The Determinants of THB Swap Spreads

Mr. Parkorn Wattanaskolpant

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By	Mr. Parkorn Wattanaskolpant
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Thesis Advisor	Associate Professor SIRA SUCHINTABANDID, Ph.D.

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INDEPENDENT STUDY COMMITTEE

..... Chairman
()
..... Advisor
(Associate Professor SIRA SUCHINTABANDID, Ph.D.)
..... Examiner
(Assistant Professor TANAKORN LIKITAPIWAT, Ph.D.)
..... Examiner
(TANAWIT SAE SUE, Ph.D.)

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This paper aims to investigate the determinants of THB swap spreads by combining the traditional explaining variables of previous researches, e.g., default risk premium, liquidity premium and slope of the government bond yield curve, with additional explaining variables that might be missed in the previous studies and unique in THB swap spreads, e.g., TED and macroeconomic factors during the different states of economy, which are classified by Bank of Thailand monetary policy rate and the presence of negative swap spread. The motivation is to investigate the different effect of the determinants of THB swap spread in the different market conditions and negative swap spread period.

Field of Study:	Finance	Student's Signature .....
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Parkorn Wattanaskolpant

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1. Introduction

1.1 Background

The outstanding of Thai Baht interest rate swaps (henceforth, called swap) has the explosive growth in recent year, and interest rate swaps are the largest product of traded OTC interest rate derivative product. Surprisingly, there are only a few literatures studied on Thai Baht interest rate swaps dynamics.

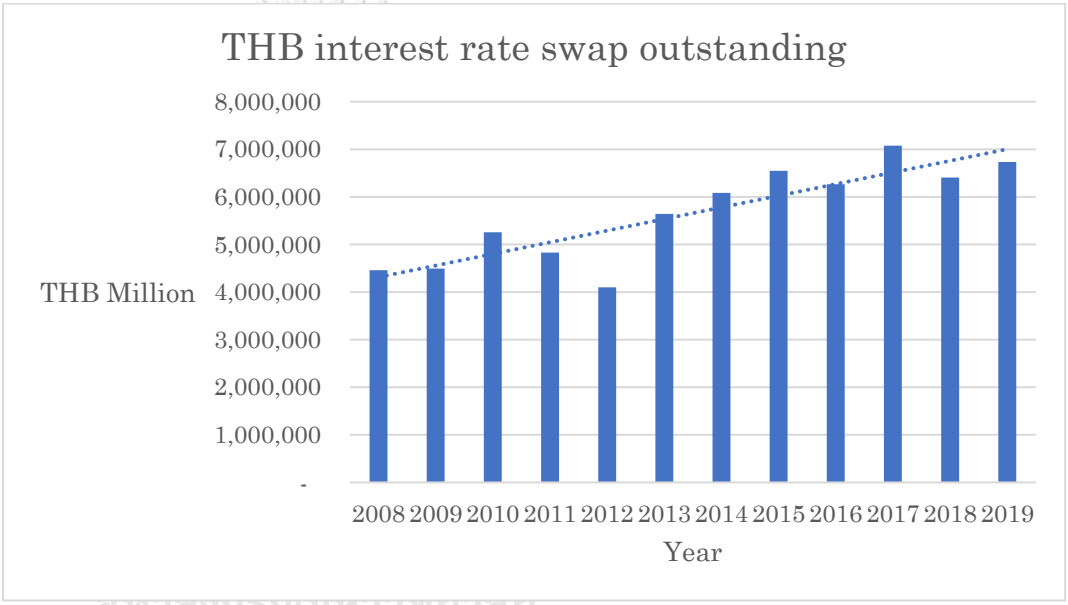


Figure 1. THB interest rate swap outstanding, source: Bank of Thailand

An interest rate swap is a contractual agreement between two counterparties to exchange a series of cash flows which are series of interest rate payments without exchanging notional principal. Normally, interest rate swaps are commonly referred to "fixed vs floating" interest rate swaps where one party promises to pay fixed interest rate (fixed rate payer) and simultaneously promises to receive floating interest rate and another party (floating rate payer) agrees to pay floating interest rate and simultaneously receives fixed rate, based on an agreed notional principal, maturity and predetermined fixed rate and floating rate index. The cash flows payment of fixed rate legs and floating rate legs can be deemed the cash flows of fixed rate bond and the floating rate bond

respectively. Therefore, when the fixed rate payer and floating rate payer enter into a swap at the initiation of the contract (time zero), it is equivalent to the two parties exchanging a fixed rate bond and a floating rate bond. In order for the contract to be fair, the values of fixed rate bond and floating rate bond must be equal which depends on the swap rate[1]. Given this characteristic, swap rate can be deemed to be the discount rate and being similar to yield to maturity of the bonds. Therefore, swap rate and government bond yield of the same maturity must be equal by assumption of no market frictions or any concerned risks e.g. default and liquidity exist.

Most studies find that the most widely studied determinants of developed countries swap spreads are the default risk premium, the liquidity premium and slope of the government yield curve. Nevertheless, there are some important gaps in those studies to understand the determinants of THB swap spreads as follow;

First, in sense of market frictions, swap rates and government bond yield in the same maturity are different across the period. Such difference is typically called swap spreads. Theoretically, swap spreads have to be positive. Sun, Sundaresan, and Wang (1993) and Sorensen and Bollier (1994) assume that the spreads are caused by the risk of counterparty default on its swap obligation. Treasury liquidity convenience yield as safe-haven status of Treasury is related to the swap spread studied by Grinblatt (1995). Huang and Chen (2007) and Huang, Chen, and Camacho (2008) find that there are more factors can drive the spreads which are counterparty default risk, liquidity premium, interest rate volatility and the slope of the government yield curve for USD and JPY swap spread respectively. However, these studies do not take into account the possibility that economic factors might affect the spread as well.

[1] In this study, swap rates are quoted by top-quality counterparties no adjustment made to swap rate quoted for more risker counterparties.

Many studies find the impact of macroeconomic variables to government bond yield and interest rate swap yield separately. For government bond yield. Ang and Piazzesi (2003) find that macro variables explain a significant portion of movements in yield curve, 85 percent in short and middle term, and around 40 percent in long-end curve. Koosakul (2016) discovers that Thai short-term yield movements are solely driven by domestic factors, namely policy rate expectations which capture market's perception of macroeconomic outlook and bond supply. For swap rate, Azad, Fang, and Wickramanayake (2011) show that macroeconomic surprises and volatility of JPY interest rate swap are closely related. Only few studies find the impact of macroeconomic variables to swap spreads. Cortes (2003) finds that the response of swap spreads to extra prospective supply of government bond is narrowing in swap spreads. Afonso and Strauch (2007) show that the fiscal policy events have positive impact to swap spreads in 13 Eu member states. Fang, Lin, and Roadcap (2012) examine the response of Australian swap spreads of the arrival of macroeconomic news information. See section hypothesis development for what macroeconomic factors are determined in this study and detail of how these variables are hypothesized to affect THB swap spreads.

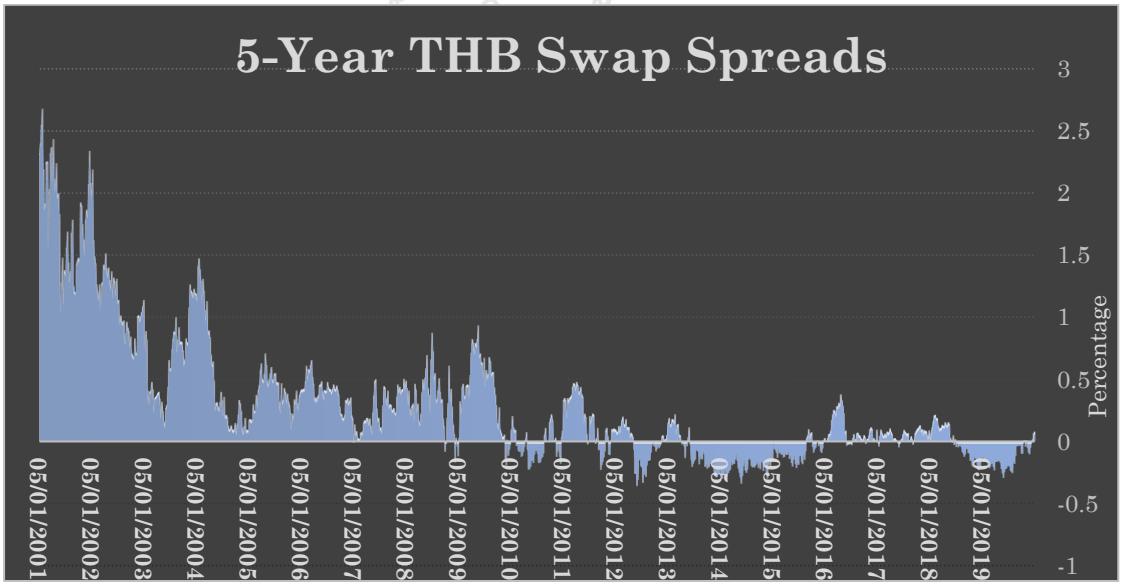


Figure 2. shows the negative territory of 5-year THB swap spreads since 2009 to 2019.

Second, theoretically, THB swap spreads are positive, and 5-year THB swap spreads followed the theory over the times. However, since 2009, 5-year THB swap spreads have been in negative territory many times, which is motivated to investigate the drivers of the negative swap spreads. The existence of negative THB swap spreads can be the serious problem for market participants who pay the swap to hedge their bond portfolios. Only few studies find the determinants of swap spread in negative territory. Klingler and Sundaresan (2018) offer that the reasons behind the persistent negative of 30-year USD swap spreads are the demand for duration hedging by underfunded pension fund combined with constrains of dealers' balance sheet. And the different of funding requirements between swap and holding bond can also explain this phenomenon as long-term bond holding are outright cash position whereas only minimal capital for initial collateral is required for entering swap transaction. And most of prior studies do not experience the phenomenon of negative swap spreads in their data spans. Therefore, the determinants in prior studies remain unchanged during the existence of negative swap spreads is interesting to be questioned.

