ISSN: 2350-0743

www.ijramr.com

International Journal of Recent Advances in Multidisciplinary Research

Vol. 06, Issue 01, pp.4568-4572, January, 2019

RESEARCH ARTICLE

TERM STRUCTURE OF INFLATIONARY EXPECTATION IN RWANDA

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ARTICLE INFO

Article History:

Received 19th October, 2018
Received in revised form
14th November, 2018
Accepted 20th December, 2018
Published online 30th January, 2019

Keywords:

Term structure of Interest rate, Inflation, expectation.

ABSTRACT

This paper examines term structure of future changes in inflation in Rwanda, using monthly Treasury bill rates spreads. Applying the dynamic vector autoregressive model, the results shows that the slope of the term structure is a good predictor of expected inflation and the yield curve provides some information on changes in inflation over periods. Confirming previous empirical findings in other countries. The implication from the findings suggest that monetary authorise should also uses the term structure of interest rate as an option of assessing inflation dynamics in Rwanda. This study relatively uses short period over which the analysis is done (TBR1t minus TBRt-1). The further study should examine the relationship between term structure and expected inflation using a broader spectrum of government securities as a longer history of data becomes available.

INTRODUCTION

Economists are interested in not just short-term interest but also in long-run rates. Changes in the short-run rates that serve as the operational targets for implementing monetary policy will affect aggregate spending decisions only if longer rates are affected (Walsh 2010). Understanding how monetary policy affects the long-run rates therefore requires a consideration of the relationship between short-term and long-run rates. This relationship between interest rates over different horizons is the so-called term structure of interest rates which captures the relationship between default-free interest rates that only differ in the length of their maturity (Cox et al. 1985). By offering a schedule of interest rates over time, the term structure incorporates the market's expectations of future events and therefore provides a means to extract this information. The conventional view is that short-term interest rates will be affected by money supply and other instruments of monetary policy such as the Central Bank Rate. The short term rates are in turn linked to long-term rates through the term structure of interest rates. This implies that the shape and characteristics of the yield curve is important for policy analysis and implementation. Shifts in the yield curve can therefore alert policymakers to changes in market expectations (Anand et al. 2011). The term structure of interest rates is also important for monetary policy and its transmission mechanisms which run from short-term interest rates that the central banks try to influence to the long-run rates, through to real economic activities. By providing information on expected inflation, the term structure is important in achieving the desired rate of inflation.

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This is because nominal interest rates are a reflection of inflation rates over the term of the loan. In this case a gap between two or more interest rates of differing maturities should be useful as a predictor of inflation over that horizon. The bond rate should be seen to contain a premium for expected inflation and serve as an indicator of a central bank's commitment to a low level of inflation. The slope of the yield curve has received considerable attention in the literature for its ability to forecast both real and nominal macroeconomic variables. Mishkin (1990a, 1990b) for example demonstrate that the slope of the curve is a relatively good predictor of the change in the rate of The term structure of interest rates is important for several other reasons. First, a critical problem in developing countries is managing the domestic debt to enhance its maturity profile. How successfully this can be done depends on the shape of the yield curve. Second, for those investors wishing to raise funds through the various debt instruments available in the market, the term structure provides information on minimizing future interest payments. Third, understanding the structure of the yield curve is important to financial institutions that take short-term deposits but provide long-term loans, since the yield curve predicts the behavior of the latter.

The objective of this paper is to analyze the term structure of interest rates in Rwanda to tease out its implications for inflationary expectations in the country. It examines the ability of the slope of the yield curve to predict inflation in Rwanda. The rest of the paper is organized as follows. Section 2 provides an overview of the theories of the term structure of interest rates; Section 3 discusses the analytical framework utilized in the paper; and Section 4 discusses the data, estimation procedure and results ended with conclusion.

Theoretical frame work about Term Structure of Interest Rates: Economists are interested in the term structure theories for a number of reasons (Rusell 1992).

