

ASIA-PACIFIC FIXED INCOME MARKETS

An Analysis of the Region's Money, Bond and Interest
Derivative Markets

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John Wiley & Sons (Asia) Pte Ltd

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Wiley — VCH, Pappelallee 3, 69469 Weinheim, Germany

Library of Congress Cataloging in Publication Data

✕ ISBN 0-471-84577-9

Typeset in 11/13 points; Linographic Services Pte Ltd
Printed in Singapore by Saik Wah Press Pte Ltd
10 9 8 7 6 5 4 3 2 1

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What Factors Affect the Credit Spreads on Emerging Market Issuers? Evidence from Thailand

Jonathan Batten, Thomas Fetherston and Pongsak Hoontrakul

1. Introduction

Given limited domestic bond market development in many emerging markets it is necessary for high quality domestic issuers to tap international debt markets for funding. However how should these debt instruments be priced, and what are the factors that affect the yields of these instruments? For example, current market practice assumes that the term structure (yield curve) for an emerging market issuer equals a benchmark, (generally the US term structure) plus a spread (De Almcida et al., 1998). Also models on the pricing of credit spreads (Longstaff and Schwartz, 1995; Jarrow, Lando and Turnbull, 1997) suggest that asset and interest rate factors negatively affect changes in credit spreads. The objective of this study is to examine these issues in more detail by investigating the relationship that exists between Government of Thailand bonds issued in the US debt market matched with another set of US Government bonds of varying maturity. This enables precise calculation of the spread in yield between these two different issuers to be determined and overcomes concerns which arise from spreads calculated from interpolated yields using splining or other techniques (Kim, Moon and Lee 1998). The sample period covers daily data for the period from 5 May 1999 to the 31 January 2001.

Understanding these relationships is important for a number of reasons. First, the results of this study will provide evidence on the nature of the risk premium that exists between the Thai and US bond markets. These findings will also provide a framework for investigating the international bonds issued by other developing countries. Second, the results will also assist the pricing and risk management of Thai debt in international markets. To price risky bonds, general market practice is to apply a yield spread to

a risk-free bond of equivalent maturity. This practice assumes an equilibrium relationship between these bonds, with pricing based on a linear, but not necessarily constant, relationship. Third, the study will provide an insight into the long-term equilibrium relationship between different maturity classes of Thai and US Government bonds. Historically studies investigating long-term equilibrium relationships have been restricted to securities of developed countries (for example see Hiraki, Shiraishi, and Takezawa, 1996).

The focus of this chapter is on the spreads of international bonds issued by Thai borrowers, specifically those bonds issued in US domestic bond markets. Issues by non-residents in the United States are termed Yankee bonds by the market participants. The attractive feature of the Yankee market is that it is available to non-investment grade corporate issuers (credit rating lower than BBB). Emerging market issuers are generally unable to tap the international Eurobond market, which has a preference for investment grade issues, and is also largely a U.S. dollar-denominated market. However from the borrower's perspective, the degree of substitutability of these different markets is ultimately a function of cost. For example there were significant increases in the level of offshore issues in the period prior to 1995 largely associated with the decline in spreads of issues over U.S. Treasury bonds of similar maturity (Kamin and Kleist, 1999). During this period, lenders favored Asian issues (e.g. spreads on Latin American issues with the same characteristics as Asian issues were 39% higher). This may have been due to: (a) Latin American and Eastern European countries exhibiting greater volatility than Asian Economies and/or (b) greater supply, since Latin American countries issue more bonds than Asian countries.

The key features of each successful international issue by Asian borrowers which encouraged high-yield investors, were the size of the issue (which ensured adequate liquidity), the size of the spread (which compensated investors for the risks of holding emerging market bonds) and the marketing of the issues (which included government and central banker representation during the international promotion or "roadshow" prior to the actual issue arranged by high-profile and credible book-runners⁶). Also, issues tend to have a simple fixed-rate pricing structure and are generally quasi-government, if not sovereign issues. It is doubtful if a more complex structure (for example having a call feature) would have found favour with investors, or if smaller tranches offered over a range of maturities would have satisfied the markets desire for liquidity⁷ since smaller issues fragment the distribution of bonds. However the key features of very large ("jumbo") Eurobond issues by prime name corporations is that they are all fixed-rate U.S. dollar-denominated securities. In the case of Thailand in the period from 1994 to 2000, international issues increased from US\$0.3 billion to

⁶ *Capital Data Bondware (Euromoney) generally list the following firms as the major bookrunners of emerging market bonds: JP Morgan, Merrill Lynch, CSFB, Union Bank of Switzerland and Lehman Brothers.*

⁷ *It is difficult to assess what issue size is necessary to maintain adequate liquidity. One of the world's largest Eurobond issuers (Federal Home Loan Mortgage Corporation or Freddie Mac) suggests one bullet maturity issues of at least US\$4 billion every quarter is necessary (Euromoney June 1998: "Borrowers, A Mad Rush for Liquidity").*

US\$13.3 billion US\$ (BIS 2000). We focus on one segment of these issues, Thai Government issues in the US market.

