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Abdul Majid, Muhamed Zulkhibri

Islamic Development Bank

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Muhamad Shukri Abdul Rani
Central Bank of Malaysia

Abdul Majid Muhamed Zulkhibri, Ph.d[#]
Islamic Development Bank

***** *Corresponding author: Economist, Economic Research and Policy Dept., Islamic Development Bank. Mailing address: 9th Floor, Economic Research and Policy Dept., Islamic Development Bank, P.O Box 5925, Jeddah, 21432, Saudi Arabia mzulkhibri@isdb.org; khibri1974@yahoo.com.Tel: +966 2 646 6533; Fax: +966 2 646 7478*

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ABSTRACT

This paper investigates the role of the term spread to predict domestic output and inflation in less developed financial market with the focus on Malaysia bond market. By controlling for past values of the dependent variable, this paper finds that the term spread of various bond maturities contain relevant information about future output and inflation at short horizons. Besides that, we employ a probit model to assess the ability for the yield curve to predict future economic slowdown. The results suggest that the term spread has contributed significantly in the probability of predicting future economic slowdown. Despite the under-developed bond market, the findings point to the potential for bond yields to play a greater role in monetary analysis beyond conventional indicators. From the policy point of views, the results from our analysis suggest that there is a significant potential for incorporating more technical and model based approaches using the yield curve beyond the usual indicator analysis.

JEL classification: E43, E52
Key words: Term spread, Forecasting, Monetary Policy, Malaysia

1. Introduction

The term structure of interest rates has intrigued and fascinated generations of academic researchers and practitioners. An understanding of the stochastic behavior of yields is important for the conduct of monetary policy, the financing of public debt, the formation of expectations about real economy activity and inflation, the risk management of a portfolio of securities, and the valuation of interest rate derivatives.

In Malaysia, there is no explicit numerical target for inflation and one has to learn about monetary policy effectiveness by studying expectations of the private sector via the term structure or the yield curve. Monetary policy can influence the slope of the yield curve. A tightening of monetary policy usually means a rise in short-term interest rates, typically intended to lead to a reduction in inflationary pressures. When those pressures subside, it is expected that a policy easing will follow. Furthermore, changes in investor expectations can also change the slope of the yield curve. The expectations might be formed based on the currently observed yield curve. Consider that expectations of future short-term interest rates are related to future real demand for credit and to future inflation. A rise in short-term interest rates induced by monetary policy could be expected to lead to a future slowdown in real economic activity and demand for credit, putting downward pressure on future real interest rates. Hence, a part of the macroeconomic forecasting literature focuses on predicting inflation and output from prices of financial assets, notably short rate and term spread (Stock and Watson, 2003).

In the last few years the slope of the yield curve has received considerable attention for its ability to forecast both real and nominal macroeconomic variables. These include future levels of interest rates (Fama, 1984; Mania and Myron, 1986; Masking, 1988); the inflation rates (Frankel and Lawn, 1991; Fama, 1990; Mishkin, 1989, 1990); consumption growth (Harvey, 1988); employment (Bernanke, 1990); and output growth (Estrella and Hardouvelis, 1991). The natural motivation for such an approach is that, because of their forward-looking nature, yields should serve as good predictors of macroeconomic activity. Mishkin (1990a, 1990b, 1991) and Jordon and Mishkin (1991) have demonstrated that the slope of the curve beyond one year is a relatively good predictor of the change in the rate of inflation. On the real side, Bernanke (1990), Friedman and Suttner (1991), Estrella and Hardouvelis (1991), and Colicky (1997), among many others, have investigated a variety of yields and yield spreads individually on their ability to forecast macroeconomic variables. Stock and Watson (1989), Bernanke (1990) and Bernanke and Blinder (1990) show that using a vector auto regression approach, that the spread between the yields on long and short bonds helps predict future economic activity. Similarly, Estrella and Hardouvelis (1991) show that the slope of the yield curve helps predict the change in real economic activity over horizons out to twelve quarters. Hamilton and Kim (2002) as well as Diebold, Piazzas, and Rosebush (2005) provide a brief summary of this line of research and the link between the yield curve and macroeconomic variables.

In the case of Malaysia, Ghazali and Low (1999) conclude that the Malaysia Treasury Bills (MTBs) spread is a significant predictor for future annual output growth. Elshareif and Tan (2010), meanwhile, find a long-run co integrated relationship between short- and long-term interest rates in Malaysia, supporting the existence of the Pure Expectation Hypothesis in the bond market. This alludes to the potential for employing the term spread to forecast future inflation and output. Similarly, Tse (1998) shows that the spread between the 3-month commercial paper and 3-month Treasury Bill rate has significant predictive power for future economic growth in Singapore.

This study contributes to the current literature in several aspects. First, this study would provide up-to-date empirical evidence on how the term spread could be used in forecasting both inflation and output in a relatively developed financial market. On this note, the paper specifically addresses three major questions: 1) What could be said about the relationship between the term spread and inflation/output?; 2) Beyond past values of inflation and output, does the term spread hold additional information about these important variables?; 3) Could we use it as a tool to forecast inflation and output as in the case of developed economies? Second, to our knowledge, no studies have been done so far in analyzing the impact of monetary policy on term structure using a long aggregated data based on our methodology for the Malaysian economy. Third, findings of this study would enable some policy recommendations with regard to monetary policy implementation and the future development of bond market in Malaysia.

The remainder of the paper is organized as follows. In Section 2, provides the stylised facts about bond market development in Malaysia. Section 3 briefly describes the theoretical framework and relevant literature on term structure. Section 4 presents the data description and methodology. Section 5 provides the empirical results and the paper is rounded off with some concluding remarks in Section 6.

2. Stylised Facts about Malaysian Bond Market - Malaysian Government Securities

The history of the Malaysian bond market dated back to post independence of the 1950s. It can therefore be consider as a developing market. In contrast to the capital market, the trading of stock and shares through the Bursa Malaysia[1] has far out-spaced the trading of bonds. This is because the secondary market for bond is rather inactive. The bond market in Malaysia is under-developed because of overregulation and pursuit of incorrect policies and not because the market infrastructure (with respect to trading, clearing and settlement) is weak.

The Malaysian bond market comprises of securities issued by the government of Malaysia, quasi-government bonds issued by government affiliated agencies, Cagamas bonds issued by the national mortgage corporation, Cagamas Berhad and bonds issued by corporations known as private debt securities (PDS). The securities issued by the government of Malaysia include Malaysian Treasury Bills (MTBs) and Bank Negara Bills (BNBs) which are short-term government securities usually less than 1 year maturity. Longer-term securities, usually with maturity exceeding 1 year include Government Investment Issues (GIIs), Malaysia Saving Bonds and the more popular Malaysia Government Securities (MGS). These securities are marketable instruments issued by the Government of Malaysia to raise funds from the domestic capital market to finance the Government's development expenditure and working capital. In the 1970s and 1980s, the Government came to rely on the MGS as a source to finance its public sector deficits. The existence of a ready market, where most financial institutions had to invest a minimum proportion of their funds in the MGS, made this exercise rather easier. The unintended

[1]Bursa Malaysia is an exchange holding company approved under Section 15 of the Capital Markets and Services Act 2007. It operates a fully-integrated exchange, offering the complete range of exchange-related services including trading, clearing, settlement and depository services.

results, however, led to the development of a captive market and discouraged the growth of an active secondary market for these papers (BNM, 1979).

