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Evidence of and Explanation for Day-of-the-Week Effects in Thailand's Government Bond Market

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Abstract

This study is the first to provide evidence of day-of-the-week effects in Thailand's government bond market. Using daily returns on constant-maturity bonds constructed from Thailand's zero-coupon yield curves from Monday, July 2, 2001 to Monday, December 21, 2015, it finds that the 1-month and 3-month bonds have significantly positive Monday returns, while those of longer maturities of 3 to 15 years have significantly positive Thursday and Friday returns. Alternative explanations for the effects are thoroughly examined. The only successful explanation is that effects result from the bond auction. This explanation is new. For shorter-maturity bonds, the positive Monday returns are the returns on auction Mondays. For longer-maturity bonds, the positive Thursday and Friday returns are spillovers from the auctions of more-than-15-year bonds.

Keywords

Day-of-the-Week Effects, Bond Auction, Government Bond Market

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Introduction

Day-of-the-week (DoW) effects are market anomalies of daily returns being significantly higher or lower on certain weekdays than on the remaining days. While studies on DoW effects have been conducted extensively for stock markets around the world, those for debt markets have been far less common (Pettengill, 2003; Philpot & Peterson, 2011). For the U.S. market, Gibbons and Hess (1981) tested for DoW effects in treasury-bill returns and found that Monday returns were lowest and Wednesday returns were highest. Flannery and Protopapadakis (1988) found negative Monday returns on treasury bonds and the negative size grew as bond maturities grew longer. Using the Dow Jones Composite Bond Average index, Jordan and Jordan (1991) tested for, but could not find, the effects for U.S. corporate bonds. Compton and Kunkel (2000) examined DoW effects using returns on managed funds which invested in both corporate and treasury bonds. The funds exhibited DoW effects. But their returns were positive and highest on Monday and Tuesday. DoW effects were also found for high-yield bonds. Alexander and Ferri (2000) used the prices of 60 high-yield bonds trading on the Nasdaq in their study and reported that Tuesday returns were positive and highest, while Friday returns were negative and lowest. Nippani and Pennathur (2004) found DoW effects for commercial paper yield rates, where yield changes were significantly negative on Wednesday. As for corporate bonds, Nippani and Arize (2008) re-examined and found DoW effects, based on three major U.S. corporate bond market indexes for the more recent 1982-2002 sample period. In contrast to Jordan and Jordan (1991), Nippani and Arize found significantly negative Monday returns.

Only a few studies on DoW effects have been conducted for debt markets outside the U.S.A. Bildik (2001) found DoW effects for Turkish overnight interest rates. The rates fell on Wednesday and rose on Friday. For the New Zealand market, Keef and Roush (2004) tested for, but did not find, the effects for bank-bill interest rates. For the Canadian market, Washer, Nippani, and Wingender (2011) found negative Monday returns for commercial papers and treasury bills but not for bank accounts in the 1980’s. The effects disappeared in 1990’s and re-emerged in the 2000’s. And for the Russian market, Compton, Kunkel, and Kuhlemeyer (2013) found DoW effects for corporate bonds using two corporate bond indexes. The returns were positive but not equal for all weekdays. The highest returns were on Friday and the lowest returns were on Tuesday. Bespalko (2009) tested for DoW effects for government bonds in emerging markets, including Brazil, Bulgaria, Mexico, the Philippines, Russia, Turkey, and Ukraine. Based on the J.P. Morgan Emerging Bond index data, Bespalko concluded that DoW effects existed in all the sample markets except for Brazil and Bulgaria. The bond returns were positive and highest on Tuesday.

Only a few studies offered possible explanations and none has successfully explained the data nor were any satisfactory. Gibbons and Hess (1981) explained that the DoW effects might result from the settlement procedure. But when Keef and Roush (2004) adjusted the returns to account for benefits from the settlement procedure, the effects still existed in their New Zealand data. Bildik (2001) related the falling Turkish overnight rates on Wednesday with the auction and redemption of public-borrowing assets. Despite detailed discussion, Bildik did not provide any supporting evidence except for showing that the redemption took place on Wednesday about 60 percent of the time.

In this study, I test for DoW effects in Thailand's government bond market and examine possible explanations for their existence. Thailand is one of the most important emerging bond markets in the world. In 2015, its market capitalization was 282.50 billion U.S. dollars at a 35.50-baht-per-U.S.-dollar exchange rate. In the sample countries of the *Asia Bond Monitor* (Asian Development Bank, 2015), in the third quarter of 2015 Thailand ranked fourth in terms of market capitalization after Japan, China, and Korea. The market was very liquid. Its average bid-ask spreads were very low at 1.5 and 3.3 basis points for on-the-run and off-the-run issues, respectively. These spreads were second lowest after Korea at 0.5 and 0.9 basis points. In spite of its importance, DoW effects have not been studied for Thailand's government bond market. Alexander and Ferri (2000) pointed out that if DoW effects were identified and the patterns continued, the information would help bond traders and investors to choose the best days of the week to execute their transactions.

The study of Thailand's government bond market offers me with the opportunity to explain DoW effects with supporting evidence once they are identified. Explanations are possible due to the unique data set on Thai bonds compiled and made available to me by the Thai Bond Market Association (Thai BMA). This is a major contribution because DoW effects have not been explained satisfactorily by previous studies.

