highlighting.

An unanticipated temporary expansionary fiscal policy has greater effects on real rates; an unanticipated permanent expansion has a greater impact on nominal rates. Turnovsky finds however that the predictive ability of the term structure of interest rates is strongly affected by the prevailing monetary policy regime, by establishing that in the periods of financial markets liberalisation and interest rates deregulation the term structure performs better in predicting economic activity.

Peel and Ioannidis (2002) tested for structural stability of an output growth forecasting equation using the term spread as a regressor, for the U.S. and Canada. Their sample covers the period 1972:2 to 1999:1 for Canada and 1959:3 to 1999:1 for the U.S. For Canada and the U.S., the short-term interest rate is the 3-month Treasury bill rate, and the long-term interest rate is the 10-years Government bond yield. In both countries they showed that the spread has a significant predictive content for real GDP changes. They showed further that researchers interested in forecasting future output change employing term spread as a predictor will realise improved forecasts if allowance is made for structural breaks in policy regime. They were able to confirm that there is a parameter instability as the coefficient associated with the term structure is reduced in size as the policy-makers apply a contractionary monetary policy (Peel and Ioannidis, 2002:2).

Kim and Limpaphayom (1997) examined the effect of economic regimes on the relation between the term structure of interest rates and future economic activity in Japan. The objective was to determine the predictive power of the Japanese term structure on future economic growth under different economic regimes. They used quarterly data for 1975 - 1991. In this study, the Generalised Method of Moments estimation was used to obtain parameter estimates which are asymptotically more efficient than OLS estimates (Hansen, 1982).

To examine the relationship between the term structure and real economic activity, Kim and Limpaphayom (1997) conducted their analysis using the following equation:

$$\Delta GDP_{t+k} = \psi + \theta_1 TERM_1 + \varepsilon_{t+k} \quad \text{......} \quad (2.3)$$

where ΔGDP_{t+k} was calculated as: $(400/k)(\log GDP_{t+k} - \log GDP)$ and represents cumulative quarterly Gross Domestic Product growth k quarters ahead, and this is consistent with Estrella and Hardouvelis (1991:557); ψ represents the intercept term; $TERM_t$ represents the difference between the long-term interest rate and the short-term interest rate; θ_1 is the coefficient which provides information to the equation in predicting the direction of a future change in output, and ε_t represents the error term.

Consistent with Estrella and Hardouvelis (1991), Kim and Limpaphayom (1997) used real and seasonally adjusted data for the economic growth variable. They used GDP as the measure of economic activity instead of GNP, as they were interested in domestic growth. To ensure the robustness of their model, they added other variables such as the Bank of Japan official discount rate, money supply (M2), and stock returns as control variables.

The study used the 10-year government bond yield as the measure of long-term interest rates and the 3-month gensaki rate as the measure for short-term rates. The use of 10-year bond to proxy for long-term rates was consistent with previous studies (Campbell and Hamao, 1991; Estrella and Hardouvelis, 1991; and Hu, 1993).

Kim and Limpaphayom (1997) tested for stationarity of the variables by using the augmented Dickey-Fuller procedure. The procedure was executed for the period of financial market regulation (1975-1983) and the period of financial market liberalisation and interest rate deregulation (1984-1991). The variables were found to be stationary with only one exception: in the first sub-period, the TERM variable was not stationary. Kim and Limpaphayom (1997:386) argued that this was not surprising since interest rates were heavily regulated in the first sub-period. The first difference adjustment to the term variable did not change their GMM results. As such they reported results without the adjustment to facilitate comparisons of the two sub-periods.

For the model which tested the one-quarter-ahead horizon, the term structure coefficient had the correct sign and the t-statistic was significant at 0.05% level. It was observed that the predictive power of the term structure is the highest at five quarters ahead. The bivariate GMM model for the second period was tested up to eight quarters ahead. For the model which predicts two to five quarters ahead, the spread coefficient was gradually declining, but maintained a significance level of 0.01.Furthermore in this study it was found that the term structure loses predictive power beyond the five-quarter growth model. For all forecast horizons, χ^2[5] statistics (d.f. = 4) were not statistically significant, indicating that the models were well specified.

[5] The χ^2 statistic has (*r-p*) degrees of freedom, where *r* is the number of orthogonality conditions in the GMM model, and *p* is the number of parameters. An insignificant χ^2 value indicates that the restrictions of the model are well specified.

For the whole period it was found that the term structure has a very low explanatory power on GDP growth. However, Kim and Limpaphayom (1997:387) argued that as these models encompass the entire period, the findings were expected, as the sample combines two distinct sub-periods with two distinct economic environments and regulatory regimes.

Finally, they examined a multivariate model which included other explanatory variables into the model to ensure the robustness of the findings. The empirical results of the multivariate model yielded consistent findings with the bivariate model.Thus Kim and Limpaphayom (1997:390) established that the term structure of interest rates is useful for discovering the expectations of market participants in Japan during the second sub-period, but not during the first sub-period. In the second sub-period, one lagged term structure moved very closely with GDP growth, while no such co-movements seem to have existed in the first sub-period.

The summary of the studies reviewed above is presented in Table 2.1 below, and it is divided into country specific studies and cross country studies.

Table 2.1: Summary of empirical studies on the predictive ability of the yield curve for economic activity

Study	Country	Period	Economic activity measure	Predictive Horizons	Spread (j,k)	Results (maximum horizon of significant prediction)
Country specific study						
Turnovsky (1989)	United States					Favourable evidence
Mishkin (1990)	United States	1953-1987	CPI	12 months	J=5 years K=3 months	9 to 12 months
Estrella and Hardouvelis (1991)	United States	1955-1988	GNP	1 to 20 quarters	J=10 years K=3 months	Cumulative: 16 quarters Marginal: 7 quarters
Chen (1991)	United States	1954-1985	Index of Industrial production	1 to 8 quarters	J=10 years K=1 month	5 quarters
Estrella and Mishkin(1997)	United States	1959-1995	Stock price indexes, monetary aggregates, interest rates and interest rate spreads	2 to 6 quarters	J=10 years K=3 months	Favourable evidence
Robertson (1992)	United Kingdom	1955-1975	GDP deflator		K=10 years J=3 months	Favourable evidence
Harvey (1997)	Canada	1960-1995	GDP		J=10 years K=3 months	Favourable evidence
Lee and Tse (1991)	Singapore	1976-1987				Favourable evidence
Alles (2001)	Australia	1976-1993	GDP		J=10 years K= 6 months	Favourable evidence

Martinez-Serna (2003)	Spain	1993-2001	CCI, ESI		J=10 years K=3 months	Favourable evidence
Nel (1996)	South Africa	1974-1993	GDP		J=10 years K=3 months	Favourable evidence
Moolman (2002)	South Africa	1979-2001	Recession	2 to 4 quarters ahead	J=10 years K=3 months	Favourable evidence
Kim and Limpaphayom (1997)	Japan	1975-1991	GDP	5 quarters	J= 10 years K= 3 months	Favourable evidence
Cross country studies						
Davis and Fagan (1997)	European Union	Various (70s)-1992	GDP or Industrial Production	4 quarters	J=long term(OECD) K=Short term (OECD)	Favourable evidence except in: Spain, Italy and Ireland
Engsted (1995)	OECD	1962-1993	CPI		J=10 years K= 3 months	Favourable evidence
Peel and Ioannidis (2002)	United States and Canada	1972-1999	GDP	5 quarters	J=10 years K= 3 months	Favourable evidence

Notes:
Where: J and K are the long-term rate and the short-term rate, respectively. In some studies they are not exactly specified and they are named as "long term rate" or "short term rate" according to the database they are obtained from. CCI is Consumer Confidence Indicator and ESI is the Economic Sentiment Indicator.

2.5 CONCLUSION

It can be concluded that there is a vast literature documenting properties of the slope of the yield curve as the predictor of economic activity. The majority of the studies done in several countries at different time periods suggested that there is a positive relationship between the slope of the yield curve and the direction of the economy.

This suggests that the difference between the long-term and short-term interest rates provides valuable information about real future growth in GDP, hence economic activity.

One other conclusion that can be drawn is that even though there is a vast literature documenting the empirical behaviour of the yield spread, the majority of these studies were done in the United States (e.g. Mishkin, 1990; Estrella and Hardouvelis, 1991; Chen, 1991; Estrella and Mishkin, 1997) and in Europe (e.g. Robertson, 1992; Martinez-Serna, 2003) while there is limited evidence from emerging markets such as South Africa. With regard to predicting real economic activity, simple regressions of different measures of economic activity (for example GDP growth, GNP, and Industrial Production) on the yield curve provided positive results. The effects of monetary policy changes on the predictive ability of the term spread were also sufficiently captured.

The two major objectives of this research are to examine the predictive ability of the term spread on economic activity and the effects of the monetary policy regime changes on the predictive ability of the term spread in South Africa. It is observed from the literature review that the yield curve is widely accepted as a predictor of economic activity; as such it can be used in South Africa as a predictor of economic activity. In using the term spread as a predictor of economic activity the effects of monetary policy on the predictive ability of the yield spread must be considered, as it is evident in the reviewed literature that under policy deregulation the term spread predicts economic activity better. This is the topic of the next chapter.

CHAPTER THREE

MONETARY POLICY, THE YIELD CURVE AND ECONOMIC ACTIVITY IN SOUTH AFRICA

3.1 INTRODUCTION

This chapter reviews the evolution of monetary policy in South Africa. Towards the end of the twentieth century South African economic policy experienced major changes: firstly, an explicit change from non-market related controls towards market oriented policies; secondly, a major transformation from a siege economy during apartheid to an economic framework which had to support a multiracial democratic political framework after the first multiracial democratic elections in 1994 (Strydom, 2000:1).

One of the objectives of this research is to investigate the effects of the different monetary policy regimes on the predictive ability of the term structure on economic activity. As such it is essential that the phases of monetary policy in South Africa be analysed.

Economists generally agree that monetary policy should primarily be concerned with the pursuit of price stability. The primary objective of the South African Reserve Bank (SARB) is:

- To protect the value of the currency in the interest of balanced and sustainable economic growth in the Republic.

The SARB, in pursuit of its primary objective, must perform its functions independently. The Constitution therefore implies that the SARB has operational autonomy. However, economists still differ on how this objective can be achieved most effectively (Van der Merwe, 2004:3).

