THE DETERMINANTS OF STOCK AND BOND INDEX RETURN CO-MOVEMENTS: EVIDENCE FROM US, JAPAN AND THAILAND

Warin Chivakanit[1] and Tatre Jantarakolica[2]

Faculty of Commerce and Accountancy, Thammasat University[1]

Faculty of Economics, Thammasat University[2]

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This paper investigates whether there exist the co-movements between stock and bond index returns in US, Japan and Thailand, and explores the impact of monetary policy stance, inflation, state of the economy and global market uncertainty on the co-movement. Daily and monthly data during March 1999 to November 2018 are analyzed using Multivariate DCC GARCH models and Autoregressive Distributed Lag (ARDL) models. The study reveals that the stock and bond index co-movements are significant in the three countries. However, the directions of the co-movement are differences. While the high positive co-movement are detected in US and Japan, the small negative co-movement is shown in Thailand. Significant factors driving co-movement are different among countries. Based on flight-to-quality explanation, the result confirms that higher global market uncertainty and state of the economy lead to higher negative relationship in developed countries, like US and Japan. On the contrary, based on contagion phenomenon explanation, higher inflation in emerging market, like Thailand, leads to negative co-movement while higher global market uncertainty causes the positive co-movement between stock and bond index returns.

Keywords: Stock-bond co-movement, Macroeconomic factors, DCC GARCH, ARDL

Introduction

Having a good understanding in volatility is important for investors, since volatility is a measure of risk and it can predict the direction of the markets. Investors should allocate capital in different assets in order to reduce risk. However, volatilities of different assets often

move together over time, in other words there are volatility linkages among assets. Since stock and bond are main asset classes that investors invest together for diversification purpose. It is important to understand the co-movement of these two assets, in order to form optimal portfolio.

In this paper, we study the time-varying co-movement between stock and bond index returns in US, Japan and Thailand. We attempt to investigate how co-movement behave and find the driving forces behind the relationship, including domestic macroeconomic factors and global market uncertainty. To examine the impact of market uncertainty and macroeconomic factors on stock-bond co-movement can considerably contribute to investors who seek benefit of diversification, since stock-bond interdependence plays a big role in asset allocation and cross-market hedging. It can be useful for risk management, as well as policy making. In this study, two research questions are aimed to be fulfilled.

1. Does co-movement between stock and bond index returns exist? If the co-movement exists, is the co-movement positive or negative?

2. What are the determinants driving the level of co-movement between stock and bond index returns?

The study covers the period from 1999 to 2018 and is based on data of three countries: US, Japan and Thailand, for the purpose of the comparison. US represents developed country and global leader in the international financial markets. Japan is middle benchmark between US and Thailand.

In order to answer the first research question, we determine whether there exists the co-movement by applying one-sample t-test on covariance and measure if there is positive or negative relationship. If the co-movement is zero, it means that co-movement between stock and bond index return does not exist. Positive relationship means that stock return and bond index return moves in the same way. Negative relationship means that stock return and bond index return moves in the opposite direction.

In order to answer the second question, we find the determinants driving the level of co-movement by performing autoregressive distributed lag model (ARDL), by using dynamic co-movement, computed from DCC GARCH as a dependent variable. Explanatory variables include monetary policy stance, inflation, state of the economy and global market uncertainty.

Review of Literature

In previous studies, most studies focus on two main influences on stock and bond co-movement: market uncertainty and macroeconomic variables. The first factor is market uncertainty. Market uncertainty can be either flight-to-quality or contagion. In times of market turmoil, Baur and Lucey (2009) states that flight-to-quality occurs when investors sell stocks to buy bonds, or sell bonds to buy stocks, thus it produces negative stock-bond co-movement. Contagion, on the other hand, produces positive relation. It is found when investors move funds out of both stock and bond markets during market crisis. If investors consider stock and bond as a choice of investments, co-movement of them should exhibit negative correlation, since investors may switch to bond when stock market is too risky and vice versa. According to pricing theory, flight-to-quality can be explained as higher equity risk premium but lower bond risk premium. While, contagion means higher equity and bond risk premium.

Flight to quality appears to be significant in most countries. In developed market, Connolly, et al. (2005), Andersson et al. (2008) and Baur and Lucey (2009) reveal that stock market uncertainty has negative impact on correlation, supporting flight-to-quality phenomenon. However, the result of developed market contradicts the previous results of Asian and emerging markets. Findings of Johansson (2010) and Saengchan (2018) shows that Thailand exhibits contagion effect. Drop in one asset class can spread to the other, thus market uncertainty causes positive co-movement. Dimic et al. (2016) also show that contagion effect exists in many emerging countries. From previous studies, we can infer that developed markets may be able to provide better diversification benefit than Asian and emerging market.

Specifically, in some emerging markets, bond may not be a safer place for investors if stock market is volatile.

Considering developed countries, with large financial markets, stock and bond are two main asset classes which can provide a good hedge, thus global market uncertainty should promote negative co-movement. Domestic investors also have higher income than those of emerging markets. Since the market size is large, domestic investors mainly allocate their funds between two main assets. Although, foreign ownership plays an important role in financial markets of developed countries, foreign investors still cannot entirely influence the whole large market, unlike emerging markets where market size is small and foreign investors have more impact.

When US stock market is turbulent, international investors may fly from US stock market to stock and bond markets in Asian and emerging countries. If fund flows go to both asset classes, it will produce positive correlation in emerging countries.