These issues are investigated using empirical models based on Hall, Anderson and Granger (1992), and Batten, Hogan and Pynnonen (2000) for the cointegration relationships between Thai and US Government bonds, and the regression model proposed by Longstaff and Schwartz (1995) for explaining the yield spread. To accommodate the time-varying volatility of the return series, a GARCH specification of the Longstaff and Schwartz (1995) empirical model is used in this paper. The data and method employed in this study are described in the next section. The results are then presented and the final section allows for some concluding remarks.

2. Data and Method

Daily Thai bond data was obtained from the Reuters Fixed Income Database for the period from the 5 May 1999 to the 1 February 2001 (450 observations). This database comprised 531 separate bonds that were denominated in a number of currencies: 451 Thai baht; 63 US dollar; 15 Japanese yen and two in Deutsche mark and French franc. A complete listing of US-denominated bonds by Thai borrowers is provided in Appendix 1. This listing includes both Eurobonds and Yankee issues. There were only six Thai Government Yankee issues in the US recorded on the Reuters database and three which had a complete set of prices. The remaining 57 issues were non-government issues or issues in Euromarkets (Eurobonds). All the Thai Government issues carried a Moody's rating of Baaa or Standard & Poors rating with BBB minus. All bonds were fixed-rate, of semi-annual coupons priced on a 30/360 day basis. The three issues were:

- a) 7.84% coupon maturing on the 15 August 2001;
- b) 6.27% coupon maturing on the 30 September 2003;
- c) 7.75% coupon maturing on the 15 April 2000.

Market practice is to price risky bonds as a spread on an underlying risk-free benchmark security, typically a US government of equivalent maturity and coupon. Fortunately, given the depth of the US Treasury bond market there were a number of US T-Bonds with equivalent maturity to the three Thai Government bonds described above (a), (c) and (e):

- a) 7.875% coupon maturing on the 15 August 2001;
- b) 5.75% coupon maturing on the 15 August 2003;
- c) 11.875% coupon maturing on the 15 November 2003;
- d) 12.0% coupon maturing on the 15 August 2013 ;
- e) and a Federal Home Loan Mortgage Bank (FHLB) bond 6.535% coupon maturing on the 30 September 2013.

Looking specifically at two bonds over the sample period: the Thai 6.27% 2003 bond and the US 5.75% 2003 T-bond, the yield on the US bond ranged from 4.64% to 6.88%, while the Thai bond ranged from 6.63% to 9.09%. The standard deviation of the Thai bond was higher (0.5573) than the US bond (0.4594) suggesting it was more volatile. Consistent with market pricing practice, the correlation between Thai and US bonds was highest for bonds of the same maturity. The correlations between the various

bonds are provided in Table 13b.1. An interesting feature of these results is that the correlations between any two of the Thai bonds tended to be higher than those correlations between US bonds of equivalent maturity. It appears the Thai bonds were all being grouped as one whereas maturity (and expectations) differences were more pronounced for the US bonds.

Table 13b.1 Correlation Coefficients of Thai Yankee Bonds and US Benchmark Bonds

Thai Government Yankee Bonds		US Bonds						
		7.84%	6.27%	7.07%	7.87%	5.75%	11.875%	6.535%
		2001	2003	2013	2001	2003	2003	2013
7.84%	2001	1.000000	0.912453	0.823389	0.940383	0.783940	0.772678	0.747092
6.27%	2003	0.912453	1.000000	0.889512	0.893701	0.948585	0.946290	0.900858
7.07%	2013	0.823389	0.889512	1.000000	0.729999	0.809523	0.825399	0.909418
7.875%	2001	0.940383	0.893701	0.729999	1.000000	0.848937	0.822754	0.751255
5.75%	2003	0.783940	0.948585	0.809523	0.848937	1.000000	0.995355	0.921400
11.875%	2003	0.772678	0.946290	0.825399	0.822754	0.995355	1.000000	0.931965
6.535%	2013	0.747092	0.900858	0.909418	0.751255	0.921400	0.931965	1.000000
12%	2013	0.773486	0.937682	0.902226	0.786231	0.962370	0.973470	0.973550