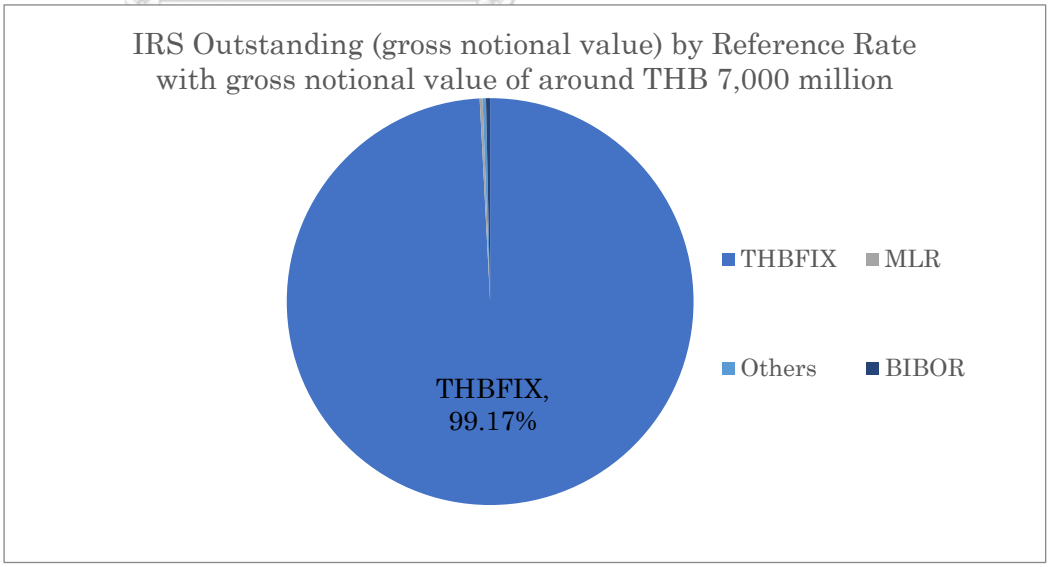


Figure 3. IRS outstanding by reference rate as of 2017 source: Bank of Thailand

Third, in the developed market, the interbank offered rates which are the short-term interest rate that major banks offer to lend to other

banks in each maturity are practically used to be the floating reference rate for relevant currency in interest rate swaps market in many countries, for instance, USD interest rate swaps use LIBOR or JPY interest rate swaps use TIBOR. Whereas, the practical floating reference rate in Thai interest rate swap is the implied short-term interest rate calculated by the interest rate parity from FX swap market or called THBFIX not Thai interbank offered rates called BIBOR.

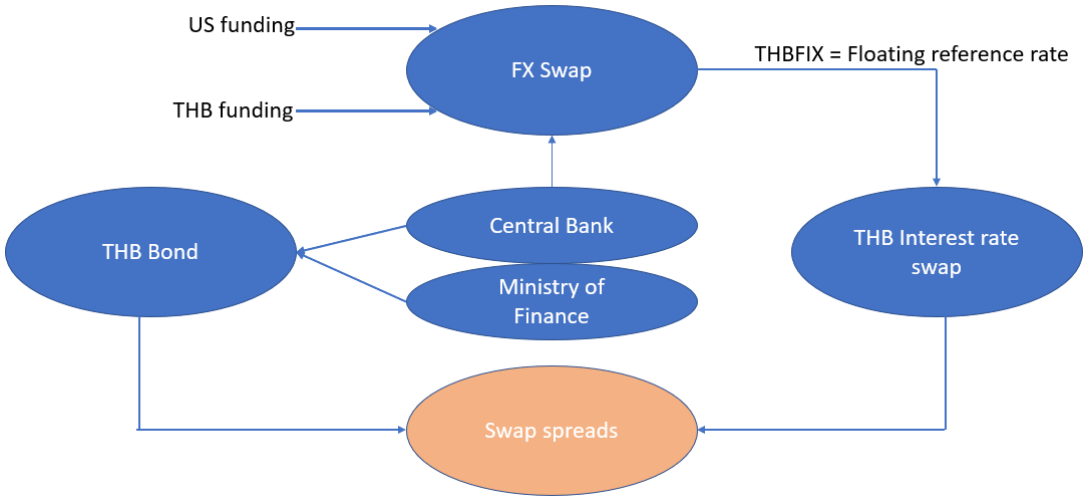
1.2 Motivation and contribution

This study thus contributes in a number of aspects. First, this study tries to find the perfect determinants of THB swap spreads by adding and combining variables studied in each research and adding the missing variables. Most of studies investigate only default risk, liquidity premium, slope of the yield curve and interest rate volatility but not taking into account for macroeconomic factors which normally drive market expectation on interest rate decisions.

Second, traditionally, the swap spread arbitrage strategy can be done in many ways depends on swap spreads, for instance, in case of swap spreads are more positive than historical level, market participants firstly enter into swap market to sell swap to received fixed rate and pay floating LIBOR rate. Secondly, to sell government bond to pay fixed rate and receive the repo rate which normally is the funding charge. Combining the cash flows from this strategy, market participants receive fixed rate equals to Fixed swap rate – Fixed government bond rate, for paying leg is equal to Floating Libor rate – Repo rate. For the contrary strategy, in case of swap spreads are negative, market participants anticipate the swap spread will become the historical level then they could make the arbitrage strategy by doing opposite transactions. Therefore, the cash flows for this strategy are just opposite of the first strategy's cash flows. Market participants can earn profit once (Fixed swap rate – Fixed government bond rate) is greater than (Floating Libor rate – Repo rate) (see Duarte, Jefferson, Longstaff, and Yu ,2007). Nevertheless, market participants are exposed to indirect default risk as Libor rate are related with credit risk of

major banks during the abnormal market condition. However, to make the similar arbitrage strategy in Thai interest swap, market participants have to experience the fluctuation of THBFIX which implied by interest rate parity. Hence, the compositions of THBFIX which are USDTHB spot, Swap point, USD Libor all might drive the swap spread. See section hypothesis development for detail of how these variables are hypothesized to affect THB swap spreads.

Figure 4. illustrates the relationship among THB bond, THB swap and FX swap.



Third, recent years, although swap market is an Over-the-counter-market but it has developed in many aspects for instance, reducing counterparty risk, increasing transparency and improving infrastructure. In particular, when the International of Swaps and Derivatives (ISDA) was established for improving the swap market to be more standard. Chung and Chan (2010) shows that especially once ISDA conducted the Credit Support Annex (CSA) which is the general rules for use of collateral, then swap transactions are collateralized and counterparty credit risk seems to be eliminated. Nevertheless, since the floating reference rate is implied from Foreign exchange swaps[2] which are subject

[2] Duffie and Huang (1996) show that FX swaps has the larger exposure to default risk than that of interest rate swaps, due to the exchange of notional amounts. Coffrey, Hrung and Sarkar (2009) and Genberg, Hui, Wong, and Chung (2009) show that the deviation of CIP is significantly caused by a sharp increase in counterparty credit risk in the interbank money market, Baba and Packer (2009) see the similar result that concern

to significantly more exposure to counterparty risk than that of interest rate swap. Therefore, even the default risk seems to be eliminated for interest rate swap but the default risk should still have positive relation with THB swap spreads is hypothesized.

Most of prior works use various credit spreads to measure the default risk embedded in LIBOR. However, since the floating reference rate for THB interest rate swap is THBFIX[3] which determined by covered interest rate parity and commercial banks in Thailand are the main players in both THB foreign exchange and interest rate swap market. In addition to the traditional determinants included in classical research works in terms of default risk measurement, we use the default risk premium of the average commercial banks having THB interest rate swap and FX swap outstanding to see the relationship between default risk premium and THB swap spreads.

Fourth, the sample studied span from 2001 to 2019, which not only offers the most updated dataset, but this time interval has the interesting phenomenon which is the occurrence of negative swap spreads and the different economic cycle separated by the policy interest rate.[4] Thus, this study can investigate the different effect of the determinants of THB swap spread in the difference market and also address the negative swap spreads. As swap spreads are nowadays commonly used by both regulator and investors (financial firms or non-financial firm), policy makers use swap spreads as indicators for credit and liquidity condition in the market, investors use swap spreads for both hedging and speculating purpose. Hence, better understanding of the dynamics of the factors

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over the counterparty risk of European financial institutions is one of the important drivers of the deviation from CIP in the FX swap market, combining with the US dollar shortage problem. Wong, Leung and Ng (2017) support that both liquidity premium and counterparty default risk are the main driver for CIP deviation.

[3] Before May 2019, the methodology of THBFIX is survey-based by commercial banks in Thailand, however, since May 2019 the methodology had changed to transaction-based by commercial banks in Thailand.

[4] Lekkos and Milas (2004) separate the market condition by slope of term structure while Huang and Chen (2007) use the Federal Reserve monetary policy to proxy the business cycle and Chung and Chan (2010) divide the sample period by major event occurred in US swap market.

associated in swap spreads in many different situations could be beneficial for all market participants. See section data and methodology for subperiods of this study.

1.3 Hypothesis Development

Traditional factors influencing swap spreads namely the default risk premiums, liquidity premiums and slop of the Treasury yield curve are widely used to find the relationship to swap spreads in many previous literatures. However, macroeconomic factors are not quite taken into account to explain the swap spreads despite these factors might have significant impact to swap spreads because market participants always focus them for interest rate expectation. Furthermore, THB swap rate is distinguished from developed countries' swap market in term of floating reference rates which is derived from FX swap transactions. Hence, this study adds 4 additional factors that might determine THB swap spreads namely TED spread, government bond supply, CPI and manufacturing production index.

Table 1: Explanatory variables and their predicted signs on THB swap spreads (descriptions and sources, see data and methodology section)

Explanatory variables	Predicted Sign on THB swap spreads	Remark
Default risk premiums	Positive	Used by Sun, Sundaresan, and Wang (1993), Soresen and Bollier (1994), and Chung and Chan[5] (2010)
Liquidity premiums	Positive	Used by Durfresne and Solnik (2001), Grinblatt (2001), Liu, Longstaff, and Mandell (2006) and Huang and Neftci (2006)
Ted Spreads[6]	Positive	Addition in this study

[5] Chung and Chan (2010) study the relationship of default risk premiums and swap spreads during the swap rate is deemed to be risk-free security as the establish of ISDA and credit enhancement but they still find that even default risk positively relates to swap spread as LIBOR rates are embedded with default risk.

[6] TED spreads are widely used in previous studies for proxy of default risk premium or liquidity premium in order to study US swap spreads. Nevertheless, in this study, we use

Government bond supply	Negative	Addition in this study
CPI	Positive	Addition in this study
Manufacturing production index	Positive	Addition in this study

First hypothesis: Does default risk premium positively relate with THB swap spreads?

As the enhancement of counterparty credit risk after the establishment of ISDA and using collateral agreement called CSA, swaps are ideally default risk free. Many studies find that even default risk premium does not directly affect swap spreads as swaps are deemed to be default risk free, but default risk premium has indirect to swap spreads as the risk could drive the LIBOR rate. Even the floating reference rate for THB swap is THBFIX which is not the interbank offering rate like LIBOR or TIBOR but THBFIX is based on FX swaps transactions which have large exposure of the default risk[7] as they have to exchange the notional amounts. Even interest rate swap is ideally default risk free by the improvement of credit and collateral management but FX swaps still have the large exposure to counterparty credit risk, hence, the default risk premium of commercial banks in Thailand should have positive relation to THB swap spreads is hypothesized.