In South Africa monetary policy decisions are in practice taken after deliberations by the SARB Monetary Policy Committee (MPC). The operation of the main monetary policy instrument, the setting of the level of the repurchase rate (the main instrument that is used by the SARB to target inflation), remains the prerogative of the Governor, in consultation with deputy governors and other members of the MPC.

South Africa has experienced numerous monetary policy regimes in the quest by the SARB to achieve price stability. The monetary policy frameworks since the 1960s are shown in Table 3.1 below, and consist of five broad frameworks.

The chapter is divided into four sections. Section two provides a review of the different monetary policy frameworks in South Africa, and this section is further divided into five sub-sections, each dealing with a particular monetary policy framework: the liquid asset ratio-based system with quantitative controls over interest and credit; a mixed system during the transition; the cost of cash reserves-based system with pre-announced monetary targets; daily tenders of liquidity through repurchase transactions (repo system), plus pre-announced M3 targets and informal targets for core inflation; and formal inflation targeting. Section three deals with the relationship between the yield curve, GDP growth, and production prices of domestic goods. At this point, the discussion turns to inspect the behaviour of the yield curve with regard to these two selected measures of economic activity. Here the chapter focuses particularly on the behaviour of the term structure during different monetary policy regimes. Section four concludes.

3.2 MONETARY POLICY IN SOUTH AFRICA

Table 3.1: Evolution of South Africa's monetary policy framework

YEARS	MONETARY POLICY FRAMEWORK
1960-1981	Liquid asset ratio-based system with quantitative controls over interest and credit
1981-1985	Mixed system during transition
1986-1998	Cost of cash reserves-based system with pre-announced monetary targets (M3)
1998-1999	Daily tenders of liquidity through repurchase transactions (repo system), plus pre-announced M3 targets and informal targets for core inflation
2000	Formal inflation targeting

Source: Casteleign (2001:5)

These frameworks are discussed in detail below:

3.2.1 Liquid asset ratio-based system with quantitative controls over interest and credit

From 1960 to 1981, there was a liquid asset ratio-based system with quantitative controls over interest rates and credit. In this framework the interest rate played a minor role as a corrective instrument whereas the main form of monetary policy control was achieved through liquid asset requirements. Monetary policy was mainly conducted through interest rate controls, liquid asset requirements, and cash reserve requirements. These measures were aimed at controlling the growth in the monetary aggregate with a view to curbing inflation. The liquid asset requirement forced the banks to invest in the liquid assets that the SARB could alter from time to time. Commercial banks were required to hold specific assets deemed as "liquid" as a minimum proportion of deposits (Casteleign, 2001:4). The rationale behind this at the time was that the limited supply and low yields of these assets would limit bank lending and money supply growth.

The assets which the banks were forced to invest in comprised SARB notes, coin, gold coin, cash balances with the SARB, and a large number of financial assets such as Treasury Bills, Government stocks, and bankers' acceptances and trade bills. However, according to Strydom (2000:2), internal contradictions and instrument inefficiencies beset these policy measures. The liquid asset requirement was a major problem, and it featured prominently in monetary policy. During the expansion and contraction phases of the business cycle the supply of these assets followed the pattern of the business cycle; as such the banks had little difficulty in complying with the variable liquid asset requirement. Banks could easily convert advances into liquid assets and comply with the policy requirement.

Banks were also able to substitute cash for liquid assets and vice versa, which meant that their cash base escaped the intended effects of the policy instruments. Furthermore, the effectiveness of the policy was greatly hindered by interest rate controls that were introduced from time to time (Strydom, 2000:2).

An important motivation behind the liquid asset requirement was that the financial sector was to finance those sectors that issued the liquid assets at reduced interest rates, which were not market related. This monetary policy regime stimulated allocation effects by favouring particular sectors, such as agriculture, exports and the government, and monetary policy further introduced a bias towards relatively low interest rates via the liquid asset requirement. These developments rendered monetary policy ineffective in controlling the monetary aggregates effectively and the authorities imposed a credit ceiling on the banks to restrain credit growth. This framework hindered the development of financial markets (Strydom, 2000:2).

The fact that banks could easily convert advances into liquid assets, and vice versa, fuelled inflation. Inflationary pressure grew even more due to international factors such as the collapse of the Bretton-Woods system of fixed exchange rates in 1971, and the two oil crises in 1973-1974 and 1979-1980 were important challenges to such a rigid policy environment (Strydom, 2000:2). This became evident in the inflation rate. During the 1970s the South African inflation rate started rising rapidly and it developed out of step with South Africa's major trading partners (Strydom, 2000:2). The authorities in South Africa followed an expansionary monetary policy stance instead of a contractionary one. As such, the inflationary cycle started to accelerate from an average rate of 4.3%pa in 1970 to an average of 15.7%pa in 1975, and decelerated to 8.7%pa in1978 (Strydom, 2000:3). This meant that monetary policy was ineffective and therefore needed to be reviewed.

3.2.2 Mixed system during transition

It is against the above background that economic reform received its first major impulse in 1977 with the appointment of the De Kock Commission with a mandate to evaluate monetary policy (Strydom, 2000:3). It was through the recommendations of the De Kock Commission that South Africa moved from the monetary policy stance of direct controls to more liberal policies. The commission's final report, which was released in 1985, placed great emphasis on the need for a market-oriented monetary policy and more effective instruments to achieve the goals of economic policy (Strydom, 2000:3). Therefore there was a change from non-market related controls towards market-oriented policies as one of the recommendations by the Commission. The managed floating exchange rate system for the rand was introduced in 1979 (Strydom, 2000:3).

The 1980s saw a gradual implementation of the market-oriented monetary policy as recommended by the De Kock Commission. This meant that the SARB largely allowed short-term interest rates to fluctuate with the business cycle.

"These reforms allowed interest rates to follow market signals and from 1980 onwards interest rates adjusted towards high levels, signalling a definite break with the rigid control system of the 1970s with its bias towards low interest rates" (Strydom, 2000:3). This monetary policy framework specifically outlined a stable price level or the control of inflation as the ultimate goal of monetary policy, while the control of the monetary aggregates featured as an immediate target. Therefore the broad money supply target was announced for the first time in the second half of 1985 (Smal and de Jager, 2001:2).

3.2.3 Cost of cash reserves-based system with pre-announced monetary targets

Following the recommendations of the De Kock Commission, growth targets for the monetary aggregate M3 were defined on an annual basis, that is, explicit monetary growth targets and later guidelines for M3 were announced annually from 1986 to 1998. The pre-announced monetary targets were to be achieved indirectly by adjusting interest rates (Casteleign, 2000:5).

In this regime, short-term interest rates became the main monetary policy instrument as the Bank's discount rate was employed to influence the cost of overnight collateralised lending and hence market interests. The Bank Rate was the lowest rate at which the SARB provided accommodation at the discount window to commercial banks. The Bank Rate featured as the principal operational variable in conducting monetary policy, and banks were allowed unlimited access to liquidity through the discount window by discounting eligible paper with the SARB. Various measures such as open-market operations were used to influence overall liquidity and credit extension to the private sector (Casteleign, 2000:5).

3.2.4 Daily tenders of liquidity through repurchase transactions (repo system), plus pre-announced M3 targets and informal targets for core inflation

Financial liberalisation and other structural developments in the 1990s resulted in a changed relationship between growth in the money supply, output and prices, and also significantly reduced the usefulness of money supply targets.

The history of targeting monetary aggregates has been one of limited success, at least in South Africa, in that the relationship between monetary aggregates and nominal variables appears to have broken down in the 1990s. Prior to South Africa's adoption of an inflation targeting regime in 2000 (see 3.2.5 below) there was persistent excessive growth in the money supply, while at the same time a definite downward trend in inflation (Dos Santos and Schaling, 2000:3). It became apparent that the change in the money supply had become a less reliable indicator of underlying inflation; and at the beginning of March 1998, a new system of monetary accommodation commenced with daily tenders of liquidity through repurchase transactions. The money supply guidelines were still announced, but they received less emphasis than before in short-term policy formulation.

Monetary policy also moved towards greater transparency, aimed at achieving greater credibility and a more pronounced effect on inflation expectations. As a result, from March 1998 the M3 growth guidelines were set for a three year period and an informal inflation target of 1% to 5% was set for the first time. This new monetary policy sought to effectively ration the amount of liquidity. From the outset the Bank aimed at signalling its policy intentions for short-term interest rates through the amount offered at the daily tender for repurchase transactions (Guma, 1999:25). By providing more liquidity than would be needed, the SARB provided a clear signal to the banks that in terms of SARB policy objectives, interest rates should decline. By providing less liquidity than is needed, the signal is that interest rates must go up (Guma, 1999:25).

3.2.5 Formal inflation targeting

Considerable success was achieved with informal inflation targeting in bringing the inflation rate down to lower levels. According to Van der Merwe (2004:1), after inflation in the consumer price index had generally fluctuated around a level of about 15%pa in the late 1980s and the beginning of the 1990s, it moved to below double digits in December 1992 and subsequently declined to an average annual rate of 5.2% in 1999. In spite of this success with informal inflation targeting, the authorities decided to change to a formal inflation-targeting framework.

There are four reasons that can be given for this decision. Firstly, the system of informal inflation targeting at times created uncertainties among the public about the monetary policy framework. Secondly, inflation targeting improves the co-ordination between monetary policy and other economic policies given that the target is consistent with other policy objectives. "This better co-ordination in an inflation-targeting framework, compared with other monetary policy frameworks, can be achieved by the structured decision-making process of this framework" (Van der Merwe: 2004:2).

Thirdly, clear targets are set by central government, through the Treasury, that the SARB has to meet; this implies that the SARB has lost its target independence. However the SARB commands instruments' independence[6] within this policy framework. Inflation targeting serves to discipline monetary policy and increase SARB accountability. In the event that the inflation rate deviates from the target, the SARB is held liable; that is, it has to explain what went wrong. This disciplines the SARB and leads to a better understanding on the part of the public why monetary policy decisions are made.

[6] In accordance with South African legislation the inflation target is determined by government in consultation with SARB, however instruments that need to be applied to achieve the target are left to the discretion of the Bank.

Finally, Van der Merwe (2004:8) states that the application of inflation targeting affects inflationary expectations, which facilitate a reduction in inflation. If inflation targets are perceived to be credible, they form the basis for future price and wage setting.