Source: Reuters Fixed Income Database

Having obtained a set of daily yields for the Thai Yankee bonds, the various factors that affect these yields will need to be established. Though a variety of statistical techniques may be applied to the data, it would be appropriate to examine (a) the long and short-term dynamics of the yields within a cointegration framework, and (b) investigate those factors which affect the changes in spreads on the risky bonds. The cointegration framework follows from Batten, Hogan and Pynnonen (2000), which was developed from the earlier work by Hall, Anderson and Granger (1992). The empirical framework investigating changes in credit spreads is based on Longstaff and Schwartz (1995) who suggested a two factor model based on asset and interest rate factors as driving changes in risky bond yields.

(i) A Cointegration Framework

Batten, Hogan and Pynnonen (2000) denote the continuously compounded yield to maturity of a k period pure discount bond as $R^*(k, t)$, ($k = 1, 2, K$) with $F(k, t)$ the forward rate of a contract at time t to buy a one period discount bond that matures at $t + k$. Using their notation, a general relationship between maturities of pure discount bonds is as follows:

$$(1) \quad R^*(k, t) = \frac{1}{k} \sum_{j=1}^k E_t[R^*(1, t+j-10)] + A(k, t) \quad \text{with} \quad A(k, t) = \frac{1}{k} \sum_{j=1}^k a(j, t).$$

Traditional theories of the term structure (Hall et al., 1992) focus on the properties of the premiums. The pure expectation hypothesis asserts that $A(k, t)$ are zero and the expectation hypothesis that the premiums are constants.

In the case of corporate bonds there is a risk premium over an otherwise similar government bond. For a corporate bond there is a risk that the coupon or principal payment may not be met, implying a distinction between the promised and expected return on the bond. Because of this uncertainty investors demand a risk premium covering the promised and expected return. Let $D(k, t)$ denote the risk premium for a corporate bond over an otherwise similar government bond, and then from (1) we get the following model for the yield of a corporate bond:

$$(2) \quad R(k, t) = R^*(k, t) + D(k, t).$$

Thus we can write $\Delta R^*(1, t+i) = R^*(1, t+i) - R^*(1, t+i-1)$. Given that $R^*(1, t+i)$ are $I(1)$ (integrated of order one), the differences $\Delta R^*(1, t+i)$ are therefore stationary, implying that the (double) summation term in the last line of (3) is stationary. Therefore the important result predicted from the theory is that the yield spread $R(k, t) - R(1, t)$ is stationary since the maturity premiums and default risk premiums $D(k, t) - D(1, t)$ are stationary.

(ii) Changes in Credit Spreads

A key empirical implication of the Merton (1974), Longstaff and Schwartz (1995) valuation model for risky fixed-rate bonds is that credit spreads are driven by two factors: an asset-value factor and an interest-rate factor. A key empirical concern is whether this model is applicable for sovereign issues. The regression equation form of Longstaff and Schwartz model (their notation) is given by:

$$(3) \quad D(k, t) - D(1, t) = \Delta S_t = a + b\Delta Y_t + c\Delta I_t + e_t$$

where $\Delta S_t = S_t - S_{t-1}$, S_t is the actual credit spread which is the difference between a risky bond (i.e. a Thai government Yankce bond) of a specified maturity (X_t) and a US government T-bond of the same maturity (Y_t). The change in the US rate is defined as $\Delta Y_t = Y_t - Y_{t-1}$. As suggested by Longstaff and Schwartz, the change in the asset-value factor is proxied by the return on a broad stock market index (i.e., in this instance the Thai SET Index), where ΔI_t is the natural logarithm of the daily change on the stock index (I_t). Finally, a , b , and c are regression coefficients.

There are three key empirical issues that need to be addressed at this point. First, is it possible to proxy the Thai Government risk using a stock market index? If so, should an adjustment be made for the exchange rate since the other two variables are denominated in US dollars? Thailand offers a rare insight into this first issue since there are a number of listed corporations on the Thai stock market that are majority-owned by the Thai Government. For example Krung Thai Bank is both a listed firm and a firm that carries the same credit rating as the Thai Government (Baaa) in international debt markets. In the later empirical analysis we use a number of alternate proxies for the asset factor variable and found no statistically significant differences in the results. This was probably due to the high correlation between changes in the prices of alternate measures and the SET index (the magnitude was 0.898 for the Krung Thai Bank and 0.916 for the Thai Military Bank which has a slightly lower credit rating).

