American International Journal of Business Management (AIJBM)
*ISSN- 2379-106X, www.aijbm.com Volume 07, Issue 01 (**January -2024**), PP 57-68*

Expectations Hypothesis and Developing Countries: A Myth or Reality

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ABSTRACT:-Expectations hypothesis, which is one among the four different theories covering the term structure, has been most deeply studied in economics. Finance specialists and economists in general have a strong interest in term structure of interest rates as it offers meaningful information regarding the inter-temporal choices made by economic agents. However, one flagrant point on all of these studies is that the expectations hypothesis has been empirically tested mostly in the developed countries thus neglecting the developing countries, in general. The main purpose of this paper is to try to address this gap and assess whether the Expectations Hypothesis theory holds from the perspective of a developing country. Mauritius, which is considered as a developing economy according to the International Monetary Fund's April 2023 World Economic Outlook, has been used in this study. Treasury Bills of 3-months, 6-months and 1-year maturities have been considered and the ARMA regression techniques have been employed. Three (3) sets of term spread have been calculated, namely, 3months – 1 year, 6months – 1year and 3months – 6months. Empirical findings demonstrate that all the three β coefficients are positive with the highest being 0.81 for the 3-6 months spread and the lowest 0.67 for the 3-12 months spread whereas for the 6-12 months spread, the β estimate is 0.70. This finding proves that the actual term spread has indeed the power to forecast future anticipated changes in the short-term rate. Another important finding is that α, the constant term, bears a negative value meaning that there may be a positive term premium as stated by the liquidity premium theory. For economies like that of Mauritius where commercial banks invest excess liquidity in Government Treasury Bills, studying these theories has all its importance as policymakers can always make reference to address key economic and monetary issues.

Keywords*:* Expectations Hypothesis, Treasury Bills Rates, Term Spreads, Autoregressive Moving Average (ARMA) Regression Model, Developing Country

I. INTRODUCTION

One of the most researched areas in economics and finance that has grabbed attention for quite some time now is without any doubt the term structure of interest rates. Finance specialists and economists in general have a strong interest in term structure of interest rates as it offers meaningful information regarding the inter-temporal choices made by economic agents. Furthermore, it gives more visibility on financial markets' efficiencies in forming expectations from the information made available and used. From a macroeconomic perspective, the term structure represents one channel of affecting monetary policy decisions and applications. While changes in the long-term rates are based on investors' expectations of future interest rates rate and real inflation, the short-term rates are influenced directly by the monetary authorities. Furthermore, expectations of future real interest rates have an impact on domestic investments and productions. Thus, effects of monetary policy are sent to the real economic sectors via the term structure. In the global open economy, international capital flows are directly affected by the term structure and hence exchange rate.

Expectations hypothesis, which is one among the four different theories covering the term structure, has been most deeply studied in economics. Several researchers ([1],[2],[3],[4],[5],[6],[7],[8],[9],[10],[11],[12],[13],[14],[15],[16],[17],[18]) have worked on the information contained in the yield curve statistically and empirically, which is used to forecast interest rates changes.

However, one flagrant point common to all the previous studies was that the expectations hypothesis theory was empirically tested mostly in the developed countries, thus giving rise to the question. "How much research has been made as regards to the term structure of interest rates theories in developing countries?"

This paper is divided into six sections, including this introduction. The second section presents the theoretical framework. The third section provides some literature review on the topic. The fourth part describes the methodology and the data used. The empirical findings are presented in the fifth section. Finally, the sixth section provides some concluding remarks.

1. Theoretical Framework

Theoretically, the term structure of interest rates is defined as the relationship between the yields to maturity on securities with the difference occurring in maturity dates. And according to the pure expectations, the expectations of the future yields are the unique factor of the term structure. The theory further claims that, over the maturity period of the long-term security, the actual long term interest rate is simply the average of the current and expected future short term interest rates. For a discount bond,

$$L_t^n = \frac{1}{k}\left[S_t^m + E_t S_{t+1m}^m + E_t S_{t+2m}^m + \cdots + E_t S_{t+(k-1)m}^m\right] \quad (1)$$

where
L_t^n = actual long-term rate of term n periods on discount bond
S_t^m = actual short-term rate of term m periods on discount bond, with $m<n$
$\frac{1}{k} = \frac{n}{m}$, assumed to be a positive integer
E_t = expectations operator based on the information available at time t

Nevertheless, [19] claimed that there was a need to modify the pure expectations theory. He argued that the higher is the risk of variations in the security's principal value to the investor when investments are made on securities with longer maturity periods. Logically, risk-averters are more likely to dominate the security market. Risk averters are those bond investors who prefer to place money on short term securities unless they are given an adequate compensation to lend long. Therefore, Hicks stressed on the fact that a constant term premium is added to the pure expectations theory. When the term to maturity is longer, the term premium representing the compensation is also larger. This is shown in equation (2) by adding a constant term premium to equation (1) as follows:

$$L_t^n = \frac{1}{k}\left[S_t^m + E_t S_{t+1m}^m + E_t S_{t+2m}^m + \cdots + E_t S_{t+(k-1)m}^m\right] + TP^n \quad (2)$$

where TP^n = constant term premium on a bond with *n* periods term.