Methodology

To test for the DoW effects, I follow previous studies, e.g. Gibbons and Hess (1981), by using the classical, linear regression model in equation (1),

$$r_t = \delta_{Mo}D_{Mo,t} + \delta_{Tu}D_{Tu,t} + \cdots + \delta_{Fr}D_{Fr,t} + \varepsilon_t, \qquad (1)$$

where r_t is the daily return on day t. $D_{d,t}$ is a dummy variable. It is 1.00 if day t falls on day d of the week. Otherwise, it is 0.00. Day $d = Mo$ (Monday), …, Fr (Friday). ε_t is the regression error. The model in equation (1) is estimated by the ordinary-least-square (OLS) technique. Because ε_t may be autocorrelated or heteroskedastic (Kamath, Chakornpipat, & Chatrath, 1998), the standard errors of the coefficients δ_d and the hypothesis tests are based on Newey and West's (1987) heteroskdasticity-and-autocorrelation-consistent (HAC) covariance matrix.

The null hypothesis is equal average returns for the five weekdays, implying $\delta_{Mo} = \cdots = \delta_{Fr}$. The test is a Wald test. Under the null hypothesis, the Wald statistic is distributed as a chi-square variable with four degrees of freedom.

Data

The data are daily Thai BMA zero-coupon yields for 1-month, 3-month, 6-month, 3-year, 5-year, 7-year, 10-year, and 15-year maturities from Monday, July 2, 2001 to Monday, December 21, 2015 (3,450 observations). The yield data are from the Thai BMA. I choose the 1-month, 3-month,and 6-month maturities because they were the maturities of treasury bills. The remaining maturities are of benchmark bonds. I compute the daily return on a constant-maturity-T bond by $-T(y_{T,t} - y_{T,t-1})$, where T is the maturity and $y_{T,t}$ is the zero-coupon yield of maturity T on day t. With respect to Flannery and Protopapadakis (1988), constant-maturity returns were considered in order to fix the characteristics of sample bonds. The descriptive statistics of bond returns are reported in Table 1.

Table 1 Descriptive statistics

Statistics	Maturities							
	1M	3M	6M	3Y	5Y	7Y	10Y	15Y
Average×100	2.51E-05	9.46E-05	2.34E-04	0.0023	0.0039	0.0062	0.0111	0.0176
Stdev×100	0.0021	0.0057	0.0114	0.1121	0.2429	0.3596	0.5430	0.6759
Skewness	2.4401	1.6765	1.4004	-0.8978	-0.4272	-0.5491	-0.8119	-0.1755
E. Kurt	52.4769	41.0727	38.2455	19.8541	8.4280	10.1708	11.2724	19.8377
AR(1)	0.2113***	0.2165***	0.2949***	0.3613***	0.2983***	0.3000***	0.2735***	0.2930***
JB Stat.	4.10E+05***	2.50E+05***	2.17E+05***	5.86E+04***	1.06E+04***	1.54E+04***	1.91E+04***	[illegible].81E+04***

Note: *** = Significance at the 99% confidence level.

From Table 1, it can be seen that the average returns and standard deviations are increasing with maturities. This finding follows the construction of bond returns. The skewnesses of short-maturity returns are large and positive, while those of longer-maturity returns are small and negative. All have large excess kurtoses. The Jarque-Bera tests reject the normality hypothesis for all bonds at the 99% confidence level. Finally, all the returns show significant, positive autocorrelation. The positive autocorrelation supports the use of the Newey-West HAC covariance matrix in the analyses.

In their study of treasury-bill returns, Gibbons and Hess (1981) noticed that daily returns equaled a one-day interest rate plus capital gain due to interest rate changes. So, the returns tended to be non-stationary and they had to be differenced to obtain stationarity. In this study, the AR(1) coefficients of bond returns in Table 1 are about 0.28. They do not suggest non-stationarity. Hence, return differencing is not needed.

Empirical Results

In Table 2, Panel 2.1 reports regression coefficients for the five weekdays and Wald statistics for the DoW hypothesis tests. The Wald tests reject the equal-weekday-return hypothesis for all maturities except for the 6-month maturity. These test results lead me to conclude that DoW effects exist in Thailand's government bond market. This finding is important because it is the first time a DoW effect has been identified in Thailand.

Table 2 Tests for day-of-the-week effects

Panel 2.1 OLS regression with the Newey-West (1987) covariance matrix

Statistics	Maturities							
	1M	**3M**	**6M**	**3Y**	**5Y**	**7Y**	**10Y**	**15Y**
$\delta_{Mo} \times 100$	2.73E-04**	9.23E-04***	-1.58E-04	-0.0051	-0.0100	-0.0236*	-0.0297	-0.0063
$\delta_{Tu} \times 100$	4.40E-07	-2.03E-04	-1.43E-04	-0.0048	-0.0127	-0.0110	-0.0171	-0.0249
$\delta_{We} \times 100$	3.60E-05	7.49E-05	7.28E-04	0.0039	0.0110	0.0187	0.0064	0.0070
$\delta_{Th} \times 100$	-1.22E-04*	-1.68E-04	2.41E-04	0.0079*	0.0087	0.0218*	0.0389**	0.0756***
$\delta_{Fr} \times 100$	-4.51E-05	-9.83E-05	4.72E-04	0.0091**	0.0212**	0.0229*	0.0543***	0.0346*
Wald Stat.	11.6431**	11.8037**	3.7073	11.7847**	10.0273**	10.9456**	14.5495***	11.4433**

Note: *, ** and *** = Significance at the 90%, 95%, and 99% confidence levels.