The second empirical issue concerns the need to adjust for exchange rates. The price of the asset proxy which is a Thai baht denominated asset should be expressed in US terms to avoid a misspecification of the regression model. Again, alternate specifications provide no significant differences, which suggests that the index had factored in exchange rate effects. In fact the Thai baht had a 0.911 negative correlation to the SET index, i.e. if the US appreciated against the Baht, the SET index fell during the sample period.

The third empirical issue concerns the significance of the regression intercept expressed as a in the equations above. We expect that this coefficient should be indistinguishable from zero. Were this not to be case, then a constant risk premium would be expected from the returns on the bonds other than those due to interest rate and asset risk factors. To provide further insights into the properties of credit spread returns the simple Ordinary Least Squares regression equation of credit spreads adopted by Longstaff and Schwartz (1995), has been extended in this study, by incorporating a GARCH specification of Bollerslev (1986). For simplicity we apply a GARCH (1,1) such that:

$$(4) \quad \Delta S_t = a + b\Delta Y_t + c\Delta I_t + e_t, \quad \sigma^2 = \alpha + \varepsilon^2_{t-1} + \gamma\sigma^2_{t-1}$$

The coefficients in these regressions are expected to be negative (i.e. $b < 0$ and $c < 0$). The explanation that $c < 0$ is non-controversial and an intuitive explanation lies with the degree of solvency of the issuer: when an issuer's value increases, the probability of default falls. As noted by Longstaff and Schwartz (1995) the explanation for the expected negative value on (c), the interest rate factor, is due to the increase in the drift of the risk-neutral process as interest rates increase, which causes the risk-neutral probability of default to fall. Thus as interest rates rise the credit spread is expected to reduce. However this theoretical relationship may or may not occur depending on the correlation between the issuer's assets and liabilities and interest rate movements, as well as the form of the volatility of interest rates. Also, as noted by Duffee (1999: 202), when the correlation between default-free interest rates and the value of the issuing firm's assets is negative, the value of the firm's assets is more stable, and the likelihood of default is therefore reduced. This occurs since a decline in the firm's assets are accompanied by an increase in the instantaneous interest rate, allowing the growth rate of the firm's assets to rise, which in turn pushes the firm away from default.

4. Results

(i) Description of Spreads

Spreads between the Thai Government Yankee bonds and the underlying US bond were calculated. Two sets of spreads were calculated for the Thai 6.27% 2003 bond (between this bond and the US 5.75% and the US 11.875% — the first had a slightly short maturity and the second had a slightly longer maturity) and the Thai 7.07% 2013 bond (between this bond and the 12% and the FHLB 6.535% — the last bond had the exact maturity while the first bond had a slightly earlier maturity). This enabled five sets of spreads to be used in the later analysis. The mean spread for the various maturity bonds varied from 1.23% to 2.07% depending on the maturity over the sample period.

Table 13b.2 Descriptive Statistics for Spreads on Thai Yankee Bonds and US Benchmark Bonds

	\$6.27% 2003-1	\$6.27% 2003-2	\$7.07% 2013-1	\$7.07% 2013-2	\$7.84% 2001
Mean	2.074586	1.988186	1.625659	1.235600	1.942502
Median	2.124298	2.007820	1.677681	1.312061	1.957538
Maximum	2.429807	2.380805	1.979243	1.616725	2.361312
Minimum	1.358417	1.303464	0.946548	0.352286	1.071712
Std. Dev.	0.189518	0.190953	0.231608	0.229560	0.181855
Skewness	21.484087	21.125098	20.980700	20.924558	21.021193
Kurtosis	4.939114	4.084273	3.468628	3.293257	5.303717

Table 13b.3 Correlation between Spreads on Thai Yankee Bonds and US Benchmark Bonds

	\$6.27% 2003-1	\$6.27% 2003-2	\$7.07% 2013-1	\$7.07% 2013-2	\$7.84% 2001
\$6.27% 2003-1	1.000000	0.972345	0.780469	0.756664	0.836434
\$6.27% 2003-2	0.972345	1.000000	0.717740	0.698810	0.747901
\$7.07% 2013-1	0.780469	0.717740	1.000000	0.959664	0.747461
\$7.07% 2013-2	0.756664	0.698810	0.959664	1.000000	0.753814
\$7.84% 2001	0.836434	0.747901	0.747461	0.753814	1.000000

Source: Reuters Fixed Income Database

The spread between the Thai 6.27% 2003 bond and the US benchmark is provided in Figure 13.1. It is clear from this figure how spreads increased over the sample period reaching a peak of nearly 2.5% in the middle of 2000. Descriptive statistics are provided in the following two Tables (13b.2 and 13b.3), which provide the other moments and the correlations between the various spreads. Interestingly the two spreads on the longest maturity bond (2013) were smaller than the other bonds. This is consistent with other US evidence that suggests declining spreads as maturity increases (Pederosa and Roll, 1998). The correlation between spreads was also positive with the largest correlations between bonds of similar maturity. The lowest correlations were between spreads on the shortest bonds (2001) and the longest bonds (2013).