Second hypothesis: Does liquidity premium positively relate with THB swap spreads?

Many studies find that the liquidity has significant explanatory power for price effect in fixed income market. Boudoukh and Whitelaw

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TED spreads for proxy the liquidity of USD funding that significantly affects FX swap point as almost commercial banks in Thailand fund USD through FX swap transactions.

[7] ISDA agreement governs the long-term (over 1 year) contract, however, FX swaps are typically less than one year.

(1993) compare the yield of US Treasury both notes and bonds with the different status, on-the-run and off-the-run and find that on-the-run has around 10 basis point lower than that of off-the run. Grinblatt (2001) models swap spreads as compensation for a convenience yield embedded in government notes. Many studies measure liquidity premium by the floating reference rate subtracting with government yield curve at the same maturity. This study follows the same measurement of liquidity premium and liquidity premium is expected to be positively associated with THB swap spreads.

Third hypothesis: Does slope of the government yield curve positively relate with THB swap spreads?

The effect of slope of the yield curve is uncertain. Theoretically, slope of the yield curve could have either positive or negative impacts to the swap spreads. For instance, Sorensen and Bollier (1994) argue that when steepening curve occurs, buyers of the swap must have mark to market gains but simultaneously they may expose the more default risk as their counterparties have to pay more interest while the curve is upward. Therefore, the gain on value may be offset by increasing of counterparty default risk which pressures swap rate to become lower. Therefore, slope of the yield curve negatively relates with swap spreads. On the one hand, slope of the yield curve can be interpreted as the market consensus for the implied forward interest rate. In this sense, slope of the yield curve should have a positive relation with THB swap spreads. However, we hypothesize that slope of the government yield curve should positively relate to THB swap spreads.

Fourth hypothesis: Does TED spread positively relate to THB swap spreads?

Foreign exchange swap (FX swap) is ubiquitously used by Thai commercial bank and asset management company as funding instruments. Baba and Packer (2009) propose that lending/borrowing in interbank market is uncollateralized funding while FX swap is collateralized funding as one party can fund one currency by pledging

another currency as collateral. Normally, the USD liquidity in Thai market is more scarce compared to the THB liquidity, therefore, the USD liquidity commonly proxied by TED spread can be the driver of THB FX swap movement. Since THBFIX is the floating reference rate of THB interest rest swap and implied by FX swap transactions. Therefore, one of other hypothesis is that does TED spread positively relate to THB swap spreads?

Fifth hypothesis: Macroeconomic variables on the THB swap spreads

We hypothesize the impact of macro variables based on assumption that when the market participants expect the interest rate hike, then market participants in THB interest rate market prefer to long swap rate positions rather than short government bonds because the physical settlement is required in Thai bond market (even in the market practice, Thailand Securities Depository is the representative to settle the securities, but the market participants have to have those particular bonds in the TSD accounts). Hence, the macroeconomic variables which theoretically increase the interest rate hiking probability are hypothesized to have positive impact to THB swap spreads. The macroeconomic variables are chosen by economic theory as follow;

- *Government bond supply*. The basic demand-supply model is the common factor driving the securities' price. The bond yield should decrease when the supply of government bond diminishes and could cause swap spreads are wider. Therefore, one of other hypothesis is that does government bond supply negatively relate with THB swap spreads?
- *Consumer price index (CPI).* The consumer price index is commonly represented for inflation. The positive path of CPI would let the hiking interest rate expectation in the market. Therefore, CPI should have a positive impact to THB swap spreads.
- *Manufacturing production index*. Since the gross domestic product (GDP) data are only available at a quarterly frequency and as

manufacturing production index is a monthly economic indicator measuring real output in the manufacturing, hence, many studies use the index to proxy the GDP. The positive result of this index would let the market participants expect interest rate to be increased. Therefore, the manufacturing production index should positively affect THB swap spreads.

Sixth hypothesis: Do determinants asymmetrically affect THB swap spreads during the different states of economy?

Since Jackwerth (2000) discovers that the level of risk aversion of investors is closely related to market conditions for option market. For swap spreads, Fang, Lin, and Roadcap (2012) suggest that market participants pay attention to different macroeconomic news releases depending on the state of the economy. Huang and Chen (2007) provide the result that each of their determinants have a different impact on the US swap spreads in the different Federal Reserve monetary policy regime. Consequently, determinants should have the different impact during the different economy cycles is hypothesized.

2. Literature Review

The determinants of swap spreads which have been widely studied are the default risk premium, the liquidity premium and slope of the government bond yield curve. Nevertheless, the results are still inconclusive.

Default risk on swap spreads

Initially, most studies mainly analyzed swap pricing on default risk. Cooper and Mello (1991) offers the closed form solutions for the value of the default risk, Sun, Sundaresan, and Wang (1993) examine the effect of dealer's credit reputation on swap quotations and bid – offer spread of swap rate. Sorensen and Bollier (1994) show that the value of the swap depends on the swap parties' default probability, interest rate volatility and the term structure of interest rates as interest rate volatility and the shape of the yield curve can be the proxies of default risk. On the

contrary, Litzenberger (1992) shows that as there are no initial and last exchange on principal only net between fixed and floating interest to be settled for swap. Therefore, the default risk is minimum. Duffie and Huang (1996) show that the impact the impact of default risk is relatively small. Grinblatt (2001) argues that the swap contracts are free of default risk.

Liquidity on swap spreads

In Treasury market, Boudoukh and Whitelaw (1993) compare the yield of US Treasury both notes and bonds with the different status, on-the-run and off-the-run and find that on-the-run has around 10 basis point lower than that of off-the run. For the swap spreads, Grinblatt (2001) shows that the swap contracts are free of default risk and swap spreads are caused by a Treasury liquidity advantages or a liquidity convenience yield. Similarly, Collin-Durfresne and Solnik (2001) show that swaps are indexed on "refreshed"- credit quality LIBOR rates and Huang and Neftci (2006) support that liquidity premium is the primary driver for swap spreads. Using different proxies of liquidity premium, Liu, Longstaff, and Mandell (2006) find that the changes in swap spreads are closely related to changes in the liquidity premium. Lekkos and Milas (2001) and In, Brown, and Fang (2003) discover that the US swap spreads movement, particularly on the short-term, is significantly caused by liquidity premium proxied by TED spread.

Slope of the government bond yield curve on swap spreads

In swap rate, Minton (1997) proxy the slope of the risk-free curve by the difference between yields of 30-year Treasury bond and 3-month Treasury bill and find that the slope of government yield curve has positive relation with swap rate. For swap spreads, Lekkos and Milas (2001) use the difference between 10-year and 2-year Treasury bond yields as the slope of the risk-free curve and identify that when steep yield curve has the positive relation with short-end swap spreads, opposite pattern for long-term swap spreads by using vector autoregressive (VAR) model. Meanwhile using smooth transition autoregressive (STVAR) model

experience the same empirical result that the effects of each factors depending on whether the yield curve is steep or flat.

Multi-factor econometric model of the term structure of interest rate swap yields.

Number of studies argue that the swap spread is not solely driven by neither default risk nor liquidity premium but the impact of both on swap spread are moderately combined. Duffie and Singleton (1997) constructs a multi-factor model and argues that swaps can be priced using standard term-structure models based on credit risk and liquidity adjustment. Minton (1997) finds that the credit risk is only determinant driving swap rate as an aggregate default risk factor is not statistically related to swap rates. There are possible explanations include slope of the term risk-free structure, transaction cost, differences in the end-users of each instrument, and variations in the regulatory and also microstructure. He (2000) presents a new approach explaining term structure of swap spreads by including notion of short-term financing spreads, liquidity premium and risk premium required for holding long-term Treasury bonds or swaps. Huang and Chen (2007) make a summary that the treasury slope, liquidity premium, interest rate volatility, and default risk premium all contribute to the US swap spreads but their impacts are different during the different business condition as same as for JPY swap spreads studied by Huang, Chen, and Camacho (2008).

Determinants during the different regimes

Number of studies find that in other market the variables may behave differently between the different market conditions. In the option market, Jackwerth (2000) focuses on the degree of risk aversion is not constant during the different market situation. In the stock market, McQueen and Roley (1993) provides that evidence that the reaction of equity market to macroeconomic news depends on the economy cycle. For swap spreads, [8]Huang and Chen (2007) show that during the different monetary cycles separated by Federal Reserve monetary policy, the

[8] The model used by Huang and Chen (2007) is a vector autoregressive (VAR), while Huang, Chen, and Camacho use a smooth transition vector autoregressive (STVAR) model.

impact of each determinant performs differently, as same as Huang, Chen, and Camacho (2008) study in JPY swap spreads with the same concept of Huang and Chen (2007).

Determinant of swap spreads among the development of the swap market

Litzenberger (1992) claims that swap spreads are hardly sensitive to credit risk because there are no credit risk adjustments when swap dealers quote the swap price as the poor-rated counterparty would be denied to access to swap market or having less negotiation power for collateral requirements. Collin-Dufresne and Solnik (2001) and He (2000) build the valuation model assuming that swaps are free from counterparty default risk in the presence of credit risk development agreement. Chung and Chan (2010) investigate the determinants of US swap spreads while swap market is more standard by establishment of ISDA, they find that changes in swap spread are jointly determined by the liquidity premium, interest rate level, credit risk premium and the stage of economy.

Macroeconomic factors on swap rate, government bond and swap spreads

For swap rate, Azad, Fang, and Wickramanayake (2011) make the expectation that JPY swap rate is expected to have a closer link with macroeconomic variables than other financial products like stocks and discover that low-frequency swap volatilities are significantly associated with most of macroeconomic risk proxies in both positive and negative relation. Many literatures find that government bond yields are significantly related with macroeconomic variables. Ang and Piazzesi (2003) find that macro factors – namely, inflation measurement and real activity explain a significant portion around 85 percent of movements in the short and middle parts of the yield curve. For swap rate, Azad, Fang, and Wickramanayake (2011) show that macroeconomic surprises and volatility of JPY interest rate swap are closely related. Subject to swap spreads, Cortes (2003) finds that the response of swap spreads to extra prospective supply of government bond is narrowing in swap spreads. Fang, Lin, and Roadcap (2012) examine the response of Australian swap

spreads of the arrival of macroeconomic news information namely; unemployment rate, money supply growth and CPI and find that each macroeconomic factor has the different relations in different tenors of swap spreads in the different market conditions.

Background of Covered Interest Rate Parity and its deviation.

Foreign exchange swap is a short-term contract is a simultaneous buy and sell (or sell and buy) of identical amounts of one currency for another with two different value dates. Baba and Packer 2009 show that FX swap can be viewed as collateralized dollar funding while the interbank lending -borrowing is viewed as uncollateralized dollar funding. Thus, in Thailand, most of participants[9] widely use FX swap as a funding dollar instrument.