Equation (2), which was the amended theory put forward by Hick's, is commonly referred to as the liquidity premium theory.[1] The underlying assumption on the term premium TP^n is that while it is decreasing in *m*, it has to be positive and increasing in *n*.[2]

Given that risk averters investors logically dominate the financial market that is where there is a preference to go for short term lending instead of longer-term lending unless given an adequate reward, the term premium will have a positive sign associated to it. However, unless the investment horizons and the risk preferences of economic agents are clearly specified, more advanced theory requires that the positive premium is decreasing in *m* and increasing in *n*. According to another theory, which is the preferred habitat hypothesis put forward by [20], if more risk averse investors with longer investments targets dominate the market, then this, could rise to a negative term premium and a higher return on short term security than that on the longer-term ones.

Another popular theory of term structure of interest rates is the one developed by [21] and known as the Capital Asset Pricing Mechanism (CAPM) model. The CAPM theory stipulates that under most cases the term structure will contain a positive term premium which rises with maturity. On a different note, provided that economy is dominated by risk-averse investors, [24] showed that the term premium could either increase or decrease across different maturities. This was dependent on whether the volatility of the changes to expectations about future output fluctuated with time.

Equation (3) is obtained following some algebraic manipulations from equation (2). Equation (3) shows that all the information about the constant term premium as well as the expected future changes in short term rate is in fact contained in the actual yield curve.

$$L_t^n - S_t^m = E_t\left[\sum_{i=1}^{k-1} \frac{k-i}{i} D_{t+im}\right] + TP^n \quad (3)$$

where $D_t = S_t^m - S_{t-m}^m$

[1]The term liquidity preference was first introduced by [22]. This term was used to describe a market reference whereby capital losses arising from changes in interest rates had no effect on the assets.
[2] [23] found that the ratio of liquidity premium to the total return from securities had an inverse relationship to the term to maturity.

In fact, the anticipations of the future financial factors do not technically shift from what the rational expectations hypothesis has actually predicted meaning that these fluctuations are basically forecasted to the value of zero. Therefore, the final interest rate can be written as a summation of future expectations and a forecast error ε_{t+im}

$$D_{t+im} = E_t D_{t+im} + \varepsilon_{t+im} \tag{4}$$

At time *t* and with the available set of information, $E_t \varepsilon_{t+im}$ = 0.

Hence, the path of future short term interest rates is reflected by the difference between the actual long term and short-term interest rates. Regression analysis can be used to test this hypothesis.

$$\sum_{i=1}^{k-1} \frac{k-i}{k} D_{t+im} = \alpha + \beta(L_t^n - S_t^m) + \mu_{t+n} \tag{5}$$

where $\mu_{t+n} = \sum_{i=1}^{k-1} \frac{k-i}{k} \varepsilon_{t+im}$, α = -θ and β = 1

The pure expectations hypothesis will be supported for any value for β which is insignificantly different from one. Furthermore, for any value of β that is significantly positive, the term structure can be said to have forecasting power for future changes in interest rates. Additionally, from equation (5), there should not be any correlation between the estimated residuals and all the information available at time *t*. More specifically, apart from the fact that the same and overlapping data give rise to the moving average correlation, the estimated residuals should be free from serial correlation issue. The moving average terms' order is specified by the theory.

II. LITERATURE REVIEW

The expectations hypothesis theory of term structure of interest rates may be regarded as one theory that has failed to give significant empirical evidence whenever developed countries have been assessed. Having been examined and expressed in different ways, it has been stated by the expectations hypothesis theory that the slope of the yield curve is a reflection of anticipated rate changes both in the short and long terms. Moreover, according to the pure expectations hypothesis whenever the rate on the long-term security exceeded that of the short-term security, there were adjustments in both yields in such a way that the gap between them was subsequently closing. Even for the altered expectations hypothesis, a similar suggestion held good.

As a consequence of the above-mentioned implications, the information content in the yield curve was tested by several researchers, both in an empirical and statistical way, in order to determine whether it had the forecasting power to capture future changes in the short term and long-term interest rates. The estimation of β = 1 as seen in equation (5), representing the joint hypothesis of pure expectations theory and rational expectations, has failed to hold in several researches ([7], [25]).

