YIELD CURVE AND BUSINESS CYCLE DYNAMICS IN SOUTH AFRICA: NEW EVIDENCE FROM A MARKOV SWITCHING MODEL

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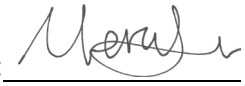
ABSTRACT

Globally, several empirical studies have demonstrated the ability of the yield spread to predict a recession in a country. In South Africa, previous studies have not only shown the yield curve's predictive power but have further demonstrated that it outperforms other commonly used variables, such as the growth rate of real money supply, changes in stock prices, and the index of leading economic indicators. However, some recent studies have shown that the yield spread (the spread between 10-year bonds and 3-month Treasury bills) gave false signals of recession. In this study, we explore the possible reasons for the false signals of the yield spread by addressing the following questions. Does the yield spread used matter? Does the measure of the business cycle used matter? And do the estimation techniques used matter? To address the first question, unlike the previous studies, this paper uses four different yield spreads- depicting short-term, medium-term, and long-term government bonds against the backdrop of a changing structure of bond holding, which reflects the increasing risk eversion of investors in South Africa. Second, the paper used different measures of business cycles, namely industrial production index, lagging, coincident, and leading economic indicators. The empirical models were estimated using both univariate and multivariate Markov switching models. As economic theory suggests, the univariate Markov switching model was used to determine if each variable exhibits a significant regime switching. The multivariate Markov switching model was estimated for each business cycle and yield spread variable, with each of the other variables serving as a non-switching explanatory variable, thereby addressing potential endogeneity concerns and the predictive power of the explanatory variable. Finally, the multivariate Markov switching model was estimated for three monthly sample periods, a full sample for 1986 to 2022, and two sub-samples – 1986 to 2009 and 2010 to 2022. This analysis consistently reveals significant regime-switching behavior across all the series thus, affirming the superiority of the regime switching model over the standard model used in previous studies. By analyzing the transition probabilities and the expected durations between these regimes, we find that including the spreads in the business cycle model improves the models' predictability, with the medium-term bonds spread performing better than the usual long-term spread. The smoothed regime probability of the best-performing models is compared with the SARB recession dates; the two closely resemble each other, proving that the Markov switching model can help predict the turning points in the business cycle in South Africa.

DECLARATION OF ORIGINAL WORK

The work produced in this thesis is my own and was conducted whilst completing the degree of Master of Commerce in Financial Markets at Rhodes University. Any work that is not my own has been credited accordingly in the references.

Signed: 

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CHAPTER ONE

INTRODUCTION

1.1 Background, Context, and Rationale for the Research

The South African Reserve Bank (SARB) has published a timeline of significant business cycle turning points in South Africa since 1946. SARB uses various techniques such as composite coincident indicators, historical diffusion indices, and current diffusion indices to date the turning points (Van der Walt & Pretorius, 1994:1). Determining the business cycle[1] turning points stems from a long tradition in business cycle analysis of separating periods which there is broad economic growth (expansions) from periods of broad economic contraction (recessions) (Chauvet & Senyuz, 2006:2).

To forecast the path of business cycle indicators and predict the direction of the economy and the possibility of recessions, central bankers, investors, and other participants in the financial market typically use sophisticated macroeconomic models and a composite index of leading business cycle indicators (Estrella & Hardouvelis, 1991). Financial factors indicative of future economic activity includes interest rates, stock prices, and monetary aggregates (Estrella & Mishkin, 1996:1). Other financial variables have been used to predict turning points in the business cycle to provide information on when the cycle might change. The yield curve[2]has been popular as an indicator for predicting business cycles since Estrella (1991).

The relationship between interest rates on bonds with varying terms to maturities is the focus of yield curve theories (Fung & Chapple, 1994:36). The three fundamental theories are the expectations, market segmentation, and liquidity preference theories. According to expectation theory, the expected average of the short-term bond's interest rate throughout its whole duration is what determines the long-term bond's interest rate (Moolman, 2002:45). Market segmentation theory states that as the bond market is divided based on maturity, investors will

[1] The business cycle is "the recurrent and varying levels of economic activity that an economy experiences over an extended period," according to the National Bureau of Economic Research (NBER).
[2] The yield curve represents the connection between the interest rates and maturities of bonds and other fixed-income products. The yield curve consists of the returns or yields on long- and short-term assets that are differentiated purely by their maturity dates (Estrella & Truben, 2006).

only purchase bonds whose maturities correspond to their needs (Fung & Chapple, 1994:38–39). Thus, supply and demand determine the yield at each maturity. According to Mishkin (2004:133), the third explanation, the liquidity preference theory, contends that investors favour short-term bonds due to their superior liquidity. Long-term bonds must, therefore, provide a greater yield to offset the added risk.

Since the yield curve slope has been used successfully in forecasting recessions, much research has explored the pathways through which the effects operate (Cooper et al., 2020). The spread reflects the current stance of monetary policy and its complex interactions with expected future economic policies that, in turn, are linked to expectations of future business cycle outcomes. The yield curve slope summarizes many unobserved and observed variables in one composite indicator (Lahiri & Yang, 2022:1).

Numerous studies have been conducted concerning the yield curve and business cycle dynamics (see the literature summary tables A1, A2, and A3 in the appendix). Global literature has provided strong evidence for the yield curve's theoretical capacity to forecast changes in the business cycle, as seen in the works of Estrella & Hardouvelis (1991) (USA), Chinn & Kucko (2009) (USA, EU countries, Canada and Japan), Bauer & Mertens (2018) (USA), Henry & Phillips (2020) (USA, Australia, New Zealand), Kumar et al. (2022) (G7 countries), and Bueno (2023) (USA).

International evidence also shows contrasting views on the forecasting ability of the yield curve. For instance, although Dombrosky & Haubrich (1996) discovered that the yield curve was among the most effective US forecasting instruments from 1961 to 1995, its anticipated accuracy was extremely low from 1985 to 1995. According to Moneta (2003), the yield curve was a good predictor of economic trends in France, Germany, and Italy during the 1970s and 1980s, but it was less effective in the 1990s. According to Chinn & Kucko (2009), the yield curve's ability to anticipate outcomes has worsened.

The failure of the experimental recession index developed by Stock & Watson (1993) was attributed to their reliance on the spread variable (Jardet, 2004). Giacomini & Rossi (2006) attributed several factors to the loss in forecasting power of the yield curve, including unconventional monetary policies, financial innovations, deregulation, deepening of the

commercial paper market, increasing globalization, structural breaks, and the inflation targeting framework.

In South Africa, the relationship between the yield curve and the business cycle has attracted a growing number of studies. Among the earliest studies in South Africa is by Nel (1996), who found a positive relationship between the yield curve and GDP growth. Turning points in the South African business cycle were correctly predicted by the yield spread two quarters ahead, according to research by Moolman (2002 & 2003). According to the empirical findings of Khomo & Aziakpono (2007), the yield curve has proven to be a reliable indicator for predicting most of the recessions in South Africa since 1980. However, their study also revealed an error in estimating the probability that approximately 80% of the economy was in recession in 2003. The lack of a downturn happening indicates a decrease in the ability of the yield curve to forecast recession. However, Clay & Keeton (2011) demonstrated that the yield curve predicted the subsequent downturn in December 2007, thus implying that the yield spread remains a valuable tool to forecast turning points in the South African business cycle. They then concluded that the term structure of interest rates had successfully predicted all five economic downswings in South Africa from 1981 to 2009. Only once, in 2002/03, did it signal a downswing that never officially happened.

Botha & Keeton (2014) contended that unique conditions at the time were represented in the yield curve's erroneous signal of a downturn in 2002, which helped to explain the missed prediction. Firstly, domestic economic activity was fragile, even though the South African Reserve Bank did not officially declare a downturn in the business cycle. Secondly, short-term interest rates continued to be higher than they should have been due to a mistake made by Statistics South Africa when calculating consumer inflation. Correctly anticipating the expected reduction in short-term rates, long-bond rates dropped as soon as the error in the CPI inflation calculation was identified and fixed.

Nel et al. (2017) tested whether the yield curve can still be considered a reliable recession indicator. The study concluded that the yield curve remains a vital forecasting tool for future economic growth paths but that the yield curve’s ability to predict business cycle turning points is less reliable.

Despite the growing research on the relationship between the yield spread and business cycle globally and in South Africa, the relatively inconclusive nature of the findings calls for further investigation. With specific reference to South Africa, except for Moolman (2004), all the research has concentrated on using linear or probit models for the estimation. These studies frequently use probit models to identify recessions, where the term spread is the input variable, and a dummy variable is the outcome. The weaknesses of these techniques are explored later in this study.

Most research concludes that, except for 2002 and 2003, the yield curve is a reliable indicator of South Africa's economic conditions. However, since 2008, the yield curve has not been inverted despite the nation experiencing two recessions and sustained economic weakness (SARB, 2023). This raises the question of why South Africa's yield curve performance is declining. We explore the possible reasons for the false signals of the yield spread by addressing the following questions. Do the estimation techniques used matter? Does the yield spread used matter? Does the measure of the business cycle used matter?

The widely used econometric model is the probability model. Among the many modelling possibilities, Markov switching models might help determine the relationship between term spread and the economic cycle. Regime shift models explicitly treat cyclical dynamics as a sequence of phases characterized by expansion and contraction. Unlike probit models, which impose the date of the business cycle phases using a dummy variable that frequently denotes a recession, a Markov switching model endogenously determines the probability of the underlying regimes of expansion or recession (Bueno, 2023). Markov switching models are a popular choice for yield curve forecasting because of their flexibility, capacity to capture non-linear correlations, and ability to integrate regime transitions (Moolman, 2004; Chauvet & Senyuz, 2016 & Bueno, 2023).

One of the main benefits of the Markov switching method is its capacity to identify non-linear relationships between the yield curve and the business cycle. According to Hamilton (1989), A non-linear relationship between the yield curve and the business cycle is possible with Markov-switching models, allowing for variations across time. Compared to linear models, this flexibility offers a more adaptable specification. This adaptability can be especially useful

for monitoring changes in the relationship between the yield curve and the business cycle during economic instability or uncertainty.

Numerous studies have demonstrated that the Markov switching technique outperforms probit models regarding yield curves and economic cycle prediction. In the case of South Africa, for example, Moolman (2004:7) found that "Markov-switching models better characterize the cyclical behaviour of the yield curve than probit models, particularly during recessions." Similar findings were made by Kim and Park (2005:34), who did a study in the USA and found that "Markov-switching models produce more accurate business cycle forecasts than probit models, particularly during periods of economic instability."

Another concern is how the yield spread is measured. The most commonly used measure of the spread is the 10-year-3month spread, which in most cases has provided significant recession predictions. As explained in Chapter 3, South Africa's bond market dynamic is changing. This is well demonstrated by the changes in bond holdings in that investors are shifting from purchasing long-term bonds to purchasing shorter-term bonds. Thus, it is essential to test whether these changes in bond holdings affect the predictability of the spread. To do so, this study uses four spread specifications representing long medium and short-term bonds.

This study differs in three crucial respects from much of the earlier research examining the relationship between the yield curve and the business cycle in South Africa. First, in contrast to most of the literature, except for Moolman (2004), the Markov switching model is used for estimation. This helps to take advantage of structural breaks, which causes the variables to exhibit different regimes. Second, in terms of the spread used, the ten-year- 3-month spread is not assumed, but instead, a variety of spreads is used in each model to determine which spread specification produces the best results. Third, in contrast to most studies that look at the one-way relationship of the yield curve predicting the turning points in the business cycle, this study considers the bidirectional relationship between the two variables. Additionally, the study extends to 2022, hence providing the latest analysis.

1.2 Objectives of the Research

The study explores the relationship between the yield curve and the business cycle in South Africa to determine the yield curve's predictive ability.

The sub-goals are:

1. Depict the historical relationship between changes in the term spreads and the business cycle phases in South Africa.
2. Investigate if business cycle and yield spread variables exhibit different regimes.
3. Investigate the extent to which changes in the yield curve predict the business cycle phases and vice versa in South Africa.
4. Explore whether the measure of the spread and the indicator used to measure the business cycle matters.

1.3 Methods, Procedures, and Techniques

The data for the study will be obtained from the SARB statistical database and the Refinitiv Eikon database. The estimation period is from 1986(5) to 2022(12). The variables include the industrial production index and the three composite indicators published by SARB (leading, lagging, and coincident indicators) to represent the economy and the government bond interest rates for different maturities to be used to estimate the yield spread.

Objective one of this study, which deals with a historical account of the yield spread and business cycle phases in South Africa, will be achieved through descriptive statistics, including graphical plots. The purpose is to lay the foundation for the subsequent econometric modeling. Following Chauvet & Senyuz (2016) and Bueno (2023), the remaining sub-goals will be met using a Markov switching model. Both the multivariate and Univariate Markov switching models will be used in this study. The full sample data is split into two sub-samples to determine the extent to which yield spread changes help predict the business cycle's turning points. The first period, from 1986 to 2009, represents the period before and including the global financial crisis. The second period, from 2010 to 2022, represents the period after the GFC.

1.4 Structure of the study

This study is structured into six chapters. The first chapter is an introductory section, providing an overview of the research issue and outlining the study's objectives. Chapter 2 presents the literature review, starting with the theoretical underpinnings of the investigation, followed by an empirical literature review. The theoretical literature covers the basic concepts of economic cycles and bond markets before delving into the underlying theories that explain their shifts and the theoretical relationship between the business cycle and the yield curve. Lastly, the chapter reviews prior empirical studies concerning using the yield curve to forecast economic cycles. Chapter 3 presents an overview of the South African economy, focusing on the business cycle and the developments observed in the bond market and their interaction. Chapter 4 presents and discusses the methods used in the analysis. It begins with model specification, definition, and measurements of the variables. Next, the econometric and estimation procedures are carefully articulated and motivated. Chapter 5 presents and interprets the results. The study is concluded in Chapter 6. This chapter summarizes the findings and highlights the implications of the results. Finally, relevant recommendations are presented.

CHAPTER TWO

THEORETICAL AND EMPIRICAL LITERATURE

2.1 Introduction

This chapter reviews the theoretical and empirical literature on the relationship between the yield curve and the business cycle. The chapter is organized as follows. Section 2.2 begins with defining relevant concepts relating to the business cycle, followed by discussing business cycle theories in section 2.2.1. Next, Section 2.3 focuses on the bond market and the yield curve theories. Section 2.4 reviews the theoretical relationship between the shape of the yield curve and the business cycle phases. Section 2.5 reviews the empirical literature on the relationship between the yield curve and the business cycle. The literature reviewed is classified into three areas: Studies focusing on developed countries, studies in emerging markets and developing countries, and studies in African countries, including South Africa.

2.2: Definition, theories and drivers

In business cycle literature, a distinction is usually made between the growth cycle and the classical business cycle (Laubscher, 2004:22). The growth cycle and the classical business cycle are two distinct frameworks for analyzing and comprehending the patterns and dynamics of economic activity. Here is a distinction between the two: The classical business cycle concerns short-term changes in economic activity that revolve around the long-term trend. It includes the four phases: expansion, peak, contraction, and trough, previously mentioned above. The difficulties in economic output, employment, and other macroeconomic indicators are highlighted with cyclical oscillations. This sequence of changes is recurrent but not periodic (Smith & Van der Walt, 1982:49).

On the other hand, the growth cycle concentrates on the long-term pattern of economic development and expansion. It emphasizes the fundamental causes and determinants behind long-term gains in economic output and living standards. The growth cycle analysis considers economic structural changes, human capital development, productivity gains, and technology advancements. It aims to comprehend the causes of economic growth and the prerequisites for

sustained growth. This sequence of changes is recurrent but not periodic (Smith and Van der Walt, 1982:49; Venter & Wolhuter, 2023:1).

In this study, the "business cycle" refers to cyclical phases in the classical sense. Hence, the subsequent discussion will focus on this form of business cycle. An advantage of using the classical sense, as mentioned by Boshoff (2005:695), is its simplicity- it does not entail any data transformation, thus reducing subsequent loss of information (Claessens et al., 2011). Also, relying on the "classical" definition of a cycle is a simple but effective way to identify turning points.

Economic expansion and development do not occur smoothly. Instead of steady growth year after year, the economy experiences cycles in economic activity, i.e., intervals of economic expansion followed by contraction phases. These cycles are termed business cycle, and Aziakpono & Khomo (2007:195) describes them as recurrent but non-periodic fluctuations in the general business activity of an economy. Each cycle consists of four phases: a lower turning point (or trough), an expansion, an upper turning point (or peak), and a contraction (Burns & Mitchell, 1946:3; Laubscher, 2004:22). According to Laubscher (2004:22) the length and intensity of each phase might vary. Below is a brief description of each of these business cycle phases.

1) Expansion/Recovery: This stage denotes a time when economic activity and growth are rising (Laubscher, 2004). During this phase, businesses go through a period of increased sales, rising production levels, rising employment, and rising consumer spending. Investing companies grow the economy, and investors and consumers are optimistic.
2) Peak: The business cycle's maximum stage of economic activity is designated as the peak phase. It denotes the completion of the expansion phase and comes before the beginning of a contraction. When an economy is at its peak, it is running at or close to total capacity, and measures like consumer spending, production, and employment are all at record highs (Laubscher, 2004).
3) Contraction: This is sometimes called the recession period; economic activity declines during this phase. Harding & Pagan (2001:3) identifies recession with the prolonged decline of economic activity. The slowdown in corporate activity results in lower production, dropping job rates, lower consumer spending, and lower firm profitability.

Investment frequently falls during recessions, and economic confidence is lacking. The economy is declining due to declining aggregate demand and excess capacity. In South Africa, recession is defined as two consecutive periods of downswings.

4) Trough: The business cycle's lowest point of economic activity is represented by the trough phase. It signals the conclusion of the contraction phase and comes before the start of an expansion. The economy reaches its lowest point during the trough, with low production and employment levels. But it is also a time of transition when things start to improve, and the economy begins to stabilize (Laubscher, 2004).

2.2.1 Business cycle theories

The business cycle theories aim to explain the reasons behind and trends in the observed economic variations. Over the years, economists have put forth several well-known hypotheses. Although there have been several competing business cycle theories, there is little agreement on the causes of cyclical economic fluctuations.

As stated by Chatterjee (2000:1), early economists believed that every phase of the business cycle is responsible for generating the following stage: a boom causing the next recession and a recession generating the next boom. This implied that the economy is trapped in a self-sustaining loop where the market economy cannot sustainably generate stable economic performance. Aggressive countercyclical policy or institutional restructuring is the best way to deal with cyclical swings (Chatterjee, 2000;1).

The main theories that influence the business cycle are discussed below:

Classical theory: Economic thinkers like Adam Smith & David Ricardo are associated with the classical approach, which emphasizes the function of aggregate supply and demand in figuring out the business cycle. This theory contends that expansions result from increasing productivity, investment, and technical improvements, which raise production, employment, and earnings. Consumer spending is increased, and as a result, promoting economic growth. However, overspending and growing wages over time degrade competitiveness and lower revenues, bringing about a contraction phase (Belongia & Ireland, 2019).

Shock-based theory suggests that the major causes of business cycle movement are shocks that manifest as deviations from macroeconomic variables. These shocks are unobservable because they cannot be connected easily to real-world events (Chatterjee, 2000:2). An advanced form of the shock-based theory is the real business cycle.

Real business cycle theory posits that the business cycle would occur regardless of monetary or financial disturbances. In such cases, countercyclical policies play no role in the economy (Chatterjee, 1999:2). This theory also suggests that changes in productivity explain cyclical movements in economic activity. These productivity changes are a result of technological improvements. According to Fuhrer (1998:2), real business cycle theory assumes that the rate of technology change is the most crucial driver of the business cycle.

Victor Zarnowitz, one of the modern-day economists specializing in real business cycle theory, argued that exogenous shocks and policy effects are more transitory and hence less critical (Zarnowitz, 1999:73). Zarnowitz puts a lot of emphasis on the leading role of corporate profitability, bank credit use, and fixed investment decisions in the propagation of economic fluctuations. According to the author, these parameters are more helpful in deciding the shape of the business cycle than exogenous shocks. One then needs to assess to what extent these variables have been influenced by external shocks to define the changes in the slope of the business cycle.

2.3 Bonds, bond prices, and interest rates

2.3.1 Introduction

A bond is a type of fixed-income investment that stands for a loan from an investor to a borrower, usually a firm or the government (Mohapi & Botha, 2013:14). It is an IOU where the issuer agrees to pay the bondholder the principal amount (also known as the face value or par value) at a specific maturity date in addition to periodic interest payments (coupons) over the bond's term (Ronald & Edgar, 2007:458). When the government or corporation wants to borrow money for a specified duration, they issue a bond.

An organization effectively borrows money from investors when it issues bonds. Whether it is the government or a business, the bond issuer commits to paying the bondholder's common

interest at a specific rate known as the coupon rate. The coupon rate is usually paid semi-annually or annually and is typically represented as a percentage of the bond's face value (Ronald & Edgar, 2007:458). Bonds are often traded on the financial markets, and their prices can change depending on various variables, including changes in interest rates, the issuer's credit rating, and market demand. Because bondholders have a more extraordinary claim on the issuer's assets in case of bankruptcy, they are viewed as safer investments when compared to stocks (Mishkin, 2004).

There are many ways of determining the interest rates on bonds. The most significant is yield to maturity. Yield to maturity (YTM) describes the total return an investor can expect on a bond if kept until its maturity date. It considers the bond's face value (or par value), the coupon rate, the time to maturity, and the bond's current market price (Hull, 2009:79). According to Hubbard (2002:72), yield to maturity is considered by economists as the explicit quantifier of interest rates. When a bond has a maturity of less than a year, it is referred to as a short-term bond; when the maturity is ten years or more, it is regarded as a long-term bond (Mishkin, 2004:26). Another category of bonds is the intermediate bonds(medium-term), which have a maturity of between one year and ten years (Mishkin, 2004:26).

According to Fung and Chapple (1994:36), the link between yield to maturity on bonds with various terms to maturity is a good indicator of how interest rates are structured over time. The yield to maturity, typically represented as an annual percentage rate, shows how profitable or appealing a bond is to investors. It is a significant statistic for contrasting and assessing various bonds and selecting investments (Mohapi & Botha, 2013:14). Another essential bond relationship to discuss is between bond prices and interest rates. Bond prices have a negative relationship with the interest rate (Saunders & Cornett, 2009:31). The idea of interest rate risk can explain the inverse relationship between bond prices and interest rates. Bond prices often decrease as interest rates rise and vice versa. The interest rate-price or price-yield connection is the name of this relationship (Fabozzi et al., 2010:177; Saunders & Cornett, 2009:31; Hubbard, 2002:72).

Bonds play a significant role in the global financial system (Hackethal & Schmidt, 2003:17-18). They allow governments, municipalities, and businesses to raise funds while providing investors a fixed income stream and a return on their principal investment. Understanding the

structures of bonds and the relationship between bond terms and interest rates is crucial to this study because it lays a vital foundation for analyzing the formation of the term structure of interest rates. The following section will examine the term structure of interest rates, their shape, and the theories used to explain their characteristics and behavior.

2.3.2 Term structure of interest rates

The relationship between the bond yields with various terms to maturities is called the term structure of interest rate. The yield curve represents the plot of interest rates of bonds against their times to maturity (Nel, 1996:162; Aziakpono & Khomo, 2007:22). Mishkin (2004:137) also defined the yield curve as the plot of bond yields with different maturity periods but with the same risk, tax considerations, and liquidity, and this only applies to a particular type of bonds such as the government bond. The yield spread is the difference between two maturity periods of bonds; it can be the difference between long-term and short-term bonds or medium-term and short-term.

The effect of term to maturity on yields after all other potential causes of yield changes have been ruled out is crucial in discussions of the term structure (Howells & Bain, 1998:183).

