

The information content of the yield spread about future inflation in South Africa¹

ABSTRACT

The proposition that accurate inflation expectations can be extracted as inflation predictions from the government bond yield curve has been supported using data from the United States and European countries. Despite the abundance of empirical studies of the proposition, relatively few relate to emerging markets, for most emerging markets lack bond markets with the liquidity, breadth, information availability, and range of maturities that would permit such yield curve studies. South Africa's highly developed capital markets do have such characteristics, warranting this study's examination of the proposition's validity for South Africa. Using South African time series data we find strong evidence for the proposition that the yield curve contains information on the future path of inflation. Examining the sub-periods separated by the adoption, in 2000, of inflation targeting we find that the monetary policy regime shift strengthened the relationship between the yield spread and future inflation. Despite the instability of this relationship as noted by Berk (1998), the yield spread can be used to help forecast inflation in the South African case.

Key words: yield spread, term structure of interest rates, interest rates, inflation expectations

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1. INTRODUCTION

Price stability is necessary for a predictable environment conducive for consumer and investment decision-making, which provides the basis for an efficient distribution of financial resources. As such, price stabilisation has been widely recognised as a main goal of modern monetary policy; and the management of inflation expectations has become the vehicle through which this objective is carried out (Reid, 2009). The formal adoption of the inflation-targeting monetary policy regime by the South African Reserve Bank in 2000 is forward-looking. It aims to anchor inflation expectations and, maintain price stability while limiting output sacrifice. In order to do this, many central banks monitor a range of leading financial/economic indicators to get an indication of inflation expectations and the yield curve has been widely used as a leading indicator for inflation owing to its simplicity and readily availability.

The yield curve shows the relationship between yields of default-free securities (normally government bonds) of different maturities (Kozicki, 1997). The shape and the slope of the yield curve changes daily and studies have shown that a change in the slope and shape of the yield curve is closely linked to changes in economic variables such as economic activity, interest rates and inflation (Khomo and Aziakpono, 2007 and Reid, 2009). A clear understanding of the yield curve, therefore, affords us a way to extract information and to predict how changes in underlying economic variables will affect the yield curve and future inflation. Given the forward-looking nature of the underlying yield prices, economists have in the past used the yield curve to extract information about the future path of inflation (Mishkin, 1990). Several studies have empirically proven that the slope of the yield curve has a predictive power for future inflation (inter alia, Mishkin, 1989; Mishkin, 1990; Kotlan, 1999; Kozicki, 1997; Stock and Watson, 1989; Estrella and Hardouvelis, 1991).

The yield spread is the difference between yields on longer and shorter-dated government debt securities which provides information on the slope of the yield curve (Wesso, 2000 and Khomo and Aziakpono, 2007). The slope of the yield curve, in turn, contains information about changes in future inflation (Schich, 1999; Wu, 2001). The yield curve can either be positively sloped, flat or downward sloping. High short-term yields relative to long-term yields portray an inverted yield curve, a flat curve reflects similar yields irrespective of the maturity and a positive yield curve results from short-term yields being lower than long-term yields (Khomo and Aziakpono, 2007).

In light of the abundant empirical literature on the yield spread's predictive power regarding future inflation, there is still a lot to be done in the case of emerging economies like South Africa. This study, therefore, attempts to bridge this gap and contribute to the existing body of knowledge within the South African context by empirically examining the ability of the yield spread to provide information about future inflation. Having identified in the literature the key role played by monetary policy on influencing the slope of the yield curve, this study will then

further attempt to examine the effect of the monetary policy regime shift on the relationship between the yield spread and future inflation.

The remainder of this paper is structured in the following manner. Section 2 provides the literature review. Section 3 describes the methodological approach employed in this paper and a derivation is also presented. Section 4 details the data used, the empirical results and interpretation of the findings, section 5 then concludes.

2 LITERATURE REVIEW

2.1 THEORY

This section presents a theoretical argument as to why the slope of the yield curve contains information about future inflation. Economists and forecasters have drawn from empirical work that changes in latent factors (level, curvature and slope) of the yield curve are linked to economic variables such as economic activity, inflation and interest rates expectations (Diebold *et al*, 2006). Cassino *et al*, (2014) further noted that different factors tend to drive different segments of the yield curve, hence the importance of differentiating between short, medium and long-term sectors of the yield curve. Real variation only affects the short end of the yield curve which is in turn influenced by monetary policy, whereas variation in long-term yields are explained primarily by shocks to expected inflation anchored by the credibility of the central bank (Fama, 1990; Wesso, 2000; Ang *et al*, 2008 and Cassino *et al*, 2014).

The literature shows that the behaviour of the yield curve normally falls between the rational expectations hypothesis theory and the market segmentation theory. Within the expectations hypothesis theory there exists pure expectations hypothesis, the liquidity theory and the preferred-habitat theory. The pure expectations hypothesis asserts that expected returns (forward rates) from investing in an n -period bond should equal the expected return from investing in a one-period bond over n consecutive periods (Tease, 1988; Durre *et al*, 2003). This theory, therefore, implies that an upward sloping yield curve reflects that the market expects short-term rates to rise in the future; the flat yield curve shows expectations of unchanged rates while expectations of a decline in future interest rates are captured by an inverted yield curve. This theory is however flawed in that it doesn't account for the risk linked to fixed income investments. That is, in addition to inflation expectations, there is risk associated with holding long-dated bonds called the risk premia (Gnan and Ritzberger-Grunwald, 2005).

The liquidity premium theory improves on the pure expectations theory by positing that the shape of the yield curve is determined by expectations about future short-term interest rates plus a risk premium (see Fabozzi, 2012 and Cox *et al*, 1985). This implies that risk aversion will cause future interest rates to be always greater than expected short-term rates as risk

premium increases with the maturity of the financial asset (government bond). This theory however fails to explain the tendency of the yield curve to invert prior to recessions due to a non-negative bond risk premium.

The preferred habitat theory deviates slightly from the liquidity premium by allowing the risk premium of the bond to assume negative values as well. This theory asserts that in addition to the shape of the yield curve being determined by inflation expectations and the risk premium (which can be positive or negative), there are investors with strong preferences for specific bond maturities, with the market forces of demand and supply determining the interest rate of a given maturity (Vayanos and Vila, 2009).

