THE DETERMINANTS OF CREDIT SPREAD CHANGES OF INVESTMENT GRADE CORPORATE BONDS IN THAILAND BETWEEN JUNE 2006 AND FEBRUARY 2012: AN APPLICATION OF THE REGIME SWITCHING MODEL

Treerapot Kongtoranin
Martin De Tours School of Management and Economics, Assumption University

Abstract

This study proposes the two-state regime-switching model to explain the change of credit spread for investment grade corporate bonds in Thailand. The regimes of low and high volatility are extracted by Markov switching model. The results suggest that the model can improve explanatory power. The sensitivities of the risk factors including interest rate, macroeconomic, and liquidity factors increase in the high volatility regime rather than in the low regime. However, the liquidity factors are not significant for low credit rating corporate bonds.

Keyword: Credit Spread, Switching Regime Model, Internet Rate Risk, Macroeconomic Risk, Liquidity Risk

บทคัดย่อ

การศึกษานี้นำเสนอแบบจำลองการเปลี่ยนแปลงตามภาวะเพื่ออธิบายการเปลี่ยนแปลงของส่วนชดเชยความเสี่ยงด้านเครดิตสำหรับหุ้นกู้เอกชนในประเทศไทยที่มีอันดับความน่าเชื่อถือที่สามารถลงทุนได้ ภาวะความผันผวนต่ำและสูงถูกค้นหาโดยแบบจำลอง Markov-switching ซึ่งผลการศึกษาพบว่าแบบจำลองการเปลี่ยนแปลงตามภาวะสามารถช่วยปรับปรุงการอธิบายการเปลี่ยนแปลงของส่วนชดเชยความเสี่ยงด้านเครดิตได้ ในภาวะที่มีความผันผวนสูงความอ่อนไหวของปัจจัยเสี่ยงด้านอัตราดอกเบี้ย สภาวะเศรษฐกิจมหภาค และสภาพคล่องจะอ่อนไหวมากกว่าภาวะที่มีความผันผวนต่ำ อย่างไรก็ตามปัจจัยด้านสภาพคล่องของตราสารไม่สามารถอธิบายการเปลี่ยนแปลงของส่วนชดเชยความเสี่ยงด้านเครดิตสำหรับหุ้นกู้เอกชนที่มีอันดับความน่าเชื่อถือต่ำได้

คำสำคัญ: ส่วนชดเชยความเสี่ยงด้านเครดิต, แบบจำลองการเปลี่ยนแปลงตามภาวะ, ความเสี่ยงด้านอัตราดอกเบี้ย, ความเสี่ยงด้านภาวะเศรษฐกิจมหภาค, ความเสี่ยงด้านสภาพคล่อง

INTRODUCTION

In Thailand, the corporate bond market is growing dramatically due to the need for diversification in portfolio risk and is facing challenging tasks as well in the global debt capital markets. Though the market is small and new, the regulator provides sufficient information about the securities, as well as transparent rules and regulations to encourage efficiency.

However, the empirical studies which focused on the determinants of corporate bond yield spread in Thailand are limited. For example the study on the effect of volatility of firm on the credit spread *level* found that 80% in low credit rating corporate bonds can be explained (Mongkonkiattichai & Pattarathammas, 2010). However, the model included specific month dummy variables and used the individual-level corporate bond data such as traditional bond characteristics as explanatory variables. This model cannot explain the dynamics of the credit spread. Other studies on the credit spread change were conducted, however, the results were limited to few corporate bonds which might not represent the majority of the corporate bond market (Tittayanurak, 2002; Tirawannarat, 2004).

From the observations, the credit spread in Thailand fluctuates in a cyclical pattern as does credit spread in other economies. It is conjectured that the Thai corporate bond market is a credit spread puzzle. This problem can be seen, when the systematic risk factors fail to explain the variation of credit spread. However, the cyclical pattern of the credit spread contains information on the recovery rate of the firm. It can be used to improve the explanatory power of the model with systematic risk factors.

The objective of this study is to show that the credit spread puzzle exists in Thailand since systematic risk factors can explain credit spread partially. Thus, the model is modified with the interaction terms incorporated with the credit cycle. The credit cycle can be different from the business cycle. The explanatory power of the modified model is compared with the original model. The improvement in explanatory power and also the sets of determinants in different regimes are discussed as to whether their signs and values are changed when the regime switches.

LITERATURE REVIEW

In this section the definition of the credit spread is discussed. To understand the dynamic of credit spread, there are many theories related with credit risk.

The interesting features of credit spread are the nonzero level, term-structure and credit cycle. Firstly, even the highest credit rating corporate bond has a credit spread, which means that the yield is higher than the government bond. Credit spread also increases when the credit quality is lower and depends on the industry of corporate issuers. Secondly, the term-structure, the relationship between credit spreads with the same credit rating and their time-to-maturity, can be either upward, humped, or downward shape. However, in Thailand, the lognormal function can fit most of the credit spread curve in the increasing function (Siwamogsatham, 2010). Lastly, the credit spread dynamic has a cyclical pattern, which is the fluctuation of yield spread during different business conditions. It is believed that the credit cycle can induce the business cycle (Maalaoui, Dionne & François, 2008). It has a persistent effect in that the spread remains high during the recession and continues to be high when the economy recovers (Collin-Dufresne, Goldstein & Martin, 2001). Therefore, the credit cycle and business cycle are dissimilar.

Corporate bond is subject to the credit risk, which is defined as the distribution of financial losses owing to unexpected changes in the credit quality of the counterparty in a financial agreement. This distribution is complex; however, the main key to explaining it is by *default probability* (Backshall, Giesecke & Goldberg, 2005). The credit risk has two components, *credit default risk* and *credit spread risk*. The former risk is the risk that a firm cannot pay back cash flow to the investors as promised when the firm defaults. The latter risk is the risk from the credit spread change, which affects the financial loss or the performance in the portfolio (Fabozzi, Mann & Wilson, 2005). The related theories and credit risk components are discussed as follows.

1. Default Risk

One of the main differences between government bonds and corporate bonds is the possibility of issuer default. Government bonds are issued by the government; therefore these securities are guaranteed by the government. However, corporate bonds are issued by either private or public companies, which are subject to default during the bond holding period. Default risk is a matter of concern for investors and therefore the yields of corporate bonds are higher than the yields of government bonds with the same time-to-maturity. The option pricing theory can explain the default risk related to the credit spread.

The structural model, developed from option pricing theory of Black and Scholes (1973) can be used to value the credit spread as a function of firm default probability, the volatility of firm value, and interest rate factors. It was modified by relaxing many assumptions to improve the pricing performance by allowing a stochastic process of independent variables, e.g. risk free rate and default boundary, and allowing the jump process of the firm value, allowing tax and liquidity premium (Merton, 1973; Black & Cox, 1976; Longstaff & Schwartz, 1995; Collin-Dufresne & Goldstein, 2001; Duffie & Lando, 2001; Zhou, 2001; Jarrow & Protter, 2004; Giesecke, 2006; Christensen, 2008; Chen & Kou, 2009). The model explains the relationship between credit spread and the default probability, such that the increase in firm default probability increases the credit spread. When the firm value increases, the default probability is low. The firm value is proxied by firm equity return (Kwan, 1996; Campbell & Taksler, 2003; Anramov, Jostova & Philipov, 2007; Chen & Kou, 2009; Mongkonkiattichai & Pattarathammas, 2010) or inversely measured through the leverage ratio (Collin-Dufresne et al., 2001b).

