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Does the Taylor Rule Outperform Market Forecasts of Interest Rates?

MASTER'S RESEARCH REPORT

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Abstract

This study sets out to investigate whether the Taylor Rule provides better the forecasts of the future short-term interest rates than the yield curve in the South African market. For the Taylor Rule we use OLS and use the open-market forward-looking Taylor Rule to forecast interest rates. For the yield curve, simple linear interpolation is used to derive forecast. We find that in the short term, forecasted one-month ahead interest rates closely track the actuals interest rates for both models. At longer horizons, there are larger deviations of forecasts from the actual. The RMSE analyses support the Taylor Rule as a superior forecasting model in all forecasting horizons.

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1. Introduction

This paper assesses the ability of the Taylor Rule to forecast interest rates in South Africa. In addition, we compare the performance of the Taylor Rule to market forecasts derived from the yield curve. As pointed out by Hardle and Majer (2012), forecasting interest rates is important for asset pricing because interest rates determine the discount factors that are used to value future cash flows. Furthermore, Mandler (2008) and Sangvinatsos (2008) argue that forecasting interest rates is important in portfolio allocation, derivative pricing, policy decisions and risk management.

Chinn and Kucko (2010) state that, the correlations between asset prices and economic activity may influence debates about the mechanisms of the macroeconomy. These authors further point out that, policy-makers usually need to make choices today based on their expectations of future economic conditions. The part played by interest rates when assigning funds across financial markets is similar to the role played by prices in apportioning resources in the goods and services markets. As pointed out by Russell (1992), just as the higher price in a certain good tends to attract resources into its production, high interest rates on a particular asset tends to draw funds into the activities for which that type of security is issued to finance.

This study is motivated by the idea that, the ability to accurately estimate and forecast interest rates allows for a precise measurement of the discount factor for the pricing of assets. In line with Cecchetti et. al. (2002), a further argument raised in this study is that, by accurately determining interest rates, asset price bubbles are avoided¹. If there is a greater dispersion between the methods used by market participants (through the yield curve) and that used by the Central Bank (the Taylor Rule), then this shows that market participants do not have confidence in the methods used by the Central Banks. This is in line with Markov (2009) who highlights that, the Taylor Rule method followed by the Central Bank becomes the art of managing the expectations of economic agents. Thus, the Central Bank is concerned about the predictability and credibility of its strategy.

¹ It should be noted that asset price bubbles cause biases in investment and consumption which lead to extreme rises and declines in real output and inflation.

As pointed out by Goodhart and Lim (2011), one of the issues concerning the question of whether the Central Bank should try to decide upon, and make public, a potential future path for its own policy rate (through the Taylor Rule), as contrasted with relying on the expected future path in the yield curve, is the relative accuracy of the two sets of forecasts. Therefore, we infer the thinking of the markets with regards to the Central Bank's ability to accurately predict interest rates.

In this paper, we focus on two methods of forecasting interest rates: the Taylor Rule and the yield curve. Taylor's (1993) rule describes the behaviour of the Central Bank in setting the interest rate. Kendall and Ng (2013) state that, a Taylor Rule equation is a commonly used method which describes the behaviour of the Central Bank in altering short-term interest rates in response to economic conditions. Specifically, in these rules, the Central Bank reacts to inflation, the output gap and the exchange rate when examining the economy.

Although various expansions have been made to the Taylor Rule, the important element to be included in this paper is the exchange rate. Ball (1999), Carvalho (2010), Orphanides (2002), Cheng and Tsang (2009), Svensson (2002), Mohanty and Klau (2004) and Tanuwidjaja and Choy (2006) have highlighted the importance of including the exchange rate in the Taylor Rule when examining open markets. Tanuwidjaja and Choy (2006) assert that a depreciation of the exchange rate is expected to influence the Central Bank to increase interest rates in the coming period. According to these authors, the exchange rate limits provide more accurate estimates of the coefficients through exchange rate pass-through. According to Yau (2010), increased exchange rate variability may have a negative influence on international trade and capital flows. Further, the Central Bank could also pay attention to movements in the exchange rate when a weak home currency indicates a possible inflationary pressure.

This evidence supports the idea of Mohanty and Klau (2004) who point out that, including the exchange rate element is important because, there exists a high level of exchange rate pass through into inflation. According to Batini and Nelson (2000), the interaction of exchange rate changes with aggregate demand and inflation is empirically plausible. Further, Tanuwidjaja and Choy (2006) point out that the exchange rate factor forces the

Central Bank to react spontaneously albeit slowly, to currency shocks so as to stabilize nominal and real exchange rates. However, Orphanides (2002) and Woodford (1999a, 2001) question the informational content and point out defects in the Taylor Rule.

The second method is forecasting interest rates using the yield curve. The yield curve shows the relationship between the yield-to-maturity on a zero-coupon bond and the maturity of the bond. The yield curve is determined by forward spot rates of the interest rates. Bieri and Chincarini (2005), Bernadell et. al. (2005) and Estrella and Trubin (2006), state that investor expectations also drive interest rates. Estrella and Trubin (2006) find that investor expectations allow the yield curve to be more forward-looking than other leading indicators. Svensson (1994) emphasizes that the yield curve can be interpreted as the expected future averages of the variables in focus, whilst the forward rate can be taken as representative of the future time path of these variables.

The gap filled by this study is to evaluate whether the Taylor Rule outperforms the yield curve. A study that compares the forecasting performance of the Taylor Rule benchmarking against the yield curve has not been published. Most studies have looked at the forecasting abilities of each of the models without making this specific comparison of the two models. We seek to answer two questions. Firstly, does the Taylor Rule outperform the yield curve in forecasting interest rates? Secondly, do markets contemplate that the Central Bank provides precise predictions of future interest rates?

This paper builds on the papers by Svensson (1994), Mohanty and Klau (2004), Qin and Enders (2008) and Milas and Naraidoo (2012), and examines the South African market. Due to data restrictions, we choose to use South Africa as a representative of emerging economies as very little scrutiny has been given to these countries as compared to the industrialized economies. This is also in line with Taylor (2000a) who emphasizes that a high priority in emerging economies is to construct and approximate macroeconomic models, and to assess policy rules in these models. This paper is based in the following hypotheses:

Null Hypothesis: The Taylor Rule outperforms the yield curve in predicting interest rates.

Alternative Hypothesis: The yield curve predicts interest rates better than the Taylor Rule.

2. Literature Review

2.1 Theoretical Background

Mitra (2010) and Hofmann and Bogdanova (2012) define the Taylor Rule as a simple monetary policy concept that mechanically relates the level of policy rate to deviations of inflation from its target and of output from its potential. Gali et. al. (2004) state that the Taylor principle is viewed as an apparent condition and it is considered a policy-stabilizing model. They highlight that when policy fails to meet the Taylor principle then this often implies that the period has been marred by large fluctuations in inflation and widespread macroeconomic instability. Mitra (2010) points out that the Taylor Rule equation represents a simple relationship, yet it captures the essence of the behaviour of the monetary authority.

Supported by Hofmann and Bogdanova (2012), the Taylor rule proposes that the Central Bank aims at stabilizing inflation around its target and output around its potential. Therefore, positive (negative) aberrations of both elements from their target or potential would imply a tightening (loosening) of monetary policy. This is in line with Skumsnes (2013) who also states that the mechanics of the Taylor rule is called "leaning against the wind", which means that a rise in output should be reacted to with an increase in the nominal interest rate to dampen the economy, and a reduction would boost the economy if inflation or output decreased. According to Nikolsko-Rzhevskyy and Papell (2012), the Taylor Rule is overtly normative with great aberrations from the target rules being defined as policy mistakes. Galimberti et. al. (n.d.) states that in a closed economy, inflation targeting and Taylor Rules perform well in stabilizing both output and inflation.

Taylor (1993) states that an optimal model should be one that is in place for a long period and one which allows people to adjust their expectations and ensure that variables are unbiased². As pointed out by Mohanty and Klau (2004) and Fendel et. al. (2011), the Taylor Rule has been extended by taking into account the forward-looking behavior of Central Banks and the intention to smooth the interest rate adjustment. Mitra (2010) suggests that the forward-looking Taylor rule aims to realize targeted inflation and targeted growth rates

² This is, of course, under the assumption that individuals' expectations are rational.

by regulating policy instruments that affect interest rates in the market. Batini and Haldane (1999) contend that since lags between the implementation of monetary policy and its first effects on inflation and output are well known, one can design forecast-based rules such that they take into account these transmission lags. Failure to recognise these lags could result in cyclical instability. Moreover, expectations of monetary authorities are in general formulated based on a broad spectrum of information. In this sense, forecast-based rules are information encompassing rules.

Bain and Howell (2002) state that the yield curve reflects the series of yields that investors in government debt expect to receive on their investments over a range of terms-to-maturity. An upward sloping yield curve is associated with an increase in real economic activity while a downward sloping yield curve is associated with a decrease in real economic activity. Dating back as far as 1978, Butler (1978) initially suggests that, the beliefs of the market do not imply that there will be a recession. This, the author explains, is because the actions of the private and the public decision makers in coming months may prevent that possibility. Further Butler (1978) points out that the market, in some instances, has poor predictive power of cyclical changes.

Kappi (1998) characterizes the yield curve in three different ways; the discount factors, the zero-coupon interest rates and the forward rates. Further, Clay and Keeton (2011) state that the yield curve should explain how interest rates on bonds with different terms to maturity move together over time, how the yield curve is normally upward sloping; and how during periods of low short-term interest rates the yield curve is upward sloping. Butler (1978) also states that, short-term interest rates generally move upward with the level of business activity.

Goodhart and Lim (2001) point out that, although the random walk theory exists, most macroeconomic variables are expected to regress back to its long-run equilibrium, all else equal. But at any point, the variables will be exposed to momentum, which is difficult to assess due to unanticipated future shocks. Thus, forecasts are determined by an autoregressive component and a mean reverting component.

The yield curve has significant influence on monetary policy. Estrella and Trubin (2006) point out that when the Reserve Bank introduces a tightening monetary policy, it is usually interpreted as an increase in short-term interest rates which is meant to reduce inflationary pressures. Gamber and Joutz (2005) also point out that a downward tilt of the yield curve is also viewed as a tightening monetary policy, as short-run interest rates increase and long-run interest rates decline. That is, a tilt in the yield curve shows changes in the short-run real interest rate whilst shifts in the yield curve show superior information held by the Central Bank about future inflation.

Dotsey (1998) states that when there is an increase in expected inflation, as illustrated by a steepening of the term structure; the Central Bank employs a contractionary monetary policy by raising short-term rates. Estrella and Trubin (2006) point out that a sluggish economy and a flat yield curve are results of a contractionary monetary policy.