The segmentation market theory is not very popular in empirical literature; it takes a slightly different stance compared to the rational expectations theory hypothesis. This theory hypothesises that investors have strong maturity preferences and that bonds of different maturities trade in distinct markets, i.e. bonds with different maturities are not substitutes of one another (Cox *et al*, 1985). This implies that market forces of demand and supply of a particular segment or maturity have little or no effect on the prices of bonds of neighbouring maturities. The shape of the yield curve is determined by asset-liability management constraints of investors and bond issuers at any maturity sector of the curve (Khomu and Aziakpono, 2007). In accordance to Balduzzi *et al* (1997), this theory however fails to explain the tendency of the yield curve to invert before downturns as it assumes that investors will not shift funds across maturity segments in anticipation of changes in inflation, monetary policy effects, economic growth etc.

Another theoretical underpinning of the term structure of interest rates which is extensively used in empirical analyses in conjunction with the rational expectations theory is the Fisher Equation (see Fisher, 1930). This theory has proven to be one of the most influential contributions to economic theory. It asserts that an exogenous shock to the rate of inflation expected to persist over a given horizon will cause an equivalent shock to the nominal yield on bonds of the corresponding maturity (Sargent *et al*, 1973). This is because in the long-run, prices are assumed to be fully flexible and real interest rates are constant.

This study however, will not be looking into proving or disproving any of the above hypotheses/theories, but to merely investigate the information content of the yield spread about the future path of inflation. This study uses the rational expectation hypothesis in conjunction with the fisher equation to investigate this relationship as in (Mishkin, 1989; Estrella, 2005 and Kozick, 1997) amongst others. We now turn to the empirical literature of the yield spread with a sole purpose of getting a better empirical understanding of what has been done and what results can be expected from this study both in terms of the inflation spread relationship and regime switch effects on this relationship.

2.2 EMPIRICAL LITERATURE

Despite the plethora of empirical evidence of the predictive power of the slope of the yield curve for future inflation, most studies use data from the European and North American countries. As such, there still remains a lot to be done in emerging economies such as South Africa. The literature generally concurs that the yield spread contains predictive power for near-term economic activity, however, empirical evidence relating the yield spread to future inflation produce a variation of results. For instance, studies of Shiller, Campbell, and Schoenholtz (1982), Mishkin (1990) Tzavalis and Wickens (1996) and Mankiw and Summers (1984) points to a weak or no evidence of the existence of this predictive power. However, on the contrary, empirical evidence reported by, *inter alia*, Estrella (2005), Fama (1984), Fama and Bliss (1987), Mishkin (1990a, 1991, 1998), Campbell and Shiller (1987), Kozicki (1997), Estrella (2004), Ang et al (2008) and Schich (1999) provided evidence that confirms that the yield spread does contain information about future inflation for the countries studied.

The reason for this variation of empirical evidence as noted by Shiller (1991) is that different studies employ different statistical and econometric methods, test different hypothesis and implications regarding the expectations theory and also use different interest rates maturities in their respective analysis. Additionally, the information content of the yield spread is also conditional on other factors such as the sample used, the country under study, the segment of the yield curve chosen and the monetary policy regime (Tabak and Feitosa, 2009; Estrella, 2005; Schich, 1999; Berk, 1998). This implies that even though the yield spread contains predictive power for future inflation in some countries, for some periods and for some segments of the yield curve, the relationship is unstable (Berk, 1998).

Despite this mixture of empirical results, the slope of the yield curve may still contain useful information about the future trajectory of inflation that may be useful for policy makers in South Africa. The hypothesis that the current yield spread helps in predicting the future path of inflation is founded on the expectations hypothesis theory and rational expectations as noted and empirically proven by Jondeau and Ricart (1999), Mishkin (1990) and Dziwura and Green (1996). Mishkin (1989, 1990, 1991) and Kotlan (1999) showed that the term structure of interest rates provides useful information about the future movements of inflation in the United States. Kozicki (1997), Schich, (1999), Estrella and Mishkin (1996), Kotlan (1999) among others also concurred with the findings of Mishkin using data from outside the United States. It is therefore conclusive that this evidence which postulates that the term structure of interest rates contains information about future interest rates movements implies that the term structure might also contain information about the future inflation movements in an inflation-targeting regime (*inter alia*, Mishkin, 1990; Kotlan, 1999).

Many emerging markets including South Africa have seen a shift in their monetary policy frameworks during the 1990s, adopting inflation targeting regimes. This paper also examines if these regime shifts have provoked changes in the predictive power of the yield spread.

Estrella (2005), Benanke (1990), Tzavalis and Wickens (1996) and Estrella (1997) for instance, did not only confirm that the yield spread helps in predicting inflation but also revealed that the prevailing monetary policy regime and monetary policy stance has a pivotal role to play in this regard. The intuition is that the sizes of the reaction parameters are important if the monetary policy reacts to deviations of inflation from the target (Reid, 2009). With South Africa having adopted the inflation targeting regime since 2000, we expect, *a priori* that this has enhanced the forecasting power of the yield spread, in line with empirical findings of Laurent (1988), Blinder (1992), Mankiw and Miron (1986) and Blinder (1999).

Unfortunately, there has been no study that the author is aware of in the South African case which explicitly attempts to analyse the information content provided by the yield spread about future inflation. However, in an attempt to better understand the dynamics of the South African future inflation, lessons can be drawn from studies of Reid (2009) and Wesso (2000). Reid found that inflation expectations in South Africa have been well anchored by the SARB over the period (2004-2009) and do not respond radically to macroeconomic shocks. Wesso on the other hand found that long-term bond yields are largely driven by inflation expectations. His results also show that a decrease in inflation expectations leads to a flat or even inverted yield spread (affirming the Expectations Hypothesis Theory), however, a flattened or inverted yield spread does not necessarily imply an actual decline in future inflation. From these studies, we then learn that long-term yields contain inflation expectations information and that monetary policy is credible in South Africa.