2.3.3 Components of the yield curve

The yield curve, as demonstrated by Chauvet & Senyuz (2016), Hännikäinen (2017), and Patel et al. (2018:1), has three components which are: slope, level, and curvature. Chauvet & Senyuz (2016) further stated that yield curve components contain valuable information for recession forecasting.

The **yield curve's slope** refers to the difference between yields of long-term and short-term bonds (Giese, 2008); it is closely related to economic activity and business cycle conditions (Kumar et al. 2021). It can be influenced by monetary policy because it captures business cycle conditions (Kumar et al, 2021). The **yield curve level** refers to the average interest rates across all maturities (Giese, 2008). It is associated with inflation expectations and is often interpreted as the long-run component of the yield curve. According to Estrella & Trubin (2006:4), the yield curve level accurately indicates incoming recession. The **curvature** of the yield curve refers to the degree to which long-term interest rates differ from expected rates based on a

linear relationship with short-term rates (Giese, 2008). It is not associated with any specific macroeconomic variable, but the curvature correlates with the NBER-dated recessions (Chauvet & Senyuz, 2016:326).

A parallel or level shift occurs when there is a uniform change in interest rates across all maturities. According to Phoa (2000), slope shifts occur when there is a change in short-term expectations while long-term rates remain unchanged or when long-term rates change while short-term expectations stay the same. These shocks affect the slope of interest rate curves. According to Colin (2006), curvature movements happen when the rates at intermediate maturities change in relation to those at short and long maturities. This leads to the formation of humped yield curves.

The slope component was used for this study because it demonstrates the difference between long-term and short-term yields, which coincides with our objective to determine which spread can best be used to predict business cycle turning points.

2.3.4 Theories of the yield curve

Theories of the term structure of interest rates explain the yield curve shape. In most instances, the yield curve slopes upward, indicating that long-term securities offer a higher yield than short-term securities. However, the yield curve can also invert (slope downward) when short-term bonds are higher than long-term bonds or be flat when the interest rates are the same across all the maturity periods (Santomero & Babel, 2001:78).

Mishkin & Eakins (1998:147) show that a practical yield curve theory must account for three crucial empirical observations: Interest rates on bonds of various maturities tend to move together over time; when short-term rates are high, yield curves are more likely to be inverted; and yield curves are typically upward sloping.

To explain these empirical observations and the yield curve's shape, economists have developed theories of the term structure of interest rates. These are the expectations theory, market segmentation theory, and liquidity premium theory (Ronald & Edgar, 2007: 64). The fourth theory is the preferred habitat theory, which is closely related to the idea of the liquidity premium (Howells & Bain, 1998:191-192). The expectations theory can only account for the

first two empirical findings. The theory cannot account for the third observation. The theory of segmented markets can only explain the third observation. The liquidity premium theory and the preferred habitat theory considered equivalent (Mishkin 2004:134), account for all three statements. The hypotheses are described in detail below.

2.3.4.1 Market Expectations Theory

According to Chisholm (2002:101), the most frequently held theory of the term structure is market expectations, and it can be regarded as the classical theory of the term structure. According to this theory, a positive yield curve indicates that the market anticipates an increase in interest rates, and the inclination of the yield curve depends solely on the future expectations of the capital markets (Dodds & Ford, 1974:18). This theory also proposes that the interest rate on long-term bonds represents the expected average of short-term interest rates throughout the bond term (Moolman, 2002:45; Fung & Chapple, 1994:34; Aziakpono & Khomo, 2007). The central premise of this theory is that all securities within a given risk class, regardless of maturity, are perfect substitutes. Therefore, the expected returns on these bonds are identical (Aziakpono & Khomo, 207:22). Therefore, bond investors do not favor one maturity over another, and they will not hold a bond if its expected return is lower than that of a bond with a different maturity (Mishkin & Eakins, 1998:149; Michaelson, 1965:445).

Mishkin (2004) explains how the assumption of perfect substitution leads to expectation theory by considering two investment strategies: Buying a one-year bond that matures in one year and, after it matures, purchasing another one-year bond. Two is buying a two-year bond and holding it until maturity.

Because both strategies have the same expected return if people hold both one-year and two-year bonds, the average interest rates of the two one-year bonds should be equal to the interest rate of the two-year bond. For example, let us say the current interest rate on the one-year bond is 10%, and the market expects the interest rate next year to be 12%. If a market participant pursues the 1st strategy of buying two one-year bonds, the expected returns of the two years will be (10% + 12%)/2 = 11% per year. The market participant will then be willing to hold the one-year and two-year bonds only if the expected return per year of the two-year bond equals this. Therefore, the interest rate of the two-year bond must be equal to 11%.

The expectations hypothesis explains why interest rates on bonds with varying maturities move together over time (Mishkin, 2004: 132), which is the 1st empirical observation. Since long-term rates are the average of expected future short-term rates, short and long-term interest rates tend to move in unison. The expectations theory also explains the inclination of the yield curve that slopes downwards when interest rates are at historical highs and upwards when rates are close to the bottom of their range (Howells & Bain, 1998: 187).

As mentioned above, investors perceive a range of 'normal' interest rates to which they expect future rates to return whenever current rates are within or outside the range's limits. When short-term rates are low, investors anticipate they will rise to a normal level; consequently, the average of expected short-term rates is higher than the current short-term rate. Long-term interest rates will be higher than current short-term interest rates so that the yield curve will slope upwards. When short-term rates are high, there is a general expectation that they will return to their average level, at which point long-term rates will fall below the present short-term rate, and the yield curve will invert (Aziakpono & Khomo, 2007:25; Dodds & Ford, 1974:18).

Expectation theory also explains the 2nd empirical observation that the yield curve is typically upward-sloping when interest rates are low and inverted when short-term rates are high. If interest rates are mean reverting (i.e., they tend to return to their normal levels if they are either unusually high or low), then long-term rates will be less volatile than short-term rates because they represent the average of future short-term rates (Mishkin, 2004: 132).

Even though the expectations theory provides a straightforward explanation of how the term structure of interest rates operates, it fails to explain the third empirical observation that the yield curve is typically upward-sloping. This observation implies that short-term interest rates will increase in the future, which is not the case (Howells & Bain, 2002:198). In practice, it is equally likely that the short-term interest rates will decrease or increase. Therefore, according to the expectations theory, the yield curve should be flat instead of its typical upward inclination. Does this imply inherent positive yield curve biases due to factors unrelated to interest rate expectations? Or are investors mistaken on average? This limitation of the expectations theory inspired the development of the market segmentation theory.

2.3.4.2 Segmented Market Theory

According to Mishkin (2004:132), the segmented markets theory sees markets for different maturity bonds as separate and segmented. Each of these bonds with another term to maturity has its market. Thus, each bond's interest rate is determined by its demand and supply in its respective market (Howells & Bain, 1998:190). Therefore, the anticipated return of one bond with a different term to maturity has no bearing on the expected return of another with another term to maturity. Unlike the expectations theory, the segmented markets theory does not assume that bonds of varying maturities are perfect substitutes. The segmented markets theory relies on the notion that bonds of various maturities are thoroughly segmented and are not substitutes for one another (Mishkin, 2004:132).

According to Howells & Bain (1998:190) and Mishkin (2004:132), the primary reason bonds of different maturities are not substitutes under the segmented markets theory is that market investors have a strong preference for bonds with specific maturities over bonds with other maturities. In this situation, only the expected return rates of bonds with maturities that investors have a strong preference for would be of interest to investors.

Moreover, market investors have a desired duration for holding a particular bond. If the investor can locate a bond with the same term to maturity as their preferred holding period, Fung and Chapple (1994:38) argue that the investor will achieve the expected return rates with minimal risk. This implies that different investors favor different maturities for other bonds. If an investor has a brief holding period, he would only be concerned with locating a short-term bond that matches his short-term preferences. Similarly, if an investor intends to hold long-term bonds, he would be concerned with finding long-term bonds that correspond to his long-term interests.

The segmented markets theory can only explain the third empirical observation of the interest rate term structure, that the yield curve typically inclines to slope upward (Mishkin, 2004). In the segmented markets theory, the supply and demand for bonds with different maturities explain the various yield curve patterns. For example, if an investor has a short-term holding period in mind, he will seek out a short-term bond corresponding to his holding period. This indicates that the investor would demand a greater quantity of short-term bonds and a smaller

quantity of long-term bonds. Long-term bonds will have more excellent interest rates and lower prices, whereas short-term bonds will have higher costs (fees) and lower interest rates. This effect induces an upward slope in the yield curve.

These two theories, market expectation and segmented market theory explain facts that the other cannot; a more logical step would be to combine the two approaches, leading to the liquidity premium theory (Mishkin, 2004:133).

2.3.4.3 Liquidity Premium Theory

According to Mishkin (2004:133), liquidity premium theory suggests that the interest rate on a long-term bond will equal the expected average of short-term interest rates over the bond's life, plus a liquidity premium (term premium) proportional to supply and demand conditions for that bond.

In contrast to the expectations and segmented markets theories, the underlying assumption of the liquidity theory is that bonds with varying terms to maturity are substitutes but not perfect substitutes (Mishkin, 2004:133). The theory assumes that a bond's expected rate of return with a particular period to maturity affects bonds with various terms to maturity. However, the idea permits investors to favor one bond with a specific maturity over another.

Since bond prices are not constant because they depend on interest rates, and a bond's duration increases a bond's interest rate elasticity, long-term bonds tend to be more volatile than short-term bonds. Thus, this theory argues that investors require compensation for the risk they undertake while holding long-term bonds and, therefore, should be paid an extra return to encourage them to buy long-term bonds (Van Zyl et al., 2003:43).

The preferable habitat theory is closely related to the liquidity premium theory, which modifies the expectations hypothesis less directly but reaches the same conclusion. This theory posits that investors prefer a particular bond maturity (preferred habitat) over others they choose to invest in. Due to this preference, they will only purchase bonds outside their preferred habitat if the expected return is higher (Fung & Chapple, 1994:38; Howells & Bain, 1998:187; Mishkin, 2004:133).

2.3.5 Relationship between the business cycle and the yield curve

To clearly understand the research objectives, it is essential to understand the relationship between the yield curve and the business cycle and, most importantly, the theoretical justification linking the two. Moneta (2003:10) suggests three theoretical arguments to explain the relationship between the term structure and economic growth. These are market expectations about future interest rates, monetary policy effects, and investor hedging.

2.3.5.1 Market expectations about future interest rates

The first rationale is based on the expectations hypothesis of the interest rate term structure. As noted above, the theory asserts that long-term interest rates reflect the anticipated future path of short-term rates. This hypothesis assumes that various maturities of bonds are perfect substitutes. Therefore, the long-term rates can be viewed as a weighted average of anticipated future short-term rates (Mishkin, 1998:156, Moolman, 2002:44).

Since returns mirror the state of the economy, a recession outlook would imply an anticipated decline in future interest rates, which translates to a decrease in long-term rates. These expected interest rate reductions may be the result of countercyclical monetary policy intended to stimulate the economy (Dueker, 1997:42). The opposite will be the case when the economy is expected to expand, in which case the central bank raises interest rates, in a bid to tighten monetary policy (Moolman, 2004:3). Financial market participants then view this as a temporary shock and therefore expect future short-term rates to rise by less than the current change in the short- term rate. Since monetary policy influences economic activity with a delay of one to two years, tightening policy will reduce future economic activity and increase the likelihood of a recession.

In addition, market expectations may reflect a low rate of return during recessions, which can be explained by credit market conditions and lower inflation expectations (Moneta, 2003:10). In a fundamental framework where the sole financial instrument is the risk-free bond, it can be observed that in the event of an anticipated decrease in income, i.e., a recession, consumers tend to exhibit a preference for saving and investing in long-term bonds to receive returns during the period of economic deceleration. Through this action, there is an increase in the

demand for long-term bonds, which subsequently results in a reduction in the associated yield. Moreover, to fund the acquisition of the extended duration bonds, a purchaser may opt to sell short-term bonds expected to yield higher returns.

In contrast, market players typically anticipate higher interest rates in the future throughout the business cycle's economic expansion/recovery phase since the central bank may tighten monetary policy to combat inflationary pressures. As a result, the yield curve tends to steepen, and the spread widens as long-term bonds increase more than short-term bonds (Moneta, 2003:11, Harvey, 1998:305, Hu, 1993:785).

The central bank directly controls the short-term interest rate, a policy instrument significantly impacting the macroeconomy. While the central bank's actions primarily affect the shorter end-of-the-term structure of interest rates, they may also influence long-term rates through expectations (Estrella & Trubin, 2006:6). The impact of monetary policy on aggregate demand is primarily determined by the changes in short-term interest rates on the yield curve, as long-term interest rates are influenced by the bond market participants' expectation of prospective short-term real interest rates, inflation, and risk premium (Kumar et al, 2021:3, Gowland, 1991:208). Before a recession, the yield spread tends to decrease (Moolman, 2004:3; Bernard and Gerlach, 1998:5).

2.3.5.2 Investor hedging

Hedging comprises various strategies investors utilize to minimize the potential risks associated with their investment activities. Within the framework of the yield curve and the business cycle, investors may employ hedging strategies to safeguard their portfolios against potential alterations in interest rates and economic fluctuations (Moneta, 2003:11, Aziakpono & Khomo, 2007:199).

Yield curve steepening occurs during the expansionary phase of the business cycle, whereby market participants anticipate an increase in interest rates. In response, investors may adopt hedging strategies to safeguard their bond investments and mitigate potential losses (Aziakpono & Khomo, 2007:199). Investors may opt to reduce the duration of their bond portfolios or transition to shorter-term bonds in anticipation of mitigating the impact of

increasing interest rates on bond prices. The heightened desire for shorter-term bonds compared to longer-term bonds can induce a steepening effect on the yield curve (Dueker, 1997:42).

Yield curve flattening or inversion occurs during economic contraction or uncertainty. As explained by Dueker (1997:42), when market participants anticipate a decrease in future interest rates, investors may choose to implement hedging strategies to protect the value of their investment portfolios. Investors may consider extending the maturity of their bond holdings or transitioning to longer-term bonds to secure higher yields in anticipation of future declines in interest rates. The heightened desire for longer-term bonds in comparison to shorter-term bonds can result in the flattening or inversion of the yield curve (Aziakpono & Khomo, 2007:199).

2.3.5.3 Monetary policy effects

The impact of monetary policy is of utmost importance in explaining the correlation between the yield curve and the business cycle. Central banks employ various monetary policy instruments, including manipulating interest rates and implementing open market operations, to exert influence over economic conditions and mitigate fluctuations in the business cycle (Gowland, 1991:207). Aziakpono & Khomo (2007:198) note that central banks directly influence short-term interest rates because they usually operate on the shorter end of the yield curve.

Central banks commonly employ adjustments in short-term interest rates as a fundamental mechanism for executing monetary policy. Central banks set the short-term interest rate based on the level of inflation in the economy (Kumar et al, 2021;3). Since short-term interest rates affect long-term rates (Orphanides & Wei, 2012), the central bank can influence long-term rates via short-term rates, hence the inflation rate and economic activity. During a phase of economic expansion within the business cycle, central banks can decrease interest rates to encourage borrowing and investment, thereby fostering economic growth (Moolman, 2002:45). The implementation of this policy measure has the potential to result in a decrease in short-term interest rates, as evidenced by the downward movement observed in the lower portion of the yield curve (Aziakpono & Khomo, 2007:199). Suppose market participants possess foreknowledge of potential economic overheating and the subsequent emergence of

inflationary pressures. In that case, it is plausible that long-term bond yields will increase in reaction to these anticipations. This, in turn, will lead to a positive yield curve (Moolman, 2004:3).

There is a lag between the business cycle and the term structure of interest rates, which means that changes in the business cycle can impact the yield spread with an inevitable delay. Central bank monetary policy actions can have significant effects. To stabilize the economy, central banks may modify short-term interest rates in response to changes in the business cycle. However, it takes time for the effects of monetary policy to permeate the economy, resulting in a delayed response in long-term interest rates (Moolman, 2004:3).

2.3.5.4 Certainty and uncertainty related to risks

Aside from the three traditional theories, the risks' effects on bond holdings are also explored. Two examples of such risks are political risks and climatic risks. Climatic risks such as natural disasters, climate change, and extreme weather events can decrease values. Like most financial shocks, it is difficult to predict how and when these broader climate risks may be realized as economic shocks. Credit rating analysts and bond investors are concerned with issuers' environmental profiles because of potential regulatory costs and their effects on financial performance (Seltzer, Starks & Zhu, 2022).

Political risks such as political instability, changes in government policies, and geopolitical tensions have a negative impact on the value of government bonds and the level of economic performance. Eichler & Plaga (2017:2) noted that investors respond to increased uncertainty about future economic policy by adjusting bond holdings per the political cycle. For example, investors hold significantly fewer government bonds in an election year. Foreign investors especially acknowledge that turnover in key political players may entail essential changes, but only if sound institutions promote the effective implementation of new policies (Block & Vaaler,2004).

This theory illustrates the impact of risks on the quantity of bonds investors hold, which is crucial in explaining the relationship between the yield curve and the business cycle. When long-term bonds appear risky to investors, they stop buying them and switch to shorter-term

bonds; hence, using the long-term yield in the spread calculation to predict the turning points in the business cycle yields inconclusive results.

According to the theories, a positive yield curve indicates that the economy is in the expansion phase of the business cycle when long-term interest rates are higher than short-term interest rates. This is because low interest rates promote borrowing, which raises consumer expenditure. Similarly, a negative yield curve indicating the business cycle's contractionary phase is produced when short-term interest rates exceed long-term interest rates. Due to the deterrent effect of high-interest rates on borrowing, consumer spending would decrease, which is a source of a downturn.

The relationship between the yield curve and the business cycle has been studied; the past literature is examined in the following section.

2.4 Empirical literature

2.4.1 Introduction

Different authors have empirically examined the theoretical relationship between the yield curve and the business cycle. Authors have used different periods, model specifications, definitions of the term spread, and recession indicators for such empirical studies.

Two broad categories of studies are undertaken concerning the yield curve's predictive ability. One set of studies focused on predicting the future values of economic variables, particularly the real GDP (Gross Domestic Product) growth (see Plosser & Rouwenhorst, 1994; Haubrich & Bombrosky, 1996; Nel, 1996). The second strand of literature focuses on building a model that focuses on directly predicting the turning point in economic activity (see Estrella & Hardouvellis, 1991; Estrella & Mishkin, 1998; Bernard & Gerlach, 1996; Moolman, 2003; Aziakpono & Khomo, 2007; Clay & Keeton, 2011; Chauvet & Senyuz, 2012; Bueno,2021). For the first set of studies, predicting the turning point is a by-product of the study, unlike the second category, where predicting the turning point is the primary goal of the research.

Given the main objective of this study, which is to explore the yield curve’s ability to predict the business cycle turning points, attention is paid to studies that aim to predict the turning

points of the business cycle or timing recessions; that is the second strand of studies. A large body of literature has focused on developed countries such as (Estrella & Hardouvelis, 1991 (USA); Estrella & Mishkin, 1996,1997,1998(USA); Bernard & Gerlach, 1998 (G7 countries); Estrella & Trubin, 2006 (USA); Chen & Tsang, 2013 (UK, USA, Canada, and Japan); Chauvet & Senyuz, 2016 (USA); Henry & Philips, 2020 (USA, Australia, and New Zealand); Bueno, 2023(USA), etc.) others have focused on emerging markets (Nath et al,2012 (India); Morales, 2008 (Chile); Silombing et al,2014(Indonesia); Ramirez & Raul, 2021(Mexico); Krishna and Nag, 2022 (India)). The study on African markets is slowly emerging; examples of works already done are Nel,1996. Moolman 2002, 2003. Aziakpono & Khomo, 2007. Mohapi & Botha, 2012. Botha & Keeton, 2014) all focus on South Africa.

The studies differ in methodology and the variables used to measure the spread and economic activity. The primary model used is the standard Probit model proposed by Estrella & Mishkin (1996); other versions of the model have come up, like the modified probit model proposed by Dueker (1997).

This section reviews the empirical studies for the various countries in three categories: developed countries, emerging markets, and finally, studies done on African countries, emphasizing studies concerning South Africa. Table 2.1 in the appendix summarizes the literature review, highlighting the countries covered, the period covered, the measure used for both the spread and economic activity, the estimation techniques used, and a summary of the findings.

2.4.2 Literature of developed countries

One of the earliest studies was by Estrella & Hardouvelis (1991), which investigated the information content of the yield curve using quarterly data from 1955 to 1988. In this study, the economic activity is measured as the annualized cumulative percentage change in the seasonally adjusted real GNP based on 1982 dollars, and the term spread is calculated as the difference between the 10-year government bond and the 3-month Treasury bills. Their study had three main objectives. One was to identify if there was any additional information provided by the yield curve that was not already in the other economic variables. The second was to test if the yield curve qualified as a leading indicator of economic activity and how helpful the term

structure is as a monetary policy tool. Estrella & Hardouvelis (1991) used data from the United States of America, which found a positive correlation between the term structure of interest rates and economic activity. Using a regression analysis on the relationship between the yield spread and GNP series, the authors found that the term structure can forecast the cumulative fluctuations in Gross National Product (GNP) for sixteen quarters. The term structure can also predict the subsequent marginal changes in real GNP up to seven quarters ahead. The study revealed that a yield curve with a greater slope indicates an accelerated pace of forthcoming economic expansion. In contrast, a yield curve with a lower slope shows a decelerated future economic growth rate.

On the question of whether the changes in the slope of the yield curve are indicative of variations in monetary policy or if they are influenced by other factors, such as interest rate expectations, Estrella & Hardouvelis (1991) incorporated the present value of the short-term rate into the regression model. The study found that the yield curve's slope primarily relates to other variables rather than the current or expected monetary policy, as the yield curve's predictive ability remained constant. This argument suggests that this distinctive feature of the term spread makes it a valuable source of information for central banks in their endeavors to stabilize employment and output.

In a similar study based on the USA, Haubrich & Dombrosky (1996) used data from 1961 quarter one to 1995 quarter three and a least square regression method on a term spread represented by differences in 3-month government rates and ten-year treasury bills. The authors found that the 10-year-3month spread has substantial predictive power. They observe that a decrease in the yield spread usually precedes a decline in real GDP growth in that a narrowing spread will signal a decline in real GDP and a widening spread forecast increase in real GDP growth.

In the case of Estrella & Mishkin (1996), using the 10-year government bond yield and the 3-month Treasury bill rate spread in France, Germany, Italy, the United Kingdom, and the United States, the authors found a significant predictive power for inflations and real economic activity. They can forecast the real GDP growth for a period ranging from four to eight quarters in advance. The authors concluded that monetary policy is a crucial determinant of the term spread predictive ability, but it is unlikely to be the only determinant.

Similar to Estrella & Hardouvelis (1991) and Estrella & Mishkin (1996), Bernard & Gerlach (1996) study the predictive ability of the yield curve in 8 developed countries: Belgium, Canada, France, Germany, Japan, the Netherlands, the UK, and the US. To obtain the extent to which the yield curve provides predictive information about future economic conditions in these countries, an index of leading economic indicators was incorporated into the probit regression model and employed to identify which variable between the yield curve and the leading index forecasts economic activity more accurately. The general finding from this study is that the term spread provided predictive information about probable future recessions in each of the eight countries (Bernard & Gerlach, 1996:4). The forecasting power of the term spread was observed to be highest in Germany, followed by the U.S. and then Canada. In contrast, the term spread provided the lowest predictive content in Japan. In comparison to the leading indicator, the yield curve was able to forecast recessions across three quarters and more into the future in all the countries except for Japan, while the leading indicator was observed to have forecasting power up to three quarters in Belgium and the Netherlands. This study confirms the findings of Estrella & Mishkin (1996) that the yield curve dominated the leading indicators in predicting future recessions with longer horizons. Estrella & Mishkin (1996:5) assert that the fact that the term spread dominates in longer horizons in forecasting future economic conditions is the quality most valued by policymakers.