Panel 2.2 Traditional OLS regression

Statistics	Maturities							
	1M	**3M**	**6M**	**3Y**	**5Y**	**7Y**	**10Y**	**15Y**
$\delta_{Mo} \times 100$	2.73E-04***	9.23E-04***	-1.58E-04	-0.0051	-0.0100	-0.0236*	-0.0297	-0.0063
$\delta_{Tu} \times 100$	4.40E-07	-2.03E-04	-1.43E-04	-0.0048	-0.0127	-0.0110	-0.0171	-0.0249
$\delta_{We} \times 100$	3.60E-05	7.49E-05	7.28E-04*	0.0039	0.0110	0.0187	0.0064	0.0070
$\delta_{Th} \times 100$	-1.22E-04	-1.68E-04	2.41E-04	0.0079*	0.0087	0.0218	0.0389*	0.0756***
$\delta_{Fr} \times 100$	-4.51E-05	-9.83E-05	4.72E-04	0.0091**	0.0212**	0.0229*	0.0543***	0.0346
Wald Stat.	13.6284***	18.8450***	3.2324	10.3486**	10.0772**	10.0182**	12.1984**	9.6144**

Note: *, ** and *** = Significance at the 90%, 95%, and 99% confidence levels.

Panel 2.3 Trimmed-OLS regression

Statistics	Maturities							
	1M	**3M**	**6M**	**3Y**	**5Y**	**7Y**	**10Y**	**15Y**
$\delta_{Mo} \times 100$	2.46E-04***	7.90E-04***	3.79E-04	-0.0005	-0.0096	-0.0269**	-0.0314*	-0.0196
$\delta_{Tu} \times 100$	7.22E-05	-7.39E-06	6.57E-05	-0.0037	-0.0042	-0.0019	-0.0103	-0.0122
$\delta_{We} \times 100$	-6.82E-05	-9.33E-05	4.11E-05	0.0015	0.0065	0.0182*	0.0276*	0.0236
$\delta_{Th} \times 100$	-1.61E-04***	-2.51E-04*	-8.60E-05	0.0067**	0.0097	0.0252**	0.0425***	0.0715***
$\delta_{Fr} \times 100$	-4.78E-05	-1.69E-04	3.64E-04	0.0105***	0.0228***	0.0244**	0.0457***	0.0349*
Wald Stat.	39.0249***	38.0623***	2.4681	12.8813**	11.9404**	17.0174***	17.5621***	14.9081***

Note: *, ** and *** = Significance at the 90%, 95%, and 99% confidence levels.

For the 1-month and 3-month maturities, the Monday returns are positive and highest. This finding is different from those of Gibbons and Hess (1981) for the U.S. market and of Washer et al. (2011) for the Canadian market where the treasury-bill returns were lowest on Monday. DoW effects for the 3-year to 15-year maturities show high, positive, and significant returns on Thursday and Friday. It is interesting to note that the high Tuesday returns on government bonds in the sample emerging markets reported by Bespalko (2009) are not generalized to Thailand. Thailand's high and positive Thursday and Friday long-maturity returns also differ from the lowest and negative Monday returns for the U.S. treasury bonds reported by Flannery and Protopapadakis (1988).

Explanations

Previous studies were not successful in explaining DoW effects in debt markets. This has changed for the present study because of the unique data set made available to me by the Thai BMA. For Thailand's government bond market I will discuss and empirically examine alternative explanations that researchers have proposed in the literature.

Explanation 1: Data snooping

Sullivan, Timmermann, and White (2001) warned that the DoW effect could be an artifact from data mining. In this study, I argue that data mining cannot explain the DoW effects in Thailand's government bond market because of three reasons. Firstly, the study is not repeated but conducted for the first time for Thailand. Secondly, it does not pick out sub-samples but covers the full samples from Monday, July 2, 2001 to Monday, December 21, 2015. Monday, July 2, 2001 is the first day the Thai BMA started to collect government-bond-yield data. Finally, the sample bonds are of various maturities. Except for the 6-month bond, DoW effects are consistently found for the sample bonds.

Explanation 2: Misspecifications

Connolly (1989) and Chen, Lee, and Wang (2002) noticed that misspecifications of the distribution and heteroskedasticity assumptions might be able to explain the DoW effect for U.S. stocks. In order to check for whether these misspecifications can or cannot explain DoW effects in Thailand's bond market, I repeat the hypothesis test using traditional OLS and trimmed OLS regressions. Traditional OLS is common in the studies of DoW effects and trimmed OLS was suggested by Connolly (1989) to accommodate for non-normality and outliers. In this study, the trimmed OLS removes the first and last observations in the first and last percentiles, constituting 3,471 usable observations.

The test results for the traditional OLS and trimmed regressions are, respectively, in Panels 2.2 and 2.3 of Table 2. The Wald tests from the two regressions agree with those of the OLS regression with the Newey-West HAC covariance matrix in Panel 2.1. Moreover, the signs and significance of weekday returns are similar. Based on this finding, I conclude that misspecifications of the regressions cannot explain the DoW effects in Thailand's bond market.