Covered interest rate parity is a no-arbitrage condition stating that the interest differential between two countries in the cash money markets should be equal to differential between Forward rate and Spot rate. Duffie and Huang (1996) show that FX swaps are subject to significantly more exposure to counterparty risk than that of interest rate swaps, due to the exchange of notional amounts. Coffey, Hrung and Sarkar (2009) and Genberg, Hui, Wong, and Chung (2009) show that the deviation of CIP is significantly caused by a sharp increase in counterparty credit risk in the interbank money market, whilst Hui, Genberg, and Chung (2011) and Mancini-Griffoli and Ronaldo (2011) explain that the funding liquidity risk is the main cause for the deviation. Baba and Packer (2009) see the similar result that concern over the counterparty risk of European financial institutions is one of the important drivers of the deviation from CIP in the FX swap market, combining with the US dollar shortage problem. Wong, Leung and Ng (2017) support that both liquidity premium and counterparty default risk are the main driver for CIP deviation.

[9] Bank of Thailand also use FX swap to provide USD liquidity and absorbing THB liquidity out of the system.

3. Data and Methodology

3.1 Data and variables

This study examines the 2-, 5-, and 10-year[10] THB swap spreads using a comprehensive data set with time interval around twenty years starting on July 2001 to December 2019. For historical THB government bond yields[11] are obtained by Thai Bond Market Association (ThaiBMA) by monthly[12] closing yields and for monthly closing rates of THB swap are collected by Bloomberg. Therefore, the dependent variables in this study are as follow;

Dependent variables	Description	Source
SS2	2-year swap spread; computed by the difference between swap rate and government bond yield of 2-year maturity.	Bloomberg for swap rate and ThaiBMA for government bond yield
SS5	5-year swap spread; computed by the difference between swap rate and government bond yield of 5-year maturity.	Bloomberg for swap rate and ThaiBMA for government bond yield
SS10	10-year swap spread; computed by the difference between swap rate and government bond yield of 10-year maturity.	Bloomberg for swap rate and ThaiBMA for government bond yield

For the descriptions and source of the explanatory variables are following:

[10] The reason for choosing those tenors of swap spreads are the representation of each tenor as 2-year swap spreads commonly represent the short term, 5-year swap spreads are representative of medium term, while 10-year swap spreads are widely used for long term representative.

[11] The yield is calculated by interpolation of the latest quotes of selected Thai government bonds which have the nearest time-to-maturity from the particular tenor from primary dealer before the cut-off time at 4:00 pm GMT+7.

[12] The reason for using monthly rather than weekly or daily basis because the weekly or daily data might be affected by sudden effects or noises in the market such as illiquidity in the market or day-of the-week effect, while the monthly data are more efficient in term of absorbing the noise, fully reflected all relevant information and easier to measure the genuine effect.

Explanatory variables	Description	Source
Default risk premiums	The difference between A rated bond and government bond yield of 5-year maturity to represent the default risk premium for commercial banks in Thailand	Bloomberg and ThaiBMA
Liquidity premiums	Computed by subtracting 6-month THB government bond from 6-month THBFIX rate	ThaiBMA and Refinitiv[13]
Slope of the government bond yield curve	Measured by the difference between 2-year THB government bond yield and 10-year government bond yield.	ThaiBMA
Ted Spreads	Computed by 3-month USD LIBOR minus 3-month US Treasury bills	Bloomberg and Refinitiv
Government bond supply	We use the outstanding of government bond each month to proxy government bond supply	Bank of Thailand
CPI	Consumer price index to see level of inflation for expectation in interest rate decision	Bloomberg
Manufacturing production index	To proxy GDP	Bank of Thailand

Different market conditions

To split our data into subperiods in order to find the impact of determinants of THB swap spreads in different states of the economy. Among many ways to partition the sample in prior studies, Fang, Lin, and Roadcap (2012) split the peak and trough of Australian business cycles by Gross Domestic Product (GDP) while Huang, Chen, and Camacho (2008) divide time interval into 2 subperiods namely; pre-Japanese banking

[13] Formally known as Thomson Reuters

crisis and post-Japanese banking crisis. Azad, Batten, and Fang (2012) use the S&P 500 index for a proxy of business cycle. However, this study follows Huang and Chen (2007) as they use Federal Reserve monetary policy while this study divides our data periods by using Bank of Thailand monetary policy rate to prevent the lag and one-way-direction problems and to capture all available and relevant information as SET index seems to move with positive trend and fundamental factors tend to lag behind the financial markets and the period of negative swap spread is added to see the relationship.

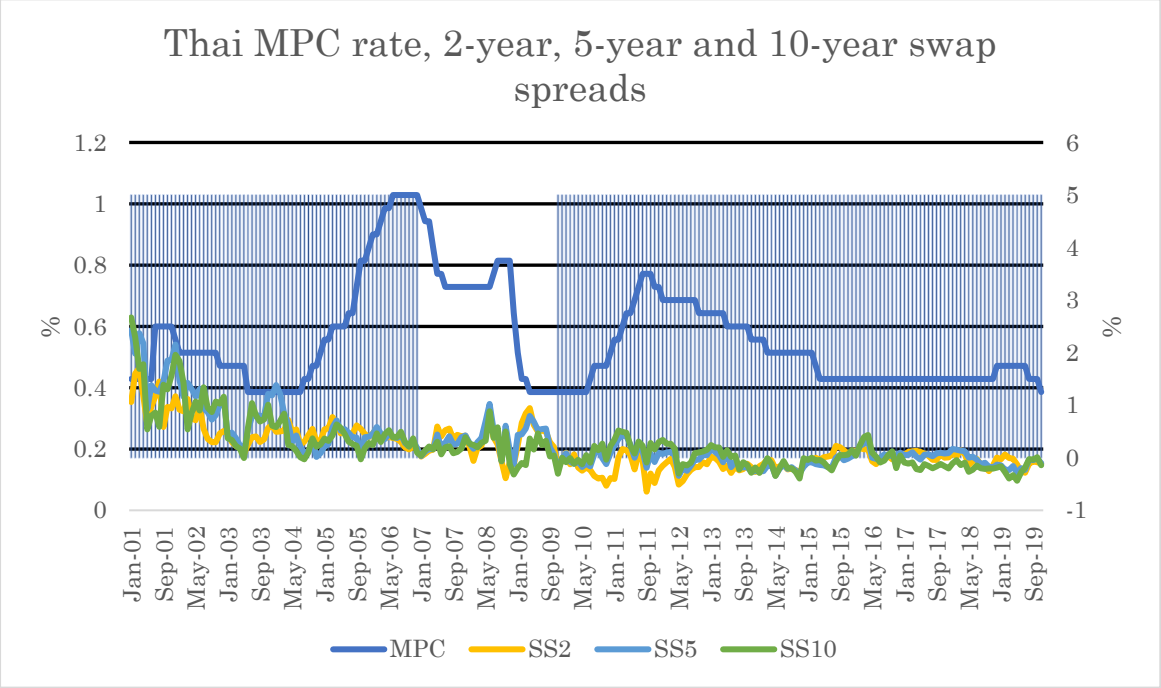

Figure 5 shows Thai monetary policy rate, 2-year, 5-year and 10-year swap spreads source: Bank of Thailand, ThaiBMA and Bloomberg.

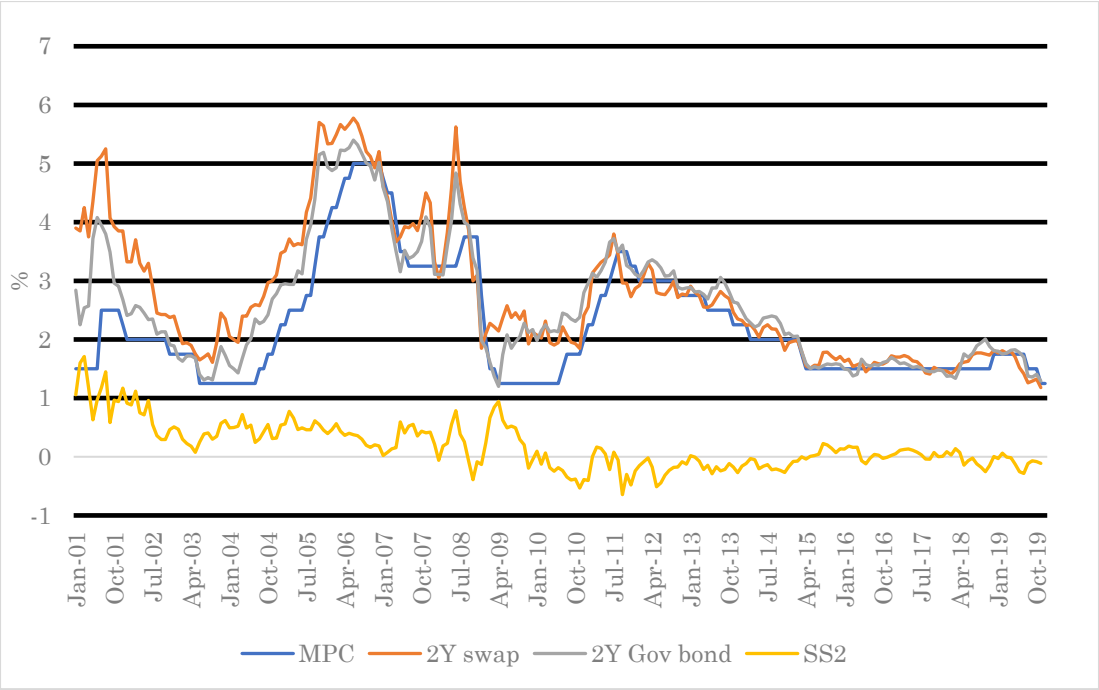

Figure 6 shows 2-year swap rate, 2-year government bond and 2-year swap spreads.