The literature extensively discusses the smoothing of interest rates. Driven by their intense interest on asset prices, Cecchetti et. al. (2002) recommend that Central Banks must undertake interest rate smoothing with their attention focused not only on Monetary Policy but also on asset prices. Their reasoning is that bubbles in asset prices result in biases in the levels of consumption and investment which lead to rises then declines in real output and inflation. Central Banks can increase interest rates when asset prices increase above target levels and can lower interest rates when asset prices fall below acceptable levels. This technique reduces the impact of bubbles on inflation and output and encourages stability in the macro-economy. In line with Mitra (2010), including the smoothing factor in the Taylor Rule equation results in an interest rate rule in which the Central Bank changes the short-term interest rate in a gradual manner to decrease the gap between the current target rate and its past value.

Academics have suggested a number of theories used to describe the empirical explanations of the profile or shape of the yield curve. Most of these academics believe that understanding the yield curve is important when examining the effect of monetary policy, predicting interest rates, exchange rates and economic activity. It also provides information about expectations of the market participants. Below is a discussion of four theories

namely; the Expectations Hypothesis, the Segmented Market Hypothesis, the Liquidity Premium Hypothesis and the Preferred Habitat Theory are discussed below.

2.1.1 The Expectations Hypothesis

The predictions made by the yield curve are related to the expectations hypothesis. Bain and Howell (2002) indicate that, this hypothesis dates back as far as 1930 when it was introduced by Irving Fisher who pointed out that the yield curve can be characterized by the market's expectation of future short-term interest rates. Kessel (1971), Butler (1978), Campbell and Shiller (1991), Longstaff (2000) and Sarno et. al (2005) suggest that, the expectations hypothesis of the term structure of interest rates proposes that the long rate is determined by the market's expectation for the short rate. Bain and Howell (2002) point out that when market participants notice a monetary shock is occurring, they will immediately adjust their expectations.

Berk and Bergeijk (n.d.) emphasize that the expectations theory is the predominant explanation of the yield curve and is founded on the arbitrage circumstance that, after accounting for risk, the expected return from holding for one period a bond that has n -periods to maturity is the same as the certain return from a one-period bond. According to Mishkin (2007;p.136) the expectations hypothesis states that *"the interest rate on a long-term bond will equal an average of the short-term interest rates that people expect to occur over the life of the long-term bond"* (cited by Clay and Keeton, 2011).

This is in line with Bieri and Chincarini (2005) who posit that, the rational expectations hypothesis of the term structure of interest rates highlights that, in a world where investors are risk neutral, the n -period long rate is a weighted average of the future spot rates. Thus, any one-period forward rate is an unbiased predictor of the corresponding future one-period spot rate. They further point out that the expectations hypothesis implies that with the possible exception of the term premium, the holding period returns (HPRs) of a class of fixed-income instruments are identical, independent of the instruments' original maturity.

The general characterization of the yield curve is that, under normal circumstances, the long-term yields are higher relative to the short-term rates of interest. Cinquegrana and

Sarno (2010) explain that the normal upward sloping yield curve is apparent when the economy is in steady growth, inflation pressure is low and there are no expectations on sudden changes in the business cycle. Clay and Keeton (2011), state that this explains the higher risk premiums that are demanded by investors especially when they place investments with higher duration. Estrella and Trubin (2006) highlight that changes in investor expectations can also change the slope of the yield curve. Bordo and Jean (2001) also point out that, when investors are enthusiastic, there is risk associated with an increased reversal in market sentiment. Campbell and Shiller (1991) summarize this notion by stating that when the term spread is low, the long-term yield tend to rise over the life of the investment and *vice versa*.

Chokroun and Abid (2013) state that the yield curve is an important indicator which is monitored by financial institutions to manage the interest rate risk and make investment decisions. Shelile (2006) suggests that, if market participants anticipate a decline in interest rates, they will desire to lock into current higher rates or higher capital gains projections by means of long term assets. These expectations will tend to influence the behaviour of investors and ultimately the term structure of interest rates. This ought to comprise of information which can be used to forecast expected short-term fluctuations of the future business cycles.

Bain and Howell (2002) argue that if the expectations hypothesis is acknowledged, and if the expectations are assumed to be correct, then the shape of the yield curve would provide and accurate forecast of the future nominal interest rates. The authors suggest that, since, according to the expectations hypothesis, the yield curve depends entirely upon the market's expectations of future short-term interest rates, the yield curve could assume any shape. However, Campbell and Shiller (1991; p.505) conclude "*we thus see an apparent paradox: the slope of the term structure almost always gives a forecast in the wrong direction for the short term change in the yields on longer bonds, but gives a forecast in the right direction for long term changes in short term rates*".

2.1.2 Market Segmentation Hypothesis

The market segmentation hypothesis asserts that the markets for bonds of different maturity are segmented (i.e. separate). According to Johnson et. al. (1992) this theory provides an economic foundation for explaining the slope of the yield curve in terms of demand and supply factors. Johnson et. al. (1992) and Gutierrez (2008) posit that market participants have strong maturity preferences which they may realize when they invest in securities. They further allude to the notion that due to these preferences, financial markets are segmented into smaller markets, with the demand and supply equilibriums unique to each fragment.

Shelile (2006) states that, the main supposition of the market segmentation hypothesis is that bonds of different maturities are not substitutes. This notion is supported by Johnson et. al. (1992) who points out that based on this hypothesis, securities with different maturities are assumed to be imperfect substitutes.

2.1.3 Liquidity Preference Hypothesis

Bain and Howell (2002) state that the liquidity premium is a premium that entices lenders away from their preference of short-term holding towards long-term holdings and a price which debtors are willing to pay for a guaranteed use of long-term funds. According to Kessel (1971) investors are risk averse, they favour short maturity investments and the require compensation in the form of a liquidity premium for them to commit to longer term investments. This notion is in line with Mishkin (1999) who points out that, the yield on longer-term securities will be equal average short-term rates over the term of the bond plus a premium that corresponds with the demand and supply forces of that bond. Alexius (2004) reinforces this notion, by stating that the yields on investment securities increase with duration. This explains why the yield curve is classically upward sloping.

2.1.4 Preferred Habitat Theory

According to Bain and Howell (2002), the notion of risk aversion requires us to drop the pure expectations theory that bonds are homogenous. The variances in their term to maturity may form different kinds of risk characteristics to which investors are sensitive. Thus,

according to these authors, the preferred habitat theory uses heterogeneity to argue that investors have different preferences for segments of the maturity scale. Gutierrez (2008) points out, that participants in the financial market are assumed to have maturity preferences which they may alter if they find a habitat with a better premium. Expectations of future interest rates are not exclusively responsible for the pattern of current bond yields, that is, stocks of bonds, and investors' demands to hold them, also influence the term structure.

Bain and Howell (2002) believe that short-term investors mostly dominate the fixed-income market, and therefore, longer-term rates tend to be higher than short-term rates, for the most part. But in some instances, short-term rates can be higher than long-term rates occasionally. This theory is consistent with both the persistence of the normal yield curve shape. The basic idea of this theory is that the rate for each horizon is decided according to the supply and demand for funds concerning that specific maturity.

2.2 Background Literature Analysis

Very few studies have made use of the forward-looking model or the forecast-based method of the Taylor Rule. For example Qin and Enders (2008) and Fendel et. al.(2011) make this specific combination. Qin and Enders' (2008) results support the notion that the forward-looking model is a better method for the Central Bank to accurately forecast interest rates based on the expected values of the future path of the economy. The overall results presented by Fendel et. al. (2011), indicate that financial market forecasts are internally consistent with Taylor-type rules at least in the forward-looking version. This is also the preferred specification of the Taylor Rule in the framework of Central Bank reaction functions. Sarno and Valente (2005) are of the view that, two important elements in forecasting out-of-sample Central Bank rates are by incorporating forward-looking and also reverting back to the target. Milas and Naraidoo (2012) also investigate the different Taylor-type rules that allow for better forecasting of interest rates. Their results show that a semi-parametric model performs better than either the linear or nonlinear Taylor Rule model.

In line with the methodology incorporated in this paper, Mohanty and Klau (2004) use the open-economy-Taylor-rule to test the predictive ability of the Taylor Rule model in emerging

economies. Their results show that, although the model explains the variation in the model by between 70%-90%, there is evidence of over- and under-prediction in Brazil and South Africa respectively. Expanding on the work of several authors (Croushore and Stark (1999), Kozicki (1999), Orphanides (1998-03), Runkle (1998)³), Hertzel (2000) finds that the Taylor Rule model is not a good fit in predicting the interest rates of the Central Bank. Tanuwidjaja and Choy (2006) find that when the Taylor Rule with the exchange rate element is used, there is marginal improvement in macroeconomic stability for the Indonesian market. Taylor (2001) examines rules that comprise of the exchange rate terms, and speculates that estimations may not find a strong independent exchange rate effect, as the effect of the exchange rate on output and inflation is implicitly accounted for by the Central Bank.

Dahlquist and Jonsson (1994) study the relationship between the implied forward rates and corresponding future spot rates in the short-end of the Swedish yield curve. The authors make use of monthly data of interest rates for Swedish Treasury-bills for the period January 1984 to July 1992. The authors find that interest rates seem to be integrated of order one and are also cointegrated. They also find that the precision in the estimates are lower for forward rates with longer maturities. The authors conclude that forward rates, for all maturities, contain information about future interest rates.

Haubrich and Dombrosky (1996) justify the use of the yield curve in predicting future GDP by stating that the yield curve reflects future output indirectly, by predicting future interest rates. They conclude that, indeed the yield curve has substantial predictive power. Clay and Keeton (2011) take a South African perspective. They find that although the yield curve fails to predict the downswing in SA of the 2002-2003, it has substantial predictive ability in the downswing of the 2008-2009. They conclude that the yield curve has the best predictive ability two quarters ahead. However, Nelson and Siegel (1985) make use of US Treasury bond which matures in 2010 and they find that actual and predicted interest rates are highly correlated but point out that the model prices tend to overshoot the actual.

Gamber and Joutz (2005) aim at separating the changes in the Federal fund's rate into two segments. The first one shows the Fed's superior forecasts about the state of the economy.

³ The authors are cited in Hertzel's (2000) study

The second one reflects the Fed's response to the forecasts made by the public about the state of the economy. They hypothesize that if a rise in the Federal funds rate causes a rise in the short-run real rates, the yield curve will merely tilt and not shift. Using a structural VAR, the authors find that a tilt in the yield curve shows changes in the short-run real rate whilst shifts in the yield curve show superior information held by the Central Bank about future inflation. The evidence presented by the authors reveals asymmetric information about high inflationary expectations.