2. Interest Risk

Firm value is related to the interest rate, either positively or negatively. If the firm and interest rate have a positive sensitivity, the firm value increases with the rise of interest rate and therefore the firm value is higher than the debt value, and the credit spread narrows. On the other hand, firm value can be negatively related to the interest rate. The credit spread widens when the interest rate increases. This relationship can be explained by option pricing theory. Additionally, the volatility of firm can be affected by the volatility of the interest rate, when the firm value and interest rate are correlated.

While in the structural model, the risk free rate were assumed to be constant, the reduced-form model allowed the factors to have a stochastic process. The model can fit the empirical data better than the structural model, but still cannot explain the determinants of credit spread variation (Jarrow & Turnbull, 1995; Lesseig & Stock, 1998; Elton, Gruber, Agrawal & Mann, 2004; Longstaff, Mithal & Neis, 2005). The negative relationship between the change of interest rate level and credit spread is expected, due to the fact that the increase in risk free rate increases the drift of the risk-neutral process of firm value, and therefore the probability of default decreases and the credit spread narrows (Longstaff & Schwartz, 1995).

Moreover, if the firm values are correlated with the interest rate, the firm value volatility is related with both equity volatility and interest rate volatility. Increasing interest rate volatility increases the firm volatility and therefore the credit spread increases (Huang & Kong, 2003).

Pure expectation theory explains that the relationship between the forward rate and the future rate are equal (Cox, Ingersoll & Ross, 1981). Therefore the slope of the term-structure can imply the future interest rate. The steeper the slope of the term-structure, the higher the future interest rate. The future probability of default decreases, when the expectation of future interest rate increases; therefore the credit spread narrows (Collin-Dufresne et al., 2001b).

3. Macroeconomic Risk

Since the structural model cannot explain credit spread change effectively, the systematic risk factors are widely selected as the choice of determinants of credit spread change (Collin-Dufresne et al., 2001b). The related theories are as follows:

> The financial instability hypothesis by Minsky (1992) explained the credit crisis of the debt market caused by the accumulation of the debt from three imbalanced numbers of three groups of borrowers, i.e. hedge borrowers, speculative borrowers, and Ponzi borrowers. The credit cycle is different from the business cycle since the assumption of the theory is based on a different economy structure. The economy structure of the business cycle based on the general economy is dominated by the real exchange of good and cash, while in the *modern* economy the trading is via contracts with different participants.

The credit cycle theory focuses on the abnormality phenomenon of the credit spread due to the cycle of credit. The credit cycle can be different from the business cycle due to persistent effects after the recession state. This credit cycle can change the structure of the model in explaining credit spread change (Maalaoui et al., 2008).

The relationship between the equity and bond market can be explained by the efficient markets hypothesis. It shows that there is a relationship between the equity and bond markets through non-synchronized perceptions of private information. The equity market with low transaction cost reacts to the information before the bond market, and therefore the relationship between the lagged return of equity market can explain the bond market return (Kwan, 1996).

4. Liquidity Risk

The aggregate liquidity factors are related to the stock returns. Stocks with higher liquidity give higher expected return to the investors (dos Santos Paiva & Savoiac, 2009). Since the corporate bond market has much lower liquidity than the stock market, the liquidity risk is higher. The liquidity can be in two parts, liquidity shock due to the firm default and unexpected less price in the future. Therefore the liquidity and credit risks are correlated (Ericsson & Renault, 2006).

Option pricing theory explains the relationship between credit spread and the liquidity of the corporate bond in terms of convenience yield. The investors require higher premiums on investing on the slow-cash-converted securities, such as corporate bonds, than the fast-cash-converted securities, such as Treasury bonds (Nakashima & Saitob, 2009). The credit spread puzzle of the Merton model may cause this by not including the liquidity factor in the model, especially in very short-term corporate bonds (Covitz & Downing, 2007). The higher the liquidity, the lower is the credit spread (Lo, Mamaysky & Wang, 2004).

5. Time-To-Maturity Risk

Since the volatility of the yield of corporate bonds is related to the time-to-maturity, the credit spread is affected by the *time-to-maturity*. This relationship is called term-structure, which can be increasing, decreasing or hump shaped. The main theory related to the increasing shape is liquidation theory.

The liquidation theory explains the relationship between yield to maturity and time to maturity to be an increasing function due to the fact that the investor demands higher premiums on longer maturity bonds in order to hold a longer one. Therefore, the yield to maturity increases with the time-to-maturity (Fabozzi, 2005).

MODEL

The credit spread change is determined from the interest rate, macroeconomic, and liquidity factors and it is controlled by controlled variables. The framework can be developed to the single- and multiple-regime models. The multiple-regime model applies the two regimes of the credit cycle, low and high regimes, where a low regime refers to the period when the credit spread mean or variance is low and not volatile and vice versa. The regimes of the credit cycle are acquired from the Markov regime switching model by Davies (2008) and Maalaoui et al. (2008). It is assumed to have two different regimes to avoid the difficulties in the interpretation of the state's phenomenon. Moreover, the computational resources and divergence of the parameters are more assured with two states assumption (Perlin, 2010). To study the change of the sensitivities during two different regimes, the interactive terms of the credit cycle are multiplied with each explanatory variable and added to the single regime model.

1. The Single-Regime Multiple Regression Model

The model is simply an ordinary multiple regression analysis with a general form expressed as

$$\Delta CS_t^j = \alpha_0^j + \sum_{i=1}^{N} \alpha_i^j X_{t,i}^{(j)} + \varepsilon_t^j \quad (1)$$

where ΔCS_t^j is the credit spread change of credit ratings and time-to-maturity portfolio j, α_0^j is a constant, α_i^j are estimated sensitivities of the observed independent variables x_{tj}.

2. The Multiple-Regime Multiple Regression Model

The multiple-regime multiple regression focuses on the regime change of the credit cycle by adding additional interaction terms (Davies, 2008;

Maalaoui et al., 2008). The general term of the multiple regime model is as follows

$$\Delta CS_t^j = \beta_0^j + \sum_{i=1}^{N} \beta_i^j X_{t,i}^{(j)} + \gamma_0^j \times inter_t^j + \sum_{i=1}^{N} \gamma_i^j X_{t,i}^{(j)} \times inter_t^j + \varepsilon_t^j \quad (2)$$

$$\Delta CS_t^{j,L} = \beta_0^j + \sum_{i=1}^{N} \beta_i^j X_{t,i}^{(j)} + \varepsilon_t^j \ \ when\ inter_t^j = 0 \quad (3)$$

$$\Delta CS_t^{j,H} = (\beta_0^j + \gamma_0^j) + \sum_{i=1}^{N} (\beta_i^j + \gamma_i^j) X_{t,i}^{(j)} + \varepsilon_t^j \ \ when\ inter_t^j = 1 \quad (4)$$

where β_0^j and β_i^j are parameters of the low regime, γ_0^j and γ_i^j are parameters of the marginal effect terms. The dummy variables $inter_t^j$ are equal to zero when the credit cycle regime of portfolio j are in low regime, otherwise one (Davies, 2008; Maalaoui et al., 2008). β_i^j and $\beta_i^j + \gamma_i^j$ can be interpreted as sensitivities of explanatory variables in low and high regimes, respectively.

DATA

The individual corporate bond data are obtained from the mark-to-market of the fixed-incomes prepared by the ThaiBMA via the iBond database, including static credit spread[1], time-to-maturity, and credit rating. To ensure that the portfolios have no additional risk, the corporate bonds with an embedded option and a floating coupon type are filtered out. Moreover, they are discarded whenever a bond has less than one year time-to-maturity (Collin-Dufresne et al., 2001b; Maalaoui et al., 2008). The bond without a credit rating either TRIS or FITCH are also filtered out. The non-investment bonds, i.e. with a credit rating lower than BBB, are filtered out.