Explanation 3: Mispricing

Keim and Stambaugh (1984) explained positive Friday returns in the U.S. stocks market by the market mispricing the stocks on Friday. If it is the Friday mispricing, the price must reverse on Monday, constituting a significant, negative autocorrelation of the Friday return with the

Monday return. An important question is whether mispricing can explain the DoW effects in Thailand's bond market.

To answer this question, recall that the bond returns are positively autocorrelated. So, it is unlikely that mispricing is the explanation. However, to ensure that it is not mispricing, I consider the regression model in equation (2),

$$r_t = \delta_{Mo}D_{Mo,t} + \cdots + \delta_{Fr}D_{Fr,t} + \rho_{Mo}D_{Mo,t}r_{t-1} + \cdots + \rho_{Fr}D_{Fr,t}r_{t-1} + \varepsilon_t, \quad (2)$$

where ρ_d is the autocorrelation coefficient of day t's return with day t-1's return, if day t is the d weekday. Weekday $d = Mo$ (Monday), … , Fr (Friday). If the mispricing explanation is correct, ρ_{Tu} must be negative and significant for the 1-month and 3-month bonds and ρ_{Fr} and ρ_{Mo} must be negative and significant for the bonds with 3-year maturities and over. The estimates of autocorrelation coefficients are in Table 3. It turns out that the estimates are positive and significant for all the bonds on all weekdays. Therefore, mispricing cannot explain the DoW effects.

Table 3 Tests for mispricing explanation

Statistics	Maturities							
	1M	3M	6M	3Y	5Y	7Y	10Y	15Y
ρ_{Mo}	0.5054**	0.3866***	0.4109***	0.3094***	0.2410***	0.2995***	0.2932***	0.2112**
ρ_{Tu}	0.1660***	0.1308***	0.1090***	0.4121***	0.3754***	0.3414***	0.3537***	0.4234***
ρ_{We}	0.1481**	0.2829***	0.2327***	0.3838***	0.3856***	0.4014***	0.2826***	0.4234***
ρ_{Th}	0.2937***	0.2940**	0.3028**	0.3227***	0.2288***	0.2037***	0.2258***	0.2148***
ρ_{Fr}	0.5054**	0.1242**	0.1349**	0.3809***	0.2806***	0.2806***	0.2424***	0.2433***

Note: ** and *** = Significance at the 95% and 99% confidence levels.

Explanation 4: Spillover effects

Choudhry (2000) and Brooks and Persand (2001) proposed that the DoW effect in emerging markets was a spillover from developed markets such as the U.S. market. I test for the spillover explanation for Thailand by using the model in equation (3),

$$r_t = \delta_{Mo}D_{Mo,t} + \delta_{Tu}D_{Tu,t} + \cdots + \delta_{Fr}D_{Fr,t} + \beta r_t^* + \varepsilon_t, \quad (3)$$

where r_t^* is the return on the referenced market, from where the DoW effect spills. If the DoW effect is a spillover from the referenced market, adding the return r_t^* in the regression should completely remove the DoW effect for the sample bonds and the equal-weekday-return hypothesis cannot be rejected.

I consider the U.S. bond market as the referenced market because the U.S. economy and bond markets are largest in the world. And in the tests for spillover effects to emerging stock markets, Brooks and Persand (2001), for example, also chose the U.S. market. r_t^* is computed from the U.S. treasury bond yields of matched maturities except for the 15-year-maturity case in which the U.S. 15-year yields are not available. I have to use the U.S. 20-year yields instead. The U.S. bond yield data are from the U.S. Department of the Treasury's database. Because of the time-zone difference between the U.S.A. and Thailand, r_t^* in the regression is a one-day lag.

Table 4 Tests for spillover effects

Wald Statistics	Maturities							
	1M	3M	6M	3Y	5Y	7Y	10Y	15Y
U.S. Yields	11.6389**	12.7059**	2.9562	12.9222**	11.3956**	13.8847***	17.4811***	14.1107***
SET Index	11.8928**	12.0373**	3.4464	10.9022**	9.8218**	10.0884**	13.5527**	11.2780**

Note: ** and *** = Significance at the 95% and 99% confidence levels.

The test results are reported in the third row of Table 4. The results of DoW effects remain unchanged even if the U.S. bond returns are incorporated into the regressions. So, the U.S. Market spillover cannot explain the DoW effects in Thailand's bond market.

Bond and stock markets in a country are not independent. Investors re-allocate their investments in these markets all the time. Recently, Khanthavit and Chaowalerd (2016) found DoW effects in the Stock Exchange of Thailand using recent stock return data. The returns on the SET and SET 50 index portfolios are positive and highest on Friday. If the bond and stock markets in a country is not independent, the positive Friday returns on the government bonds may spill over from the stock market. To check for this possible spillover from the Stock Exchange of Thailand, I re-estimate equation (3) by substituting r_t^* for the SET index portfolio return. The SET index data are from the Stock Exchange of Thailand. The test results are in the fourth row of Table 4. The DoW results are the same, therefore the DoW effects in the bond market do not spill over from the stock market.

Explanation 5: Order flows

Miller (1988) and Abraham and Ikenberry (1994) explained the DoW effect in the U.S. stock market by increased trading activities of some investor groups. Khanthavit and Chaowalerd (2016) reported that order flows of local institutes and foreign investors explained the positive Friday returns and those of local institutes, foreign investors, and local investors did negative Monday returns in the Stock Exchange of Thailand. With respect to the order-flow reasoning, if the order flows are able to explain DoW effects in Thailand's bond market, the test should not be able to find the effects when r_t^* is substituted for the trading volume in equation (3).