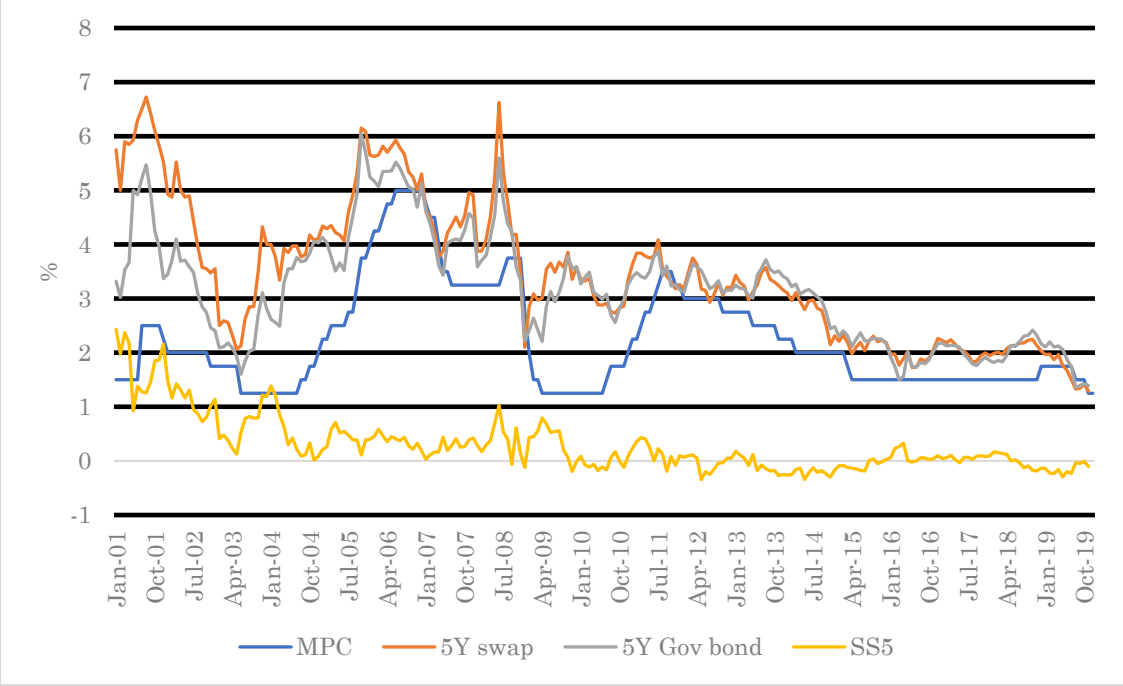

Figure 7 shows 5-year swap rate, 5-year government bond and 5-year swap spreads.

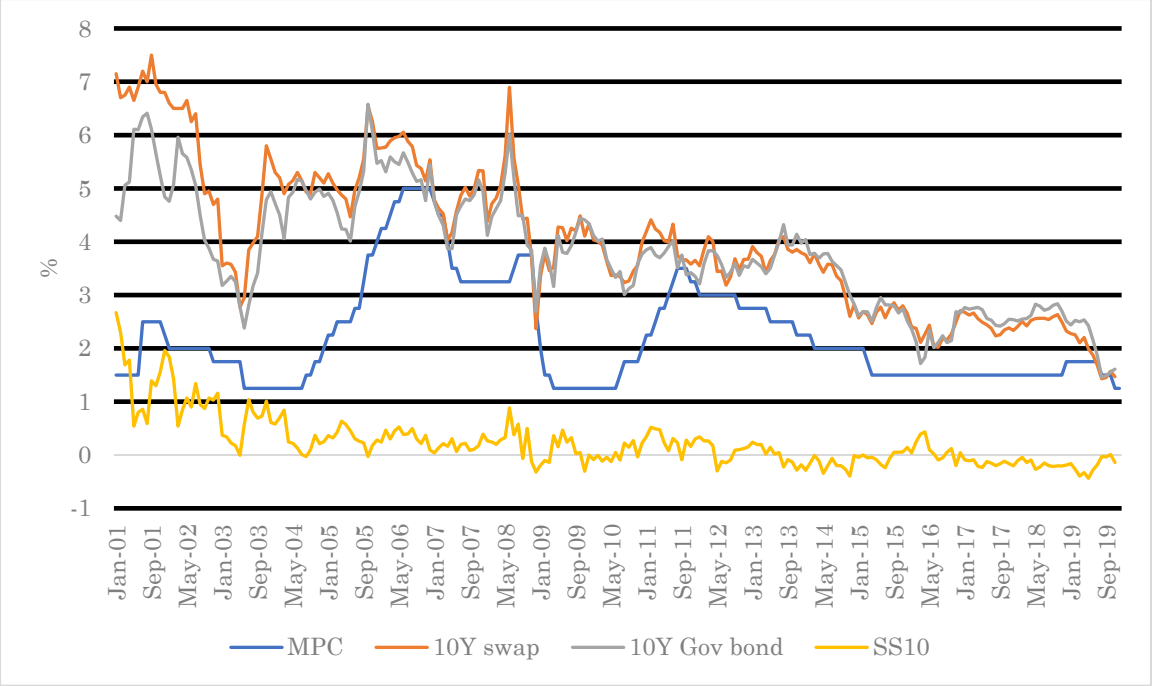

Figure 8 shows 10-year swap rate, 10-year government bond and 10-year swap spreads.

According to figure 5 to 8, we divide period into 3 subperiods namely; Pre-US Subprime period, US Subprime period and period of negative swap spreads. To specific, the first subperiod is from July 2001 to Dec 2006 and from Jan 2007 to October 2009 for the second subperiod, and the period of negative swap spreads[14] is November 2009 to December 2019 (as figure 6 – 8). It can be seen that in the first period, BOT had increased the monetary policy rate rapidly from 1.25 percent to 5 percent within less 2 years. For the second subperiod, BOT had decreased the monetary policy rate promptly from 5 percent to 1.25 percent within less 2 years to handle with US subprime crisis. And for the last period, the occurrence of negative swap spreads is quite persistent while overall monetary policy rate is quite moderate in the low interest rate territory without prompt hiking or cutting the rate.

3.2 Methodology

Swap spreads in a 3-traditional-factor

[14] The first negative swap spreads of 2-year, 5-year and 10-year tenor occurred on 29 February 2008, 30 September 2008 and 31 May 2003, respectively, however they were temporary existence. On the one hand, since 30 November 2009, the occurrence of negative swap spreads of 2-year, 5-year and 10-year has been regular.

Based on previous studies, the 3 traditional factors were widely used to study namely the default risk premiums, the liquidity premiums and slope of the government bond yield. This study follows the previous studies by regressing only 3 factors first. Therefore, the first regression equation in this study is as follows:

$$(1)\ \Delta SS_{i,t} = \beta_{i,1}\Delta DP_t + B_{i,2}\Delta LIQ_t + \beta_{i,3}\Delta SLOPE_t + \varepsilon_{i,t}$$

Where the dependent variable, $\Delta SS_{i,t}$, is the change in the swap spreads of maturity i (2-year, 5-year and 10-year) at time t. Whereas the definitions of explanatory variables are as following; ΔDP_t is the change of credit spread of bonds rating A at time t, ΔLIQ_t is the change of the spread between the 6-month THBFIX and the 6-month THB government bond yield on time t and $\Delta SLOPE_t$ is the change in difference between the 10-year THB government bond yield and 2-year THB government bond yield at time t.

Swap spreads in a 3-traditional-factor plus 4-additional-factor

Since our hypothesis that there are 4 additional factors having the relationship with THB swap spreads namely TED spreads, government bond supply, CPI and manufacturing production index. Therefore, the second regression equation is as follows:

$$(2)\ \Delta SS_{i,t} = \beta_{i,1}\Delta DP_t + B_{i,2}\Delta LIQ_t + \beta_{i,3}\Delta SLOPE_t + B_{i,4}\Delta TED_t + \beta_{i,5}\Delta GOVB_t + \beta_{i,6}\Delta CPI_t + \beta_{i,7}\Delta MPI_t + \varepsilon_{i,t}$$

Where the dependent variable, $\Delta SS_{i,t}$, is the change in the swap spreads of maturity i (2-year, 5-year and 10-year) at time t. Whereas the definitions of explanatory variables are as following; ΔDP_t is the change of credit spread of bonds rating A at time t, ΔLIQ_t is the change of the spread between the 6-month THBFIX and the 6-month THB government bond yield on time t , $\Delta SLOPE_t$ is the change in difference between the 10-year THB government bond yield and 2-year THB government bond yield at time t , ΔTED_t is the change in the spread between the 3-month LIBOR minus the 3-month Treasury bill yield on time t , $\Delta GOVB_t$ is the change of outstanding of government bond at time t, ΔCPI_t is the change of

consumer price index at time t and ΔMPI_t is the change of manufacturing production index at time t. And we will run a test to make sure that there is no multicollinearity among the variables.

And this study runs regression equation (1) and (2) in different time intervals which are (i) whole period starts from July 2001 to December 2019, (ii) Pre-US Subprime period starts from July 2001 to December 2006, (iii) US Subprime period starts from January 2007 to October 2009 and (iiii) period of negative swap spreads starts from November 2009 to December 2019 to see the different impact of each determinants during the different circumstances.

4. Empirical Results

Whole period (Jul 01 - Dec 19)				**Pre-US Subprime period (Jul 01 - Dec 06)**			
	Mean	**S.D.**	**ADF**		**Mean**	**S.D.**	**ADF**
Swap spreads (level)				*Swap spreads (level)*			
SS2	0.149%	0.351%	-4.65***	SS2	0.507%	0.258%	-4.43***
SS5	0.242%	0.441%	-3.52***	SS5	0.690%	0.486%	-1.91
SS10	0.187%	0.404%	-4.13***	SS10	0.589%	0.450%	-2.44
Swap spreads (difference)				*Swap spreads (difference)*			
ΔSS2	-0.005%	0.166%	-17.29***	ΔSS2	-0.015%	0.187%	-11.58***
ΔSS5	-0.006%	0.180%	-17.09***	ΔSS5	-0.017%	0.222%	-8.11***
ΔSS10	-0.004%	0.216%	-19.91***	ΔSS10	-0.012%	0.280%	-8.85***
Explanatory variables (level)				*Explanatory variables (level)*			
DP	1.034%	0.347%	-2.97**	DP	1.173%	0.315%	-2.00
LIQ	0.085%	0.389%	-3.98***	LIQ	0.355%	0.297%	-2.11
SLOPE	1.193%	0.789%	-2.31	SLOPE	1.774%	0.998%	-0.78
TED	0.396%	0.392%	-4.24***	TED	0.264%	0.104%	-3.83***
GOVB (THB mil)	2,559,381	1,240,433	1.28	GOVB (THB mil)	1,151,510	240,828	-1.31
CPI	2.1%	2.0%	-2.20	CPI	2.8%	1.8%	-1.13
MPI (Unit)	90.86	14.96	-2.56	MPI (Unit)	71.31	11.17	-0.76
Explanatory variables (difference)				*Explanatory variables (difference)*			
ΔDP	-0.001%	0.135%	-12.91***	ΔDP	-0.009%	0.162%	-6.97***
ΔLIQ	-0.003%	0.199%	-16.58***	ΔLIQ	-0.003%	0.156%	-8.21***
ΔSLOPE	-0.009%	0.218%	-13.04***	ΔSLOPE	-0.030%	0.264%	-6.49***
ΔTED	0.001%	0.214%	-17.27***	ΔTED	0.003%	0.087%	-11.56***
ΔGOVB (THB mil)	19,295.81	38,286.07	-15.86***	ΔGOVB (THB mil)	12,863.05	39,244.63	-7.75***
ΔCPI	0.0%	0.6%	-10.39***	ΔCPI	0.0%	0.5%	-7.09***
ΔMPI (Unit)	0.2088	3.4321	-16.99***	ΔMPI (Unit)	0.5325	1.9995	-14.20***

Table 1 shows descriptive statistics for Whole and Pre-US Subprime period.