But still in studies conducted later, several researchers have found some empirical evidence on the yield curve and its ability to forecast future changes in the short term and long-term rates. However, the evidence remained weak and not to the level as postulated by the expectations hypothesis theory ([1], [2], [4], [5], [6], [7], [11], [26], [27], [28]).

To predict changes in the rates of the three-month Treasury Bill in the United States, [1] found that the term structure between Treasury Bills of maturity 3-months and 6-months rates was helpful. However, the hypothesis was rejected when considering very small m and very large n values.

[2] found some empirical evidence by adopting a different approach. When the current change in the one-month Treasury Bill rate over one month was regressed on the anticipated change, the slope of the yield curve predicted interest rate changes over a few months. In another study, taking into consideration the forward term premia, [25] found empirical evidence that the predicting ability of the yield curve became more powerful with an increasing time period of the long-term rate.

[7]demonstrated that there is a situation where the long term and short-term rates reacted differently. In fact, longer-term interest rates performed in contradiction to the expectations theory and the shorter-term rates followed the theory, when the difference between the long term and short-term rates was high. Actually, the theory of expectations hypothesis was not rejected for predicting fluctuations in the short rates, when moving up the yield curve. To explain the inconsistency, they proposed the time-varying risk premia as a possible reason. They added that the term premia could have been correlated with anticipated increases in short term rates of the yield curve. Their model proved two implications. Firstly, the long-term interest rates were different to the short-term rates in the way suggested by the expectations theory. And secondly, the yield spread was bigger than what the rational expectations of future short rate changes stipulated.

Other empirical studies ([1], [29]) supported the findings that the spread forecasted the changes in the long-term rates in an opposite direction to what has been advocated in the theory. Furthermore, [6] proposed a possible solution to the issue for some developed countries such as Canada, Germany, Japan and UK. By using the instrumental variables technique, a white noise error was added to the long-term rates. However, when it comes to the United States the problem remained unanswered despite working with the most advanced and liquid financial market. [7] and [30] have tried to provide plausible explanations to the empirical failure of the US. They advanced that the over-reaction hypothesis could be the reason.

In view of finding solutions to the US puzzle, [31] based their work on the Vector Autoregressive (VAR) model. They found empirical evidence that the presence of time varying term premia could be the reason as to why the short-run tests of the expectations hypothesis theory were rejected.

New ideas together with a different way of looking at the existing literature were initiated by [3]. Over a period of almost 100 years ranging from 1890 to 1979 and by looking at different monetary regimes, they started by analysing the US data. They found positive evidence of the expectations hypothesis prior to the setting up of the Federal Reserve whereas in more recent times, the theory failed. When the change in the 3-month interest rates was regressed on the difference between the 3 and 6-month interest rates, the β coefficient over the period 1890 to 1914 happened to be significantly positive although not equal to one. [3] claimed that the rejection of the theory after the setting up of the Federal Reserve was on account of the levelling up of interest rates. They further added that interest rates in the short term were made to follow nearly random walks pattern. The findings of Mankiw and Miron were further backed by [5] research on the United States which was conducted during the modern monetary regime. The forecasting power of forward rates improved drastically during the period of non-borrowed reserve targeting when interest rates were allowed by the Federal Reserve to vary rather freely. Nevertheless, post October 1982, the forecasting power did not fall when the Fed started using as its policy instrument the Federal funds rate with the ultimate objective of controlling the rate of inflation and GDP growth.

One common feature about the expectations theory failure was that most of the studies focused only on the United States. The researchers such as [6], [10], [32] assessed the theory in the case of European countries; the results were quite different to that of the United States.[10] found that better results in situations where a transitional exchange rate target had control over the monetary policy were produced by the expectations hypothesis. An example could be the European Exchange Rate Mechanism. In other words, the short-term rates became more predictable with a methodical policy response resulting in the acceptance of the expectations hypothesis theory.

[33] based his work on the period when the Federal Reserve did not intervene to alter the funds rate, and he found that the difference between federal funds and the three-month Treasury bill had significant forecasting power for coming changes in the funds rate of the Federal Reserve. He further suggested that to have better and more accurate predictions about future changes in funds rate, monetary policy should have more dependency on rules rather than mere choice and decisions. This is an additional support for the Mankiw-Miron hypothesis.

[8]Has empirically explained, using a theoretical model, the failure of the expectations hypothesis. The model included several elements among which a reaction function of monetary policy responding to the actual spread and catering for the levelling of interest rates and also a random term premium exogenous in nature.

Looking at the Mankiw-Miron hypothesis, [9] explicitly modelled the connection between Federal Reserve's behaviour and the term structure. Over different periods and in various studies, the theoretical model accounted for the outcomes of the changing capacity of the term spread to predict future interest rates empirically. The model depicted interest rate patterns of the Federal Reserve in the form of persistent target, steady target adjustment and movement of the target on a daily basis. Therefore, the interest rate smoothening by the Federal Reserve has been done in the medium term.