Prior to 1989, the secondary market for Malaysian Government Securities (MGS) is under-developed because of a captive demand for MGS (a shortage of MGS, an illiquid cash market and a lack of a futures market). Therefore, it is not possible to separate the problem of determining the risk-free rate from the problem of pricing credit risk. This has curbed activity in issuing and trading of private debt securities (PDS). As a benchmark for pricing fixed rate papers the government has to issue MGS papers periodically (even if it does not have to borrow) and to consolidate its existing MGS issues into fewer, larger issues. Unless this is done the captive demand for and shortage of MGS will continue to depress MGS yields. As an alternative, if Khazanah (the government investment corporation) becomes a regular issuer and its issue set the benchmark yield curve then the best way to utilise the issue proceeds is to build a portfolio of foreign assets. As a further alternative, Cagamas bonds (the national mortgage corporation) are near riskless papers to free up the Cagamas market, offers a solution to generate a proxy yield curve.

To develop an active and liquid secondary bond market, it is necessary to free yields, to reduce or eliminate reserve and liquidity costs, to reduce interest rate risk premium, to create an institutional framework for borrowing and lending securities as well as to remove existing restrictions on repo and reverse repo transactions. The incidence, from time to time, of high reserve and liquidity cost combined with the phenomena of depressed MGS yields has often made it unprofitable for dealers and traders to make a market or trade in bonds. Restrictions on the borrowing and shorting of securities as well as the lack of a futures market have made these activities highly risky i.e. it has made for a high risk premium.

The development of the MGS market over the years has seen several changes, particularly as from January 1989, a financial reform was introduced. This was necessary to encourage a more active secondary market, which prior to 1989 was hardly in existence. Coupon rates for MGS were predetermined by the government prior to 1989. Now, the pricing of these bonds are market driven where appointed principal dealers (PDs) are required to bid for a minimum of 10% of the primary issue size. The coupon rate is calculated by the weighted average yield of the successful bids of the auction. Other changes to reflect transparency in the Malaysian bond market include a pre- announced auction calendar for MGS issuance. This was introduced by BNM in March 2000. This is an improvement over the past practice of announcing MGS auction at very short notice, usually only one or two weeks in advance. In 1970, the MGS market size was only RM 3.48 billion. However the financial reform of 1989 reduced the liquid asset requirement from the 20% minimum to 17%, hence paving way for a more active secondary market. This reached a peak of RM 66.643 billion by 1992. As at December 2002, the total outstanding MGS stands at RM 109.55 billion.

Liberalisation has been implemented under BNM's new liquidity framework by reducing reserve costs via reducing reliance on statutory reserves as a tool for monetary policy or exempting financial institutions from holding reserves against their bond inventories and by improving the opportunities for hedging to reduce interest rate premium. The process is still unfolding and it is still too early to judge the extent of the liberalisation that is likely to materialise. A well-developed cash and futures market in bonds will enable investors to trade based on their views on interest rates, on the shape of the yield curve, on the spread between MGS and PDS yields and on the spread on yields between the cash and futures markets. Thus, these behaviours will boost trading volume and market liquidity. A well-developed bond market will also increase the supply of fixed income products whose short supply has been a contributory factor in EPF's under-investment in marketable securities and in constraining the development of the market in annuity products.

The recent Asian financial crisis was a major turning point for the MGS market and in general, the bond market. It showed the degree of risks and the level of vulnerabilities associated with borrowing from the traditional banking system. Maturity mismatches, borrowing short and lending long, as well as rapid contraction in loan supply during the crisis had resulted in shortage of liquidity in the financial markets. The contraction in credit, in particular, contributed to severe liquidity crunch in the private sector as businesses deleveraged and struggled to meet their financial obligations. As a result, the need for a bigger and deeper bond markets have became an important agenda for the policy makers in Malaysia as well as in the region.

Today, the size of the sovereign bond market has increased manifold, increasing to RM244.6 billion ringgit as at end 2009 (end-1998: RM75 billion). The sheer increase in the sovereign debt market, coupled with private securities, has positioned Malaysia as the third-largest bond market in Asia (ex-Japan) and one of the most advanced in Asia (BNM & SC, 2009). On top of that, the Government also welcomes foreign participation into the bond market, either to raise funds or for investment purposes. In terms of market advancements, the issuance of callable MGS, made in December 2006, has allowed the Government to better manage its cash flows. In addition, the issuance of Islamic instruments such as Government Investment Issues (GII) has also spearheaded the development of an Islamic sukuk market in Malaysia.

3. Theoretical Framework

There are at least three main explanations for the relationship between the slope of the yield curve and real economic growth that may also clarify why the yield curve might contain information about future recessions: 1) the expectations hypothesis of the term structure of interest rates states that long-term interest rates reflect the expected path of future short-term interest rates; 2) the relationship between the slope of the yield curve and real economic growth is related to the effects of monetary policy; and 3) the maximization of the intertemporal consumer choices (Harvey, 1988; Hu, 1993). In general, this relationship is positive and, essentially, reflects the expectations of financial market participants regarding future economic growth. A positive spread between long- and short-term interest rates (a steepening of the yield curve) is associated with an increase in real economic activity, while a negative spread (a flattening of the yield curve) is associated with a decline in real activity.

3.1 The yield curve and future changes in output

Although several studies have found the term spread to contain information with respect to future economic activity, the theoretical basis for this relationship has remained unclear (Plosser and Rouwenhorst, 1994; Dotsey, 1998). Thus, Estrella and Hardouvelis (1991), while documenting the predictive ability of the term spread, also cautioned that the relationship could easily wane.

The slope of the yield curve may be influenced by factors such as expected real interest rates, current and expected inflation, and risk or term premiums. A starting point for the link between the term spread and real economic activity could therefore be the theoretical relationship between real interest rates and macroeconomic activity, for example, through consumption and investment (see Taylor, 1999, for a survey). One can use a simple optimizing model of consumption to derive a theoretical model of the link between future consumption and the real term structure as follows. Consider a representative agent whose real consumption in period t is C_t whose instantaneous utility function is $U(.)$, and whose subjective rate of time preference is ρ. If the j-period real interest rate is $i_t^{(j)}$, then, making the usual assumptions such as additive separability of preferences, we can derive from the first-order conditions for the agent's optimal consumption plan Euler equations of the form:

$$U'(C_t) = (1 + i_t^{(1)})(1+\rho)^{-1} E_t U'(C_{t+1}) \tag{1}$$

$$U'(C_t) = (1 + i_t^{21)})(1+\rho)^{-2} E_t U'(C_{t+2}) \tag{2}$$

where $U'(.)$ denotes the first derivative of the utility function and hence marginal utility, and E_t denotes the mathematical expectation operator conditional on information at time t. The intuition is standard: if the agent is optimizing, then it is impossible to improve the plan by, say, reducing consumption slightly today at a cost of $-U'(C_t)$, investing for j periods at the real interest rate $i_t^{(j)}$ and increasing consumption in period j, yielding an expected gain, in period-t present-value terms, of $(1 + i_t^{(j)})(1+\rho)^{-j} E_t U'(C_{t+j})$ the cost just offsets the expected gain. From Eq. (1) and Eq. (2) we can, however, derive a close approximation:

$$(i_t^{(2)} - i_t^{(1)}) = (1+\rho)\left[\frac{E_t U'(C_{t+1})}{E_t U'(C_{t+2})}\right] - 1 \tag{3}$$

Eq. (3) thus describes a very simple possibility for how movements in the *real* yield curve may affect future economic activity. An increase in the slope of the real term structure will induce optimizing agents to take advantage of the better yield available at longer maturities by reducing consumption in the short-term and increasing consumption in the long-term. With diminishing marginal utility, a rise in $(i_t^{(2)} - i_t^{(1)})$ requires a reduction in C_{t+1} and an increase in C_{t+2}. As movements in the nominal term spread move with the real term spread, increased consumption demand raises economic activity. Under this framework, the prediction that rises in the nominal term spread will indeed be associated with increases in future economic activity.