Ahrens (1999) assessed the informative value of the term structure as a forecaster in the eight OECD nations (identical countries used by Bernard & Gerlach in 1996). This study employs a combination of Markov switching and probit models to re-examine the yield spread across eight countries. The empirical results indicate that the term spread is a dependable indicator of an impending recession. For each country examined, it was observed that the two estimated regimes were linked to economic downturns or upswings, respectively. The analysis suggests that the Markov switching model is a suitable approach for refining the term spread signals, resulting in more precise and stable estimations of recession probabilities.

Karunaratne's (1999) study in Australia used quarterly data from 1972(Q3) to 1993(Q3) and the Probit model to estimate the relationship between real GDP growth and the spread, which is represented by the difference between the ten-year government bond rate and the 90-day treasury bill. Probit modeling of recessions demonstrated that the inverted slope of the yield

curve is a dependable predictor of recessions occurring four quarters in advance. Dueker's (1997:12) use of a dynamic lag structure enhanced the probability of predictions and the estimated fit of the probit equations. The empirical evidence showed that the yield curve is a superior predictor of recessions in Australia compared to other financial indicators. Conraria et al. (2012) used wavelet analysis to assess the relationship between the yield curve shape and the U.S. macroeconomy between 1961 month six and 2011 month twelve across time and frequencies[3]. In this study, the shape of the yield curve was modeled by latent factors corresponding to level, slope, and curvature, as described by Nelson & Siegel (1987). The general findings from the study showed evidence of a reaction of monetary policy to expectations of recessions. The monetary policy explanations for the predictive power of the yield curve, the federal funds rate, and the slope have significantly moved together at all cyclical frequencies across most of the sample period.

Chin & Kucko (2015) base their analysis on eight countries (Canada, France, Germany, Italy, Spain, Japan, Sweden, the UK, and the US. They use monthly data from 1970 to 2013. Their measure for economic activity is the industrial production index, and the measure for the spread is the difference between the 10-year government bond and the 90-day bond. This study concludes that the term spread is statistically significant in predicting recession in all eight countries. From the study, it is argued that even though the yield curve is statistically significant in predicting a recession, it could only predict accurate forecasts for the US, Germany, and Canada but not for Japan and Italy.

All these studies focus on using the yield curve to predict the business cycle without considering the bidirectional relationship between the two variables. Chauvet and Senyuz (2016) are among the earliest studies to consider the bidirectional relationship between term spread and the business cycle. The study employed a multivariate joint bi-factor model to extract two latent Markov switching variables. The first variable was derived from monthly industrial production, while the second variable was obtained from empirical proxies that

[3]According to Conraria et al 2008:3, wavelet analysis is a mathematical technique used in analysing data considering both time and frequency. wavelet analysis performs the estimation of spectral characteristics of a time series as a function of time, revealing how the different periodic components of the time-series change over time.

capture the yield curve's level, slope, and curvature. The two latent factors are subject to an unobservable autoregressive mechanism, whereby two separate Markov switching variables determine the intercepts. The Markov switching model[4] successfully predicted all peaks and troughs of the business cycle, both within the sample and beyond it.

Bueno (2023) builds on Chauvet & Senyuz (2016). It analyzes the interrelated connection between the term spread and the business cycle. The process entails deriving two interconnected latent Markov variables. The first variable is derived from four distinct activity[5] indicators, simulating the specific phases of the business cycle that occur in the United States. The second variable pertains to the term spread and distinguishes between two distinct regimes: the normal regime, characterized by a positive slope, and the flattening regime. The study found that the term spread is a reliable indicator of a change in the business cycle. However, the cyclical factor only indicates the beginning of the yield curve's upward slope (Bueno, 2023).

2.4.3 Literature on Emerging Markets

Many studies have explored the relationship between the yield curve and economic activities in emerging markets. Table A2 in the appendix summarizes studies in emerging markets.

Kaya (2013) investigates the yield curve forecasting performance and the role of macroeconomic variables in forecasting the yield curve in Turkey from 1993 to 2009. The study used different models to explore the yield curve forecasting performance- Dynamic Nelson-Siegel Model (DNS), no-arbitrage affine term structure VAR (ATSM) model, and principal component (PC) analysis. There were four results from the study. First, it was found that macroeconomic variables are instrumental in forecasting the behavior of the other macroeconomic variables. Second, the forecasting performance of the yield curve depends on the period under review. Third, considering structural breaks associated with changes in monetary policy leads to better forecasts. Lastly, the role of the exchange rate should not be

[4] Markov switching model will be clearly explained in the methodology chapter.

[5] The variables included in Bueno (2023) are Index of Industrial production, personal income less transfer payments, manufacturing & trade industries sales and the number of non-farm employees.

ruled out when forecasting the behavior of other macroeconomic variables in emerging markets like Turkey.

Khandwala's (2015) study is based in India. This study uses wavelet-based filtering to explore the predictive power of the yield curve's slope in predicting economic slowdowns in India[6]. The study developed a new approach using duration models to enable the construction of real-time forecasting of recession probabilities. The duration model is fitted to estimate the conditional probability of a recession using the yield curve slope as a predictor. Economic activity is modeled using real GDP. The author concludes that there is strong empirical evidence of the yield curve in predicting economic slowdowns in India and that monetary policy directly affects the term spread, a leading indicator in predicting macroeconomic activity over long horizons.

To examine business cycle predictions in 8 of Mexico's most critical metropolitan economies, Fullerton & Rojo (2018) use the probit model and quarterly data from 1990 to 2015. Results from the analysis indicate that both the Mexican and the US yield spreads[7] contain information about recessions for at least some of the eight urban economies included in the sample.

The general conclusion from the studies on emerging markets is that the slope of the yield curve seems to anticipate the behavior of economic activity. Thus, the yield curve is a suitable indicator of future economic activities.

2.4.4 Literature on African Countries

Many studies have been done on developed and emerging markets regarding the relationship between the yield curve and the business cycle. Still, there has been limited research in African countries, except for South Africa, where some studies have been conducted. This is shown in Table A3 in the appendix.

[6] According to Joo & Kim (2015), wavelet filtering is a technique that divides the original time series into the trend and variation parts before building a distinct model for each portion.
[7] In this study aside from testing the Mexican yield curve a comparison was done with the US yield curve.

This literature review will focus on two strands of literature that have been done in relation to African markets. The first strand is studies that focus on the yield curve forecasting economic activity, e.g., Nel (1996) (South Africa), Treba (2006) (Nigeria), & Oboh & Abdulsalaam (2021) (Nigeria). Second strand of studies focuses on the yield curve's ability to predict recessions, e.g., Moolman (2002) (2004) (South Africa), Clay & Keeton (2011) (South Africa), Mohapi & Botha (2012) (South Africa), Botha & Keeton (2014) (South Africa), Boukhatem & Sekouhi (2017) (Tunisia), Aziakpono & Khomo (2007) (South Africa), & Aye et al. (2019) (South Africa).

Nel (1996) examines how the yield curve relates to economic activity. This study used quarterly GDP data to measure economic activity and the difference between 10-year government bonds and 3-month Treasury bills as the term spread to determine this relationship. Nel (1996) uses cointegration techniques for the analysis, and the results show that the yield curve is statistically significant in explaining changes in economic growth in South Africa.

Moolman (2002) explored the effectiveness of the term structure of interest rates in predicting business cycle turning points between 1979 and 2000. The author used the yield spreads calculated as the difference between the three-month bankers' acceptance bills and the 10-year government bonds. Moolman (2002) estimated a probit model using quarterly data. The author found that the yield spread accurately predicted the turning points, though with a two-quarter lag. The study also showed that there is an inverse correlation between the yield spread from two quarters prior and the probability of a recession occurring in each quarter (Moolman, 2002:48). Also, the author found that the yield curve can be considered a dependable indicator for predicting changes in the business cycle, providing a lead time of two quarters.

Furthermore, the study showed that the yield curve has a shorter forecasting horizon in South Africa. This finding contradicts most US and European studies, which suggest the yield curve is most accurate in predicting outcomes within four to eight quarters. Moolman's methodology relies exclusively on the yield curve's slope as a recession predictor. However, it does not compare its effectiveness against other financial indicators to determine if the yield spread performs better.

Moolman (2004) provides a comparative evaluation of the effectiveness of the Markov switching and logit models. First, the study employs a two-regime, first-order Markov switching approach to model the business cycle in South Africa. Moolman (2004) uses the yield spread as the explanatory variable to estimate the transition probabilities. Next, using the same yield spread and a dummy variable for recession, the study estimated a logit model determining the ability of the yield to predict a recession. The analysis revealed that both models[8] accurately predicted the historical turning points of the South African business cycle. According to the study, there is a significant correlation between interest rates and the business cycle. Moreover, the yield spread accurately predicts the turning points of the business cycle, indicating whether the economy is in a recession or not, up to six months in advance (Moolman, 2004:645).

Khomo & Aziakpono (2007) use two specifications of the probit model: the standard probit model, as proposed by Estrella & Mishkin (1996), and the modified model, as suggested by Dueker (1997). The study investigated the predictive content of the term spread and how best it performs against other financial variables such as the real money supply (M3), ALSI, and the leading index of economic indicators. The results were consistent with previous studies (e.g., Estrella & Mishkin 1996 and Bernard & Gerlach 1998) in that the yield curve outperforms other financial indicators in recession forecasting. The study by Khomo and Aziakpono (2007) presents empirical evidence that the yield curve successfully predicted most South African recessions since 1980. However, the findings also demonstrate an 84% probability of error in predicting a recession in South Africa in 2003. This contradicts the SARB quarterly bulletin of March 2011, which reported that South Africa underwent economic expansion from September 1999 to November 2007.

Clay and Keeton (2011) employ both static and dynamic probit models to investigate the yield curve's ability to predict economic downturns in South Africa within the sample. They affirm Khomo and Aziakpono conclusion that the yield curve incorrectly predicted a downturn in 2002/03. However, they also find that the yield curve has not lost its predictive power during

[8] The version of the MS model that Moolman (2004) used in her study compared favorably with the logit model and the MS model made the least mistakes as compared to the logit model.

the most recent recession of 2007/09 and that it has been able to provide a better forecast since 1980 than the JSE All Share Index, the SA Reserve Bank's leading economic indicator, and M3 money supply, with the best forecast occurring two quarters in advance.

Mohapi and Botha (2013) assess the capacity of the South African term spread and those of China, the United States (U.S.), and Germany to predict South African recessions. This study considered the 2009 global fiscal crisis and was motivated by the inconsistencies in the term spread in forecasting, as seen in the false signal of recession in 2003. A dynamic probit model and quarterly data from 1980:1 to 2012:2 indicate that the South African term spread accurately predicted every South African recession since 1980. The spread of the Chinese term accurately predicted the 1996 and 2008 recessions. The US term spread predicted some recessions, while the German term spread predictions were countercyclical.

To explain the yield spread's false prediction in 2002/03. Botha and Keeton (2014) discover that, except for 2002/03, the yield spread has successfully predicted all previous economic downturns in South Africa, with the best prediction occurring five months in advance. From the South African studies, the optimal forecasting horizon is shorter (two quarters) than that obtained by most studies, particularly in the United States and Europe, where the yield curve produces the most outstanding results with an optimal forecasting horizon of four to eight quarters. According to this study, a downswing occurred in 2002-2003 but was not reported because of a mismeasurement of CPI inflation.

Aye et al. (2019) utilized a fractional integration approach to break the yield curve into its expectation and term premium components[9]. Data from 1990: Q1 to 2012: Q1 is analyzed using ten specifications of the probit model. The term "spread" refers to the difference between the rates of 10-year government bonds and three-month treasury bills. The SARB provided the indicator of recession. All models utilized in the analysis successfully predicted the three recession periods within the samples. The best model included the expectation component and economic policy uncertainty. According to Aye et al. (2019:9), the model comprising the

[9] In this study the term spread is decomposed into its term premium and expectation spread using the fractional integration approach. This approach allows the order of integration of a variable to be determined without the restriction of having to choose a priori between zero and one (Aye et al,2019).

expectation component and economic uncertainty offers the most accurate prediction for South Africa's recession over the next four quarters.

This study differs in three crucial ways from much of the earlier research examining the relationship between the yield curve and the business cycle in South Africa. First, in contrast to most of the literature, which uses the probit models, the Markov switching model is used for estimation. Second, in terms of the spread used, the ten-year- 3-month spread is not assumed, but instead, a variety of spreads is used in each model to determine which spread specification produces the best results. Third, in contrast to most studies including, Moolman (2004) which also employed the Markov switching model, that look at the one-way relationship of the yield curve explaining the business cycle, this study considers the bidirectional relationship between the two variables. Hence, this study is similar in spirit to Chauvet & Senyuz (2016) and Bueno (2023), but while the two studies were based on USA data, the current study focuses on South Africa. Thus, this study providing the first analysis of the bidirectional relationship between the two variables in South Africa, while at the same time accounting for changes in the stochastic structure of the economy, such as the possibility of recurrent breaks in the form of switching states of business cycle.

2.5 Conclusion

As has been shown throughout this chapter the yield curve has a strong connection to the business cycle. There is a positive relationship between the slope of the yield curve and the direction of the economy. These suggests that the difference between long-term and short-term interest rates provide valuable information about the direction of the economy.

One other conclusion from this chapter and this can better be seen in the summary of literature table in the appendix is that while there is a vast literature documenting the yield curve’s ability to forecast the turning points of the business cycle, majority of the studies have been done in developed countries. In African context, especially in relation to South Africa, there has not been many studies done.

From the studies done, majority of the literature speaks to the yield curve's ability in forecasting recession, however, there is a growing interest in the yield curve's ability to predict the turning points in the business cycle.

Most studies done in South Africa, except for Moolman (2004), have focused on using linear or probit models for estimation. These studies often employ probit models, with the term spread as an explanatory variable and a dummy variable as the outcome to indicate recessions. The conclusion from most of the studies is that except for 2002/2003 the yield curve is a good predictor for South Africa, but the yield curve has failed to invert since 2008 yet the country has had 2 downswings and prolonged economic weakness (SARB, 2023).

This sets the scene for using an alternative model to explore the nature of the relationship. Another way to understand the changing dynamic of the yield curves and business cycle relationship is to discuss their context in relation to South Africa, this will be the focus of the next chapter.

CHAPTER THREE

OVERVIEW OF THE RELATIONSHIP BETWEEN SOUTH AFRICA'S BUSINESS CYCLE AND THE BOND MARKET

3.1 Introduction

This chapter presents an overview of the historical relationship between changes in the term spreads and business cycle phases in South Africa. The aim is to provide a brief overview of the business cycle and of the bond market, which, in this case, relates to the yield curve. In specific terms, the background events affecting the South African business cycle over the years will be explained, and a brief overview of the structural changes affecting the bond market will be provided.

3.2 Background of South Africa's business cycle

Schumann (1935), marked the first in-depth exploration of economic cycles in South Africa, covering the period from 1806 to 1936. The author observed a total of 31 cycles[10], consisting of 15 complete cycles and 16 incomplete cycles, with an average length of 3.5 years. The author also examined the impact of several factors, such as the discovery of gold, wars, droughts, trade policy, and monetary conditions, on the business cycle (Plumptre, 1940).

Building on Schumann's (1935) research, Du Plessis (1950) presents a second major attempt to measure the business cycle in South Africa covering the period from 1910 to 1948. This period coincides with the establishment of the Union of South Africa and its transition towards a more industrialized economy. Du Plessis's (1950) study revealed the presence of 10 complete cycles and two incomplete cycles, each with an average lifespan of 4.1 years. Furthermore, the author analysed the consequences of fiscal and monetary policy while also delving into the various roles that manufacturing, commerce, mining, and agriculture play in the business cycle.

[10] In this context, cycles are categorized as either complete or incomplete. A complete cycle includes both expansion and contraction phases, starting from one apex and ending at the next. On the other hand, an incomplete cycle has not yet reached the next turning point, so it consists of only one phase.

The National Bureau of Economic Research (NBER) in the United States has served as the foundation for the current period of business cycle measurement, which commenced in 1945. The South African Reserve Bank (SARB) has published a timeline of significant business cycle turning points since 1946. According to Van der Walt & Pretorius (1994:1), they use various techniques, such as composite coincident indicators, historical diffusion indices, and current diffusion indices. The growth cycle definition describes the fluctuations in overall economic activity around the long-term trend (Venter, 2005). This definition forms the foundation for how the SARB evaluates business cycles (Van der Walt & Pretorius, 1994:2).

Early in the 1980s, the South African economy was export-driven, and its domestic business cycle was closely tied to that of the major industrialized nations. Due to the country's heavy reliance on gold exports, the international commodity price cycles had a significant impact on the domestic business cycle (Aziakpono & Khomo, 2007:8). The country's interconnectedness with the global economy contributed to the September 1981 to March 1983 downswing. The 1st oil shock caused a slowdown in the US and other industrial countries during this period. This global slowdown led to exports declining in South Africa and thus the economic downswing (SARB ,1983).

During the late 1990s and early 2000s, South Africa experienced an economic boom fuelled by high commodity prices, particularly gold and other minerals. Additionally, financial deregulation increased foreign investment and contributed to this period of strong economic growth (Venter,2005). The removal of economic sanctions following the end of apartheid further simulated the openness and development of the economy. The Global Financial Crisis (GFC) in 2008-2009 brought about the next phase, which affected the entire global economy, and SA was not immune. The country experienced a significant economic slowdown during this period, marked by declining export demand, reduced investment, and rising unemployment.

Throughout the 2010s, SA faced several challenges that impacted its business cycle (Boshoff, 2020). These included high unemployment rates, income inequality, and policy uncertainty, which affected investor confidence and economic growth. There were periods of modest economic expansion, but overall growth was sluggish compared to other emerging markets.

Table 3.1 below show the business cycle phases in south Africa as presented in the March 2023 Quarterly bulletin by South African Reserve Bank (SARB, 2023).

Table 3.1: South Africa's business cycle phases since 1978

Upward Phase	**Duration in months**	**Downward phase**	**Duration in months**
January 1978 - August 1981	44	September 1981-March 1983	19
April 1983 - June 1884	15	July 1984-March 1986	21
April 1986- February 1989	35	March 1989- May 1993	51
June 1993 -November 1996	42	December 1996- August 1999	33
September 1999- November 2007	99	December 2007- August 2009	21
September 2009- November 2013	51	December 2013- April 2017	41
May 2017- June 2019	26	July 2019- April 2020	10
May-2020- to date			

Source: SARB Quarterly Bulletin, June 2023

The South African Reserve Bank (SARB) considers the upward phases in Table 3.1 to be periods of economic expansion in South Africa. Conversely, the downward phases are seen as segments of the business cycle that represent periods of economic contraction (SARB, 2023). The duration of the downward and upward movements can be determined by the number of months they last. The turning points of the business cycle are represented by the transitions from one phase to the next.

Venter & Wolhuter (2023:1) revisited the business cycle measurement; after the statistical and econometric techniques were applied, the reference date of the South African lower turning point, previously November 2013, was established to be April 2017 with the downward phase lasting 41months. The upward phase, which started in May 2017 till June 2019, went on for 26 months, and June 2019 was identified as the peak. This was followed by a downward phase, which lasted for only ten months and was mainly brought about by the effects of the Covid-19

pandemic. When the recovery phase from the exogenous COVID-19 shock started, the economy entered an upward phase in May 2020 and has been going on till now (SARB, 2023).

The subsequent section provides an overview of the bond market. The analysis of business cycles reveals that the capital markets and the foreign economy have a significant impact on the changes in the cycle.

3.3 South African bond market

3.3.1 Introduction

South Africa has several unique features that make it a compelling case study. It has a large domestic savings base and can borrow from both domestic and international sources (Kapingura & Ikhide, 2011:2). In comparison with other emerging markets, South Africa has a high percentage of bonds issued in domestic currency (over 85%) and percentage of these bonds held by non-residents (over 35%) (Steenkamp et al, 2022).

South Africa experienced substantial capital outflows in 2020, with more significant flows than any other emerging market (IMF 2020). This was driven by a decline in non-residents' participation and increased yields and volatility in mid- to late-March 2020. The long-term debt market is an extension of the short-term debt market (i.e., the money market). It comprises the markets in all long-term debt, including non-marketable debt such as mortgages and marketable debt. The latter is the bond market for long-term marketable debt instruments. Few borrowers can access this market because of the lenders' demands regarding credit risk, marketability, etc. (Elton et al., 2014).

This study will analyse the bond market based on its market mechanism, trading in the bond market, and participants in the market.

3.3.2 Market mechanism

The bond market mechanism is the structure, systems, and conventions that have been put in place to facilitate the issue and trading of bonds (Faure, 2017:15). There are two types of market, i.e., the over the counter (OTC) market and the exchange-regulated market (Kapingura

& Ikhide, 2015). Most bond markets worldwide are OTC markets; the South African bond market is one of the few markets primarily exchange regulated. Kapingura & Ikhide (2017) observed that the South African bond market structure has been an essential factor contributing to its liquidity.

The historical development of the bond market in South Africa began after the country's Union in 1910. The first issuance of bonds occurred in 1911 with the enactment of the General Loans Act, which established loan procedures for the central government. Initially, bonds were either issued through public tender or directly to investors. However, from around 1917, investors were invited to subscribe to bonds, which became the primary issuance method by the government, municipal authorities, and public corporations until the early 1980s (Faure, 2017). In 1982, the Treasury introduced a new way of issuing bonds through tender, facilitated by the Reserve Bank as its agent. Later that year, the Reserve Bank also started issuing government bonds on a tap basis (Kapingura & Ikhide, 2015). This approach was adopted by other major bond issuers in the country. During the 1980s, many issuers actively traded in their bonds to enhance marketability, a practice uncommon in other countries.

In the late 1980s, the bond market in South Africa saw the introduction of options trading, which further increased liquidity (Faure, 2007). In the late 1990s, the National Treasury appointed market makers (primary dealers) to ensure a liquid and active government bond market, and this method has been the primary means of issuing bonds since then.

According to Kapingura and Ikhide (2015), the regulatory environment has played a significant role in the growth of the bond market in South Africa. Considerable modifications have been made to regulating the South African bond market. This includes the transition from Over the Counter (OTC) to Exchange-Traded Markets. Exchange-driven markets eliminate or reduce a variety of risks that are present in OTC markets. These include counterparty risk, settlement risk, broker-dealer fraud, and contaminated securities risk. Efficiency in trading is closely linked to the elimination or reduction of risk. Faure (2008:92) states that a secure and efficient trading environment may involve minimizing or eliminating risks and improving trade efficiency. Faure further emphasizes that this type of setting attracts more participants from within the country and internationally. This increased participation increases turnover and

liquidity, leading to more accurate price discovery. Additionally, there is the possibility of reduced transaction costs.

3.3.3 Trading in South African bonds

Faure (2017) describes the key South African secondary-market players.