In the regressions, I consider the outright-trading-volume turnover ratio, i.e. the aggregate outright trading volume over market capitalization, and the ratios of outright trading volumes of investor groups to market capitalization. The trading-volume and market-capitalization data are from the Thai BMA, covering a period from Tuesday, March 5, 2002 to Wednesday, December 9, 2015. The volumes for the 1-month to 6-month bonds are the trading volumes of all treasury bills. Those for the 3-year maturing bonds are the trading volumes of government bonds with a three-year maturity or shorter. The volumes for the 5-year and 7-year bonds are the volumes of 3-year to 7-year government bonds. Finally, the volumes for the 10-year and 15-year bonds are those of 7-year to 10-year bonds and of the more-than-10-year bonds, respectively.

Table 5 reports the Wald-test results for the order-flow explanation. With respect to the significant Wald statistics, the dealer-to-client volumes are able to explain the DoW effects of the 1-month bond. But order flows cannot explain the DoW effects for the bonds of 3-month and 3-year-or-longer maturities. Although the test statistics are not significant for the 6-month bond, I do not conclude that the flows explain the effects because the effects for this bond do not exist in the first place.

Table 5 Tests for order-flow explanation

Wald Statistics	Maturities							
	1M	3M	6M	3Y	5Y	7Y	10Y	15Y
Aggregate	11.2563**	12.3316**	4.9215	13.3608***	10.9972**	11.0338**	15.7375***	11.1821**
Dealer to Dealer	7.9512*	9.0542*	5.6007	13.7443***	11.5934**	12.5281**	15.9138***	10.9380**
Dealer to Client	7.4098	7.8223*	5.8516	14.3600***	11.5301**	12.5174**	15.9018***	11.1888**
AMC	11.0232**	11.9233**	4.9277	14.0869***	12.3928**	13.4951***	16.1638***	10.8837**
INS	11.4937**	12.4845**	4.6495	13.8161***	12.3399**	13.5117***	16.2449***	10.9653**
DCO	8.0246*	10.9685**	4.7805	14.0206***	12.1130**	13.2701***	15.8969***	11.1043**
NDL	12.3497**	13.4507***	4.3616	13.9469***	11.9864**	12.7505**	16.0751***	11.1585**
FCO	13.1558**	13.5697***	4.7500	13.9442***	12.3609**	13.4734***	15.8985***	11.0619**
IND	11.6925**	12.9035**	4.6894	13.9988***	14.4793***	15.8598***	15.9564***	11.0745**
OTH	9.3061*	10.5071**	5.2145	13.4274***	10.8071**	10.9365**	15.7743***	11.1855**

Note: *, ** and *** = Significance at the 90%, 95%, and 99% confidence levels. AMC = asset management companies, INS = insurance companies, DCO = domestic companies, NDL = financial institutions which do not have debt-instruments-trading licenses, FCO = foreign companies, IND = individual investors, OTH = other investors.

Explanation 6: Auctions

In Thailand, the auctions of government securities are facilitated by the Bank of Thailand. The schedule is fixed for Monday and Wednesday for treasury bills and government bonds respectively. If those Mondays or Wednesdays fall on a public holiday, the auction is rescheduled to the prior business day.

Auctions can influence treasury-bill returns. Baldik (2001) explained for the Turkish money market that the auction affected treasury-bill returns because market participants adjusted and rebalanced their positions to prepare themselves for the auctions. Nippani and Pennathur (2004) noticed for the U.S. market that dealers bid for treasury bills and commercial papers and resold them to investors for profits. According to D. Domethong (personal communication, January 15, 2016), Head of the Thai BMA's Bond Pricing and Product Development Department, in Thailand, primary dealers bid for treasury bills for their clients and charge spreads. The treasury-bill prices on the auction day must be high to compensate re-selling dealers so that it is worth them buying and selling. The returns on auction Mondays should be high, because treasury-bill auctions are scheduled for Monday, hence leading to a high average Monday return on and DoW effects for treasury bills.

Auctions can also influence government-bond returns. De Vassal (1998) and Ahmad and Steeley (2008) found for the U.S. and U.K. markets, respectively, that bond prices exhibited a V-shaped pattern surrounding bond auction days. For Thailand, according to Sirichotikul and Pattarathammas (2015), however, the pattern differed. The bond prices rose on days 1 and 2 following the auction date.

The rising prices following bond auctions can be caused by at least three possible mechanisms. Firstly, de Vassal (1998) noticed that, given the same maturity, on-the-run bond prices were higher than off-the-run prices. After the auction, auctioned bonds are on the run and trading on the market for higher prices. Secondly, according to Beetsma, Giuliodori, de Jong, and Widijanto (2013), primary dealers with limited risk-bearing capacity raise auction yields to compensate for price and inventory risks. The yields fall and prices rise once they sell their inventory in the secondary market. Thirdly, Cammack (1991) argues that the secondary market prices do not reflect all the information in the market. Auction aggregates traders' private information and traders in the secondary market can learn from auction results. Cammack (1991) contends that auction results raise the secondary market price if the number of bidders is greater than anticipated and lessen the prices if the diversity of opinion is greater than anticipated. Learned information from auction results reduces uncertainty and information asymmetry in the market. Glosten and Milgrom (1985) showed that reduced uncertainty and asymmetric information could raise bidding prices due to falling bid-ask spreads. Because government bond auctions are scheduled for Wednesday and the auction results raise bond prices on the following days, the returns on Thursdays and Fridays following auction Wednesday will be high, hence constituting the DoW effects.

