Determinants of New Taiwan Dollar Interest Rate Swap Spreads

新台幣利率交換之決定因素

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Determinants of New Taiwan Dollar Interest Rate Swap Spreads

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Abstract

This study examines the determinants of New Taiwan Dollar interest rate swap spreads. Prior literature provides evidence that the term structure of interest rates, liquidity, and credit risk comprise the swap spreads. The empirical results for the full sample period show that these factors are all important in affecting the swap spreads and that default risk is the most important factor among the five components. Furthermore, default risk plays a more important role than other factors in a bear market, but the key factor varies with the maturities of swap contracts in a bull market.

Key words: Swap spreads, term structure of interest rates, liquidity risk, credit risk, market conditions

I. Introduction

The purpose of this paper is to explore the determinants of interest rate swap spreads in the New Taiwan Dollar (NTD). Interest rate swaps are important tools for managing interest rate risk in financial markets. The interest rate swap spread (hereafter referred to as swap spread) is the difference between the fixed-rate paid on an interest-rate swap over the yield of a government bond of similar maturity. Variations in swap spreads reflect the different types of market information. Therefore, understanding the determinants of swap spreads is helpful for traders developing trading strategies and pricing derivative products (see Poskitt (2007)).[1]

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1 The emerging government bond markets are illiquidity. Hence, no baseline interest rate exists as a reference for the pricing of derivatives. Because the interest rate swap market is liquid, Poskitt (2007) indicates that the swap rate can be used as the basic reference index for pricing. Bhansali et al. (2009)

More importantly, a current trend in international financial regulation is in enhancing the transparency and institutionalization of over-the-counter (OTC) derivatives, such as interest rate swaps. The objective is to gradually advance information reporting, matching, clearing centralization, and central counterparty clearing. Taiwan's governing authorities and related financial institutions have recently conducted research on regulations for disclosure, reporting, and matching for OTC derivatives, especially for interest rate swap contracts (Chou et al. (2010)).[2] Thus, exploration of this issue will provide regulators and research institutions with an understanding of the sources of risk for swap spreads.

Previous research indicates that the main factors affecting interest rate swap spreads are the interest rate level, the slope of the yield curve, interest rate volatility, liquidity risk, and default risk (Lekkos and Milas (2001), Fang and Muljono (2003), Asgharian and Karlsson (2008), Huang et al. (2008), and Chung and Chan (2010)). However, the data used by previous studies are from various countries, and there is no consistent conclusion for these variables. This finding shows that the factors driving swap spreads may be different because of the particular characteristics of different markets. In addition, previous studies have examined the determinants of swap spreads in mature markets, such as those in Europe and the United States. However, few studies explore the determinants of swap spreads in emerging markets. Data from the Central Bank of the Republic of China (Taiwan) show that the trading volume of the NTD swap contracts is growing. In particular, the trading volume of NTD swap contracts increased sharply after the subprime mortgage crisis.[3] Thus, the trading and hedging demand of interest rate swaps has become an important issue that cannot be ignored by academic research. However, no studies have explored the determinants of NTD interest rate swap spreads. Hence, this paper attempts to fill the gap.

Previous studies have examined whether determinants for swap spreads are affected by different interest rate slope regimes and interest rate volatility regimes. For example, Lekko and Milas (2004) and Huang et al. (2008) investigate whether the determinants of swap spreads change under different interest rate regimes. However, Lucas and Klaassen (2006) indicate that a higher default probability exists in a bear market than in a bull market. Alexander and Kaeck (2008) examine the determinants of credit default swap spreads and find that the explanatory power of determinants for credit default swap spreads is higher during a period of high volatility of credit default swap spreads. Chen (2009) and Henry (2009) suggest that bull and bear stock markets can appropriately describe the economic growth and recession of the

also report that investors use the interest rate swap market as interest rate hedging or investing. Therefore, understanding the interest rate swap spread can be helpful for investors using the interest rate swap as a market tool for pricing, hedging, and investing.

2 See Chou et al. (2010) "OTC Derivatives Centralized Transaction and Settlement System Feasibility Analysis," MOEA Department of Industrial Technology outsourced research program.

3 See the financial statistics of the Central Bank of the Republic of China (Taiwan): http://www.cbc.gov.tw/.

overall economy. However, no research has been conducted on the influence of economic conditions on the determinants of swap spreads. Therefore, in line with the research conducted by Chen (2009) and Henry (2009), this paper uses the Markov switching model to estimate bull and bear regimes of the stock market and uses the bull and bear regimes of the stock market as the proxies of economic conditions. This study examines whether the determinants of swap spreads change under different market conditions.

The empirical results of this study show that the interest rate level, yield curve slope, interest rate volatility, liquidity risk, and default risk are important factors in explaining swap spreads for the full sample. In addition, the results also show that the slope of the yield curve contains different information across the maturity of swap spreads. The empirical results for variance decomposition show that the most important factor for 1-year swap spreads is the interest rate slope, whereas the most important factor for 2-year to 10-year swap spreads is the default risk. Our empirical results also show that the regression coefficients during bear markets are all significantly different from zero, and these results are similar to those of the full sample. However, during bull markets, only three factors, namely, the interest rate level, the slope of the yield curve, and default risk, are significantly different from zero. Furthermore, for the model's explanatory power (adjusted R^2), the five factors can explain swap spread variations in a bear market more adequately, compared to in a bull market, over the same maturity of swap contracts. Finally, the results of the variance decompositions show that default risk is the most important explanatory factor for swap spreads in a bear market. The most important factor for explaining swap spreads varies with maturities of swap contracts in a bull market.

This study contributes to the literature in three ways. First, this paper is one of the few studies that explore determinants of interest rate swap spreads by using data from an emerging market. Changes in the interest rates of bond markets caused by shocks are greater in emerging markets because of a lack of market depth. Thus, interest rate swaps are not only hedging tools used by manufacturers, banks, and investors, but are important indicators of interest rates for traders. Furthermore, understanding the determinants of swap spreads is helpful for regulators and policymakers in risk management. Second, with the exception of the study by Bhansali et al. (2009), no research examined the determinants of swap spreads during the subprime mortgage crisis. To fill the gap, the present study uses a sample period from November 1, 2006 to October 27, 2009, which covers the period before and after the subprime mortgage crisis, to examine the determinants of swap spreads. In addition, the sample period provides an opportunity to investigate whether market conditions affect the determinants of swap spreads. Finally, our approach for differentiating market regimes is different from those used by Lekko and Milas (2004) and Huang et al. (2008). In line with the approach used by Chen (2009) and Henry (2009), this paper uses the Markov switching model to estimate bull and bear stock markets and to investigate the determinants of swap spreads under different conditions.

Our empirical results can provide additional information for investors and policymakers.

The remainder of this study is organized as follows: Section II presents the literature review and research hypotheses; Section III provides on the operational definitions of variables, the data sources, and the research methodology; Section IV reports the empirical results; and lastly, Section V draws the main conclusions.

II. Literature Review and Research Hypotheses

This section provides the literature review and develops the hypotheses. Previous studies have indicated that factors influencing swap spreads include the interest rate level, slope, interest rate volatility, the liquidity risk, and default risk, and are individually explored below.

A large volume of extant research has focused on the impact of interest rate levels on swap spreads, but the empirical evidence does not present a consistent conclusion. Lekkos and Milas (2001) argue that a low interest rate is indicative of unfavorable economic prospects and high uncertainty, causing the default risk to rise. Therefore, the interest rate level has a negative relationship with swap spreads. The empirical results indicated by Lekkos and Milas (2001) show a negative relationship between swap spreads and interest rate levels, and the empirical results support this argument. Using data from the Australian swap market, Brown et al. (2002) find a negative relationship between interest rate levels and swap spreads. Similarly, using data from the U.S. swap market, In et al. (2003) present a negative relationship between interest rate levels and swap spreads. Conversely, Chung and Chan (2010) argue that the relationship between interest rate levels and swap spreads should be positive if investors use interest rate swaps to manage interest rate risks. Thus, when investors expect interest rates to rise, they are willing to pay a fixed swap rate and receive a floating interest, and vice versa. When investors expect the interest rate to rise, they are willing to pay a higher fixed interest rate in exchange for a future floating interest rate. Accordingly, when investors expect the interest rate to increase, thereby raising the swap rate, if the interest rates on government bonds remain relatively stable, the swap spread increases. Conversely, when investors expect the interest rate to decrease, thus reducing the swap rate, if the government bond interest rates remain stable, the swap spread declines. Chung and Chan (2010) conduct an analysis of the U.S. swap market, and their empirical results indicate a positive relationship between interest rate levels and swap spreads. However, Fang and Muljono (2003) argue that the relationship between the interest rate level and the swap spread is unclear. Fang and Muljono (2003) indicate that when interest rates rise, swap rates rise as well. However, whether the increase in the swap rate is actually higher than that in the interest rate levels remains unclear. Therefore, the impact of an increase in the interest rate on swap spreads cannot be determined. Based on these arguments, this study hypothesizes that the effect of the interest rate level on a spread swap cannot be determined. Hypothesis 1 is as follows:

Hypothesis 1: The expected sign of the relationship between swap spreads and interest rate levels is positive or negative.