1. Board exchanges – the Bond Exchange of South Africa (BESA) was taken over by the JSE in 2009 and transformed into the JSE Interest Rate Market (JSE-IRM). Which later changed its name to Debt Market in 2014 (Faure, 2017). The members of the JSE-DM are banks, smaller broker-dealers, and interdealer brokers. The South African bond is listed in the JSE but traded only through the central bank or the national treasury.
2. Issuers – issuers aim to make a market in their paper to enhance liquidity, thus reducing their interest rate (Faure, 2007). For this study, the bond issuer that will be discussed is the South African government.
3. Investors – investors play a significant role in the bond market. Investors are clients of the members of the JSE-DM (Faure, 2007 & 2017). The major investors are the foreign sector, banks, insurers, local pension funds, and other financial institutions, as will be further discussed.
4. Credit Rating Agencies – the ratings assigned by rating agencies to issuers' bonds significantly impact the rate premium they must pay above the benchmark rates (Faure, 2007 & 2017). These agencies endeavour to arrive at a probability of default. Moody's, S & P, and Fitch IBCA are the principal rating agencies. SA government is rated 'BB-'with a stable outlook by Fitch, 'BB' with a stable outlook by S& P, and 'Ba2' with a stable outlook by Moody's. In 2020, Moody's downgraded SA to junk status, below investment grade. This move reflected a continued deterioration in fiscal strength and structurally feeble economic growth. A result of the downgrade would be a reduction in foreign investments through buying bonds.

3.3.4 Issuers and investors of bonds

In most countries, the central government is the primary issuer of bonds. The bonds are commonly known as government bonds or RSA[11] bonds. Government entities issue bonds and list them on the JSE debt bonds to raise funds for significant infrastructure projects like roads, power stations, and hospitals. This practice has been in effect since the enactment of the Debt Boards Inception Act in 1994 (Bacher, 2022). Another reason the government issues long-term debt obligations is to help finance the budget deficit (Faure, 2017). The growth in RSA bonds reflects the accumulation of government budget deficits. RSA bonds are not the sole instruments utilized to finance the deficit. Other instruments, such as Treasury bills and foreign loans, are also employed. However, RSA bonds are the primary instrument (SARB, 2023). The deficit plays a crucial role in fiscal policy, which refers to the government's taxing, spending, and deficit financing programs and how they impact economic growth and employment.

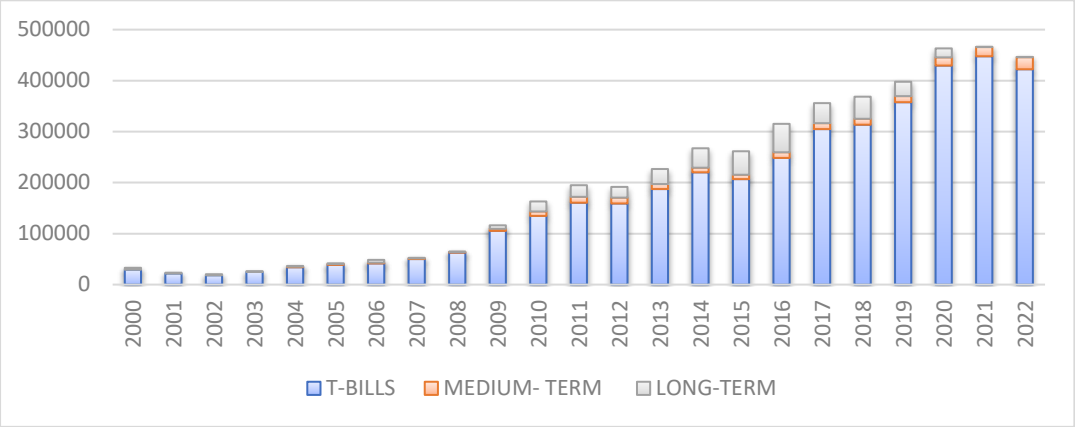
The national government's cash book deficit decreased to R310.0 billion in fiscal year 2022/23. This amount was lower than the initial projection in the 2022 Budget Review. The decrease in debt was due to an increase in revenue collections, which outpaced the growth in expenditure (SARB, 2023). This led to a reduction in the overall borrowing needs covered by issuing domestic debt securities. The national government's primary deficit for fiscal year 2022/23 was R1.7 billion, significantly lower than the initial budget estimate of R85.4 billion. However, as of 31 March 2023, the national government's gross loan debt saw a year-on-year increase of 11.4%, reaching R4 765.5 billion. According to the South African Reserve Bank (SARB, 2022), interest paid on the national government's debt experienced the highest growth rate among expenditure items. It increased by 15.1% compared to the previous fiscal year of 2022/23.

To finance this deficit and other projects, the government must issue bonds. Figure 3.1 and Table 3.2 present the quantity and percentage share of RSA bonds issued at the end of each year respectively, starting from 2000 to 2022. The data is categorized into short-term, medium-term, and long-term bonds. As evident in the Figure 3.1 and Table 3.2, there has been a

[11] RSA stands for Republic of South Africa

remarkable growth in bonds holding especially since 2009. This is evident, not only in the short-term bonds that has witnessed a phenomenal growth, but also in the long term and medium-term bonds. The Treasury bills (short term bonds) have a maturity of 3 months, thus less risk and highly liquid, hence the most preferable for short-term investments. The medium-term bonds have seen a moderate growth over time and for the first time surpassed long-term bonds since 2021. The long-term bonds witnessed a surged between 2010 and 2019.

Figure 3. 1: Bond holdings per year



Source: compiled by the author using data from the Reserve Bank website.

Table 3.2 Shows each maturity proportion compared to the total annual bond holdings. These tables show that after the financial crisis of 2008/2009, the proportion of medium- and long-term bonds increased at a higher rate than short-term bonds.

According to Table 3.2, the holdings of short-term bonds have shown consistent growth. However, the increase in long-term bonds has been inconsistent. Medium-term bonds were not issued between 2000 and 2003. The issuance of these bonds began in 2004, but percentage share of the medium-term bonds fluctuated during that time. Subsequently, the medium-term bond has consistently maintained its percentage share of the total. During the financial crisis, the value of long-term bonds experienced a significant decline while the value of short-term bonds increased. Following the financial crisis, the long-term bond experienced a considerable increase, reaching a peak of 17.68% in 2016. Since 2017, there has been a consistent decrease

in long-term holdings, which has remained unchanged up to the present. In 2022, the percentage dropped to as low as 0.10%.

Table 3. 2: Bond holdings by maturity as a share of the total per year

Date	T-BILLS	MEDIUM-TERM	LONG-TERM
2000	88.75	0.00	11.25
2001	92.84	0.00	7.16
2002	89.49	0.00	10.51
2003	93.60	0.00	6.40
2004	92.90	3.07	4.03
2005	92.63	4.08	3.29
2006	85.72	3.16	11.12
2007	95.42	2.55	2.02
2008	96.83	2.01	1.16
2009	90.64	3.54	5.82
2010	82.59	5.36	12.05
2011	82.37	5.92	11.71
2012	83.02	5.99	10.99
2013	82.67	4.33	13.00
2014	82.36	3.41	14.23
2015	79.11	3.28	17.61
2016	78.79	3.53	17.68
2017	85.69	3.27	11.04
2018	85.08	3.17	11.75
2019	89.92	3.00	7.08
2020	92.73	3.47	3.80
2021	96.06	3.87	0.07
2022	94.61	5.29	0.10

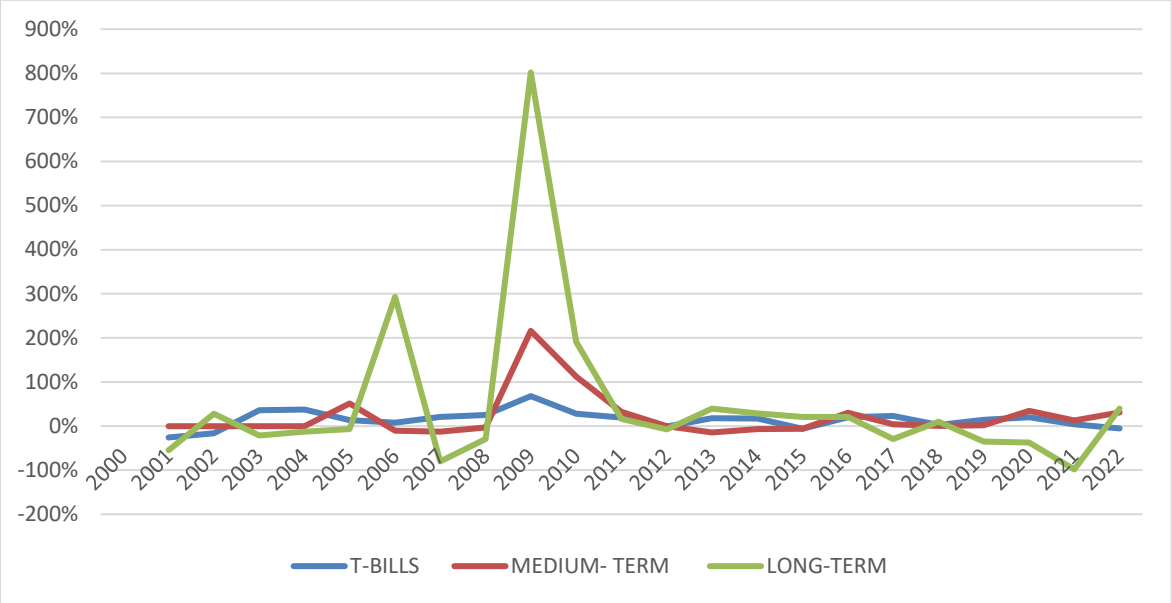
Note: The values are in percentages.
Source: SARB (2023)

South Africa's financial markets have experienced substantial volatility primarily triggered by apprehensions surrounding the COVID-19 pandemic, the Russia-Ukraine war, and the worsening energy crisis (SARB, 2022). This led to Moody's downgrade of the sovereign credit rating to sub-investment grade and South Africa's exclusion from the World Government Bond Index, contributing to the heightened volatility. Due to increased levels of uncertainty, risk aversion led to movement from longer-term investments to shorter-term ones (SARB,2020:1).

Figure 3.2 shows the percentage growth in bond holdings annually. The sharp increase in medium and long-term bonds in 2009/2010 can be attributed to: (i) after the global financial

crisis (GFC), South Africa offered relatively attractive interest rates, and this encouraged people to purchase more bonds (Faure, 2017). (ii) in a bid to increase their exposure to south African bonds as a broader strategy to diversify their holdings and reduce concentration risk institutional investors, such as pension funds and asset managers increased their purchases of bonds (Faure, 2017). (iii) GFC led to unconventional monetary policies such as Quantitative easing where central banks increased their purchases of government bonds (SARB, 2020).

Figure 3. 2: Annual percentage growth rate of Bond Holdings by Maturity



Source: compiled by the author using data sourced from the SARB

Investors buy government bonds to earn from regular interest payments and receive the money they have invested back after a predetermined period. More than R1 trillion is currently listed on the JSE's debt board, and these instruments account for 90% of all liquidity reported on the JSE (Investing.com, 2023). Table 3.3 shows the distribution of the government bonds and the prominent investors in the bonds; this is particularly important because it helps to know which sector highly influences the bond market.

According to a recent article (Bern, 2021), the main investors in South African bonds are domestic institutional investors, such as pension funds, insurance companies, and asset managers. They account for about 60 of the total bond markets. The remaining 40 is held by

foreign investors, mainly from the US, UK, and Europe. The high real interest rates, including South African bonds in global bond indices, such as the Bloomberg Barclays Global Aggregate Bond Index and the JP Morgan Emerging Market Bond Index, attract foreign investors.

Table 3.3: Share of Bond holdings in South Africa by Type of Investors (2006 to 2022)

Period	Foreign sector	Banks	Insurers	Local pension funds	Other financial institutions	Other
2006	8.6	14.0	10.0	44.8	21.1	1.5
2007	10.4	16.3	13.0	46.4	12.0	1.9
2008	12.8	18.0	13.7	43.9	10.2	1.4
2009	13.8	18.3	12.4	39.9	13.2	2.4
2010	21.8	17.7	14.1	36.5	8.1	1.8
2011	22.6	17.1	14.1	36.9	7.1	2.2
2012	32.3	17.1	10.9	30.7	6.7	2.2
2013	37.4	14.8	8.6	28.9	7.3	3.1
2014	37.0	13.9	8.8	31.5	7.6	1.3
2015	34.5	16.1	8.3	31.3	9.0	0.8
2016	35.5	17.0	7.9	29.2	9.7	0.7
2017	39.8	16.7	6.6	26.9	9.5	0.4
2018	40.2	15.7	6.5	25.9	11.3	0.5
2019	37.9	16.9	6.5	25.2	13.0	0.5
2020	31.7	20.8	6.5	23.4	16.6	0.9
2021	29.5	20.8	7.1	22.9	18.3	1.4
2022	27.4	19.7	6.4	23.6	21.1	1.8

Note: The values are in percentages
Source: Compiled by the author using data from the South African Treasury.

However, foreign investors are also sensitive to market sentiment and risk appetite changes. They tend to sell South African bonds when there are signs of fiscal deterioration, political uncertainty, or global market turmoil. For example, in March 2020, when the COVID-19 pandemic triggered a global sell-off of emerging market assets, foreign investors withdrew

about R60 billion from the South African bond market. This caused the bond yields to spike and the rand to depreciate sharply.

3.4 Role of South African Reserve Bank in the bond market

The SARB manages government bond and Treasury bill auctions and oversees foreign exchange reserves for the nation (SARB, 2020). The bank's operations fall under the regulation of the SARB Act 90 of 1989, which grants it the authority to possess and trade various bond types without restrictions on their quantity relative to other assets. While the SARB rarely engages in primary market bond purchases, it has the option for restricted buying as per legal provisions. The SARB remains committed to its price stability mandate, ensuring that its liquidity interventions do not compromise this objective (Steenkamp et al., 2022).

The SARB's responsibility encompasses maintaining financial markets' smooth and efficient operation. The emergence of the COVID-19 pandemic in March 2020 induced liquidity constraints and volatility within money and capital markets. To counteract this, the SARB instituted multiple measures to infuse liquidity, stabilize markets, and foster organized functionality (Havemann et al.,2022). As Havemann et al. (2022) mentioned, one of these measures involved a secondary market government bond purchase initiative. This program spanned the yield curve and effectively mitigated undue government bond price fluctuations while facilitating price discovery and diminishing market dysfunctionality.

In March 2020, the outbreak of the COVID-19 pandemic led to liquidity challenges and market volatility in the money and capital sectors (SARB, 2022). Responding to this, the SARB introduced various measures to inject liquidity, stabilize markets, and ensure systematic operation. One of these measures involved purchasing government bonds in the secondary market. This initiative directly reinstated functionality in the domestic bond market. Despite the primary aim of enhancing domestic bond market stability, the bond purchase program (BPP) inadvertently yielded multiple fiscal advantages. It lowered bond yields, reduced government funding costs, and amplified involvement in non-competitive auctions, culminating in higher-than-anticipated proceeds (SARB, 2020).

Apart from supplying liquidity and facilitating the smooth operation of domestic financial markets, the bond purchase program (BPP) offered the SARB an opportunity to bolster its monetary policy portfolio (MPP) (Havemann et al., 2022). The MPP is a SARB tool for managing liquidity in the money market, allowing liquidity injections or withdrawals. The bond purchases adhered to the SARB's duty to maintain orderly functionality in the local currency bond market and to ensure accurate transmission of price signals that align closely with prevailing economic conditions in the bond market. This orderly operation of the bond market holds significant importance to the SARB, given its role in conveying monetary policy positions to the broader economy.

While the program effectively mitigated immediate liquidity pressures in the bond market, the influence on bond yields seems to have been counteracted by the heightened sovereign credit risk during the COVID-19 pandemic (Steenkamp et al., 2020). The program notably contributed to enhancing the smooth operation of the domestic bond market. Over the initial two weeks of its implementation, the SARB acquired ZAR 6.5 billion worth of government bonds. Concurrently, yields across the South African government bond (SAGB) spectrum decreased by an average of 60 basis points, and bid-offer spreads tightened by an average of 6 basis points after initially widening by 14 basis points (SARB, 2022:3).

The developments that have taken place in the bond market in recent years have affected the interest rates of the bonds and, thus, the demand for the bonds. Different spreads will be used for the analysis to illustrate these effects, with each spread including different rates for each maturity period.

3.5 Relationship between South African business cycle and the yield curve.

This section demonstrates the relationship between the yield spread and the business cycle. First, we define the different yield spreads used in this section and in the subsequent analysis.

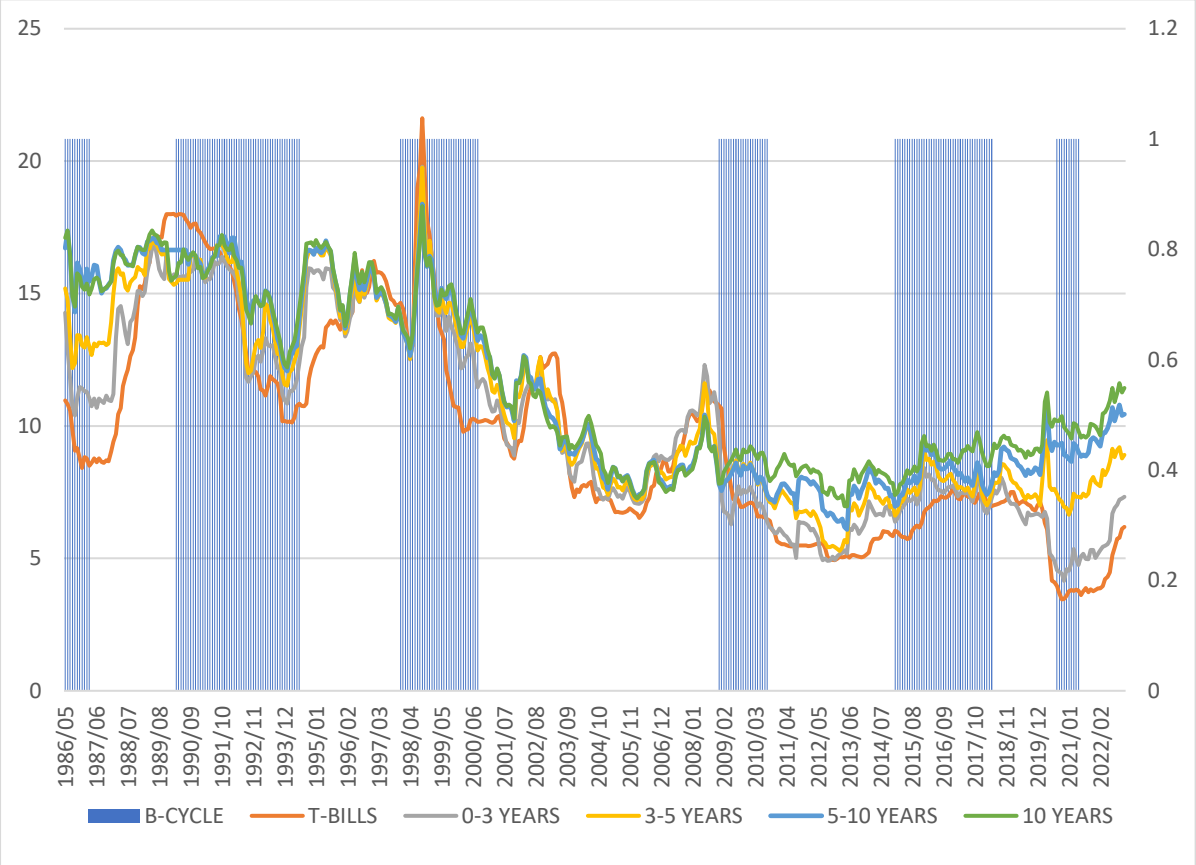
Table 3.4 shows how the spreads are calculated. The 91-day Treasury bill is subtracted from the different maturities of the bonds, which are the (0-3) years bond, the (3-5) year bonds, the (5-10) year bonds, and the ten-year and above bond.

Table 3. 4: Spread calculations

SPREAD	CALCULATION
SPREAD 1	0-3 years bond minus 91-day Treasury bills
SPREAD 2	3-5 years bond minus 91-day Treasury bills
SPREAD 3	5-10 years bond minus 91-day Treasury bills
SPREAD 4	Ten-year bond minus 91-day Treasury bills

Source: The Reserve Bank of South Africa.

Figure 3. 3: Relationships between the yields and the business cycles in South Africa



Note: the primary axis is for the yields, and the secondary axis is for the business cycle. The yields for the different maturities were sourced from the Reserve Bank.

Figure 3.3 shows the relationship between the individual yields and the business cycle. The shaded regions represent periods of economic downswings. The graph shows the Treasury bill rates rise during periods of upswings, as seen from 1987/90 to the point that they are higher than the other rates. In almost all the cases when the Treasury bill becomes higher than the

other rates for the different periods, the business cycle went into a downward phase, as seen in 1989/, 1997/98, and 2009; the only exception was 2002/3 For most of the periods, the different interest rates have moved very closely together, especially the medium to long term yields. It is worth noting that since 2010, the gap between the long-term bond yields (5-10 years and ten years) has widened, even more so since 2019. Coincidentally, while the initial widening gap increased demand for longer-term bonds, as shown earlier in Figure 3.1 and Table 3.2, there has been a significant decline in the demand for long-term bonds since 2017.

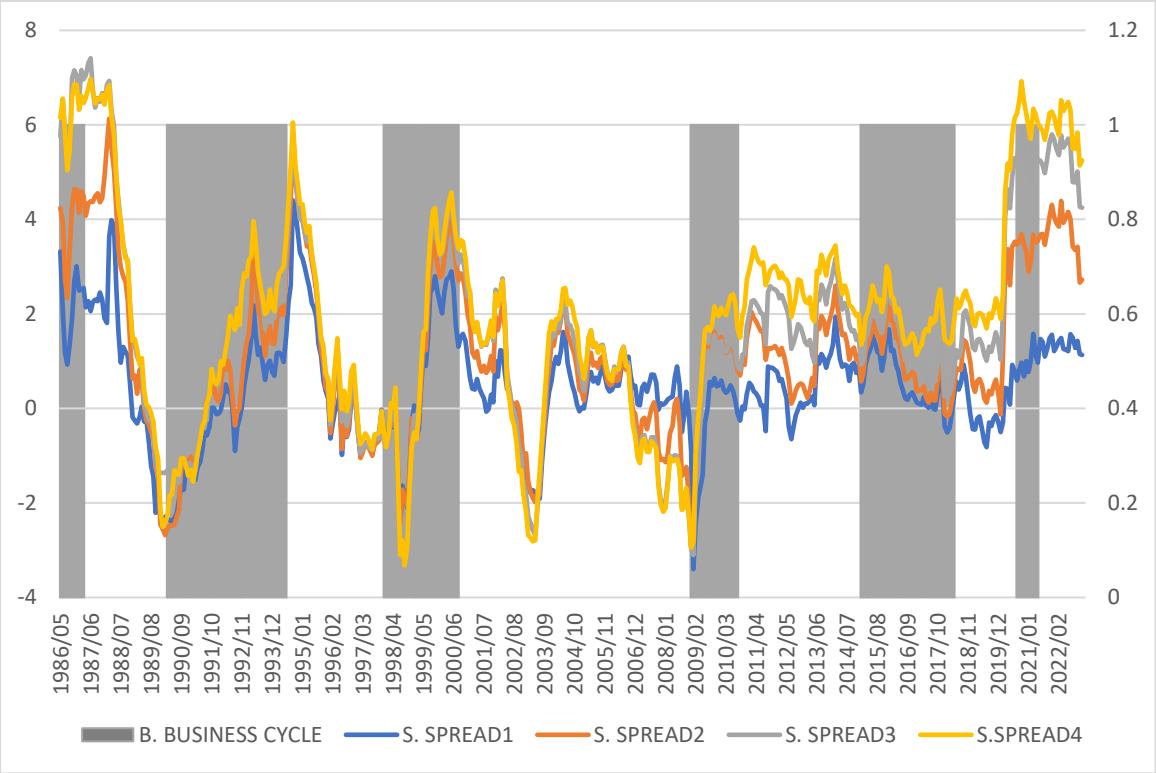
Figure 3.4 shows the relationship between the yield curve and phases of the business cycle. The shaded regions represent periods of economic downswings. In this case, the spread is the difference between the rates of two bonds with different maturity periods. The yield curve in South Africa is positively related to growth in real economic activity. Between 2014 and 2017, a downswing was not predicted by the yield curve, and in 2019-2020. The 2019-2020 downswing was attributed to the COVID-19 pandemic that affected the global economy.