According to Mishkin (2001:521) “Inflation targeting is a recent monetary policy strategy that encompasses five main elements:

- The public announcement of the medium-term numerical targets for inflation;
- An institutional commitment to price stability as the primary goal of monetary policy, to which other goals are subordinate;
- An information inclusive strategy in which many variables, and not just monetary aggregates or the exchange rate, are used for deciding the setting of policy instruments;
- Increased transparency of the monetary policy strategy through communication with the public and markets about the plans, objectives, and decisions of the monetary authorities; and
- Increased accountability of the central bank for attaining its inflation objectives.

In February 2000 the SARB announced that formal inflation targeting would be adopted in South Africa as the monetary policy framework (Van der Merwe, 2004:1). This led the SARB to switch to the direct targeting of the rate of inflation as an anchor for monetary policy. South Africa is considered as a fully-fledged inflation targeter.

3.3 The relationship between the yield curve, GDP growth, and production prices of domestic goods

Section 3.2 dealt with the major monetary policy frameworks in South Africa from 1960 to 2004. This section deals with the relationship between the yield curve and GDP growth. The graphical presentation of the yield curve in South Africa is presented in Figure 3.1.

Figure 3.1 shows the relationship between the Government bond of 10-years and over (long-term rate) and the 91-day Treasury Bill rate (short-term rate). The yield spread is given by the difference between the long-term rate and the short term rate. The short-term and long-term rates are subjected to the same cyclical trends; however Figure 3.1 shows that the differences in the degree of variation over time results in changes in the shape of the yield curve. It is evident in Figure 3.1 that when the long-term rate is above the short-term rate the yield curve is upward sloping. For instance in the period 1970:1 to 1980:1 the long-term rate was above the short-term rate, therefore the yield curve in this period was upward sloping or positively sloped. During the period 1982:1-1984:4 the long-term rate was above the short-term rate; the yield curve was thus downward sloping or negatively sloped.

In Figure 3.2 two measures of economic activity: GDP growth and production prices of domestic goods are related to the yield curve.

Figure 3.1: The relationship between the rate on government bond of 10-years and over and the 91-day Treasury bill rate

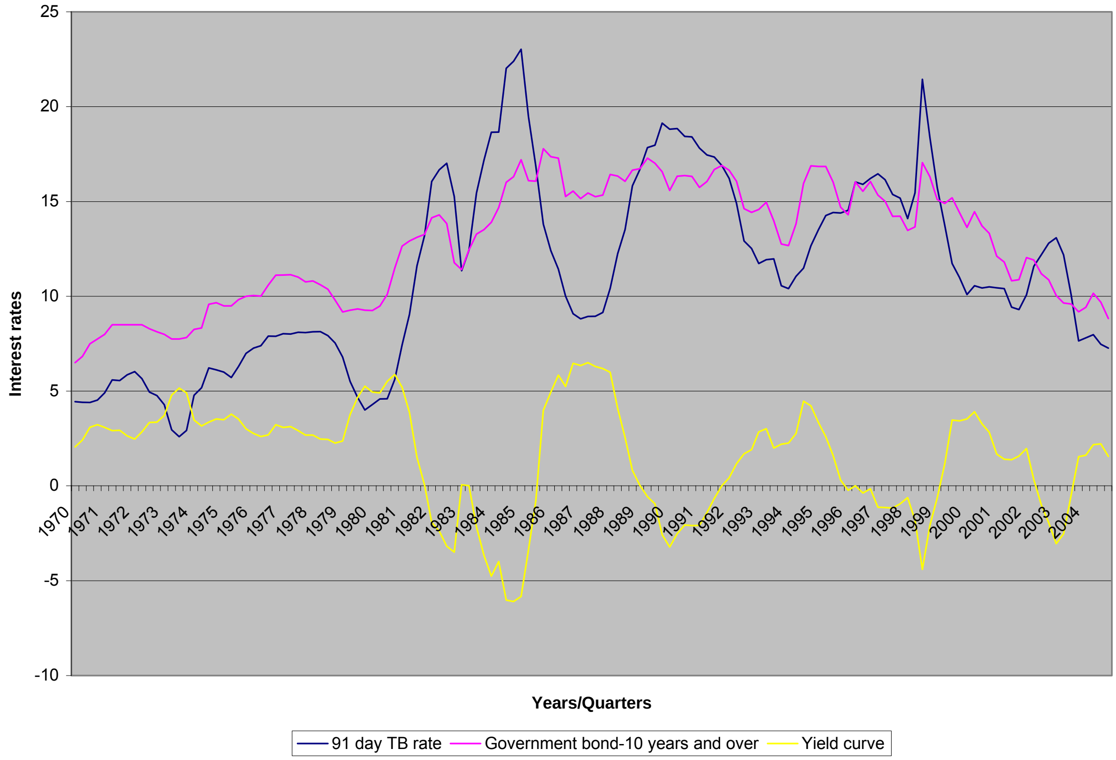


Figure 3.2: The relationship between the yield curve, GDP growth, and production prices of domestic goods

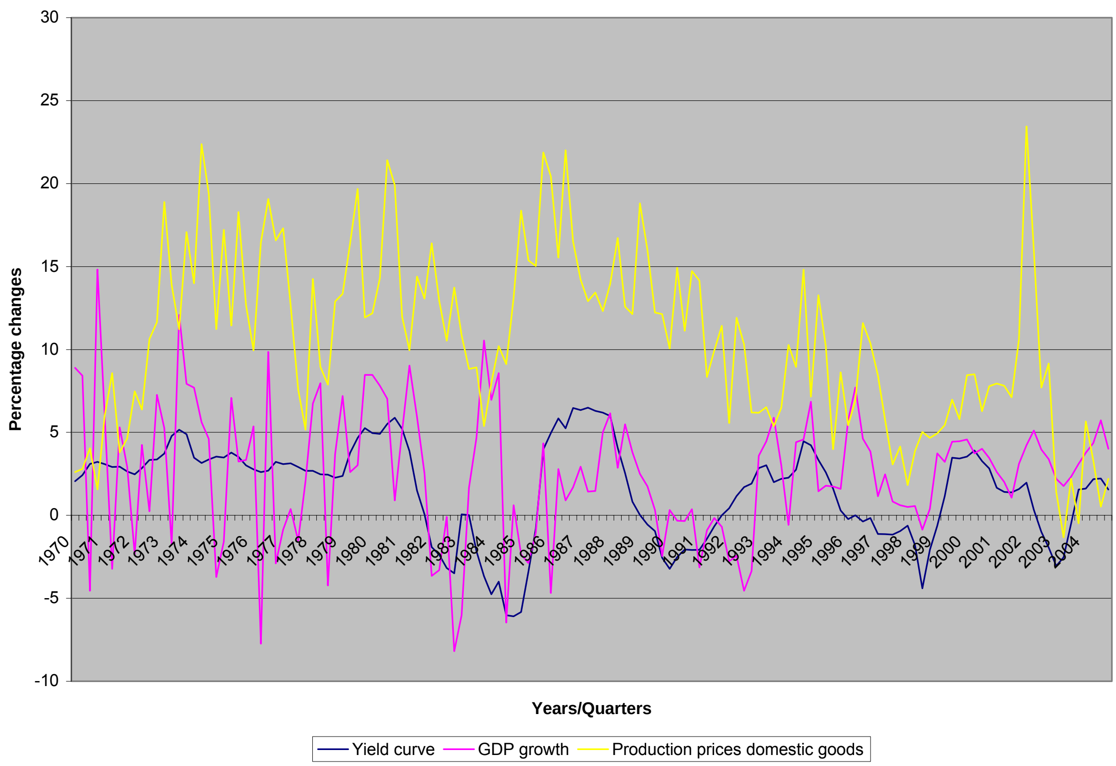


Figure 3.2 depicts the relationship between the yield curve, GDP growth and production prices of domestic goods. GDP growth and production prices of domestic goods are measures of economic activity. The essence of this figure is to compare different monetary policy regimes, and ascertain whether the yield curve was able to predict the direction of economic activity during the different monetary policy frameworks.

Under the theory of the term structure of interest rates, during an economic upswing long-term rates are normally above short-term rates; this is portrayed by the upward sloping or positive yield curve. This is one of the reasons that greater risk is attached to long-term lending, while liquidity considerations also play a part. Banks refrain from increasing lending rates during the early stages of an economic upswing, due to the availability of excess reserves. Monetary policy control also contributes towards the upward sloping yield curve, because authorities are usually somewhat hesitant to counter inflation or a depreciation of the exchange rate at a time when the economic recovery has not yet gained momentum (Nel, 1996:162).

In comparing the different policy regimes, Figure 3.2 shows that during the control era of the 1970s, fewer changes were made to monetary policy. This is evident in the relatively flat yield curve. Monetary policy was mainly conducted through interest rate controls, liquid asset requirements, and cash reserve requirements. Since these policy instruments were highly regulated, this resulted in the relatively flat yield curve. From Figure 3.2 the following observations are made: (1) the yield curve is more stable during the control era 1970-1981 than during the market-oriented era 1981-1985. (2) The yield curve mirrors more closely the growth in GDP growth than production prices of domestic goods (the other indicator of economic activity). (3) The yield curve has a closer association with GDP growth during the market-oriented era than the control era.

The second regime, from 1980-1985, experienced more frequent changes. This was due to a move to a more market-oriented era. Interest rates were allowed to follow market signals and from 1980 onwards interest rates adjusted towards high levels, signalling a definite break with the rigid control system of the 1970s with its bias towards low interest rates (Strydom, 2000:3). It is also evident from Figure 3.2 that the yield curve was still able to predict the direction of economic activity measured by GDP growth but not production prices of domestic goods. This period experienced more frequent changes in the interest rates, hence positive and negative yield curves were easily distinguished.

The third regime, from 1986-1998, was a cost of cash reserves-based system with pre-announced monetary targets (M3). Interest rates were still allowed to move with the market, and this is evident in the relatively rapid up and down movements of the yield curve.

During the period from 1986:1-1988:1 long-term interest rates were above short-term interest rates, hence the positive or upward yield curve in Figure 3.1. In the same period GDP growth was positive, indicating an economic upswing. During the period from 1988:2-1999:4 long-term interest rates were below short-term interest rates; the yield curve in this period was inverse, indicating an economic downturn. This can be seen in the negative GDP growth curve. In the period 1992:1-1996:1 long-term rates were once again above short-term rates, hence the positive yield curve in this period. In this period the South African economy experienced an economic upswing, which is evident from the positive GDP growth curve. However, under this monetary policy regime short-term interest rates did not respond immediately to changes in the overall liquidity position of banks. Correct signals were not always emitted, even at times when money market shortages increased to very high levels. This is, amongst other factors, the result of more frequent changes of the yield curve in the said period (SARB, 2005:2).