Prior research has suggested that the slope of the term structure of interest rates is an important factor in determining swap spreads (Minton (1997), Lekkos and Milas (2001), and Chung and Chan (2010)). However, empirical studies do not provide a consistent conclusion. Minton (1997) conducts an empirical analysis of the U.S. swap market, and the results show that the slope of the yield curve has a significantly positive effect on short-term swap spreads. Lekkos and Milas (2001) analyze empirical evidence from the U.S. and U.K. swap markets, and the results show that the slope of the yield curve has a positive effect on short-term swap spreads and a negative effect on long-term swap spreads. Using data from the Australian swap market, Brown et al. (2002) show that the slope of the yield curve has a negative relationship with swap spreads. Using data from the U.S. swap market, In et al. (2003) demonstrate that the relationship between the slope of the yield curve and swap spread is negative. Fehle (2003) conducts an empirical analysis of interest rate swaps using data from international swap markets, and the results show a negative effect of the slope of the yield curve on swap spreads. Similarly, Fang and Muljono (2003) analyze the Australian swap market and find a negative effect of the slope of the yield curve on swap spreads. Asgharian and Karlsson (2008) also find a negative relationship between the yield curve slope and swap spreads. However, utilizing data from the Japanese swap market, Huang et al. (2008) present a positive relationship between the slope of the yield curve and swap spreads. Using data from the U.S. swap market, Chung and Chan (2010) provide evidence that the impact of the slope on swap spreads is mostly positive, but occasionally negative.

In summary, if the slope of the yield curve is found to have a negative effect on swap spreads, then the explanations tend to link this relation to default risk (Sorensen and Bollier (1994) and Lekkos and Milas (2001)).[4] In contrast, previous studies explain that if the relationship between the slope of the yield curve and swap spread is positive, the slope of the term structure of interest rates does not contain default risk (Chung and Chan (2010)). Lekkos and Milas (2001) report that a long-term swap spread has a negative relationship with the slope of the term structure of interest rates, and that the opposite relationship is

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4 Sorensen and Bollier (1994) argue that the credit risk between the two parties is asymmetric and can be explained using the option pricing model. Sorensen and Bollier (1994) suggest that because the shape and volatility of the yield curve influence the option price of the replacement cost of swaps, the pricing of the default risk is influenced by the current volatility and slope of the yield curve. When the slope of the yield curve is positive, the trader with the right to receive a fixed interest rate has a less valuable option than the trader paying the fixed interest, because the forward rates are higher than the current rates. In this situation, the investor paying the fixed rate faces a higher default risk. Thus, the investor paying the fixed rate requires a lower fixed swap rate to compensate for this risk.

found for short-term swap spreads. Lekkos and Milas (2001) suggest that a steepening of the yield curve is an indicator of favorable economic conditions; thus, the default probability is relatively low. Accordingly, the relationship between the slope of the yield curve and the swap spread is negative. In the short term, however, this means that floating-rate payers face higher interest rates without fully benefiting from the expanding economy because actual improvements in business conditions typically occur with a considerable lag. Hence, floating-rate payers require higher swap rates to compensate for this loss. In this case, investors no longer focus on default risk. Hence, the relationship between short-term swap spreads and the slope of the yield curve is positive. Chung and Chan (2010) suggest that if the slope of the yield curve represents as implied forward rates, investors are willing to pay higher a swap rate in exchange for future floating interest rates. Therefore, the swap spread has a positive relationship with the slope of the yield curve.[5] Thus, Hypothesis 2 is as follows:

Hypothesis 2: If the slope of the term structure of interest rates implies default risk, then the effect of the slope of the yield curve on the swap spread is negative; conversely, if the slope of the term structure of interest rates does not imply default risk, then the impact of the slope of the yield curve on the swap spread is positive.

Previous studies have proposed two explanations for the positive relationship between interest rate volatility and swap spreads. First, higher interest rate volatility indicates greater uncertainty and higher default risk. Hence, a positive relationship exists between the swap spread and interest rate volatility (Borensen and Bollier (1994)).[6] Second, when interest rates become more volatile, the demand to hedge the interest rate exposure by derivatives will increase as well, thus increasing the demand for swaps. The rising demand for “fixing” the interest rate by swaps will in turn push swap rates to be higher and hence causing the spreads to increase (Fang and Muljono (2003)). Using data from the U.S. and U.K. swap markets, Lekkos and Milas (2001) show that the impact of interest rate volatility on swap spreads is unclear, and that the effect of interest rate volatility on swap spreads varies with maturities. Using data from

5 Chung and Chan (2010) show that if the slope of the yield rate is explained as an implied forward rate, then the swap spread and the slope of the yield curve have a positive relationship. A steepening slope for the yield curve indicates that the implied forward rate will rise. A flat slope for the yield curve indicates that the implied forward rate will decline. Therefore, when the slope of the yield curve rises, it indicates that the implied forward rates will rise and, with no consideration of default risk, the investor is willing to pay a slightly higher fixed rate in exchange for a future floating rate to hedge interest rate risks. Then, the swap spread increases. The reverse is also true.

6 According to Sorensen and Bollier (1994), when interest rate volatility increases, the value of the option by the parties of swap contracts should also increase by equal amounts if their credit ratings are equal. However, in practice, the investor with the lower credit quality typically reduces the cost of the fixed rate through an interest rate swap. Thus, if the volatility increases, the value of the option for the higher credit quality investor (as a fixed-rate receiver) increases. To compensate for this increase, the high credit quality investor then demands a higher coupon rate (premium). Subsequently, this causes the swap spread to increase.

the Australian swap market, Brown et al. (2002) find an insignificant influence for interest rate volatility on swap spreads. Using data from the U.S. swap market, In et al. (2003) present a positive relationship between interest rate volatility and swap spreads. In an empirical study on the Australian swap market, Fang and Muljono (2003) find that the relationship between interest rate volatility and swap spreads is positive. Using data from the U.S. swap market, Asgharian and Karlsson (2008) show a positive relationship between interest rate volatility and swap spreads. Huang et al. (2008) examine the Japanese swap market, and also show a positive relationship between interest rate volatility and swap spreads, and that interest rate volatility has a great effect on short-term swap spreads. Using data from the U.S. swap market, Chung and Chan (2010) find a positive relationship for the effect of interest rate volatility on swap spreads. Therefore, Hypothesis 3 is as follows:

Hypothesis 3: The relationship between interest rate volatility and swap spreads is positive.

In addition to examining the impact of the term structure of interest rates on swap spreads, prior literature also indicates that liquidity risk is an important factor influencing swap spreads. Grinblatt (2001) suggests that when the liquidity of the government bond market increases, the swap rate should increase to compensate for the risk of holding interest rate swaps of relatively insufficient liquidity. Therefore, Grinblatt (2001) presents that the relationship between liquidity risk and swap spreads is positive. Numerous empirical studies have reinforced this argument. Lekkos and Milas (2001) analyze data from the U.S. and U.K. swap markets, and their results support the argument suggested by Grinblatt (2001). In addition, Lekkos and Milas (2001) also show that the impact of liquidity risk is greater for short-term interest rate swaps. Utilizing data from the Australian swap market, Brown et al. (2002) present a positive effect of liquidity risk on swap spreads. Using data from the U.S. swap market, In et al. (2003) show a positive relationship between liquidity risk and swap spreads. Fang and Muljono (2003) find that the impact of liquidity risk on swap spreads is insignificant in the Australian swap market. Using data from the U.S. swap market, Liu et al. (2006) suggest that liquidity risk is an important factor for determining swap spreads. In addition, Liu et al. (2006) show that liquidity risk changes over time. Using data from the Japanese swap market, Huang et al. (2008) present that liquidity risk affects swap spreads positively. Using data from the U.S. swap market, Chung and Chan (2010) also find the relationship between liquidity risk and swap spreads to be positive. Thus, Hypothesis 4 is as follows:

Hypothesis 4: A positive relationship exists between swap spreads and liquidity risk.

The final determinant of interest rate swap spreads is default risk. Previous studies have all been based on the argument by Sorensen and Bollier (1994), and have conducted empirical analyses on how default risk affects swap spreads.[7] Sorensen and Bollier (1994) suggest that the credit risk between the two parties in an interest rate swap is asymmetric, and that the relationship between credit risk and swap spreads can be explained using the options pricing model. Sorensen and Bollier (1994) indicate that the relationship between default risk and swap spreads is positive. Minton (1997) conducts an empirical analysis of the U.S. swap market, and results show a positive relationship between default risk and swap spreads. Using data from the U.S. swap market, Duffie and Singleton (1997) show that default risk only affects 10-year swap spreads. Utilizing data from the U.S. and U.K. swap markets, Lekkos and Milas (2001) present that swap spreads for the U.S. swap market have a negative relationship with default risk, whereas swap spreads in the U.K. have a positive relationship with default risk. Using data from the Australian swap market, Brown et al. (2002) find the impact of default risk on swap spreads to be positive. Using data from the U.S. swap market, In et al. (2003) also present a positive relationship between default risk and swap spreads. Using data from the Australian swap market, Fang and Muljono (2003) suggest a positive relationship between default risk and swap spreads. Liu et al. (2006) indicate that default risk is an important determinant of swap spreads, and that default risk changes over time. Utilizing data from the Japanese swap market, Huang et al. (2008) show that the effect of default risk on swap spreads varies with the regimes of interest rate volatility. By analyzing data from the U.S., Chung and Chan (2010) find the effect of default risk on swap spreads to be mostly positive, but occasionally negative. Hence, Hypothesis 5 is as follows:

Hypothesis 5: A positive relationship exists between swap spread and default risk.

III. Definitions of Variables, Data Set, and Research Methodology

This section defines operational variables according to prior studies, provides an explanation of the data sources, and introduces the research methodology.

A. Definitions of Variables

A.1. Swap Spread

Previous studies, such as those by Minton (1997), Lekkos and Milas (2001), Brown et al. (2002), In et al. (2003), Huang et al. (2008), and Chung and Chan

[7] Johannes and Sundaresan (2007) explore how the two systems of mark-to-market and collateral influence swap spreads. The purpose of these two measures is to lower the default risk. Johannes and Sundaresan (2007) find that the enactment of these two systems increases swap rates and swap spreads (page 385).