(ii) Cointegration analysis between Thai Government Yankee Bonds and US Government bonds

Given that the risk premiums, can be assumed stationary, theory predicts that the series should be cointegrated with a cointegration vector . Table 13b.2 reports the Johansen unrestricted cointegration analysis with the corresponding likelihood ratio for various combinations of bond pairs between the three Thai Yankee bonds and the various US Government bonds. The Augmented Dickey-Fuller tests for stationarity of the spreads are also reported. Not reported in this table are the stationarity tests for the yields. The full sample test statistics show no evidence against the null hypothesis that there was a unit root in yield levels, but the data clearly rejects the null hypothesis that there was

a unit root in the difference. A reasonable conclusion from these results is that each yield to maturity is integrated at order one (i.e. they are an I(1) process) with all tests supporting the unit root hypothesis at the 1% level of significance for all the data series. However all combinations of spread (levels) are non-stationarity which suggests the spreads also follow I(1) processes, or equivalently, that the stochastic trends which play the dominating role in the behavior of the yields are independent of one another. The five lags proved to be sufficient to ensure that the residuals were not serially correlated.

Table 13b.4 Johansen Cointegration and Stationarity Tests of Thai Government Bonds with US Government Bonds

Bond pairs	Likelihood ratio test for cointegration*	ADF test for stationarity of the spread
Bonds with the equivalent maturity		
Thai 7.84% 15/08/2001-US 7.875% 15/08/2001	6.172	21.13
Thai 6.27% 30/09/2003-US 5.75% 15/08/2003	12.961	20.93
Thai 6.27% 30/09/2003-US 11.875% 15/11/2003	16.124	21.34
Thai 7.07% 30/09/2013-FHLB 6.535% 30/09/2013	7.335	0.12
Thai 7.07% 30/09/2013-US 12% 15/08/2013	6.559	20.40
Short Thai Bonds with Long US Bonds		
Thai 7.84% 15/08/2001-US 5.75% 15/08/2003	17.792*	20.59
Thai 7.84% 15/08/2001-US 11.875 15/11/2003	19.729*	20.85
Thai 7.84% 15/08/2001-FHLB 6.535% 30/09/2013	13.775	20.77
Thai 7.84% 15/08/2001-US 12% 15/08/2013	19.981*	20.93
Thai 6.27% 30/09/2003- FHLB 6.535% 30/09/2013	12.547	21.74
Thai 6.27% 30/09/2003-US 12% 15/08/2013	20.432**	22.05
Long Thai Bonds with Short US Bonds		
Thai 6.27% 30/09/2003-US 7.875% 15/08/2001	12.401	21.43
Thai 7.07% 30/09/2013-US 5.75% 15/08/2003	12.927	22.28
Thai 7.07% 30/09/2013-US 11.875% 15/11/2003	11.548	22.51
Thai 7.07% 30/09/2013-US 7.875% 15/08/2001	14.036	21.93
Critical values		
	5 %	22.87*
	1 %	23.45**

Augmented Dickey-Fuller test with four difference lags and an intercept

The null hypothesis is that the series are not cointegrated; the intercept is restricted within the cointegration space

Source: Reuters Fixed Income Database

Contrary to the theoretical predictions, the results from the likelihood ratio test indicate that the Thai bonds are generally not cointegrated with the US Government bonds of equivalent maturity. There was only one bond pair (Thai 6.27% 30 September 2003 — US 11.875% 15 November 2003) that was cointegrated (likelihood ratio of 16.124, significant at the 5% level). This also means that the risk spreads, defined in Equation (3), should be $I(1)$ series, implying that these Thai Government bonds and the US Government bonds do not have any ties with one another and the two bond markets are effectively independent in terms of pricing. This suggests that pricing the Thai Government bonds as a spread over the equivalent maturity US Government bond may not be appropriate. The alternate perspective is that this anomalous result may be due to the specific sample period studied.

The results were more significant for combinations of short maturity Thai bonds and long maturity US bonds with almost all bond pairs cointegrated at the 5% level. What is interesting is that the long maturity Thai bonds are not cointegrated with shorter maturity US bonds. Thus it appears from these results that the defining pricing relationship is between the US long bonds and the Thai bonds of a shorter maturity.