The fourth monetary policy framework, from 1998-1999, was the period of daily tenders of liquidity through repurchase (repo system), plus pre-announced M3 targets and informal targets for core inflation. In this period long-term interest rates were below short-term interest rates, hence the inverted yield curve in Figure 3.1. The South African economy was on a down-turn, which is also evident in the downward GDP growth curve. The last monetary policy framework, from 2001:3 to date (formal inflation targeting), has experienced moderate changes in interest rates. This is due to fairly infrequent changes in the official rate (repo rate), which is regarded as the genesis of all other rates.

3.4 CONCLUSION

This chapter dealt with the evolution of monetary policy in South Africa. The South African economy experienced different policy stances in the quest to achieve stability in prices. The most important conclusion that can be drawn from this chapter is with regard to the effects of monetary policy on the predictive ability of the term spread.

During the periods when the South African monetary policy was highly regulated it was shown in Figure 3.2 that the yield spread does not mirror the changes in GDP growth curve closely. During the periods of monetary policy deregulation the yield spread closely mirrors the changes in GDP growth. This implies therefore that in South Africa the prevailing monetary policy may affect the predictive ability of the term spread on economic activity. This issue will be addressed in the coming chapters since it is one of the objectives of this research.

CHAPTER FOUR

ANALYTICAL FRAMEWORK

4.1 INTRODUCTION

This chapter presents the method used in this study to examine the predictive ability of the term structure of interest rates. Specifically, it gives an overview of the generalised method of moments (GMM), and it highlights the argument for the use of the GMM.

4.2 MODEL SPECIFICATION

To examine the relationship between the term structure of interest rates and real economic activity, this study uses the following equation, which is consistent with that of Kim and Limpaphayom (1997):

$$\Delta GDP_t = \Psi + \theta_1 TERM_t + \varepsilon_t \qquad (4.1)$$

where ΔGDP_t represents Gross Domestic Product growth at market prices; ψ represents the intercept term; $TERM_t$ represents the difference between long-term interest rates and short-term interest rates (long-term minus short-term); θ_1 is the coefficient which provides information to the equation predicting the direction of a future change in output, and ε_t represents the error term. Consistent with Kim and Limpamphayon (1997) this paper uses GDP as a measure of economic activity instead of GNP, since the main interest is on domestic growth.

The 10-year and over government bond rate is used as a measure for long-term interest rates and the 91-day Treasury Bill rate as a measure for short-term rates.

The use of the 10-years and over bond yield to proxy for the long-term rates is consistent with the previous literature (Campbell and Hamao, 1991; Estrella and Hardouvelis, 1991; Hu, 1993; and Kim and Limpaphayom, 1997). The Treasury bill rate has been used in previous studies as a proxy for the risk-free rate (Nel, 1996; and Estrella and Mishkin, 1997).

The multivariate model which includes other explanatory variables into the bivariate model (4.1) above will be examined to ensure the robustness of the results. The model is specified thus:

$$\Delta GDP_t = \psi + \theta_1 TERM_t + \theta_2 ALSI_t + \theta_3 M3_t + \varepsilon_t \quad \text{……………………………………} (4.2)$$

where *ALSI* represents Johannesburg Securities Exchange All Share Index and *M3* represents broad money supply.

Consistent with the discussions on the theories of the term structure, one expects a positive sign for the term structure. In Estrella and Hardouvelis (1991:555) it is argued that a flattening yield curve predicts a drop in future spot interest rates and that these lower rates are associated with a lower level of real GNP. Another study that supports this behaviour of the yield curve is that of Nel (1996:163), who stated that the upward sloping yield curve is associated with the expectation that the growth of real output in the economy is improving, while the downward sloping yield curve represents an expectation of a recession. This, therefore, leads to a positive relationship between the term structure of interest rates and economic activity. *A priori*, a positive relationship is expected between changes in ALSI and growth in economic activity. The relationship between changes in M3 and growth in economic activity is expected to be positive.

4.3 ESTIMATION METHOD

The study employs the GMM technique. As with other econometric estimation techniques using time series data, GMM technique requires that the variables under consideration be stationary. However, in practice most financial time series data is non-stationary. If the non-stationary variables are applied, the GMM technique may produce spurious results. Hence in the event that the series are non-stationary at level it is suggested that they be differenced (Gujarati, 2003:792).

Most term structure studies have used ordinary least squares (OLS) regression and applied Newey and West (1987) corrections for heteroskedasticity and autocorrelation. This research employs GMM technique since it has advantages over other estimation techniques.

In using the GMM technique there are theoretical moment conditions that the parameters of interest θ should satisfy. These moment conditions are denoted as follows:

$$E(m(y,\theta))=0 \qquad (4.3)$$

Where θ are the parameters to be estimated.

The GMM estimator belongs to a class of M-estimators that are defined by minimising some criterion function. GMM is a robust estimator in that it does not require information of the exact distribution of the disturbances (Kim and Limpaphayom, 1997:384). GMM estimation is based on the assumption that the disturbances in the equations are uncorrelated with a set of instrumental variables. The GMM estimator selects parameter estimates so that the correlations between the instruments and disturbances are as close to zero as possible defined by a criterion function. By choosing the weighting in the criterion function appropriately, GMM is known to be robust to heteroskedasticity and autocorrelation of unknown form (Kim and Limpaphayom, 1997:384).

This method has several advantages over other estimation techniques. First, it encompasses several standard approaches such as the OLS method. The GMM estimates are asymptotically more efficient than OLS estimates (Hansen, 1982; and Kim and Limpaphayom, 1997). The first reason is that the disturbance term may be serially correlated in the context of time series analysis. Secondly, when compared with classical regression methods such as OLS, with spherical disturbance, the GMM requires relatively weaker assumptions for measuring the residuals. By adjusting a covariance matrix, GMM estimators become robust to autocorrelation.

Similarly, endogeneity bias can also be dealt with by introducing instrumental variables. For estimation, GMM uses the following compact equation:

$$y = X\beta + u \quad \text{.......... (4.4)}$$

where y is a $(T \times 1)$ vector and x is a $(T \times n)$ matrix containing explanatory variables, and they are assumed to be a covariance stationary process. The residual is U and $E[Xu] = 0$, and β is a $(n \times 1)$ vector of parameters of interest. Assume Z is a $(T \times q)$ matrix of instrumental variables and $q > n$, GMM estimators β satisfying the following orthogonal condition:

$$Eg_t(\beta) = E(z_t - x_t\beta)) = E(z_t u_t) = 0 \quad \text{.......... (4.5)}$$

The GMM estimator $(\hat{\beta})$ can be found by minimising the following equation:

$$Q(\beta) = \overline{g}(\beta)' W \overline{g}(\beta) \quad \text{.......... (4.6)}$$

where $\bar{g}(\beta)$ is a $(q \times 1)$ vector with a sample mean of $g(\beta)(i.e, \bar{g}(\beta)) = T^{-1}\sum_{t-1}^{T} g_t(\beta))$.

The W is a $(q \times q)$ symmetric and positive definite weighting matrix, and $p\lim(\hat{w} - w) = 0.$ The GMM estimators then can be expressed as follows:

$$\beta = (X^{'}ZWZ^{'}X)X'ZWZ'Y \quad (4.7)$$

where the residual is IID and $\hat{\beta}$ is $\sqrt{T}$ consistent and asymptotically normally distributed. One condition necessary to obtain an asymptotically efficient estimator of β is $W = \Omega^{-1}$ where Ω is a covariance matrix of $g(\beta)$, i.e., $\Omega = \sum_{s=1}^{T} \sum_{t-1}^{T} E(g_t(\overset{\cap}{\beta})g_s(\overset{\cap}{\beta}))/T$.

However, often financial time series data does not follow a IID process. In the presence of a residual (u) with possible autocorrelation and heterogeneity, the optimal GMM estimators are obtained by calculating a consistent *W*. The heteroskedastic and autocorrelation consistent (HAC) robust weighting matrix can be obtained using the method developed by Newey and West (1987):

$$\hat{\Omega}_{HAC} = S_0 + \left(\sum_{j=1}^{k} w(j)(\hat{S}(j) + \hat{S}(j)' \right) \quad (4.8)$$

where $\hat{S}(j) = \frac{1}{T-K} t = \sum_{t=j+1}^{T} Z_t u_t Z_{t-j}^{'} \overset{\cap}{u}_{t-j}$.

The Kernel $w(j)$ is the Bartlett Kernel $(w(j) = 1 - (j/k+1) fork \geq j \geq 0)$. The estimated matrix in (4.8) is consistent, where K→ ∞ as T→ ∞ and $K/T^{1/2} \rightarrow 0$.

In this study the QS Kernel was chosen because it has a faster rate of convergence than the Bartlett Kernel and is smooth and not truncated (Andrews, 1991). Even though the QS Kernel is not truncated, it still depends on the bandwidth.

E-views provide two bandwidth selection methods, namely, Andrews and Variable-Newey-West. The latter poses a problem in that one has to choose a lag selection parameter. Hence, following Kim and Limpaphayom (1997:384) Andrews was chosen in this research.

When there are more instruments than parameters (i.e. q > n), the appropriateness of the model, including the choice of instruments, can be checked using the over-identification test (Hansen, 1982).

$$J = T \overset{\frown}{g}_T (\overset{\frown}{\beta}_T) w \bar{g}_T (\beta_T) \quad \text{...} \quad (4.9)$$

The above statistic is asymptotically distributed as χ^2 with a degree of freedom equal to q-n. Based on this, an over-identification test can be conducted that can be used as the standard diagnostic method.

There is no established theory by which to determine the composition of instrumental variables, the choice of instruments is often left to the researchers' judgment. That is, more often instruments are chosen by *ad hoc* arguments or by availability, resulting in potentially invalid instruments. The instruments must however be uncorrelated with the error term, and explain part of the variability in the endogenous regressor. This implies that the instruments cannot have a direct effect on the dependent variable. The number of instruments should be parsimonious because the asymmetric efficiency can be improved only when additional instruments bring about extra information.

Following Kim and Limpaphayon (1997:386) this research employs the lags of the variables in the model as the instrumental variables.