(2010), calculate the swap spread as the difference between the swap rate and the government bond rate of comparable maturity. The present study uses the same approach to calculate the swap spreads.

A.2. Interest Rate Level

In line with Lekkos and Milas (2001), Brown et al. (2002), In et al. (2003), Fang and Muljono (2003), and In et al. (2004), this paper uses the 3-month risk-free rate as the proxy for the interest rate level. Although the interest rate level of the Nelson-Siegel (NS) model and the Nelson-Siegel-Svensson (NSS) model can also be used as a proxy for the interest rate level, Fang and Muljono (2003) indicate that the interest rate level estimated by the NS and NSS models is a long-term interest rate, and long-term interest rates usually adjust to equilibrium implied by short-term interest rates. Hence, using short-term interest rates as a proxy for interest rate levels is more appropriate.[8]

A.3. Slope of the Yield Curve

According to Minton (1997), Lekkos and Milas (2001), In et al. (2003, 2004), Huang et al. (2008), and Chung and Chan (2010), this paper uses the long-term interest rate minus the short-term interest rate as the proxy for the slope of the yield curve. This study uses the 3-month interest rate as the proxy for the interest rate level. To reduce problems of collinearity, the 2-year government bond rate is used as a proxy for the short-term interest rate to calculate the slope of the yield curve.[9] Hence, this study calculates the slope of the yield curve as the difference between 10-year and 2-year government bond rates. Huang et al. (2008) and Chung and Chan (2010) also use the difference between 10-year and 2-year interest rates as the proxy for the slope of the yield curve.

A.4. Interest Rate Volatility

Previous studies use the square of the difference of short-term interest rates as the proxy for interest rate volatility. Thus, in line with Minton (1997), Lekkos and Milas (2001), In et al. (2003, 2004), and Chung and Chan (2010), this study uses the square of the difference in the 3-month risk-free rate as the proxy for interest rate volatility.

A.5. Liquidity Risk

To measure liquidity risk, previous studies such as those by Grinblatt (2001), Lekkos and Milas (2001), In et al. (2003, 2004), Huang et al. (2008), and Chung and Chan (2010) use the difference between the LIBOR rate and the short-term government bond rate as the proxy for liquidity risk. In line with Grinblatt (2001), Lekkos and Milas (2001), In et al. (2003, 2004), and Chung and Chan (2010), this study uses the difference between the 3-month LIBOR rate and the

[8] The authors thank the reviewer for this suggestion.
[9] The authors thank the reviewer for this suggestion.

3-month government bond rate as the proxy for liquidity risk.[10]

A.6. Default Risk

Empirical studies, such as those by Minton (1997), Lekkos and Milas (2001), Brown et al. (2002), Fang and Muljono (2003), In et al. (2004), Huang et al. (2008), and Chung and Chan (2010), use the difference between corporate and government bond interest rates of the same maturity as the proxy for default risk. In addition, Minton (1997) and Chung and Chan (2010) also consider the effects of the term structure of default risk in the regression model. Therefore, this study follows the approach of Minton (1997) and Chung and Chan (2010) and uses the tw-BBB corporate bond interest rate in maturity (m) minus the corporate bond interest rate of the same maturity as the proxy for default risk.[11]

B. Data Sources

The sample period in this study is between November 1, 2006, and October 27, 2009, comprising 743 trading days. In the NTD swap market, interest rate swap contracts currently include maturities of 1, 2, 3, 4, 5, 7, and 10 years. Daily swap rates are obtained from the Datastream database. Government bond rates for each maturity and the 3-month LIBOR rate are obtained from the CMoney database.[12] The tw-BBB corporate bond interest rates are provided by the TEJ database.

C. Research Methodology

Following Brown et al. (2002), In et al. (2003), Fang and Muljono (2003), and Chung and Chan (2010), and this paper uses the ordinary least squares (OLS) regression model to explore the impact of the interest rate level, yield curve slope, interest rate volatility, liquidity risk, and default risk on swap spreads. The regression model is presented as follows (see In et al. (2003))[13,14]:

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10 Another indicator for measuring liquidity risk is the term structure of the liquidity premium. However, previous studies have not used the term structure of the liquidity premium to examine the impact of liquidity risk on swap spreads. To enable a comparison with prior studies, this study does not consider the term structure of liquidity risk premium in the model. Future studies can explore how the term structure of the liquidity premium affects swap spreads. The authors are grateful to the reviewer for providing this valuable suggestion.

11 Minton (1997) defines the aggregate default spread as the same maturity of difference of the BAA corporate bond and government bond rates and uses this spread as the proxy for default risk.

12 Because the government bond rates cannot be obtained directly through the bond market, this study constructs the term structure of government bond rates using the NSS model. The authors thank the reviewer for highlighting this point.

13 To ensure that all variables are stationary, all variables are differenced in this paper.

14 Before analyzing the determinants of swap spreads, this study estimates the correlation coefficients of each variable. The results show that a high correlation exists between some variables; thus, regression analysis would generate potential collinearity problems. To reduce potential collinearity, the variables are processed in the order below.

Step 1: Default risk

As mentioned by the reviewer, default risk and liquidity risk may include duplicate information. Moreover, in the correlation matrix, the default risk and the yield curve slope have a high correlation

$$\Delta SS_{m,t} = \beta_{m,0} + \beta_{m,1}\Delta Level_t + \beta_{m,2}\Delta Slope_t + \beta_{m,3}\Delta Vol_t + \beta_{m,4}\Delta Liq_t + \beta_{m,5}\Delta Default_{m,t} + \beta_{m,6}\Delta SS_{m,t-1} + \varepsilon_{m,t} \quad (1)$$

where $\Delta SS_{m,t}$ is the difference of swap spreads at maturity *m* in period *t*, $\Delta Level_t$ is the difference of the interest rate level in period *t*, $\Delta Slope_t$ is the difference of the slope in period *t*, and ΔVol_t is the difference of the interest rate volatility in period *t*. ΔLiq_t is the difference of the liquidity risk premium in period *t*, and $\Delta Default_{m,t}$ is the difference of the default risk premium at maturity *m* in period *t*. To avoid the autocorrelation of regression residuals, this study includes one lagged period $\Delta SS_{m,t-1}$ to the regression model. $\varepsilon_{m,t}$ is the residual at maturity *m* in period *t*. Although prior studies use OLS to examine the determinants of interest rate swap spreads, the correlations between swap spreads with various maturities are ignored. To address this issue, this study also uses the seemingly unrelated regression (SUR) model, which considers correlations between the swap spreads with various maturities, to investigate the determinants of swap spreads.

Using the OLS and the SUR methods enable us to examine the effects of variables on swap spreads, but it could not identify the most influential factor in swap spreads. To overcome this problem, following Duffie and Singleton (1997), Lekkos and Milas (2001), and In et al. (2004), this study uses the variance decomposition of vector autoregression (VAR) to examine the importance of variables. For variance decomposition, the ordering that the variables are placed in affects the estimation results. Thus, this paper uses the variable ordering as suggested by Lekkos and Milas (2001) to conduct VAR variance decomposition. The VAR model variable ordering is as follows:

coefficient for 1 to 3-year and 7 to 10-year maturities. Both correlations are higher than 0.30. Thus, this study estimates the following regression and extracts the residual as the proxy for default risk: ΔDefault(m) = a + b × ΔSlope + c × ΔLiq + u, m = 1, 2, and 3-year maturities and 7- and 10-year maturities. Furthermore, the correlation coefficient for the default risk and the slope of the yield curve for 4- and 5-year maturities is extremely low. Therefore, as suggested by the reviewer, we only remove data that contained duplicate information regarding default risk and liquidity risk. We estimate the following regression and extract the residual as the proxy for the default risk: ΔDefault(m) = a + b × ΔLiq+u, m = 4 and 5-year maturities.

Step 2: Liquidity risk

This study finds that the correlation coefficient between the liquidity risk and the interest rate level is high at approximately -0.96. Therefore, we estimate the following regression and extract the residual as the proxy for liquidity risk: ΔLiq = a + b × ΔLevel + u.

Step 3: Slope of the yield curve

In the correlation matrix, a high correlation coefficient is found to exist between the slope of the yield curve and interest rate level at approximately -0.31. Therefore, we estimate the following regression and extract the residual as the proxy for the slope of the yield curve: ΔSlope = a + b × ΔLevel + u.

In these adjustments, except for the -0.24 correlation coefficient between default risk and liquidity risk in 1-year maturity, none of the correlation coefficients between the variables are higher than the absolute value of 0.15 (most are of the absolute value 0.1 and below). Hence, problems of collinearity reduce after the adjustments. The authors thank the referee for this insightful suggestion.

$$y_t = [\Delta Level_t, \Delta Slope_t, \Delta Vol_t, \Delta Liq_t, \Delta Default_{m,t}, \Delta SS_{m,t}] \quad (2)$$

Each variable is identical to those in Eq. (1). Variance decomposition is used to interpret the variance of the forecasting error of each variable from the proportion of its own innovation and those of other variables. The proportion of the innovations can be used to determine the importance and degree of influence of each variable in the system. A higher proportion value of a certain variable in variance decomposition indicates that the variable is more important in the system.