A different perspective is taken by Modugno and Nikolau (2009) who look at the ability of international yield curves to predict patterns in the domestic yield curve using data from Germany, the US and the UK. They find evidence in support of the notion that using international yield curves reduces discrepancies in the prediction of the domestic yield curve. Mehl (2006) also investigates the predictive ability of the yield curve in 14 emerging economies. The author concludes that the yield curve is a useful forecasting tool for those economies. Furthermore, the author states that inflation targeting in emerging economies appears to have exchange rates driven by forward-looking macro variables.

The literature shows that some authors focus on other factors when testing the forecasting ability of the yield curve. Ducker (1997), Chauvet and Potter (2001) and Estrella and Trubin (2006) concentrate on the ability of the yield curve to forecast a recession. Using US data the three studies find that the yield curve is a good predictor of economic down turns. Butler (1978) uses data from numerous Federal-agency securities issued by the Federal Home Loans Banks, the Federal Land Banks and the Federal National Mortgage Association as of December 1978. The author's results show that, during a recession, short-term rates tend to fall sharply and they continue to do so for about three or four quarters after the recession ends at the trough in the real Gross National Product (GNP). Goodhart and Lim (2011) find that when interest rates are on an upward (downward) cyclical path, the forecast underestimates (overestimates) the actual subsequent path of interest rates.

Krippner and Thorsrud (2009) test the predictive power of the information provided by the yield curve for the future economic position of New Zealand. The authors use the Nelson-Siegel yield curve data to fit the government yield curve data for the period 1992-2009.

Their in-sample OLS results show that the yield curve has significant explanatory power for GDP growth in the future. Their out-of-sample forecasting outcomes support the in-sample results. The authors conclude that the short-term interest rates and the slope of the yield curve are better at forecasting future GDP growth than using GDP growth on its own.

On the other hand, studies have focused on the ability of the yield curve to forecast output. The results found by Haubrich and Dombrosky (1996), Dotsey (1998) and Hamilton and Kim (2001), show that using probit models US Treasury Bill data, the yield curve is a good predictor. Moneta (2003), using data from the Euro area, finds support for the yield curve as a good predictor of recessions using probit models. From these papers, a general conclusion is that the yield curve has significant forecasting power. Haubrich and Dombrosky (1996), Dotsey (1998) and Chinn and Kucko (2010) however, point out that term structure is an important variable but it becomes less useful over time. Brown and Manasse (n.d.) reinforce these findings by concluding that the yield curve has substantial forecasting ability but this weakens as the yields on securities of even more distant maturities are employed as long-term rates.

3. Data and Methodology

3.1 Data

The data collected is for South Africa. The period under study is from January 1986 to November 2011. Interest rates will be estimated from 1986 to 2004. From 2005 to 2011 out-of-sample forecasting will begin. We use the rolling regression where the in-sample estimates (from 1986-2004) are used to re-estimate the models to obtain the forecasts. This sample period is suitably large as it provides enough data points for observation. The data is collected from the South African Reserve Bank (SARB) database and the International Monetary Fund (IMF) database.

The Treasury bill rate is used to estimate short-term interest rates. According to Filipovic (2005), the short rate is a key interest rate in the models and essential to no-arbitrage pricing. But it cannot be directly observed. Mohanty and Klau (2004) and Skumsnes (2013) point out that, in line with the vast literature, we should include the lagged short term

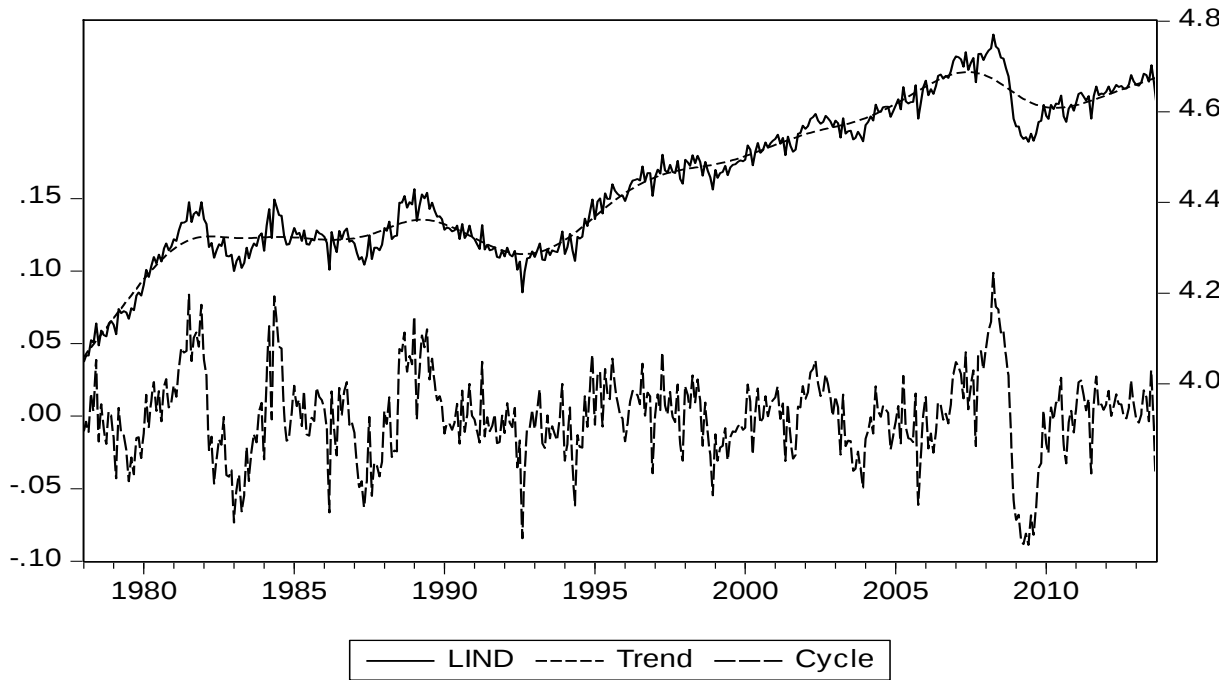
interest rate to show that the Central Bank aims to smooth interest rate changes. The authors further state that, by moving the policy in minor stages, yet in the same direction there is a larger effect on the long-term interest rate. They argue that, this is because participants in the market believe that this change will continue and hence they will price their expectations into the future. Further, this policy action will reduce the danger of making policy mistakes when the parameters used in the policy model are ambiguous and policymakers have incomplete information.

Hamalainen (2004) states that if interest rate smoothing reflects the reaction of monetary authorities to persistent macroeconomic variables, one would expect the coefficient on the lagged interest rate to be small or insignificant. However, estimated Taylor-type rules that include a lagged interest rate typically yield large and significant coefficients, indicating that interest rate smoothing is deliberate.

For periods longer than one year, we derive long rates from government bonds with different maturities. We use monthly yields on government bonds with maturity between 0-3 years and for bonds with maturity of 3-5 years. Government bonds are quoted as annual rates on a monthly basis. Industrial output is used to represent economic output. Based on the argument made by Chinn and Kucko (2010), while GDP provides a broader signal of economic activity, the industrial production series do not get revised as often as GDP. Further, industrial production is seen to follow the GDP indicator closely and whilst GDP is reported on a quarterly basis, industrial production is reported at a monthly frequency.

We use the logarithm of industrial output to compute the output gap. To do this we make use of the Hodrick-Prescott (HP) filter which separates the cyclical component of the time series from the potential levels. We set the filter, λ , at 14400 based on the suggestion by Schlicht (2004) that the larger the λ the smoother the trend. According to Schlicht (2004), the HP filter estimates potential output by minimizing the sum, over the sample period, of squared distances between actual and potential output at each point in time, subject to a restriction on the variation of potential output. It is reasonable to use the HP filter on the logarithm of the industrial output so that the first difference represents the growth rate and the gap (cyclical component) is then expressed as the percentage deviation from the trend.

Figure 1: Output Gap



Note: Monthly industrial output data is used collected from the South African Reserve Bank database.

From equation 1, make use of the annualized CPI inflation rate. Therefore, to compute the annualized CPI inflation rate, we take the annual CPI and make use of the logarithm of the annual CPI. We then take the difference between the current year's logged annual CPI and the previous year's logged annual CPI. Since we use a forward looking rule, in line with Skumsnes (2013), we assume that the Central Bank considers the expected inflation in a future period when changing the interest rate, rather than current inflation.

We collect the logarithms of the dollar-rand exchange rate, the nominal effective exchange rate (NEER) and the real effective exchange rate (REER). Based on the argument presented by Molodtsova and Papell (2009), real exchange rate is used because the Central Bank sets the target exchange rate that allows Purchasing Power Parity (PPP) to hold. However, we collect the three different types of exchange rate and choose the one most consistent with our data. From the initial assessment of our data we choose to make use of the dollar-rand exchange rate because it is consistent with our analysis.

From the above discussions we assume our data is stationary. We take measures to account for stationarity in our data. Firstly, for output we perform the filtration method by making use of the HP filter. Secondly, for our CPI inflation rate, we calculate the annualized logged percentage change. Lastly, we used the logged difference in the exchange rate.

3.2 Methodology

We use the OLS method for the forward-looking method in line with Mohanty and Klau (2004), Ang and Piazzessi (2003) and Krippner and Thorsrud (2009). This is because our model does not include forward-looking variables. We build on Mohanty and Klau's (2004) forward-looking open-economy-Taylor-Rule using the following specification:

$$i_t = \delta_0 + \delta_1\pi_t + \delta_2y_t + \delta_3\Delta xr_t + \delta_4\Delta xr_{t-1} + \delta_5i_{t-1} \quad (1)$$

Where:

i = the short-term nominal interest rate or Central Bank rate

π = annualized rate of inflation

y = deviation of actual output from its expected level

xr = log of the real effective exchange rate

Δ = first difference operator

δ = coefficient

From the above equation we can see that there is a positive relationship between the interest rate and the variables that make up the equation. Brown and Manasse (n.d.) posit that, when asset holders expect an increase in future inflation, they are likely to substitute out of long-term bonds into short-term or real assets to avoid capital losses. This results in higher nominal returns on long-term assets relative to short-term assets. According to Clarida et.al (1998), as market participants anticipate an increase in inflation and the output gap, the Central Bank will respond by raising interest rates. However, Clarida et. al. (1998) and Mohanty and Klau (2004) do not find sufficient evidence to support the notion that the Central Bank responds to the output gap independently of inflation. Mohanty and Klau

(2004) further state that, the Central Bank is expected to raise interest rates in response to depreciation of the currency in the current period. The authors point out that, if exchange rate shocks are large and persistent, the Central Bank tends to place a higher weighting on the exchange rate variable and we would expect significant negative coefficients on both the current and the lagged exchange rate values.