[34]In their study examined the Mankiw-Miron hypothesis from a different angle. Their work consisted of mutually assessing a modern yield structure relationship connecting the six-month interest rate to the actual and future 3-month rate while at the same time looking at a new rule for the 3-month rate. They found that the increased transparency adopted by policy makers in the United States, boost up in confidence and the latest importance laid on Taylor-type interest rate rules increased expectations hypothesis model predictions.

[35]Attributed the rise in policy changes likelihood to the improved transparency in formulating policies, thus having an impact on the term spread. They further showed that, since the late eighties, the first difference of the Federal Reserve funds rate has been more serially correlated.

Using short term repo rates, [11] showed that the short end of the yield curve empirically supported the expectations hypothesis theory. He opted for a VAR-GARCH approach and also used a single equation estimation with a changed specification. His findings were that longer-term interest rates were almost unbiased predictors of mean over-night rate with zero term premium during the span of the longer-term rate. Longstaff additionally added that other factors, for example liquidity, could be the reason explaining the large premia changing with time as seen in the securities market studies. He concluded by saying that short term riskless yield curve could be better explained by repo rates rather than the Treasury bills rates.

The different findings found in literature are somewhat based on account of changes in the data, empirical approaches and specifications. However, globally, several results agreed on the capacity, to some extent, to forecast short term changes that the very short end of the term structure possessed. Although the power to forecast is reduced as the time period is increased. Nevertheless, differences remained as regards to the period over which the forecasting power existed and the amount of information contained by the term spread.

One general fact about the previous studies was that the focus was laid mainly on testing expectations hypothesis validity in developed countries with very little and rare attention given to developing countries. While most of the reports were concentrated on the United States, a few researchers ([6], [10], [32], [36]) based their works on European countries. But again, countries having strong financial markets were considered. [37] focused their work on the Swedish financial market. The link between the forward rates and the resulting short end interest rates in the yield curve was empirically tested. As opposed to other works, they found that the joint hypothesis of no term premium and rational expectations could not be rejected. Over the period January 1984 to July 1992 and using Treasury Bills interest rates with maturities ranging from one month to one year, the co-integrating association between the rates was assessed empirically through regressions. The slope coefficients were found to be significant and furthermore close to one. However, in some sub-periods, parameter instability was found by the researchers.

[38]Studied the Spanish Financial market. They tested the expectations hypothesis theory for both, short and long rates over the period 1993 to 1998 and by using securities with maturities starting 1-month and stretching up to 10-years. They gathered the information from the public debt market. Once more, contrary to developed markets, the pure expectations hypothesis of $\beta = 1$ is not rejected. More surprisingly, the results help in all the cases involving short rates and in almost all those having long rates. The Spanish scenario supported the idea that the developing markets may respond differently and that the empirical tests on expectations hypothesis done in the developed countries may not necessarily give identical results if conducted in developing countries. This could further strengthen the stand of monetary policy makers in the developing countries.

[39]Decomposed nominal interest rates into expected inflation and real rates movements. Given that expected inflation and real rates are not directly observable, they build a model to infer these factors from their impact on other variables in the economy. They found that short term real rates tend to be highly volatile, while long term rates are smooth and persistent. They concluded that the positive slope coefficient found in the nominal yield curve was on account of an inflation risk premium that kept on increasing with maturity.

[26]Tested the expectations hypothesis theory for the US by using monthly data over the period 1953 to 2003 on bonds with lowest maturity of 1 month up to maximum of 10 years. The Lagrange Multiplier Test of [36] was applied. They found that while mixed results were obtained with the traditional bivariate procedure, more advanced procedures rejected the expectations hypothesis throughout the maturity range.

[40] Studied the expectations hypothesis theory using Tunisian government securities. Using cointegrated-VAR on different sets of term spreads, it was found that when considering medium-term maturities, the expectations hypothesis failed. However, better and valid results were obtained when considering longer-term maturities.

[41]Studied the impact of term spreads on economic growth in Mauritiususing an ARDL model on a production function. They found thatfound that the variable spread had a positive impact on economic growth though being weakly significant and very low. Furthermore, the production function did not have any long-run relationship.

III. METHODOLOGY & DATA

a. Methodology

As per the pure expectations hypothesis theory, the difference between the short term and the long-term rates also known as the yield spread is in fact equal to the algebraic sum of futures changes in the short term rates. Under the rational expectations theory, it is assumed that at time *t*, the model does not suffer from serial correlation. And given that the error term is not correlated with any other variables, Ordinary Least Squares (OLS) would offer reliable outcomes.