IV. Empirical Results

A. Descriptive Statistics

Table I displays the descriptive statistics and unit root tests of the variables employed in this study. Panel A shows that the increase in swap contract maturity accompanies the decrease in swap spreads. Bhansali et al. (2009) indicate that when liquidity risk occurs, short-term swap spreads are higher than long-term swap spreads. Nippani and Smith (2010) find long-term swap spreads to be negative during the subprime mortgage crisis. Because the sample period of the paper covers the subprime mortgage crisis, the results of Panel A may be caused by the subprime mortgage crisis. For unit root tests of swap spreads, the null hypothesis for the level of swap spreads cannot be rejected, indicating that the level of swap spreads is non-stationary. For the first order difference, all the variables reject the null hypothesis, suggesting that all the variables are stationary. Panel B presents the default risk premiums. The results of Panel B show that the mean values of the default risk premiums appear to be highly stable. The 1-year default risk premium is slightly higher than the 10-year default risk premium.[15] In addition, for the unit root tests of the default risk premium, the level of the default risk premium cannot reject the null hypothesis. For the first order difference, all the default risk premiums are stationary. Panel C reports the descriptive statistics and unit root tests for interest rate level, the

[15] In the subprime mortgage crisis, the lack of liquidity can be observed in the international financial markets. To rescue financial institutions and stimulate the economy, the many central banks around the world all greatly reduce short-term interest rates, leading to a large decline in short-term interest rates. In addition, during the subprime mortgage crisis, investors were concerned with budget deficits for governments and the possibility of their default; thus, investors require a higher interest rate for long-term government bonds. As indicated by Nippani and Smith (2010), during the subprime mortgage crisis, investors were concern with the possibility of government default; thus, long-term government bond rates increased. This study finds that a similar phenomenon occurred in Taiwan. During the subprime mortgage crisis, short-term rates decreased by a substantially greater amount than that of long-term rates in Taiwan. The definition of default risk in this study is the BBB corporate bond rate minus the government bond rate for the same maturity. According to this analysis, the short-term default risk premium was substantially higher than the long-term default risk premium during the subprime mortgage crisis. Thus, the average 1-year default risk premium was higher than the 10-year default risk premium.

slope of yield curve, interest rate volatility, and liquidity risk premium. The results show that all the variables are stationary for the first order difference.

Table I
Descriptive Statistics and Unit Root Test

The interest rate swap spread is the swap rate for maturity (m) minus the government bond rate of the same maturity. The default risk premium is the tw-BBB corporate bond rate for maturity (m) minus the government bond rate of the same maturity. The interest rate level is the 3-month risk-free rate. The slope of the yield curve is the 10-year government bond rate minus the 2-year government bond rate. Interest rate volatility is the square of the difference in the 3-month risk-free rate. Liquidity risk premium is the 3-month LIBOR rate minus the 3-month risk-free rate.
* indicates 10% significance, ** indicates 5% significance, and *** indicates 1% significance.

	Panel A: Interest rate swap spread						
	1-year	2-year	3-year	4-year	5-year	7-year	10-year
Mean	0.0036	0.0027	0.0021	0.0017	0.0015	0.0012	0.0013
Standard deviation	0.0023	0.0021	0.0021	0.0019	0.0017	0.0014	0.0017
Level ADF	-2.7302	-2.5693	-2.0385	-1.6609	-1.4812	-1.6262	-2.0078
Difference ADF	-15.6743***	-16.0590***	-15.8870***	-15.0505***	-14.7236***	-14.1254***	-13.8947***

	Panel B: Default risk premium						
	1-year	2-year	3-year	4-year	5-year	7-year	10-year
Mean	0.0109	0.0100	0.0095	0.0090	0.0088	0.0092	0.0101
Standard deviation	0.0068	0.0065	0.0058	0.0051	0.0044	0.0036	0.0030
Level ADF	-2.3581	-2.2090	-2.1810	-2.1895	-2.2247	-2.2956	-2.1772
Difference ADF	-15.4379***	-15.5040***	-14.2991***	-13.7331***	-13.7504***	-13.8373***	-13.9021***

	Panel C: Other variables			
	Interest rate level	Slope of the yield curve	Interest rate volatility × 100	Liquidity risk premium
Mean	0.0123	0.0063	0.0001	0.0040
Standard deviation	0.0070	0.0048	0.0002	0.0019
Level ADF	-1.6079	-1.9562	-8.5022***	-3.0233
Difference ADF	-16.5081***	-15.4040***	-20.5367***	-19.1844***

Figure 1 displays time series patterns of the interest rate swap spreads. The results indicate that the volatility of short-term interest rate swap spreads is higher than that of long-term interest rate swap spreads. In addition, the long-term interest rate swap spread from January 2009 to May 2009 is negative. This result may be because, to accommodate long-term debt management, investors sell a large amount of long-term interest rate swaps to effectuate a substantial drop in the swap rate, leading to a negative value of the swap spread (Bhansali et al. (2009)). Another possible explanation is that investors are concerned with the governments' ability to repay national debt (Nippani and Smith (2010)). These two explanations can explain why the swap spreads of short-term contracts are higher than that of long-term contracts (see also Table I). Figure 2 displays time series patterns of the interest rate level, the slope of the yield curve, and the interest rate volatility. The results indicate that the interest rate level declines gradually after November 2008. This may be attributed to the subprime mortgage crisis because the central bank gradually reduced the interest rates to stimulate the economy. In addition, Figure 2 also shows that after November 2008, the slope of the yield curve gradually increases. This finding indicates that with economic stimulation through government policy, investors expected the economy to recover gradually after the financial tsunami. Figure 3 shows the default risk premium, revealing a sharp rise in the default risk premium after November 2008. Figure 4 shows the liquidity risk premium. The results indicate that, except for the period of March to June 2008, the liquidity risk premium remains steady. Overall, Figures 2 and 3 indicate that after the subprime mortgage crisis, sharp changes occurred in interest rate levels, yield curve slope, and default risk.

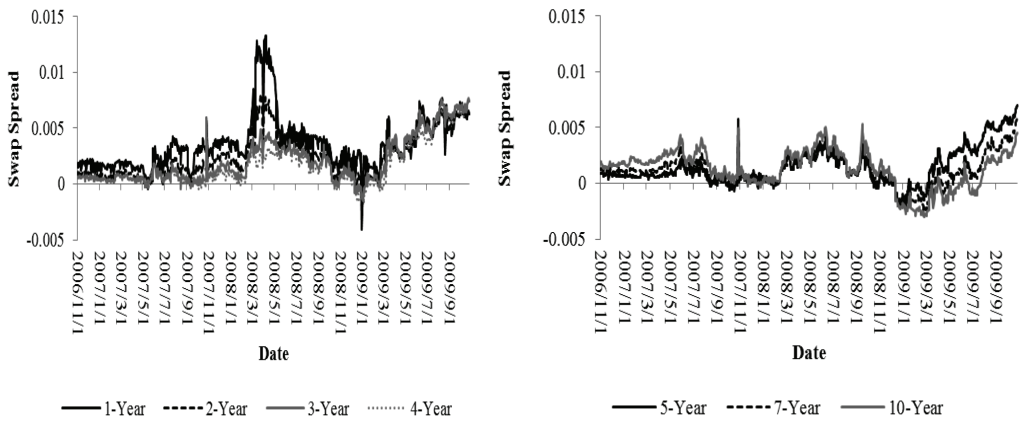

Figure 1. Interest rate swap spreads.

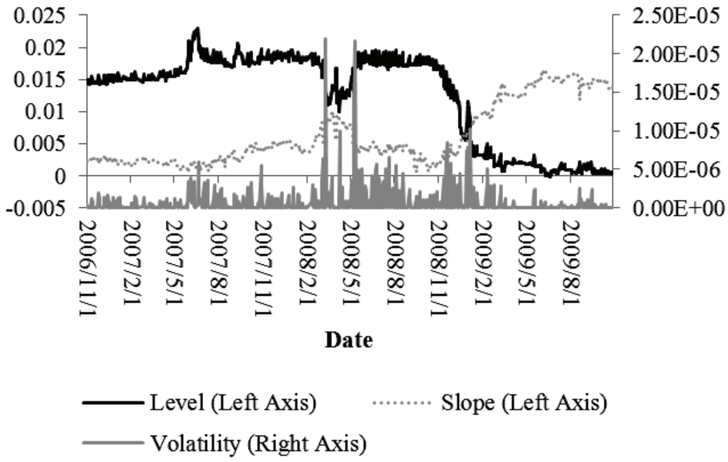

Figure 2. Interest rate variables.

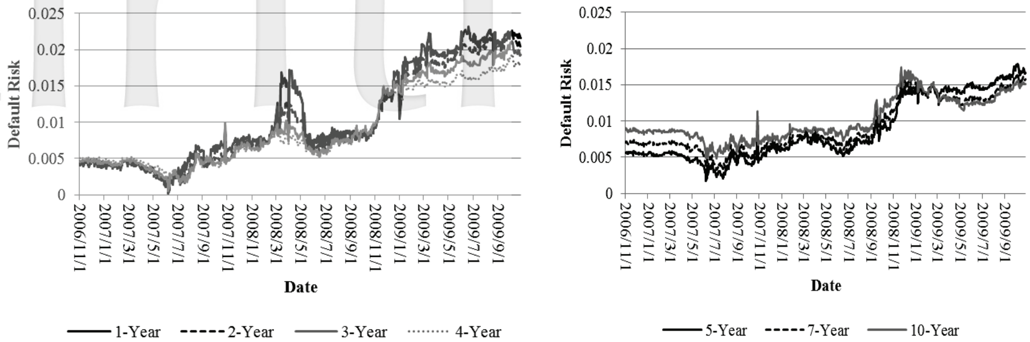

Figure 3. Default risk premium.