Baldik (2001) proposed auctions as one of the explanations for the DoW effects in the Turkish money market. He discussed the mechanism but did not provide supporting evidence. In this study, I propose to test for the auction explanation for the DoW effects in Thailand's bond market. I collected the auction data from the Thai BMA database, covering a period from Tuesday, July 3, 2001 to Monday, December 21, 2015. Table 6 reports the classifications of trading days and auction days by weekdays and maturities. Because the maturities of auctioned bills and bonds do not exactly match the maturity classification, I group the auctions into the nearest classifications. The range of maturities in each classification is reported in the second line of each row in Column 1.

Over the sample period, 1,156 bills and bonds were auctioned. The results agree with the Monday and Wednesday schedule for Thailand's bill and bond auctions. Five hundred and twenty-two out of 618 auctions of treasury bills were on Monday, while 509 out of 543 auctions of government bonds were on Wednesday.

Table 6 Classification of trading days and auction days

Maturities	Days of the Week					Sum
	Monday	Tuesday	Wednesday	Thursday	Friday	
1M (T ≤ 34D)	435	4	4	18	57	518
3M (86D ≤ T ≤ 95D)	410	0	1	14	60	485
6M (178D ≤ T ≤ 187D)	382	0	0	15	54	451
All Bills*	***522***	***4***	***4***	***21***	***67***	***618***
3Y (T ≤ 3Y)	0	2	53	0	0	55
5Y (3Y < T ≤ 5Y)	0	4	90	0	0	94
7Y (5Y < T ≤ 7Y)	0	6	135	0	1	142
10Y (7Y < T ≤ 10Y)	0	10	137	1	1	149
15Y (10Y < T ≤ 15Y)	0	11	213	1	2	227
≤ 15Y (T ≤ 15Y)	0	21	425	1	2	449
> 15Y (T > 15Y)	0	14	184	0	0	198
All Bonds	***0***	***31***	***509***	***1***	***2***	***543***
All Auctions	**522**	**35**	**510**	**21**	**68**	**1,156**
Trading Days	**669**	**715**	**720**	**721**	**715**	**3,540**

NOTE: * = Not including the only 1-year bill auction on Friday, October 19, 2001.

I modify the model in equation (3) to test for the auction explanation. For 1-month, 3-month, and 6-month bonds, I run the regression in equation (4), where $D_{Auc,t}$ is the auction-dummy variable and δ_{Auc} is the return coefficient on auction day. $D_{Auc,t}$ is 1.00 if day t is the treasury-bill auction day. It is 0.00, otherwise. I use this specification for short-maturity bonds because the DoW effects in the 1- month and 3-month returns are induced by the Monday return and the treasury-bill auctions are scheduled for Monday.

$$r_t = \delta_{Mo}D_{Mo,t} + \delta_{Tu}D_{Tu,t} + \cdots + \delta_{Fr}D_{Fr,t} + \delta_{Auc}D_{Auc,t} + \varepsilon_t. \quad (4)$$

I run the regression in equation (5) to test for the auction explanation for longer-maturity bonds. Equation (5) corresponds to the fact that the DoW effects of long-maturity bonds are from high, positive Thursday and Friday returns, government bonds are auctioned on Wednesday and auction results can reveal private information to the market and raise prices on the days following the auction day. $D_{Auc1,t}$ and $D_{Auc2,t}$ are auction dummies. They are 1.00 if day t is days 1 and 2 following the auction day. Otherwise, they are 0.00. δ_{Auc1} and δ_{Auc2} are the return coefficients for days 1 and 2 following the auction day.

$$r_t = \delta_{Mo}D_{Mo,t} + \delta_{Tu}D_{Tu,t} + \cdots + \delta_{Fr}D_{Fr,t} + \delta_{Auc1}D_{Auc1,t} + \delta_{Auc2}D_{Auc2,t} + \varepsilon_t. \quad (5)$$

If the auction explanation is correct, the DoW effects must not exist in equations (4) and (5). The test results are reported in Table 7. Turn first to the results for short-maturity bonds in Panel 7.1. In the test, I consider both the auctions of treasury bills of the matched classifications (Same-Maturity) and all the treasury-bill auctions (All Bills). Once the regressions control for auction, the hypothesis of equal weekday returns cannot be rejected for the 3-month and 6-month bonds. It is weakly rejected at the 90% confidence level for the 1-month bond. This finding is consistent with the auction explanation for the DoW effects in the short-maturity bond returns.

Table 7 Tests for auction explanation

Panel 7.1 Short-maturity bonds

Maturities	Types of Auctions	
	Same-Maturity	All Bills
1M	8.9579*	9.0785*
3M	2.1976	3.0655
6M	3.8913	7.1725

NOTE: * = Significance at the 90% confidence level.