There are also cases where the yield curve inverted, but there was no recession, for example, 2002-203. Clay & Keeton (2011:176) suggest that although a downswing was not recorded in that period, a downswing did occur according to SARB's definition of a recession. During the 2002-2003 period, there was a slowdown in gross domestic expenditure due to a reduction in manufacturing and reduced exports (Clay & Keeton, 2011). In the 2002-2003 period, it is interesting to note that while the yield on the long-term bond rate was declining, the 91-day Treasury bill was increasing, which was attributed to the structural developments in the bond and money market (Aziakpono & Khomo 2007).

A noticeable thing from Figure 3.4 is that (i): There are periods when the spreads move together; that is, there is no significant difference between the spreads; an example is between 1988 and 1991, 1995 and 1999 & 2001 and 2004. Looking at Figure 3.3, these were the periods where the short terms were rising faster than the long-term and middle-term rates or the periods where the short-term rates were higher. (ii) These are the periods with a significant difference between the spreads, such as 1987-89, 2006-09, and 2009-22. During 2006-2009, the short-term spread was higher than the long-term spread, which coincided with the global financial crisis. A noticeable trend is also since 2017 to 2022 when the long-term yields and spreads are significantly higher than their short-term counterpart. Coincidently, that period also witnessed

a significant drop-in long-term bond holding (see Table 3:2). This is typical of investors behaviour in an environment with heighten risks[12] (Seltzer, Starks & Zhu, 2022).

Figure 3. 4: Relationships between the spreads and the business cycle in South Africa



Note: The primary axis represents the spreads, and the secondary axis represents the business cycle.

The spreads were calculated using data sourced from the Reserve Bank.

The question that arises is whether such trend could affect the predictive ability of the yield spreads. For instance, if investors are not buying the long-term bond, will it still be a suitable maturity to use to calculate the spread and thus be used for predicting the turning points? This will be explored by using yield spreads with different maturities.

[12] In addition to the heightened risk environment the bond purchase program by the government could have also led to the reduction of long-term government bonds by investors especially during the covid period 2020/2021.

3.6 Conclusion

This chapter shows the context of the relationship between the business cycle and the bond market in South Africa. Structural changes have occurred over the years concerning the business cycle and the developments in the bond market. This analysis is fundamental because it helps understand the shift in dynamics in the relationship between the yield curve and the business cycle.

South African economy has been impacted by several adverse global developments and domestic structural constraints, which have led to protracted periods of heightened uncertainty and resulted in a gradual decline in the potential economic growth rate.

The implications of these trends relate to the effects such uncertainties and risks might have as discussed in chapter two. In an environment with a heighten risks, risk-averse investors may avoid risky investments; thus, switching to buying bonds they can be certain of. The evidence presented in this chapter seems to confirm this behaviour in South Africa, where investors are moving away from long-term riskier bonds to short term less risky bonds. The next chapter will present the methods the study uses to explore the relationship between the yield spread and business cycle in South Africa.

CHAPTER FOUR

METHODOLOGY AND ANALYTICAL FRAMEWORK

4.1 Introduction

The main aim of this study is to examine the relationship between the yield curve and the business cycle in South Africa to determine the extent to which the yield curve predicts business cycle turning points. This chapter, therefore, outlines the analytical framework that this study will use to achieve this objective together with the sub-objectives (1), (3), and (4), as outlined in Section 1.3. This chapter builds on the previous two chapters, which provided the theoretical background and empirical literature on the relationship between the yield curve and business cycle, and the context of the South African business cycle and the bond market and yield curve.

4.2 Variables and Data sources

Three sets of variables are required for the analysis – variables measuring business cycle, yield spread, and control variables.

4.2.1 Business cycle variables

The business cycle variables include three composite indicators and the industrial production index. According to Venter (2004) and Venter & Pretorius (2004), three composite business cycle indicators exist. These indicators consist of economic time series that are categorized based on their ability to lead, coincide with, or lag movements in the business cycle. The behaviour of each time series varies across different business cycle phases due to the uniqueness of each phase. The reliability of individual time series as indicators is affected by this uniqueness. According to Venter (2004), one way to enhance the consistency and reliability of time series data is by consolidating individual time series into composite indicators, hence why the composite indicators were downloaded from the SARB and used in this study.

The Industrial Production Index (IPI) is a metric used to measure the production levels of the industrial sector. This sector encompasses manufacturing, mining, and utilities. The metric presented in the study by Miron & Romer (1990) offers a comprehensive assessment of the production capacity and operational efficiency of these vital economic sectors. According to Romer (1994:12), the IPI is considered one of the most comprehensive aggregate series available monthly. As a result, it is beneficial for dating business cycles. Some studies that have utilized the IPI as a measure of business cycle turning points include Bueno (2023) and Chauvet & Senyuz (2016).

4.2.2 Measuring the yield spread

Estrella & Mishkin (1996) suggested that the best spread to test the yield curve's forecasting ability is the ten-year-3-month spread. Typically, the case here is that an inverted yield curve precedes recessions. However, out-of-sample forecasts in South Africa predicted a recession in 2003, which was false (Aziakpono & Khomo, 2007). Botha et al. (2017) found that the economic downswing starting in 2013 was not preceded by an inverted yield curve but rather by a narrowing spread, whereby the long rate fell but did not fall below the short rate. In chapter 3 of this study, it is explained that the dynamics of the bond holdings have changed, and the amount of medium-term bonds in issue has increased; this can be a possible reason why using the long-term spread has not been producing conclusive results. Thus, this research tests different spread variations to see which spread is the best fit for forecasting.

The spreads used are: spread 1, spread 2, spread 3 and spread 4. Spread 1 is the difference between the (0-3) year bond and the 91-day Treasury bill. Spread is the difference between the (3-5) year bond and the 91-day Treasury bill. Spread3 is the difference between the (5-10) year bond and the 91-day Treasury bill. And Spread4 is the difference between the 10 year bond and the 91-day Treasury bill.

4.2.3 Control variable

To effectively analyse the relationship between the South African yield curve and the business cycle, it is essential to consider the influence of monetary policy. Including the repo rate as a control variable would provide valuable insights into the impact of monetary policy on the

yield curve and the business cycle. The repo rate[13] set by the South African Reserve Bank (SARB, 2022) determines commercial banks' borrowing costs. The South African Reserve Bank (SARB) uses the repo rate to manage inflation and stimulate economic growth. Changes in the repo rate can impact both the yield curve and the business cycle. By incorporating the repo rate as a control variable, we can isolate and analyse its specific effect on the yield curve and business cycle while accounting for other factors that may influence them.

4.2.4 Data sources

The data were obtained from the SARB online database and the Refinitiv Eikon DataStream. Interest rates on bonds, Treasury bill data, composite indicators, and the business cycle dates were downloaded from the SARB online database. The Refinitiv Eikon DataStream was the source of the index of industrial production data and the repo rate. Monthly data is used from 1986(5) to 2022(12). The South African 91-day Treasury Bill[14] rate was only available as weekly data, so a monthly series was created by finding the average of the weekly measures for each month.

4.3 Model specification and econometric procedures

There have been various econometric approaches to predicting business cycle turning points. The first approach was to build a model forecasting future GDP values. Filardo (1999:39) stated that the GDP forecasting model is a straightforward multivariate regression model in which historical real GDP growth rates, historical real GDP growth rates of the index of leading economic indicators, and historical changes in the yield differential between government bonds and the three-month Treasury bill are all considered when estimating real GDP. Such a model would, therefore, produce GDP forecasts, and a signal of a forthcoming recession would be represented by a projection of two consecutive quarterly declines in real GDP.

[13] According to SARB (2022) in South Africa the repo rate is set by the Monetary Policy Committee (MPC) in its aim to deliver a flexible inflation targeting framework.
[14] Monthly data for the 91day treasury bill can be obtained from the IMF or Reuters database but for the case of uniformity all the bond data for this study was downloaded for the South African Reserve Bank.

Given the significant forecasting errors of large-scale GDP forecasting models around the turning points of the business cycle, Estrella and Hardouvelis (1991) proposed a different approach to forecasting turning points in the business cycle. They estimate a non-linear probit model that directly estimates the probability of a recession at a given time horizon. This approach has subsequently become very popular and has been used by, among others, Moolman (2002), Aziakpono & Khomo (2007), Clay & Keeton (2011), Mohapi & Botha (2012), Botha & Keeton (2014), Benzoin et al. (2018), Cooper et al. (2020) etc to model the likelihood of recessions.

According to Bueno (2023), the studies that employ the probit model consider the term spread as an input variable that signals recession as an output. There have, however, been alternatives to using the probit model, among which is the Markov regime-switching model proposed by Hamilton (1989). The model has been used by Chauvet & Piger (2002 & 2008), Moolman (2004), Chauvet & Senyuz (2016), and Bueno (2023).

The regime-switching model effectively identifies the relationship between term spread and the business cycle. This model explicitly considers the cyclical dynamics of successive downswings and upswings of business cycles. Unlike the probit models, with the Markov switching (MS) model, a dating of the business cycle phases with a dummy variable is not imposed. Instead, the MS model endogenously produces the probabilities of the underlying regimes of recession/expansion. A priori business cycle is not assumed, but the established dates, e.g., by the SARB, are used as a reference point to validate the model (Bueno, 2023;2, Chauvet & Piger, 2002;5).

The advantages of using this model, as discussed by Chauvet & Piger (2002) and Bueno (2023), are that:

1. It incorporates comprehensive information from the components of the yield curve and the economy in a parsimonious setting.
2. This methodology considers the interrelationship between the yield curve components and economic activity through Markov processes.

3. The multivariate framework, combined with non-linearities in the form of switching states, can capture changes in the stochastic structure of the economy (such as the possibility of structural breaks).

In line with Chauvet & Senyuz (2016) and Bueno (2023), this study uses a Markov switching model with four variables representing the business cycle. These are three composite indicators published by SARB and the industrial production index, together with four measures of the slope of the yield curve of South African government bonds. The overall assumption is that the transition probabilities of both Markov processes are time-varying; that is, the business cycle variable depends on the term spread, while the transition probabilities between term spread regimes rely on the business cycle variables (Chauvet & Piger, 2006:12).

4.4 Markov switching analysis

Four alternative models were estimated in this study:

i. Model 1 – univariate Markov switching models for the business cycle indicators (lag, lead, coincident, and IPI).
ii. Model 2 – univariate Markov switching models for the different yield spread (spread [1-4]).
iii. Model 3 – multivariate Markov switching models with a business cycle indicator as dependent variables and a spread as a regressor.
iv. Model 4 – multivariate Markov switching models with a yield curve variable as dependent variable and a business cycle indicator as a regressor.

4.4.1 Univariate Markov switching models

In general, an autoregressive univariate model of order P with first-order M-state Markov switching mean and variance is written as.

$$y_t = \emptyset_1\left(y_{t-1} - \mu_{s_{t-1}}\right) + \cdots + \left(y_{t-p} - \mu_{s_{t-p}}\right) + \varepsilon_t \qquad 1$$

Where $\varepsilon_t \sim N(0, \sigma^2{}_{st})$

$\mu_{s_t} = \mu_1 s_{1t} + \cdots + \mu_m s_{mt,}$ For simplicity assume m=2

$$\sigma^2{}_{st} = \delta^2{}_1 s_{1t} + \cdots + \delta^2{}_m s_{mt},$$

$$P[s_t = j | s_{t-1} = i] = p_{ij} : i, j = 1,2, \ldots\ldots, M \qquad 2$$

$$\sum_{j=1}^{m} = 1$$

The parameters in Eqn (1) can switch between two regimes (states 1 and 2 as represented by S_t). A state variable governs the switching, S_t *= {0,1} (Hamilton.1989).*

When $S_t = 0$ the parameters of the model are different from when $S_t = 1$. The previous state determines the persistence in one state. Under this assumption, the probability process driving S_t is shown by the following four transition probabilities:

$$P(S_t = 1 | S_{t-1} = 1) = p$$

$$P(S_t = 0 | S_{t-1} = 1) = 1 - p$$

$$P(S_t = 0 | S_{t-1} = 0) = q \qquad 3$$

$$P(S_t = 1 | S_{t-1} = 0) = 1 - q$$

According to Chauvet & Piger (2002:8), when S_t changes, it varies depending on which model parameters are allowed to change. S_t in Equation 1 depends on the transition probabilities in (3). When S_t switches from 0 to 1, the growth rate of economic activity switches from μ_0 to $\mu_0 + \mu_1$.

Logically, the duration period of either an expansion or a contraction is supposed to vary depending on the underlying strength of the economy (Moolman, 2004:4). Filardo & Gordon (1998) proposed that a solution to this problem would be to incorporate time-varying transition probabilities (TVTP) that reflect information about where the economy is headed. The

variations in the transition probabilities will then generate the variations in the expected durations.

The TVTPs are:

$$P(S_t = s_t | S_{t-1} = s_{t-1}, z_t = \begin{bmatrix} p_{00}(z_t) & 1 - p_{11}(z_t) \\ 1 - p_{00}(z_t) p_{11}(z_t) & p_{11}(z_t) \end{bmatrix} \quad 4$$

Where z_t represents the explanatory variables upon which the unobserved regime will depend on. In this study, an example of the explanatory variable is the repo rate or the lag of the dependent variable.

After estimating the means and variances of the two regimes, the next step would be to establish if the two regimes are significantly different. This can be done using the Wald coefficient diagnostic test. The test was developed by (Andrews,1987)

The hypothesis of the Wald test is:

H_0- the coefficients are the same, i.e., $\mu_{1=}\mu_2$

The test generates 3 test statistics (t-statistic, f-statistic, and chi-square); if the values of the test statistics are not significant, we fail to reject the null that the coefficients are the same and conclude that the two regimes are not significantly different. The opposite is the case if the test is statistically significant. This Wald test is estimated for the mean and variance.

The next step is to estimate the expected durations and extract the filtered and smoothered regime probabilities. These steps are explained below.

4.4.1.1 Expected Duration

One relevant question when dealing with Markov switching models is, given that we are in regime 1 (for example, downswing), how long, on average, will the regime last? This question can be answered by calculating the expected duration, as Hamilton (1989) defined.

The expected duration of regime one is given by:

$$E(D) = \frac{1}{1-P_{11}} \quad 5$$

The expected duration of regime two is given by:

$$E(D) = \frac{1}{1-P_{22}} \quad 6$$

Where P11 and P22 are the probability of being in regime 1 and remaining in regime 1 in the next period and the probability of being in regime 2 and remaining in regime 2, respectively.

4.4.1.2 Filtered and Probability Smoothing

Filtered probabilities, $P(S_t|\varphi_t)$, refer to references about S_t conditional on information up to $t(\varphi_t)$ (Hamiton,1989). Observing the value of the dependent variable in each period provides additional information about which regime is in effect. Contemporaneous information is used to obtain updated estimates of the regime probabilities (Hamilton,1989; Kim,1992).

Smoothed probabilities, $P(S_t|\varphi_t)$, refers to inferences about S_t conditional on all information in the sample φ_t in contrast to the filtered probabilities, which employ only contemporaneous information (Kim,1992). Smoothed probabilities are generally used to date breaks if $P_{11} > 0.50$ (Chauvet 1998). Estimates of the established regime probabilities may be improved by using all the information contained in the sample.

If the univariate models found significant regimes in each variable, then it will be necessary to use a regime switching model in estimating the relationship between the yield spread and the business cycle. The next section briefly describes the multivariate Markov switching model.

4.4.2 Multivariate Markov Switching Models

The next set of models has the variables for the business cycle, the spread, and the control variable, which is the repo rate. The dependent variable is switching between the regimes while the independent variable is included as a non-switching regressor. In the first sets of models,

each business cycle indicator is used as dependent variable in turns with a measure of yield spread as a non-switching explanatory variable. In the second sets of models, each measure of yield spread becomes the dependent variable, while an indicator of business cycle is the explanatory variable. This analytical technique relates the business cycle and the term spread through a model that permits a bidirectional relationship between the two variables (Ang et al., 2006; Chauvet & Senyuz, 2016; Diebold et al., 2006). The modelling framework helps to address endogeneity[15] concerns.

The general multivariate MS model adopted from Chauvet's (1998) is specified as follows:

$$Y_t = \mu_{s_t} + \sum_{i=1}^{p} \rho_1 \, y_{t-1} + X_t\beta + \epsilon_t \qquad \epsilon_t \sim \mathrm{N}(0,\sigma^2) \qquad 7$$

Where:

Y_t : is the dependent variable.

s_t : is the variables denoting the regimes (0 for low and 1 for high states).

X_t : is a row vector of k exogenous variables included in the model as non-switching regressors and

β : is the corresponding column vector of the k parameters of the regression.

The other tests for the model are carried out the same way as described above with the univariate models.

The study estimated the multivariate Markov switching model using three monthly sample periods: a full sample from 1986 to 2022 and two sub-samples from 1986 to 2009 and 2010 to 2022. The purpose of examining different periods is to determine if there has been a change in the impact of the non-switching regressors on the transition between regimes. We are especially interested in knowing if the predictive ability of the yield spread on the business cycle has

[15] Endogeneity refers to a situation where an explanatory variable is correlated with the error term. This leads to biased estimates and violates the exogeneity assumption of the Gauss-Markov theorem (Roberts & Withed,2015).

changed among the different yield spreads because of the shift in the holding of bonds from long-term to medium-term, which we documented earlier. Specifically, we are interested in comparing the period before the global financial crisis to the period after the global financial crisis.

4.4.3 Model selection and specification tests

Several different specifications of the various models were estimated, including AR (1) to AR (8) processes for the variables in the transition and measurement equations. More highly parameterized models were also assessed, but the coefficients of higher dynamic orders were insignificant at the 5 statistical level. Akaike Information criterion (AIC), Schwarz Information criterion (SIC), and Durbin Watson statistic were used to choose alternative model specifications. The selected model is expected to have no autocorrelation while the model that minimises the AIC and SIC is preferred.

To determine the ability of the alternative models to predict turning points and thus choose the best variable for spread and business cycle, we conduct a forecasting experiment that relies on one-step-ahead prediction errors. The forecasting performance of the models is compared based on the Theil inequality coefficient (TIC). The model with the lowest TIC is selected.

After the best fit model has been chosen, a final step to the estimation procedure is an alternative model, which includes the predictive variables as a switching regressor. In this model both the dependent and the independent variable are allowed to switch between the regimes. The results of the alternative model is then compared with the best fit model to assess the robustness of the results.

4.5 Conclusion

This chapter set out the methodological framework used to examine the relationship between the business cycle indicators and the term spread variables in this study. This chapter started by specifying and discussing the Markov switching and highlighted its advantages over the commonly used linear and probit models. The chapter also discussed the variables, data sources, and estimation procedures used. The next chapter presents and discusses the results.

CHAPTER FIVE

EMPIRICAL RESULTS

5.1 Introduction

The previous chapter provided an in-depth description of the models and the analytical framework used in this study. This research aims to examine the connection between the business cycle and the yield curve in South Africa. This chapter uses the Markov switching technique to analyse the relationship between the business cycle and government bond yield spread from May 1986 to December 2022. In doing this, the chapter addresses the study's primary objective and three sub-goals, as stated in Chapter 1. The study's primary goal is to examine the yield curve's effectiveness in predicting business cycle turning points in South Africa. The subgoals (ii), (iii), and (iv) aim to determine if the business cycle and yield spread variables exhibit different regimes and determine the extent to which changes in the yield curve predict the business cycle phases and vice versa in South Africa, and to determine whether the measure of the spread and the indicator used to measure the business cycle matters. The presentation of the results starts with results of the univariate models followed by the multivariate model results.

5.2 Univariate Markov Switching Model results for the yield curve components and the business cycle components.

The model was estimated using a state-dependent mean and variance. When the mean and variance of a Markov process are considered, they primarily establish whether the variable of interest exhibits regime changes. There are two distinct states or regimes to consider. The first state is characterized by a low variance and a high mean, corresponding to long and steady expansions. The second state, on the other hand, is characterized by high variance and a low mean. The results of the univariate Markov switching model for each variable are presented in Table 5.1. The Markov Switching models were estimated based on the maximum likelihood following the routine in EViews 13. The aims of this estimation were to:

1. Establish the existence or not of regimes in each of the variables.
2. To determine if each of the regimes are significantly different.

3. Testing the transition probabilities between the regimes and how long the variable stays in each regime.

The reported results include the means and variances of regime one and regime two, the transition probabilities, expected durations, and F-statistics for the Wald test of mean and variance equality for the two regimes. Before discussing the results, we assess the adequacy of the model specification using residual diagnostics. If the model is appropriately specified, the estimated residuals for each variable should exhibit no serial correlation. In this study, the Durbin-Watson test was employed to assess autocorrelation. A value close to 2 indicates a minimal level of autocorrelation. According to the results presented in Table 5.1, all Durbin Watson values are approximately 2. This shows that the residuals are not serially correlated with each other over time, suggesting that the models are well behaved.

To demonstrate the existence of regimes in each variable, we compare the means and variances of the two regimes. In this case, "means" refers to each regime's average value of the dependent variable. It is clear from Table 5.1 that the means in regime 1 are distinct from the means in regime 2. All the means are statistically significant, except for the means of spread1 and spread3 in regimes 1. Furthermore, a Wald test was conducted to examine the coefficients of the means in both regimes. The test has the null hypothesis that there is no difference between the means and variances. If the P-value of calculated F-statistic is significant the null hypothesis is rejected, and the conclusion is that the coefficients are statistically different (Andrews, 1987).

The calculated values of the F-statistics reported in Table 5.1 are all statistically significant. Therefore, based on this, we can reject the null hypothesis and conclude that there is a difference in means between the different regimes.

The variance represents the variability or dispersion of the dependent variable in each regime. The variances of all the variables are significant. The initial test for variance involves determining if there is a significant difference between the regimes. This is accomplished by employing the Wald test, using the same criteria for rejection as discussed above. The F-statistics of the Wald test indicate that all the variances are statistically significantly different. Therefore, we can reject the null hypothesis and conclude that the variance behaves differently between the regimes.

Table 5.1: Results for univariate models

		REGIME 1	REGIME 2	P11	P22	Expected Duration		WALD	D-W
						1	2	F-STAT	
BUSINESS CYCLE INDICATORS									
COINCIDE	MEAN	148.01[a]	146.76 [a]	99.33	66.51	150.56	3.62	25.08[a]	1.76
	VARIANCE	-0.65 [a]	1.98 [a]					130.28[a]	
LAG	MEAN	109.28 [a]	111.34[a]	98.13	91.53	53.69	11.81	27.78[a]	1.84
	VARIANCE	-0.24 [a]	-0.27 [a]					53.89[a]	
LEAD	MEAN	104.26 [a]	105.96 [a]	83.55	98.18	6.08	54.99	16.28[a]	1.79
	VARIANCE	0.88 [a]	-0.22 [a]					55.96[a]	
IPI	MEAN	191.73 [a]	197.93 [a]	45.09	63.91	1.82	2.77	135.43[a]	1.68
	VARIANCE	2.29 [a]	0.86 [a]					228.86[a]	
YIELD CURVE INDICATORS									
SPREAD 1	MEAN	0.34 [d]	0.61 [a]	94.26	79.96	17.43	4.99	6.61[a]	2.10
	VARIANCE	-1.45 [a]	-0.36 [a]					132.7[a]	
SPREAD 2	MEAN	1.17 [a]	0.74 [a]	77.02	90.89	4.35	10.98	40.84[a]	1.96
	VARIANCE	-0.59 [a]	-1.40 [a]					74.11[a]	
SPREAD 3	MEAN	1.02 [d]	1.41 [b]	95.36	74.27	21.56	3.89	7.38[a]	2.04
	VARIANCE	-1.21 [a]	-0.30 [a]					58.52[a]	
SPREAD 4	MEAN	1.48 [a]	1.52 [a]	81.13	95.05	5.32	20.19	6.27[a]	1.94
	VARIANCE	-0.23 [a]	-1.44 [a]					64.03[a]	

NOTE: a, b, c represents 1, 5, and 10 levels of significance, and [d] represents values that are not significant.
P12 and P21 can be calculated from P11 and P22 i.e., P12= (1-P11) and P21 = (1-P22).
Coincide represents coincident business cycle indicators, lag represents lagging business cycle indicators, lead represents leading business cycle indicators, and IPI represents Industrial Production Index.
D-W represents the Durbin-Watson statistic.
The AR order used for each estimation was four, and the order selection was based on the Durbin-Watson statistic. The aim was to get a value closest to 2, which was achieved by including four autoregressive terms.