From literature, it was found that studies, except [6], [42], [43], applied the Ordinary Least Squares estimations. The majority of these studies did not find empirical evidence for the simple expectations hypothesis theory.

Several reasons were put forward to explain why the expectations theory failed. One option was in the formulation of the hypothesis itself. It was believed that the joint hypothesis of market efficiency with rational expectation was an incorrect hypothesis. This was how the inclusion of a term-premium varying with time became a possible alternate solution. A time-varying random element, ς_t, was added to the term premium, *TP*.

$$L_t^n = \frac{1}{k}\left[S_t^m + E_t S_{t+1m}^m + E_t S_{t+2m}^m + \cdots + E_t S_{t+(k-1)m}^m\right] + (TP^n + \varsigma_t) \qquad (6)$$

This would change equation (6) into

$$\sum_{i=1}^{k-1} \frac{k-i}{k} D_{t+im} = \alpha + \beta(L_t^n - S_t^m) + \mu_{t+n} - \varsigma_t \quad (7)$$

Other than the uncorrelated forecast error, the regression error in the yield curve estimation could contain a random element as well. This random element could be arising as a result of a term premium varying over time or due to a shift from the rational expectations. This situation was interpreted by [6] as possibly a measurement error.

Having measurement errors particularly in developing countries' yields and interest rates was a real possibility. Developing countries' financial markets were, furthermore, not well developed and liquid in nature. A weakly developed financial market or strong fiscal or monetary policy decisions could have significant impact on the interest rates and the information they hold.

The result of adding an error term to the equation, which may, furthermore, be serially correlated with the regressors, would make that consistent and significant estimates of the yield curve may no more be obtained through OLS regressions. Instead, a two stage least squares method would have to be adopted in order to get consistent estimates.

Based on the assumptions underlying the expectations hypothesis theory, the regression errors were supposed to be serially uncorrelated to the regressors. However, with normal regressions and without ARMA terms, severe serial correlation was found in the residuals. This resulted in estimates that were inconsistent. A possible explanation for the serial correlation issue in the regression estimates was due to the overlapping data. The data would be moving average of *k-1* order. Furthermore, with a constant term premium in the regression, the expectations hypothesis theory may fail on account of serial correlation in the residuals. This could provide strong evidence of the possible presence of factors other than the term spread or that of a term-premium that varies with time.

In all the regressions, ARMA terms were included so as to eliminate the effect of serial correlation in the residuals. Low values of p and q would likely be sufficient for developing markets. The addition of ARMA terms would provide acceptable LM statistics from Breusch-Godfrey test. In the final regression, only the most significant terms would be used.

$$\sum_{i=1}^{k-1} \frac{k-i}{k} D_{t+im} = \alpha + \beta(L_t^n - S_t^m) + \mu_{t+n} \quad (8)$$

where

$$\mu_{t+n} = \rho_1 \mu_{t+n-1} + \rho_2 \mu_{t+n-2} + \cdots \rho_\rho \mu_{t+n-\rho} + \varepsilon_{t+1} + \emptyset_1 \varepsilon_{t+n-1} + \emptyset_2 \varepsilon_{t+n-2} + \ldots + \emptyset_q \varepsilon_{t+n-q}$$

Non-linear regression methods would be used to estimate the ARMA model. The estimates obtained from the non-linear least square method would be asymptotically equivalent to estimated generated from maximum likelihood models; hence they would be efficient.

b. Data

Mauritius has been selected for the purpose of this study as it is classified as a developing country and the securities used were the 364-day Treasury Bills as the longest financial security, the 180-day Treasury Bills and the 91-day Treasury Bills as the shortest one. Monthly data has been collected over the period April 2008 to March 2020 (144 monthly records). Data beyond March 2020 was interrupted due to the outbreak of the COVID-19. Data has been collected from the Bank of Mauritius[3]. Three (3) sets of spread were calculated and used in the empirical section; (i) 3months – 1 year, (ii) 6months – 1year and (iii) 3months – 6months.

IV. EMPIRICAL DISCUSSIONS & RESULTS

Three stages are used to describe the ARMA regression analysis. These three stages are the same as defined by [44]. IDENTIFY, ESTIMATE, and FORECAST are the three respective stages which are described briefly below.

1) The first stage is the identification. Two functions are covered by the IDENTIFY statement. Firstly, it is used to state the response series and secondly, possible ARMA models are identified. The IDENTIFY statement is very important in the sense that it captures the time series which will be used again in following statements, differencing them if possible, and also computing all sorts of the autocorrelations be it cross, partial or inverse. Stationarity tests can be used to decide whether differencing is necessary or not. To determine whether one or more ARMA models are appropriate is possible after analyzing the IDENTIFY statement.