The aggregate static spread curves, CS_t^j, are constructed for each credit rating, j, e.g. AAA, AA, A, BBB[2], through the lognormal function as in equation (5).

$$CS_t^j(T) = a_0 \ln(1+T) + a_1 \quad (5)$$

where CS_t^j is the static spread curve of portfolio j at month t. It is a function of time-to-maturity T, and a_0 and a_1 are the parameters from the OLS of $CS_t^j(T)$ and its related time-to-maturity T (Siwamogsatham, 2010). The lognormal function gives an increasing function which is reasonable for the credit spread of corporate bonds that is increasing with the time-to-maturity. The $CS_t^j(t,T)$ is a series of credit spread at time-to-maturity T can be calculated from the parameter obtained from the OLS.

The interest rate risk is captured by the interest rate level, the slope of the yield curve, and the interest rate volatility. The interest rate level (r_t^{2y}) is obtained from the yield of two-year Treasury yield ThaiBMA zero coupon yield curve. The proxy of the slope of the yield curve ($slope_t^{10y-2y}$) is the spread between 10-year and 2-year maturity Treasury bonds. The historical interest volatility ($\sigma_t^{r^{10y}}$) is calculated from the one-year historical interest rate volatility using the daily spot rate of ten-year-maturity Treasury bond yield from the ThaiBMA zero coupon yield curve.

Macroeconomic risk includes equity market return and historical volatility of equity market return. The equity market index is obtained from the Bloomberg database via Stock Exchange of Thailand (SET). The return of the stock market (set_t) is the percentage change of the stock index. The historical volatility of equity market return (σ_t^{set}) is calculated from the standard deviation of daily return back for 180 days from the Bloomberg database.

Liquidity factors are measured by the missing price, the ratio of non-trading days to the number of days in the month of each bond. and the turnover ratio ($turn_t$) is a ratio between the total trading volume in the month to the number of outstanding bonds (Maalaoui et al., 2008). The higher the ratio, the more frequent trades are in the secondary market. The trading volume data is from the pricing data from the ThaiBMA website. The outstanding volume is calculated by using value of the outstanding at the end of the month divided by par value of 1,000 THB.

The interaction terms of each portfolio $inter_t^j$ are obtained from the Markov Switching Model using the time-series data of credit spread of each portfolio as an input of the analysis. The credit spread of each portfolio is assumed to have the following process

$$\ln CS_t^j = \mu_{S_t}^j + \varepsilon_{S_t}^j \quad (6)$$

where S_t, 1, 2 $\mu_{S_t}^j$ is the mean of $\ln CS_t^j$ at state S_t, and $\varepsilon_{S_t}^j$ follows a normal distribution with zero mean and variance $\sigma_{S_t}^{2^j}$. The means and variances in regime 1 and 2 are different. The transition of the state is assumed stochastic or it is uncertain whether the state will change or not. Since the switching process is assumed to be known, a transition matrix that controls the probability of making a switch from one to another state is represented by the probability of a switch from state n to state m between time t and $t + 1$ (p_{mn}).

The estimation of the parameters in the Markov Switching model is based on the maximum likelihood using Hamilton's filter (Hamilton, 1990). The calculation process is to estimate the parameters by employing Expectation-Maximization (EM) algorithm, the iterative process to find the maximum likelihood of the model with a latent variable (Dempster, Laird & Rubin, 1977). The calculation of the *smoothed probabilities* can be obtained from an iterative process. The smoothed probability is then used to weight y_t. The OLS calculation of the weighted y_t is performed to generate the new estimate parameter. The process is repeated again until the value of the likelihood function is maximum and the fixed parameter of θ is found (Maalaoui et al., 2008).

For this study, the calculation of smoothed probability and parameter θ is performed by MATLAB package MS_Regress written by Perlin (2010). Whenever the smoothed probability is lower than 0.5, the credit spread is in the low regime and vice versa. The smooth probability is converted to dummy variable, $inter_t^j$, using this criteria (Maalaoui et al., 2008).

The control variables are default and time-to-maturity risk. Corporate bonds with similar credit ratings are assumed to have similar default risk, while the same time-to-maturity reflects the same time-to-maturity risk. Therefore, they are controlled by setting portfolios of four ratings (e.g. AAA, AA, A, and BBB) and three time-to-maturity (e.g. short, medium, and long time-to-maturity) (Collin-Dufresne et al., 2001b; Maalaoui et al., 2008). Only the systematic risk factors are studied, due to the fact that the idiosyncratic risk can explain a little part of the credit spread variation.

There are many problems related with the OLS regression for time-series data. Firstly, the nonstationary problem of the dependent and independent variables can be conducted using ADF test. If the null hypothesis cannot be rejected, the series has non-stationary problems. The solution is to calculate the first difference to the variable and retest ADF again. Secondly, the multicollinearity problem in the independent variables can be tested by calculating the correlation matrix and VIF test. The criteria for severe collinearity is high correlation (more than 0.80 or less than -0.80) and VIF > 5. Thirdly, the appropriate lag terms of independent variables is found by testing the univariate OLS with credit spread change to minimize the AIC.

After running the OLS of either single-regime or multiple-regime models, it is necessary to check the other two problems, serial correlation and heteroscedasticity problems in the error terms of the regressions. To detect the serial correlation in the error terms, the Botch Goffin Serial LM test is used. If there is a serial correlation, the standard errors are corrected by Newey-West standard error before reading the t-test. The heteroscedasticity problem can be detected by the White test and the standard errors can be corrected by the White standard error. However, if two problems are found, the Newey-West standard error is selected (Gujarati, 2003).

FINDINGS

The corporate bond data contains total transaction of 11,364. The number of samples in each credit rating groups are different. Most of the samples are in A with 324 bond issues and 5,907 observations. The OLS is used to fit the data for each credit rating group on month t. Using these parameters from the credit spread curve, the credit spread at time-to-maturity at 2, 5 and 10 years of each credit rating group at month t can be estimated. Table 1 shows the descriptive statistics of credit spread of all portfolios.

The preliminary results is the Markov switching parameters as shown in Table 2, respectively. The ADF test (The results are not shown here.) shows that all variables are nonstationary except for the volatility of the interest rate and return on the equity market. Therefore, they are corrected with the first difference. The ADF of the first difference shows that the first difference of the variables are stationary. The collinearity problem is tested with correlation matrix and VIF test (The results are not shown here.). The explanatory variables do not have severe collinearity problem. The appropriate lags of the explanatory are tested and it is found that the appropriate lags for equity market return and volatility are two months (The results are not shown here.).

The summary of estimated parameters from Markov regime switching model is in Table 2 using the assumption of a common mean and different variance. The smooth probability can be plotted against time as in Figure 1a. Interaction terms can be constructed by using a continuous probability. Whenever the continuous probability is lower than 0.5, the credit spread is in a low regime, otherwise it is in a high regime. The interaction terms are plotted in Figure 1b. Most of the credit spreads have similar patterns of interaction terms, a high regime between the end of 2008 to the beginning of 2010, except for the medium-term AA, which has a high regime from 2006 to the beginning of 2010 and becomes low afterwards.

THE EMPIRICAL RESULTS

The results of the OLS analysis of a single-regime model are presented in Panel A in Table 3. The change of short-term interest for most of the portfolios are negatively related to the credit spread change, except for the low credit rating group. The coefficient value increases with the time-to-maturity. The result is consistent with the expected sign. Only in the AAA rating group, the change of slope of the term-structure is slightly positively related with the credit spread change. Across all ratings and time-to-maturity groups, the volatility of long-term interest rate is not very significant and the signs are mixed. The lag of return of the equity market is negatively correlated with credit spread change both economically and statistically. Moreover, the sensitivities increase consistently across credit ratings and time-to-maturity groups. However, the change of the historical volatility of return of equity market is not statistically significant across all portfolios. While the turnover ratio is statistically significant in AA and A rating groups, the missing price ratio is only statistically significant in the AAA rating group. The sign of both liquidity factors are as expected and the value of sensitivities increase with the time-to-maturity. Surprisingly, the BBB rating group is the only group that is not related with liquidity factors.