Source: Estimation results by author.

The variance measures the level of variability in the variables. High variances indicate high volatility, indicating that the variables can easily change states. On the other hand, low

variances suggest low variability, meaning that the variables tend to remain in one state (Perlin, 2015:5). For instance, using the IPI exhibits the highest variances of 2.29 in regime 1 and 0.86 in regime 2. From this analysis, we observe that the probability of IPI remaining in its current state is low, with p11 being 45.09 and P22 being 63.91. Spread two exhibits a low variance of -0.59 in regime 1 and -1.40 in regime 2. It follows that there is a high probability of remaining in the same state, with P11 being 77.02 and P22 being 90.89.

Of the four business cycle measures, the lowest mean and variance are leading, then lagging, followed by leading and the one with the highest mean and variance is IPI. With the spreads, spread 1 has the lowest mean and variance, followed by spread three, then spread 2. Spread 4 has the highest mean and variance.

The transition probabilities indicate the likelihood of a variable transitioning from one state to another. P11 refers to a situation where a variable remains in state one after initially being in that state. In the business cycle context, this means that if the economy is in a recession state, it will remain in recession state in the next period. The same logic applies to the yield spread: if it is in a positive slope state, it will maintain that positive slope. Transition probabilities are valuable because they allow us to predict the likelihood of the next state. For instance, if IPI is currently in state 1, there is a 45.09 chance that it will remain in state 1 in the next period and a 63.91 chance to transition to state 2 (calculated as 1-P11) in the next period. Comparing the four measures of the business cycle, we can see that IPI is followed by lag, lead, and finally, coincident, which, in that order, has the lowest transition probability. In the case of the yield spreads, spread 1, followed by spreads 2, 3, and 4, have the lowest transition probability.

Next, consider the expected durations. Expected duration provides information about the time a variable is expected to last within a given regime. For instance, in the case of coincident indicators, if the economy is in regime 1, it is likely to remain in that state for approximately 150 months. Similarly, if the economy is in regime 2, it is expected to stay in that state for about four months before transitioning to a different regime. For the coincident indicator

regime 1 is the high mean state regime[16] and regime 2 is the low mean state regime, therefore this means that the economy stays more in the expansion phase that in the recession phase. Considering the other business cycle indicators, the variables that stay longer in the high mean state than the low mean state are lead and IPI. For the lag it stays more in the low regime than in the high regime. According to Hamilton (1989) the duration of expansions is shorter than the duration for recessions. From the SARB dated recessions the durations for recessions (18months) are shorter than for expansions (51 months). Therefore, the variables that relate to the SARB in terms of durations are IPI, lead and lag.

The same logic can be applied to the spreads. For spread1, the expected duration in regime1 is 17 months, while regime two is five months. For spread 1 regime 2 is the high mean regime while regime 1 is the low mean regime. Spread 2 stays longer in the low mean state than the high mean. Spread 3 stays longer in the low mean state and spread 4 stays longer in the high mean state.

5.4 Multivariate Markov Switching Models Results

Next, we consider the results of the multivariate Markov Switching models. Two sets of models were estimated. The dependent variables in the first set of model results, as reported in Table 5.2, are the business cycle indicators. The model includes the spread as non-switching regressors, meaning they do not change across different regimes. However, they still impact the changes in the dependent variable's regime.

[16] The high and low state regimes are determined by considering the regime with the higher mean and the one with the lower mean.

Table 5.2: Results for multivariate models when the business cycle is the dependent variable

BUSINESS CYCLE									
LAG	REGIME 1	REGIME 2	Coefficient	P11	P22	D-1	D-2	SIC	TIC
SPREAD1(MEAN)	105.94[a]	106.69 [a]	-0.29 [a]	0.98	0.88	8.39	42.03	2.9	0.04
VARIANCE	-0.25 [a]	0.72 [a]							
SPREAD2(MEAN)	101.88 [a]	102.54 [a]	-0.25 [a]	0.94	0.98	16.84	60.54	2.9	0.04
VARIANCE	-0.29 [a]	0.67 [a]							
SPREAD3(MEAN)	102.45 [a]	101.75 [a]	-0.26 [a]	0.94	0.98	16.39	58.13	2.9	0.03
VARIANCE	0.47 [a]	-0.29 [a]							
SPREAD4(MEAN)	103.13 [a]	102.45 [a]	-0.31 [a]	0.92	0.98	62.41	18.55	2.9	0.04
VARIANCE	0.69 [a]	-0.27 [a]							
LEAD									
SPREAD1(MEAN)	111.18 [a]	110.28 [a]	0.47 [a]	0.85	0.98	6.74	72.52	2.9	0.06
VARIANCE	-0.25 [a]	1.06 [a]							
SPREAD2(MEAN)	122.73 [a]	109.31 [a]	-0.04 [a]	0.99	0.85	69.9	6.5	1.84	0.04
VARIANCE	1.04 [a]	-0.24 [a]							
SPREAD3(MEAN)	109.43 [a]	108.49 [a]	0.53 [a]	0.99	0.89	44.98	9.21	3.36	0.02
VARIANCE	1.16 [a]	-0.21 [a]							
SPREAD4(MEAN)	108.78 [a]	107.84 [a]	0.57 [a]	0.99	0.89	37.82	8.94	2.82	0.05
VARIANCE	1.15 [a]	-0.21 [a]							
COINCIDENT									
SPREAD1(MEAN)	102.28 [a]	101.94 [a]	0.09[d]	0.99	0.7	91.92	5.79	1.83	0.06
VARIANCE	2.03 [a]	-0.69 [a]							
SPREAD2(MEAN)	203.18 [a]	202.29 [a]	-0.04 [a]	0.76	1	38.03	5.11	1.84	0.05
VARIANCE	2.13 [a]	-0.64 [a]							
SPREAD3(MEAN)	217.88 [a]	217.00 [a]	-0.06[d]	0.76	1	5.62	81.92	1.84	0.05
VARIANCE	2.13 [a]	-0.64 [a]							
SPREAD4(MEAN)	115.92 [a]	115.82 [a]	-0.05[d]	1	0.83	5.65	79.93	1.84	0.06
VARIANCE	-0.66 [a]	2.30 [a]							
IPI									
SPREAD1(MEAN)	115.91 [a]	124.02 [a]	0.81[c]	0.5	0.75	2.79	1.81	6.63	0.36
VARIANCE	2.30 [a]	1.09 [a]							
SPREAD2(MEAN)	125.66 [a]	117.53 [a]	0.05[c]	0.75	0.49	11.57	17.24	6.64	0.34
VARIANCE	1.09 [a]	2.31 [a]							
SPREAD3(MEAN)	128.41 [a]	120.27 [a]	-2.51 [a]	0.75	0.49	2.79	1.82	4.86	0.05
VARIANCE	1.09 [a]	2.31 [a]							
SPREAD4(MEAN)	131.81 [a]	123.67 [a]	-2.30 [a]	0.75	0.49	12.83	57.68	6.87	0.15
VARIANCE	1.09 [a]	2.31 [a]							

NOTE: *The coefficient represents the parameter of the non-switching regressor. In this case, with the variables of the business cycles as dependent variables, the spreads are the non-switching regressors to determine the impact of the spread on the switching business cycle regimes.*
D-1 and D-2 represent expected durations in regimes 1 and 2. TIC represents the Theil Inequality Coefficient
SIC represents the Schwarz Information Criterion
a, b, c represents 1, 5, and 10 levels of significance and, [d] represents values that are not significant.
Source: Results generated by author

Table 5.3: Results for multivariate models when yield curve spread is dependent variable

SPREADS									
SPREAD 1	REGIME 1	REGIME 2	COEFF	P11	P22	D-1	D-2	SIC	TIC
LAG(MEAN)	5.27[a]	5.01[a]	-0.06[a]	0.78	0.94	17.82	4.41	0.79	0.49
VARIANCE	-0.39[a]	-1.45[c]							
COINCIDE(MEAN)	2.14[a]	2.79[a]	-0.02[a]	0.74	0.96	17.86	4.87	0.84	0.55
VARIANCE	-0.26[b]	-1.36[a]							
LEAD(MEAN)	-0.55[a]	-0.80[a]	0.07[a]	0.8	0.94	4.97	18.29	0.81	0.58
VARIANCE	-0.39[a]	-1.46[a]							
IPI(MEAN)	1.33[a]	1.07[a]	0.01[c]	0.8	0.95	19.16	5.1	0.81	0.59
VARIANCE	-0.36[a]	-1.45[a]							
SPREAD 2									
LAG(MEAN)	8.77[a]	8.39[a]	-0.09[a]	0.79	0.94	4.2	11.68	1.08	0.22
VARIANCE	-0.50[a]	-1.31[a]							
COINCIDE(MEAN)	15.19[d]	4.90[a]	-0.07[a]	0.36	1	4.34	15.15	1.13	0.4
VARIANCE	1.83[d]	-0.93[d]							
LEAD(MEAN)	-1.20[a]	-0.91[a]	0.12[a]	0.95	0.82	5.12	15.7	1.11	0.23
VARIANCE	-1.28[a]	-0.46[a]							
IPI(MEAN)	46.55[a]	47.02[a]	0.01[d]	0.95	0.77	14.72	4.72	1.14	0.42
VARIANCE	-1.29[a]	-0.47[a]							
SPREAD 3									
LAG(MEAN)	9.03[a]	9.80[a]	-0.13[a]	0.71	0.96	4.37	21.07	1.17	0.25
VARIANCE	-0.45[a]	-1.25[a]							
COINCIDE(MEAN)	133.70[a]	133.57[a]	-0.08[a]	0.82	0.96	24.12	4.82	1.16	0.33
VARIANCE	-0.39[a]	-1.24[a]							
LEAD(MEAN)	131.42[a]	131.78[a]	0.12[c]	0.96	0.77	4.12	25.75	1.79	0.29
VARIANCE	-1.24[a]	-0.38[a]							
IPI(MEAN)	126.64[a]	126.21[a]	0.01[b]	0.76	0.96	25.13	4.26	1.16	0.34
VARIANCE	-0.34[a]	-1.22[a]							
SPREAD 4									
LAG(MEAN)	26.97[b]	26.53[b]	-0.12[a]	0.86	0.96	7	24.49	1.04	0.25
VARIANCE	-0.58[b]	-1.25[b]							
COINCIDE(MEAN)	39.66[a]	39.34[a]	-0.08[a]	0.85	0.96	27.33	6.88	1.01	0.4
VARIANCE	-0.48[a]	-1.22[a]							
LEAD(MEAN)	106.08[a]	105.70[a]	0.13[b]	0.84	0.97	32.18	6.29	1.01	0.55
VARIANCE	-0.46[a]	-1.23[a]							
IPI(MEAN)	96.04[a]	95.54[a]	0.01[a]	0.84	0.97	29.7	6.23	1.1	0.33
VARIANCE	-0.49[a]	-1.23[a]							

NOTE : a, b, c represents 1, 5, and 10 levels of significance, and [d] represents values that are not significant.
P12 and P21 can be calculated from P11 and P22 i.e., P12= (1-P11) and P21 = (1-P22).
Coincide represents coincident business cycle indicators, lag represents lagging business cycle indicators, lead represents leading business cycle indicators, and IPI represents Industrial Production Index.
D-W represents the Durbin-Watson statistic.
The number of lags used for each estimation was four, and the lag selection was based on the Durbin-Watson statistic. The aim was to get a value closest to 2, which was achieved by including four autoregressive lags.

Source: Estimation results by the author.

Table 5.3 presents the results for the models where the spreads are the dependent variable, and the business cycle indicators are included as non-switching regressors. Thus, the bi-factor model considers the dynamic interplay between the term structure and the real economy. The tables present the means and variances of the two regimes and the coefficient of the non-switching regressors. Additionally, the tables include the transition probabilities, expected durations, Schwarz information criterion, and Theil inequality coefficient (TIC)[17][18].

In the univariate model with a lagging indicator, the variable remains in the high state for 12 months and in the low for 53 months. These results indicated that the economy stay more in expansion than in recession which did not compare to the SARB dated recessions. However, when the spread (1-4) is included in the models, the durations for the high and low mean states respectively becomes (42,8), (60,16), (16,58), and (62,18) respectively. These results support the findings of Hamilton (1989) and Chauvet (1998) that recessions' average durations are shorter than expansions' durations. SARB data shows that the average recession duration is 18 months, while the upward phase typically lasts 51 months. Although the model results may not align precisely with the SARB findings, they fall within a similar range. One possible reason for the variation is including different numbers of autoregressive lags in the model (Chauvet,1998).

The coefficient representing the non-switching regressors indicates how much the variable added to the model influences the states or the transition between different regimes. The coefficients for spread [1-4] in the model with the lagging indicator are -0.33, -0.37, -0.37, and -0.45, respectively and they are statistically significant. The coefficients have similar implications, indicating that they all impact the business cycle similarly. This result compares to Moolman (2004:12) conclusion on results in that the parameters which govern the time variation of the transition probabilities have opposite signs. In this case the parameters involved are the business cycle variable and the yield curve variable included in the model. This is

[17] Wald test was not estimated for the multivariate models since it had already been established that each variable exhibits 2 regimes from the Wald test estimated for the univariate models.

[18] The repo rate was included in the estimation as a control variable, but the results of the repo rate was not reported in the tables.

consistent with the intuition that an increase in the yield spread increases the probability of remaining in an expansion and decreases the probability of remaining in a recession (Moolman, 2004).

The optimal combination of the multifactor model is determined by evaluating the performance of the different models. This evaluation takes into consideration the coefficient of the regressor (the highest is preferred), the value of the SIC (the lowest is preferred), and the forecasting ability of the model using the Theil inequality coefficient (TIC) (the value closest to zero is preferred). The TIC model with a value most closed to zero indicates a more accurate forecast and less disparity between the predicted and actual values (Cook, 2019).

As seen in Tables 5.2 and 5.3, the values SIC and coefficients of the models are very close. An example is when the lag is the dependent variable, all the spreads have a SIC of 2.9. In this situation, the forecasting ability takes precedence; thus, the spread with the value of TIC closest to zero is considered the best model. The best performing models are reported in Table 5.4. As shown in the Table 5.4, the lagging indicators are the most suitable non-switching regressor to include when spreads are the dependent variable. Spread 3 is the most suitable non-switching regressor to use with the lagging, coinciding and IPI. Spread 2 is best used with the leading indicator.

Table 5.4: Best regressor to be used with the dependent variable

Dependent variable	**Best Regressor**
Lag	Spread 3
Lead	Spread 3
Coincide	Spread 2
IPI	Spread 3
Spread 1	Lagging indicators
Spread 2	Lagging indicators
Spread 3	Lagging indicators
Spread 4	Lagging indicators

Source: estimations by author.

Including different measures of the spread in the models can help determine which spread is more suitable for forecasting recessions. Chapter 3 discusses how changes in the structure of the market, such as monetary development, have influenced investor preferences. Specifically, there has been a shift from long-term bonds to medium-term bonds. This shift is evident in the amount of bond holdings for each term.

However, given that the change has occurred gradually and more recently, a more practical approach to testing it would be to divide the dataset into two parts. The first period, period 1, spans from 1986 to 2009 and represents the time up to the global financial crisis. The second period, depicted as Period 2, covers the years from 2010 to 2022 and represents the period after the global financial crisis, the global pandemic, and the Russia-Ukraine war. The multivariate model was estimated to replicate the multivariate model for the overall period after the periods were split. The results are extracted using the same method as in Tables 5.2 and 5.3. The coefficients for the spreads are compared across the periods, and the results are illustrated in the graphs shown in Figure 5.1.

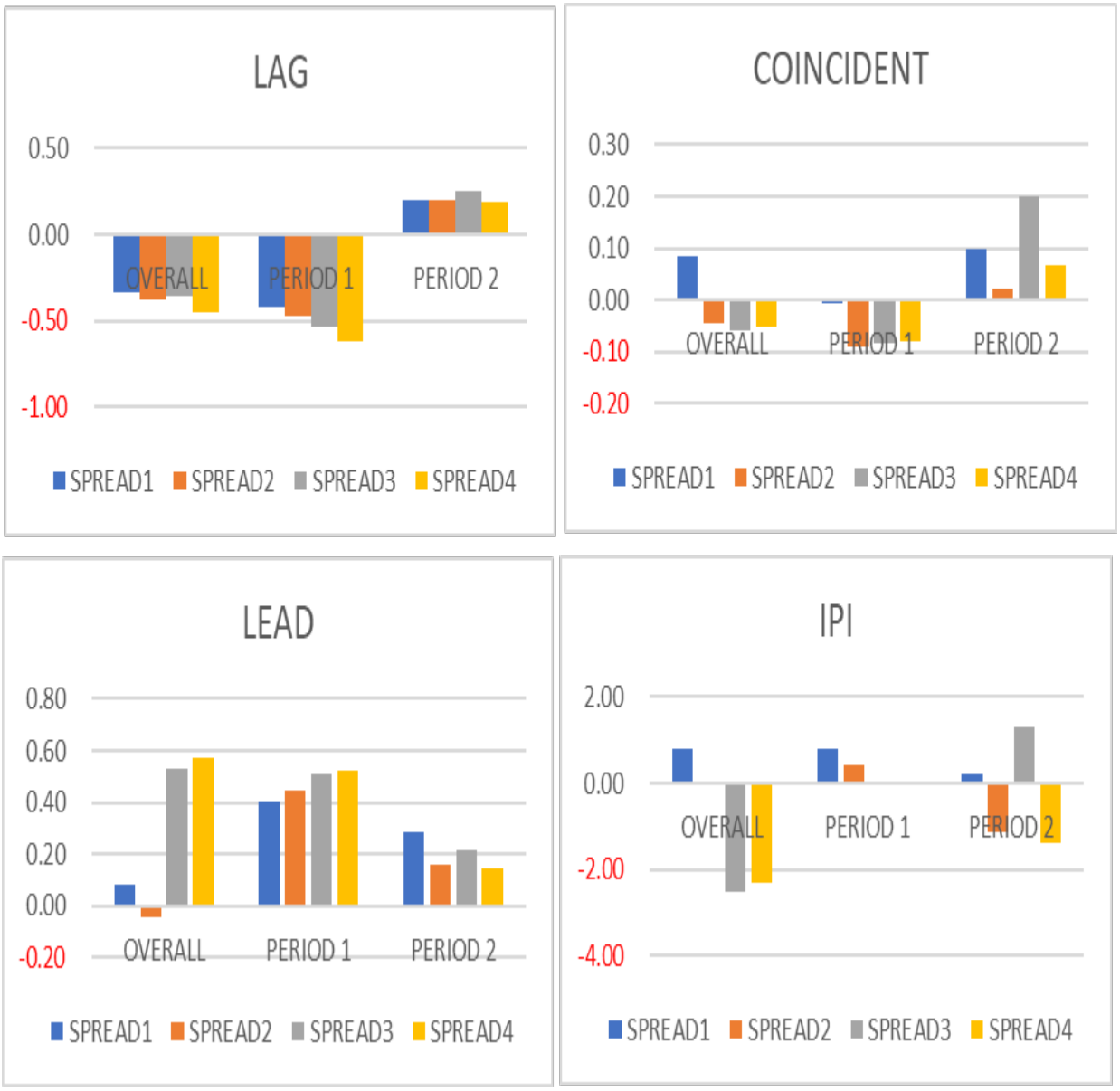
The graphs demonstrate that the most substantial coefficient in the business cycle is spread 1, as seen in period 1. However, there is a shift in period 2, where spread 3 becomes the strongest coefficient. Furthermore, in period 2, all the coefficients positively influence the business cycle indicator.

The lagging indicators in the overall period and period 1 exhibit negative coefficients, with the highest coefficient being spread 4. However, there is a change in the dynamics in period 2. Although all the coefficients are positive, the highest spread is spread 3. The same pattern is evident with the leading indicator. The movements of the Industrial Production Index do not exhibit a clear pattern over the two periods. One potential explanation for the change in period two could be a decrease in preference for long-term bonds following the global financial crisis, changing political dynamics, and global pandemics, which led to the choice of medium-term and short-term bonds as opposed to the long-term bonds.

In chapter two, when discussing theories explaining the relationship between the business cycle and the yield curve, the 4th theory discussed investors' response to political uncertainty. When investors are not confident enough about the political environment, they tend to hold fewer

long-term bonds because of the risk associated with them. This is further confirmed in chapter three when looking at the number of bonds in issue, where it is shown that since 2017, the number of long-term bonds reduced, and the number of medium-term bonds and short-term bonds increased.

Figure 5.1: Graphs of the coefficient of the spreads across the different periods



NOTE 1: Overall, it represents the entire sample period; period 1 represents the period from 1986 to 2009, and period 2 represents the period from 2010 to 2022.

Source: Graph generated by author in Excel using EViews data.

5.4: Regime Probability Models and Determining the turning points of the business cycle

Another aspect of this study focuses on identifying business cycle turning points. These are the peaks and the troughs. We adhere to the same rule as outlined in Chauvet (1998) and Chauvet & Senyuz (2016:331). The rule states that the recession probabilities should be converted into a binary variable, represented by 0 or 1, determining whether the economy is in an upswing or downswing state at time t. The assumption is that if the economy were in an upswing state in month t, a business cycle peak would occur in month (t+1). Similarly, if the economy were in a recession in month t, a business cycle trough would occur in month (t+1).

The smoothing probabilities are used to identify the peaks and troughs of the business cycle. A cut-off value of 0.5 is applied to determine whether a value should be classified as in regime 1 or 2. Periods with smoothing probabilities greater (or less) than 0.5 are more likely to be associated with rapid (or low) growth. We also follow a simple rule: the last period with a smoothing probability greater (or less) than 0.5 is considered the peak (or trough).