[3]Data from Bank of Mauritius can be accessed through www.bom.mu

2) The second stage involves the ESTIMATE statement. It is in this stage that the best fit ARMA model to the variables, which was identified in the first stage that is the IDENTITY statement, is specified. The parameters of the selected model are also estimated. Furthermore, diagnostic statistics are produced in this second stage. These statistics provide assurance of whether the model is appropriate or not. Significance tests are required to show whether all terms specified in the model are necessary and important. To compare the selected model with others, the goodness-of-fit will be used. Additionally, it is important to perform the white noise residuals tests to better understand the residuals and know whether they hold information that might prove useful for more complex models. If ever problems are found following the diagnostic tests, another model is chosen, then stage two tests, that is the estimation and diagnostic tests, are repeated.

3) Finally, the FORECAST statement is used in the third stage. The purpose of the FORECAST statement is for the prediction of the time series future values and also to produce confidence intervals for these estimates from the ARMA model.

a. Identification Stage

The results of ADF unit roots test are presented in TABLE 1.

Table 1Unit Root Test Results

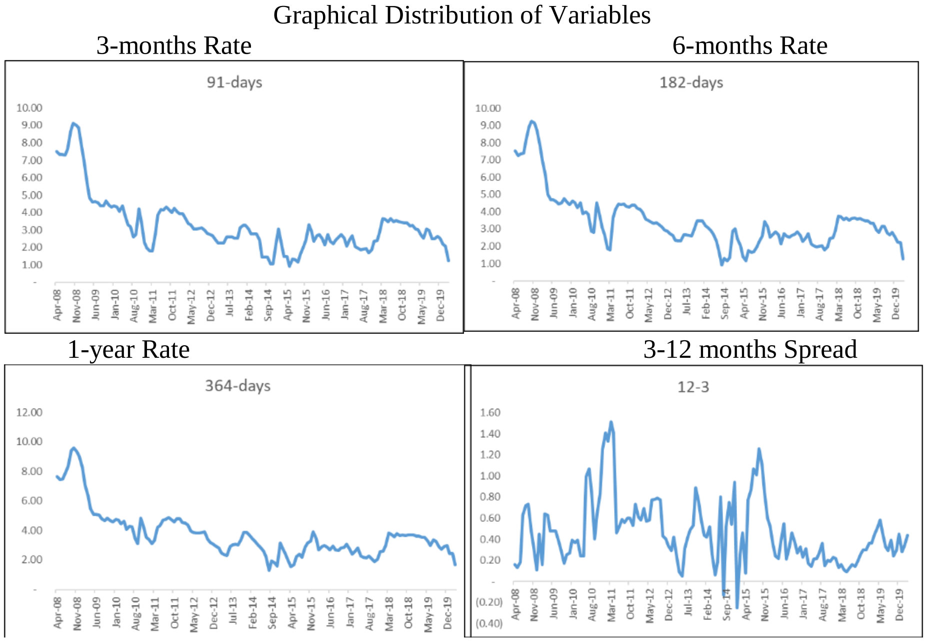
	Level Form		First Difference	
Variable	P-value	Decision	P-value	Decision
Rate 3-months	0.1999	Non-Stationary	0.0000	Stationary
Rate 6-months	0.2148	Non-Stationary	0.0000	Stationary
Rate 1-year	0.2922	Non-Stationary	0.0000	Stationary
Spread 3-12 months	0.0002	Stationary		
Spread 6-12 months	0.0000	Stationary		
Spread 3-6 months	0.0000	Stationary		

Source: Author's conceptualization

Note: Considering a 5% significance level, the null hypothesis (H_0), that is the variable has unit root or likewise it is non-stationary, is not accepted when the p-value is less than 0.05.

The results were also cross-checked by plotting the graphs. The graphical representation could be seen in Fig 1.