Panel B in Table 3 shows the results from the regression of the multiple-regime model. For the low regime, for the BBB rating group, there is no explanatory variable explaining credit spread change. The interest rate factors are statistically significant only for the AA and A rating groups as expected. Only in the AA-medium term, the return of equity market and its historical volatility are slightly statistically significant. However, the sign of the market return is not as expected. The liquidity factors are significant for all portfolios, except the BBB rating group. Surprisingly, the significant liquidity factors in a low regime are switched from the single-regime model, i.e. the missing price ratios are significant in the AA and A rating groups, while the turnover ratio is significant for the AAA rating group. The missing price ratio has a similar sign as expected, while the sign of the turnover ratio is positive. Note that the liquidity factor is significant only for the short- and long-term time-to-maturity and not significant for the medium-term time-to-maturity.

The marginal effect can be interpreted from the second half of the Panel B in Table 3. The marginal coefficient of the change of short-term interest rate of most of the portfolios are strongly statistically significant, except the BBB rating group. The change of short-term interest rate is negatively related with the credit spread change. The value of the sensitivity increases with longer time-to-maturity and lower credit ratings. The sensitivity of the slope of the term-structure is positively significant in all portfolios, except the A rating group that the value increases with longer time-to-maturity. The relationship between interest rate volatility is slightly statistically significant in the medium-term AAA, the short- and the long-term AA groups. However, the signs are mixed. For the AAA rating group the relationship is positive as in theory, however, for the AA rating group the relationship is negative. All portfolios have strong negative relationships between the lag of return of equity market and the credit spread change. However, the lag of change of historical volatility of the equity market return is statistically related with credit spread changes in the AA and A rating groups and the medium-term BBB group. The signs are as expected, except the short-term AA. The sensitivities are not economically significant in comparison to other explanatory variables. The liquidity factors only play important roles for the medium-term AA and A rating groups and the long-term A rating group. The market liquidity has a negative effect on the credit spread change, while the individual liquidity factor has no relationship to all portfolios. Liquidity cannot explain the credit spread change for the AAA and BBB rating groups. The adjusted R-squared for multiple-regime models is between 0.44 and 0.83, while the adjusted R-square for single-regime models is between 0.29 to 0.45. The multiple-regime models can explain the credit spread change better than the single-regime models. For all portfolios, the Akaike criterions in multiple-regime models are lower than single-regime models.

There is evidence of sign switch in the change of interest rate in the AAA rating and the long-term AA rating groups, the slope of the term-structure in all portfolios except for the A rating group, the volatility of the interest rate in the medium-term AAA rating, the short- and the long-term AA rating groups. For the return of equity market all portfolios have a sign switch. The change of the equity market return has a sign switch in the A rating and the medium-term AA rating groups. Liquidity factor has no evidence of sign switch, except for the turnover ratio in the medium-term AA rating group.

DISCUSSION

The application of Markov switching model can improve the explanatory power of the model. However, the low credit rating portfolio cannot be explained by the systematic risk as in previous studies (Collin-Dufresne et al., 2001b; Maalaoui et al., 2008; Mongkonkiattichai & Pattarathammas, 2010). One of the possible reasons for this contradiction is the low number of samples in the BBB rating group. Furthermore, the credit spread change of a low credit rating can be explained by idiosyncratic risk factors or other systematic factors.

The relationship between the change of short-term interest rate and the credit spread change is consistent with Longstaff and Schwartz (1995) and Duffee (1998) who found that the increase of change of short-term interest during an inflationary period increases the firm value above the default threshold; therefore the default probability of the firm is lower. The consequence is the narrow credit spread change. This evidence confirms the interest rate risk as in the structural model proposed by Merton (1974).

The slope of the term-structure and the long-term interest rate volatility are not significantly related with credit spread change in most of the portfolios. These results are consistent with Collin-Dufresne et al. (2001b), Campbell and Taksler (2003), Lepone and Author (2009), and Mongkonkiattichai and Pattarathammas (2010). The slope of the term-structure can explain the credit spread change only for the AAA rating group, however, the sign is different from the expected outcome. This is the indication that the change of term-structure and volatility of long-term interest rate are not the driving force of credit spread change. When including the credit cycle in the model, the slope of the term-structure has a positive relationship with the AAA, A, and BBB rating groups in high regime. Though the sign is not as in the expectation theory by which the increase in the slope of the term-structure refers to the higher future interest rate and therefore the economy seems to be better and the firm should gain more profit and reduce the default probability as well as the credit spread. During the credit crunch, the information of increases of interest rate seemed to be bad news for the market, such that during this period, the market needed to have low cost of funds and required the authorities to stimulate the economy. Therefore, when the signal of the raise of interest rate occurs, the credit spread also increases.

The credit spread change is more sensitive to the two-month lag of the return of equity market than the change of interest rate. The result is similar to the previous studies (Longstaff & Schwartz, 1995; Duffee, 1998; Davies, 2008). The sensitivities monotonically increase with the lowering of credit rating. Increases in equity market return dramatically impact the credit spread change of the lower rating groups more than the higher rating groups. Moreover, the return of the equity market can be a leading indicator for the credit spread change. The change of equity market impacts the credit spread approximately after two months. This result shows that the information flow from equity market can affect the credit spread change, such that the increase in the return of equity market reduces the default probability of a firm; therefore the credit spread narrows. The efficient markets hypothesis is rejected, since the past return of equity market can explain the change of credit spread of corporate bonds as proposed in Smith (1990) and Kwan (1996). However, in the low regime the equity market return is not related with the credit spread. Surprisingly, the lag of the change of volatility of the equity market is statistically insignificant. This result is inconsistent with most of the credit spread change studies in the U.S. (Collin-Dufresne et al., 2001b; Huang & Kong, 2003; Maalaoui et al., 2008), but is consistent with studies in Australian market (Lepone & Author, 2009) and Thai market (Mongkonkiattichai & Pattarathammas, 2010). This shows that the volatility of the equity market may have a similar effect on both Treasury and corporate bond in the same direction. Therefore the spread does not have the relationship with the volatility of the equity market return.

Liquidity cannot explain the change of the BBB rating group, while in the other portfolios the relationship between liquidity and credit spread is as expected. This result is contradictory to the study of Driessen (2005), Maalaoui et al. (2008), and Nakashima and Saito (2009) who found that the factor loading of liquidity factor is more significant in the low rating group. However, the BBB rating is the least traded portfolio among the others. The liquidity factor seems to be ineffective when using the very illiquid corporate bond.

The market liquidity and credit spread of the AA and A rating groups are found to be negatively correlated, while the missing price ratio, as a local liquidity, can explain the change of the credit spread in the AAA rating group with a positive relationship. For the AA and A rating groups, the number of corporate bonds is more than the number of corporate bonds in AAA and BBB rating group. Therefore the liquidity of the market can reflect the liquidity of the two rating groups, while the credit spread of the AAA rating group can be explained better with the local liquidity factor. It also shows that including more than one liquidity proxy in the models can help to explain the credit spread change of different rating and time-to-maturity groups.