Cointegration relationships were also calculated between various pairs of Thai bonds, and between various pairs of US bonds. These results are not reported in Table 13.4 though there was strong cointegration in each case. In the case of the Thai bonds the likelihood ratio tests between the 2003 and the 2001 and 2013 maturities were all significant at the 5% level (ratios of 15.606 and 14.529 respectively), however the short (2001) and the long bonds (2013) were not cointegrated — suggestive of independent return processes. Consistent with other cointegration studies on the US term-structure (eg. Hall et al., 1992) the US bond pairs were clearly cointegrated, at least at the 5% level. The exception was between the two sets of bonds with the similar maturity, though different coupons—the 5.75% and the 11.875% 2003 bonds, and the 6.535% (FHLB) and the 12% 2013, both had low likelihood ratios (9.319 and 7.508 respectively) which rejects cointegration at the 5% level.

(iii) Changes in Credit Spreads

Regressions of the change in the credit spread against the change in the US Government bond and the return on the SET Index were conducted using the Bollerslev (1986) GARCH (1,1). The SET index was expressed in US dollar terms for these calculations. However the analysis was also conducted with the SET index in Thai baht terms and a separate exchange rate variable (the change in the spot Thai baht against the US dollar). These results are not reported, however in each case the exchange variable was not statistically significant and the SET Index was as statistically significant as the US dollar specification. The GARCH specification was undertaken to adjust for the time-varying volatility structure of the return series. To ensure that the statistical significance of the results was not affected by conditionally non-normally distributed residuals, we also applied the methods described by Bollerslev and Wooldridge (1992) when calculating the standard errors. Adopting this procedure tended to reduce the statistical significance of the asset factor for the credit spreads on longer maturity bonds. Only these adjusted results are reported in Table 13b.5.

Table 13b.5 Regressions of Changes in Credit Spreads on Changes in the US Government Bond Yields and Returns on the SET Index (5 May 1999 to 31 January 2001)

Spread between Thai and US Bonds	GARCH (1,1) estimation of changes in credit spreads $\Delta S = a + b\Delta Y + c\Delta I + \varepsilon_t$, $\sigma_t^2 = \alpha + \beta \varepsilon_{t-1}^2 + \gamma \sigma_{t-1}^2$							
	α	β	ψ	α	β	γ	R^2	F
Thai 7.84% 15/08/2001-US 7.875% 15/08/2001	-0.0023 -1.04 (0.302)	-0.3963 -11.74 (0.000)	-0.2562 -2.86 (0.004)	0.0009 4.05 (0.000)	0.3010 4.74 (0.000)	0.3968 3.22 (0.000)	13.88%	14.26 (0.000)
Thai 6.27% 30/09/2003-US 5.75% 15/08/2003	-0.0014 -0.86 (0.389)	-0.2250 -11.44 (0.000)	-0.2430 -3.18 (0.001)	0.0005 5.42 (0.000)	0.3272 5.46 (0.000)	0.4009 4.49 (0.000)	16.83%	17.89 (0.000)
Thai 6.27% 30/09/2003-US 11.875% 15/11/2003	-0.0013 -0.75 (0.451)	-0.177 -8.87 (0.000)	-0.174 -2.33 (0.000)	0.0005 5.83 (0.000)	0.3643 5.88 (0.000)	0.427 6.08 (0.000)	12.66%	12.82 (0.000)
Thai 7.07% 30/09/2013-FHLB 6.535% 30/09/2013	-0.0005 -0.2801 (0.779)	0.2394 15.67 (0.000)	-0.2495 -3.33 (0.000)	0.0007 8.02 (0.000)	0.2891 5.43 (0.000)	0.2758 3.62 (0.000)	4.09%	3.77 (0.000)
Thai 7.07% 30/09/2013-US 12% 15/08/2013	-0.0020 -2.53 (0.011)	0.296 11.12 (0.000)	-0.593 -12.79 (0.000)	0.0006 8.66 (0.000)	2.2734 9.459 (0.000)	0.045 2.965 (0.003)	7.09%	4.68 (0.000)

The table reports the results from a GARCH (1, 1) specification of the regression model $\Delta F = a + b\Delta Y + c\Delta I + \varepsilon_t$, $\sigma_t^2 = \alpha + \beta \varepsilon_{t-1}^2 + \gamma \sigma_{t-1}^2$. The term (Y) is the daily change in the US Government T-Bond with equivalent maturity as S , the change in the credit spread, and (I) is the natural logarithm of the daily change on the SET Index. Z-statistics and associated probability values (in brackets) are reported below each of the regression coefficients. The model was estimated using the heteroskedasticity consistent covariance procedure of Bollerslev and Wooldridge (1992).