US Subprime period (Jan 07 - Oct 09)				**Negative period (Nov 09 - Dec 19)**			
	Mean	**S.D.**	**ADF**		**Mean**	**S.D.**	**ADF**
Swap spreads (level)				*Swap spreads (level)*			
SS2	0.332%	0.292%	-2.40	SS2	-0.092%	0.168%	-4.48***
SS5	0.361%	0.244%	-3.63**	SS5	-0.030%	0.157%	-4.30***
SS10	0.190%	0.234%	-4.07***	SS10	-0.028%	0.201%	-4.32***
Swap spreads (difference)				*Swap spreads (difference)*			
ΔSS2	0.001%	0.222%	-4.89***	ΔSS2	-0.002%	0.132%	-13.71***
ΔSS5	-0.004%	0.259%	-7.29***	ΔSS5	0.000%	0.116%	-14.40***
ΔSS10	-0.001%	0.274%	-10.94***	ΔSS10	0.000%	0.147%	-15.77***
Explanatory variables (level)				*Explanatory variables (level)*			

DP	1.167%	0.590%	-1.08	DP	0.923%	0.201%	-4.22***
LIQ	0.435%	0.385%	-1.91	LIQ	-0.157%	0.232%	-5.12***
SLOPE	1.229%	0.633%	-1.52	SLOPE	0.873%	0.450%	-3.09**
TED	1.013%	0.691%	-2.29	TED	0.293%	0.114%	-3.37**
GOVB (THB mil)	1,822,242	149,330	-0.03	GOVB (THB mil)	3,514,908	793,505	-0.13
CPI	2.3%	3.3%	-0.95	CPI	1.6%	1.5%	-1.31
MPI (Unit)	94.34	6.39	-1.54	MPI (Unit)	100.31	5.61	-4.12***
Explanatory variables (difference)				*Explanatory variables (difference)*			
ΔDP	0.012%	0.217%	-4.33***	ΔDP	-0.001%	0.075%	-12.59***
ΔLIQ	-0.019%	0.278%	-5.21***	ΔLIQ	0.001%	0.194%	-14.40***
ΔSLOPE	0.051%	0.297%	-5.22***	ΔSLOPE	-0.015%	0.152%	-10.22***
ΔTED	-0.003%	0.518%	-6.51***	ΔTED	0.001%	0.067%	-10.58***
ΔGOVB (THB mil)	18,382.00	25,295.46	-6.07***	ΔGOVB (THB mil)	22,977.76	40,256.39	-12.50***
ΔCPI	-0.1%	1.2%	-3.71***	ΔCPI	0.0%	0.4%	-8.38***
ΔMPI (Unit)	0.3659	3.4580	-4.69***	ΔMPI (Unit)	-0.0074	3.9706	-12.80***

Table 2 shows descriptive statistics for US Subprime and Negative period.

Notes: ***, ** and * stand for significance at 1%, 5% and 10% respectively. Without any * means nonstationary.

Stationarity in swap spreads and explanatory variables

Table 1 and 2 indicate that some of swap spreads and explanatory variables in level basis are not stationary, for instance ,5-year and 10-year swap spread during Pre-US Subprime period are not stationary as their Augmented Dickey Fuller test (ADF) values are more than critical values (-3.56, -2.919 and -2.594 are the 1%, 5% and 10% critical values respectively during that period. The results are consistent with previous studied showing the swap spreads are nonstationary process.

Stationarity is tested by ADF test having null hypothesis as the variable under consideration has a unit root process (nonstationary) while the alternative hypothesis is that the variable has no unit root process or can be implied as being stationary. The test statistical are summarized in Table 1 and 2. To test whether both level and first difference of swap spreads and explanatory variables are stationary, this study uses the model that includes a constant but no time trend (this is because most of variables in this study are nonzero mean despite the first difference of some variables have a mean that is not significantly from zero). The results show that all variables in this study are stationary in their first differences with 1% significance in every period then we can run static time-series model to study contemporaneous relationship between stationary time-series variables and can estimate the parameter by using OLS.

Correlation among explanatory variables

Table 3 shows Correlation matrix for explaining variables for first equation regression of whole period (Jul 01 – Dec 19)

	ΔDP	**ΔLIQ**	**ΔSLOPE**
ΔDP	1.0000		
ΔLIQ	-0.0548	1.0000	
ΔSLOPE	0.0031	0.0625	1.0000

Table 4 shows Correlation matrix for explaining variables for first equation regression of Pre-US Subprime period (Jul 01 – Dec 06)

	ΔDP	**ΔLIQ**	**ΔSLOPE**
ΔDP	1.0000		
ΔLIQ	-0.0721	1.0000	
ΔSLOPE	-0.1688	-0.1343	1.0000

Table 5 shows Correlation matrix for explaining variables for first equation regression of US Subprime period (Jan 07 – Oct 09)

	ΔDP	**ΔLIQ**	**ΔSLOPE**
ΔDP	1.0000		
ΔLIQ	-0.0490	1.0000	
ΔSLOPE	0.0793	0.3993	1.0000

Table 6 shows Correlation matrix for explaining variables for first equation regression of negative period (Nov 09 – Dec 19)

	ΔDP	**ΔLIQ**	**ΔSLOPE**
ΔDP	1.0000		
ΔLIQ	-0.0614	1.0000	
ΔSLOPE	0.2042	-0.0380	1.0000

Table 7 shows Correlation matrix for explaining variables for second equation regression of whole period (Jul 01 – Dec 19)

	ΔDP	**ΔLIQ**	**ΔSLOPE**	**ΔTED**	**ΔGOVB**	**ΔCPI**	**ΔMPI**
ΔDP	1.0000						
ΔLIQ	-0.0548	1.0000					
ΔSLOPE	0.0031	0.0625	1.0000				
ΔTED	-0.1203	0.0927	-0.0756	1.0000			
ΔGOVB	-0.0841	0.0837	-0.0674	0.0260	1.0000		
ΔCPI	-0.1419	0.0350	0.0039	0.0808	0.0088	1.0000	
ΔMPI	-0.1310	-0.0555	0.0003	0.0486	0.0306	0.0359	1.0000

Table 8 shows Correlation matrix for explaining variables for second equation regression of Pre-US Subprime period (Jul 01 – Dec 06)

	ΔDP	**ΔLIQ**	**ΔSLOPE**	**ΔTED**	**ΔGOVB**	**ΔCPI**	**ΔMPI**
ΔDP	1.0000						
ΔLIQ	-0.0731	1.0000					
ΔSLOPE	-0.1672	-0.1318	1.0000				
ΔTED	-0.0057	0.0912	-0.0940	1.0000			
ΔGOVB	-0.1084	0.1579	-0.2969	0.2125	1.0000		
ΔCPI	-0.2111	0.0262	0.0050	0.0595	0.0375	1.0000	
ΔMPI	0.0727	0.0774	0.0604	0.3009	-0.1472	0.0446	1.0000

Table 9 shows Correlation matrix for explaining variables for second equation regression of US Subprime period (Jan 07 – Oct 09)

	ΔDP	**ΔLIQ**	**ΔSLOPE**	**ΔTED**	**ΔGOVB**	**ΔCPI**	**ΔMPI**

ΔDP	1.0000						
ΔLIQ	-0.0462	1.0000					
ΔSLOPE	0.0789	0.4002	1.0000				
ΔTED	-0.2041	0.1167	-0.0822	1.0000			
ΔGOVB	-0.1026	0.2527	0.1779	0.1007	1.0000		
ΔCPI	-0.2150	0.0804	-0.0230	0.1114	0.1317	1.0000	
ΔMPI	-0.6002	0.2209	-0.0779	0.0954	0.1732	0.1931	1.0000

Table 10 shows Correlation matrix for explaining variables for second equation regression of negative period (Nov 09 – Dec 19)

	ΔDP	**ΔLIQ**	**ΔSLOPE**	**ΔTED**	**ΔGOVB**	**ΔCPI**	**ΔMPI**
ΔDP	1.0000						
ΔLIQ	-0.0585	1.0000					
ΔSLOPE	0.1984	-0.0375	1.0000				
ΔTED	0.0340	0.1401	-0.1598	1.0000			
ΔGOVB	-0.0942	0.0170	0.0349	-0.1342	1.0000		
ΔCPI	0.1169	-0.0153	0.0793	-0.0540	-0.0669	1.0000	
ΔMPI	0.0134	-0.1811	0.0090	-0.0409	0.0698	-0.0679	1.0000

It can be seen that correlation among explanatory variables of every scenarios (different equation regressions, different periods) is quite low, however, the first difference of manufacturing production index and the first difference of default risk premium in US Subprime period (January 2007 to October 2009) shows the strongest correlation of -0.6002. Nevertheless, the absolute value of that correlation is lower than 0.7 which is the level that indicates the presence of multicollinearity. Therefore, there is no multicollinearity problem among explaining variables in this study.