Note, however, that this analysis is based on a consideration of Euler equations rather than proper reduced forms: these are conditions that must hold *at the margin*, rather than being reduced-form equations. Moreover, the issue becomes complicated when the move is made from considering the behavior of the representative agent to considering the behavior of the economy in aggregate. In fact, the implication of a large empirical literature on consumption is that the statistical link between real interest rates and aggregate consumption is extremely tenuous (Deaton, 1992; Taylor, 1999), suggesting that it is unlikely that the nominal term spread, by acting as a proxy

3.2 The yield curve and changes in inflation.

Mishkin (1990 and 1991) provides a theoretical exposition on the relationship between term spreads and inflation via the Fisher equation as follow

$$E_t \pi_t^m = i_t^m - r_t^m \tag{4}$$

where E_t denotes the expectation at time t, π_t^m the inflation rate between time t and m, i_t^m the nominal period interest rate and r_t^m the real period interest rate.

The observed rate of inflation π_t^m equals the expected rate plus a forecast error:

$$\pi_t^m = E_t \pi_t^m + \varepsilon_t^m \tag{5}$$

Substituting Eq.(5) into Eq.(4) yields:

$$\pi_t^m = m_{tt}^m - r_t^m + \varepsilon_t^m \tag{6}$$

To obtain a relationship between the slope of the yield curve and the change in the inflation rate the n-period inflation rate is subtracted from Eq.(6) yielding:

$$\pi_t^m - \pi_t^n = (i_t^m - i_t^n) + (r_t^m - r_t^n) + (\varepsilon_t^m - \varepsilon_t^n) \tag{7}$$

Mishkin (1990) assumes that the slope of the real yield curve is constant through time so that $r_t^m - r_t^n$ is a constant. Given the additional assumption of rational expectations, the forecast errors cannot be forecasted given information at time *t.* The dual assumptions of a constant real term structure and rational expectations underpin the following equation which forms the basis of Mishkin's tests:

$$\pi_t^m - \pi_t^n = \alpha + \beta(i_t^m - i_t^n) + \mu_t^{m,n} \tag{8}$$

If prices are fully flexible and instantaneously adjust to changes in monetary policy, the assumption of a constant real rate spread is appropriate and β should equal one. As Frankel and Lown (1991) argue, the assumption of a constant slope to the real yield curve is overly restrictive. Indeed, due to the existence of sticky prices, long term interest rates are more likely to accurately reflect inflationary expectations than short term rates. They argue that in an inflation change equation such as Eq.(4) the slope of the entire yield curve is likely to outperform the spread between securities matching the period for which the change in inflation is being forecast.

4. Data and Model Selection

To determine the predictive content of the term spread on Malaysia's inflation and output, we analyse the predictive power of the spread between long-term Malaysia Government Securities (MGS) yields and short-term Malaysia Treasury Bills (MTBs). In this exercise, the industrial product index (IPI) is used as a proxy of output, while inflation is measured by the annual growth in the Consumer Price Index (CPI). Specifically, the annual growth rates for both variables are computed in the following manner:

$$P_t = 1{,}200 * \ln\left(\frac{CPI_t}{CPI_{t-12}}\right)$$

$$IP_t = 1{,}200 * \ln\left(\frac{IP_t}{IP_{t-12}}\right) \quad (9)$$

where, the factor 1,200 standardized the units to annual percentage growth rates. Meanwhile, the proxies for the term spreads are derived in the following manner

$$spread_t = iMGS_t - jMtbill_t \quad (10)$$

where, i =1-year, 3-year, 5-year and 10-year MGS and j=3-month and 6-month MTBs. For completeness, we also extend the analysis to include the difference between the longer dated MGS against the 1-year MGS. The sample data runs from February 1992 to December 2009. Table 1 defines the data use in our analysis and Table 2 provides a summary of the stylized facts for our variables of interest. With regard to bond yields, most data suggest a relatively low level of volatility, although they exhibit some degree of positive skewness. Since the Kurtosis values are below three, this suggests to us the presence of a flat tail or a playkurtic distribution. Meanwhile, both the CPI and IPI exhibit higher volatility relative to the bond yields. Nevertheless, the levels of skewness and kurtosis are somewhat similar to those found in the bond yields.

[Table 1 & Table 2]

For the predictive content of the term spread, we follow the approach suggested by Stock and Watson (2003) and Mehl (2006) that control for past values of the dependent variable. Following a general-to-specific approach, all explanatory variables were initially tested with 12-lags. The linear regression model is the following form:

$$Y_{t+1} = \beta_0 + \beta_1 X_{t-k} + \sum_{i=0}^{p} \alpha_i Y_{t-i} + u_{t+1}, \qquad K = 0, \ldots, T \quad (11)$$

where β_0, β_1 and α_i are unknown parameters, u_{t+1} is the error term and the maximum lags are of the order *p* and *k* respectively. If β_1 is not equal to 0, the slope of the yield curve could be used to predict both output and inflation over a certain forecast horizon.

As noted in Stock and Watson (2003), there is the potential for the error term to be serially correlated given overlapping data. Hence, the test of predictive content was computed using the Heteroscedasticity-Consistent Standard Errors (HAC) to take into account for possible autocorrelation and heteroscdasticity in the time series. The LM test was implemented to check for possible serial correlation in the error term. In addition, two dummy variables are also included in the test, representing the ringgit peg and the Asian financial crisis.

Two unit root tests (augmented Dickey-Fuller and Philip-Perron) were performed on both dependent variables and they were determined to be of I(1) in nature (see Table 3). Subsequently, the regression analyses were conducted on the first difference term of the dependent variable. All term spread series are treated as I(0) in accordance with literature (Estrella, 2005b).

[Table 3]

The final model selection is based on the following criteria. A part from having the correct sign and a significant relationship with the dependent variable, the author decides to choose those models which carry a single term spread coefficient. Finally, the forecasting powers of these models are tested by simulating an in-sample forecast and comparing their results against a simple autoregressive (AR) model for both output and inflation. In addition, various cross-correlation and Granger causality tests were conducted. Residual tests and stability tests were executed to confirm the viability of each candidate model. Tables 4 reports the results of the Granger causality test between the term spread, output and inflation. In line with economic theory and similar studies, one could observe that the term spread does Granger cause output especially in the short-run. On the contrary to expectation, all term spread candidates do not Granger cause inflation. This reflects the findings of various studies that suggest there is no significant relationship between term spread and inflation once lag inflation is considered. Finally, the term spread coefficient for the long- and short-end of the MGS spectrum does not Granger cause both output and inflation.

[Table 4]

Finally, we use cross correlation analysis to determine our model selection. A few interesting results were obtained from Table 5 to Table 7 of the cross correlation analysis. First, most term spread variables tend to lead inflation to a varying degree, from as low as two months to up to 19 months. Only one result remains inconclusive. A similar analysis was also conducted on output and term spread. In general, evidences seem to suggest a somewhat mixed picture with some of the term spread variables lagging output by a certain degree. Albeit the above results are somewhat mixed, they all point to the potential for the term spread to hold vital information regarding future economic activity and expectations about future monetary policy. As Plosser and Rouwenhorst (1994) note, the slope of the term structure of interest rates is believed to be influenced by a combination of factors, namely the path of expected inflation, expected real interest rates and risk premiums. Further analysis of the term structure, in particular the term spreads, could unlock additional information beyond the existing information about future movement in inflation and output.