Panel 7.2 Long-maturity bonds

Maturities	Types of Auctions			
	Same Maturity	≤ 15Y Bonds	> 15Y Bonds	All Bonds
3Y	10.4516**	14.0519***	7.6417	10.3428**
5Y	9.5774**	10.2832**	6.6439	7.8367*
7Y	12.7506**	12.2747**	7.3261	9.1817*
10Y	9.2674*	11.5786**	9.2601*	7.0839
15Y	11.2860**	10.2709**	6.2462	5.1383

NOTE: * and ** = Significance at the 90% and 95% confidence levels.

Panel 7.2 of Table 7 reports the test results for the long-maturity bonds. The returns following matched-maturity and 15-year-or-shorter-maturity auctions cannot explain the DoW effects of sample long-maturity bonds.

Fleming and Rosenberg (2007) observed in the U.S. bond market that return patterns surrounding auction dates could spill over from longer-maturity bond auctions to shorter-maturity bond auctions. I checked to see if the auction effects can spill over from longer-maturity bond auctions as was suggested by Fleming and Rosenberg's observation. I consider the auctions of bonds with more-than-15-year maturities in the regressions. The results are in the column labeled >15Y Bonds. These very-long maturity bond auctions can explain the DoW effects of all sample bonds except for the 10-year bond. For the 10-year bond, the all-bond auctions can explain the effects as is shown in the column labeled All Bond.

Discussion

I found that the dealer-to-client volumes were able to explain the DoW effects of the 1-month bond. This finding is puzzling because the DoW effects of the 1-month and 3-month bonds are from significantly positive Monday returns. And, their regressions of equation (3) use the same trading volume of treasury bills. Why do the volumes explain the effects for the 1-month but not the 3-month bonds?

I argue that the order flow explanation cannot be the correct explanation for the 1-month bond's DoW effects. The Monday order flows and returns are driven by Monday treasury-bill auctions. I analyze the order flow explanation further by checking for the auction effect on Monday volumes. I use the regression of equation (4), where r_t is now the trading volume. I report the regression results in Table 8. The volumes on auction day are positive, significant, and higher than those on weekdays. Once the auction day is incorporated into the regressions, for all investor groups the Monday coefficients drop precipitously. They are lower than or about the same as those on the remaining weekdays. This finding leads me to conclude that order flows cannot explain the DoW effects in 1-month bond returns

Table 8 Tests for auction effects on treasury-bill trading volume

Statistics	Aggregate	Dealer to Dealer	Dealer to Client	AMC	INS	DCO	NDL	FCO	IND	OTH
$\delta_{Mo} \times 100$	-0.5680	-0.2564	-0.1920	-0.0687	-0.0759	0.0664	0.1070***	0.0076***	-0.1007	-0.8244
$\delta_{Tu} \times 100$	0.9119***	1.6423***	0.7652***	0.0679***	0.2672***	0.1422***	0.1307***	0.0155***	0.2535***	2.5542***
$\delta_{We} \times 100$	0.9183***	1.7677***	1.0595***	0.0765***	0.1927***	0.0950***	0.0959***	0.0188***	0.2294***	2.6860***
$\delta_{Th} \times 100$	0.4626***	1.0256***	0.5128***	0.0505***	0.1167***	0.0700***	0.1159***	0.0101***	0.1497***	1.4882***
$\delta_{Fr} \times 100$	0.2084*	0.5491***	0.2640***	0.0070	0.0726***	0.0507***	0.0677***	0.0105***	0.0766***	0.7575***
$\delta_{Auc} \times 100$	4.3217***	5.9293***	3.1965***	0.3622***	0.9911***	0.5389***	0.1165***	0.0259***	0.6982***	10.2510***
Wald Stat.	33.8545***	77.1790***	76.4608***	30.3574***	23.4182***	25.4536***	19.0281***	11.6198**	31.1495***	67.1477***

Note: * and *** = Significance at the 90% and 99% confidence levels. AMC = asset management companies, INS = insurance companies, DCO = domestic companies, NDL = financial institutions which do not have debt-instruments-trading licenses, FCO = foreign companies, IND = individual investors, OTH = other investors.

I concluded that the treasury-bill auction explained the DoW effects of 1-month and 3-month bonds. The high Monday returns result from the spreads charged to their clients by primary dealers for the re-selling of auctioned bills (Nippani & Pennathur, 2004; Domethong, 2016). The results in Panel 2.1 of Table 2 and Panel 7.1 of Table 7 together imply that the spreads can be recovered from the δ_{Auc} estimates. I calculate the re-selling spreads from the δ_{Auc} estimates for the 1-month and 3-month bonds and find that the spreads are low with 1.00 and 0.80 basis points, respectively.

I concluded that the DoW effects of long-maturity bonds could be explained by the auction results spilling over from the auctions of very-long bonds of more-than-15-year maturities.

I discussed earlier that the rising prices following bond auctions could be caused by at least three possible mechanisms. It is interesting to analyze which mechanism, exactly, causes the rising prices.

De Vassal's (1998) on-the-run-bond mechanism and Beetsma et al.'s (2013) price-and-inventory-risk mechanism cannot be the cause of rising prices because it is not the auction of the matched-maturity but the very-long-maturity bonds that explains the positive returns. So, one possible mechanism is learned information as proposed by Cammack (1991) and Glosten and Milgrom (1985).