VIF of explanatory variables

Table 11 shows VIF of explaining variables for first equation regression of whole period (Jul 01 – Dec 19)

Variable	**VIF**
ΔDP	1.0000
ΔLIQ	1.0100
ΔSLOPE	1.0000
Mean VIF	1.0033

Table 12 shows VIF of explaining variables for first equation regression of Pre-US Subprime period (Jul 01 – Dec 06)

Variable	**VIF**
ΔDP	1.0400
ΔLIQ	1.0300

ΔSLOPE	1.0500
Mean VIF	1.0400

Table 13 shows VIF of explaining variables for first equation regression of US Subprime period (Jan 07 – Oct 09)

Variable	VIF
ΔDP	1.0100
ΔLIQ	1.2000
ΔSLOPE	1.2000
Mean VIF	1.1367

Table 14 shows VIF of explaining variables for first equation regression of negative period (Nov 09 – Dec 19)

Variable	VIF
ΔDP	1.0500
ΔLIQ	1.0000
ΔSLOPE	1.0400
Mean VIF	1.0300

Table 15 shows VIF of explaining variables for second equation regression of whole period (Jul 01 – Dec 19)

Variable	VIF
ΔDP	1.0600
ΔLIQ	1.0300
ΔSLOPE	1.0200
ΔTED	1.0300
ΔGOVB	1.0200
ΔCPI	1.0300
ΔMPI	1.0200
Mean VIF	1.0300

Table 16 shows VIF of explaining variables for second equation regression of Pre-US Subprime period (Jul 01 – Dec 06)

Variable	VIF
ΔDP	1.1200
ΔLIQ	1.0500
ΔSLOPE	1.1600
ΔTED	1.1900
ΔGOVB	1.2400
ΔCPI	1.0500
ΔMPI	1.1800
Mean VIF	1.1414

Table 17 shows VIF of explaining variables for second equation regression of US Subprime period (Jan 07 – Oct 09)

Variable	VIF
∆DP	1.6700
∆LIQ	1.3700
∆SLOPE	1.2800
∆TED	1.0900
∆GOVB	1.1200
∆CPI	1.0700
∆MPI	1.7400
Mean VIF	1.3343

Table 18 shows VIF of explaining variables for second equation regression of negative period (Nov 09 – Dec 19)

Variable	VIF
∆DP	1.0700
∆LIQ	1.0600
∆SLOPE	1.0800
∆TED	1.0700
∆GOVB	1.0400
∆CPI	1.0300
∆MPI	1.0400
Mean VIF	1.0557

Another method to quantify the extent of correlation between explanatory variables is to use the Variance Inflation Factor (VIF). And it can be seen that the maximum mean VIF of all scenarios is only 1.3343 (in second equation regression of US Subprime period), whereas he maximum individual VIF is 1.74 (for first difference of manufacturing production index during US Subprime period). In general, a VIF above 10 or more conservative at 2.5 indicates high correlation and is cause for multicollinearity concern but the results of VIF in this study are lower than those levels. Therefore, it can be reconfirmed that there is no multicollinearity problem in this study.

Results of regression analysis

Tables 19 shows Regression coefficients, T-statistics R-squared and for explanatory variables in first equation.
Notes: ***, ** and * stand for significance at 1%, 5% and 10% respectively.

	Whole period Jul 01 - Dec 19	Pre-US Subprime period Jul 01- Dec 06	US Subprime period Jan 07 - Oct 09	Negative period Nov 09 - Dec 19

SS2(%)					
Δ*DP*	Coeff.	0.0702	0.1581	0.0677	-0.0878
(%)	t-statistics	1.0300	1.2100	0.3900	-1.0800
Δ*LIQ*	Coeff.	0.4559***	0.4955***	0.1542	0.6072***
(%)	t-statistics	9.9100	3.6500	1.0600	19.6100
Δ*SLOPE*	Coeff.	0.1517***	0.2504***	0.2183	0.0864**
(%)	t-statistics	3.6100	3.0900	1.6000	2.1500
	R^2	0.3492	0.2482	0.1724	0.7680
SS5(%)					
Δ*DP*	Coeff.	0.2153***	0.7771***	-0.1627	-0.2048*
(%)	t-statistics	2.6200	5.2900	-0.9300	-1.7000
Δ*LIQ*	Coeff.	0.3578***	0.1954	0.5473***	0.3205***
(%)	t-statistics	6.4400	1.2800	3.6900	7.0100
Δ*SLOPE*	Coeff.	0.0496	0.1742*	0.0266	-0.0686
(%)	t-statistics	0.9800	1.9100	0.1900	-1.1600
	R^2	0.1828	0.3247	0.3780	0.3248
SS10(%)					
Δ*DP*	Coeff.	0.1399	0.5651***	-0.2350	-0.1173
(%)	t-statistics	1.4100	2.8800	-1.1400	-0.8000
Δ*LIQ*	Coeff.	0.2829***	-0.0977	0.4214**	0.3269***
(%)	t-statistics	4.2200	-0.4800	2.4000	5.8600
Δ*SLOPE*	Coeff.	-0.3253***	-0.3232***	-0.2810*	-0.3847***
(%)	t-statistics	-5.3100	-2.6500	-1.7100	-5.3100
	R^2	0.1709	0.2358	0.2194	0.3706

Multiple regressions are performed based on the first differences of both dependent variable and explanatory variables. According to table19, the result of the multiple regression for first equation shows that the liquidity premium is significant and positively related to the swap spreads in all tenors and under all sample period except for 10-year swap spread during Pre-US Subprime period which liquidity premium has the negative affect. Interestingly, during the period of negative swap spread, the liquidity premium also has the value in negative (-0.1572%[15] is mean of liquidity premium during the period of negative swap spread). Therefore, it implies that during the negative, the decreasing of 100 basis point of liquidity premium can cause the decreasing of 60.72, 32.05 and 32.69 basis point in 2-year, 5-year and 10-year swap spread respectively. The

[15] According to table 2, shows that the mean of level of liquidity premium is -0.1572%.

findings are consistent with second hypothesis, which posits a positive relation between the liquidity premium and swap spread.

The slope of the government bond yield curve shows the positive relation in 2-year swap spread, especially in Pre-US subprime period, it can be implied that the increasing of 100 basis point in the slope of the government bond yield curve can cause 2-year swap spread higher 25.04 basis point. However, the positive impact of the slope of the government bond yield curve tends to become weaker for 5-year swap spread and become negative relation for 10-year swap spread. Interestingly, the slope of the government bond yield curve has positive impact to 2-year swap spread for all periods but the impact is not the same direction to 5-year swap spread as it is positive for whole period and Pre-US Subprime period whereas during Subprime period and Negative period face the negative impact. However, the impact of the slope of the government bond yield curve to 10-year swap spread is negative in all period. These results are consistent with previous studies as they find both positive and negative impact of the slope of the government bond yield curve to swap spread.

The default risk premium has the positive relation which is consistent with first hypothesis to the all tenor of swap spread for whole period and Pr-US Subprime period where we find the significant and strongest relation as increasing of 100 basis point of the default risk premium can cause 5-year swap spread higher 77.71 basis point and 56.51 basis point for 10-year swap spread and the impact of default risk premium to 2-year swap spread is least compared to the others, however during US Subprime period , the default risk premium has negative impact to 5-year and 10-year swap spread, which is not consistent with previous studies as they find that default risk premium plays an important and positive role to swap spreads during the periods of weak economic activities, which correspond to monetary loosening regimes and this premium has negative relation to all tenors of swap spread during Negative period.

Overall, the impacts of the explanatory variables are different during the different period especially for 5-year and 10-year swap spread

which are consistent with sixth hypothesis, which hypothesizes that determinants have different impact to swap spread during the states of economy.

Table 20 shows Regression coefficients, T-statistics and R-squared for explanatory variables in second equation.

		Whole period Jul 01 - Dec 19	Pre-US Subprime period Jul 01- Dec 06	US Subprime period Jan 07 - Oct 09	Negative period Nov 09 - Dec 19
SS2(%)					
Δ*DP*	Coeff.	0.0671	0.1971	0.0118	-0.0702
(%)	t-statistics	0.9600	1.4200	0.0500	-0.8500
Δ*LIQ*	Coeff.	0.4596***	0.4763***	0.1562	0.6172***
(%)	t-statistics	9.9100	3.4000	1.0000	19.4100
Δ*SLOPE*	Coeff.	0.1473***	0.2604***	0.1703	0.0797*
(%)	t-statistics	3.4900	3.0000	1.0000	1.9500
Δ*TED*	Coeff.	-0.0847*	-0.1250	-0.0808	-0.0722
(%)	t-statistics	-1.9600	-0.4700	-1.0800	-0.7800
Δ*GOVB*	Coeff.	1.86E-05	3.37E-05	2.12E-04	6.77E-06
(THB 10 bil)	t-statistics	0.7700	0.5600	1.3700	0.4500
Δ*CPI*	Coeff.	0.0152	0.0517	0.0210	-0.0074
(%)	t-statistics	1.0000	1.1200	0.6400	-0.4800
Δ*MPI*	Coeff.	-3.86E-06	2.73E-05	-7.40E-05	2.12E-05
(1 unit)	t-statistics	-0.1400	0.2400	-0.5200	1.3800
	R^2	0.3648	0.2643	0.2691	0.7749
SS5(%)					
Δ*DP*	Coeff.	0.2057**	0.8271***	-0.2014	-0.1915
(%)	t-statistics	2.4400	5.4500	-0.9200	-1.5700
Δ*LIQ*	Coeff.	0.3718***	0.1998	0.5638***	0.3255***
(%)	t-statistics	6.6200	1.3000	3.6500	6.9300
Δ*SLOPE*	Coeff.	0.0408	0.1914**	-0.0175	-0.0726
(%)	t-statistics	0.8000	2.0100	-0.1300	-1.2000
Δ*TED*	Coeff.	-0.0865	0.4782	-0.1560**	-0.1467
(%)	t-statistics	-1.6500	1.6400	-2.1100	-1.0700
Δ*GOVB*	Coeff.	-1.33E-05	-2.41E-05	1.12E-04	-2.51E-05
(THB 10 bil)	t-statistics	-0.4600	-0.3600	0.7300	-1.1200
Δ*CPI*	Coeff.	-0.0014	0.0496	-0.0123	-0.0203
(%)	t-statistics	-0.0700	0.9800	-0.3800	-0.8900
Δ*MPI*	Coeff.	2.96E-05	-1.88E-04	3.02E-05	6.18E-07
(1 unit)	t-statistics	0.9100	-1.4800	0.2200	0.0300
	R^2	0.1966	0.3768	0.4808	0.3381

SS10(%)					
Δ*DP*	Coeff.	0.1014	0.5917***	-0.2112	-0.1095
(%)	t-statistics	1.0000	2.9400	-0.8300	-0.7300
Δ*LIQ*	Coeff.	0.3039***	-0.0388	0.4567***	0.3285***
(%)	t-statistics	4.5100	-0.1900	2.5400	5.7000
Δ*SLOPE*	Coeff.	-0.3416***	-0.3290**	-0.2961*	-0.3875***
(%)	t-statistics	-5.5800	-2.6100	-1.8200	-5.2400
Δ*TED*	Coeff.	-0.1496**	0.1747	-0.1873**	-0.1317
(%)	t-statistics	-2.3800	0.4500	-2.1800	-0.7800
Δ*GOVB*	Coeff.	-3.53E-05	-8.51E-05	-1.05E-04	-1.98E-05
(THB 10 bil)	t-statistics	-1.0100	-0.9700	-0.5900	-0.7200
Δ*CPI*	Coeff.	-0.0056	0.0152	-0.0054	-0.0221
(%)	t-statistics	-0.2500	-2.2800	-0.1500	-0.7900
Δ*MPI*	Coeff.	1.17E-06	-3.82E-04**	1.30E-04	-8.40E-06
(1 unit)	t-statistics	0.0300	-2.2800	0.8000	-0.3000
	R^2	0.1968	0.3048	0.3700	0.3792

Notes: ***, ** and * stand for significance at 1%, 5% and 10% respectively.