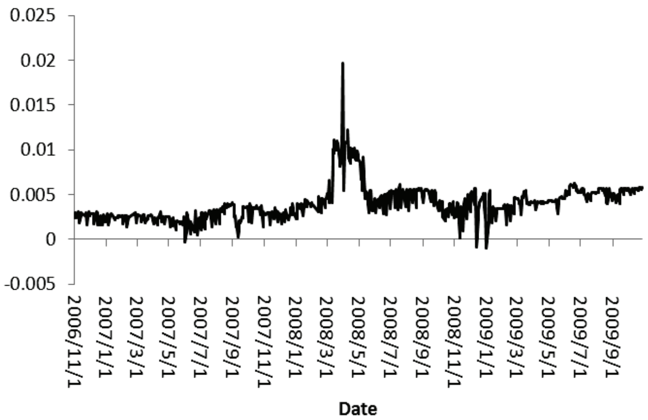

Figure 4. Liquidity risk premium.

B. OLS and SUR Estimation Results

Table II displays the impact of the term structure of interest rates, liquidity risk, and default risk on swap spreads. Panels A and B are the OLS estimation results and the SUR estimation results, respectively. A comparison of Panel A with Panel B reveals that the significance of the coefficient estimated by SUR is slightly higher than that by OLS. However, the conclusions of the OLS are similar to those of the SUR. Thus, for the regression coefficients, this study focuses on the SUR results. Nevertheless, the results of the SUR do not provide values for adjusted R^2. The results of the OLS provide the adjusted R^2. Hence, this paper also focuses on the adjusted R^2 of the OLS and complements the SUR results. In Panel B, most of the coefficients are significant at the 10% level, indicating that the variables considered in this study are significantly influential in the determination of swap spreads. The results for the effects of the term structure of interest rates are discussed first. For short-term (1- to 2-year) and long-term (10-year) interest rate swaps, the effect of the interest rate level on swap spreads is negative, and the influence of the interest rate level on mid-term (3 to 5 years) swap spreads is positive. These findings are consistent with

Hypothesis 1, that is, the effect of the interest rate level on swap spreads may be positive or negative. This result indicates that when interest rates rise, the swap rates also increase. However, whether the increase in the swap rate is higher than the increase in the interest rate level cannot be determined. This result is consistent with the argument by Fang and Muljono (2003). Empirical results provide investors with important information, that is, when interest rate levels increase, the short-term (1 to 2 years) and long-term (10 years) swap rates also increase. However, the increase in the swap rate is smaller than the increase in the interest rate level. Conversely, when interest rate levels increase, the mid-term (3 to 5 years) swap rates also increase, and the magnitude is larger than that of interest rate levels.

Table II
Impact of Interest Rate Term Structure, Liquidity Risk Premium, and Default Risk Premium on Swap Spreads

$$\Delta SS_{m,t} = \beta_{m,0} + \beta_{m,1}\Delta Level_t + \beta_{m,2}\Delta Slope_t + \beta_{m,3}\Delta Vol_t + \beta_{m,4}\Delta Liq_t + \beta_{m,5}\Delta Default_{m,t} + \beta_{m,6}\Delta SS_{m,t-1} + \varepsilon_{m,t}$$

$\Delta Level_t$ is the difference of the interest rate level in period *t*, $\Delta Slope_t$ is the difference of the slope in period *t*, and ΔVol_t is the difference of the interest rate volatility in period *t*. ΔLiq_t is the difference of the liquidity risk premium in period *t*, $\Delta Default_{m,t}$ is the difference of the default risk premium at maturity *m* in period *t*, and $\Delta SS_{m,t}$ is the change of the swap spread at maturity *m* in period *t*. $\varepsilon_{m,t}$ is the residual at maturity *m* in period *t*.
* indicates 10% significance, ** indicates 5% significance, and *** indicates 1% significance.

Term (*m*)	*m* = 1 year	*m* = 2 years	*m* = 3 years	*m* = 4 years	*m* = 5 years	*m* = 7 years	*m* = 10 years
Panel A: OLS estimation results							
$\beta_{m,0} \times 100$	-0.001*	0.000	0.000	0.001	0.001	0.001	0.001
$\beta_{m,1}$	-0.397***	-0.046***	0.043***	0.052***	0.060***	0.010	-0.032***
$\beta_{m,2}$	**0.863*** **	**0.789*** **	**0.456*** **	**0.170*** **	**0.104*** **	**-0.120*** **	**-0.128*** **
$\beta_{m,3}$	0.254***	0.128***	0.068	0.076	0.105*	0.113**	0.129**
$\beta_{m,4}$	**0.518*** **	**0.252*** **	**0.132*** **	**0.066* **	**0.067* **	**0.121** **	**0.142*** **
$\beta_{m,5}$	**0.662*** **	**0.609*** **	**0.618*** **	**0.610*** **	**0.610*** **	**0.565*** **	**0.480*** **
$\beta_{m,6}$	-0.016	-0.067***	-0.113***	-0.130***	-0.126***	-0.167***	-0.118***
Adj. R^2	0.915	0.806	0.646	0.516	0.467	0.388	0.285
Panel B: SUR estimation results							
$\beta_{m,0} \times 100$	-0.001	0.000	0.000	0.001	0.001	0.001	0.001
$\beta_{m,1}$	-0.393***	-0.047***	0.042***	0.052***	0.062***	0.013	-0.028**
$\beta_{m,2}$	**0.861*** **	**0.785*** **	**0.453*** **	**0.166*** **	**0.109*** **	**-0.120*** **	**-0.128*** **
$\beta_{m,3}$	**0.221*** **	**0.135*** **	**0.091* **	**0.101** **	**0.126** **	**0.133** **	**0.137** **
$\beta_{m,4}$	**0.538*** **	**0.256*** **	**0.133*** **	**0.070** **	**0.071** **	**0.128*** **	**0.151*** **
$\beta_{m,5}$	**0.730*** **	**0.723*** **	**0.692*** **	**0.658*** **	**0.651*** **	**0.623*** **	**0.564*** **
$\beta_{m,6}$	-0.045***	-0.094***	-0.155***	-0.197***	-0.208***	-0.256***	-0.227***

For the effect of the slope of the yield curve on swap spreads, the empirical results show that all regression coefficients are significant at the 10% level. For the 1- to 5-year swap contracts, the increase in the slope of the yield curve induces swap spreads to increase; thus, the relationship between the slope of the yield curve and swap spreads is positive. However, for the 7- and 10-year swap contracts, the increase in the yield curve slope causes the swap spread to decrease; thus, a negative relationship exists between the yield curve slope and swap spreads. According to Hypothesis 2, the empirical results indicate that the slope of the yield curve does not contain information on default risk for the 1- to 5-year swap contracts, whereas the slope of the yield curve contains information on default risk for the 7- and 10-year swap contracts. The empirical results of this study show that the slope of the yield curve contains different information for various maturities of swap contracts. Hence, this study presents an important result that has not been observed by extant literature.

For the effect of interest rate volatility on swap spreads, the empirical results show that all regression coefficients are significant at the 10% level and the results support Hypothesis 3. The regression coefficients gradually drop from the 1-year swap contracts of 0.221 to the 3-year swap contracts of 0.091, and then gradually increase from the 3-year swap contracts of 0.091 to the 10-year swap contracts of 0.137. These findings imply that the impact of interest rate volatility is higher on short-term (1-year) and long-term (10-year) swap contracts. Although prior studies have provided an explanation for the positive effect of interest rate volatility on swap spreads, no study develops a theory to explain the magnitude of interest rate volatility effects on swap spreads for various maturities. Furthermore, the empirical results of previous studies indicate that the impact of interest rate volatility on swap spreads remains inconclusive. For example, for the U.S. swap market, the findings of Lekkos and Milas (2001) indicate that interest rate volatility has a small effect on short-term swap spreads, but has a significant effect on long-term swap spreads. In contrast, for the U.K. swap market, Lekkos and Milas (2001) present that interest rate volatility has a substantial effect on short-term swap spreads, but has a small effect on long-term swap spreads. Using data from the Japanese swap market, Huang et al. (2008) show that interest rate volatility has a large effect on long-term swap spreads. Chung and Chan (2010) also find that the magnitude of the effect of interest rate volatility on short-term and long-term swap spreads depends on the sample period. According to the results of previous studies, this paper provides a possible explanation as follows. The effects of interest rate volatility on swap spreads include two types of information: hedging demand and default risk premium. During the sample period used by this study, the daily volatility of 1-year government bond rates (0.0008) is higher than that of 10-year government bond rates (0.0004). Because the daily volatility of short-rates is higher than those of long-rates, the hedging demand for the short-term interest rate increases, thereby increasing the effect of interest rate volatility on short-term swap spreads. Hence, the impact of interest rate volatility on short-term swap spreads contains information on hedging demand for short-term swap contracts. Moreover, interest rate volatility contains information on default risk for long-term swap spreads. Accordingly, the impact of interest rate volatility on long-term swap spreads is also large. This study provides a possible explanation for the effects of interest rate volatility on swap spreads. A more rigorous study of this unresolved issue is warranted for future research.

For the effect of liquidity risk on swap spreads, the empirical results show that all regression coefficients are significant and positive at the 10% level. These results support Hypothesis 4. The effect of the liquidity risk premium on swap spreads is similar to that of interest rate volatility. The results show that the regression coefficients gradually decline from the 1-year swap contracts of 0.538 to the 4-year swap contracts of 0.070, and then gradually increase from the 4-year swap contracts of 0.070 to the 10-year swap contracts of 0.151. This indicates that the effect of liquidity risk is greater on short-term (1-year swap contracts) and long-term (10-year swap contracts) contracts.[16] In summary, the effect of liquidity risk on short-term swap contracts is larger than that of other maturities of swap contracts. This empirical result is consistent with the findings of Fehle (2003). Fehle (2003) explains this phenomenon as follows. For a 2-year interest rate swap, the settlement of the swap contract needs to use two LIBOR interest rates, one of which is the current LIBOR interest rate. For a 5-year swap contract, the settlement of the swap spread requires the use of five LIBOR interest rates, one of which is the current LIBOR interest rate. Accordingly, the longer the swap contract maturity, the smaller the impact short-term liquidity has on swap spreads. For the impact of default risk on swap spreads, the regression coefficients are all positive and significant at the 10% level. This finding supports Hypothesis 5. In addition, the results also indicate that the regression coefficient of default risk is large for short-term swap contracts and small for long-term swap contracts.