[Table 5 to Table 7]

Next step, we use our model to forecast output growth. Controlling for past values of Y_t, we employ the following forecasting structure on the identified term spread models:

$$Y_{t+h}^{h} = \beta_0 + \beta_1(L)X_t + \beta_2(L)Y_t + u_{t+h}^{h} \quad (12)$$

where X_t represents the term spread and Y_t is the dependent variable of interest.

Our second approach tests whether the term spread helps predict the direction of future output growth, In this line of research, Estrella and Hardouvelis (1991) and Estrella and Mishkin

(1997) extend the analysis on the predictive power of the term spread by looking at its potential to predict an economic recession some four quarters ahead[2]. In both cases, a probit model was employed in order to determine the relative probability of an economic recession given certain levels of the term spread. We employ their strategy, with some minor modifications, by defining a non-linear model that relates the probability of an economic recession to the term spread 12-month down the road.

The probit can be described following Yusoff and Zulkhibri (2000) and Gujarati (1995) approaches, Let P_i be the cumulative normal distribution for the i-th observation, where

$$P_i = \Pr(Y = 1) = F(x_i\beta) = \frac{1}{2\pi}^{\frac{1}{2}} \int_{-\infty}^{t} e^{\frac{-t^2}{2}} dt \tag{13}$$

where $s = x_i\beta$. The probit model is then written in the following form

$$\begin{aligned} y_i &= F^{-1}(P_i) + \varepsilon_i \\ &= x_i + \varepsilon_i \end{aligned} \tag{14}$$

where $F^{-1}(P_i) = x_i + \varepsilon_i$ is the inverse of the cumulative distribution function of $F(x,\beta)$. The dependent variable y_i carries the value of 0 and 1, the latter marks the period where a deceleration in economic activity has occurred. The dating of such an event is in accordance with the steps taken by the Malaysian Department of Statistics[3]. Furthermore, as the probit model is a non-linear model, one is unable to interpret the coefficients in the usual manner. Instead, we report the marginal effect of each explanatory variable on the dependent variable, which reflects the effect of a one percent change in the regressor on the probability of a slowdown occurring. Specifically, we estimate the following model

$$\Pr[X_t = 1 \mid Spread_{t-12}] = F(\alpha + \beta\, Spread_{t-12}) \tag{15}$$

[2] Recently, Chauvet and Potter (2005) provide an in-depth and technical discussion on using the Probit model to forecast economic recession.

[3] Unlike in the U.S. where the National Bureau of Economic Research (NBER) is responsible for dating the timing of economic recession and recovery, no such agency carries that responsibility in Malaysia. As such, the dating of economic recession and recovery is done indirectly. See "Malaysia Economic Indicators: Leading, Coincident and Lagging Indices", Department of Statistics Malaysia, Putrajaya, March 2010, pp. 3. Among the early signs of a slowdown in economic activity is the sustained decline in the leading index growth rate.

where $\Pr$ denotes probability, F is the cumulative normal distribution and X_t equals 1 for periods of economic slowdown and 0 otherwise. We regress the above dependent variable against three term spread coefficients (vs. 3-month MTB), namely the 3-year MGS, 5-year MGS and 10-year MGS[4].

5. Estimation Results

As indicated earlier, we use monthly term spread, indicator of real economic activity and prices in order to determine the relative relationship between these variables. The final end game is to find several stable and robust relationships, which could then be further evaluated for their forecasting capability. In all, we test each of the 11 term spread candidates on output and inflation, imposing a lag length of 12. In addition, past values of the dependent variables were also added to the analysis to address possible issues of persistence. Two dummy variables were added in the analysis in order to mark the start and end of the Asian financial crisis in 1997-98 and the ringgit peg. A general-to-specific approach was adopted, whereby insignificant explanatory variables were dropped and the equation was re-estimated. This was done until a significant relationship was established and all other diagnostic tests were satisfied. Finally, the best models with the correct signs were chosen. Tables 8 to 10 capture the predictive power of the term spread for output and inflation. In all, only eight significant relationships were detected, of which three were chosen. These candidates have the correct signs, apart from passing the diagnostic tests.

[Table 8 to Table 10]

Specifically, the regression analysis between the term spread (3-year MGS vs. 3-month MTBs) and IPI yields a negative relationship, with a one percentage increase in the term spread resulting in a decline of 25.61% in the growth rate of the latter. The adjusted goodness of fit stands at 86% and the overall standard error of regression stands at 37.45. For comparison, a simple AR model of output was put to the mill, where the overall goodness-of –fit stands at 78%.

[4] A similar analysis for the 1-year MGS was also conducted but not reported here. Results are available from the author upon request.

The dummy variables are both insignificant when regress against output and hence, were dropped from the regression. The Andrew-Quandt of Unknown Breakpoint Test was employed to determine possible breakpoints in the relationship, especially during the Asian financial crisis, but none were found. Clearly, the inclusion of a term spread has improved the overall fit of the model and supports the intuition that the term structure of interest rates may yield relevant information about future output. Another interesting point is the fact that the significant relationship occurs at the very short-end of the interest rate spectrum (3-year MGS vs. 3-MTBs), a period where monetary policy may have some influence on it. This result alludes to the potential for the current monetary stance to influence future output, albeit in the short-run.

Meanwhile, the regression analyses between the term spread and inflation indicate that the difference between a 3-year MGS and a 3-month MTBs and a 5-year MGS and a 3-month MTBs may hold pertinent clues about future inflation. In the latter, ceteris paribus, a 1% increase in the nominal term spread may result in an increase of 2.08% in inflation, with an adjusted R-squared of 93%. In contrast, a simple AR inflation model with two lags carries an adjusted R-squared of 89%. Furthermore, the presence of dummy variables has also helped to improve the overall fit of these models. Overall, these results are in line with our earlier discussion on the Fisher's equation.

The next step of the study is to conduct an in-sample forecast for output and inflation, utilizing our results from the previous subsection. The sample period runs from February 1992 to December 2008, after which the in-sample forecasting period begins. Results for the dynamic forecast for output and evaluation are presented in Chart 1 and Table 11 respectively[5]. In general, the descriptive statistics in Table 19 reveals that the simple AR model of real economic activity outperforms the (3,3) term spread model in all areas of the forecast evaluation. The inferior results could be due to the fact that the term spread is best suited to help explain past developments in output. In other words, it may better reflect the effect of past monetary policy decisions on current output.

[5] The 95% confidence intervals are mark as dotted lines.

[Table 11, Chart 1]

For forecasting inflation, there are two term spread models for consideration namely the (3,3) model and the (5,3) model. Results are display in Charts 2 and Chart 3, while Table 12 holds the descriptive statistics.

[Table 12, Chart 2 and 3]

The results are quite surprising, to say the least. Contrary to the forecast results on output, the predictive performance of the term spread models on inflation is somewhat better to the simple AR model. On the other hand, Charts 2 and 3 indicate to us that the model seems to under predict the actual outturn for inflation during the recent period. For completeness, we combine the two term spread models and re-run the whole forecasting exercise in order to determine its superiority. Clearly from Table 12 combining both term spread variables yield a better result when compare to the simple AR model. Its performance, however, is somewhat inferior to the individual term spread model. Notwithstanding, the pictorial descriptions, these results suggest for the potential usage of the term spread to predict future changes in inflation.