First, since the actual term structures of interest rates are easy to observe, the accuracy of the predictions of the various theories would be easy to evaluate. Second, these theories help explain ways in which short-term interest rates impact on long-terms rates which is important for understanding the effectiveness of monetary policy. Lastly, the term structure may provide expectations of participants in the securities market. In standard textbook analyses, there are basically four theories of the terms structure (Kettell 2001). The expectations hypotheses postulate that securities are priced such that the implied forward rates are equal to the expected spot rates. This implies that the return from holding a long-term bond to maturity is equal to the expected returns on repeated investment in a seriesof short-term securities. Under this hypothesis, the long-term interest rates are a function of the current short-term rates given the investors' expectations about the future. In other words, the interest rate on the long-run bond must average the interest rates on short-term bonds over its own life time (Romer 2006). Hence the term structure is determined by the time path of the expected short-term rates. Since these future short-term rates are functions of monetary policy, expectations about future policy play an important role in determining the shape of the term structure.

On the other hand, the liquidity premium theory argues that the long-run rate is a function of current and expected future short-term rates plus a liquidity premium. Bondholders for example care about the purchasing power of the real return they receive from bonds, not just the nominal value of the coupon payments. Uncertainty about inflation creates uncertainty about a bond's real return, making the bond a risky investment. The further the future, the greater the uncertainly about the level of inflation, which implies that a bond's inflation risk increases with its time to maturity.

Similarly, interest-rate risk arises from a mismatch between investor's investment horizon and a bond's time to maturity. If a bondholder plans to sell a bond prior to maturity, changes in the interest rate generate capital gains or losses. The longer the term of the bond, the greater the price changes for a given change in interest rates and the larger the potential for capital losses. As in case of inflation, the risk increases with the term to maturity, so the compensation must increase with it. The liquidity premium theory therefore views bonds of different maturities as substitutes, but not perfect substitutes. The liquidity premium is an incentive to investors to induce them to commit their resources to greater risk. The liquidity hypothesis therefore places more weight on the effects of the risk preferences of market preferences of market participants (Cox et al. 1985). It asserts that risk aversion will cause forward rates to be systematically greater than expected spot rates, usually by an amount increasing with maturity. This term premium is the increment required to induce investors to hold long-term 'riskier' securities. The segmented markets hypothesis postulates that individuals have strong maturity preferences and that bond of different maturities trade in separate and distinct markets. This theory therefore assumes that markets for different maturity bonds are completely segmented. As a result, returns on bonds with differing maturities are determined in the markets via demand and supply of bonds with differing terms. In other words, longer bonds that have associated withthem inflation and interest rate risks are completely different assets than the shorter bonds. Thus, the bonds of different maturities are not substitutes at all, so the expected returns from a bond of one maturity has no effect on the demand for a bond of another maturity. The yield curve is therefore unable to explain the direction of future interest rates. Finally, the related preferred habitat theory postulates that individual investors have a preferred range of bond maturity lengths, and will only go outside of this range if a higher yield is promised. Besides interest rate expectations, investors have distinct investment horizons and require a meaningful premium to buy bonds with maturities outside their "preferred" maturity, or habitat. The theory argues that the long-term interest rate is dependent upon investor expectations regarding short-term rates, a term premium, and the demand and supply conditions of bonds of differing maturity profiles traded in the market. The term structure literature has been mainly pre-occupied with testing one or the other of these theories. Anticipation of future events is important as are risk preferences and the characteristics of other market alternatives, while investors can have specific preferences about the timing of their consumption, and hence preferred habitat (Cox et al. 1985). Determining the term structure therefore requires to be done in a general equilibrium framework that takes into account expectations, investment alternatives and preferences about the timing of consumption in the future.