For the yield curve we describe an equation that is suggested by the expectations hypothesis. Jondeau and Ricart (1999) state that the expectations hypothesis describes long-term interest rates as the average of expected future short-term interest rates plus a risk premium which is reliant on time. Stated differently, the yield on a long-term until maturity is equal to the expected yield from acquiring a sequence of short-term bonds. We use simple linear interpolation to obtain the missing interest rates falling between two time periods. In line with Jondeau and Ricart (1999) we concede that this technique is imperfect, but from it we can obtain unvarying data and avoid estimation problems that arise from more complex interpolation procedures. From there, we use the available data to extrapolate the one-month-ahead rates of interest using the expectations hypothesis. Our forward interest rates are derived as follows:

Starting at time period 2, let:

$$R_t^2 = \frac{1}{2}(r_t + r_{t+1}) \quad (2)$$

To find the interest rate one-month ahead we rearrange equation (2) to obtain:

$$r_{t+1} = 2R_t^2 - r_t \quad (3)$$

For period 3, we have:

$$R_t^3 = \frac{1}{3}(r_t + r_{t+1} + r_{t+2}) \quad (4)$$

Therefore:

$$3R_t^3 = r_t + r_{t+1} + r_{t+2}$$

$$3R_t^3 = r_t + 2R_t^2 - r_t + r_{t+2}$$

The interest rate two-months ahead can be found as follows:

$$r_{t+2} = 3R_t^3 - 2R_t^2 \quad (5)$$

For period 4, we have:

$$R_t^4 = \frac{1}{4}(r_t + r_{t+1} + r_{t+2} + r_{t+3})$$

The interest rate three-months ahead can be obtained as follows:

$$r_{t+3} = 4R_t^4 - 3R_t^3 \quad (6)$$

Through iterations, we can derive the general equation represented as follows:

$$r_{t+(n-1)} = nR_t^n - (n-1)R_t^{n-1} \quad (7)$$

Where:

R_t^n	=	the yield at time t
$r_{t+(n-1)}$	=	the forward interest rate at time t
n	=	the number of periods

4. Results

4.1 Taylor Rule Specification

Table 1 below shows the results of equation (1). The variable DLCPI represents the annualized CPI inflation rate. The variable LINDGAP represents the output gap, the DLEXCH shows the log difference of the dollar-rand exchange rate and PTBILL is the lagged interest rate value which is also the smoothing parameter. We also include dummy variables in our Taylor Rule computation. After testing the three types of exchange rates; namely the NEER, REER and the dollar-rand exchange rate, we find that the dollar-rand exchange rate provides us with a relationship consistent with the Taylor Rule equation. We therefore do not consider the NEER and the REER as they do not provide the desired relationship.

Two lags of the interest rates are introduced in the regression analysis to increase the significance of our variables. The first lag of interest rates captures persistent macroeconomic variables and the Central Bank inertia. In line with Coibion and Gorodnichenko (2010), we believe that the second lag of interest rates captures the Central Bank's response to the private sector's information set. This is consistent with Molodtsova and Papell (2009) who further state that, for monthly data the lag is normally two months. Furthermore, Woodford (2003b) proves that the optimal interest rate rule in New Keynesian models should have AR (2) interest rate smoothing and, therefore, there are theoretical arguments to have interest rate smoothing with higher autoregressive orders. The idea of including a second lag is also supported by Clarida et. al. (1998) who suggest that, in each period the Central Bank adjusts short-term interest rates to eliminate a fraction of the gap between its current target level and some linear relationship of its past values.

We include dummy variables allow us to control for outliers. For example the 1983 to 1985 period saw the brief lifting of exchange control which was re-established in 1985 due to the backdrop of political unrest and the removal of credit lines by foreign banks in South Africa. This caused a severe depreciation of the Rand. Another noteworthy outlier found in our data can be explained by the 1998 global financial crisis which negatively affected the South African market. We impose shock factor dummy variables that take into account the persistent economic shocks which may have a negative effect on the South African market. The dummy takes the value of 1 in the presence of persistent shocks and 0 otherwise.

In line with the literature, expect that there is a positive relationship between short-term interest rates and the rate of inflation. As pointed out by Mohanty and Klau (2004), this relationship is borne from association of aggregate demand (AD) and aggregate supply (AS) curves, plotted against price level. The authors elaborate that, due to the negative relationship between AD and inflation (price levels), a shock in the prices will see the Central Bank increase interest rates by more than the increase in inflation. This ultimately leads to a rise in the real interest rates.

Initial assessment of the data shows that the dollar-rand exchange rate is most suitable for this analysis. Thus, as the South African Rand appreciates against the US dollar, we expect

that the Central Bank will increase the interest rate. We do not report on the results of the lagged exchange rate because it is highly insignificant at the 5% level, with a p-value of 0.7696.

Table 1: Taylor Rule Results

Variable	Coefficient	t-Statistic	Prob.
DLCPI(-1)	0.009183	1.977225	0.0487
LINDGAP(-1)	0.023947	3.515395	0.0005
DLEXCH(-1)	-0.0002178	-0.533519	0.5940
PTBILL(-1)	1.373582	36.37464	0.0000
PTBILL(-2)	-0.389368	-10.39573	0.0000
DUM8302	-0.017198	-4.452133	0.0000
DUM8408	0.026139	6.801713	0.0000
DUM8501	0.011380	2.961258	0.0032
DUM8506	-0.019981	-5.152821	0.0000
DUM8509	-0.014387	-3.754327	0.0002
DUM9806	0.030279	7.938660	0.0000
DUM9605	0.015606	4.088265	0.0001
DUM9807	0.018391	4.625547	0.0000
DUM9810	-0.027397	-7.019044	0.0000

The results from Table 1, to a larger extent, substantiate the discussion above of the expected relationship of the Taylor Rule variables included in equation (1). The results have an R-squared of 99.24% which means that about 99% of the variation in the short-term interest rate is explained by the variation in the regressors; namely DLCPI, LINDGAP, DLEXCH, the lag of PTBILL.

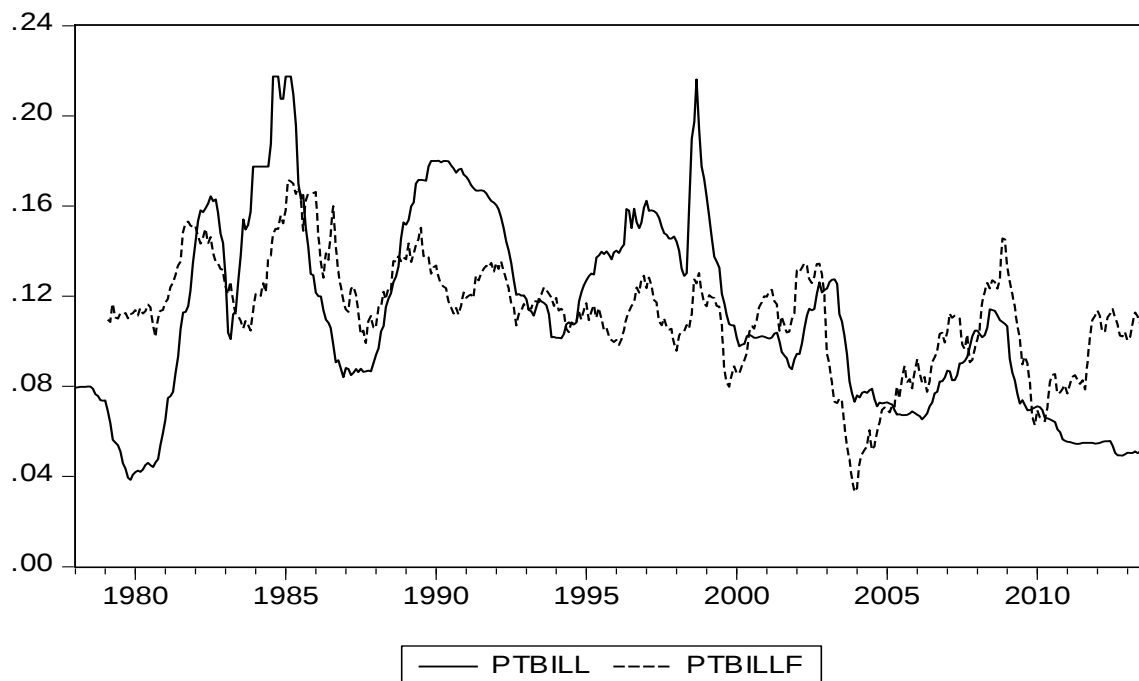
The coefficients for the regressors provide the relationship expected in equation (1). All variables except the exchange rate are significant at the 5% level. An interesting result is the coefficient of the exchange rate which is negative but it is not significant at the 5% level. This result suggests that although the relationship does hold, the Central Bank does not react much to movements in the exchange rate when they are determining interest rates. Mohanty and Klau (2004) and Clarida et. al (1998) suggest that, the exchange rate is non-significant in interest rate determination because it does not affect inflation. Central Banks are expected to react more to deviation to factors that affect inflation. However, Mohanty and Klau (2004) propose that since exchange rate is mean reverting, Central Banks tend to

react less this variable. The authors further point out that, empirical evidence is generally limited with regards to the significance of the exchange rate for interest rate decisions.

The results in Table 1 further show that the PTBILL (-1) is highly significant. This variable, as mentioned earlier is referred to as the smoothing parameter. Academics such as Cecchetti et.al (2002), Mohanty and Klau (2004), Mitra (2010) and Fendel et.al (2011), have included a lagged variable of the interest rate as an additional regressor, which has a positive coefficient and is significant. As mentioned earlier, the smoothing parameter is included to allow the Central Bank to make gradual changes to the interest rate and allows market participants to price their assets accordingly. Thus, investors make decisions on their asset allocation based on the information provided by past interest rates. PTBILL (-2) is significant at the 5% level, which shows that the Central Bank responds to the private sector's information set.

Figure 2 below shows the Taylor Rule results using raw data and without testing for serial correlation. The variable PTBILL represents the actual one-month ahead interest rate whilst PTBILLF is the forecasted short-term interest rate at time $t-1$. The graph shows that there is a wide deviation of forecasted one-month ahead interest rates from the actual one-month ahead interest rate using the Taylor Rule specification.