I test for the learned-information mechanism by examining the pattern of return volatilities on weekdays. In the test, I regress the absolute residuals from equation (1) on weekday dummies. The choice for absolute residuals for measuring volatilities follows de Vassal (1998). If the auction results reveal private information and raise Thursday and Friday returns, the average volatility of Thursday and Friday returns must be lower than those of Monday, Tuesday, and Wednesday returns. The regression coefficients and Wald statistics are reported in Table 9. Under the hypothesis of equal volatility, the Wald statistic is distributed as a chi-squared variable with one degree of freedom. The volatilities on Thursday and Friday are lower than those on Monday, Tuesday and, especially, Wednesday, hence their averages are not equal. The Wald tests reject equal average volatilities for a lower average volatility on Thursday and Friday. This finding supports the learned-information mechanism.

Table 9 Tests for learned-information mechanism

Statistics	**Maturities**				
	3Y	**5Y**	**7Y**	**10Y**	**15Y**
$\delta_{Mo} \times 100$	0.0639***	0.1477***	0.2194***	0.3322***	0.3682***
$\delta_{Tu} \times 100$	0.0702***	0.1570***	0.2259***	0.3303***	0.3867***
$\delta_{We} \times 100$	0.0690***	0.1641***	0.2491***	0.3843***	0.5222***
$\delta_{Th} \times 100$	0.0660***	0.1491***	0.2144***	0.3190***	0.3775***
$\delta_{Fr} \times 100$	0.0561***	0.1333***	0.1911***	0.2958***	0.3350***
Wald Stat.	7.2903***	7.6888***	11.5493***	10.1680***	20.2611***

Note: *** = Significance at the 99% confidence level.

It is interesting to ask why the secondary market had to learn from the auctions of more-than-15-year bonds. One explanation can be thin trading of very-long-maturity bonds. Over the sample period, the trading-volume-to-market-capitalization ratio of 10-year-or-shorther bonds is 0.53%. The ratio of more-than-10-year bonds is only 0.31%. In the market, the longest maturity is 50 years. I conjecture that the ratio of longer-maturity bonds, such as more-than-15-year bonds, is much lower. If bonds do not trade, prices are polled from primary dealers. Information in the polled prices can be limited and partial. Among the 198 auctions of more-than-15-year bonds, 115, 15, 40, and 28 auctions were from 15-to-20-year, 20-to-25-year, 25-to-30-year, and 45-to-50-year bonds. The auction yields provide the market with fresh information such as long-term expected inflation rates and inflation premiums (Khanthavit, 2014).

The literature suggested several explanations other than the ones I discussed. For example, in the psychology study (Pettengill, 1994), investors were relatively more pessimistic on Monday and relatively more optimistic on Friday. So, the Monday returns should be negative and the Friday returns should be positive. Gibbons and Hess (1981) proposed that settlement procedures could explain high Thursday and Friday returns from two-day deferred payments. Chen and Singal (2003) proposed a speculative-short-selling explanation. Short sellers did not want to hold their positions and take risks over weekends. So, they bought the assets to close their short positions, drove the prices up and, therefore, led to significant, positive Friday returns. French (1980) proposed firm-specific, private information flow effects, while Pettengill and Buster (1994) proposed general and public information flow effects. Finally, Wang and Walker (2000) explained the DoW effects by activity levels of institutional investors.

These explanations were intended for DoW effects in stock returns. For the bond returns in this study, these explanations are unlikely. The pessimistic-Monday and optimistic-Friday explanation cannot explain the positive Monday returns of short-maturity bonds and the positive Thursday returns of long-maturity bonds. The settlement-procedure explanation cannot explain the positive Monday returns of the short-maturity bonds. The speculative-short-selling explanation cannot explain the positive Thursday returns of long-maturity bonds. The firm-specific explanation is irrelevant to government bond returns, while the public-information explanation cannot, simultaneously, account for the short bonds' Monday returns and long bond's Thursday and Friday returns. Finally, the activity-level explanation is not possible. Most bond traders and investors are financial institutions or large investors.

Conclusion

Although tests for day-of-the-week effects have been studied extensively in stocks market around the world, only a few studies consider debt markets. Despite the fact that Thailand's bond market is one of the most important emerging bond markets, such a study for Thailand has never been conducted. A DoW effect study is important for bond trading and investment. If DoW effects are identified and the patterns continue, the information will help bond traders and investors to choose the best days of the week to execute their trades.

In this study, I test for DoW effects in Thailand's government bond market and examine possible explanations for them. I use daily return data on constant-maturity bonds constructed from Thailand's zero-coupon yield curves from Monday, July 2, 2001 to Monday, December 21, 2015. I am able to identify the DoW effects for 1-month, 3-month, 3-year, 5-year, 7-year, 10-year, and 15-year benchmark bonds. The 1-month and 3-month bonds have high, positive Monday returns, while the long-maturity bonds have high, positive Thursday and Friday returns.

I empirically test for possible explanations. The test results lead me to conclude that the DoW effects are, in fact, auction effects. For short-maturity bonds, the Monday returns are auction-Monday returns. And for long-maturity bonds, the Thursday and Friday returns are induced by information learned from the auctions of more-than-15-year bonds.

My study is traditional and primary. It provides and successfully explains the stylized facts on weekday-price patterns for Thailand's government bond market. In the literature, e.g. Doyle and Chen (2009), DoW effects may be wandering over time, meaning the weekday price and return patterns may be time-varying. If the DoW effects are wandering, bond traders and investors will have to predict the changing patterns to improve their trades. I leave the test for wandering DoW effects and the prediction of return patterns for future research.

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