This study draws heavily from the studies of Campbell and Shiller (1991), Mishkin (1989), Kozicki (1997) and Kotlan (1999) among others who use the Mishkin methodology to derive inflation forecasting equation. This calls for the analysis to be carried out using two building blocks. The first hypothesis is the Fisher equation (1930) which decomposes the nominal interest rate into expected inflation rate and (*ex-ante*) real interest rate. This then implies that if movements in nominal interest rates are primarily driven by fluctuations in expected inflation rate rather than changes in real interest rates, the spread will therefore help predict the future path of inflation (see Balduzzi et al, 1997; Fama, 1975, Mishkin, 1990 and Kotlan, 1999). The second hypothesis is the expectations hypothesis theory, which asserts that the spread between long-term and short-term interest rates contains information about future inflation (Engsted and Tanggaard, 1995). Monetary policy has more direct effect on the short end of the yield curve than the long end through interest rates (Mankiw, 1986, Kotlan, 1999; and Frankel and Lown, 1991). Monetary policy makers however influence the long end of the yield curve through messages contained in the monetary policy statement. This, therefore, implies that monetary tightening reduces the spread and leads to a slowdown in economic activity and inflation (Berk, 1998 and Kotlan, 1999).

The aim of this study is to test the information content of the yield spread about future inflation trajectory and to further assess the impact of monetary policy regime switching in the

South African case. In the next section, the methodology used to test the predictive power of the yield spread for future inflation is presented, which is then followed by the empirical results and interpretation.

3. METHODOLOGY

This study estimates the Inflation forecasting equation which suggests that the yield spread has a predictive power for the future trajectory of inflation. This forecasting equation is essentially a regression of the change in the future m -period inflation rate from the n -period inflation rate ($\pi_t^m - \pi_t^n$) on the slope of the yield spread ($i_t^m - i_t^n$) (Mishkin, 1990, 1991). The predictive power of this equation is dependent on the size of the estimate of the coefficient of the spread, which is normally positive and increases with the length of the spread (Tzavalis and Wickens, 1996). This approach is however limiting as it restricts us to extract information about the future inflation path by only using the slope of the yield curve while neglecting other economic variables. This study also includes past inflation as one of the regressors to determine if the spread still contains its predictive power over and above lagged inflation.

This equation is expressed as:

$$\pi_t^m - \pi_t^n = \alpha_{m,n} + \beta_{m,n}[i_t^m - i_t^n] + \varepsilon_t^{m,n} \quad (1)$$

3.1 THE DERIVATION OF THE INFLATION-CHANGE FORECASTING EQUATION

The approach adopted in this paper follows the generally used methodology which was formulated by Mishkin (1990) and has been further employed and refined by studies of Kozicki (1997), Kotlan (1999), among others. As shown in equation 2, it begins with the Fisher equation which examines the linkage between real interest rates, future inflation and nominal interest rates which then affords us the ability to clearly understand and interpret the final results.

$$i_t^m = E_t \pi_t^m + r_t^m \quad (2)$$

Where: i_t^m : Denotes the nominal m -period interest rate at time t .

E_t : Denotes the rational expectations operator based on information available at time t .

π_t^m : Denotes inflation rate between time t and m .

r_t^m : Denotes (ex-ante) real m -period interest rate at time t .

However the observed inflation rate over the next m -period can be expressed as expected rate of inflation plus the forecast error of inflation, that is:

$$\pi_t^m = E_t \pi_t^m + \varepsilon_t^m \quad (3)$$

Substituting in for $(E_t \pi_t^m)$ from (2) into (3), yields the following equation.

$$\pi_t^m = i_t^m - r_t^m + \varepsilon_t^m \quad (4)$$

To obtain an expression for the relationship between the slope of the yield curve and the change in the inflation rate, a similar n -period inflation rate equation is subtracted from equation (4), $(m > n)$ yielding the slope of the yield curve:

$$\pi_t^m - \pi_t^n = (i_t^m - i_t^n) - (r_t^m - r_t^n) + (\varepsilon_t^m - \varepsilon_t^n) \quad (5)$$

This equation is then re-written into a regression which will then be used for empirical testing:

$$\pi_t^m - \pi_t^n = \alpha_{m,n} + \beta_{m,n}[i_t^m - i_t^n] + \varepsilon_t^{m,n} \quad (6)$$

Where,

$$\alpha_{m,n} = \bar{r}_t^n - \bar{r}_t^m \quad (6a)$$

$$\beta_{m,n} = 1 \quad (6b)$$

$$\varepsilon_t^{m,n} = (\varepsilon_t^m - \varepsilon_t^n) - (u_t^m - u_t^n) \quad (6c)$$

$$u_t^m = r_t^m - \bar{r}_t^m \quad (6d)$$

$$u_t^n = r_t^n - \bar{r}_t^n \quad (6e)$$

To ensure consistent estimates, Mishkin (1990) assumes a constant slope for the real yield curve throughout time such that $(r_t^m - r_t^n) = \alpha_{m,n}$ (constant). If this condition holds, $u_t^m - u_t^n$ term in (6c) disappears and the error term $\varepsilon_t^{m,n}$ in equation (6) reduces to $(\varepsilon_t^m - \varepsilon_t^n)$. Also, turning into the assumption of rational expectations, the forecast error cannot be forecasted given the information at time t , that is. $E_t \varepsilon_t^m = E_t \varepsilon_t^n = 0$ and the forecast errors ε_t^m and ε_t^n are then orthogonal to the RHS variables of equation (6). A violation of these assumptions makes the interpretation of the yield curve complicated and reduces its forecasting power for inflation.

The constancy of the slope of real interest rate has been subject to scrutiny. For example, Lowe (1992) asserts that if prices instantaneously adjust to monetary policy and are fully flexible, the assumption of a constant slope of the real interest rate is plausible and beta ($\beta_{m,n}$) should equate to one. This is also supported by Frankel and Lown (1991) who claim that even though real interest rate may be variant in the short run, it however converges to a constant in the long run, ensuring a robust forecasting power. These assumptions therefore ensure that the ordinary least-squares (OLS) estimates of equation (6) produce consistent estimates of $\beta_{m,n}$. However, if the price flexibility assumption fails and the real yield curve

varies over time, the nominal yield spread will still contain information about the future inflation path but it is no longer going to be the optimal predictor because $(u_t^m - u_t^n)$ is no longer zero (Kotlan, 1999 and Mishkin, 1990,1991).