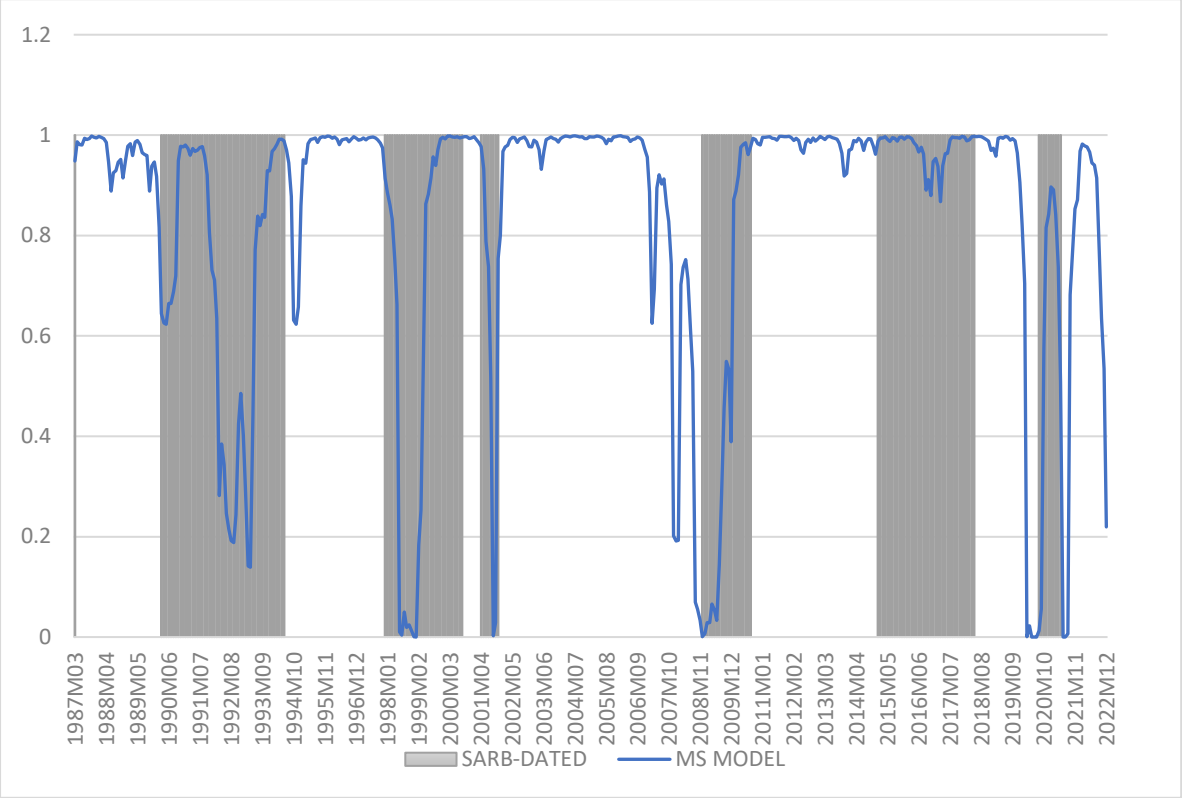
The proposed method of dating using lagging composite indicators offers the advantage of being easily accessible and can be estimated in real-time. In contrast, SARB dating is only available ex-post and typically involves significant delays. The methods used by SARB are explicitly used to classify the beginning of the “downswing” (or “upswing”) and not the actual “recessions.”

Figure 5.2 illustrates the smoothed probabilities for the multivariate model of the lagging indicator; spread three is added into the Markov switching model as a non-switching regressor, and an AR (6) process is used. The choice of AR (6) is consistent with Chauvet (1998). The probability of being in the recession state is extracted and plotted.

Since the goal is to forecast business cycle turning points in real time, this study uses both the monthly business cycle dating from lagging indicators and the SARB dating as a benchmark for evaluating the real-time forecasting performances of the models.

The estimated probability of a recession (regime 0) at time t, conditional on the entire sample I_T, denoted as $\Pr[S_t = 0/I_T]$, is plotted in Figure 5.2, along with the recessions as dated by SARB (shaded area)

Figure 5. 2: Probability of low state for the multivariate model for lag and spread 3



Note 1: Shaded regions are SARB-dated recessions.
Source: Based on estimated results by author

It is clear from Figure 5.2 that the probability of a recession aligns with the SARB chronology, although not precisely. When the SARB classifies the economy as an upswing, the likelihood of a recession is nearly zero. The probability of a recession increases significantly when the SARB identifies downward trends, and this elevated probability persists until the end of the recessionary period. The model accurately represents the economic downturns of the early and late 1990s, the 2008-2009 recession triggered by the global financial crisis, and the 2020 recession resulting from the global COVID-19 pandemic. The 2015-2018 recession period's depiction is inaccurate as it only shows a minor decline in 2016-2017. Thus, with the exception of the period 2016-2017, the results suggest strong correlation between the Hamilton's Markov switching model results and the SARB's identified recessions. The lag-spread 3 model is the most closely associated with SARB in this study.

The low correlation in the period 2016-2017 is consistent with Chauvet (1998) who used Hamilton's univariate model to analyse monthly growth rates in industrial production. The author also employed an AR (6) process and plotted the smoothed probabilities of a recession. The inferred probabilities did not accurately account for some the recessions.

5.5 Alternative model

The Multivariate Markov switching model estimated above adds the independent variable into the model as a non-switching regressor; therefore, it does not switch states with the dependent variable. To further explore the robustness of the best fit model, lag-spread3 multivariate model, we re-estimated the model, but with the spread3 being a regime switching regressor. The results are reported below in Table 5:5.

When the lag is the dependent variable, regime 2 is the high state regime and regime 1 is the low state mean and the effect of spread 3 is higher when the lag is in regime 1 than when the lag is in regime 2. The variable stays in regime 1(32months) longer than in regime 2(7 months). This illustrates that the variable stays longer in the recession state. In both the regimes, the coefficient of the spreads is negative. The F-Stat test for the means of the lag, the coefficients of the spreads and the variance are all statistically significant to signify that the regimes are statistically different.

When spread3 is the dependent variable regime 1 is the high mean regime and regime 2 the low mean regime. The variable stays more in regime 1 (29 months) than in regime 2 (5 months). The coefficient of the lags is negative for both regimes, the effect in regime 2 is higher although the difference is minimal. The coefficients of the F-statistics for the Wald test are not statistically significant for the means of spread 3 and the coefficients of the lags meaning that the two regimes are not significantly different.

When the two models are compared, that is the model with lag as dependent variable and the model with spread 3 as dependent variable, the model with lag as dependent is best performing model based on the forecasting ability of the model.

Table 5.5: Results for the alternative Markov Switching model

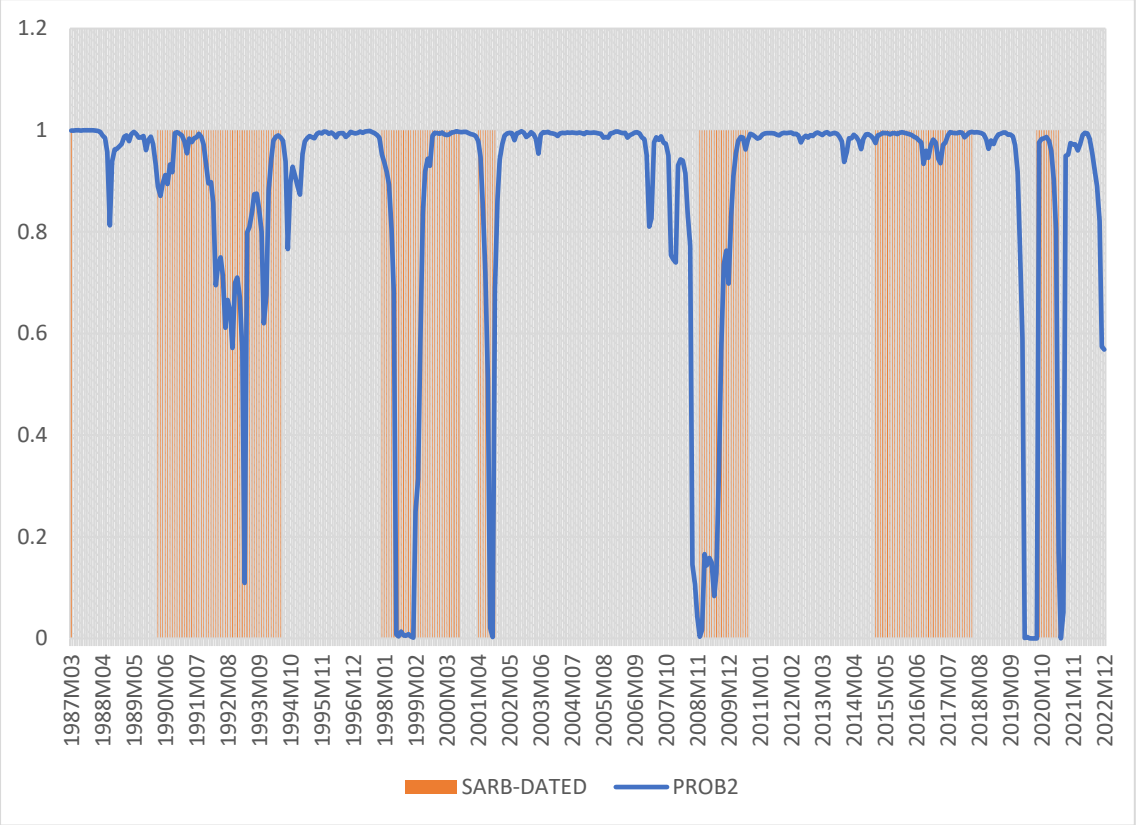
	REGIMES		T. PROBABILITIES		E. DURATION				WALD	
	REGIME 1	REGIME 2	P11	P22	1	2	D-W	SIC	F-STAT	TIC
C	104.384[a]	104.886[a]	96.92	85.39	32.498	6.84	1.83	2.92	0.699[c]	0.003
SPREAD 3	-0.264[a]	-0.651[c]							6.056[a]	
VARIANCE	-0.281[b]	0.603 [b]							37.109[a]	
C	9.833[a]	8.924[b]	96.56	78.71	29.1	4.7	2.12	1.01	0.668[d]	0.323
LAG	-0.064[a]	-0.062[a]							0.019[d]	
VARIANCE	-1.250[a]	-0.411[b]							41.183[a]	

NOTE: [a, b, c] represents 1, 5, and 10 levels of significance, and [d] represents values that are not significant.
P12 and P21 can be calculated from P11 and P22 i.e., P12= (1-P11) and P21 = (1-P22).
TIC represents the Theil inequality coefficient used for forecasting.
D-W represents the Durbin-Watson statistic.

Source: estimations by author

Figure 5:3 presents the smoothed probability for alternative multivariate model combined with the SARB-dated recessions. The alternative model produces the same results. This means that there is no difference when the spread is included as a switching regressor and when included as a non-switching variable.

Figure 5.3: Probability of low state for the alternative multivariate model for lag and spread 3



Note 1: Shaded regions are SARB-dated recessions.

To sum up our discussion. The results of this study complement the other studies that have been done in South Africa, such as (Moolman 2004, Aziakpono and Khomo 2007, Nel 1996 etc), that the yield curve is a good indicator of economic activity. This study set out to explain why the yield spread has recently failed to produce accurate forecasts. One way of answering that question was changing the methodology. The MS model produced results that mirror the SARB-dated recessions.

The results show that the best spread for business cycle turning points prediction is spread 3, representing the difference between the 5-10-year bond and the Treasury bill. This spread outperforms spread 4, the conventional 10-year minus 91-day Treasury bill. These results is in line with what was discussed in Chapter 3, that investors are shifting from long-term bonds to medium-term bonds. It also aligns with the 4th theory in Chapter 2 that the riskiness of a bond affects its holdings.

5.5 Conclusion

This chapter presents and discusses the empirical results. The analyses begin with the univariate Markov switching models before the multivariate model. The univariate results revealed that all variables exhibit two regimes. The study examined the transition probabilities and expected durations. The results indicate that the variables remain in the high state more frequently than in the low state.

A multivariate model was estimated to incorporate economic factors and the spread with a control variable- the repo rate. The results demonstrate that a model including spread information and business cycle data performs better than a univariate model. The spread3-lag model was the best-fit model based on the coefficients of the regressor and its forecasting ability. The best-fit model regime probabilities were plotted against the SARB-dated recessions. The graph demonstrated a close correlation between the Markov switching regime probabilities and the SARB dating, accounting for all the recessions.

The multivariate models were re-estimated using two sub-periods. The results of the sub-period analyses confirm that the dynamics of the yield curve effects on the business cycle have changed in relation to the period before and after the financial crisis. Shorter-term bonds provide more accurate estimates compared to long-term spreads. This shift in investors' preference from long-term to medium-term bonds is the primary explanation.

CHAPTER SIX

CONCLUSIONS AND LIMITATIONS

6.1 Introduction

This study sets out to examine if the yield curve can still predict business cycle turning points in South Africa. The study provided an alternative approach to testing this relationship: the Markov switching model. The other questions addressed were: (i) Does the measure of the yield spread matter? (ii) Does the variable used to indicate the business cycle matter? And (iii) Do the variables representing the business cycle and the yield curve exhibit distinct regimes?

In chapter one, the research context, study contributions, and the problem statement were outlined. It also provided the research objectives and a concise description of the methods used. Chapter 2 provided an overview of the existing literature and empirical findings. Additionally, the theoretical justification of the study was described. Chapter three focuses on providing a comprehensive overview of the current state of South Africa's economy. It delves into the driving forces behind the business cycle and examines the recent developments in the bond market. In chapter four, a detailed description of the data used in the analysis was provided, along with a thorough explanation of the methods and procedures employed to obtain the empirical results. Finally, Chapter Six summarises and concludes the study.

6.2 Summary and findings of the study

The study reviewed the theoretical and empirical literature. The evidence from the theoretical literature review on the relationship between the yield curve and the business cycle suggests that the relationship between the business cycle and the yield curve is bidirectional. This means that the different phases of the business cycle can be used to predict the shape of the yield curve, and conversely, the shape of the yield curve can also provide insights into the phases of the business cycle.

From the literature review, we identify three strands of studies. First, studies that use correlation techniques to test the relationship between the yield curve and economic activity. Second, there are studies that test the ability of yield curves to predict recessions. Furthermore, there are

studies that examine the ability of yield curves to determine the turning points of the business cycle. Lastly, a new set of studies explores the two-way relationship between the turning points of the business cycle and the shape of the term spread.

Based on previous literature, it is widely agreed that the yield curve is more effective than other indicators when it comes to predicting the turning points in the business cycle. However, in South Africa, the predictive ability of the yield curve seems to have declined over time. There have been instances where it falsely predicted a recession and times when it failed to foresee a recession. The question that arises is whether the yield curve remains a reliable indicator of an impending recession.

The initial step in addressing this question is outlined in chapter three, which explores the context surrounding the business cycle and the yield curve. We gather from these chapters that South Africa has undergone significant structural changes. The changes impact both the business cycle and the bond market. Several important events have occurred during our study period from 1986 to 2022. These include the global financial crisis of 2008/2009, the energy crisis in South Africa, political restructuring, the global COVID-19 pandemic, and the Russia-Ukraine war.

When considering the number of bonds in circulation, it is evident that the Treasury bills are frequently issued. This is primarily due to their short-term maturity, which makes them highly sought after and consequently leads to a higher issuance rate. Initially, there was a high demand for longer-term bonds and little need for medium-term bonds. However, the demand for medium-term bonds has increased over the years. The demand for medium-term bonds has now surpassed the demand for longer-term bonds. Investor preference and expectations can be considered as the factors contributing to this. Several significant events have occurred in recent years, particularly following the financial crisis. These include the deterioration of the energy crisis, the global pandemic, and Moody in 2020 downgraded South Africa's sovereign credit rating to junk status, among others. The effect of these factors is that investors exercise more caution when considering investing in RSA bonds. They are becoming more risk-averse and prefer investing in shorter-term bonds.

In 2020, a Reuters report highlighted that South Africa's bond market faced a shortage of buyers, resulting in a notable decrease in listed stocks. In response to the COVID-19 crisis, the SARB had to implement additional measures to manage liquidity in the financial markets effectively. The SARB found it necessary to purchase an undisclosed quantity of RSA bonds in the secondary market to address government debt and improve liquidity (Havemann et al.,2022). The bond-buying program played a role in boosting investor confidence to some extent.

The bond-buying program implemented by the SARB from 2020 to 2021 was designed to decrease the overall maturity of the country's public debt (Havemann et al, 2022). This was accomplished by obtaining longer-term bonds from the private sector and substituting them with short-term sterilization instruments. If we assume that the South African Reserve Bank's credibility in controlling inflation remained strong, bond prices would probably have risen. The intended outcome was to offer financial support to bondholders and transfer the associated risk back to the public sector by utilizing the central bank's balance sheet (Havemann et al.,2022). This fact can help explain why some investors openly and privately supported the implementation of quantitative easing (QE) by the SARB.

Chapter 4 provides a detailed account of the methodology employed in the study, including a theoretical explanation of how the sub-goals would be accomplished. This includes the rationale for why the Markov Switching model was chosen as the preferred model for this study. The chapter described the data utilized in the analysis, including the data period, source, and the justifications for selecting specific variables.

The business cycle variables include the three composite indicators (lagging, leading, and coincident) and the industrial production index. The reason for having the IPI (Industrial Production Index) was to use it as a benchmark, similar to how it was used in other studies such as Chauvet & Senyuz (2016) and Bueno (2023). This would allow for a comparison with the recessions identified by the SARB. However, upon estimation, it was found that the IPI exhibited instability and high variability. The variables chosen to represent the yield curve are the four spreads (1-4). These spreads were selected to address the question of whether the measure of the spread matters. As observed in this study, investors are transitioning from

holding longer-term bonds to investing in medium-term bonds. Considering this, assuming that the 10-year-3-month spread will yield satisfactory results is not advisable.

6.3 Discussion of estimated results

Chapter 5 of the study presents the results obtained and discusses the findings derived from these results. A univariate Markov switching model addresses the first sub-goal of determining if business cycle and yield spread variables exhibit different regimes. A model is estimated for each of the eight variables, and the means and variances of all the variables are significant in regimes 1 and 2. There are two primary states: the high mean state and the low mean state. The existence of two regimes implies that modelling the business cycle using the yield spread without a direct account for the regime changes will lead to model misspecification. Additionally, there are high and low mean states. The results of the expected durations indicate that the variables tend to remain in the high state for a longer duration compared to the low state.

The second sub-goal assesses the relationship between changes in the yield curve, the prediction of business cycle phases, and the reverse relationship. A multivariate Markov switching model is estimated in this study, which combines the factors of the business cycle and the yield curve with the repo rate as a control variable. The means and variances of the univariate models are compared to those of the multivariate models. The analysis shows that including spreads in the business cycle model increases the model's significance.

The sample period is divided into two parts: the first represents the time before the global financial crisis, and the second represents the time after the global financial crisis. An examination of the coefficients of the spreads in business cycle appears to be a shift towards medium-term or short-term bonds after the financial crisis. This can be attributed to investors' risk aversion and changing preferences.

The forecasting ability of the multivariate models and the strength of the coefficients of the non-switching regressors were analysed to identify the variable that produces the best-fit model. After careful consideration, the lag-spread 3 model was selected as the most suitable. The best-fit model was subsequently utilized to generate a graph representing the probability

series of different regimes. This graph was then plotted alongside the recessions identified by the SARB. Our results show a strong relationship between the business cycle and the yield curve. The components of the yield curve contain information that is useful for forecasting business cycle turning points, and the components of the business cycle include information that can predict the shape of the yield curve.

6.4 Implications of the findings

One crucial discovery from the results is that spread 3, representing the difference between the 5-10-year bond and the Treasury bill, is the most effective spread for predicting business cycle turning points. This indicates a shift away from long-term bonds towards medium-term bonds. When analysing the relationship between the yield curve and the business cycle, it is crucial to consider the specific measure of the spread used. Traditionally, the 10-year to three-month spread has been the measure used. However, this study's findings suggest that the medium-term spread provides a more accurate forecast. Therefore, not focusing on one specific measure and testing different spreads in the analysis is essential.

The second implication is that regime switching in both the business cycle and the spread variables suggests that a linear or probit model cannot adequately represent the relationship between the spread and the business cycle. On the contrary, using a model that considers the different regimes would be more appropriate.

6.5 Areas for further research

This study explored an alternative approach to analysing the relationship between the business cycle and the yield curve in South Africa by proposing Hamilton’s (1989) Markov Switching model. However, this study did not compare the results from the MS model to those of other models, e.g., Probit models, to show which model produces the best predictions. Therefore, an area for further research would include model comparisons.

A limitation of this study is that this research only estimated for the models with non-switching regressors. While the alternative model for the robustness check based lag-spread3 model used regime switching regressor, this was not done for all the multivariate models due to time constraint for this thesis. This, an aspect that further research may explore.

Despite these limitations, this study has provided an important insight into the changing dynamics in the business cycle and yield curve in South Africa. The yield curve still proves to be a reliable predictor of business cycle turning points in South Africa. The study did confirm that the indicators use for the yield spread and the business cycle matter. Also, a model that accounts for the regime switching is necessary in the case of the relationship between the yield spread and business cycle in South Africa.

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APPENDIX

Literature summary tables

Summary of studies on the relationship between the yield curve and economic activity/recession.

Table A 1: Studies done on developed countries

AUTHOR	COUNTRY COVERED	PERIOD COVERED& FREQUENCY	MEASURE OF THE SPREAD	MEASURE OF ECONOMIC ACTIVITY	ESTIMATION METHOD USED	SUMMARY OF THE FINDINGS
Kumar et al (2022)	G7 countries	Canada: March 1994 – dec 2018 France: Jan 1999 – Dec 2018 Germany: Oct 2005 – Dec 2018 Italy: July 2009-Dec 2018 Japan: July 1994-June 2019 UK: Jan 1994-Dec 2018 US: Feb 1990-Jan 2019	-spread of interest rates of govt bond.	Industrial production index	-least squares regression method	-The term spread has a positive association with the k-month ahead economic activity for Canada, France, Japan, Uk and Us. -There is a negative association with Italy, even when additional factors were included in the estimation.
Seip & Zhang (2021)	-United states	1971-2019	Federal funds rate	-GDP growth rate	-multiple regression -probit model	-recession appears to be the easiest to predict if there has been a long and uninterrupted increase in GDP, such as the increase before the 2001 recession.

Bueno (2021)	-United states	1960-2021	-spread of govt interest rates.	-business cycle	-Probit model -regime switching approach	-the bidirectional relationship is not symmetrical. The term spread signals a change in the business cycle regime while the cyclical factor only signals the beginning of the ordinary regime of the term spread, not the ending.
Cooper et al (2020)	-United states	1961-2019	-diff between long term and short term govt interest rates	-composite concurrent index	Probit model	-The yield curve inversion likely overstates the probability of a recession when the stance of monetary policy, judged relative to a time varying neutral federal funds rate is accommodative.
Suimon et al (2020)	Japan	1992-2018 (Monthly data)	-Japan govt bond rates 1yr,3yr and 5yr	-business cycle	-autoencoder machine learning approach -three factor model -nelson Siegel model	- this research focused on the model parameters of the intermediate layer of neural network that constitute the autoencoder and confirmed that the three automatically generated factors represent the 'level', 'curvature' and 'slope' of the yield curve.
Henry & Phillips (2020)	-United states -Australia -New Zealand	-1971Q1-1993Q3 -1992Q2-2003Q4 1992Q3-2005Q3 Quarterly data	-10-year govt bond minus 3-month treasury bill rate	-business cycle	-Var Model	-the findings reveal number cases in which forecasting with a model that includes yield curve information leads to more accurate forecasts than those made using simple autoregressive process. -whilst the yield curve may act as a leading recession indicator, this property does not translate materially into better out-of-sample performance.
Tavares (2019)	-Portugal	Jan 1996-November 2018	-10-year govt bond minus 3-month treasury bill rate	-GDP growth rate	-dynamic latent Siegel model -wavelet analysis	-wavelet tools such as phase difference and coherency provide a different approach which not only considers the time domain but also the frequency domain, -slope fails to predict the activity index for Portugal.
Peron & Bonparte	-United States	1962-2019 Daily data	-federal rates	-recession index	-AR model	-this paper shows that the inversion of the yield curve does not necessarily predict recession, especially in the short-term.