As mentioned earlier, another approach to testing the predictive powers of the term spread is via a probit model assessment. Chart 4 provides a visual representation of the predictive power of the yield curve. Further results are presented in Table 13. There are few interesting patterns that could be observed. First, the estimated probability of an economic slowdown had actually peaked just before the start of the slowdown period. The time interval between the peak and the start of the slowdown ranges from as a low as 6 months to a maximum of 18 months. This could be seen for the periods running from September 2000 to February 2002, and January 1997 to January 1999. Second, in most cases, at the onset of the slowdown its probability declined sharply after the peak before picking up later. Two deceleration periods are worth pointing namely September 2000 to February 2002, and April 2004 to November 2005. And finally, unlike the previous two slowdown periods, the probability of slower economic activity (January 2008 to March 2009) was, to some extent, smaller in size.

[Table 13, Chart 4]

6. Conclusion

The term spread has been proved to be a useful indicator and predictor of output and to a lesser extent, inflation. This is especially true for a developed market economy where historical data are abundant. In emerging market economies, however, similar studies are scarce. This research is an attempt to bridge that gap, especially for Malaysia. It begins by asking three basic research questions namely on the relationship between the term spread and output/ inflation, potential additional information beyond what is already imbedded in the lagged values of both inflation and output and the predictive power of the term spread to forecast future changes in both output and inflation.

In general, our results suggest that there exist significant relationships between the term spread, output and inflation. The short-end of the interest rate spectrum holds additional information beyond what is not captured by the lagged values of inflation and output. The term spread could be used to forecast both inflation and output although their performances are somewhat mixed. Perhaps this could be attributed to the shorter sample period, as well as, smaller market size, relative to what is available in more matured economies such as the U.S. and Japan, The results also pointed to the fact that the there is some information about future inflation and output beyond the short-term horizon indicates to us that the long-end of the yield curve is simply reflecting market expectations about future monetary policy. In the term predicting the economic slowdown, the results from the probit model suggest that the term spread has contribute significantly in the probability of future economic slowdown. This would significantly aid policy analysis and forecast for the monetary authority as it flags out the risk of an impending recession.

From the policy point of views, the results from our analysis suggest that there is a significant potential for incorporating more technical and model based approaches using the yield curve beyond the usual indicator analysis. In this respect, models that depict the above relationships could be used in tandem with other monetary and financial indicators in order to bring support and depth to future discussion on monetary policy. Second, it could provide some insights into the future, especially on the behaviour of output and inflation. This could provide valuable lead time to policymakers as they could design specific policies to pre-empt an economic slowdown or a sharp increase in headline inflation. Finally, an efficient bond market could also play an important role in propagating monetary impulses via the relevant monetary transmission channels. In extreme economic conditions, the bond market could also play a vital role in resuscitating the credit market as evident from the recent global financial crisis.

The above considerations suggest to us for the need to undertake further initiatives to deepen the domestic bond market. This would greatly enhance better price discovery among market participants, improve risk management away from the traditional source for funds namely the banking system and address supply related issues. One such initiative was the introduction of the Institutional Securities Custodian Programme (ISCAP) in 2005 by the Central Bank of Malaysia as a measure to address these issues. And lastly, the presence of large inflow of foreign capital should be encouraged as they provide avenues for better pricing of bonds and efficient dissemination of information among market players. To this end, Government policies that could boost the attractiveness of the local bond market to international investors should be further expanded and introduced.

Notwithstanding these limitations, the usefulness of the yield curve in providing additional information to policymakers beyond what is available in standard monetary and financial indicators should not be underestimated. As research in this paper has shown, there are valuable insights that could be gained from analysing movements in the bond yields. For future research, one may want to extend the analysis of the probit model beyond the current set up. And finally, the emergence of Islamic sukuk (bond equivalent) as an asset class could open up new research opportunities in the future. A relevant question to research is whether these new financial assets also hold vital forward looking information about the economy in a way similar to their conventional cousins and if otherwise, why is it the case.

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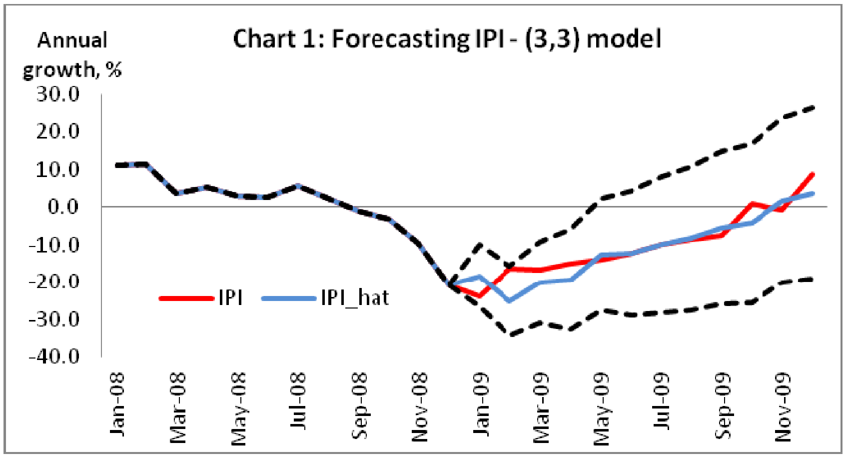
Chart 1: Forecasting IPI - (3,3) model
Annual growth, %
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
IPI
IPI_hat
Jan-08
Mar-08
May-08
Jul-08
Sep-08
Nov-08
Jan-09
Mar-09
May-09
Jul-09
Sep-09
Nov-09

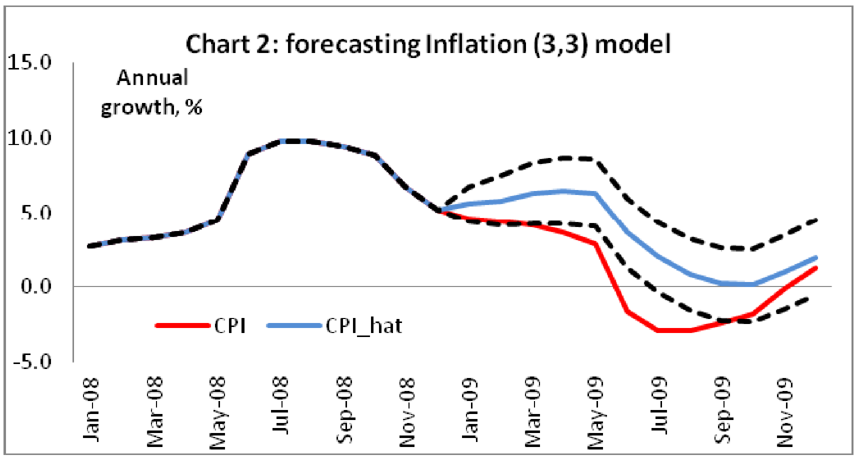
Chart 2: forecasting Inflation (3,3) model
Annual growth, %
15.0
10.0
5.0
0.0
-5.0
CPI
CPI_hat
Jan-08
Mar-08
May-08
Jul-08
Sep-08
Nov-08
Jan-09
Mar-09
May-09
Jul-09
Sep-09
Nov-09