Finally, for the explanatory power of the regression model (adjusted R^2), the longer the swap contract maturity, the weaker the explanatory power of the variables. This finding implies that uncertainty is high for swap contracts with long-term maturity; thus, explanatory variables have a lower explanatory power for swap spreads. Furthermore, a low explanatory power for long-term swap contracts also implies that other potential variables affect swap spreads.

C. Empirical Results of Variance Decomposition

Table III reports the results of variance decompositions for the swap contracts with various maturities. Panel A shows the variance decomposition of 1-year swap contracts. The results indicate that the slope of the yield curve and

[16] This study finds that the bid-ask spread of 10-year contracts is the highest, followed by the 1-year contract. The bid-ask spreads for other maturity contracts are lower. Thus, this finding can be related to the liquidity of interest rate swaps.

Table III
Swap Spread Variance Decomposition

$$y_t = [\Delta Level_t, \Delta Slope_t, \Delta Vol_t, \Delta Liq_t, \Delta Default_{m,t}, \Delta SS_{m,t}]$$

$\Delta Level_t$ is the difference of the interest rate level in period *t*, $\Delta Slope_t$ is the difference of the slope in period *t*, ΔVol_t is the difference of the interest rate volatility in period *t*, ΔLiq_t is the difference of the liquidity risk premium in period *t*, $\Delta Default_{m,t}$ is the difference of the default risk premium at maturity *m* in period *t*, and $\Delta SS_{m,t}$ is the difference of the swap spread at maturity *m* in period *t*.

Days	$\Delta Level_t$	$\Delta Slope_t$	ΔVol_t	ΔLiq_t	$\Delta Default_{m,t}$	$\Delta SS_{m,t}$
Panel A: 1-year swap rate						
1	5.337	**24.661**	5.114	17.416	20.879	26.592
10	5.087	**27.983**	3.867	11.303	23.602	28.158
20	5.109	**27.973**	3.883	11.298	23.611	28.126
Panel B: 2-year swap rate						
1	0.118	28.929	2.399	7.667	**25.552**	35.335
10	0.548	25.159	2.458	7.131	**28.827**	35.877
20	0.549	25.153	2.483	7.129	**28.821**	35.866
Panel C: 3-year swap rate						
1	0.463	18.055	0.796	2.902	**32.990**	44.794
10	0.425	16.099	1.318	2.960	**35.050**	44.149
20	0.426	16.098	1.322	2.960	**35.048**	44.147
Panel D: 4-year swap rate						
1	0.585	4.991	1.261	0.990	**38.944**	53.229
10	0.557	4.469	2.511	0.912	**38.112**	53.439
20	0.557	4.469	2.517	0.912	**38.109**	53.435
Panel E: 5-year swap rate						
1	0.719	3.229	2.541	0.948	**40.404**	52.159
10	0.646	2.939	4.260	0.925	**37.596**	53.635
20	0.646	2.939	4.289	0.925	**37.585**	53.617
Panel F: 7-year swap rate						
1	0.003	2.400	3.238	2.868	**39.445**	52.045
10	0.057	2.055	5.454	2.822	**40.081**	49.532
20	0.057	2.054	5.491	2.821	**40.066**	49.510
Panel G: 10-year swap rate						
1	0.327	3.324	4.327	3.917	**33.788**	54.316
10	0.362	3.043	7.276	4.379	**32.893**	52.048
20	0.363	3.044	7.304	4.378	**32.884**	52.027

default risk have greater effects on swap spreads, at 27.93% and 23.61%, respectively. This finding indicates that the slope of the yield curve and the default risk are important determinants for 1-year swap contracts. Panels B to G show the variance decompositions for 2-year to 10-year swap contracts. Empirical results indicate that default risk is the most important among five explanatory variables for the 2- to 10-year swap contracts. In addition, this paper also finds that the importance of interest rate volatility and liquidity risk vary with the maturity of swap contracts. The effects of interest rate volatility and liquidity risk on swap spreads decline from the 1-year swap contracts to the 4-year swap contracts. However, after dropping to the 4-year swap contracts, the influence gradually increases until 10-year swap contracts. This finding is consistent with those of OLS. Finally, this study shows that the importance of the five explanatory variables gradually decreases with the increase in the maturity of swap contracts. For example, regarding the 1-year swap contracts, the explanatory power of the five variables is 71.874% (= 100% - 28.126%). For 10-year swap contracts, the explanatory power of the five variables is 47.973% (= 100% - 52.027 %). This finding is consistent with the adjusted R^2 of OLS.

In summary, the most important factor for 1-year swap contracts is the slope of the yield curve, whereas the most important factor for 2- to 10-year swap contracts is default risk. Furthermore, the importance of the five variables gradually drops with an increase in the maturity of swap contracts. This empirical result can provide an important insight for risk management. Policymakers and risk managers can manage risks according to swap contracts with various maturities.

D. Results of OLS and SUR Estimation under Different Market Conditions

Das et al. (2006) and Lucas and Klaassen (2006) indicate that the probability of default risk increases during recessions. In addition, Lekko and Milas (2004), Huang et al. (2008), and Bhansali et al. (2009) report that the determinants and importance of interest rate swap spreads vary with economic conditions. Specifically, Huang et al. (2008) find the determinants have a substantial effect on swap spreads during periods of high interest rate volatility. Alexander and Kaeck (2008) examine the determinants of credit default swap spreads, and show that the explanatory power of the determinants is higher during periods with high volatility of credit default swap spreads. Based on the empirical results of these studies, this study divides the economic states into bull and bear markets and examines the impact of determinants on swap spreads. According to the findings of Alexander and Kaeck (2008), this study expects that the explanatory power of the five determinants for swap spreads would be higher in a bear market than in a bull market.

Following Chen (2009), Henry (2009), and Kurov (2010), this study uses the Markov switching model to estimate bull and bear markets for the Taiwan stock market. The Markov switching model is shown as follows:

$$mret_t = u_{S_t} + \varepsilon_t\,,\ \ \varepsilon_t \sim i.i.d \quad \mathrm{N}(0, \sigma^2_{S_t}) \tag{3}$$

where $mret_t$ is the return of the Taiwan weighted stock price index in period t.[17] u_{S_t} and $\sigma^2_{S_t}$ are the mean return and standard deviation of return in state S_t,

[17] The Taiwan weighted stock price index is obtained from the Taiwan Economic Journal.

respectively. S_t is the unobservable variable for market conditions. In addition, $S_t = 0$ indicates a bear market, and $S_t = 1$ indicates a bull market. A transition probability matrix of the Markov switching model is presented as follows:

$$P = \begin{bmatrix} P^{00} & 1-P^{11} \\ 1-P^{00} & P^{11} \end{bmatrix} \tag{4}$$

where $P^{00} = P(S_t = 0 \mid S_{t-1} = 0)$ and $P^{11} = P(S_t = 1 \mid S_{t-1} = 1)$.

This paper uses the maximum likelihood approach to estimate the Markov switching model, the results of which are shown in Table IV. The empirical results displayed in Table IV show that the Markov switching model can divide the markets into two states: low return (-0.0014) accompanies by high volatility (0.0004) and high return (0.0023) accompanies by low volatility (0.0001). This result is consistent with those obtained by Chen (2009) and Henry (2009). Following Chen (2009) and Henry (2009), this paper defines low return with high volatility as a bear market and high return with low volatility as the bull market. Table IV also shows that the bear market regime persists for an average of 68.20 days, and the bull market regime persists for an average of 46.75 days. Figure 5 shows the bull and bear market regimes and stock index prices. Figure 5 indicates that the Markov switching model designates the period as a bear market when stock prices decline and the period as a bull market when stock prices increase. Hence, Figure 5 shows that the Markov switching model can be used to designate bull and bear markets (Chen (2009) and Henry (2009)).

Table IV
Bear and Bull Market Interval Estimation: Markov Switching Model

$$mret_t = u_{S_t} + \varepsilon_t, \;\; \varepsilon_t \sim i.i.d \;\; \mathrm{N}(0, \sigma^2_{S_t})$$

$mret_t$ is the return of the Taiwan weighted stock price index in *t* period. u_{S_t} and $\sigma^2_{S_t}$ are, respectively, the average and standard deviation for state S_t, which is an unobservable variable of market conditions. In addition, $S_t = 0$ indicates a bear market and $S_t = 1$ indicates a bull market.
* indicates 10% significance, ** indicates 5% significance, and *** indicates 1% significance.

	Bear: $S_t = 0$	Bull: $S_t = 1$
u_{S_t}	-0.0014***	0.0023***
$\sigma^2_{S_t}$	0.0004***	0.0001***
State probability	0.9900***	0.9800***
Average duration (days)	68.20	46.75

Table V displays the impact of the term structure of interest rates, liquidity risk, and default risk on swap spreads in a bear market. Panels A and B are the OLS and the SUR estimation results, respectively. Similarly, this study focuses on the results of the SUR. For Panel B, most of the regression coefficients are significant at the 10% level, indicating that the five important determinants have a significant impact on swap spreads in a bear market. The empirical results shown in Table V are similar to those reported in Table III. For example, for the short- and long-term interest rate swaps, the impact of the interest rate level on swap spreads is significantly negative. Conversely, the effect of the interest rate level on medium-term swap spreads is significantly positive. Furthermore, as shown in Table III, the results in Table V also suggest that the slope of the yield curve does not contain information on default risk for swap contracts with short-term maturity. By contrast, the slope of the yield curve contains information on default risk for swap contracts with long-term maturity. In addition, interest rate volatility, liquidity risk, and default risk have a positive and significant effect on swap spreads.