4.4 DATA AND SOURCE

All the economic data for the period 1970 to 2004 was obtained from the SARB economic and statistical database, except for the All Share Index (ALSI) and broad money supply (M3) which was obtained from the Quoin Institute. The quarterly interest rates data was derived by calculating averages from monthly interest rates which were obtained from the monthly economic data file. These interest rates are the 91-day Treasury bill rate (short-term interest rates), long-term government bond (long-term interest rates), ALSI, and M3. GDP was obtained from the SARB quarterly economic and statistical database. The use of quarterly data is consistent with other previous studies (Nel, 1996; Kim and Limpaphayon, 1997).

4.5 TESTING FOR UNIT ROOT

Econometric analysis and inferences from time-series regressions are generally based on the assumption that such time series data are stationary (Bah and Amusa, 2003:12). There are various methods that are used to test for the stationarity of time-series data. Firstly one can plot the data against time and graphically analyse the data for stationarity.

Another graphical technique is to look at the autocorrelograms; the correlogram plots the sample autocorrelation function (SACF) which starts at a very high value then declines slowly towards zero, if non-stationary (Gujarati, 2003:809). The problem, however, with the above technique is that it is very subjective and, therefore, it is necessary to use formal tests, namely, Augmented Dickey-Fuller (ADF) and the Phillip-Perron (PP) to test for the existence of a unit root.

The basic objective of the ADF test is to examine the null hypothesis that $\phi = 1$ in

$$y_t = \phi y_{y-1} + u_t \quad \text{(4.10)}$$

against the one-sided alternative $\phi < 1$.Thus the hypotheses of interest are:

H_0: Series contains a unit root, versus
H_1: Series is stationary

In practice, instead of employing (4.10) the following regression is applied, for ease of computation and interpretation (Brooks, 2002:377):

$$\Delta y_t = \psi y_{t-1} + u_t \quad (4.11)$$

So that a test of $\phi = 1$ is equivalent to a test of $\psi = 0$ (since $\phi - 1 = \phi$).

The ADF test is conducted by adding lagged values of the dependent variables in the model. This is done to absorb any dynamic structure present in the dependent variables and ensures that the residuals in (4.11 above) are not correlated (Brooks, 2002:380)

$$\Delta y_t = \beta_1 + \beta_2 T + \delta y_{t-1} + \sum_{i=1}^{p-1} \alpha \Delta y_{t-1} + \varepsilon_t \quad (4.12)$$

where ε_t is a pure white noise error term (ε_t ~ IID (0, σ^2)), Δ is the difference operator, T is a time trend, $\Delta y_{t-i} (\Delta y_{t-1} = y_{t-1} - y_{t-2}; \Delta y_{t-2} = y_{t-2} - y_{t-3} ....)$ are lagged differences, and β_1, β_2, σ and α are the parameters to be estimated.

The series is said to be stationary if the coefficient δ =0 using the τ statistic. The unit root tests are valid only if ε_t is white noise. ε_t is assumed not to be autocorrelated, but would be autocorrelated in the dependent variable of the regression (Δy_t) which has not been modelled (Brooks, 2002:379).

The ADF does not have the standard t-distribution, but applies the critical values of the t statistic that are similar to those in the DF test (Gordon, 1995:188).

If the computed absolute value of the τ statistic exceeds the DF or Mackinnon DF absolute critical τ values, then the hypothesis that the given time series is stationary is not rejected. If, on the other hand, it is less than the critical value, the time series is non-stationary (Aziakpono, 2000:135).

The major problem in testing for unit root is the choice of the optimal number of lags of the dependent variable. Brooks (2002:380) states that there are two ways to choose an optimal number of lags. First, the frequency of the data can be used to decide. That is, for example, if the data is monthly, use 12 lags, and if the data is quarterly, use 4 lags. Second, an information criterion can be used to decide. In this study the optimum lag length for each of the variables has been chosen using Eviews 5 automatic lag selection option and is based on the Schwartz information criterion (SIC).

According to Brooks (2002:381), Phillips and Perron have developed a more comprehensive theory of unit root non-stationarity test. The tests are similar to ADF tests; however Phillips and Perron incorporate an automatic correction to the DF procedure to allow for autocorrelated residuals. The tests often give the same conclusions as, and suffer from most of the limitations of the ADF test.

4.6 CONCLUSION

The objectives of this study are to examine the predictive ability of the term structure of interest and the effects of the monetary policy changes on the predictive ability of the term spread. In order to achieve these goals the study employs both the bivariate and the multivariate models.

First the bivariate model is tested; in this model the term spread is the only explanatory variable. That is, the term spread is used to assess the direction of the economy, hence economic activity.

The analysis is repeated whereby control variables are added to the bivariate model to test whether the inclusion of other variables affects the predictive performance of the term spread and also to see if these other variables outperform the term spread in predicting economic activity. The estimation of the model and the results are the subject of the next chapter.

CHAPTER FIVE

ESTIMATION AND RESULTS

5.1 INTRODUCTION

While the previous chapter discussed the analytical framework of the study and the GMM procedure, this chapter will employ the GMM methodology: firstly, to empirically examine the relation between the term structure of interest rates and GDP growth using the South African experience, and secondly to investigate the effects of the different monetary policy regimes on the predictive ability of the term spread.

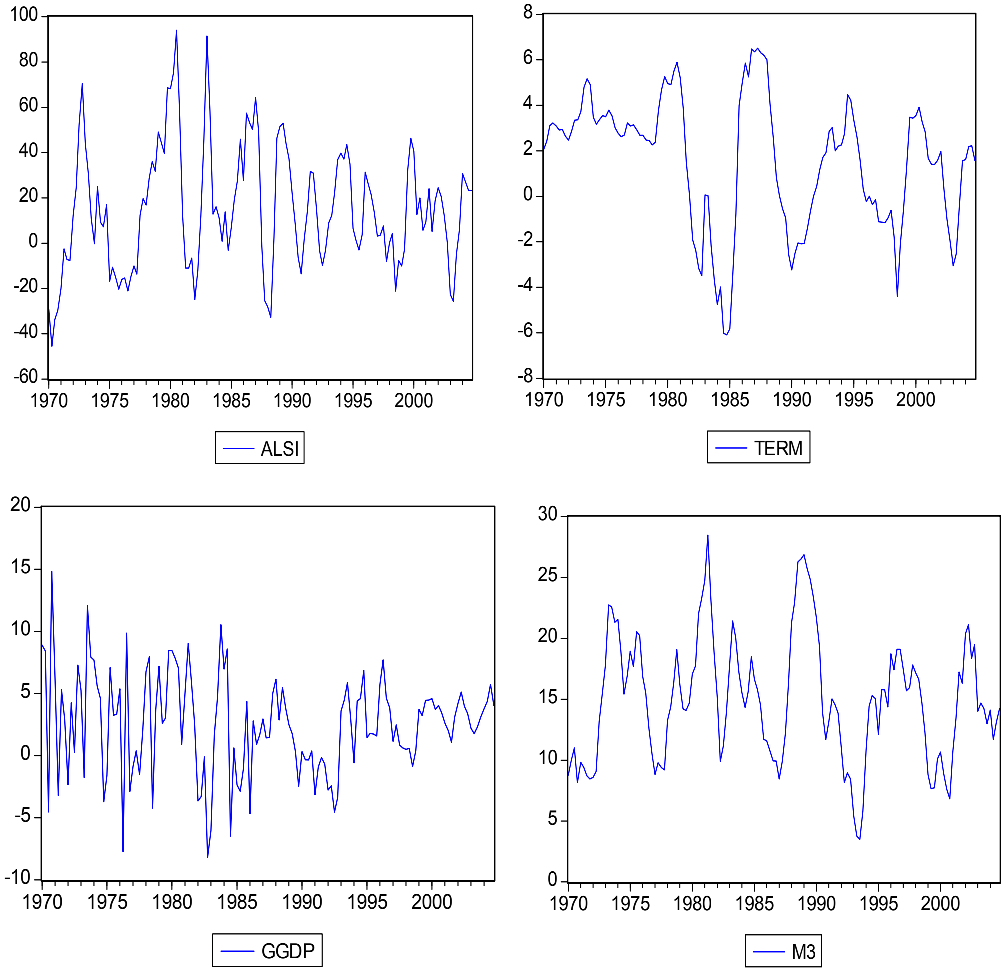
The research results will be presented, interpreted and evaluated against theory and results of other studies.

5.2 TIME SERIES PROPERTIES

As mentioned above, in time series analysis it is important to plot the variables before proceeding to the unit root test. This gives a researcher a pictorial overview of the variables, and reveals the properties of the data, for example, it reveals whether there are any structural breaks, trends, or stationarity in the data. For this purpose Figure 5.1 plots the time series variables for the whole period of the study (1970:1-2004:4).

The plots of the time series variables suggest that all these variables have an intercept. The movements of the variables suggest that they are all stationary (some variables are level stationary and others are first difference stationary). This however will be ascertained by carrying out formal unit root tests as explained in Chapter four.

Figure 5.1: Plots of time series



The unit root tests, the ADF and PP are carried out for the periods 1970 to 2004; 1970 to 1980; 1981 to 1999; and 2000 to 2004 and are presented in table 5.1 below. These tests are performed on both levels and first difference for all the variables in the model. These sub-periods are the periods being investigated in this research, they capture the main monetary policy frameworks in South Africa since 1970s to-date.

Table 5.1: Unit root tests for stationarity

	ADF		PP	
Variables	Level	1st Difference	Level	1st Difference
Whole period (1970:1-2004:4)				
ALSI	-4.406413***	-9.070506***	-3.505977***	-11.26333***
GGDP	-9.315483***	-19.26175***	-9.333532***	-50.60568***
M3	-4.007669***	-7.906897***	-3.670521***	-7.835903***
TERM	-3.795006***	-7.119567***	-3.108650**	-7.018568***
First sub-period (1970:1-1980:4)				
ALSI	-2.436407	-4.384706***	-1.515534	-6.617964***
GGDP	-7.392280***	-10.41673***	-7.369976***	-15.65449***
M3	-2.837641*	-1.838939	-1.760739	-4.838852***
TERM	-2.091333	-4.034443***	-1.465904	-3.641936***
Second sub-period (1981:1-1999:4)				
ALSI	-4.035446***	-5.842986***	-3.211277**	-6.478934***
GGDP	-7.680292***	-11.09641***	-7.744412***	-18.41360***
M3	-4.160399***	-3.839909***	-2.564085	-5.536327***
TERM	-2.694843*	-4.870858***	-2.235945	-4.871876***
Third sub-period (2000:1-2004:4)				
ALSI	-1.452232	-0.686867	-1.452232	-3.627420**
GGDP	-5.093445***	-7.490415***	-5.182589***	-12.43027***
M3	-1.122619	-3.588391**	-1.171411	-3.069412**
TERM	-2.495249	-3.509049**	-2.010117	-2.488617

Notes: (***) means that unit root (non-stationarity) is rejected at the 1% level of significance.
(**) means that unit root (non-stationarity) is rejected at the 5% level of significance.
(*) means that unit root (non-stationarity) is rejected at the 10% level of significance.