Gogas et al (2018)	-United states -Australia -Canada -Japan	1976: Q3-2011Q4	-treasury rates	-recession indices	-Logit and Probit model -Support vector machines technique (SVM)	-an accuracy of 66.7 and 100 can be achieved in forecasting recessions.
Bauer & Mertens (2018)	Unites States	Jan 1955-Feb 2018	-federal fund rate	-asset valuation	-Probit model	-Term spread has a strikingly accurate record for forecasting recessions. -period with inverted yield curve are reliably followed by economic slowdowns.
Andersen (2018)	-European country	2003(1)-2005(12) Monthly data	-federal funds rate	-GDP growth rate	-spline-based model -parsimonious model	-the yield curve offers a particularly extensive and useful set of information about the expected path of future short-term rates and the outlook for economic activity and inflation, which is valuable for monetary policy purposes. -yield curve via the calculation of implied forward rates contain information on market participants expectations of the relative level of future short- and long-term interest rates at a certain point in time expressed by the slope of the yield curve.
Shi et al (2018)	-United States	1980-2015	-federal funds rate	-GDP growth rate	-Stochastic volatility model. -Multivariate Garch (1,1) -Granger causality	-slope of the yield curve is a potentially important explanatory variable in the prediction of real economic activity. -causal relationships show considerable sensitivity to the subsample period.
Benzonin et al(2018)	-United states	2000-2016 Monthly data	-govt interest rates.	-business cycle peaks & troughs	-Probit Model	-many different variables determine the condition and evolution of the economy and the yield curve summarizes them into a single indicator. -a change in the yield curve slope due to a monetary policy easing measured by the current real interest rate level and its expected path is associated with an increase in the probability of future recession.

Hannikainem (2017)	-Japan -USA	June 2961 – April 2015	-Treasury yields	-GDP growth rate	-Dynamic Nelson-Siegel Model -AR models	-while the slope contains predictive powers, the level and curvature are not successful leading indicators. -the predictive power of each of the yield curve factors fluctuates over time -economic conditions matter for the predictive ability of the slope. -inflation persistence emerges as a key variable that affects the predictive content of the slope. the slope tends to forecast the output growth better when inflation is highly persistent.
Giacomini & Ragusa (2017)	-United states	2004-2012	-federal funds rate	-GDP growth rate	-Dynamic Nelson Siegel model -Anchoring method	-anchoring offers a way to formally incorporate into the yield curve forecasts "hidden" or "unspanned" factors that go beyond the information contained in the cross-section of yields.
Levant & Ma (2017)	-United States	Jan 1970 – Dec 2000 Monthly data	-govt bonds rate	-composite concurrent indices	-Dynamic Nelson-Siegel model -Markov switching model	-this model investigated and modelled the parameter instability in the term structure using regime switching dynamic Nelson-Siegel models. The conclusion is that factor leading parameter and the factor's conditional volatilities show significant switching when allowed.
Alquist et al	Canada	April 1989-June 2013	-long term and short-term interest rates.	-production price index	-least squares regression	-the term structure of crude oil convenience yields contains information for future crude oil production, an index of global demand for commodities and the price of oil.
Chauvet & Senyuz (2016)	-United States	1971;08-2012;12 Monthly data	-diff between short term treasury bill and long term fed funds	-GDP growth rate.	-dynamic factor models -Markov switching models	-the result indicates a strong interrelationship between the yield curve and the economy -the proposed model has substantial incremental predictive value relative to alternative specifications. this result holds both in-sample and out-sample, using revised and real-time unrevised data.

Hvozdenska (2015)	-selected EU countries -United States	2000-2012	- treasury rates	-GDP growth rate	-Regression analysis	-the yield curve is useful to investors and is an indicator of future economic activity. -the 10 year and 3 months spread has significant predictive power to real GDP growth after financial crisis. -the best lags to use are lags of 4 and 5 quarters.
Hvozdeska (2014)	EU-15	2000Q1-2013Q2 Quarterly data	-treasury rates 10 yr. and 3 months	-GDP growth rate	-regressions using real GDP.	-the 10year, 3month spread has substantial predictive power and provide good forecast of real growth four quarters into the future. -simple yield curve growth forecasts should not serve as a replacement for predictions of companies, it however does provide enough information to serve as a useful check on the more sophisticated forecast.
Chen & Tsang (2013)	-UK -United States -Canada -Japan	August 1985-July 2005	-federal funds rate	-business cycle movements	OLS Regression	-the yield curve factors predict exchange rate movements and explains excess currency returns one month to two years ahead
Abdymomunov (2013)	-United states	1953; Q1-2001Q4 Quarterly data	-govt bond rates	-gdp growth rate	-Nelson Siegel model	-the dynamic yield curve model produces better out of sample forecasts of real GDP growth than the traditional term spread.
Lange (2013)	-Canada	Jan 1986 – Dec 2010 Monthly data	-govt bonds rate	-GDP growth rate	-dynamic Nelson Siegel model. -VAR model	-the reactions of the yield curve are consistent interpretations of inflation expectations based on the Fisher relation and interest rate based on "expectation hypothesis." -there is evidence of both strong macroeconomic effects on the future yield curve and yield curve effects on future macroeconomic developments.
Alfonso & Martins (2012)	-United states -Germany	1981(1)-2009(4) Quarterly data	-govt bonds rate	-GDP growth rate	-Nelson Siegel Model -Var	-fiscal behavior has had a different impact on the yield curve in the US and in Germany -in the US, fiscal shocks bring about an immediate response of the short-end of the Yield curve that is associated to the reaction of monetary policy to the macroeconomic effects of fiscal development.

Conraria et al (2012)	-United States	1961(6)- 2011(12)	-federal funds rate	-business cycle	-Wavelet analysis	- changes with the slope of the yield curve were significantly associated with changes in federal funds rate in the same direction across all the sampling period. this evidence is consistent with the monetary policy explanation for the predictive power of the yield curve. - fail in the level of yields in the last decade has damaged the ability of the slope to predict business cycles and the related changes in inflation.
Kauppi & Heikki (2010)	Unites states	January 1995 – February 2009	- govt zero coupon bonds	-recession indicator index	-Probit Model	-this analysis shows that the simple dynamic specification is successful in capturing the apparent serial dependence of the US recession indicator and it provides more plausible recession probability forecasts than the static yield-curve based Probit model that is commonly applied in previous literature.
Chonis et al (2010)	-European countries	1994Q1-2008Q3	-govt interest rates	-real GDP growth rate	-Probit Model	-the yield curve augmented with the composite stock index has significant forecasting power in terms of the European union's real output.
Schrimpf & Wang (2010)	-Canada -Germany -UK -USA	1962(Q1)-2009(Q1)	-govt interest rates	-recession indices	-VAR model	- the window selected methods recently developed for forecasting in the presence of structural change generally offer some improvements in terms of forecasting accuracy.
Aazim (2010)	-United States	2000-2009 Monthly data	-zero coupon bonds	-GDP growth rate	-Probit Model	-monetary policy impact monotonically decreases over the yield curve.
Chinn & Kucko (2010)	-United States -European countries -Canada -Japan	1990- sept 2009	-treasury yields 3month and 10 years	-Industrial Production Index (IPI)	-simple bivariate model. -regression analysis	-predictive power of the yield curve has deteriorated over time. -European countries models perform better than non-European countries when using more recent data. -yield curve proves to have predictive power even after accounting for other leading indicators of economic activity.

Rudebusch & Williams (2008)	-Unites States	1955; Q1 – 2007; Q1 Quarterly data	-treasury rates	-business cycle movements	Probit Model	-yield curve has real time predictive power for distinguishing between expansions and contractions several quarters out relative to predictions of professional macroeconomic forecast.
Bordo & Haubrich (2008)	-United states	1975-1997 Quarterly data	-govt bond rates	-recession index	-predictive recessions	-yield curve predictability varies over time however; it has been the best since the post-World War ii period.
Giacomini & Rossi (2006)	-United States	1965-2001 Monthly data	-3 moth and 10-year govt interest rate	-GDP growth rate	-Regression analysis	-regime shifts in monetary policy are associated with changes in forecasting ability of the yield curve. and can therefore be used as possible predictions of future forecast breakdowns.
Ang et al (2006)	-United states	1952: Q2- 2001; Q4 Quarterly data	-govt bonds	-movement in stock prices	-VAR model -OLS regression	-the yield curve model can capture the same amount of conditional predictability that is picked up by simple ols regressions. - a better out-of-sample test than just using U.S data is to use international data to test the efficiency gains of factor approaches implied by a term structure model.
Estrella & Trubin (2006)	-United States	1968-2006 Quarterly data	Treasury rates	NBER* dates. Every month between a peak and a subsequent trough is a recession.	-Probit model	-treasury rates produce accurate forecasts. -Best maturity combination is 3 months and 10years
Bernadell et al (2005)	United states	1953;4 – 2004;4 Quarterly data	-treasury rates	-industrial production index	-Nelson Siegel dynamic model	-the generation of long -term expectations to the level, shape and evolution of the yield curve are key inputs to the strategic investment process applied by investment managers in private and public organizations.
Bordo & Haubrich (2004)	United states	1875-1997 Quarterly data	-govt interest rates short term and long term	-GDP growth rate	-Probit Model	-the paper provide reinforcement for the notion that the monetary regime is critical in interpreting the yield curve and that the term structure of interest rates is highly conditioned on monetary regime.

Lint & Stolin (2003)	-United states -G7 countries	1960(1)-1998(2)	-govt interest rates	-consumer price index	-Probit Model	-short term interest rates always react more than long term rates, resulting in a negative correlation between the term spread and future consumption growth rates.
Diebold et al (2003)	-United states	Jan 1972- Dec 2000	-federal rates	-level of real growth	-Var Model -Latent factor model	-expectation hypothesis may hold reasonably well during certain periods but that it does not hold across the sample period.
Estrella et al (2003)	-Germany -United States	1967(1)-1990(12) Monthly data	-interest rates of govt bonds	-industrial production index	-stability tests -Lagrange multiplier -predictive tests (PR)	-models that use the yield curve to predict inflation tend to have poorer performance than those that predict real activity. -models that predict inflation tend to exhibit more instability than those that predict real activity. -models that use the yield curve to predict recessions may be employed to a certain confidence in their continued reliability.
Chauvet & Potter (2002)	-United States	Jan 1967-Dec 2000	-federal funds	-recession index	-Probit model	-there is considerable uncertainty over the value of probability due to uncertainty over the correct breakpoint.
Berk & Bergeijk (2000)	-12 countries from the Euro system	1970-1998	-euro interbank offered rate short term and govt bond rate long term.	-level of inflation -GDP growth rate	-AR models	-practical usefulness of the yield spread for predicting future movements in inflation and output in the euro area is limited. -the euro system should be cautious in using the yield curve for monetary policy purposes, this is because the information content is sensitive to the relative variability of expected future inflation changes and changes in real interest rates.
Berk (1998)	-United states -OECD	*Review of other studies previously done				-empirical evidence in support of the yield curve having predictive power regarding future inflation change is not stable the opposite is the case for the yield curve as predictor of future economic activity.
Bernard & Gerlach (1998)	-8 developed counties	1972-1993 (Monthly data)	- govt interest rates	-recession index	-Probit model	-the yield curve provides info for up to 8 quarters on the likelihood of occurrence of future recessions. -the slope of the yield curve in the US and Germany helps predict recessions in other G7 countries in particular UK and Japan significantly.

Peel & Taylor (1998)	-United States -United Kingdom	1957(1)-1994(4)	-short- and long-term interest rates	-level of real economic activity	-Regression analysis	-regressions of cumulative movements in output are strongly correlated with the slope of the yield curve for several forecasting horizons for both the United Kingdom and united states. -movements in the nominal interest rates yield curve affect real economic activity through the demand side of the economy.
Smets &Tsatsarinis (1997)	-Germany -Unites States	1960-1995 Quarterly data	- treasury bill short term and federal funds long rate	-GDP output rate	VAR model	-monetary policy plays a central role in determining the intensity of the relationship between the term structure and output growth
Estrella & Mishkin (1996)	-Europe -United States	1973-1995	-govt bonds with different maturities	-GDP growth rate. -inflation rate	VAR model	-monitory policy is an important determinant of term spread, but is unlikely to be the only determinant. - the yield curve has significant predictive power for real activity and inflations. -the relationship between monetary policy actions and the term structure spread are unlikely to remain invariant overtime.
Gamber (1996)	-United States	1955(1)-1992(7)	-federal funds rate	-GDP growth rate	-VAR model -granger causality	-the yield curve slope appears to obtain much of its predictive power for output growth from the federal funds rate.
Haubrich & Dombrosky (1996)	-United states	1961(Q1)-1995(Q3)	-difference of govt and 3-month treasury rates	-GDP growth rate	-least squares regression method	--10 year- 3month spread has substantial predictive power. -decline in growth of real GDP is usually preceded by a decrease in the yield spread, a narrowing spread often signals a decrease in real GDP growth. -negative yield spread (inverted curve) usually precedes recession but not always.
Jaeger (1992)	Germany	1968-1983	- treasury rates	-business cycle	-least square regressions	-empirical evidence based on German macroeconomic time series shows that the slope of the yield curve is indeed a powerful predictor of future movements in various measure of real economic activity.

Keen (1989)	-United states	1955-1988	-govt bonds	-recession indices	-ordinary least squares regression	-no single measure including the yield curve is capable of telling us if we are about to embark on a recession. The most that can be expected from a good forecasting measure is that it provides a reliable indication that the pace of economic activity is about to change.

Table A 2: Studies done on emerging markets.

AUTHOR	COUNTRY COVERED	PERIOD COVERED& FREQUENCY	MEASURE OF THE SPREAD	MEASURE OF ECONOMIC ACTIVITY	ESTIMATION METHOD USED	SUMMARY OF THE FINDINGS
Krishna & nag (2022)	India	2005Q2-2018Q1	-10yr govt bond and 3-month govt t-bill.	-business cycle & growth rate cycle.	-Principal Component Analysis (PCA) -Composite Index of Lead indicator (CILI) -Probit Model	-using the specified data series, the yield spread has predictive power when forecasting NAGDP growth -Probit model shows that the slope of the yield curve forecasts 89.7 observations in the recession phase while the CILI correctly forecasts 76 observations in the recession phase
Ibarra (2021)	Mexico	2004-2019	-treasury bills and federal funds rate	-GDP growth rate	-threshold model -var model	-the slope of the yield curve seems to anticipate the behavior of economic activity only when the term premium is above a threshold.
Ramirez & Raul (2021)	Mexico	2004-2019 (Monthly data)	-fed rates	-composite concurrent index	-threshold model -Probit model -Linear model	-the nonlinear models used suggest that the slope of the yield curve seems to anticipate measures of future economic activity, and to predict future contractions in Mexico, but only when the term premium is above a determined threshold.

Fullerton & Rojo (2018)	Mexico	1990(4)-2015(1) Quarterly data	-govt interest rates	-GDP growth rate	-Probit Model -LS Regression	-the results indicate that both the Mexico and US yield spreads contain info about recessions for at least some of the 8 urban economies included in the sample.
Cepni et al (2018)	Turkey	2006(02)-2017(08)	-govt bonds	-industrial production price index	Nelson-Siegel Methodology	-the result indicates the significance of macroeconomic information on the yield curve, especially domestic financial variables and global variables.
Ayderir & Ovenc (2016)	Turkey	2002-2014	-short term and long-term interest rates	-GDP growth rate	-dynamic panel model	-while the short-term interest rate and the slope of the yield curve have a negative and significant impact on profits in the short-run, the effects of these variables turn out to be positive in the long-run.
Chen et al (2016)	Australia	1969-2014	-spread of 3 month and 10-year treasury rates	-GDP growth rate	-time series analysis	-the results support the usefulness of the spread to predict output growth in Australia both in-sample and out-sample for up to eight quarters ahead.
Khandwala (2015)	India	March 1971-December 2012	-government bonds	-level of macroeconomic activity	-duration models (wavelet-based filtering	-there is strong empirical evidence of the impact of the yield curve in predicting economic slowdowns in India. -monetary policy directly affects the yield curve which acts as a leading indicator in predicting macroeconomic activity.
Oztuk & Pereira (2014)	-32 countries in the organization of the economic cooperation & development	1990--2011	-3-month European offer rate minus 10yr govt bond rate	-turning points in the business cycle to represent recession	-Panel data	-results shows that with a type 1 error of 25, the models deliver a power of roughly 63 and can be used as an effective instrument to predict recessions one year ahead.
Sihombing et al (2014)	Indonesia	2005-2013 (Monthly data)	-govt interest rates	GDP rate	VECM	-developments of the yield curve on government bonds experienced a fluctuating movement influenced by liquidity factors, fundamental macroeconomics, external factors, fundamental macroeconomics, and market risk factors.

Kaya (2013)	Turkey	1993(M1)-2009(M1) Monthly data	-govt bonds	-macroeconomic variables.	-dynamic Nelson Siegel Model -regression analysis	-the relationship between yields and the macroeconomic variables has a structural break. -regression analysis suggest that the macroeconomic variables have become the main driving force for the yield curve movement.
Aljinovic (2012)	Croatia	2011&2012 Weekly data	-govt bonds	-business cycle	-Nelson-Siegel model -Svenson Model	-shape of the yield curve reflects the shape of the economy i.e., it can predict recession.
Nath et al (2012)	India	1997-2011	-govt interest rates	-industrial production index	-Probit Model -Logit Model	-the yield curve spread has predictive power to estimate the economic activity in terms of index of industrial production
Kanjilal(2011)	India	July 1997-Feb 2004	-govt bonds	-GDP growth rate	-Var modelling -granger causality	-there exists strong causality from financial factors, defined by the three parameters of the yield curve('level','slope','curvature') to macroeconomic factors such as growth and inflation.
Bae & Kim (2011)	East Asian countries	-Nov 2000-Dec 2010	-govt bonds yields	-GDP growth rate	-DNS model	-using the sample from 2001 to 2010 the global yield factors are important for all 4 Asian countries included in the study.
Mehl (2008)	-14 emerging markets including south Africa	1996-2005 (Monthly data)	-treasury bill rates for diff maturities	-GDP growth series	-Probit Model -Linear regression	-the yield curve contains information in almost all countries, even after controlling for inflation and growth persistence. -the US yield curve is found to contain information content for growth in all economies.
Morales (2008)	Chile	April 1996-July 2001 (Monthly data)	-govt bonds	-GDP	-Nelson & Siegel Model	- the level and the slope of the yield curve seems to be responsive to real activity and monetary policy shocks.
Karunaratne (1999)	Australia	1972(Q3)-1997(Q3)	-govt 3 month and 10-year interest rates	-business cycle	-Probit Model	-empirical evidence demonstrates that the yield curve outperforms other financial indicators as a predictor of recessions in Australia. It is a simple and operational tool.

Schiff (1999)	New Zealand	June 1987-Sept 1998 (Quarterly data)	-federal funds	-recession index	-Probit Model	-the ability of the yield curve to forecast recession comes from a straight forward application of the expectation hypothesis. -the fact that nominal interest rates incorporate expectations of inflation rates means that the slope of the yield curve reflects how investors expect that the rate of inflation will change over time.
Fisher & Felmingham (1998)	Australia	1985; Q4-1995; Q4	-1yr and 2 yr. treasury bonds	-consumer price index	-Neoclassical Model	-this study derives a model linking consumption growth and the interest rates. -the relationship between the real one- and two-year nominal spreads and real consumption are significant.
Iowe (1992)	Australia	Sept 1972 to June 1991 Quarterly data	-treasury bonds	-business cycle	-Regression analysis	- positive slope of the yield curve implies faster growth in the economic activity over the next one to two years.

Table A 3: Studies done on African countries.

AUTHOR	COUNTRY COVERED	PERIOD COVERED& FREQUENCY	MEASURE OF THE YILED SPREAD	MEASURE OF ECONOMIC ACTIVITY	ESTIMATION METHOD USED	SUMMARY OF THE FINDINGS
Erasmus & Steenkamp (2022)	South Africa	2000-2020	-diff between the nominal 10 yr. sovereign bond and average expected short rates.	-level of macroeconomic activity	-Nelson-Siegel – Svenson model	-The study shows that the term premium embedded in 10year SA sovereign bond has been positive for the last 20 years, this reflects the steepness of the SA yield curve with long term rates
Oboh& Abdulsalaam (2021)	Nigeria	2007Q1-2019Q1 Quarterly data	-10-year govt bond minus 3-month treasury bill rate	-industrial production index.	-least squares regressions	-There is a positive relationship between economic activity and yield spread.
Patel et al (2018)	-south Africa -USA	2000-2014 2015-2014	-difference btwn 10-year bond and 3-month bond	-GDP growth rate	-principal component analysis (PCA) -Nelson-Siegel model	-findings revealed that monetary policy shocks across both marked played a prominent role in affecting the form and importance of slope and curvature shifts. - the level shifts in SA were observed to play far less dominant role.
Boukhatem& Sekouhi (2017)	-Tunisia	2003:06-2014:01 Monthly data	- difference btw 10-year bond and 3-month bond	-investment index -GDP growth rate	-probit model	-the result show that the spread can provide useful information to both private investors and policymakers. The yield curve can then be used for purposes of economic and monetary policy.
Ahokpossi(2016)	-Morocco	January2004-may2015 Monthly data	- difference btw 10-year bond and 3-month bond	-GDP growth series	-Dynamic Nelson-Siegel (DNS)model -PCA VAR model	-higher monetary policy increases short-end maturities and the impact is small and short-lived. -fiscal improvements significantly lower yield levels.
Oyedele (2014)	-Nigeria	1986-2008 Quarterly data	-10-year govt bond minus 3-month treasury bill rate	-GDP growth rate	-ordinary least squares	-there is a positive long run relationship between economic activity and inflation and can be predicted by the yield curve

Botha & Keeton (2014)	South Africa	2002-2003	10-yr govt bonds and 3-month treasury rates	-business cycle.	-Basic Probit model	--this study suggests that the bond market participants were aware of the overall weakness of the economy and correctly anticipated the cut in the short-term interest rates.
Mohapi (2012)	-South Africa -China -Us -Germany	1980Q1:2012 Q2	10-yr govt bonds and 3-month treasury rates	-business cycle. -GDP growth rate	-Binary Probit model	-the SA term structure of interest rates has not lost its ability to forecast SA recessions. -SA and China are closely linked emerging market countries
Clay & Keeton (2011)	-South Africa	1980-2010 (Monthly data)	diff between 10yr govt bonds and 91-day T-bills.	-GDP growth – recession is defined as 2 consecutive quarters of negative real GDP growth.	-Probit Models (Simple and modified)	-the yield curve remains the most powerful tool for predicting downswings in SA. -the yield curve can forecast downswings up to 18months ahead but provides the best predictive power 2 quarters ahead.
Khomo & Aziakpono (2007)	-South Africa	Jan 1980- June 2004	-diff between 10yr govt bonds and 91-day T-bills.	-change in composite index of leading economic indicators	-Standard Probit Model -Modified Probit Model	-yield curve as represented by the yield spread between 3-month to 10-year government bond can be used to estimate the likelihood of recession in south Africa.
Treba (2006)	-Nigeria	1996-2003	-10-year govt bond minus 3-month treasury bill rate	-business cycle	-simple regression equations	-the term spread is useful in predicting real activity as measured by real GDP - there is stronger predictive power for future growth in domestic gross capital formation and real expenditure than real GDP
Moolman (2002)	South Africa	1979-2001 (Quarterly data)	-diff between 10-yr govt bonds and 3-month banker's acceptances	-business cycle movements	Probit Model	-the term structure of interest rates can be used to predict turning points of the south African business cycle.

Nell (1996)	South Africa	1976-1993 (Quarterly data)	-diff between 10-yr govt bonds and 3-month banker's acceptances	-business cycle movements	Cointegration techniques	-slope of the yield curve is positively related to growth in real economic activity. -the yield curve contains information about the real sector of the economy and may be used to forecast future economic activity.