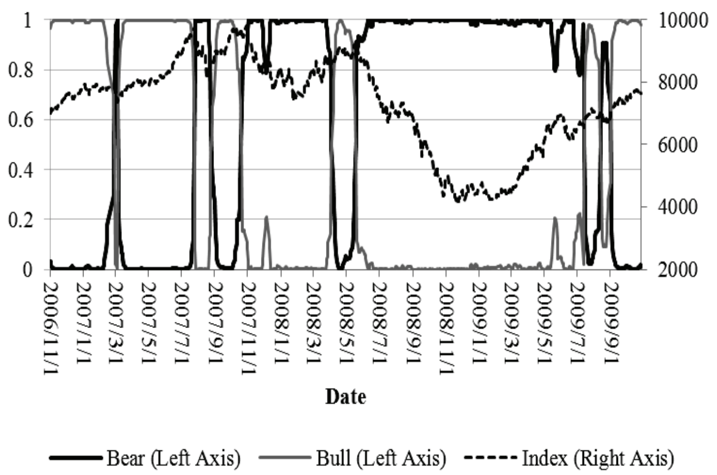

Figure 5. Bear and bull market regime and stock index.

Table VI shows the impact of the term structure of interest rates, liquidity risk, and default risk on swap spreads in a bull market. The results of Panel B indicate that the effects of the interest rate level, the slope of the yield curve, and default risk on swap spreads are significant at the 10% level for swap contracts with various maturities. Interest rate volatility and liquidity risk do not have a significant effect on swap spreads for swap contracts with various maturities. Except for the 10-year swap contracts, the regression coefficients of the interest rate level are significant at the 10% level. The effect of the slope of the yield curve on swap spreads for short-term swap contracts is positive, implying that the slope of the yield curve does not contain information default risk for short-term swap contracts. On the contrary, the effect of the slope of the yield curve is negative for long-term swap contracts, indicating that the slope of the yield curve contains information on default risk for long-term swap contracts. These findings are similar to those shown in Tables III and V. For interest rate volatility, the regression coefficients for 2-, 7-, and 10-year swap contracts are significant at the 10% level. For liquidity risk, the regression coefficients are positive and significant at the 10% level for 1-year and 2-year swap contracts. For default risk, the regression coefficient is larger for short-term swap contracts (approximately 0.693) than for long-term swap contracts (approximately 0.389).

Table V
Impact of Interest Rate Term Structure, Default Risk Premium, and Liquidity Risk Premium on Swap Spreads in a Bear Market

$$\Delta SS_{m,t} = \beta_{m,0} + \beta_{m,1}\Delta Level_t + \beta_{m,2}\Delta Slope_t + \beta_{m,3}\Delta Vol_t + \beta_{m,4}\Delta Liq_t + \beta_{m,5}\Delta Default_{m,t} + \beta_{m,6}\Delta SS_{m,t-1} + \varepsilon_{m,t}$$

$\Delta Level_t$ is the difference of the interest rate level in period *t*, $\Delta Slope_t$ is the difference of the slope in period *t*, and ΔVol_t is the difference of the interest rate volatility in period *t*. ΔLiq_t is the difference of the liquidity risk premium in period *t*, $\Delta Default_{m,t}$ is the difference of the default risk premium at maturity *m* in period *t*, and $\Delta SS_{m,t}$ is the change of the swap spread at maturity *m* in period *t*. $\varepsilon_{m,t}$ is the residual at maturity *m* in period *t*.
* indicates 10% significance, ** indicates 5% significance, and *** indicates 1% significance.

Term (*m*)	*m* = 1 year	*m* = 2 years	*m* = 3 years	*m* = 4 years	*m* = 5 years	*m* = 7 years	*m*=10 years
Panel A: OLS estimation results							
$\beta_{m,0}$ × 100	-0.003***	-0.002*	-0.001	-0.001	-0.001	-0.001	-0.002
$\beta_{m,1}$	-0.399***	-0.049***	0.036***	0.040***	0.051***	-0.001	-0.040***
$\beta_{m,2}$	**0.872*** **	**0.804*** **	**0.478*** **	**0.184*** **	**0.131*** **	**-0.107*** **	**-0.099*** **
$\beta_{m,3}$	0.336***	0.150***	0.092	0.124	0.159*	0.104	0.140*
$\beta_{m,4}$	**0.522*** **	**0.265*** **	**0.150*** **	**0.095*** **	**0.090*** **	**0.152*** **	**0.178*** **
$\beta_{m,5}$	**0.659*** **	**0.671*** **	**0.695*** **	**0.682*** **	**0.681*** **	**0.628*** **	**0.537*** **
$\beta_{m,6}$	-0.021	-0.063***	-0.091***	-0.099**	-0.099**	-0.138***	-0.106**
Adj. R^2	0.921	0.819	0.691	0.569	0.523	0.438	0.331
Panel B: SUR estimation results							
$\beta_{m,0}$ × 100	-0.003***	-0.002	-0.001	-0.001	-0.001	-0.001	-0.002
$\beta_{m,1}$	-0.394***	-0.050***	0.035***	0.041***	0.053***	0.004	-0.036**
$\beta_{m,2}$	**0.869*** **	**0.799*** **	**0.473*** **	**0.182*** **	**0.131*** **	**-0.108*** **	**-0.101*** **
$\beta_{m,3}$	**0.277*** **	**0.152** **	**0.114* **	**0.153** **	**0.188** **	**0.134* **	**0.157* **
$\beta_{m,4}$	**0.543*** **	**0.271*** **	**0.154*** **	**0.099** **	**0.095** **	**0.159*** **	**0.189*** **
$\beta_{m,5}$	**0.721*** **	**0.744*** **	**0.724*** **	**0.684*** **	**0.680*** **	**0.645*** **	**0.594*** **
$\beta_{m,6}$	-0.051***	-0.097***	-0.151***	-0.190***	-0.201***	-0.256***	-0.236***

In addition, for the adjusted R^2, the empirical results of Tables V and VI indicate that, for the swap contract with same maturity, the explanatory power of the five determinants is higher in a bear market than in a bull market. For example, for 5-year swap contracts, the five determinants can explain 52.3% of variations for swap spreads in a bear market, but can explain only 24.5% of variations in a bull market. Finally, the SUR results show that the correlations for swap contracts with various maturities are larger in a bear market than in a bull market. This finding is consistent with the results of Kim et al. (2008).[18] In summary, this study finds that the explanatory power of the five factors for swap spreads and the correlations between swap spreads are higher in a bear market. This empirical result is consistent with our expectations.

Table VI

Impact of Interest Rate Term Structure, Default Risk Premium, and Liquidity Risk Premium on Swap Spreads in a Bull Market

$$\Delta SS_{m,t} = \beta_{m,0} + \beta_{m,1}\Delta Level_t + \beta_{m,2}\Delta Slope_t + \beta_{m,3}\Delta Vol_t + \beta_{m,4}\Delta Liq_t + \beta_{m,5}\Delta Default_{m,t} + \beta_{m,6}\Delta SS_{m,t-1} + \varepsilon_{m,t}$$

$\Delta Level_t$ is the difference of the interest rate level in period *t*, $\Delta Slope_t$ is the difference of the slope in period *t*, and ΔVol_t is the difference of the interest rate volatility in period *t*. ΔLiq_t is the difference of the liquidity risk premium in period *t*, $\Delta Default_{m,t}$ is the difference of the default risk premium at maturity *m* in period *t*, and $\Delta SS_{m,t}$ is the change of the swap spread at maturity *m* in period *t*. $\varepsilon_{m,t}$ is the residual at maturity *m* in period *t*.
* indicates 10% significance, ** indicates 5% significance, and *** indicates 1% significance.

Term (*m*)	*m* = 1 year	*m* = 2 years	*m* = 3 years	*m* = 4 years	*m* = 5 years	*m* = 7 years	*m*=10 years
Panel A: OLS estimation results							
$\beta_{m,0}\times 100$	0.001	0.002*	0.002**	0.003***	0.003***	0.004***	0.004***
$\beta_{m,1}$	-0.402***	-0.050***	0.060***	0.090***	0.082***	0.038**	-0.020
$\beta_{m,2}$	0.835***	0.737***	0.395***	0.154***	0.039	-0.143***	-0.226***
$\beta_{m,3}$	0.061	0.119	0.087	0.034	0.043	0.145	0.127
$\beta_{m,4}$	0.498***	0.214***	0.065	-0.067	-0.036	-0.056	-0.073
$\beta_{m,5}$	**0.646****	**0.349****	**0.324****	**0.368****	**0.348****	**0.313****	**0.227****
$\beta_{m,6}$	0.027	-0.065*	-0.159***	-0.184***	-0.174***	-0.210***	-0.122**
Adj. R^2	0.903	0.789	0.498	0.316	0.245	0.230	0.190
Panel B: SUR estimation results							
$\beta_{m,0}\times 100$	0.001	0.002**	0.003**	0.003***	0.003***	0.004***	0.004***
$\beta_{m,1}$	**-0.397****	**-0.042****	**0.062****	**0.090****	**0.088****	**0.046***	-0.012
$\beta_{m,2}$	**0.836****	**0.748****	**0.401****	**0.143****	**0.057***	**-0.135****	**-0.210****
$\beta_{m,3}$	0.077	0.113**	0.086	0.033	0.032	0.153**	0.130*
$\beta_{m,4}$	0.495***	0.178***	0.024	-0.092	-0.061	-0.077	-0.088
$\beta_{m,5}$	**0.693****	**0.571****	**0.501****	**0.516****	**0.497****	**0.501****	**0.389****
$\beta_{m,6}$	0.006	-0.065***	-0.160***	-0.245***	-0.253***	-0.249***	-0.181***

18 Because of space limitations, the correlation coefficients of the SUR are not reported here, but can be provided upon request.