The Analytical foundation: The literature on the ability of the yield curve to predict changes in inflation typically begins with the standard Fisher equation (Mishkin 1990a, 1990b):

$$E_t \pi_t^p = i_t^p - r_t^p \tag{1}$$

where E_t denotes the expectation at time t, π_t^p is the inflation rate between time t and t+p, i_t^p is the nominal p period interest rate and r_t^p the real p period interest rate. Assuming rational expectations, the observed rate of inflation (πpt) equals the expected rate plus a forecast error:

$$\pi_t^p = E_t \pi_t^p - \varepsilon_t^p \tag{2}$$

By Substituting Equation (1) into (2) become

$$\pi_t^p = i_t^p - r_t^p - \varepsilon_t^p \tag{3}$$

To obtain a relationship between the slope of the yield curve and the change in the inflation rate, the q period inflation rate is subtracted to yield:

$$(\pi_t^p - \pi_t^q) = (i_t^p - i_t^q) - (r_t^p - r_t^q) - (\varepsilon_t^p - \varepsilon_t^q) \tag{4}$$

Economist typically assumes that the slope of the real yield curve is constant through time so that $(r_t^p - r_t^q)$ is a constant. The dual assumptions of a constant real term structure and rational expectations underpin the following equation which forms the basis of the tests:

$$(\pi_t^p - \pi_t^q) = \alpha + \beta\,(i_t^p - i_t^q) + \mu_t^{p,q} \text{ or } \Delta\pi_t = \alpha + \beta\Delta i_t + \upsilon_t \tag{5}$$

If prices are fully flexible and rapidly adjust to changes in monetary policy, the assumption of a constant real rate spread is appropriate and β should equal to one and α equal to zero.

Otherwise β is less than one and α not necessarily equal to zero if these conditions do not hold. Tests of the statistical significance of β coefficient and whether it differs from one reveal how much information is in the slope of the term structure about future changes in inflation.

Empirical results

Data visualization: Figureshows the evolution of the term structure of monthly Treasury bills as well as changes in inflation over 2004M1-2016M11. The figure shows that changes in inflation are quite noisy compared to the term structure of monthly Treasury bills, but they track one another quite well.

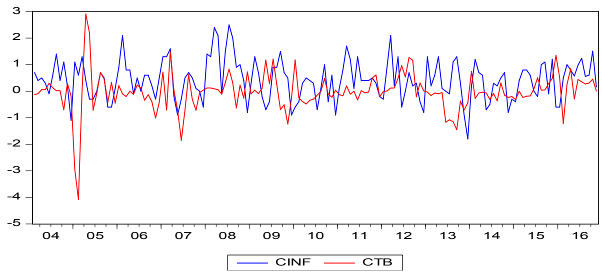


Figure 1. Term structure of inflation change

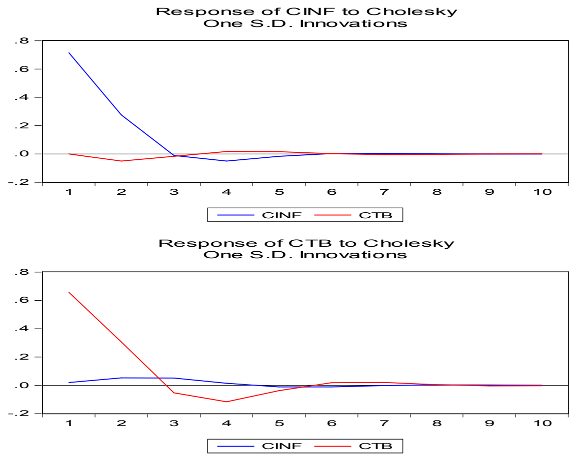
Unit root test: Show that INFL and INFL (+1) as well as the Treasury bill rates are I(0) at most at the 5% level.

Variable	ADF Test Statistic		
	At level		Decision
CINF	$\tau\tau$	-8.596***	I(0)
	$\tau\mu$	-8.619***	
	τ	-2.564**	
CTB	$\tau\tau$	-9.369***	I(0)
	$\tau\mu$	-9.342***	
	τ	-9.362***	

Causality test: Table abovealso shows insignificant Granger-causality (at three lags each) between term structure and changes in inflation at the 10% level, indicating that the series are fairly independent of one another.