Compared with the single-regime model, the coefficient of local liquidity is significant in the AAA rating group, and the coefficient of market liquidity is significant in the AA and A rating groups, the low-regime seems to have different relationship, such that the local liquidity can explain the credit spread change for the AA and A rating groups as expected and the coefficient of the market liquidity is significant in the AAA rating group. However, the sign of market liquidity is not as expected. This evidence shows that an increase in local liquidity can reduce the credit spread for the AA and A rating groups, however, the market liquidity can increase the credit spread of the AAA rating group. If the market liquidity refers to the trade volume of the AA and A in the credit market, during the low regime, it seems that the demand of the credit market goes to the AA and A rating groups more than the AAA rating group. The investors seem to be more confident to trade in the low rating group; therefore this behavior makes the high rating corporate bonds more attractive and the credit spread should increase.

The market liquidity seems to have a negative correlation with the credit spread change for the AA and A rating groups. Increases in market liquidity can reduce the credit spread. This same conclusion can be carried as in the single-regime. The local liquidity and credit spread change of the AAA rating group is not correlated.

Though most of the coefficients of the explanatory variables of a single-regime model and marginal effect seem to be identical, the multiple-regime model can clarify the explanation of the relationship between the slope of the term-structure and credit spread change under a high regime and shows that there is no relationship between the equity and the debt market during a low regime. Liquidity factors can drive the credit spread change regardless of credit cycle. The sign switch during regime shift exists in interest rate and macroeconomic factors, but there is no sign shift in liquidity factors.

CONCLUSIONS AND RECOMMENDATIONS

For the academic side, the results also show that the Markov Switching Model can identify the credit cycle regime in Thailand appropriately under the assumption of different variances in two regimes and the information of recovery rate can help improve the explanatory power of the model.

For individual investors and bond issuers, they should be aware of systematic risk in different regimes. In the low variance period, only the interest rate and liquidity factor play an important role with credit spread. However, in high variance period the interest rate and macroeconomic factors affect the credit spread change.

For the regulator, the setting of monetary policy can reduce the severe economic shock which results from the high cost of funding. As discussed on the expectation of interest rate during the high regime, if the regulator increases the interest rate during this period, the credit spread will increase. The regulator should relax the monetary policy until the credit cycle reverses to a low regime.

In general, the higher the liquidity, the lower the credit spread; therefore for all market participants in a secondary market, the high frequency of trading can reduce the cost of funding, as well as increase the NAV of the portfolio.

Future studies can focus on the idiosyncratic risk factor regarding default and liquidity at the firm level. Moreover, the study can be extended to find other systematic risk factors that can relate to the recovery rate and credit cycle of credit spread. Changes in political policy, tax, and the effect of sovereign risk of the credit spread can be tested using event study. There should be awareness of asymmetrical effects during high and low variance of equity market return as discussed in Collin-Dufresne et al. (2001b). Researchers thus can implement the event study together with interactive terms to refine the results during the transition period.

Other techniques on other regime switching models, such as SETAR[3], PSTAR[4], or LSTAR[5] can be further studied to improve the explanatory power of the model (Granger, Teräsvirta & Anderson, 1993). The liquidity proxies have many varieties of choices. The higher frequencies of the data and more aspects of the data, e.g., price and volume of portfolio or bond market or co-movement market, if available, should be included into the model. The dummy variable of the regime of credit cycle can be obtained by other methods such as time-dummy variable, and self-extracting threshold models.

References

Anramov, D., Jostova, G., & Philipov, A. (2007). Understanding changes in corporate credit spreads. *Financial Analysts Journal*, 63(2), 90-105.

Backshall, T., Giesecke, K., & Goldberg, L. (2005). Credit risk modeling. In F. J. Fabozzi & S. V. Mann (Eds.), *The handbook of fixed income securities* (7th ed.). chapter 33, 779-798, New York: McGraw-Hill.

Black, F. & Cox, J. (1976). Valuing corporate securities: Some effects of bond indenture provisions. *The Journal of Finance*, 31, 351-367.

Black, F. & Scholes, M. (1973). The pricing of options and corporate liabilities. *Journal of Political Economy*, 81(3), 637-654.

Campbell, J. & Taksler, G. B. (2003). Equity volatility and corporate bond yields. *The Journal of Finance*, 58(6), 2321-2350.

Chen, N. & Kou, S. (2009). Credit spreads, optimal capital structure, and implied volatility with endogenous default and jump risk. *Mathematical Finance*, 19(3), 343-378.

Christensen, J. (2008). The corporate bond credit spread puzzle. *FRBSF Economic Letter*, (10), 1-3.

Collin-Dufresne, P. & Goldstein, R. (2001). Do credit spreads reflect stationary leverage ratios? *The Journal of Finance*, 56(5), 1929-1957.

Collin-Dufresne, P., Goldstein, R. S., & Martin, J. P. (2001). The determinants of credit spread changes. *The Journal of Finance*, 56(6), 2177-2207.

Covitz, D. & Downing, C. (2007). Liquidity or credit risk? The determinants of very short-term corporate yield spreads. *The Journal of Finance*, 62(5), 2303-2328.

Cox, J., Ingersoll, J., & Ross, S. (1981). A re-examination of traditional hypotheses about the term-structure of interest rates. *The Journal of Finance*, 48(2), 769-799.

Davies, A. (2008). Credit spread determinants: An 85 year perspective. *Journal of Financial Markets*, 11, 180-197.

Dempster, A., Laird, N., & Rubin, D. (1977). Maximum likelihood from incomplete data via the EM algorithm. *Journal of the Royal Statistical Society B*, 39, 1-38.

dos Santos Paiva, E. V. & Savoiac, J. R. F. (2009). Pricing corporate bonds in Brazil: 2000 to 2004. *Journal of Business Research*, 62, 916-919.

Driessen, J. (2005). Is default event risk priced in corporate bonds? *Review of Financial Studies*, 18(1), 165-195.

Duffee, G. R. (1998). The relation between treasury yields and corporate bond yield spreads. *The Journal of Finance*, 53(6), 2225-2241.

Duf?e, D. & Lando, D. (2001). Term structures of credit spreads with incomplete accounting information. *Econometrica*, 69, 633-664.

Elton, E. J., Gruber, M. J., Agrawal, D., & Mann, C. (2004). Factors affecting the valuation of corporate bonds. *Journal of Banking & Finance*, 28(11), 2747-2767.

Ericsson, J. & Renault, O. (2006). Liquidity and credit risk. *The Journal of Finance*, 61(5), 2219-2250.

Fabozzi, F., Mann, S., & Wilson, R. (2005). Corporate bonds. In F. J. Fabozzi & S. V. Mann (Eds.), *The handbook of fixed income securities* (7th ed.). chapter 13, (pp. 305-350). New York: McGraw-Hill.

Fabozzi, F. J. (2005). Credit analysis for corporate bonds. In F. J. Fabozzi & S. V. Mann (Eds.), *The handbook of fixed income securities* (7th ed.)." chapter 32, (pp. 733-778). New York: McGraw-Hill.

Giesecke, K. (2006). Default and information. *Journal of Economic Dynamics & Control*, 30, 2281-2303.

Granger, C., Terasvirta, T., & Anderson, H. (1993). Modelling nonlinearity over the business cycle. In J. Stock & M. Watson (Eds.), Business cycles, indicators and forecasting. *Studies in Business Cycles*, volume 28. The Chicago Press. 20

Gujarati, D. N. (2003). *Basic Econometrics* (fourth ed.). Singapore: McGraw Hill.

Hamilton, J. D. (1990). Analysis of time series subject to regime changes. *Journal of Econometrics*, 45, 39-70.

Huang, J.-Z. & Kong, W. (2003). Explaining credit spread changes: New evidence from option-adjusted bond indexes. *Journal of Derivatives*, 11(1), 30-44.