The results for the whole period 1970:1 - 2004:4 show that all the variables with exception of TERM series with PP test at level, are all level stationary at 1% level of significance, while the term series is level stationary at 5% level of significance i.e. they are I (0) at 1% level and TERM series is level stationary I (0) at 5% level of significance.

In the first sub-period (1970:1-1980:4), ALSI and TERM series are first difference stationary at 1% level of significance, using both the ADF and PP tests. The GGDP series is level stationary at 1% level of significance with both the ADF and PP tests. The M3 series is only level stationary at 10% level of significance with the ADF test and first difference stationary at 1% level of significance with PP test.

The results of the second sub-period (1981:1-1999:4) show that all the variables are level stationary at different levels of significance, with the exception of M3 and TERM series when the tests were carried out with PP, which were both stationary at the first difference at 1% level of significance.

The results of the last sub-period (2000:1-2004:4) show that ALSI series is first difference stationary at 5% level significance when the test uses PP. The GGDP series is level stationary at 1% level of significance. The M3 series is first difference stationary at 5% level of significance with the ADF and PP tests. The TERM series is first difference stationary at 5% level of significance with the ADF test.

5.3 EMPIRICAL RESULTS

The estimated bivariate model coefficients are reported in Table 5.2 below. The bivariate GMM in all the time horizons were tested for up to five lags. This was done with the intention of choosing the best specified models. Therefore, this study reports the results of the best specified model in each period.

For all forecast horizons, the χ^2 statistics (d.f. = 4) are not statistically significant, indicating that the models are well specified (Kim and Limpaphayom, 1997:387).

The statistical significance of the term structure coefficient provides information on the reliability of the equation in predicting the direction of growth in GDP. The coefficient of the term structure variable is statistically significant for the whole period (1970:1-2004:4). This is evident in the p-value of zero which suggests that the coefficient is highly statistically significant at 1% level of significance, further the term variable has a positive sign, and this is in line with a priori expectations. In this period the adjusted R^2 is 0.068854. The typically low explanatory power of the model is due to the fact that GDP growth is determined by a host of other factors. The low R^2 does not invalidate the main result of the model. The MSE of 3.849412 is the lowest relative to the MSEs of 4.875053, 4.789582 and 5.533800 of the first, second, and third sub-periods respectively.

In the first sub-period (1970:1-1980:4) in the best specified model, the right sign for the term spread coefficient was obtained; the p-value is 0.0228, which suggests that the term spread coefficient is significant at 2.28%. Based on the adjusted R^2 of 0.020806 it is observed that the predictive power of the term structure is lower in this period relative to the periods (1970:1-2004:4) and (1981:1-1999:4). This is the period when interest rates and financial markets were highly regulated in South Africa, therefore this observation is not surprising since it is expected that during periods of financial markets liberalisation the predictive power of the term spread on economic activity would be high.

In the second sub-period (1981:1-1999:4) the correct sign for the term spread was obtained, and the p-value of 0.0101 suggests that the term spread coefficient is statistically significant at 1% level of significance. The adjusted R^2 of 0.022686 suggest that in this period predictive power of the term spread was relatively higher than periods 1970:1-1980:4 and 2000:1-2004:4.

This was the period of interest rates and financial markets deregulation, as such the results of this period are not surprising, since it is expected that the term spread variable should have higher predictive power during the periods of interest rates and financial markets deregulation. As in Kim and Limpaphayom (1997:390) it was found that interest rate deregulation and financial liberalisation increase the quality of the information contained in the term structure. However what is surprising is a relatively lower predictive power for the period (1970:1-2004:4), one would have expected a lower explanatory power of the term spread on growth in GDP in the entire period since the sample of the entire period combines various monetary policy regimes with different regulatory frameworks. This finding is consistent with Kim and Limpaphayom (1997:387).

In the last sub-period the correct sign for the term spread was obtained, and the p-value of 0.0190 suggests that the term spread coefficient is statistically significant at 1.9%. The spread coefficient of this period outperforms that of the first sub-period (1970:1-1980:4), however the measure of in-sample forecasting accuracy is negative in this period.

Table 5.2: Generalised Method of Moments Results: Bivariate Model

	Number of Lags	ψ	θ_1	MSE	χ^2	R^2
Whole period (1970:1-2004:4)	2	1.468422 (0.0023)	0.637172 (0.0000)	3.849412	3.7536×10^{-29}	0.068854
First sub-period (1970:1-1980:4)	1	-2.709752 (0.3046)	1.816329 (0.0228)	4.875053	1.7157×10^{-32}	0.020806
Second sub-period (1981:1-1999:4)	2	1.111751 (0.2961)	0.678439 (0.0101)	4.789582	5.9126×10^{-30}	0.022686
Third sub-period (2000:1-2004: ,4)	1	-6.723222 (0.1550)	3.175531 (0.0190)	5.533800	9.576×10^{-30}	0.067622

Notes: Generalised method of moments (GMM) estimators of the model between GDP growth and term structure are presented for the whole period and for three sub-periods. The table reports the best specified model while the others are reported in Appendix A, where the model was run from lags one to five in all the research horizons. In parentheses are the p values. MSE indicates mean squared error. The χ^2 (d.f. = 4) was calculated by multiplying the number of observations with the minimised value of GMM criterion function. Over-identifying restrictions were tested at both 1% and 5% level of significance, and the critical values were 13.2767 and 9.48773 respectively. R^2 denotes the adjusted R square.

The multivariate model, which included other explanatory variables in the model, was examined to ensure the robustness of the findings. For all forecast horizons, the χ^2 statistics (d.f. = 12) are not statistically significant, indicating that the models are well specified. The estimated multivariate model coefficients are given in Table 5.3 below.

The control variables that were considered are: the Johannesburg Stock Exchange all share index (ALSI), and money supply (M3). The empirical results of this multivariate model for the whole period (1970:1-2004:4) yielded consistent findings with the bivariate model, in that the term spread coefficient is statistically significant at 1% level of significance. It was found that the adjusted R^2 of 0.105576 is higher than of the bivariate model in the same period. This confirms our earlier assertion that the low R^2 was due to omission of other growth determining variables. The p-values indicate that the term structure coefficient outperformed other control variables as a predictor of growth in GDP.

In the first sub-period (1970:1-1980:1) the results were also consistent with the findings of the bivariate model, in that the coefficient of the term spread variable is statistically significant. However in the multivariate model the term spread coefficient is only significant at 6.23%. Based on the p-values the spread coefficient outperformed other control variables as the predictor of growth in GDP.

It was also found that the coefficient for the term spread variable is significant in the second sub-period (1981:1-1999:4). These findings were consistent with the findings of the bivariate model. The term spread was observed to have outperformed other control variables as the predictor of growth in GDP.

In the last sub-period (2000:1-2004:4) the coefficient of the term spread outperformed other control variables, but this coefficient is insignificant. However, this is not surprising, since in the bivariate analysis when more variables are included in the model, the yield spread loses its marginal forecasting power, although the forecasting power of the equation may increase (Davis and Fagan, 1997:705). Hence the addition of the other variables has resulted in the term spread coefficient gradually declining; however it remains significant, with the exception of the last sub-period.

Table 5.3: Generalised Method of Moments Results: Multivariate

	Number of Lags	ψ	θ_1	θ_2	θ_3	MSE	χ^2	R^2
Whole period (1970:1-2004:4)	2	-1.638968 (0.3250)	0.594237 (0.0003)	(-0.000598) (0.9826)	(0.211946) (0.0262)	3.777247	$1.16886*10^{-29}$	0.105576
First sub-period (1970:1-1980:4)	1	-3.648579 (0.1462)	1.657249 (0.0623)	-0.013588 (0.5351)	0.113375 (0.3484)	10.05733	$4.588*10^{-30}$	0.038854
Second sub-period (1981:1-1999:4)	2	-4.585318 (0.1362)	0.560699 (0.0154)	0.002759 (0.9269)	0.377406 (0.0327)	4.738057	$2.9304*10^{-29}$	0.061623
Third sub-period (2000:1-2004:4)	1	-10.57652 (0.1872)	5.512673 (0.1620)	-0.034858 (0.2346)	-0.267380 (0.5315)	5.591123	$1.8544*10^{-29}$	0.223798

Notes: Generalised method of moments (GMM) estimators of the model between GDP growth and term structure are presented for the whole period and for three sub-periods. The table shows the best specified models from Appendix B, where the model was run from lags one to five in all the research horizons. In parentheses are the p values. MSE indicates mean squared error. The χ^2 (d.f. = 12) was calculated by multiplying the number of observations with the minimised value of GMM criterion function. Over-identifying restrictions were tested at both 1% and 5% level of significance, and the critical values were 26.2170 and 21.2170 respectively. R^2 denotes the adjusted R square.

Overall, the coefficients in both Table 5.2 and 5.3 indicate that the slope of the yield curve is positively related to the GDP growth in South Africa. This is also evident from the visual inspection of the time series in Figure 3.2. The term spread contains information about the real sector of the economy in South Africa, and may be used to forecast economic activity. The relatively high p-values support the significance of the yield curve as a better predictor for the growth in economic activity.

5.4 CONCLUSION

The term structure of interest rates is a useful predictor of economic activity in South Africa in all the sub-periods with the exception of the last sub-period with the addition of the other variables.

The bivariate model ascertained that the term structure of interest rates is able to predict GDP growth in all the forecast horizons, but with different magnitudes. For example, as mentioned above, in the entire period (1970:1-2004:4) the term spread is statistically significant at 1% level of significance. In the first sub-period it was significant at 2.8% level of significance. Using the multivariate model the term structure of interest rates is able to predict GDP growth in the entire period and all other sub-periods, but the last sub-period (2000:1-2004:4) was not significant. In all the periods the term spread coefficient outperformed all other control variables.

In both the bivariate and the multivariate models the spread as the predictor of real economic activity is relatively low in the last sub-period (2000:1-2004:4). This may be influenced by the fact that this period covers only 20 quarters.