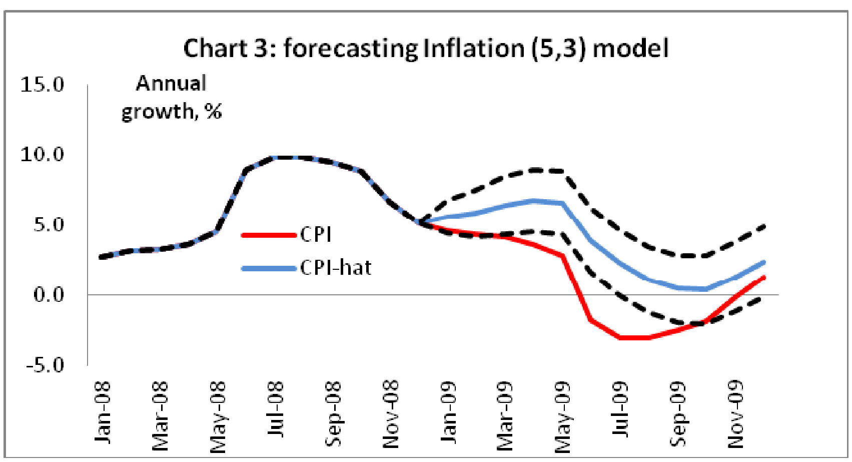
Chart 3: forecasting Inflation (5,3) model
Annual growth, %
15.0
10.0
5.0
0.0
-5.0
CPI
CPI-hat
Jan-08
Mar-08
May-08
Jul-08
Sep-08
Nov-08
Jan-09
Mar-09
May-09
Jul-09
Sep-09
Nov-09

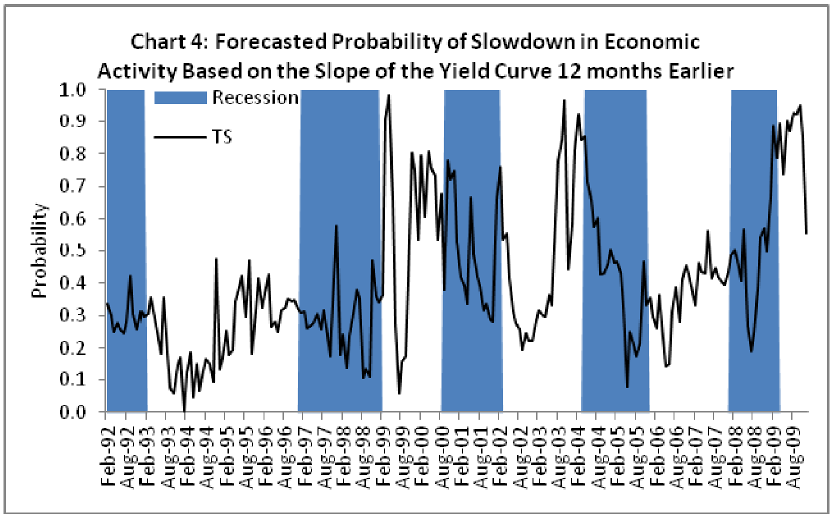
Chart 4: Forecasted Probability of Slowdown in Economic Activity Based on the Slope of the Yield Curve 12 months Earlier
Recession
TS
Probability
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Feb-92
Aug-92
Feb-93
Aug-93
Feb-94
Aug-94
Feb-95
Aug-95
Feb-96
Aug-96
Feb-97
Aug-97
Feb-98
Aug-98
Feb-99
Aug-99
Feb-00
Aug-00
Feb-01
Aug-01
Feb-02
Aug-02
Feb-03
Aug-03
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Aug-08
Feb-09
Aug-09

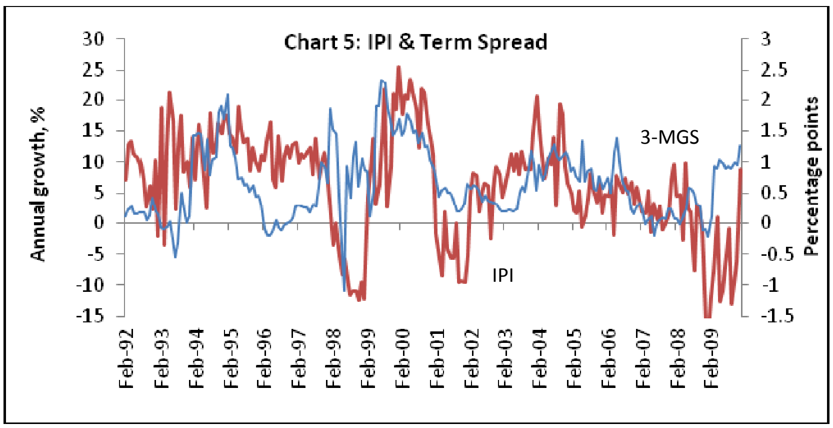
Chart 5: IPI & Term Spread
Annual growth, %
Percentage points
3-MGS
IPI
30
25
20
15
10
5
0
-5
-10
-15
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
Feb-92
Feb-93
Feb-94
Feb-95
Feb-96
Feb-97
Feb-98
Feb-99
Feb-00
Feb-01
Feb-02
Feb-03
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Feb-05
Feb-06
Feb-07
Feb-08
Feb-09

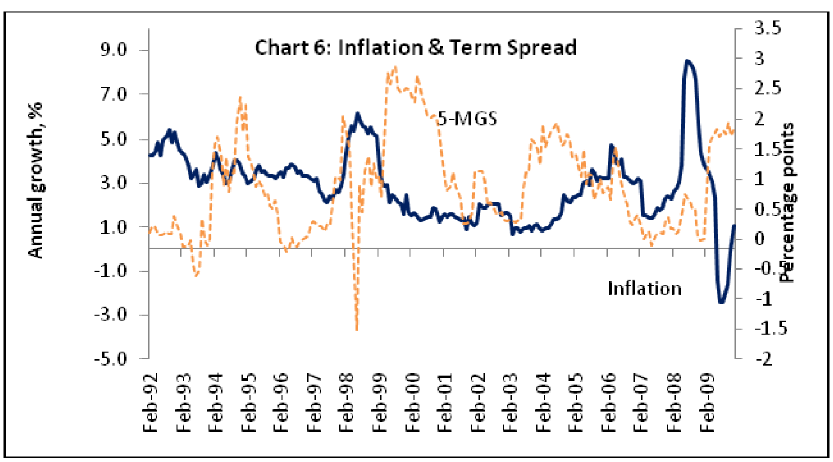
Chart 6: Inflation & Term Spread
Annual growth, %
Percentage points
5-MGS
Inflation
9.0
7.0
5.0
3.0
1.0
-1.0
-3.0
-5.0
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
Feb-92
Feb-93
Feb-94
Feb-95
Feb-96
Feb-97
Feb-98
Feb-99
Feb-00
Feb-01
Feb-02
Feb-03
Feb-04
Feb-05
Feb-06
Feb-07
Feb-08
Feb-09

Table 1. Variables Used in the Estimation

Dependent variables	Short-term Malaysian Treasury Bill (MTB)	Malaysian Government Securities (MGS)	Start date – end date
Inflation (CPI, annual growth), Output (IPI, annual growth)	3-month, 6-month	1-year 3-year 5-year 10-year	February 1992 – December 2009 (monthly)

Table 2. Summary of Descriptive Statistics

	CPI Index	PPI Index	3-month MTB	6-month MTB	1-yr MGS	3-yr MGS	5-yr MGS	10-yr MGS
Mean	91.5	181.6	4.1	4.1	4.5	4.8	5.0	5.5
Median	92.8	180.7	3.4	3.4	3.5	4.2	4.5	5.1
Max.	114.9	279.2	10.0	9.7	10.1	9.0	9.0	8.2
Min.	69.5	79.9	1.8	1.7	1.8	2.5	2.8	3.1
Std. Dev.	12.2	54.3	1.8	1.9	1.9	1.7	1.6	1.4
Skewness	0.1	-0.1	0.8	0.8	0.7	0.6	0.5	0.3
Kurtosis	-0.9	-1.2	-0.6	-0.6	-0.7	-1.0	-1.0	-1.2