Jarrow, R. & Protter, P. (2004). Structure versus reduced form models: A new information based perspective. *Journal of Investment Management*, 2, 1-10.

Jarrow, R. & Turnbull, S. (1995). Pricing derivatives on financial securities subject to credit risk. *The Journal of Finance*, 50(1), 53-85.

Kwan, S. H. (1996). Firm-specific information and the correlation between individual stocks and bonds. *Journal of Financial Economics*, 40, 63-80.

Lepone, A. & Author, C. (2009). Determinants of credit spread changes: Evidence from the Australian bond market. *The Australasian Accounting Business & Finance Journal*, 3(2), 26-36.

Lesseig, V. & Stock, D. (1998). The effect of interest rates on the value of corporate assets and the risk premia of corporate debt. *Review of Quantitative Finance and Accounting*, 11, 5-22.

Lo, A., Mamaysky, H., & Wang, J. (2004). Asset prices and trading volume under fixed transaction costs. *Journal of Political Economy*, 112, 1054-1090.

Longstaff, F., Mithal, S., & Neis, E. (2005). Corporate yield spreads: Default risk or liquidity? New evidence from the credit default swap market. *The Journal of Finance*, 60(5), 2213-2253.

Longstaff, F. & Schwartz, E. (1995). A simple approach to valuing risky fixed and floating rate debt. *The Journal of Finance*, 50(3), 789-820.

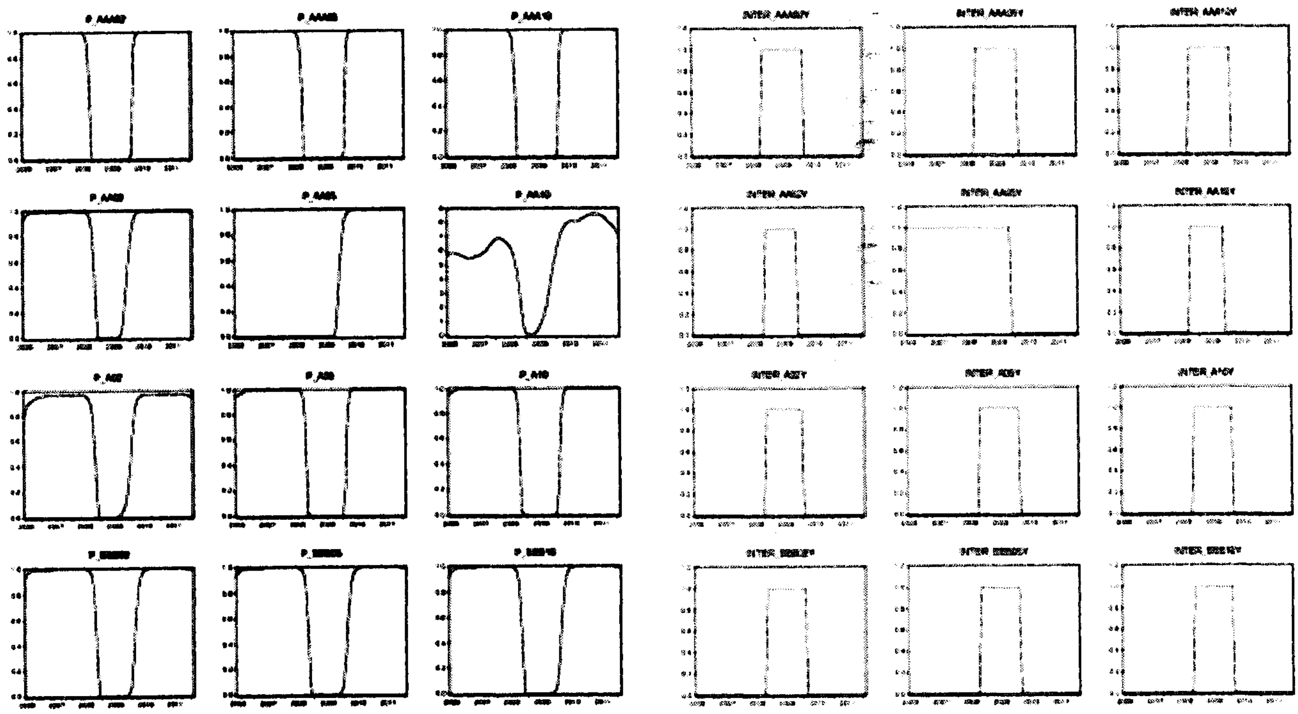
Maalaoui, O., Dionne, C., & François, P. (2008).

Credit Spread Changes under switching regimes. PhD thesis, HEC Montréal.
Merton, R. (1973). A rational theory of option pricing. *Bell Journal of Economics and Management Science*, 4(1), 141-183.
Merton, R. (1974). On the pricing of corporate debt: The risk structure of interest rates. *The Journal of Finance*, 29, 449-470.
Minsky, H. (1992). The financial instability hypothesis. Working Paper No. 74, The Jerome Levy Economics Institute of Bard College.
Mongkonkiattichai, S. & Pattarathammas, S. (2010). Linkage between stock volatility and corporate bond yield spread in Thailand. *China-USA Business Review*, 9(1), 1-26.
Nakashima, K. & Saitob, M. (2009). Credit spreads on corporate bonds and the macroeconomy in Japan. *Journal of The Japanese and International Economies*, 23, 309-331.
Perlin, M. (2010). MS_Regress - the MATLAB package for Markov regime switching models. Available at SSRN:http://ssrn.com/abstract=1714016.
Siwamogsatham, T. (2010). Development of ThaiBMA credit and liquidity spread. Working Paper, Thai BMA.
Smith, C. W. J. (1990). The theory of corporate finance: A historical overview. In C. W. J.
Smith (Ed.), *The modern theory of corporate finance* (2nd ed.). New York: McGraw-Hill.
Tirawannarat, W. (2004). Corporate bond pricing: an empirical comparison of Longstaff and Schwartz (1995) and Merton (1974) model: evidence from Thailand. Master thesis, Faculty of Commerce and Accountancy, Thammasat University, Bangkok, Thailand.
Tittayanurak, A. (2002). Determinants of spreads on new corporate bond offerings. Master thesis, Thammasat University, Bangkok, Thailand.
Zhou, C. (2001). The term structure of credit spreads with jump risk. *Journal of Banking & Finance*, 25, 2015-2040.

About the Author:

Treerapot Kongtoranin obtain his doctorate degree in Business Administration majoring in Finance, from the Martin de Tours School of Management and Economics. He can be reached at treerapot @hotmail.com

Figure 1: The Smooth Probability and Interaction Terms of Each Portfolio of Corporate Bonds including short, medium, and long term time-to-maturity of credit ratings AAA, AA, A, and BBB. The smoothed probability has a value between zero and one. The value shown here is the smoothed probability of p_{11}. When p_{11} is near 1, it can be implied that the probability that the credit spread change is in high regime state at time t - 1 would stay in the high regime at time t. The interaction terms are converted from the smooth probability such that if the smoothed probability crosses the value 0.5, the regime of the credit spread change from a low regime to a high regime, and vice versa. Therefore the smooth probability which is more than 0.5 is converted to 1, otherwise 0.



A) Smoothed Probability **B) Interaction Terms**

Source: created for this study

Table 1: Descriptive Statistics of Credit Spread

This table shows the descriptive statistics of credit spread. The statistical results include mean, median, max. and min., standard deviation, skewness, Kurtosis, Jarque-Bera and its p-value. For the normality test, skewness and Kurtosis of the normally distributed residual is at 0 and 3.0. When the p-value (p) of Jarque-Bera (JB) is sufficiently low, the null hypothesis that the residual is normally distributed is rejected. The notation on the first column are, CS_t^j is the aggregate credit spread of portfolio j. σ, S and K stand for standard deviation, skewness and Kurtosis, respectively.