This assertion therefore leads us to testing if the spread, $(\pi_t^m - \pi_t^n)$, predicts the change in the n -period rate over the life of the $(m - n)$ periods rate. We therefore go on to test for the statistical significance of the nominal interest rate spread $\beta_{m,n}$ and also investigate if it differs from one or not. The statistical rejection of the null hypothesis ($\beta_{m,n} = 0$) leads us to conclude that the slope of the yield spread contains information about the change in the future m -period inflation rate from the n -period inflation rate (Mishkin, 1990, 1991 and Kotlan, 1999). This also implies that the yield spreads of both the nominal and real interest rates do not move in tandem with the elasticity of one with one another. On the other hand, the rejection of the null hypothesis ($\beta_{m,n} = 1$) leads to the conclusion that the slope of the real yield curve is not constant over time and hence the nominal yield spread is not an optimal predictor of future inflation (Mishkin, 1989; Mishkin, 1990 and Kotlan, 1999).

This method, however, carries a number of drawbacks, namely; i) It cannot be assumed that the error terms are independent and identically distributed (IID). This could emanate from the fact that the error term is made up of three components, that is, real interest rate, risk premium and inflation innovations which could cause estimation bias and heteroskedasticity. Another drawback is that of the existence of sticky prices, with Frankel and Lown (1991) and Lowe (1992) arguing that the assumption of a constant slope of the real yield curve is overly restrictive. This implies that a long-term interest rate is more likely to reflect inflationary expectations more accurately than short-term rates. Also, as pointed out by Kotlan (1999) that the forecast horizon is longer than the quarterly interval of the data, the forecasts are overlapping (Kotlan, 1999). This is, therefore, likely to result in serial correlation with the Moving Average process. To account for these problems of autocorrelation and heteroscedasticity, a Newey-West correction procedure will therefore be employed. This procedure ensures that the variance-covariance matrix is positive definite by down-weighting the off-diagonal elements (Mishkin, 1989; Mishkin, 1990). The corrected standard errors will therefore lead to correct inference asymptotically. We now turn to the empirical analysis for this study where a description the data used is given.

4. DATA AND EMPIRICAL RESULTS

4.1 DATA

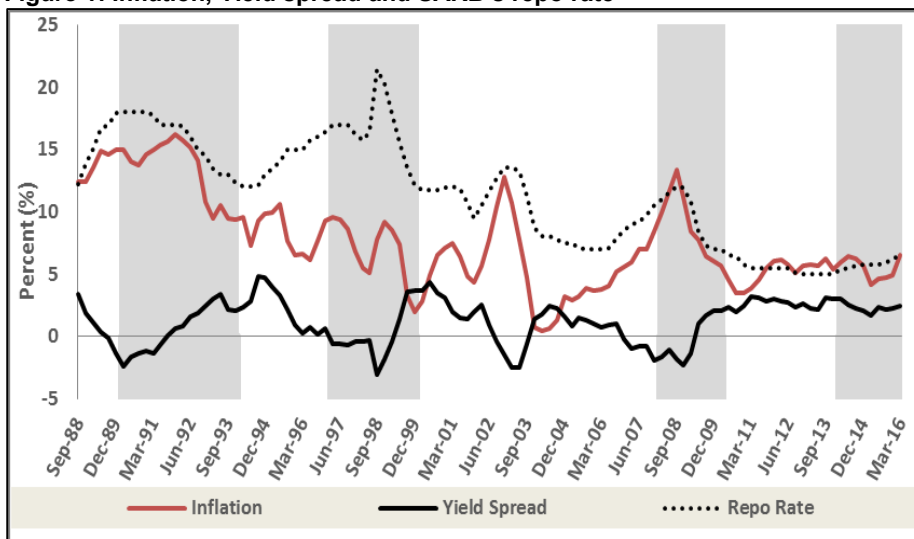
This analysis uses of South African quarterly data on consumer price index (year on year inflation rates), government's 91-day Treasury bill, and 10-year government bond yields. The analysis spans the period 1988 – 2016) since this is when all the data on all government Treasury bills of all maturities became available (data for 10-year government bond was not

available before July 1988). Treasury bill, government bond data and inflation data were all obtained from the South African Reserve Bank.

The analysis starts by investigating the properties of the time series using unit root tests and cointegration techniques. For unit roots, the ADF and the KPSS procedures were used, results show that long and short-term yields are not stationary in levels, they are only stationary after first differencing, that is: they are all integrated of order one. It is, however, noteworthy that the yield spread is stationary in levels, i.e. integrated of order zero. Inflation, on the other hand, is stationary at 10% level only when we test for stationarity from 1991 quarter one, it is therefore assumed that inflation is stationary. This, therefore, guarantees the feasibility of the usage of ordinary least squares regression in levels. The standard errors of the OLS regression are however likely to be incorrect due to serial correlation caused by the use of overlapping data, this implies that the observational interval is shorter than the horizon of the inflation rate and the yields. To account for this, as in Mishkin (1989), Mishkin (1990), and Kotlan (1999), we estimate equation (6) using the Newey-West correction procedure, which takes into consideration any possible heteroscedasticity and autocorrelation in residuals.

The analysis is firstly conducted over the full sample period (1991Q1 – 2016Q1); the series is then fragmented at February 2000, since a shift in the South African monetary policy regime occurred at that time. Towards the end of the 1980s and prior to February 2000, the Reserve Bank moved to an “eclectic” inflation targeting (Van der Merwe, 2004). This regime is normally pursued by countries with high credibility of maintaining low and stable inflation without the need of being fully transparent and accountable. As a result of this new framework, we suspect that this may have provoked a change in the information content of the yield spread on future inflation.