Pairwise Granger Causality Tests			
Date: 12/21/16 Time: 09:08			
Sample: 2004M02 2016M11			
Lags: 3			
Null Hypothesis:	Obs	F-Statistic	Prob.
CTB does not Granger Cause CINF	150	0.47220	0.7021
CINF does not Granger Cause CTB		0.31987	0.8110

Impulse responses: Granger-causality may not tell us the complete story about the interaction between variables in a system in applied work; it is often of interest to know the responseof one variable to an impulse in another variable in a systemthat involves a number of further variables as well.One would like to investigate the impulse response relationshipbetween two variables in a higher dimensional system. Standard deviation shock to T- bills rate causes significant increases in inflationfor first. Three months periods and start to falls up to six months, after which the effect become neutral.



On other hands, the T-b ill has peaks in period first three months. The minimum impact is experienced fourth and the effect become normal for lasts of period. However, the Johansen (1998) cointegration test procedure is preceded by the determination of the optimal lag length in the VAR model. On this matter, the paper has used the Schwartz Information Criterion (SIC), Akaike Information Criterion (AIC), Schwarz Bayesian Criterion (SBC) and Adjusted Likelihood Ratio (ALR) tests. three lags have been selected as the optimal lag length. We have also tested the deterministic structure of the model. The results show that the model allow for linear deterministic trend in the data with an intercept and trend in the cointegrating equation but with no intercept in the VAR. Table reveals that the trace and max-eigenvalue tests indicate the presence of two cointegrating equations and therefore the existence of a long-run cointegrating relationship between the variables of the model.

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.310630	97.86235	15.49471	0.0001
At most 1 *	0.244548	42.06589	3.841466	0.0000
Trace test indicates 2 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.310630	55.79646	14.26460	0.0000
At most 1 *	0.244548	42.06589	3.841466	0.0000
Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Looking at Table 2, the results indicate a positive long-run relationship between the Inflation expectation and T-bill rate. This is an indication that interms of proportion T-bill rate affects more the inflation expectation.

Long run coefficients for expected inflation in Rwanda

Dependent variable	Coefficient	Variable
CINF	0.521 (0.1446)	CTB

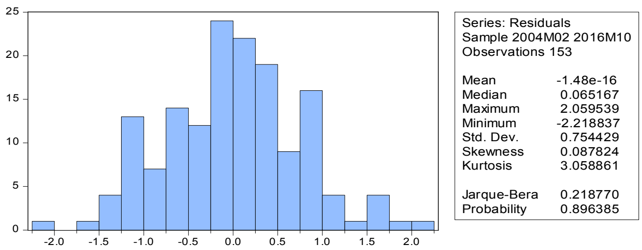
The results show that the slope of the yield curve provides significant information about the change in inflation in the case for monthly spread. The term structure however explains only about 52% of the anticipated inflation, so that the nominal term structure does not fully explain future inflation changes. It is nevertheless possible to reject the hypothesis that the coefficient on the yield spread equals zero.

Vector Error correction Model

Error Correction:	D(CINF)	D(CTB)
CointEq1	-0.782851	0.425086
	(0.12796)	(0.12470)
	[-6.11773]	[3.40883]
D(CINF(-1))	0.188044	-0.260950
	(0.11184)	(0.10899)
	[1.68130]	[-2.39421]
D(CTB(-1))	-0.396133	-0.116441
	(0.09266)	(0.09029)
	[-4.27529]	[-1.28958]
C	0.009807	0.005264
	(0.06003)	(0.05850)
	[0.16337]	[0.08998]
R-squared	0.342590	0.297427

In the short run, this spread is useful in predicting inflation because a significant impact of expansionary monetary policy falls on prices rather than output. An increase in term structure leads to a lower forecast inflation, as the monetary authorities are expected to pursue a tight monetary policy. A policy induced rise in short rates would be interpreted as meaning that a tight monetary policy is expected to lower future inflation, thereby lowering long-term interest rates and future short-term rates. Similar other studies find diverse results. In a study of the US term structure for maturities less than 12 months, Mishkin (1990a) finds that for maturities of 6 months or less the term structure provides no information on inflation while for maturities of 9 to 12 months the term structure does provide some term structure for a number of OECD countries, Mishkin (1991b) finds little evidence that the term structure provides information about future changes in inflation. Browne and Manasse (1990), however, present conflicting evidence arguing that the inflation forecasting ability declines as the maturity lengthens. In a study of G-7 countries, Schich (1999) also found substantial variation of results across countries and over time, with significant information content identified for the US, the UK, Germany and Canada. In one of the few studies on developing countries, Mehl (2009) finds that the predictive power of changes in the slope of the yield curve holds in a sample of fourteen different emerging countries between 1995 and 2005.