Variables	Mean	Median	Max	Min	σ	S	K	JB	P	Obs.
CS_t^{AAA02}	40.75	32.58	98.95	26.56	18.80	1.96	5.71	65.16	0.000	69
CS_t^{AAA05}	65.42	52.64	156.86	42.63	29.57	1.94	5.66	63.53	0.000	69
CS_t^{AAA10}	87.00	70.18	207.50	56.68	39.00	1.93	5.63	62.85	0.000	69
CS_t^{AA02}	59.27	53.01	128.97	34.99	24.92	1.49	4.59	32.69	0.000	69
CS_t^{AA05}	96.30	86.60	207.98	56.55	40.29	1.44	4.48	30.11	0.000	69
CS_t^{AA10}	128.67	116.24	277.07	75.41	53.74	1.42	4.44	29.07	0.000	69
CS_t^{A02}	83.36	66.49	198.66	52.73	39.40	1.79	4.99	48.30	0.000	69
CS_t^{A05}	133.66	110.03	304.21	84.15	58.03	1.82	5.16	51.59	0.000	69
CS_t^{A10}	177.64	149.01	396.51	111.61	74.42	1.83	5.23	52.68	0.000	69
CS_t^{BBB02}	180.02	169.57	332.22	123.80	54.34	1.38	4.09	25.15	0.000	69
CS_t^{BBB05}	292.98	275.91	540.11	201.82	88.18	1.38	4.12	25.49	0.000	69
CS_t^{BBB10}	391.76	368.89	721.91	270.04	117.77	1.38	4.13	25.63	0.000	69

Source: created for this study

Table 2: Estimated Parameters from Markov Regime Switching Model

This table presents the parameters of the switching regime model for AAA, AA, A, and BBB Thai corporate bonds credit rating groups maturing in 2, 5, and 10 years. The natural logarithm of credit spread has a common mean and two different standard deviations in the first and the second regime, i.e. $\ln CS_t^j = \mu^j + \varepsilon_{s_t}^j$, where $\varepsilon_{s_t}^j$ follows a normal distribution with zero mean and variance $\sigma_{s_t}^{2j}$. The parameters include μ, σ_1, σ_2, p_{11} and p_{22} stand for mean, standard variation of regime 1 and 2, conditional probabilities of the process being in state 1 and 2, respectively. The values in parentheses are the p value from the estimation.

Var.	AAA	AAA	AAA	AA	AA	AA	A	A	A	BBB	BBB	BBB
(p)	2 yrs	5 yrs	10 yrs	2 yrs	5 yrs	10 yrs	2 yrs	5 yrs	10 yrs	2 yrs	5 yrs	10 yrs
μ	3.45	3.93	4.22	3.89	4.56	4.72	4.12	4.66	4.96	5.05	5.54	5.83
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
σ_1	0.01	0.01	0.01	0.05	0.01	0.10	0.08	0.01	0.01	0.02	0.02	0.02
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.017)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
σ_2	0.60	0.58	0.57	0.54	0.21	0.17	0.34	0.57	0.54	0.29	0.29	0.29
	(0.005)	(0.005)	(0.005)	(0.025)	(0.000)	(0.000)	(0.000)	(0.007)	(0.007)	(0.01)	(0.01)	(0.01)
p_{11}	0.98	0.98	0.98	0.98	1.00	0.90	0.93	0.98	0.98	0.98	0.98	0.98
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
p_{22}	0.94	0.94	0.94	0.91	0.98	0.90	0.67	0.93	0.93	0.93	0.93	0.93
	(0.000)	(0.000)	(0.000)	(0.013)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.002)	(0.002)

Source: created for this study

Table 3: Determinants of Credit Spread Changes in Thailand by Rating and Time-to-Maturity Group

The results of the regression analysis of single- and multiple-regime model are presented in panel A and B, respectively. The single-regime model is: $\Delta CS_t^j = \beta_0^j + \beta_1^j \Delta r_t^{2y} + \beta_2^j \Delta slope_t^{10y-2y} + \beta_3^j \sigma_t^{r_t^{10y}} + \beta_4^j set_{t-2} + \beta_5^j \Delta\sigma_{t-2}^{set} + \beta_6^j \Delta turn + \beta_7^j \Delta mis_t^j + \varepsilon_t^j$. The multiple-regime model is: . In each panel, the coefficients of explanatory variables and their t-statistics, adjusted R-square, Akaike criterion, and the adjusted standard error methodology are presented. The values in parentheses are t-statistics. The asterisk sign of ***, **, * indicate the significance level at 1%, 5%, and 10%, respectively. The critical t-value at significance level at 1%, 5%, and 10% are 2.663, 2.002, and 1.296 for the single regime model, and 2.678, 2.009, and 1.299 for the multiple regime model, respectively. The adjusted standard methodology is noted with N and W in row adj. Med. for Newey West and White Heteroscedasticity respectively.

	AAA02Y	AAA05Y	AAA10Y	AA02Y	AA05Y	AA10Y	A02Y	A05Y	A10Y	BBB02Y	BBB05Y	BBB10Y
Panel A. Single Regime Model												
Constant	-0.18	-0.38	-0.56	0.98	1.58	2.1	0.99	2.58	3.96	0.12	0.3	0.46
	(-0.12)	(-0.16)	(-0.177)	(0.418)	(0.418)	(0.418)	(0.345)	(0.531)	(0.681)	(0.026)	(0.037)	(0.037)
Δr_t^{2y}	-4.95***	-7.63***	-9.97**	-9.98***	-15.85***	-20.98***	-16.78***	-25.33**	-32.82**	-9.66	-15.91	-21.37*
	(-2.769)	(-2.678)	(-2.639)	(-3.563)	(-3.51)	(-3.487)	(-2.704)	(-2.341)	(-2.652)	(-1.281)	(-1.218)	(-1.447)
$\Delta slope_t^{10y-2y}$	3.32*	5.15*	6.75*	2.4	3.81	5.04	2.34	2.96	3.5	8.81*	14.61	19.68
	(1.805	(1.756)	(1.734)	(0.832)	(0.818)	(0.813)	(0.623)	(0.67)	(0.452)	(1.341)	(1.048)	(1.294)
$\sigma_t^{r^{10y}}$	0.59	1.09	1.53	-1.18	-1.84	-2.41	-2.62	-5.64	-8.27	2.18	3.32	4.32
	(0.21)	(0.244)	(0.258)	(-0.268)	(-0.259)	(-0.256)	(-0.469)	(-0.597)	(-0.73)	(0.287)	(0.211)	(0.186)
set_{t-2}	-25.05***	-36.87***	-47.2***	-44.19***	-71.34***	-95.09***	-60.12*	-96.44**	-128.2**	-109.46**	-178.82**	-239.47***
	(-3.022)	(-2.789)	(-2.691)	(-3.404)	(-3.409)	(-3.411)	(-1.925)	(-2.089)	(-2.043)	(-2.28)	(-2.643)	(-3.514)
$\Delta\sigma_{t-2}^{set}$	0.08	0.14	0.2	0.06	0.09	0.13	0.54	0.74	0.92	0.36	0.57	0.75
	(0.41)	(0.462)	(0.482)	(0.189)	(0.192)	(0.193)	(0.687)	(0.665)	(0.617)	(0.454)	(0.416)	(0.472)
$\Delta turn$	-13.72	-1	10.13	-539.29*	-851.1*	-1123.78*	-1060.68**	-1581.21**	-2036.4**	-982.57	-1615.25	-2168.52
	(-0.062)	(-0.003)	(0.022)	(-1.448)	(-1.418)	(-1.405)	(-2.519)	(-2.113)	(-2.335)	(-1.198)	(-1.275)	(-1.21)
Δmis_t^j	28.65**	43.91**	57.25*	27.6	46.64	63.29	-39.9	-57.55	-72.98	306.79	501.75	672.24
	(2.112)	(2.03)	(1.994)	(0.474)	(0.497)	(0.506)	(-0.353)	(-0.368)	(-0.325)	(1.202)	(1.144)	(1.112)
$\overline{R}^2$	0.35	0.33	0.32	0.39	0.38	0.38	0.45	0.45	0.45	0.29	0.29	0.29
aic	5.73	6.66	7.23	6.63	7.59	8.16	7.40	8.24	8.77	8.38	9.37	9.96
adj. Med.adj. Med.							W	N	W	N	W	
Panel B. Multiple Regime Model												
Constant	-0.47	-0.75	-1	-0.79	-1.04	-1.72	-0.51	0.61	1.2	-2.61	-4.35	-5.87
	(-0.516)	(-0.394)	(-0.507)	(-0.503)	(-0.161)	(-0.511)	(-0.305)	(0.193)	(0.384)	(-0.58)	(-0.738)	(-0.592)
Δr_t^{2y}	-0.91	-1.49	-1.99	-3.45*	-19.02***	-5.84	-5.86**	-8.13*	-10.45**	-3.45	-5.51	-7.31
	(-0.782)	(-0.586)	(-0.789)	(-1.672)	(-3.625)	(-1.275)	(-2.111)	(-1.964)	(-2.042)	(-0.595)	(-0.577)	(-0.573)
$\Delta slope_t^{10y-2y}$	-1.67	-2.63	-3.47	-1.61	-9.7	-4.13	-0.38	-3.45	-4.66	-3.73	-6.06	-8.09
	(-0.96)	(-0.853)	(-0.908)	(-0.629)	(-1.291)	(-0.752)	(-0.126)	(-0.67)	(-0.877)	(-0.511)	(-0.488)	(-0.502)