Table VII
Swap Spread Variance Decomposition in a Bear Market

$$y_t = [\Delta Level_t, \Delta Slope_t, \Delta Vol_t, \Delta Liq_t, \Delta Default_{m,t}, \Delta SS_{m,t}]$$

$\Delta Level_t$ is the difference of the interest rate level in period t, $\Delta Slope_t$ is the difference of the slope in period t, ΔVol_t is the difference of the interest rate volatility in period t, ΔLiq_t is the difference of the liquidity risk premium in period t, $\Delta Default_{m,t}$ is the difference of the default risk premium at maturity m in period t, and $\Delta SS_{m,t}$ is the difference of the swap spread at maturity m in period t.

Days	$\Delta Level_t$	$\Delta Slope_t$	ΔVol_t	ΔLiq_t	$\Delta Default_{m,t}$	$\Delta SS_{m,t}$
Panel A: 1-year swap rate						
1	5.118	**24.164**	8.906	15.907	19.733	26.172
10	6.662	**27.333**	14.844	12.333	20.466	18.361
20	6.673	**27.535**	14.788	12.167	20.718	18.120
Panel B: 2-year swap rate						
1	0.139	28.051	3.945	7.779	**26.741**	33.345
10	0.681	22.152	8.701	5.938	**29.321**	33.209
20	0.697	22.136	8.822	5.937	**29.274**	33.135
Panel C: 3-year swap rate						
1	0.295	17.684	1.953	3.698	**34.884**	41.486
10	0.441	14.412	5.301	3.074	**36.668**	40.103
20	0.450	14.404	5.328	3.081	**36.650**	40.087
Panel D: 4-year swap rate						
1	0.310	5.093	3.513	2.080	**40.573**	48.432
10	0.373	4.414	8.922	1.729	**38.296**	46.266
20	0.381	4.414	8.950	1.737	**38.281**	46.238
Panel E: 5-year swap rate						
1	0.461	3.940	5.295	1.771	**41.389**	47.144
10	0.453	3.492	8.316	1.628	**37.868**	48.243
20	0.460	3.490	8.357	1.637	**37.849**	48.208
Panel F: 7-year swap rate						
1	0.029	1.940	2.753	4.450	**41.891**	48.936
10	0.201	1.741	6.729	4.170	**41.025**	46.134
20	0.217	1.739	6.838	4.170	**40.973**	46.063
Panel G: 10-year swap rate						
1	0.387	2.095	4.587	5.881	**36.445**	50.606
10	0.593	1.965	13.259	5.654	**33.098**	45.432
20	0.617	1.966	13.373	5.648	**33.056**	45.340

E. Empirical Results of Variance Decomposition under Different Market Conditions

In addition to examining the explanatory power of the five factors for swap spreads under different market conditions, this study also investigates the importance of five factors for swap spreads under different market conditions. Understanding the importance of five factors under different market conditions can be helpful for risk managers and government agencies in conducting risk

Table VIII
Swap Spread Variance Decomposition in a Bull Market

$\Delta Level_t$ is the difference of the interest rate level in period *t*, $\Delta Slope_t$ is the difference of the slope in period *t*, ΔVol_t is the difference of the interest rate volatility in period *t*, ΔLiq_t is the difference of the liquidity risk premium in period *t*, $\Delta Default_{m,t}$ is the difference of the default risk premium at maturity *m* in period *t*, and $\Delta SS_{m,t}$ is the difference of the swap spread at maturity *m* in period *t*.

Days	$\Delta Level_t$	$\Delta Slope_t$	ΔVol_t	ΔLiq_t	$\Delta Default_{m,t}$	$\Delta SS_{m,t}$
Panel A: 1-year swap rate						
1	5.930	24.622	0.448	20.509	**21.202**	27.290
10	4.243	18.148	2.914	25.368	**29.942**	19.385
20	4.243	18.159	3.032	25.309	**29.867**	19.389
Panel B: 2-year swap rate						
1	0.133	**31.760**	1.199	6.499	15.127	45.282
10	0.710	**28.623**	9.165	11.244	13.179	37.079
20	0.716	**28.450**	9.645	11.205	13.119	36.865
Panel C: 3-year swap rate						
1	1.147	**18.974**	0.631	0.220	18.181	60.846
10	1.035	**19.000**	5.768	0.541	17.652	56.005
20	1.046	**18.912**	6.158	0.573	17.577	55.733
Panel D: 4-year swap rate						
1	2.110	5.983	0.202	3.050	**23.274**	65.382
10	1.946	6.968	2.659	3.908	**21.381**	63.139
20	1.950	6.963	2.796	3.933	**21.354**	63.004
Panel E: 5-year swap rate						
1	1.657	1.574	0.687	1.493	**24.968**	69.621
10	1.497	3.848	6.615	2.629	**21.451**	63.960
20	1.508	3.855	6.910	2.686	**21.388**	63.652
Panel F: 7-year swap rate						
1	0.152	2.794	6.669	2.177	**21.177**	67.032
10	0.368	3.383	12.657	3.413	**22.082**	58.096
20	0.385	3.391	12.891	3.434	**22.056**	57.842
Panel G: 10-year swap rate						
1	0.295	9.105	**6.086**	2.092	11.298	71.123
10	0.761	8.286	**17.162**	3.252	12.644	57.895
20	0.783	8.276	**17.439**	3.343	12.687	57.473

management. Table VII shows the variance decomposition in a bear market. Overall, the empirical results in Table VII are similar to those in Table III. Table VII shows that, except for the 1-year swap contracts, default risk is the most important factor among the five variables. The most important factor for the 1-year swap contracts is the slope of the yield curve. In addition, the results of Table VII also show that whereas the effects of the yield curve slope and liquidity risk gradually decrease as the maturity increases for the 1-year to 3-year swap contracts, the effects of the yield curve slope and liquidity risk increase as the maturity increases for 4-year to 10-year swap contracts. This result is consistent with the empirical results displayed in Table III. Table VIII shows the variance decomposition in a bull market. The results in Table VIII show that the influential variables for swap spreads vary with the maturity of swap contracts. For the maturity of 1-, 4-, 5-, and 7-year swap contracts, default risk is the most important factor among the five variables, at 29.867%, 21.354%, 21.388%, and 22.056%, respectively. For swap contracts with 2-and 3-year maturities, the slope of the yield curve is the most important factor among the five variables. The proportions of variance decompositions for 2-and 3-year swap contracts are 28.450% and 18.912%, respectively. For the 10-year swap contracts, interest rate volatility is the most important factor among the five variables. The proportion of variance decomposition is 17.439%.

The empirical results in Tables VII and VIII present that, except for the 1-year swap contracts, default risk is the most important factor for explaining swap spreads in a bear market. In a bull market, the most important factor for explaining swap spreads varies with the maturity of swap contracts. Specifically, the important factors in a bull market are the slope of the yield curve, interest rate volatility, and default risk. These results provide valuable information for investors and governing authorities in risk management.

V. Conclusions

Using data from the Taiwan swap market, this paper explores the determinants of interest rate swap spreads. The most widely studied determinants of swap spreads are the interest rate level, yield curve slope, interest rate volatility, liquidity risk, and default risk. This study uses OLS, SUR, and variance decomposition to explore how the five factors affect swap spreads. The empirical results of OLS and SUR show that the five variables affect swap spreads significantly. Specifically, the effects of interest rate volatility, liquidity risk, and default risk on swap spreads are positive and significant at the 10% level. The effect of the slope of the yield curve is significantly positive for short- and medium-term swap contracts, but significantly negative for long-term swap contracts. This result suggests that the slope of the yield curve contains different information for swap contracts with various maturities. In addition, the empirical results of variance decomposition show that, among the five explanatory variables, the most important for 1-year swap contracts is the slope of the yield curve, and the most important for 2- to 10-year swap contracts is default risk. Moreover, the importance of the five variables gradually decreases as the maturities of the swap contracts increase.

This paper also conducts empirical analyses by using the Markov switching model to divide the market regimes into bull and bear markets, and then explores whether the explanatory power and importance of the five factors for swap spreads vary with market conditions. The empirical results of OLS and SUR show that the regression coefficients in a bear market are essentially all significantly different from zero. These results are consistent with those of the full sample. In a bull market, the coefficients for the interest rate level, yield curve slope, and default risk are significantly different from zero. For the explanatory power of the regression model, the explanatory power of the five factors is higher in a bear market than in a bull market for the same maturity of swap contracts. Finally, the results of variance decomposition show that, during the bear market regime, default risk is the most important factor among the five variables, except for the 1-year swap contracts. In a bull market, the key factor for explaining swap spreads varies with the maturity of swap contracts.

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新台幣利率交換之決定因素

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摘 要

本研究欲探討臺灣利率交換市場中影響交換價差的因素。實證結果指出，就全樣本期間而言，利率期限結構、流動性風險的變化與違約風險的變化均為交換價差的重要決定因素，而違約風險則為決定交換價差最重要的因素。此外，在空頭時期違約風險為決定交換價差最重要的因素，在多頭時期則依契約到期日而不同。

關鍵詞：利率交換價差、利率期限結構、流動性風險、違約風險、市場狀態

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