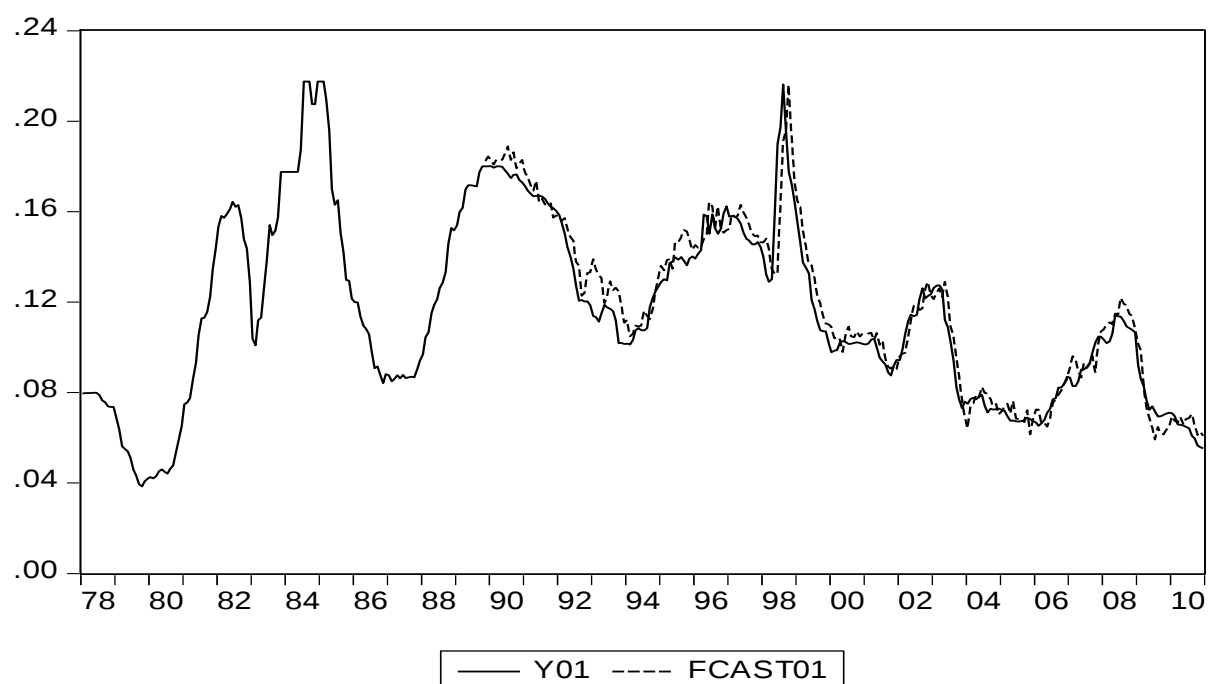
Figure 2: Short Rate Taylor Rule Forecast



4.2 Unadjusted interest rates

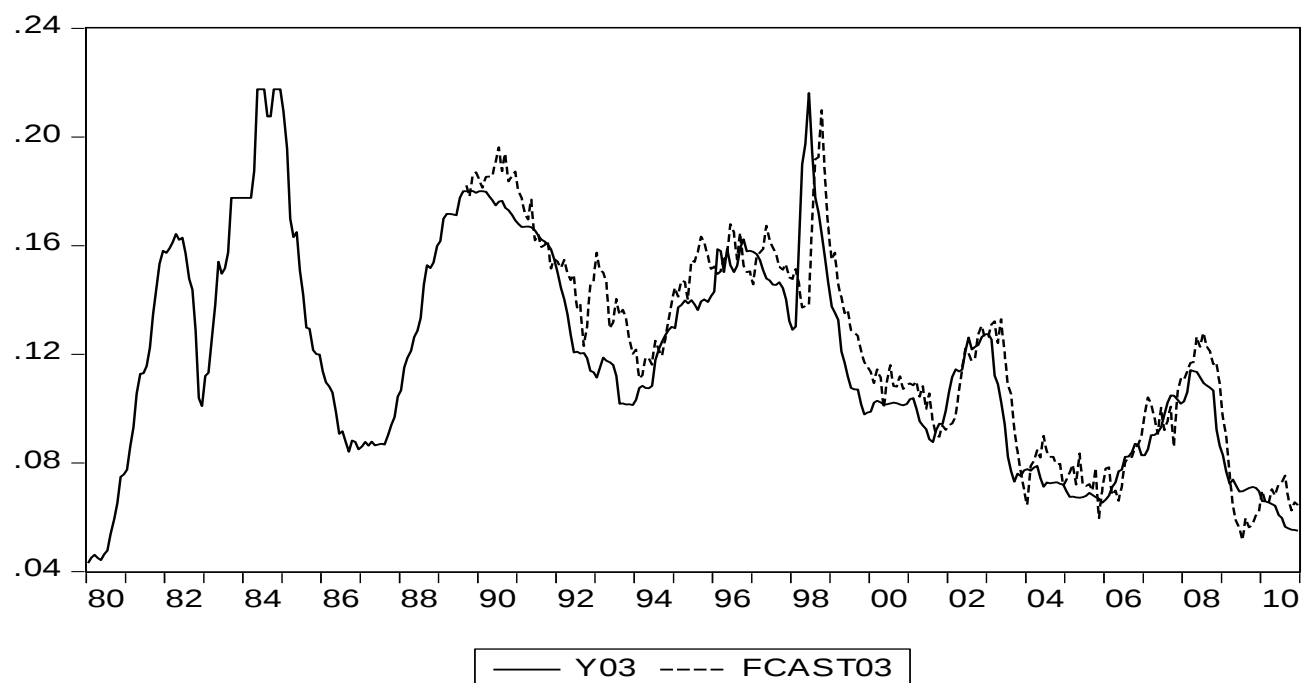
In multiple and simple regression analysis, one of the main assumptions is that the residual terms are independent from each other or uncorrelated. However, if this assumption is violated, the effectiveness of the regression model may be disturbed. The data used in this paper is time series data. Therefore, due to the presence of serial correlation, the residual in one period may affect the residual for the next period and further. The initial Taylor Rule forecasting regressions that we run are not adjusted for serial correlation. Figure 3 to Figure 6 show the results of the Taylor Rule forecasts for the 1-month, 3-month, 12-month and 18-month horizons.

Figure 3: Taylor Rule 1-Month Forecast Unadjusted for Serial Correlation



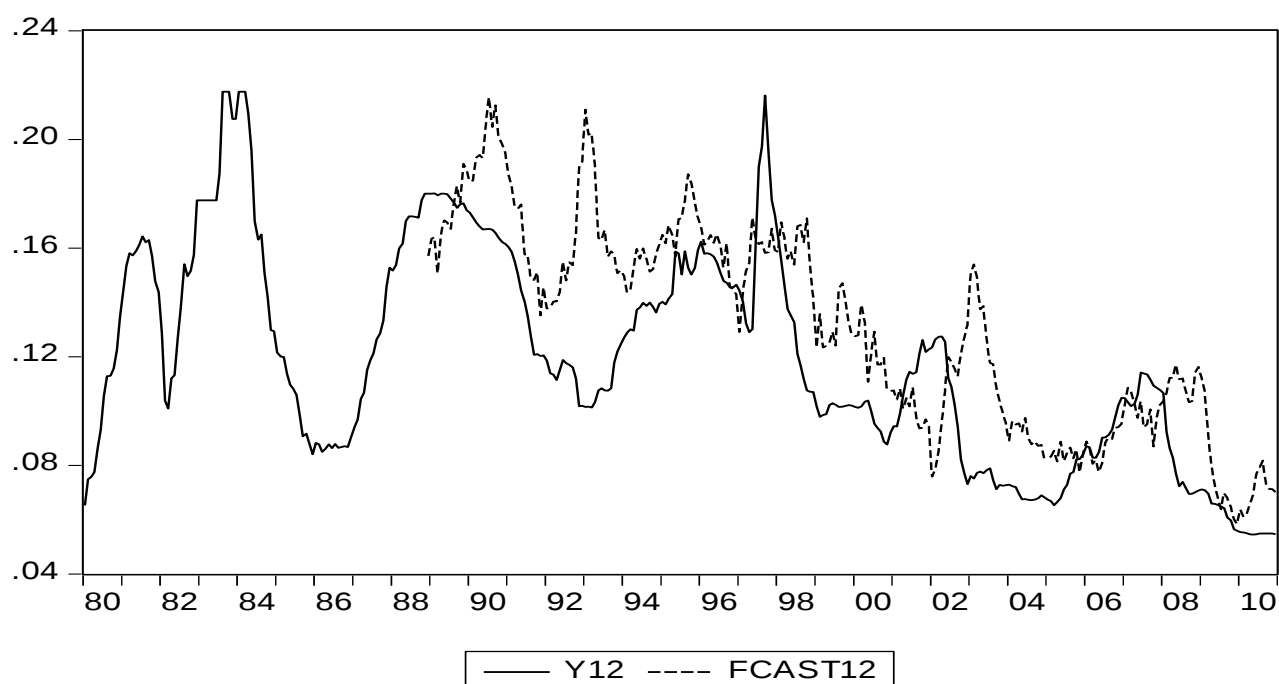
Note: Y01 represents the actual interest rate in one month's time whilst FCAST01 represents the 1-month forecast

Figure 4: Taylor Rule 3-Month Forecast Unadjusted for Serial Correlation



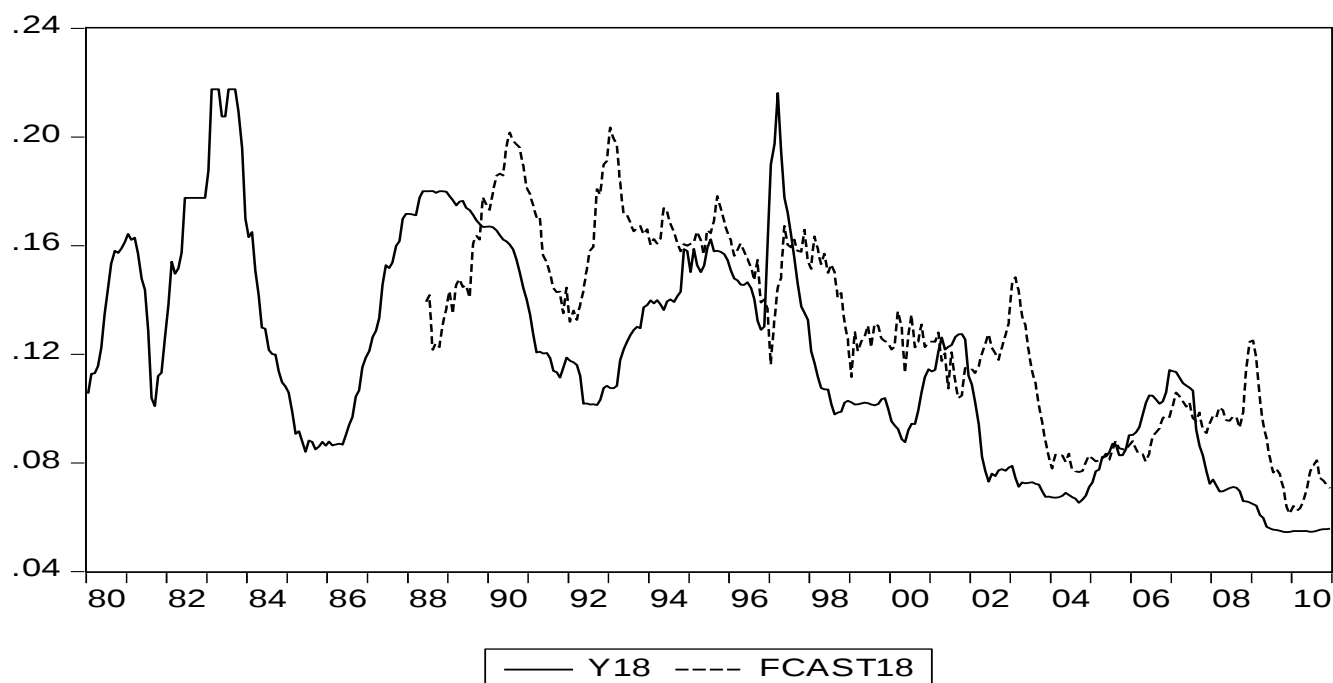
Note: Y03 represents the actual interest rate in 3 months' time whilst FCAST03 represents the 3-month forecast