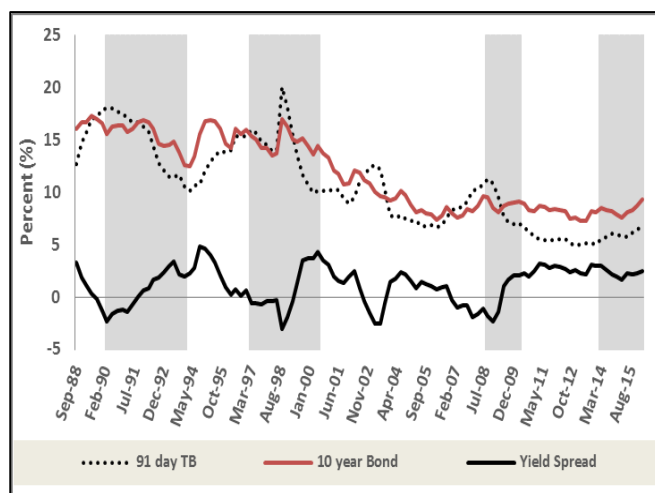
Figure 1: Inflation, Yield spread and SARB's repo rate



Source: SARB

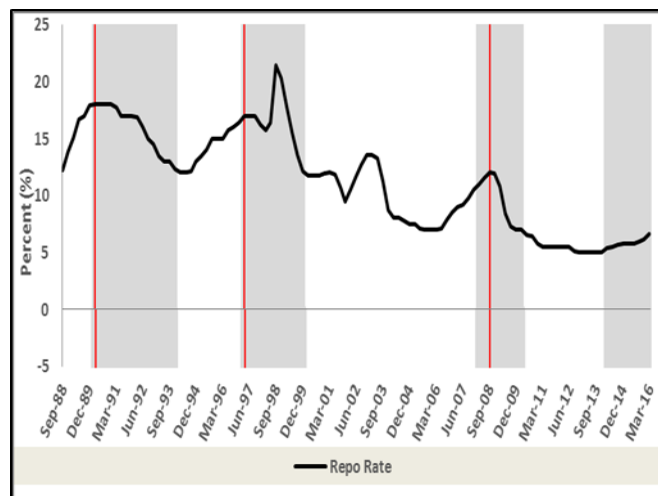
Figure 1 above shows the SARB's repo rate, inflation and the yield spread (difference between yields on the 10-year RSA government bond and 91-day Treasury bill) series over the period 1988Q3 – 2016Q1. The shaded bands show historical recessions as defined by the SARB business cycles (SARB QB, June 2016). The figure shows that the spread tends to decline as the repo rate and inflation increases and in some cases as the economy enters the downward phase of the cycle. The spread tends to move in the opposite direction of the monetary policy cycle, which is in line with economic theory. Higher short-term rates imply lower future inflation and lower short rates in the future.

Figure 2: 91-Day TB, Yield Spread and 10-year Bond



Source: SARB

Figure 3: SARB's Repo Rate and end of MP cycles



Source: SARB

Figure 2 shows the movements of the yield spread against its individual components (long-term and short-term yields). This graph shows whether changes in the yield spread are driven either by the longer or shorter end of the yield curve. It is clear in Figure 2 that short-term yields generally move faster than long-term yields during a monetary policy easing/tightening cycle. Recessionary periods are generally associated with inverted yield curves with the spread becoming negative.

Figure 3 Shows the SARB's repo rate and the end of monetary policy tightening cycles. These cycles are defined as when one of these conditions is satisfied i) the repo rate is higher than at any time from 12 months prior to 9 months after and it is 50 basis points higher than at the beginning of the period. Or ii) the SARB's repo rate is higher than at any time from six months before to six months after and is 150 basis points than the average at these points (Adrain et al 2010).

4.2 EMPIRICAL RESULTS AND INTERPRETATION

The relationships between the yield spread and inflation are estimated over varied time frames and horizons. They broadly do agree with international evidence which shows that during the period of inflation targeting, the spread has substantial predictive power (Engsted

and Tanggaard, 1995). Results are reported in Table 1 to 3, Table 1 shows results for the entire period (1990Q3 to 2016Q1), the sub-periods evidence (1990Q1 - 1999Q4) and (2000Q1 - 2016Q1) are reported in Tables 2 and 3 respectively.

Panel B includes lagged inflation as one of the explanatory variables, as in the study by Kozicki (1997) which showed that past inflation rate does help in predicting current inflation. This exercise is done to see if the yield spread does still explain future inflation over and above the inclusion of past inflation and also to improve the regression fit of the data. Estimation results indicate that the yield spread has predictive power in the South African data, particularly for the full sample period and for the Inflation targeting regime sub-period. The yield spread has a substantial predictive power between 2000 quarter 1 to 2016 quarter 1 as reported in Table 3, these results tend to be in support of the rational expectations theory. The results for the period 1990 quarter 3 to 1999 quarter 4, however, do not show any predictive power of the spread in forecasting inflation.

Table 1: Panel A

Estimates of inflation-change Equation

$$\pi_t^m - \pi_t^n = \alpha_{m,n} + \beta_{m,n} [i_t^m - i_t^n] + \varepsilon_t^{m,n}$$

Period: July 1988 to March 2016 sample (Newey-West OLS)

Yield Spread	Horizon (in Quarters)						
		4	8	12	24	30	32
91TB , 10yr Bond	Constant	7.17	7.29	6.76	6.33	5.65	5.41
		0.94	0.97	0.63	0.57	0.50	0.51
	t-stat	7.63*	7.55*	10.66*	11.09*	11.20*	10.55*
	Beta	-0.20	-0.05	0.18	-0.10	0.49	0.72
		0.37	0.35	0.24	0.21	0.20	0.22
	t-stat	-0.53	-0.14	0.74	-0.50	2.44**	3.24*
	R^2	0.01	0.00	0.01	0.01	0.12	0.26
	Wald Test Beta=0	0.60	0.89	0.46	0.62	0.02	0.00
	Wald Test Beta=1	0.00	0.00	0.00	0.00	0.01	0.21

Table 1: Panel B

Estimates of inflation-change Equation

$$\pi_t^m - \pi_t^n = \alpha_{m,n} + \beta_{m,n} [i_t^m - i_t^n] + \varepsilon_t^{m,n}$$