Table 3 : Unit Root Test: ADF and PP

	Augmented Dickey-Fuller (ADF)		Philips-Perron (PP)	
	Constant	Constant & linear trend	Constant	Constant & linear trend
		Level		
IPI	-1.29	-3.46**	-1.48	-5.52***
CPI	-0.38	-2.68	-0.17	-2.68
		1st difference		
IPI	-3.53***	-3.61***	-2.7.07***	-27.14***
CPI	-10.32***	-10.29***	-10.28***	-10.24***

Note: all term spread variables are assumed to be stationary, *** and ** denote 1% and 5% significance level respectively

Table 4: Granger-causality Test: Term Spread for 3-month MTB, 6-month MTB and 1-year MGS

	3-month MTB		*6-month MTB*		*1-year MGS*	
	Output	Inflation	Output	Inflation	Output	Inflation
1 MGS	1.61**	1.16	2.02***	0.94	1.09	0.65
3 MGS	1.42*	0.80	1.46*	0.86	1.12	0.65
5 MGS	1.46*	0.74	1.35	0.86	1.00	0.70
10 MGS	1.13	0.79	1.15	0.93	1.09	0.65

Note: Sample from Feb1992-Dec 2009. Reported results are F-statistics, with a lag length of 36. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively. Results are based on the hypothesis that H_0: the term spread does not Granger Cause the dependent variable. For brevity, results from the reverse Granger Causality tests are not reported but are available from the author.

Table 5. Cross Correlation Analysis: Term Spread (3-month MTB), Inflation and Output

						Inflation						
Lag	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
1-yr MGS	0.329	0.329	0.316	0.295	0.265	0.233	0.226	0.208	0.182	0.158	0.100	0.053
3-yr MGS	-0.082	-0.085	-0.092	-0.102	-0.113	-0.127	-0.129	-0.135	-0.142	-0.144	-0.176	-0193
5-yr MGS	-0.226	-0.227	-0.237	-0.237	-0.246	-0.246	-0.246	-0.249	-0.249	-0.252	-0.274	-0.282
10-yr MGS	-0.306	-0.310	-0.316	-0.332	-0.344	-0.353	-0.352	-0.348	-0.347	-0.352	-0.363	-0.371
Lead	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
1-yr MGS	0.253	0.199	0.168	0.137	0.106	0.174	0.020	0.192	0.204	0.225	0.245	0.232
3-yr MGS	-0.105	-0.129	-0.126	-0.112	0.266	-0.013	0.033	0.058	0.088	0.119	0.147	0.151
5-yr MGS	-0.241	-0.254	-0.244	-0.221	0.257	-0.126	-0.074	-0.039	-0.002	0.035	0.068	0.084
10-yr MGS	-0.325	-0.325	-0.335	-0.310	0.262	-0.211	-0.161	-0.129	-0.096	-0.059	-0.031	-0.011
						Output						
Lag	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
1-yr MGS	0.259	0.235	0.186	0.152	0.106	0.102	0.061	0.026	0.226	0.024	0.062	0.068
3-yr MGS	0.301	0.294	0.279	0.284	0.266	0.266	0.229	0.174	-0.048	0.099	0.088	0.073
5-yr MGS	0.275	0.272	0.265	0.273	0.256	0.238	0.214	0.164	-0.127	0.079	0.052	0.028
10-yr MGS	0.286	0.284	0.277	0.279	0.262	0.253	0.228	0.183	0.148	0.112	0.081	0.065
Lead	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
1-yr MGS	0.284	0.292	0.327	0.338	0.324	0.263	0.280	0.264	0.226	0.156	0.175	0.108
3-yr MGS	0.239	0.205	0.187	0.146	0.098	0.026	0.007	-0.014	-0.048	-0.087	-0.105	-0.129
5-yr MGS	0.203	0.158	0.127	0.081	0.033	-0.027	-0.051	-0.076	-0.102	-0.134	-0.156	-0167
10-yr MGS	0.221	0.182	0.144	0.099	0.051	-0.013	-0.045	-0.076	-0.111	-0.154	-0.179	-0.193

Note: yellow shade indicates negative correlation

Table 6. Cross Correlation Analysis: Term Spread (6-month MTB), Inflation and Output

						Inflation						
Lag	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
1-yr MGS	0.224	0.249	0.247	0.241	0.218	0.196	0.206	0.197	0.151	0.113	0.039	-0.029
3-yr MGS	-0.155	-0.148	-0.151	-0.145	-0.135	-0.125	-0.097	-0.094	-0.103	-0.103	-0.148	-0.186
5-yr MGS	-0.313	-0.307	-0.305	-0.294	-0.274	-0.215	-0.215	-0.189	-0.192	-0.192	-0.219	-0.242
10-yr MGS	-0.357	-0.358	-0.358	-0.362	-0.349	-0.327	-0.295	-0.267	-0.274	-0.275	-0.298	-0.322
Lead	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
1-yr MGS	0.224	0.151	0.111	0.048	0.026	0.035	0.028	0.029	0.032	0.032	0.044	0.020
3-yr MGS	-0.155	-0.176	-0.171	-0.160	-0.110	-0.042	0.013	0.091	0.110	0.110	0.131	0.125
5-yr MGS	-0.313	-0.311	-0.277	-0.239	-0.170	-0.091	-0.021	0.078	0.101	0.101	0.132	0.139
10-yr MGS	-0.357	-0.358	-0.336	-0.300	-0.237	-0.165	-0.098	-0.014	0.015	0.015	0.038	0.046
						Output						
Lag	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
1-yr MGS	0.117	0.101	0.103	0.043	0.044	0.059	0.011	0.001	0.058	0.064	0.076	0.118
3-yr MGS	0.228	0.225	0.237	0.225	0.232	0.232	0.200	0.200	0.158	0.125	0.100	0.101
5-yr MGS	0.222	0.221	0.234	0.229	0.231	0.231	0.192	0.192	0.137	0.098	0.061	0.054
10-yr MGS	0.242	0.241	0.251	0.242	0.240	0.241	0.209	0.209	0.155	0.125	0.087	0.084
Lead	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
1-yr MGS	0.126	0.151	0.162	0.184	0.167	0.135	0.174	0.174	0.117	0.117	0.163	0.015
3-yr MGS	0.159	0.136	0.105	0.073	0.022	-0.035	-0.039	-0.039	-0.102	-0.100	-0.101	-0.178
5-yr MGS	0.144	0.107	0.068	0.028	0.022	-0.072	-0.083	-0.083	-0.140	-0.143	-0.152	-0.202
10-yr MGS	0.172	0.140	0.096	0.056	0.006	-0.049	-0.071	-0.071	-0.140	-0.161	-0.175	-0.219

Note: yellow shade indicates negative correlation

Table 7. Cross Correlation Analysis: Term Spread (1-yr-MGS), Inflation and Output