Figure 5: Taylor Rule 12-Month Forecast Unadjusted for Serial Correlation



Note: Y12 represents the actual interest rate in 12 months' time whilst FCAST12 represents the 12-month forecast

Figure 6: Taylor Rule 12-Month Forecast Unadjusted for Serial Correlation



Note: Y18 represents the actual interest rate in 18 month's time whilst FCAST18 represents the 18-month forecast

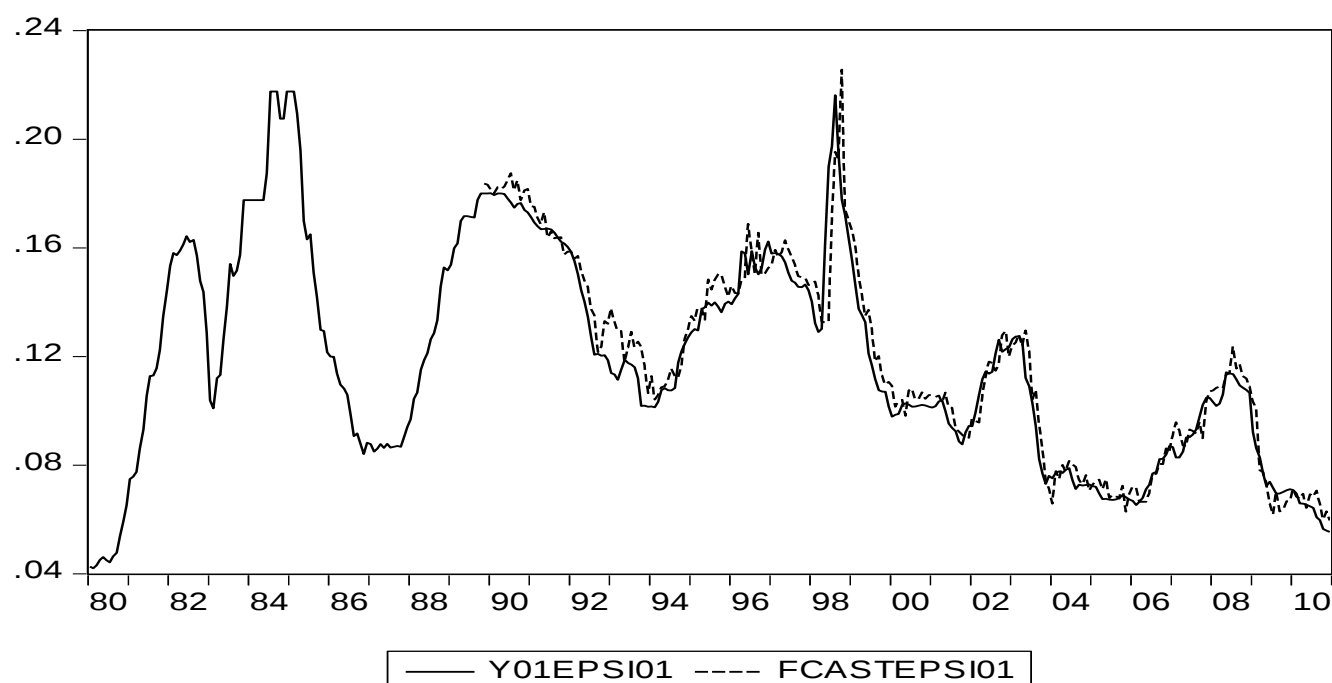
Figure 3 provides evidence that, the 1-month forward forecast of the short term interest rate narrowly tracks the actual interest rate 1-month ahead. Figure 4 also exhibits the same pattern, in which the predictions made for the three-month short-term interest rates are close to the actual interest rate observed in three months' time.

Figure 5 and Figure 6 however, present a different picture. Figure 5 shows that there is increased deviation of the forecasted 12-month short term interest rate from the actual interest rate at 12 months. The deviation of forecasted short-term interest rates from the actual short term interest rates increases at the 18-month interval.

4.3 Adjusted interest rates

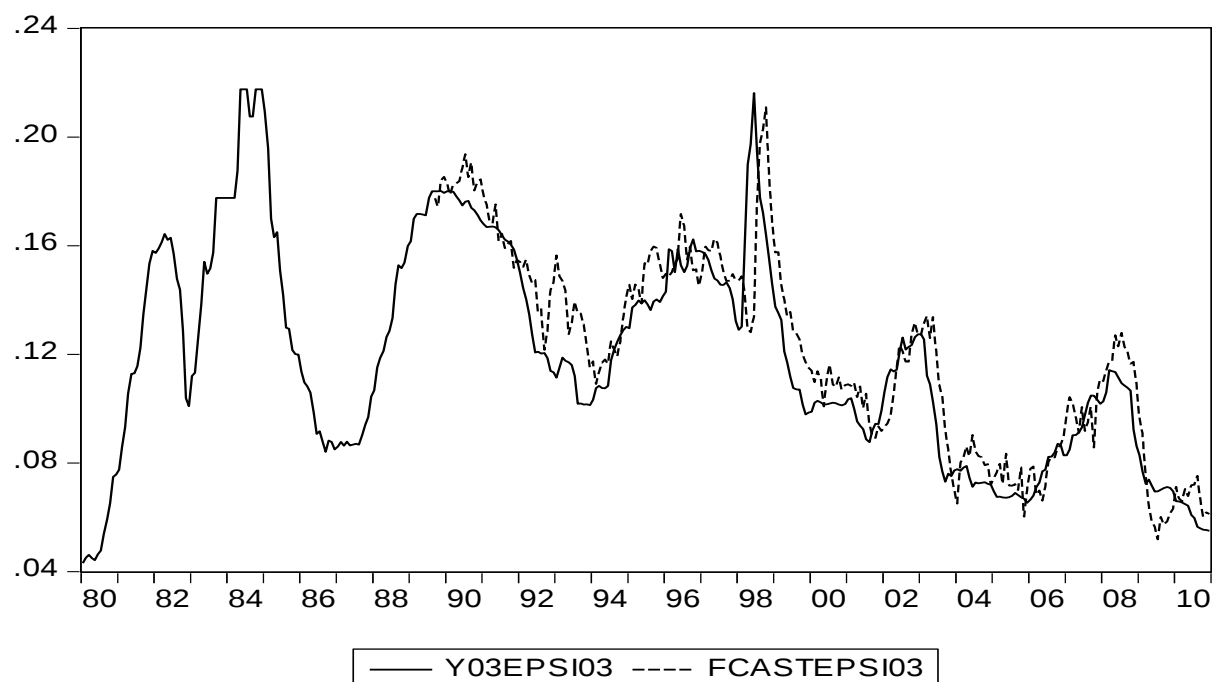
This section adjusts the data for serial correlation. To adjust for serial correlation, lagged values of the residual term are introduced into Taylor Rule equation. It is important to make this adjustment so as to improve the regression model.

Figure 7: Taylor Rule 1-Month Forecast Adjusted for Serial Correlation



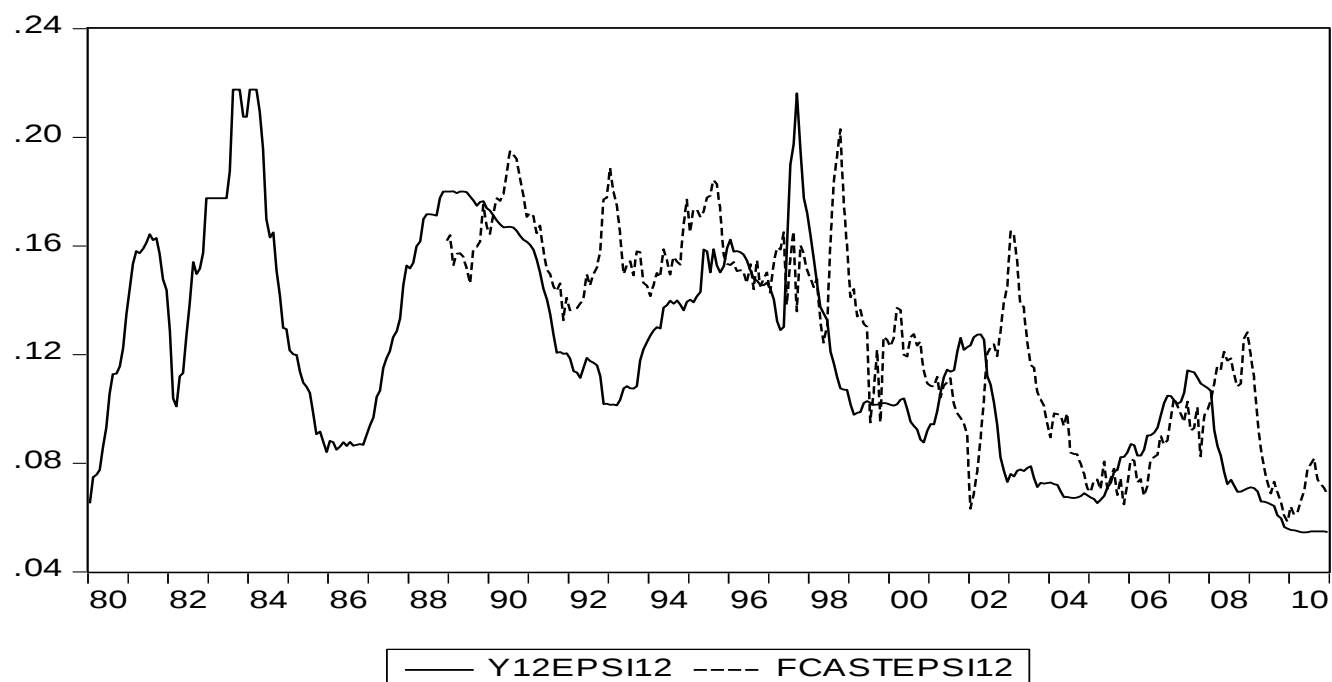
Note: Y01EPSI01 represents the actual interest rate in one month's time whilst FCASTEPSI01 represents the 1-month forecast adjusted for serial correlation