Period: July 1988 to March 2016 sample (Newey-West OLS)

Yield Spread	Horizon (in Quarters)						
		4	8	12	24	30	32
91TB , 10yr Bond	Constant	3.29	3.10	3.61	5.84	5.58	5.63
		1.24	0.94	0.98	1.39	0.96	0.94
	t-stat	2.66*	3.32*	3.67*	4.20*	5.80*	6.02*
	Beta	0.08	0.12	0.18	-0.07	0.49	0.72
		0.33	0.21	0.19	0.23	0.20	0.23
	t-stat	0.24	0.59	0.93	-0.30	2.37**	3.09*
	Inflation (-4)	0.50	0.53	0.43	0.07	0.01	-0.04
		0.14	0.15	0.15	0.19	0.16	0.17
	t-stat	3.56*	3.59*	2.84*	0.38	0.07	-0.22
	R^2	0.27	0.31	0.23	0.01	0.12	0.26
	Wald Test Beta=0	0.81	0.56	0.35	0.76	0.02	0.00
	Wald Test Beta=1	0.01	0.00	0.00	0.00	0.01	0.24

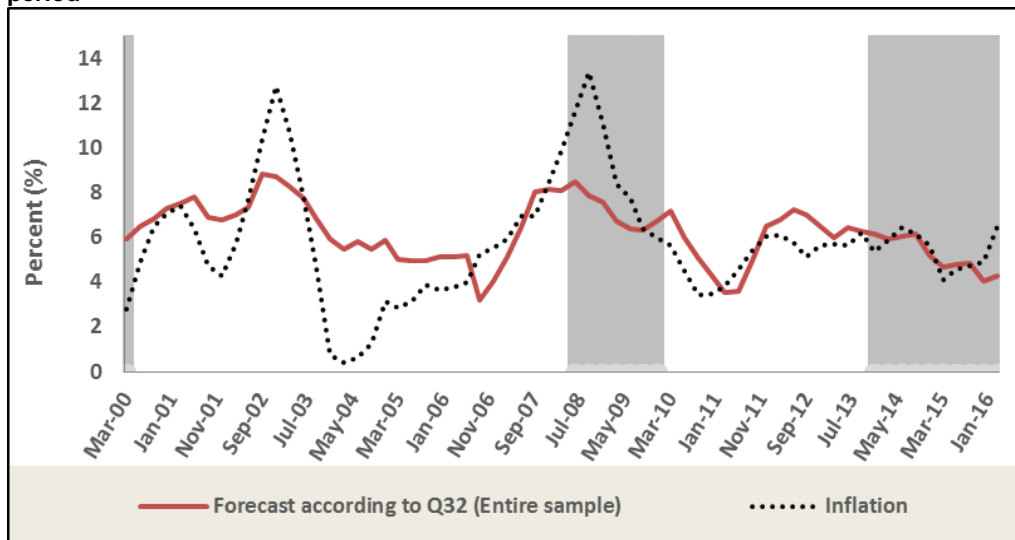
Note:*, ** and * denotes significance at 1%, 5% and 10% critical level respectively

Standard errors calculated for Newey-West adjusted covariation matrixes

Wald-test: p-values of F-statistic reported

The results in Table 1 which cover the entire sample period for both panel A and B are roughly the same and show that the spread has no to little predictive power for short to medium term (that is, for 4 - 24 quarters (1 – 6 years)). In most cases the $\beta_{m,n}$ coefficients have the wrong signs and are insignificant. However forecast horizons over 30 quarters (that is, 7.5 years) the coefficients of the yield spread are significant and close to one. The fit of the regression is very poor as shown by very low adjusted R-squared with panel B's relatively better to those of panel A. There is a significant improvement in the adjusted R-squared for forecast horizons of over thirty quarters. This study also presents results of the Wald test. This test assumes the null hypothesis of $\beta_{m,n} = 0$ or 1 and fails to reject at 1%, 5% and 10% significance level respectively. The results of the Wald-test: $\beta_{m,n}$ coefficient being significantly different from zero is not rejected for over 32 quarter's forecast horizons. For quarter 30 however, the Wald-test rejects both the cases that the $\beta_{m,n}$ coefficient is significantly different from one and zero, this is a border line scenario.

Figure 4: inflation, forecasts according to an eight-year lag spread for the Entire sample period



On a broader view, these results can be interpreted as follows. The yield spread for the South African data does contain useful information about the future trajectory of inflation for forecast horizons above 30 quarters. Even though not precisely, the results of this paper broadly agree with those of Mishkin (1990, 1991, 1998), Campbell and Shiller (1987), Kozicki (1997), Estrella (2004), Ang et al (2008), Balduzzi et al (1997), Kotlan (1999) and Schich (1999) in that the term structure of interest rates contains little to no predictive power in the short end of the yield curve about future changes of inflation. As noted by Kotlan (1999), this could be as a result of great variability of real interest rates in the short run which could eclipse the inflation expectations component. Figure 4 shows how well the forecast according to 32 quarters model tracks the actual data of inflation in South Africa.

Table 2 : Panel A

Estimates of inflation-change Equation

$$\pi_t^m - \pi_t^n = \alpha_{m,n} + \beta_{m,n} [i_t^m - i_t^n] + \varepsilon_t^{m,n}$$

Period: September 1990 to December 1999 sample (Newey-West OLS)

Spread		Horizon (in Quarters)					
		4	8	12	24	30	32
91TB , 10yr Bond	Constant	10.06	10.12	9.49	7.63	7.02	7.18
		1.32*	1.33*	0.93*	0.59*	0.71*	0.86*
	t-stat	7.62	7.61	10.23	13.00	9.88	8.32
	Beta	-0.53	-0.42	-0.32	-0.11	-0.51	0.25
		0.54	0.46	0.28	0.31	0.36	0.33
	t-stat	-0.97	-0.90	-1.15	-0.34	-1.39	0.75
	R^2	0.08	0.05	0.03	0.01	0.12	0.03
	Wald Test Beta=0	0.34	0.37	0.26	0.73	0.19	0.47
	Wald Test Beta=1	0.01	0.00	0.00	0.00	0.00	0.04