Graphical Distribution of Variables



6-12 months Spread 3-6 months Spread

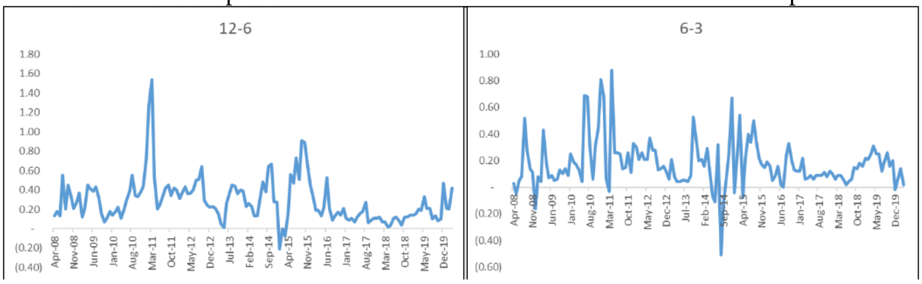


Figure 1
Source: Author's conceptualization

5.1.1 Correlogram Plotting

Correlogram is useful for identifying a pure moving average model, since there will tend to be cut-off significant points on the correlogram after appropriate lag length. And for autoregressive or mixed processes, the order of the autoregressive component may be harder to determine from the correlogram. For this reason, it is usual to use a complementary procedure which involves the plotting the estimated coefficient of X_{t-k}, from an Least Square estimate of an AR(p) model. If the observations are generated by an AR(p) process, then the theoretical partial autocorrelations are zero at lags beyond p. Since any invertible MA process can be represented as an AR process with geometrically decreasing coefficients, the partial autocorrelation function for an MA process should decay slowly. The identification of a mixed model may be more difficult to determine.

The different correlograms for the 3 sets of spread are depicted graphically as shown in Fig 2 below.

Correlograms

3-12 months Spread

Lag	AC	PAC	Q-Stat	Prob
1	0.628	0.628	40.654	0.000
2	0.432	0.061	60.045	0.000
3	0.229	-0.106	65.565	0.000
4	0.161	0.063	68.317	0.000
5	0.043	-0.097	68.519	0.000
6	-0.004	-0.014	68.521	0.000
7	-0.011	0.048	68.533	0.000
8	0.086	0.151	69.360	0.000
9	0.039	-0.118	69.528	0.000
10	0.039	0.008	69.700	0.000
11	-0.017	-0.048	69.731	0.000
12	-0.049	-0.071	70.006	0.000

6-12 months Spread

Lag	AC	PAC	Q-Stat	Prob
1	0.518	0.518	27.638	0.000
2	0.355	0.119	40.788	0.000
3	0.082	-0.197	41.487	0.000
4	0.024	0.018	41.548	0.000
5	-0.076	-0.059	42.172	0.000
6	0.008	0.101	42.178	0.000
7	0.046	0.066	42.414	0.000
8	0.027	-0.088	42.493	0.000
9	-0.017	-0.047	42.526	0.000
10	-0.101	-0.095	43.683	0.000
11	-0.092	0.030	44.661	0.000
12	-0.086	0.021	45.514	0.000

3-6 months Spread

Lag	AC	PAC	Q-Stat	Prob
1	-0.404	-0.404	16.694	0.000
2	-0.108	-0.324	17.886	0.000
3	-0.087	-0.368	18.674	0.000
4	0.119	-0.221	20.167	0.000
5	0.011	-0.165	20.180	0.001
6	0.003	-0.100	20.181	0.003
7	0.011	-0.000	20.194	0.005
8	-0.074	-0.064	20.790	0.008
9	-0.032	-0.145	20.907	0.013
10	0.160	0.048	23.766	0.008
11	-0.106	-0.064	25.036	0.009
12	-0.007	-0.066	25.042	0.015

Figure 2
Source: Author's conceptualization

The tentative models based on the correlograms are:

1) Spread 3-12 months: ARMA(1,1), ARMA(1,2), ARMA(1,3)
2) Spread 6-12 months: ARMA(1,1), ARMA(1,2)
3) Spread 3-6 months: ARMA(1,1), ARMA(2,1), ARMA(3,1)

b. Estimation Stage

The estimation results for each spread are shown in TABLE 2.

Table 2Estimation Results

Spread 3-12 months	ARMA(1,1)	ARMA(1,2)	ARMA(1,3)
Significant Coefficients	2	1	2
$Sigma^2$ (Volatility)	0.088	0.099	0.096
Adj. R^2	0.143	0.030	0.060
AIC	0.520	0.610	0.580
SIC	0.620	0.720	0.680

Spread 6-12 months	ARMA(1,1)	ARMA(1,2)
Significant Coefficients	2	1
$Sigma^2$ (Volatility)	0.060	0.070
Adj. R^2	0.208	0.081
AIC	0.148	0.264
SIC	0.253	0.369

Spread 3-6 months	ARMA(1,1)	ARMA(2,1)	ARMA(3,1)
Significant Coefficients	2	1	1
$Sigma^2$ (Volatility)	0.064	0.066	0.067
Adj. R^2	0.413	0.395	0.391
AIC	0.221	0.224	0.232
SIC	0.326	0.329	0.336