According to table 20, the 3 explanatory variables that have been in first equation namely, the default risk premium, the liquidity premium and the slope of the government bond yield curve show the results as same as the first regression result.

Whereas the 4 additional factors namely, TED, Government bond supply, CPI and MPI can be shown their results as;

TED has negative impact to all tenor of swap spread in all period except we see the positive impact of TED to 5-year and 10-year swap spread during Pre-US subprime period. And the impact is quite weaker than those of default risk premium, liquidity premium and the slope of the government bond yield curve. For whole period, the increasing of 100 basis point in TED can cause 2-year, 5-year and 10-year swap spread lower 8.47, 8.65 and 14.96 basis point respectively. The negative impact of TED to swap spread can be described by since TED can proxy the US dollar liquidity, the higher TED can be implied that US dollar is shortage, and normally Thai commercial banks ubiquitously fund US dollar liquidity by FX swap and to acquire US dollar, Thai commercial banks have to sell FX swap and making swap point lower causing THBFIX lower and making swap spread also lower. The findings are contrary with fourth hypothesis, which assumes TED has positive impact to swap spread.

For the government bond supply, the results show that the government bond supply has negative relation as expected to 10-year swap spread in all period, the increasing of government bond supply of THB 10 billion can cause 10-year swap spread lower 0.0035 basis point for whole period (the average of absolute change in government bond supply during whole period is THB 31.41 billion) and 5-year swap spread in every periods except during US Subprime period. On the other hand, the relation of government bond supply to 2-year swap spread is contrary with our hypothesis.

For CPI, overall the impacts of CPI to swap spread are mixed, as the results show positive relation for 2-year swap spread as increasing of 100 basis point can cause 2-year swap spread higher 1.52 basis point for whole period. On the one hand, 5-year and 10-year swap spread face the opposite pattern as increasing of 100 basis point can cause 5-year and 10-year swap spread lower 0.14 and 0.56 basis point respectively. And the impacts CPI to swap spread are different during the different periods.

The positive relation of MPI only occurs for the longer-dated swap spread in whole period, e.g., 5-year and 10-year swap spread as expected, but not in 2-year tenor. An increasing of 1 unit of MPI can cause 5-year and 10-year swap spread higher 0.00296 and 0.000117 basis point respectively, whereas, 2-year swap spread drops 0.000386 basis in an increasing of 1 unit of MPI. And the relation between MPI and swap spread are different during the different periods.

Robustness checks

Since the impact of default risk premium is not consistent with the hypothesis and previous studies especially to the 5-year and 10-year swap spreads for both first and second regression equation′s results. As the results show that the impact of default risk premium is negative and not significant to 5-year and 10-year swap spreads during US Subprime period and negative period, whereas the previous studies find that during the period of bad condition, default risk premium has a significantly positive to swap spreads. Consequently, we have performed robustness checks by including an interaction terms between default risk premium

variable and dummy variable by determining the value of 1 to dummy variable during US Subprime and negative swap spread period in both first and second regression equations for whole period. And we do the same process to robustness checking to slope of the government bond yield as well.

Table 21 shows Regression coefficients, T-statistics and R-squared for explanatory variables in first robustness check regression equation.

Whole period (Jul 01 – Dec19)		**SS2 (%)**	**SS5 (%)**	**SS10 (%)**
Δ*DP*	Coeff.	0.1570	0.7968***	0.6081***
(%)	t-statistics	1.5000	6.8300	4.1000
Δ*DumDP*	Coeff.	-0.1175	-0.9817***	-0.8178***
(%)	t-statistics	-0.8500	-6.3800	-4.1000
Δ*LIQ*	Coeff.	0.4675***	0.3656***	0.2794***
(%)	t-statistics	10.1100	7.1100	4.2700
Δ*SLOPE*	Coeff.	0.2484***	0.1899***	-0.2833***
(%)	t-statistics	3.8700	2.6600	-3.1200
Δ*DumSLOPE*	Coeff.	-0.1632*	-0.1730*	-0.0103
(%)	t-statistics	-1.9000	-1.8100	-0.0800
	R^2	0.3617	0.3196	0.2332

Notes: ***, ** and * stand for significance at 1%, 5% and 10% respectively.

Table 22 shows Regression coefficients, T-statistics and R-squared for explanatory variables in second robustness check regression equation.

Whole period (Jul 01 – Dec19)		**SS2 (%)**	**SS5 (%)**	**SS10 (%)**
Δ*DP*	Coeff.	0.1768*	0.7952***	0.5949***
(%)	t-statistics	1.6900	6.8000	4.0400
Δ*DumDP*	Coeff.	-0.1530	-1.0149***	-0.8839***
(%)	t-statistics	-1.1000	-6.5300	-4.5100
Δ*LIQ*	Coeff.	0.4716***	0.3783***	0.2989***
(%)	t-statistics	10.1700	7.3200	4.5900
Δ*SLOPE*	Coeff.	0.2590***	0.1857**	-0.3012***
(%)	t-statistics	4.0100	2.5800	-3.3200
Δ*DumSLOPE*	Coeff.	-0.1865**	-0.1803*	-0.0047
(%)	t-statistics	-2.1600	-1.8700	-0.04
Δ*TED*	Coeff.	-0.0923**	-0.1173**	-0.1736**
(%)	t-statistics	-2.1400	-2.4400	-2.8700
Δ*GOVB*	Coeff.	2.68E-09	-3.04E-10	-3.27E-09
(THB 10 bil)	t-statistics	1.1100	-0.1100	-0.9700

Δ*CPI*	Coeff.	0.0161	-4.08E-05	-0.0050
(%)	t-statistics	1.0700	-0.0000	-0.2400
Δ*MPI*	Coeff.	-7.61E-06	2.21E-06	-2.30E-05
(1 unit)	t-statistics	-0.2800	0.0700	-0.6100
	R^2	0.3814	0.3385	0.2676

Notes: ***, ** and * stand for significance at 1%, 5% and 10% respectively.

The results of regressions for robustness check for both first and second equation show that the negative impact of default risk premium to swap spreads during US Subprime and negative period can be confirmed by the negative coefficients with 1% significance of Δ*DumDP* for both regression equations. The negative impact of default risk premium during the bad economic condition is consistent with *Ito (2007)* [16]*, Ito (2010)*[17] as the study finds that the function of price discovery in the market might have been lowered because of economic shocks.

Whereas, the impact of the slope of the government bond yield curve from robustness test in first equation shows the negative relation to 2-year and 5-year swap spreads with significance at 10% during US Subprime and negative period, meanwhile, the result in second equation provides the same impact of slope to 2-year and 5-year swap spreads but with 5% and 10% significance respectively.

The robustness results for both equation regressions can confirm that for entire time interval of this study, the impacts of default risk premium, liquidity premium and slope of government bond yield curve are significantly positive to 2-year and 5-year swap spreads which are consistent with previous works. Whereas, the negative impact of slope of the government bond yield curve to 10-year swap spread which is not consistent with our hypothesis can be confirmed by the negative coefficient with 1% significance, however, this negative impact is consistent with *Lekkos and Milas (2001).* Furthermore, the negative coefficients with 5% significance of TED can support that the increasing in TED can narrow swap spreads during whole period and this negative impact can be explained by US dollar funding by FX swap transactions and interest rate parity.

[16] Ito (2010) finds that when the monetary policy was easing, JPY swap spreads decreased as credit risk increased. When monetary policy was tightening, 10-year swap spread decreased in accordance with the increase of corporate bond spread.

[17] Ito (2010) finds that the default risks measured both in Aaa and Baa corporate bonds are negatively incorporated in US interest rate swap spreads in the period of financial crisis during 2005 to 2009.

5. Conclusion

This paper aims to investigate the determinants of THB swap spreads by combining the traditional explaining variables of previous researches, e.g., default risk premium, liquidity premium and slope of the government bond yield curve, with additional explaining variables that might be missed in the previous studies and unique in THB swap spreads, e.g., TED and macroeconomic factors during the different states of economy, which are classified by Bank of Thailand monetary policy rate and the presence of negative swap spread. The motivation is to investigate the different effect of the determinants of THB swap spread in the different market conditions and negative swap spread period.

The key findings can be recapitulated as follows; *(1)* the liquidity premium is a significant and important determinant of THB swap spreads in every period. And the liquidity premium may be the cause of negative swap spread as during the period of negative swap spread, the liquidity premium is in negative territory also. *(2)* For whole period, the slope of the risk-free term structure is more like the implied forward rate for short-term and medium-term of swap spreads, as evidenced by the positive relation of slope the of the government bond yield curve with 2-year and 5-year. However, the positive relation tends conversely to be negative for 10-year swap spread that can be explained by *Lekkos and Milas (1994)* that increases in the slope of the yield curve are associated with an expanding economy and an improvement of business conditions, this is in turn should be alleviate any default considerations and cause swap spreads to decline. *(3)* Even, the presence of ISDA and CSA, default risk premium remains the positive determinant of THB swap spreads in all tenors in whole period and it has a significant and important impact during Pre-US Subprime period and its impact during this period is the greatest which is not consistent with most of previous works which find that default risk premium has the biggest size of impact when economy is contracted, which corresponded to expansionary monetary policy. Whereas, during the US-Subprime, the function of price discovery in the market might have been lowered because of financial shock as we find the negative

impact of default risk to swap spreads confirmed by robustness check, this negative impact is consistent with *Ito (2007), Ito (2010). (4)* This is a new and interesting discovery that TED spread which is an abroad factor not domestic factor has a significant and negative impact to swap spreads which can be explained by US funding by FX swap transactions and interest rate parity, and this finding maybe beneficial to market participants in order to prevent hedging and investment losses by monitor both domestic and dollar factors. *(5)* Unfortunately, the impact of 3 additional macro factors are not significant, however, in case of focusing of only the sign of the impact, the government bond supply plays negative role to 5-year and 10-year, this finding is consistent with Cortes (2003) find the bond price could drop to response increasing of bond supply and making swap spreads to narrow. On the one hand, the impact of CPI and MPI are quite directionless and not significant. This could suggest either the fact that the estimated model does not suit, or these additional macro factors do not significantly affect the swap spread at least for the period of the data used to implement the model. *(6)* During the negative period, the liquidity premium is the most important determinant as it has a significant and positive relation with all tenor of swap spreads implying that decreasing in liquidity premium can cause swap spread more negative.

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VITA

NAME	Parkorn Wattanaskolpant
DATE OF BIRTH	25 March 1992
PLACE OF BIRTH	Bangkok, Thailand
INSTITUTIONS ATTENDED	Master of Science in Finance
HOME ADDRESS	81/5 Ratchadamnoen Road, Phra Pathom Chedi Subdistrict, Mueang Nakhon Pathom District, Nakhon Pathom Thailand