Figure 8: Taylor Rule 3-Month Forecast Adjusted for Serial Correlation



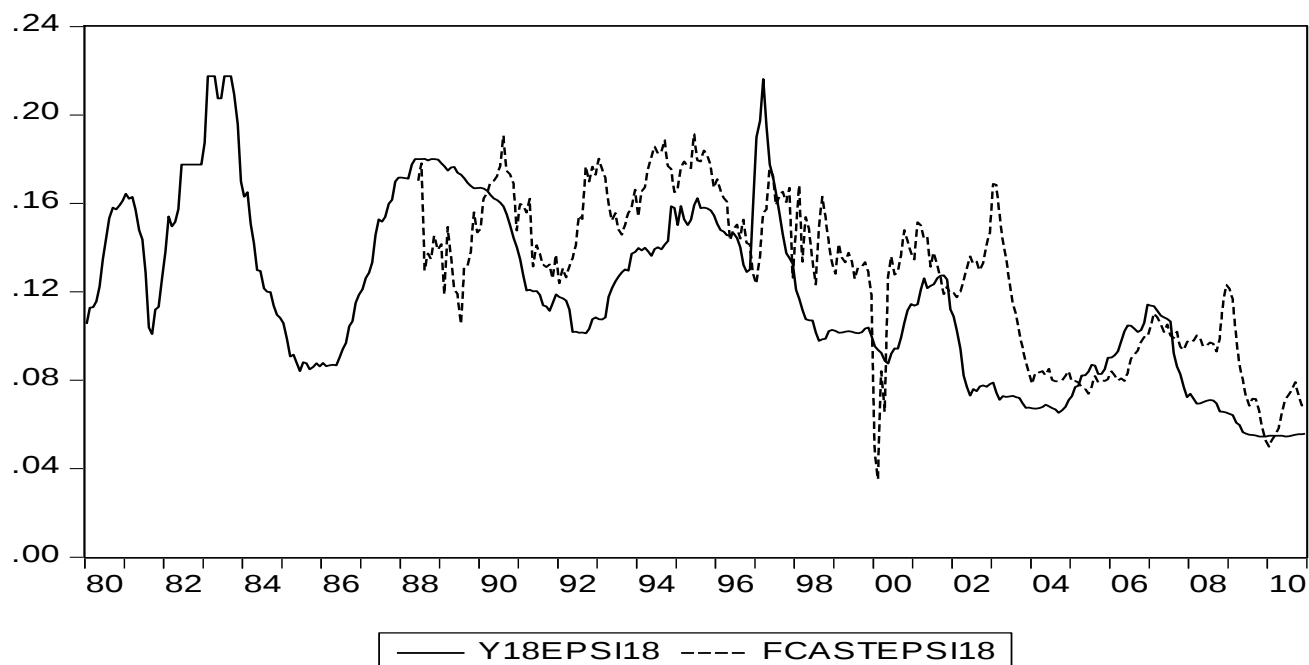
Note: Y03EPSI03 represents the actual interest rate in 3 months' time whilst FCASTEPSI03 represents the 3-month forecast adjusted for serial correlation

Figure 9: Taylor Rule Adjusted 12-Month Forecast Adjusted for Serial Correlation



Note: Y12EPSI12 represents the actual interest rate in 12 months' time whilst FCASTEPSI12 represents the 12-month forecast adjusted for serial correlation

Figure 10: Taylor Rule 18-Month Forecast Adjusted for Serial Correlation



Note: Y18EPSI18 represents the actual interest rate in 18 months' time whilst FCASTEPSI18 represents the 18-month forecast adjusted for serial correlation

The graphical depictions show that the deviations of the forecasted from the actual values are lower for the 1-month and 3-month intervals and are seen to increase for the 12-month and 18-month time intervals. At lower time horizons, the Central Bank is able to make more accurate forecasts of the short-term interest rates. The increased deviations observed at the 12-month and 18-month intervals can arise due to the uncertainty stemming from the increased time horizon.

4.4 Yield Curve Results

We continue to show the yield curve results for the 1-month, 3-month, 12-month and 18-month forecast intervals. These are shown in Figure 11 to Figure 14.