	AAA02Y	AAA05Y	AAA10Y	AA02Y	AA05Y	AA10Y	A02Y	A05Y	A10Y	BBB02Y	BBB05Y	BBB10Y
$\sigma_t^{r^{10y}}$	0.68	1.05	1.38	1.59	-0.24	3.27	-0.93	-3.3	-4.93	5.05	8.4	11.33
	(0.437)	(0.303)	(0.405)	(0.546)	(-0.011)	(0.526)	(-0.323)	(-0.572)	(-0.898)	(0.613)	(0.726)	(0.625)
set_{t-2}	2.24	4.8	7.04	5.71	34.56*	10.52	8.4	22.22	29.67	27.98	45.89	61.55
	(0.301)	(0.335)	(0.44)	(0.501)	(1.37)	(0.431)	(0.556)	(0.952)	(1.06)	(0.86)	(0.802)	(0.858)
$\Delta\sigma_{t-2}^{set}$	-0.04	-0.05	-0.06	-0.14	1.44*	-0.27	-0.09	-0.03	-0.02	0.06	0.11	0.14
	(-0.431)	(-0.178)	(-0.32)	(-0.605)	(1.677)	(-0.545)	(-0.349)	(-0.07)	(-0.036)	(0.096)	(0.122)	(0.099)
Δturn	217.73*	336.38	440.14*	62.76	240.33	210.51	78.33	222.6	348.33	-101.43	-144.74	-182.61
	(1.696)	(1.147)	(1.566)	(0.234)	(0.527)	(0.365)	(0.289)	(0.402)	(0.675)	(-0.145)	(-0.11)	(-0.119)
Δmis_t^j	11.23	17	22.05	52.38*	81.91	123.94*	123.29*	191.31	252.97*	196.54	319.93	427.83
	(1.137)	(0.905)	(1.022)	(1.325)	(1.214)	(1.46)	(1.528)	(1.269)	(1.664)	(0.894)	(1.128)	(0.883)
$inter_t^j$	-6.7*	-11.51*	-15.72*	15.13*	4.65	34.71*	-0.33	1.45	4.58	14.44	25.88	35.88
	(-1.425)	(-1.777)	(-1.458)	(1.56)	(0.374)	(1.841)	(-0.023)	(0.124)	(0.216)	(0.878)	(0.908)	(0.99)
$\Delta r_t^{2y} \times inter_t^j$	-10.47***	-15.78***	-20.42**	-17.97***	4.97	-38.01***	-29.77***	-45.72***	-59.09***	2.2	2.88	3.48
	(-2.874)	(-3.2)	(-2.465)	(-3.706)	(0.508)	(-4.085)	(-3.845)	(-5.155)	(-3.774)	(0.171)	(0.147)	(0.122)
$\Delta slope_t^{10y-2y} \times inter_t^j$	8.89***	13.72***	17.95***	9.06**	16.53*	20.71**	3.92	8.74	10.98	24.86**	41.2***	55.49**
	(3.202)	(3.076)	(2.907)	(2.371)	(1.846)	(2.539)	(0.553)	(1.081)	(0.821)	(2.298)	(2.769)	(2.328)
$\sigma_t^{r^{10y}} \times inter_t^j$	11.18	19.86*	27.46	-31.42*	-4.7	-71.71**	-1.78	-7.04	-14.19	-24.46	-44.98	-62.91
	(1.171)	(1.555)	(1.259)	(-1.739)	(-0.173)	(-2.063)	(-0.062)	(-0.3)	(-0.33)	(-0.742)	(-0.81)	(-0.866)
$set_{t-2} \times inter_t^j$	-32.38*	-49.26**	-64.02*	-79.98***	-149.44***	-172.7***	-78.48***	-144.04***	-196.97***	-256.71***	-419.52***	-561.89***
	(-1.899)	(-2.351)	(-1.656)	(-4.366)	(-3.287)	(-4.524)	(-3.12)	(-4.128)	(-3.805)	(-5.241)	(-4.311)	(-5.206)
$\Delta\sigma_{t-2}^{set} \times inter_t^j$	0.01	0.01	0.02	0.37	-1.67*	0.89	1.38**	1.73*	2.11*	1.17	1.9*	2.54
	(0.017)	(0.028)	(0.03)	(0.744)	(-1.545)	(0.882)	(2.259)	(1.897)	(1.828)	(0.902)	(1.368)	(0.892)
$\Delta turn \times inter_t^j$	-285.95	-308.81	-328.8	-475.06	-1829.42*	-1133.91	-1436.42	-2287.61*	-3159.66*	-89.31	-381.09	-636.24
	(-0.442)	(-0.411)	(-0.223)	(-0.643)	(-1.686)	(-0.728)	(-1.152)	(-1.444)	(-1.475)	(-0.051)	(-0.125)	(-0.164)
$\Delta mis_t^j \times inter_t^j$	15.33	24.73	32.96	-133.77	-126.57	-313.78	-169.04	-254.48	-362.55	738.43	1210.83	1623.94
	(0.686)	(0.601)	(0.675)	(-0.902)	(-0.565)	(-0.989)	(-0.452)	(-0.704)	(-0.62)	(1.064)	(1.111)	(1.062)
$\bar{R}^2$	0.67	0.63	0.62	0.75	0.44	0.75	0.80	0.83	0.83	0.61	0.61	0.61
aic	5.15	6.16	6.75	5.82	7.58	7.35	6.46	7.17	7.72	7.88	8.87	9.46
adj. Med.	W		W		W		W		W		W	

Source: created for this study