The results are not surprising, since interest rate deregulation and financial markets' liberalisation are expected to increase the quality of the information contained in the term structure which, in turn, makes it more useful for discovering the forecast of market participants. In the first sub-period (1970:1-1980:4) the SARB followed the policy of liquid asset ratio-based system with quantitative controls over interest and credit. This suggests that the interest rates and financial markets were highly regulated. The information contained in the term structure as the predictor of real economic activity during this period is low relative to the second sub-period (1981:1-1999:4) and the last sub-period (2000:1-2004:4).

The second sub-period (1981:1-1999:4) saw the gradual implementation of the recommendations of the De Kock Commission, hence this was the period of interest rate deregulation and financial markets liberalisation. In the last sub-period (2000:1-2004:4) the financial markets are deregulated; this is, as mentioned above, one of the reasons for an increase in the quality of the term structure as the predictor of real economic activity.

The empirical results of the multivariate model are consistent with the findings of the bivariate model, in that in the period which was highly regulated, the term structure of interest rates poorly predicted real economic activity. In the periods where interest rates were deregulated, the term structure was a better predictor of real economic activity.

The result of this research emphasises the importance of considering existing monetary policy frameworks and government intervention in conducting empirical research on the term structure of interest rates.

CHAPTER SIX

SUMMARY OF FINDINGS, POLICY IMPLICATION AND RECOMMENDATIONS FOR FURTHER RESEARCH

6.1 SUMMARY OF FINDINGS

The study examined the predictive ability of the term structure of interest rates on real economic activity in South Africa, using quarterly data from 1970 to 2004. To capture the effects of the term structure under different monetary frameworks the study period was divided into different sub-periods. To this end, five distinct monetary policy regimes that have evolved in South Africa were discussed. The five distinct monetary policy regimes were grouped into three sub-periods for the purpose of the empirical analysis.

As explained in the first chapter, as part of ascertaining the predictive ability of the term structure of interest rate, two sub-objectives were addressed. Firstly, the relationship between the yield spread and GDP growth in South Africa was graphically analysed. It was observed from the visual inspection of time series that the term structure of interest rates is positively related to the growth of real GDP in South Africa. In addition the visual presentation indicated that the term structure of interest rates mirrors the growth in real GDP more closely than do production prices of domestic goods.

The study first tested for unit root in all the variables using both ADF and PP tests. These tests showed that the variables were either level or first difference stationary. Having tested for unit root, the study employed the GMM technique. The results that are reported in this research are those of the best specified models. The best specified models indicated that the spread coefficient is statistically significant in both the bivariate and multivariate models, with the exception of the last sub-period (2000:1-2004:4).

The result of this study indicates that the South African term structure of interest rates contains useful information in predicting economic activity. The slope of the yield curve in South Africa is positively related to the growth in real economic activity. These findings further concur with that of Kim and Limpaphayom (1997), in that they showed that the spread performs differently as the predictor of real economic activity under different monetary policy frameworks.

The second objective, which is to investigate the effects of the different monetary policy regimes on the predictive ability of the term structure of interest rates, was first addressed by a review of empirical studies that determine the effects of different monetary policy regimes on the predictive ability of the term structure. The empirical literature, such as (Kim and Limpaphayom, 1997; and Nel, 1996), suggests that interest rate deregulation and financial market liberalisation increase the quality of the information contained in the term structure.

These underscore the conclusion that the predictive ability of the term structure is highly sensitive to the nature of the underlying monetary policy framework. This suggests that researchers interested in forecasting economic activity using the term spread as a predictor will realise improved forecasts if allowance is made for changes in the monetary policy framework

6.2 LIMITATIONS OF THE STUDY

It is argued that the yield curve performs quite well in out-of-sample tests for predictive accuracy. However this study focused on in-sample predictive ability of the term structure of interest rates, hence out-of-sample predictions were not considered. This may impede monetary authorities in assessing whether to adjust their policy instrument in order to achieve price stability.

6.3 POLICY IMPLICATION AND RECOMMENDATIONS FOR FURTHER RESEARCH

The results of this study present evidence that the slope of the yield curve can predict economic activity in South Africa. The slope of the yield curve has extra predictive power over and above the predictive power of ALSI and M3. The term spread outperformed these variables in predicting economic activity in South Africa. The shape of the yield curve helps to forecast changes in real economic activity. The term spread, being the difference between interest rates of different maturities incorporates an element of expected changes in rates and is thus indicative of changes in real economic activity. The observed predictive power of the term spread shows that historically the information in the yield curve could be useful not only to the private market participants but also to the South African Reserve Bank because it can reflect among other things factors that are not under the control of the monetary authorities. Therefore the South African Reserve Bank can read out economic activity from the yield curve.

Much of the research on the term structure of interest rates has been based on formal econometric models, such as linear regressions and non-linear statistical equations. However, simple rules of thumb are available, and they make the yield curve a simple forecasting tool; for example the fact that yield curve inversions (negative spreads) are followed by recessions. Therefore, because of its simplicity and easier of computation the yield spread should be added as one of the leading indicators for economic activity in South Africa.

The last sub-period (2000:1-2004:4) of this study covered only twenty quarters. This is a relatively small sample size that may affect the outcome of the results. Further research could contribute by extending the research horizon to see if it is possible to produce better results. The term structure research should be viewed as ongoing research, since the findings are prone to changes in monetary policy framework. Further, if one could do out-of-sample forecasting, this might lead to better results that could even assist the monetary policy authorities in South Africa in policy formulation.

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APPENDICES

The appendices below provide the regression results of both the bivariate and multivariate models that were run from one up - to five lags. The best specified models for interpretation were selected from these results, and regression equations for the best specified models.

Appendix A

Generalised Method of Moments Results: Bivariate Model

Whole period (1970:1-2004:4)					
Number of Lags	ψ	θ_1	MSE	χ^2	R^2
1	1.676742	0.525581	3.814574	$1.9877*10^{-33}$	0.087741
	(0.0015)	(0.0023)		(9.48773)**	
				(13.2767)*	
2	1.468422	0.637172	3.849412	$3.7536*10^{-29}$	0.068854
	(0.0023)	(0.0000)			
3	1.435838	0.697748	3.878091	$1.9317*10^{-33}$	0.062930
	(0.0192)	(0.0005)			
4	1.322780	0.718653	3.891336	$6.1064*10^{-32}$	0.046895
	(0.0768)	(0.0107)			
5	1.310829	0.714118	3.889225	$3.348*10^{-32}$	0.045101
	(0.2478)	(0.1978)			
First sub-period (1970:1-1980:4)					
Number of Lags	ψ	θ_1	MSE	χ^2	R^2
1	-2.709752	1.816329	4.875053	$1.7157*10^{-32}$	0.020806
	(0.3046)	(0.0228)			
2	-5.373722	2.536009	4.809140	$1.68*10^{-26}$	0.001468
	(0.2485)	(0.0551)			
3	0.434590	0.919948	5.084985	$7.626*10^{-29}$	0.039503
	(0.9410)	(0.5728)			
4	5.835780	-0.707355	13.095669	$1.332*10^{-26}$	-0.144290
	(0.5266)	(0.7826)			
5	202.9487	-56.96056	35.70892	$1.4274*10^{-24}$	-161.9458
	(0.9334)	(0.9344)			

Second sub-period (1981:1-1999:4)					
Number of Lags	ψ	θ_1	MSE	χ^2	R^2
1	1.560246	0.520305	4.721670	$1.6425*10^{-31}$	0.049529
	(0.1106)	(0.0426)			
2	1.111751	0.678439	4.789582	$5.9126*10^{-30}$	0.022686
	(0.2961)	(0.0101)			
3	1.143561	0.710143	4.806556	$6.4386*10^{-32}$	0.020063
	(0.3346)	(0.0176)			
4	1.095956	0.662728	4.782797	$2.9376*10^{-33}$	0.027134
	(0.4158)	(0.1098)			
5	1.354428	0.533872	4.731542	$2.0874*10^{-32}$	0.051776
	(0.4928)	(0.4212)			
Third sub-period (2000:1-2004:4)					
Number of Lags	ψ	θ_1	MSE	χ^2	R^2
1	-6.723222	3.175531	5.533800	$9.576*10^{-30}$	-0.067622
	(0.1550)	(0.0190)			
2	-14.85100	5.414189	6.436570	$4.6444*10^{-28}$	-0.190953
	(0.2954)	(0.1779)			
3	8.738747	-1.282225	5.459199	$6.783*10^{-27}$	-0.219920
	(0.8046)	(0.8987)			
4	10.88168	-2.081273	5.691272	$1.448*10^{-27}$	-0.508474
	(0.9075)	(0.9384)			
5	-28.43026	9.096635	8.711777	$9.81*10^{-26}$	-1.443278
	(0.8441)	(0.8271)			

Appendix B

Generalised Method of Moments Results: Multivariate Model

Number of Lags	ψ	θ_1	θ_2	θ_3	MSE	χ^2	R^2
Whole period (1970:1-2004:4)							
1	-1.316435	0.544978	-0.010574	0.208665	3.752673	$1.38861*10^{-30}$	0.109498
	(0.2742)	(0.0011)	(0.4723)	(0.0034)			
2	-1.638968	0.594237	(-0.000598)	(0.211946)	3.777247	$1.16886*10^{-29}$	0.105576
	(0.3250)	(0.0003)	(0.9826)	(0.0262)			
3	-1.868647	0.605275	0.036380	0.190130	3.987102	$9.7955*10^{-30}$	0.016003
	(0.5574)	(0.0028)	(0.5154)	(0.2734			
4	-15.35266	0.280039	0.282430	0.841739	9.759329	$4.2432*10^{-27}$	-4.668755
	(0.6936)	(0.7903)	(0.7129)	(0.6467)			
5	79.92451	3.894080	-1.415254	-3.948947	9.759329	$4.0095*10^{-27}$	-130.0270
	(0.9242)	(0.9035)	(0.9237)	(0.9262)			
First sub-period (1970:1-1980:4)							
Number of Lags	ψ	θ_1	θ_2	θ_3	MSE	χ^2	R^2
1	-3.648579	1.657249	-0.013588	0.113375	10.05733	$4.588*10^{-30}$	-0.038854
	(0.1462)	(0.0623)	(0.5351)	(0.3484)			
2	-8.291706	4.997725	-0.049207	-0.321763	4.891432	$2.2554*10^{-29}$	-0.375872
	(0.4376)	(0.3080)	(0.6030)	(0.4177)			
3	4.862944	-1.539680	0.066283	0.197036	5.603233	$4.551*10^{-26}$	-0.234016
	(0.7408)	(0.8852)	(0.6188)	(0.8863)			
4	-4.868740	4.692153	0.019610	-0.557417	5.261499	$1.524*10^{-27}$	-0.545373
	(0.4229)	(0.4105)	(0.7633)	(0.5980)			
5	-4.795638	2.503110	0.081302	-0.148458	5.778435	$1.9344*10^{-28}$	-4.795638
	0.3589	0.4169	0.0272	0.8042			