Diagnostic tests



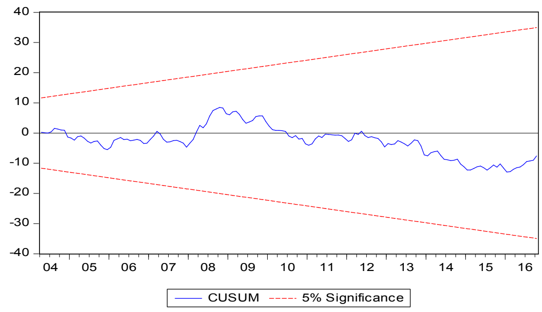
Normality test: Residuals show signs to symmetric) and kurtosis (no skewness of residuals bunchedright or left) and do not null hypothesis, since the residual are normally distributed.

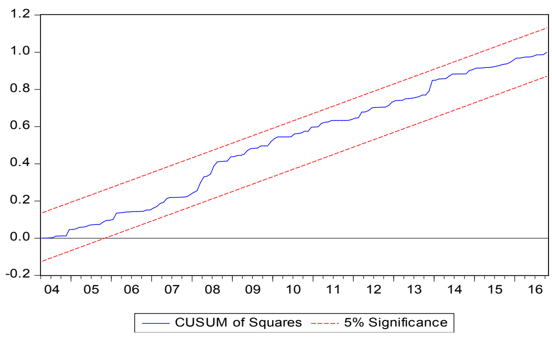
Heteroskedasticity Test: White			
F-statistic	0.483334	Prob. F(2,150)	0.6177
Residuals show signs of right skewness (residuals bunched to lef	Residuals show signs of right skewness (residuals bunched to lef	Residuals show signs of right skewness (residuals bunched to lef	Residuals show signs of right skewness (residuals bunched to lef
Scaled explained SS	0.982327	Prob. Chi-Square(2)	0.6119

Based on the p-values of both tests (White and B-P above) which are greater than alpha (of say 5%), we conclude that there is no heteroskedasticity.

Misspecification Test: Based on above result our model was correctly specified due to the probability is greater than 5% level of significance

Ramsey RESET Test			
Equation: UNTITLED			
Specification: CINF CTB C			
Omitted Variables: Squares of fitted values			
	Value	df	Probability
t-statistic	0.193654	150	0.8467
F-statistic	0.037502	(1, 150)	0.8467
Likelihood ratio	0.038247	1	0.8449





Cusum and Cusum squire residual tests: Based on the figure, the CUSUM and CUSUMSQ parameter stability tests confirm thatthe model is stable over the period of analysis as indicated by the fact that theplot lies within the 5 percent bounds.The plots do not cross the two lines denoting the 95% confidence interval bounds; they indicate that there has not been structural shift. Having found evidences on the existence of long run relationship between variablesand that the parameters are stable.All assumptions of normal linear regression estimator hold, then the OLS estimator remains the Best Linear Unbiased Estimator (BLUE), i.e. it has the constant variance and covariance.

Conclusion

The evidence presented in this paper suggests that the slope at the short-end of nominal yield curve is useful in predicting the future path of inflation. The slope of the yield curve provides some information on changes in inflation over research periods.

This empirical result is not without some qualifications. Foremost amongst these is the relatively short period over which the analysis is done monthly (TBRt minus TBRt-1). At a more abstract level, the above tests are predicated on the assumption that both the authorities and other agents in the economy did not change their behaviour with respect to the yield curve over the sample period. Any such changes could alter the relationship between the slope of the yield curve and the future path of the rate of inflation. Notwithstanding this qualification, this paper provides some support for using at least the short-end slope of the yieldcurve as an indicator of the future paths of inflation. Parameter stability shows the OLS coefficients were quite stable over the study period as they are within two standard errors.

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