Figure 11: Yield Curve 1-Month Ahead Forecast

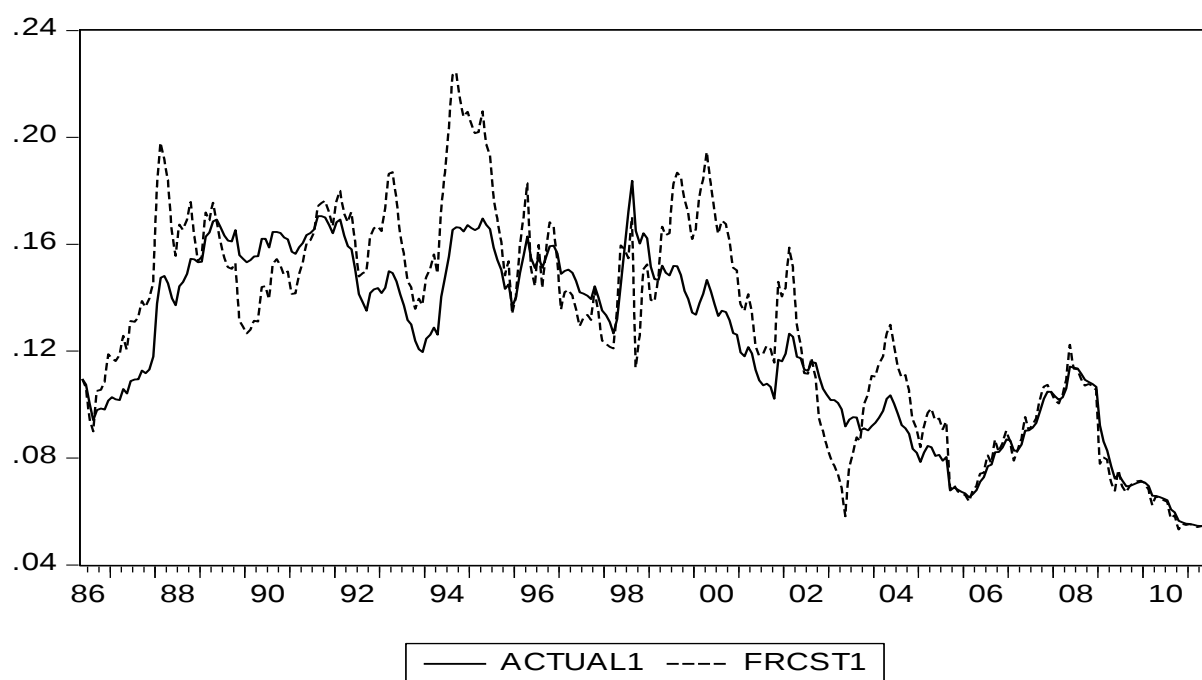


Figure 12: Yield Curve 3-Month Ahead Forecast

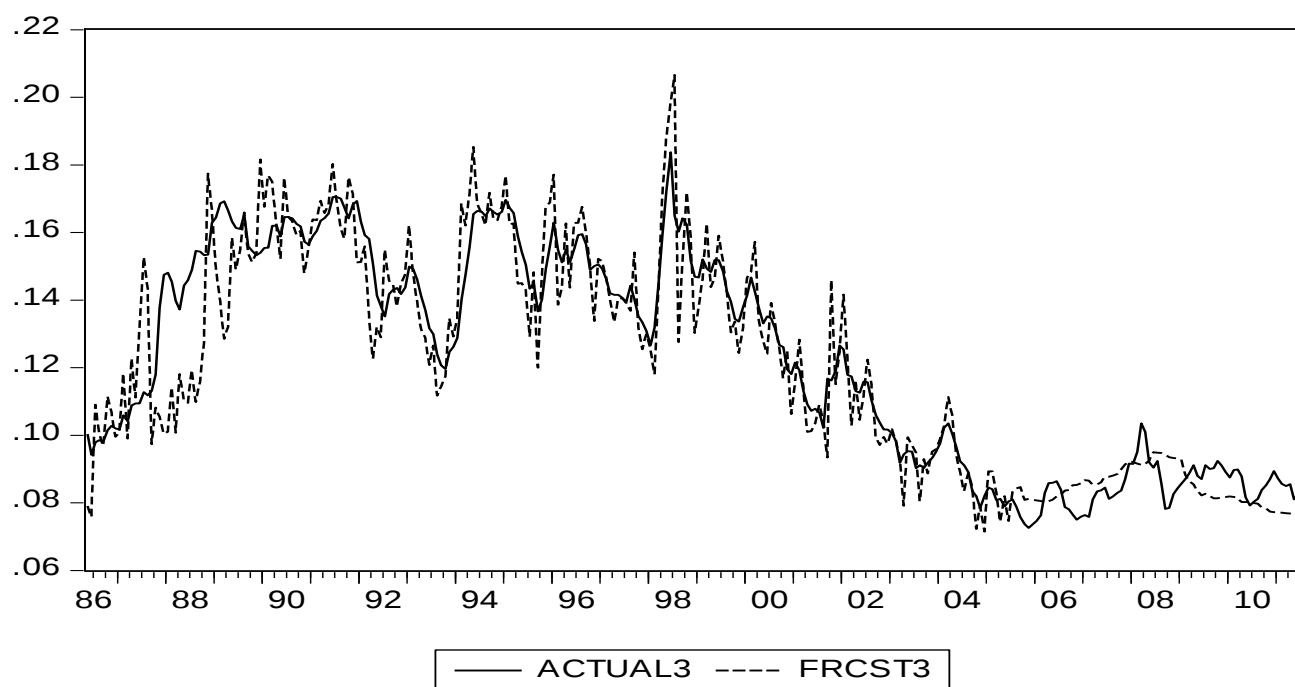


Figure 13: Yield Curve 12-Month Ahead Forecast

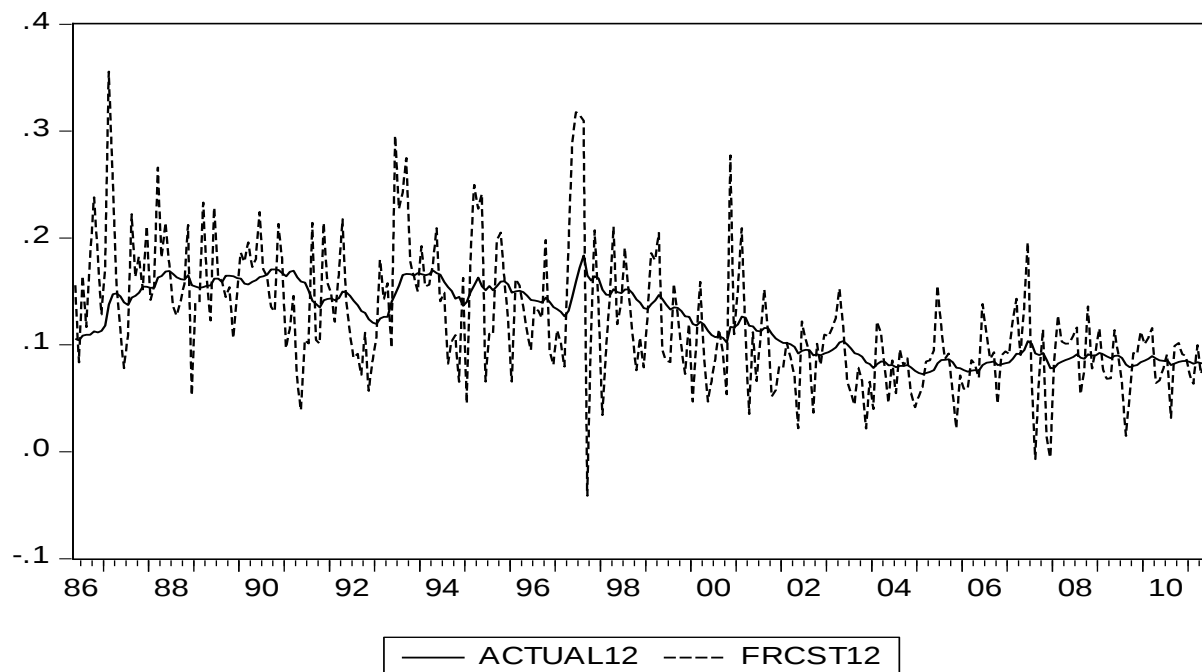
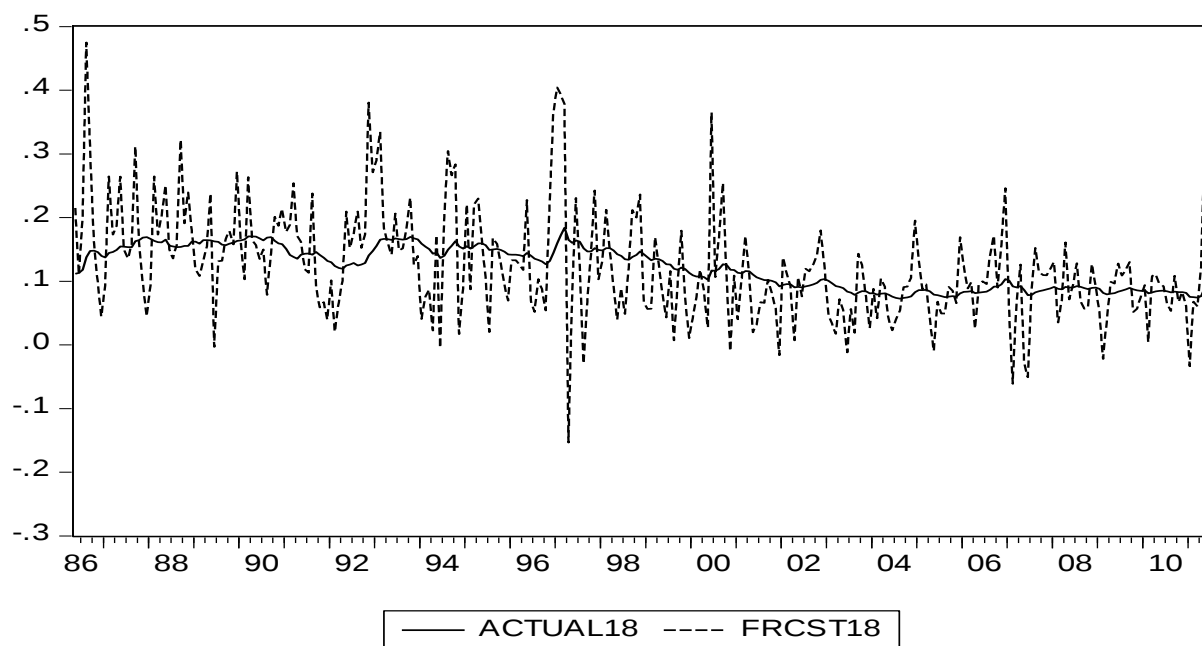


Figure 14: Yield Curve 18-Month Ahead Forecast



The results show that at shorter forecast horizons, that is, for t+1 and t+3 horizons, the forecasts of the yield curve closely track the actual one-month ahead interest rates. However, as the forecast horizon increases, to t+12 and t+18, there is a larger deviation of the forecasted (FRCST) interest rates from the actual one-month ahead rates.

4.5 Forecast Evaluation

This paper asks two questions namely; does the Taylor Rule outperform the yield curve in forecasting interest rates? Do markets contemplate that the Central Bank provides precise predictions of future interest rates? By using the Root Mean Square Errors (RMSE) this section focuses on the comparing whether the Taylor Rule forecasts interest rates better than the yield curve.

4.5.1 Root Mean Square Errors

Table 2 shows the results of the RMSEs for the Taylor Rule and the yield Curve specifications for the entire sample period. This analysis is based on the following hypothesis:

$H_0: \rho > 0$; no serial correlation

$H_1: \rho \neq 0$; there is serial correlation

From Table 2, the RMSEs for both specifications are highly significant at the 5% level. The results show that the RMSE for the yield curve are higher than those of the Taylor Rule model at the all forecast horizons. Thus, the Taylor Rule is a better forecasting method compared to the yield curve.

Table 2: RMSE for Period January 1986- November 2011

Forward rate	Taylor Rule	Yield curve	Difference(YC-TR)
r(t+1)	0.0000783	0.000362	0.0002837
r(t+3)	0.000226	0.001012	0.000786
r(t+12)	0.000887	0.002449	0.001603
r(t+18)	0.00148	0.006014	0.004534

Note: YC represents Yield Curve RMSE and TR represents Taylor Rule RMSE

This study further investigates the performance of the Taylor Rule specification compared to the yield curve for four five-year sub-periods. The results show that in all four sub-periods, the Taylor Rule is a superior forecasting tool compared to the yield curve even in distant time horizons.

Table 3: Sub-period RMSE for the Yield Curve

	1986/01- 1990/12	1991/01- 1995/12	1996/01- 2000/12	2001/01- 2005/12	2006/01- 2011/12
$r(t+1)$	0.000410	0.000646	0.000488	0.000292	0.0000956
$r(t+3)$	0.000484	0.000150	0.000160	0.000250	0.0037460
$r(t+12)$	0.002984	0.003134	0.004151	0.001142	0.0010120
$r(t+18)$	0.006878	0.006631	0.010083	0.002297	0.0043980

Table 4: Sub-period RMSE for the Taylor Rule

	1986/01- 1990/12	1991/01- 1995/12	1996/01- 2000/12	2001/01- 2005/12	2006/01- 2011/12
$r(t+1)$	0.0000426	0.0000923	0.000191	0.0000345	0.0000344
$r(t+3)$	0.0001310	0.0003220	0.000443	0.0001320	0.0001080
$r(t+12)$	0.0006620	0.0017070	0.000527	0.0010200	0.0003440
$r(t+18)$	0.0012540	0.0017370	0.001023	0.0009060	0.0004970

The results for the full-period and sub-period analysis suggest that the Taylor Rule is a superior forecasting model compared to the yield curve in short horizons. In the short-term, the Taylor Rule provides more accurate forecasts of the future short-term interest rates. These results are supported by the findings of Dahlquist and Jonsson (1994) who emphasize that the Taylor Rule provides highly accurate forecasts of short-term interest rates in the short horizon. However, the authors find that at longer time horizons the Taylor Rule loses its precision. This is in contrast with our findings which show that the Taylor Rule continues to exhibit superior forecasting performance in the short and long horizons.

5. Conclusion

This study set out to investigate whether the Taylor Rule provides better the forecasts of the future short-term interest rates than the yield curve in the South African market. Research that compares the forecasting performance of the Taylor Rule benchmarking against the yield curve has not been published. The paper is motivated by the idea that that, the ability to accurately estimate and forecast interest rates provides an accurate measurement of the discount factor for the pricing of assets. Thus, with a better model, market participants can accurately adjust their expectations in market activity.

The period under examination is from January 1986 to November 2011. The tests were run using the Ordinary Least Squares method and focus mainly on the $t+1$, $t+3$, $t+12$, $t+18$ horizons. The forward-looking Taylor Rule specification following the study by Mohanty and Klau (2004) was used. We modified to include the dollar-rand exchange rate variable and the lag of the interest rate which represents the smoothing parameter. The yield curve specification was based on the expectations theory for which simple linear interpolation was used to find missing interest rates. From the interpolated rates the one-month ahead short term interest rates were extrapolated.

The results for the Taylor Rule support the discussion of the expected relationship of the Taylor Rule variables. However, the exchange rate variable is non-significant at the 5% level. This implies that the Central Bank does not consider exchange rate movements when short-term interest rates. Further, the results show that there is a wide deviation of forecasted one-month ahead interest rates from the actual one-month ahead interest rate using the Taylor Rule specification. After adjusting for serial correlation in the Taylor specification the results show the deviations of the forecasted from the actual values are lower for the 1-month and 3-month intervals and are seen to increase for the 12-month and 18-month time intervals.

The results of the yield curve show that at shorter horizons the forecasts of the yield curve closely track the actual one-month ahead interest rates. However, as the forecast horizon increases there is a larger deviation of the forecasted interest rates from the actual one-month ahead rates.

We further scrutinize our regression models by conducting the Root Mean Square Error (RMSE) analysis. From both the full period analysis and the sub-period analysis, we conclude that the Taylor Rule is a better forecasting method compared to the yield curve in all forecasting horizons. The Taylor Rule provides more accurate forecasts of the future short-term interest rates. The recommendation provided by this study is that, in the short-term, market participants should use the Taylor Rule specification when making portfolio analysis.

Adding more variables to the Taylor specification to test the predictive ability of the Taylor Rule is an area of further research. A final point to note is that, the results for the yield curve presented above could be affected by the methodology used in testing. Specifically the simple linear interpolation method is viewed as less robust. More complex interpolation methods could be incorporated in future research.

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