Second sub-period (1981:1-1999:4)							
Number of Lags	ψ	θ_1	θ_2	θ_3	MSE	χ^2	R^2
1	-3.228944	0.4704265	-0.012520	-0.012520	4.620336	$1.2225*10^{-30}$	0.0790885
	(0.0475)	(0.0483)	(0.4683)	(0.0004)			
2	-4.585318	0.560699	0.002759	0.377406	4.738057	$2.9304*10^{-29}$	0.061623
	(0.1362)	(0.0154)	(0.9269)	(0.0327)			
3	-4.886231	0.615483	0.032601	0.359898	4.990614	$2.3433*10^{-30}$	-0.039155
	(0.2942)	(0.0198)	(0.3490)	(0.2163)			
4	-9.602614	0.480442	0.054597	0.637642	5.688323	$1.6128*10^{-28}$	-0.180110
	(0.1422)	(0.1921)	(0.2629)	(0.1317)			
5	-12.17469	0.642623	0.1111283	0.700208	6.936395	$4.0044*10^{-30}$	-0.671660
	(0.1099)	(0.2736)	(0.2049)	(0.1326)			
Third sub-period (2000:1-2004:4)							
Number of Lags	ψ	θ_1	θ_2	θ_3	MSE	χ^2	R^2
1	-10.57652	5.512673	-0.034858	-0.267380	5.591123	$1.8544*10^{-29}$	-0.223798
	(0.1872)	(0.1620)	(0.2346)	(0.5315)			
2	14.49595	-7.5955210	-0.025914	1.095370	6.252092	$1.7532*10^{-27}$	-0.877191
	(0.4510)	(0.4467)	(0.8509)	(0.2787)			
3	0.9502	0.7656	0.9430	0.8369	5.146532	$5.389*10^{-27}$	-0.090456
	(0.9502)	(0.7656)	(0.9430)	(0.8369)			
4	-14.82727	7.444440	-0.116480	-0.368232	6.153420	$1.2592*10^{-28}$	-0.947057
	(0.1674)	(0.3209)	(0.4968)	(0.7091)			
5	-15.54647	6.559976	-0.046267	-0.202542	6.105295	$5.145*10^{-29}$	-0.576077
	(0.5118)	(0.6196)	(0.8132)	(0.8765)			

Appendix C

GMM MODEL BIVARIATE REGRESSION RESULTS

i) Whole period (1970:1-2004:4)

Dependent Variable: GGDP
Method: Generalized Method of Moments
Date: 02/27/06 Time: 14:46
Sample (adjusted): 1970Q3 2004Q4
Included observations: 138 after adjustments
Kernel: Quadratic, Bandwidth: Variable Newey-West (1), No prewhitening
Simultaneous weighting matrix & coefficient iteration
Convergence achieved after: 1 weight matrix, 2 total coef iterations
Instrument list: C TERM(-2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.468422	0.472645	3.106819	0.0023
TERM	0.637172	0.150329	4.238524	0.0000

R-squared	0.075650	Mean dependent var	2.431522
Adjusted R-squared	0.068854	S.D. dependent var	3.981952
S.E. of regression	3.842422	Sum squared resid	2007.932
Durbin-Watson stat	1.574158	J-statistic	2.72E-31

ii) First sub-period (1970:1-1980:4)

Dependent Variable: GGDP
Method: Generalized Method of Moments
Date: 02/23/06 Time: 18:48
Sample (adjusted): 1970Q2 1980Q4
Included observations: 43 after adjustments
Kernel: Quadratic, Bandwidth: Variable Newey-West (2), No prewhitening
Simultaneous weighting matrix & coefficient iteration
Convergence achieved after: 1 weight matrix, 2 total coef iterations
Instrument list: C TERM(-1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.709752	2.606329	-1.039682	0.3046
TERM	1.816329	0.767943	2.365186	0.0228

R-squared	0.044120	Mean dependent var	3.564186
Adjusted R-squared	0.020806	S.D. dependent var	4.950652
S.E. of regression	4.898880	Sum squared resid	983.9602
Durbin-Watson stat	2.472170	J-statistic	3.99E-32

iii) Second sub-period (1981:1-1999:4)

Dependent Variable: GGDP
Method: Generalized Method of Moments
Date: 02/27/06 Time: 15:31
Sample (adjusted): 1981Q3 1999Q4
Included observations: 74 after adjustments
Kernel: Quadratic, Bandwidth: Variable Newey-West (4), No prewhitening
Simultaneous weighting matrix & coefficient iteration
Convergence achieved after: 1 weight matrix, 2 total coef iterations
Instrument list: C TERM(-2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.111751	1.056214	1.052581	0.2961
TERM	0.678439	0.256660	2.643341	0.0101

R-squared	0.036074	Mean dependent var	2.711216
Adjusted R-squared	0.022686	S.D. dependent var	4.872550
S.E. of regression	4.816963	Sum squared resid	1670.626
Durbin-Watson stat	1.751159	J-statistic	7.99E-31

iv) Third sub-period (2000:1-2004:4)

Dependent Variable: GGDP
Method: Generalized Method of Moments
Date: 02/23/06 Time: 19:30
Sample (adjusted): 2000Q2 2004Q4
Included observations: 19 after adjustments
Kernel: Quadratic, Bandwidth: Variable Newey-West (5), No prewhitening
Simultaneous weighting matrix & coefficient iteration
Convergence achieved after: 1 weight matrix, 2 total coef iterations
Instrument list: C TERM(-1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-6.723222	4.516961	-1.488439	0.1550
TERM	3.175531	1.225379	2.591468	0.0190

R-squared	-0.008309	Mean dependent var	4.046842
Adjusted R-squared	-0.067622	S.D. dependent var	5.404707
S.E. of regression	5.584456	Sum squared resid	530.1645
Durbin-Watson stat	2.509640	J-statistic	5.04E-31

Appendix D

GMM MODEL MULTIVARIATE REGRESSION RESULTS

i) Whole period (1970:1-2004:4)

Method: Generalized Method of Moments
Date: 02/27/06 Time: 15:04
Sample (adjusted): 1970Q3 2004Q4
Included observations: 138 after adjustments
Kernel: Quadratic, Bandwidth: Variable Newey-West (2), No prewhitening
Simultaneous weighting matrix & coefficient iteration
Convergence achieved after: 1 weight matrix, 2 total coef iterations
Instrument list: C TERM(-2) ALSI(-2) M3(-2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.638938	1.659080	-0.987859	0.3250
TERM	0.594237	0.161415	3.681422	0.0003
ALSI	-0.000598	0.027407	-0.021815	0.9826
M3	0.211946	0.094292	2.247754	0.0262

R-squared	0.125162	Mean dependent var	2.431522
Adjusted R-squared	0.105576	S.D. dependent var	3.981952
S.E. of regression	3.765892	Sum squared resid	1900.380
Durbin-Watson stat	1.695940	J-statistic	8.47E-31

ii) First sub-period (1970:1-1980:4)

Dependent Variable: GGDP
Method: Generalized Method of Moments
Date: 02/23/06 Time: 18:52
Sample (adjusted): 1970Q2 1980Q4
Included observations: 43 after adjustments
Kernel: Quadratic, Bandwidth: Variable Newey-West (6), No Prewhitening
Simultaneous weighting matrix & coefficient iteration
Convergence achieved after: 1 weight matrix, 2 total coef iterations
Instrument list: C TERM(-1) ALSI(-1) M3(-1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-3.648579	2.460580	-1.482813	0.1462
TERM	1.657249	0.863525	1.919168	0.0623
ALSI	-0.013588	0.021716	-0.625714	0.5351
M3	0.113375	0.119452	0.949124	0.3484

R-squared	0.035350	Mean dependent var	3.564186
Adjusted R-squared	-0.038854	S.D. dependent var	4.950652
S.E. of regression	5.045913	Sum squared resid	992.9882
Durbin-Watson stat	2.472190	J-statistic	1.06E-30

iii) Second sub-period (1981:1-1999:4)

Dependent Variable: GGDP
Method: Generalized Method of Moments
Date: 02/27/06 Time: 15:25
Sample (adjusted): 1981Q3 1999Q4
Included observations: 74 after adjustments
Kernel: Quadratic, Bandwidth: Variable Newey-West (2), No Prewhitening
Simultaneous weighting matrix & coefficient iteration
Convergence achieved after: 1 weight matrix, 2 total coef iterations
Instrument list: C TERM(-2) ALSI(-2) M3(-2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-4.585318	3.041750	-1.507461	0.1362
TERM	0.560699	0.225855	2.482568	0.0154
ALSI	0.002759	0.029980	0.092029	0.9269
M3	0.377406	0.173160	2.179528	0.0327

R-squared	0.100186	Mean dependent var	2.711216
Adjusted R-squared	0.061623	S.D. dependent var	4.872550
S.E. of regression	4.720034	Sum squared resid	1559.510
Durbin-Watson stat	1.951842	J-statistic	3.96E-31

iv) Third sub-period (2000:1-2004:4)

Dependent Variable: GGDP
Method: Generalized Method of Moments
Date: 02/23/06 Time: 19:32
Sample (adjusted): 2000Q2 2004Q4
Included observations: 19 after adjustments
Kernel: Quadratic, Bandwidth: Variable Newey-West (6), No prewhitening
Simultaneous weighting matrix & coefficient iteration
Convergence achieved after: 1 weight matrix, 2 total coef iterations
Instrument list: C TERM(-1) ALSI(-1) M3(-1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-10.57652	7.652806	-1.382045	0.1872
TERM	5.512673	3.748450	1.470654	0.1620
ALSI	-0.034858	0.028145	-1.238537	0.2346
M3	-0.267380	0.417459	-0.640495	0.5315

R-squared	-0.019831	Mean dependent var	4.046842
Adjusted R-squared	-0.223798	S.D. dependent var	5.404707
S.E. of regression	5.978978	Sum squared resid	536.2226
Durbin-Watson stat	2.513714	J-statistic	9.76E-30