The intercept term (a) was not statistically significant apart from the last regression for the 2013 maturity bond. A significant alpha implies a risk premium in addition to that proposed by theory. However the size of this coefficient (20.0020) is small compared with the size of the other coefficients in the equation, and so would not have a significant effect on the spread return. The coefficients for the asset factor (c) were all negative and all statistically significant at the 99.9% level. This suggests that changes in credit spreads are negatively related to changes in the stock market index. This result — consistent with theory — is an important result for emerging market issuers. The interest rate factor (b) was positive for long bonds and negative for short bonds. The result predicted from theory is for the latter.

The size of the coefficients, and therefore their contribution to the return on the credit spread was of a similar order, though the size of the asset coefficient was slightly greater than that for the interest factor in four of the five regressions. The R^2 also declined as maturity increased suggesting that this model is a better predictor of the credit spread behavior in shorter rather than longer maturity bonds.

The statistical significance of the variance equation is specified by the three terms (alpha, beta and gamma in Table 13b.5). The constant, a, represents the long-term average; the coefficient ω of the ARCH term, represents the significance of volatility observed in the previous period, and the coefficient b of the GARCH term represents the forecast variance from the last period. These coefficients are all significant in the five bonds in the sample. The first coefficient, a, though significant, has a smaller value than the other two coefficients. The size of the β and γ coefficients were of a similar order suggesting that both past and forecast volatility have a similar effect on predicting variance.

5. Conclusions

In this study the yield spread between Thai Government bonds issued in the US domestic market (Yankee bonds) and US Treasury bonds of different maturities were investigated. There were two objectives: first, to determine the long-term equilibrium dynamics in the cointegration framework of Hall, Anderson and Granger (1992) and Batten, Hogan and Pynnönen (2000), and then to investigate the extent that interest rate and asset factors affect changes in credit spreads as predicted by Longstaff and Schwartz (1995). The results from cointegration analysis suggest that the long-term equilibrium relationship holds between Thai Yankee bonds and long-term US bonds rather than shorter or equivalent maturity bonds. This result was contrary to the results from simple correlation analysis that suggested equivalent maturity bonds were more highly correlated. The implication of this result is that there are definite limitations to the market approach for pricing and managing the risk of Thai bonds using equivalent maturity US Treasury bonds.

Also a GARCH (1,1) specification derived from the regression equation proposed by Longstaff and Schwartz (1995) to accommodate the time-varying volatility structure of credit spread returns, suggests credit spreads of Thai Government bonds are negatively related to changes in the Thai SET Index. This was the case whether this variable was expressed in US dollar or Thai baht terms. Changes in US Treasury bond yields also

equally affect these spreads albeit negatively for short-term bonds and positively for long-term bonds.

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Appendix 1: Outstanding USD Issues by Thai Corporations at February 2001

ISSUER: 18/1/2001	COUPON	MATURITY	AGENCY	RATING
ADVANCE AGRO PUBLIC CO LTD	3.5	17/06/2001	MOO	Caa1
ADVANCE AGRO PUBLIC CO LTD	13	15/11/2007	MOO	NR
BANGKOK BANK PUBLIC COMPANY LTD	1.5	7/08/2006	MOO	Ba1
BANGKOK BANK PUBLIC COMPANY LTD	7.25	15/09/2005	MOO	Ba3
BANGKOK BANK PUBLIC COMPANY LTD	8.25	15/03/2016	MOO	Ba3
BANK OF AYUDHYA PCL	8.09	29/07/2001	MOO	B1
BANKTHAI PCL	7.875	19/06/2002	—	—
BANPU PUBLIC CO LTD	2.75	10/04/2003	—	—
BANPU PUBLIC CO LTD	3.5	25/08/2004	—	—
CENTRAL PATTANA PUBLIC CO LTD	2.75	10/04/2001	—	—
COGENERATION PCL	2.5	12/02/2007	—	—
ELECTRICITY GENERATING AUTHORITY OF THAILAND	6.9375	25/03/2005	—	—
ELECTRICITY GENERATING AUTHORITY OF THAILAND	7	14/10/2008	MOO	A3
ELECTRICITY GENERATING AUTHORITY OF THAILAND	7	14/10/2008	MOO	A3
FINANCE ONE PUBLIC CO LTD	5.75	17/06/2003	—	—
GOVERNMENT HOUSING BANK	6.75	4/10/2001	MOO	Baa3
HEMARAJ LAND AND DEVELOPMENT PUBLIC CO LTD	3.5	9/09/2003	—	—
INDUSTRIAL FINANCE CORPORATION OF THAILAND	7.2875	22/04/2002	—	—
INDUSTRIAL FINANCE CORPORATION OF THAILAND	7.125	4/08/2002	MOO	Ba1
INDUSTRIAL FINANCE CORPORATION OF THAILAND	6.875	1/04/2003	MOO	Ba1
INDUSTRIAL FINANCE CORPORATION OF THAILAND	7.375	14/01/2007	MOO	Ba1
INDUSTRIAL FINANCE CORPORATION OF THAILAND P	7	4/08/2007	MOO	Ba1
JASMINE SUBMARINE TELECOMMUNICATIONS CO LTD	8.483	30/05/2011	—	—
JULDIS DEVELOP PUBLIC CO LTD	4.25	22/12/2003	—	—
KIATNAKIN FINANCE PCL	4	30/11/2003	—	—
KRUNG THAI BANK PCL	9.00688	29/09/2004	MOO	Ba3
LAND & HOUSE PUBLIC CO LTD	5	29/04/2003	—	—
LOXLEY PUBLIC CO LTD	2.5	4/04/2001	—	—
LOXLEY PUBLIC CO LTD	3.5	20/04/2005	—	—
MDX PUBLIC COMPANY LTD	4.75	17/09/2003	—	—