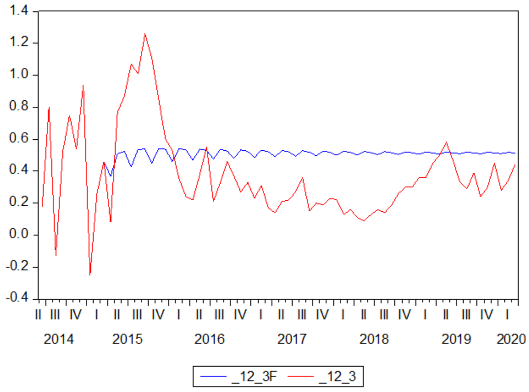
Source: Author's conceptualization

c. Forecasting Stage

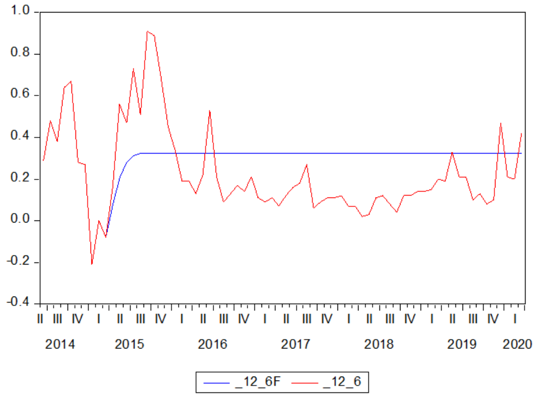
The basic essence of fitting an ARMA model is to predict future values on the series by using its own past values. The best way to know whether the chosen models are correct is to plot the forecast against the actual data. This is depicted in Fig 3.

Forecasted Values Against Actuals

3-12 months Spread



6-12 months Spread



3-6 months Spread

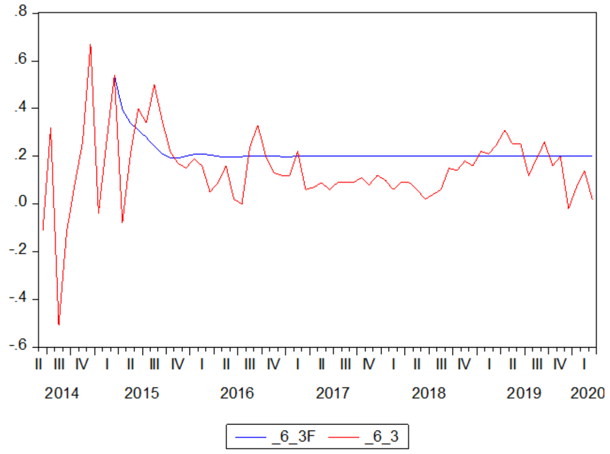


Figure 3
Source: Author's conceptualization

It has been found that for all three sets of spreads, the forecast is more or less within the range of the actual data.

d. Empirical Findings

The empirical findings are as shown in TABLE 3 below.

Table 3Expectations Hypothesis Test

n	m	β	H_o: β = 1	Std Error
12	6	0.70**	1.25	0.18
12	3	0.67***	2.07	0.19
6	3	0.81***	1.02	0.14

Source: Author's conceptualization

$$\sum_{i=1}^{k-1} \frac{k-i}{k} D_{t+im} = \alpha + \beta(R_t^n - r_t^m) + \mu_{t+n}$$

where

$$\mu_{t+n} = \rho_1 \mu_{t+n-1} + \rho_2 \mu_{t+n-2} + \cdots \rho_\rho \mu_{t+n-\rho} + \varepsilon_{t+1} + \emptyset_1 \varepsilon_{t+n-1} + \emptyset_2 \varepsilon_{t+n-2} + \ldots + \emptyset_q \varepsilon_{t+n-q}$$

n and m = maturity in months of long term and short term rates respectively
Chi square statistic from Wald test with H_0 : β=1
LM statistic from Breusch-Godfrey test for serial correlation up to 12 lags
***, ** and * at 1%, 5% and 10% significance level respectively

V. CONCLUSION

For analysis regression purposes, three spreads had been used for Mauritius. All the three β coefficients were positive with the highest being 0.81 for the 3-6 months spread and the lowest 0.67 for the 3-12 months spread. For the 6-12 months spread, the β estimate was 0.70. This showed that the β has a value which is typically different from zero and was furthermore positive. This finding proved that the actual term spread had indeed the power to forecast future anticipated changes in the short-term rate. Another important finding was that α = -θ, a negative sign of the constant in this regression meaning that there may be a positive term premium as stated by the liquidity premium theory. For economies like that of Mauritius where commercial banks invest excess liquidity in Government Treasury Bills, studying these theories has all its importance as policymakers can always make reference to address key economic and monetary issues.

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APPENDIX

List of Abbreviations

Abbreviations	**Meanings**
AR	Autogressive
ARMA	Autoregressive Moving Average
CAPM	Capital Asset Pricing Mechanism
GARCH	GeneralizedAutoregressiveConditionalHeteroskedasticity
LM	Lagrange Multiplier
MA	Moving Average
OLS	Ordinary Least Squares
VAR	Vector Autoregressive

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