						Inflation						
Lag	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
3-yr MGS	-0.371	-0.374	-0.375	-0.363	-0.334	-0.304	-0.278	-0.255	-0.233	-0.214	-0.214	-0.208
5-yr MGS	-0.452	-0.453	-0.449	-0.434	-0.401	-0.363	-0.332	-0.303	-0.278	-0.262	-0.256	-0.247
10-yr MGS	-0.458	-0.462	-0.461	-0.463	-0.442	-0.411	-0.381	-0.352	-0.332	-0.326	-0.322	-0.322
Lead	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
3-yr MGS	-0.347	-0.333	-0.295	-0.236	-0.156	-0.079	-0.004	0.053	0.091	0.112	0.128	0.139
5-yr MGS	-0.425	-0.401	-0.352	-0.281	-0.196	-0.116	-0.036	0.028	0.070	0.099	0.121	0.141
10-yr MGS	-0.439	-0.421	-0.389	-0.328	-0.255	-0.183	-0.112	-0.058	-0.025	0.004	0.024	0.040
						Output						
Lag	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
3-yr MGS	0.193	0.201	0.217	0.246	0.254	0.242	0.239	0.195	0.154	0.106	0.065	0.043
5-yr MGS	0.182	0.189	0.203	0.227	0.229	0.211	0.203	0.164	0.119	0.075	0.028	0.001
10-yr MGS	0.201	0.212	0.212	0.235	0.232	0.224	0.218	0.178	0.138	0.106	0.062	0.043
Lead	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
3-yr MGS	0.101	0.052	0.007	-0.049	-0.100	-0.147	-0.181	-0.197	-0.213	-0.214	-0.246	-0.232
5-yr MGS	0.094	0.043	0.004	-0.058	-0.104	-0.143	-0.175	-0.196	-0.201	-0.211	-0.243	-0.226
10-yr MGS	0.131	0.089	0.039	-0.009	-0.055	-0.101	-0.137	-0.165	-0.187	-0.209	-0.241	-0.233

Note: yellow shade indicates negative correlation

Table 8. Regression Estimates: 3-month Malaysian Treasury Bill for Output and Inflation

Lags	1,3	3,3	5,3	10,3	1,3	3,3	5,3	10,3
1	9.28	13.02	12.13	7.89	1.02	-0.63	0.07	0.39
2	17.84	10.37	6.99	-4.48	2.69	2.26**	2.08**	0.62
3	-0.91	-1.60	0.36	-0.30	0.99	-0.33	-1.10	0.82
4	-19.96	2.77	6.00	9.30	0.48	-0.31	-0.37	-0.84
5	-5.13	2.49	-5.39	-26.57	1.21	1.04	0.77	-0.12
6	11.68	2.48	0.08	24.56	0.32	0.63	0.34	-0.45
7	-2.07	14.56	15.70	8.75	1.42	0.64	0.33	0.57
8	-9.84	-12.75	-17.41	-41.40	2.76	1.30	1.11	1.06
9	18.28	13.83	14.58	51.07	1.13	-0.93	-0.73	-1.23
10	-32.09	-25.61***	-17.06	7.83**	1.94	1.17	0.57	-0.50
11	11.07	-7.11	-9.87	15.23	0.15	-0.86	-1.37	-0.40
12	33.93	7.69	4.93	5.76	-0.42	-0.35	-0.05	-1.17
Adjusted R^2	0.86	0.86	0.86	0.86	0.93	0.93	0.93	0.93
Standard error	37.45	37.75	37.84	37.68	5.20	5.13	5.14	5.23

Notes: ** indicates significance at the 5% level, *** indicates significance at the 1% level, estimates for lag values of the dependent variable are not reported for brevity but available upon request.

Table 9. Regression Estimates: 6-month Malaysian Treasury Bill for Output and Inflation

Lags	1,6	3,6	5,6	10,6	1,6	3,6	5,6	10,6
1	13.78	9.04	11.91**	6.14	-0.48	-0.88	-0.60	-0.18
2	0.90	5.94	5.12	1.43	0.83	0.44	0.37	0.47
3	6.36	6.20	6.59	7.80	1.09	0.12	-0.27	0.29
4	-12.66	-9.21	-8.19	-11.10	2.33	1.15	0.89	0.17
5	-1.20	4.19	2.99	-2.90	1.53	0.56	0.21	-0.65
6	-3.73	11.54	9.67	14.40	1.60	0.57	0.28	-0.14
7	-7.78	-5.68	-6.61	-6.98	2.44	1.14	0.84	0.48
8	-7.90	-4.67	-7.49	-9.55	2.98	1.44	1.13	0.56
9	16.80**	13.76	13.56	14.84	1.85	0.25	0.08	-0.72
10	2.89	-7.67	-8.25	-5.69	1.05	0.43	0.24	-0.23
11	4.51	-9.48	-12.04**	-12.46	1.06	-1.11	-1.27	-0.89
12	13.79	8.26**	10.66**	18.01	-1.91	1.67	-1.52	-1.16***
Adjusted R^2	0.85	0.86	0.87	0.86	0.93	0.93	0.93	0.93
Standard error	38.82	37.86	37.21	37.87	5.13	5.15	5.16	5.23

Notes: ** indicates significance at the 5% level, *** indicates significance at the 1% level, estimates for lag values of the dependent variable are not reported for brevity but available upon request.

Table 10. Regression Estimates: 1-year Malaysian Government Securities for Output and Inflation

Lags	3,1	5,1	10,1	3,1	5,1	10,1
1	10.10	9.19	15.15	1.95	-0.28	1.81
2	13.76	4.94	-6.75	0.75	0.68	-3.08
3	1.00	6.02	15.46	-0.26	-0.98	5.55
4	6.45	3.16	-4.89	-0.74	-0.16	-6.10
5	4.88	5.63	-8.32	1.17	-0.02	4.28
6	-12.64	-13.75	2.96	0.15	0.16	-2.77
7	34.43***	23.10**	18.32	0.85	0.52	2.02
8	-33.81	-23.94	-10.36	0.69	0.31	-0.80
9	21.00	12.30	-8.79	-1.73	-1.00	0.10
10	-29.57	-16.89	13.96	1.07	-0.15	-0.73
11	4.74	-2.56	-27.58	-1.07	-1.25	0.34
12	-10.35	-8.34	18.88	0.77	0.51	-0.30
Adjusted R^2	0.85	0.85	0.86	0.93	0.93	0.92
Standard error	39.01	39.08	38.49	5.22	5.25	5.41

Notes: ** indicates significance at the 5% level, *** indicates significance at the 1% level, estimates for lag values of the dependent variable are not reported for brevity but available upon request.

Table 11: In-sample Forecast Evaluation for Output and Inflation

	3,3 Model	AR Model	3,3 Model	5,3 Model	Combined	AR Model
RMSE	82.96	53.33	29.80	32.29	33.72	43.30
MAE	79.28	41.74	25.93	28.54	30.03	33.60
MAPE	70.80	63.26	384.51	183.85	158.48	85.33
THEIL	0.27	0.23	0.41	0.44	0.45	0.61

Note: *RMSE* is defined as Root Mean Square Error, *MA* is defined Mean Absolute Error, *MAPE* is defined as for Mean Absolute Percentage Error, *THEIL* is defined as for Theil inequality coefficient.

Table 12: A simple AR Model for Output and Inflation

Lags	Output	Inflation
Constant	6.65	2.68
1	0.65***	1.24***
2	0.25***	-0.33***
Adjusted R-squared	0.78	0.89
S.E. of regression	47.18	6.38

Notes: ** indicates significance at the 5% level, *** indicates significance at the 1% level, estimates for lag values of the dependent variable are not reported for brevity but available upon request.

Table 13: Estimates of Probit Model for Slowdown in Economic Activity

Variable	Coefficient	Std. Error	Marginal Effect
Constant	-0.138	0.195	-
TS 3 (-12)	-3.806***	0.951	-1.245
TS 5 (-12)	3.978***	1.056	1.269
TS 10 (-12)	-0.842**	0.393	-0.275
McFadden R-squared	0.140		
Pr (LR statistics)	0.000		
S.E. of regression	0.443		

*** and ** significant at the 1% and 5% level respectively, standard errors computed via QML (Huber/White) method.