Table 2 : Panel B

Estimates of inflation-change Equation

$$\pi_t^m - \pi_t^n = \alpha_{m,n} + \beta_{m,n} [i_t^m - i_t^n] + \varepsilon_t^{m,n}$$

Period: September 1990 to December 1999 sample (Newey-West OLS)

Spread		Horizon (in Quarters)					
		4	8	12	24	30	32
91TB , 10yr Bond	Constant	2.98	1.30	2.84	12.19	12.60	14.56
		2.14	2.11	2.81	2.12	2.00	2.58
	t-stat	1.39	0.62	1.01	5.76*	6.29*	5.65*
	Beta	-0.31	0.28	0.11	-0.22	-0.35	-0.01
		0.37	0.33	0.40	0.35	0.41	0.29
	t-stat	-0.83	0.85	0.29	-0.62	-0.86	-0.03
	Inflation (-4)	0.65	0.76	0.60	-0.55	-0.71	-0.98
		0.18	0.19	0.27	0.29	0.24	0.35
	t-stat	3.54*	3.92*	2.25**	-1.90*	-2.89**	-2.82**
	R^2	0.45	0.44	0.33	0.16	0.40	0.39
	Wald Test Beta=0	0.41	0.40	0.77	0.54	0.40	0.98
	Wald Test Beta=1	0.00	0.04	0.03	0.00	0.01	0.01

Note: *, ** and * denotes significance at 1%, 5% and 10% critical level respectively

Standard errors calculated for Newey-West adjusted covariation matrixes

Wald-test: p-values of F-statistic reported

Switching to the analysis of the regime switch effect, Table 2 presents results for the first regime (1990Q1 – 1999Q4) where the SARB did not formally target inflation. This analysis is aimed at uncovering the usefulness of the inflation-targeting regime in anchoring inflation expectations post the year 2000. Estrella (2005), Gurkaynak *et al* (2006) and Reid (2009) all concurred that the relationship between the yield spread and the future inflation evolution are broadly influenced by the monetary policy regime. In Table 2 Panel A and B, we see that the $\beta_{m,n}$ coefficients are all insignificant across all forecasts horizons and most of them even carry wrong signs. Even though the adjusted R-squared are slightly higher compared to

Table 1, the Wald-test which hypothesizes that the β coefficients significantly differ from zero cannot be rejected for all forecast horizons. As such, these results are in agreement with those of Estrella, Gurkaynak *et al*, and Reid that in the absence of inflation targeting regime, inflation expectations are not anchored and hence the yield spread tend to have weak or no predictive power about future inflation.

Table 3 : Panel A							
Estimates of inflation-change Equation							
$\pi_t^m - \pi_t^n = \alpha_{m,n} + \beta_{m,n} [i_t^m - i_t^n] + \varepsilon_t^{m,n}$							
Sub-Period: Feb 2000 to March 2016 sample (Newey-West OLS)							
Spread		Horizon (in Quarters)					
		4	8	12	24	30	32
91TB , 10yr Bond	Constant	5.84	5.58	5.49	5.87	5.05	4.76
		1.04	0.64	0.47	0.70	0.42	0.46
	t-stat	5.60*	8.72*	11.80*	8.36*	11.93*	10.36*
	Beta	-0.03	0.20	0.34	-0.08	0.74	0.94
		0.42	0.21	0.22	0.24	0.17	0.22
	t-stat	-0.07	0.95	1.57	-0.35	4.26*	4.20*
	R^2	0.00	0.02	0.06	0.00	0.29	0.44
	Wald Test Beta=0	0.95	0.35	0.12	0.73	0.00	0.00
	Wald Test Beta=1	0.02	0.00	0.00	0.00	0.14	0.79

Table 3: Panel B							
Estimates of inflation-change Equation							
$\pi_t^m - \pi_t^n = \alpha_{m,n} + \beta_{m,n} [i_t^m - i_t^n] + \varepsilon_t^{m,n}$							
Sub-Period: Feb 2000 to March 2016 sample (Newey-West OLS)							
Spread		Horizon (in Quarters)					
		4	8	12	24	30	32
91TB , 10yr Bond	Constant	1.86	2.30	2.40	1.92	2.36	3.05
		0.61	0.58	0.62	0.54	0.48	0.66
	t-stat	3.07*	3.96*	3.88*	3.57*	4.94*	4.61*
	Beta	0.23	0.12	0.10	0.21	0.57	0.67
		0.26	0.18	0.21	0.12	0.14	0.22
	t-stat	0.88	0.66	0.48	1.80***	4.08*	3.01*
	Inflation (-4)	0.64	0.59	0.58	0.65	0.50	0.35
		0.10	0.12	0.12	0.12	0.10	0.13
	t-stat	6.12*	4.85*	4.64*	5.48*	4.96*	2.74*
	R^2	0.40	0.38	0.38	0.40	0.53	0.53
	Wald Test Beta=0	0.38	0.51	0.63	0.08	0.00	0.00
	Wald Test Beta=1	0.00	0.00	0.00	0.00	0.00	0.14

Note:*, ** and * denotes significance at 1%, 5% and 10% critical level respectively