Appendix 1: Outstanding USD Issues by Thai Corporations at February 2001 (cont'd)

ISSUER 18/1/2001	COUPON	MATURITY	AGENCY	RATING
NAKORNTHON BANK PUBLIC CO LTD	7.865	11/06/2006	—	—
PETROLEUM AUTHORITY OF THAILAND	6.9375	30/03/2005	—	—
PROPERTY PERFECT PUBLIC CO LTD	3.25	28/03/2001	—	—
PTT EXPLORATION AND PRODUCTION PLC	7.625	1/10/2006	MOO	Baa3
ROBINSON DEPARTMENT STORE PUBLIC CO LTD	7.93875	15/02/2001	—	—
ROBINSON DEPARTMENT STORE PUBLIC CO LTD	4.25	7/04/2004	—	—
SG ASIA CREDIT PCL	3.75	17/11/2003	—	—
SIAM CITY BANK PCL	7.375	25/09/2001	MOO	Ba2
SIAM SYNTECH CONSTRUCTION PUBLIC CO LTD	4.5	25/02/2002	—	—
SINO-THAI ENGINEERING AND CONSTRUCTION PUBLIC	1.75	17/12/2003	—	—
SRITHA SUPERWARE PUBLIC CO LTD	3.25	13/06/2006	—	—
TANAYONG PUBLIC CO LTD	3.5	1/03/2004	—	—
THAI CENTRAL CHEMICAL PCL	3.75	25/10/2003	—	—
THAI MILITARY BANK PUBLIC CO LTD	8.96	17/05/2005	MOO	B1
THAI OIL COMPANY LTD	7.4	16/11/2001	—	—
THAILAND	8.25	15/03/2002	MOO	Baa3
THAILAND	6.27	30/09/2003	MOO	Baa3
THAILAND	8.09	15/08/2004	MOO	Baa3
THAILAND	7.75	15/04/2007	MOO	Baa3
THAILAND	7.07	30/09/2013	MOO	Baa3
THAILAND	7.84	15/08/2001	S&P	BBB-
THE SIAM COMMERCIAL BANK PCL	6.15	3/06/2001	—	—
THE SIAM COMMERCIAL BANK PCL	3.25	24/01/2004	MOO	Ba3
THE SIAM COMMERCIAL BANK PCL	7.5	15/03/2006	MOO	Ba3
TIPCO ASPHALT PUBLIC CO LTD	2.75	19/09/2006	—	—
TOTAL ACCESS COMMUNICATIONS PCL	2	31/05/2006	MOO	B2
TOTAL ACCESS COMMUNICATIONS PCL	7.625	4/11/2001	S&P	BB
TOTAL ACCESS COMMUNICATIONS PCL	8.375	4/11/2006	S&P	BB
TPI POLENE PUBLIC CO LTD	2.75	8/02/2006	—	—
UNION ASIA FINANCE PUBLIC CO LTD	3.375	22/12/2003	—	—
UNITED COMMUNICATION INDUSTRY PUBLIC CO LTD	7.78	15/12/2003	—	—
WALL STREET FINANCE AND SECURITIES PUBLIC CO LTD	3.75	3/02/2004	—	—
WATTACHAK PCL	3.5	6/12/2003	—	—

Source: Reuters Fixed Income Database