Standard errors calculated for Newey-West adjusted covariation matrixes

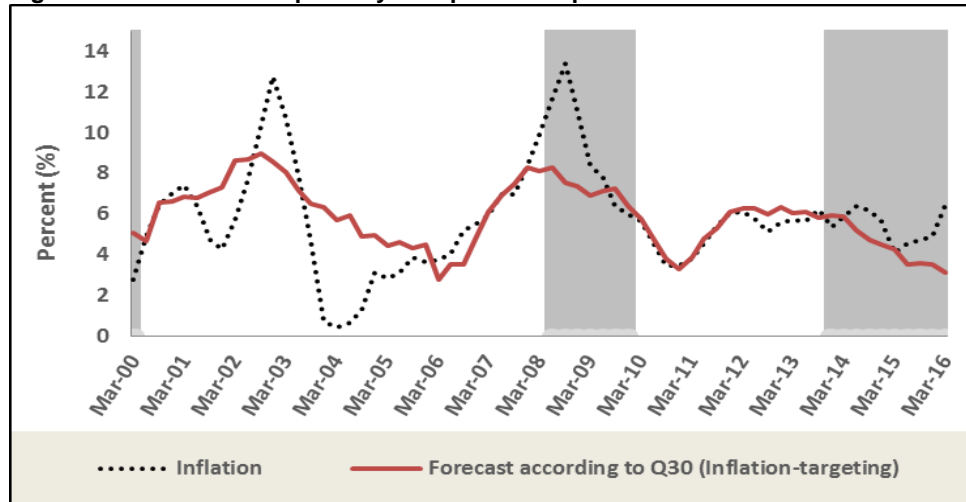
Wald-test: p-values of F-statistic reported

Table 3 presents the results of the inflation targeting regime employed by the SARB in February 2000. In Panel B we lag Inflation by 2 instead of 4, this is as a result that current inflation within an inflation-targeting regime is more forward looking and hence if lagged by 4 quarters it fails to explain current inflation and is insignificant. The results for panel A and B

differ slightly from each other in that the inclusion of the inflation component makes the spread to have a predictive power as early as from quarter 24 going forward. The results of Table 3 also prove to be more robust relative to the previous results.

The $\beta_{m,n}$ coefficients of Table 3 Panel A are insignificant up to quarter 26 (6.5 years), however from quarter 27, the yield spread coefficient is significant and thus explains the future changes of inflation. Interestingly, including a two lag inflation term, the spread starts becoming significant as early as quarter 24 (six years) and has correct signs across all forecast horizons. The adjusted R-squared are very low for Panel A prior to quarter 30 indicating a poor fit of the regressions, there is however a slight improvement from quarter 30 going forward. Panel B on the other hand shows relatively higher adjusted R-squared across all horizons; this shows that including a lagged inflation term as one of the regressors significantly improves the fit. In Panel A, the hypothesis that $\beta_{m,n}$ significantly differs from zero is not rejected from quarter 30 onwards. For Panel B, we can conclude that since we cannot reject the null ($\beta_{m,n} = 0$) for quarters 4, 8 and 12, the slope of the real yield curve is varies over time and hence the nominal yield spread is not an optimal predictor of future inflation.

Figure 5: Forecast of 30 quarter yield spread compared to actual inflation



The results of Table 3 can, therefore, be broadly interpreted as follows. The South African yield spread contains useful information about the future evolution of inflation only for forecast horizons from 24 quarters onwards. Figure 5 shows that the forecast using quarter 30 model tracks the actual data of inflation more closely than the one showed in Figure 2, this confirms and complement the findings of Estrella, Gurkaynak *et al*, and Reid (2006). Table 3 further shows that inflation expectations are well anchored under the inflation targeting regime which implies that long-term yields provide useful information about the future path of inflation.

Table 4: Forecast comparison between the entire sample and the inflation-targeting regime

Estimates	30 quarter Lag	
	2000Q1-2016Q1	1991Q1-2016Q1
$\beta_{m,n}$	0.57	0.49
<i>t-stat</i>	4.08*	2.37**
Adjusted R ²	0.53	0.12
AIC	4.19	4.67
SIC	4.13	4.76

Note: *, ** and * denotes significance at 1%, 5% and 10% critical level respectively

Table 4 shows the comparison of the forecast equation estimates using 30 quarters (7.5 years) spread lag for both the entire period and the inflation targeting regime to see which of the two models is more robust. The results for the inflation targeting regime are more robust compared to those of the entire period. For instance, the adjusted R-squared for the entire period regression (0.12) is much lower than that of the inflation targeting regime (0.51). This shows that the regression for the inflation targeting regime is a better fit and produces better results. Table 5 in the appendix shows the estimates for all the lags and the results for the inflation-targeting regime tend to outperform those of the entire period across horizons.

5. CONCLUSION

The evidence provided in this paper suggests that the slope of the yield curve is useful in forecasting the future path of inflation. These results put forward that the yield spread should not be used to forecast near-term inflation rate (that is, 23 quarters or less). The yield spread is however useful for predicting changes in future inflation over 24 quarters in the South African case. The results are much robust for the inflation-targeting regime confirming the credibility of monetary policy in anchoring long-term inflation. These findings are in harmony to those of Reid (2009), affirming that the SARB has been able to stabilise and manage inflation expectations through its transparent and credible monetary policy. The results of this paper are consistent with the theory that monetary policy has direct effects on the short end (real interest rates) of the yield curve because of prices stickiness. Long-term yields, however, more closely mimic the behaviour of inflation expectations than do short-term rates as prices are fully flexible in the long-run. Berk (1988) however, points out that caution should be exercised by policy makers when using the yield spread as a tool to forecast inflation. This is because many factors can shift the ends of the yield curve and at face value may prompt monetary authorities to respond inappropriately.

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6. APPENDIX

Table 5: Forecast comparison between the entire sample and the inflation-targeting regime

Comparing the Entire period and linflation targeting period							
Spread	Horizon (in Quarters)						
		4	8	12	24	30	32
2000Q1-2016Q1	Beta	0.23	0.12	0.10	0.21	0.57	0.67
	<i>t-stat</i>	0.88	0.66	0.48	1.80***	4.08*	3.01*
	Adjusted R-squared	0.40	0.38	0.38	0.40	0.53	0.53
	AIC	4.35	4.37	4.48	4.35	4.19	4.09
	SIC	4.45	4.47	4.42	4.45	4.13	4.20
1991Q1-2016Q1	Beta	0.08	0.12	0.18	-0.07	0.49	0.72
	<i>t-stat</i>	0.24	0.59	0.93	-0.30	2.37**	3.09*
	Adjusted R-squared	0.27	0.31	0.23	0.01	0.12	0.26
	AIC	5.04	5.04	5.08	4.82	4.67	4.62
	SIC	5.12	5.12	5.03	4.91	4.76	4.56

Note: *, ** and * denotes significance at 1%, 5% and 10% critical level respectively