The second group of factors is macroeconomic variables, consisting of monetary policy stance (short-term interest rate), inflation, state of the economy and other economic indicators. Impact of macro-variables are investigated by Li (2002), Andersson et al. (2008), Yang et al. (2009), Dimic et al. (2016) and Saengchan (2018). All studies show that macro-variables significantly explain how stock and bond comove.

In terms of monetary policy stance, Li (2002) and Yang et al. (2009) study stock-bond correlation, based on developed market. Two studies indicate that interest rate promotes positive stock-bond co-movement, since when interest rate increases, meaning that discount rate rises. Present values or prices of stock and bond will decline. Therefore, easing monetary policy, reducing short-rate, can help boost stock and bond prices as well as stock-bond relation. However, in emerging markets and Thailand, the result is not consistent with developed market. Dimic et al. (2016) find that effect of interest rate on correlation varies across countries. Saengchan (2018) also finds that the growth of interest rate promotes negative co-movement in the case of Thailand.

For inflation, Yang et al. (2009) and Dimic et al. (2016) address that inflation also promotes positive stock-bond relationship in US, UK and emerging countries. The possible explanation is that inflation has negative impact on both stock and bond. When inflation increases, return from stock and bond will be less attractive, leading to a decline in stock and bond prices. However, it is not consistent with Saengchan (2018). The finding shows that inflation has negative impact on stock-bond linkage. The possible explanation is that in high inflation periods, which mostly occurs during expansion, investors can gain higher return in bond market than stock market. Li (2002) takes a step further by decomposing inflation into expected and unexpected inflation. The finding shows that the expected inflation increases the stock-bond relation, whereas unexpected inflation dampens stock-bond correlation.

In terms of state of the economy, by dividing into expansions and recessions, Yang et al. (2009) finds that US exhibits higher stock-bond relations during expansions than those in recessions. However, UK shows a higher stock-bond relation during recessions than those in expansions. Investors will benefit more from cross-market hedging, in a presence of lower correlation during recession, hence it can be addressed that US offers a better diversification opportunity when it comes to recessions due to the lower correlation. Dimic et al. (2016) find that the industrial production index appears significant in most countries and it causes positive co-movement. Saengchan (2018) finds that higher unemployment rate promotes positive correlation in the case of Thailand. Typically, higher unemployment rate will occur during recession. Thus, investors may take money out of both stock and bond markets during recession.

According to pricing model, macroeconomic factors we consider in this study, monetary policy stance, inflation and state of the economy, affect both cash flows and discount rates and they may have different exposures toward stock and bond index returns. Monetary policy stance has discount rate effect on both stock and bond prices, thus it should promote the positive co-movement between stock and bond. For inflation, Fabozzi (2012) addresses that inflation has negative impact on bond price, when inflation increases, coupon

payment decreases in value because bond has fixed coupon payment. Inflation has an ambiguous impact on stock price, since higher inflation may lead to higher growth of dividend, leading to cash flow effect. However, it also has discount rate effect on stock. If the impact on discount rate is higher than cash flow effect, inflation should have positive impact on stock price. Similar to state of the economy, when economy is strong, demand of money is high, thus interest and inflation are likely to increase, resulting in drop of bond price. Impact on stock price is ambiguous, strong economy boosts both discount rate and growth of dividend.

Research Methodology

In this study, we employ mixed frequency data, both monthly and daily data, during March 1999 to November 2018. First, we determine covariance between stock and bond index returns by estimating dynamic conditional correlation (DCC) GARCH model, using daily data. Then, we perform autoregressive distributed lag model (ARDL) analysis by using monthly data to investigate the driving forces behind co-movement between the stock and bond index returns.

In determining co-movement between stock and bond index return, the dynamic conditional correlation (DCC) GARCH models, proposed by Engle (2002), are employed. The DCC-GARCH models can help providing us the daily time-varying covariance. DCC-GARCH is the model in analyzing dynamic volatility of each asset and their co-movements. The model combines univariate GARCH models with time-varying cross-equation weights to model the conditional covariance matrix of the errors. Conditional variances (diagonal elements of the variance-covariance matrix of error terms) are modeled as GARCH models and conditional covariances (off-diagonal elements) are time-varying assumed modeled. In this study, we assume that the time varying covariance of stock and bond index returns follows DCC(1,1). Estimating the dynamic covariance coefficients involves two steps. First, we employ demeaning process. The regression is specified as follows:

$$Y_t = A_0 + A_1 Y_{t-1} + \varepsilon_t \quad (1)$$

Where Y_t is $\begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix}$, vector of returns at time t. y_{1t} is stock return and y_{2t} is bond index return. ε_t are 2 x 1 vector of residual returns.

Second, the variance models are estimated based on the ε_t from the first step by using a standard GARCH model.

$$\varepsilon_t = D_t \nu_t \sim N(0, H_t) \quad (2)$$

Where ε_t are 2 x 1 vector of residual returns. D_t is diagonal matrix of conditional standard deviations of ε at time t. ν_t is iid standardized residual such that $E(\nu_t) = 0$ and $\mathrm{E}(\nu_t \nu_t^{\mathrm{T}}) = \mathrm{I}$. H_t is time varying variances.

$$H_t(\varepsilon_t) = \begin{bmatrix} \sigma_{1t}^2 & \sigma_{12t} \\ \sigma_{21t} & \sigma_{2t}^2 \end{bmatrix} \quad (3)$$

Where σ_{1t}^2 is variance of residual of stock return, σ_{2t}^2 is variance of bond index return. Both σ_{1t}^2 and σ_{2t}^2 follow GARCH process. σ_{12t}. σ_{21t} represent covariance of residuals of stock and bond index returns models.

After we obtain daily covariance of residuals of stock and bond index returns, in order to answer the first research question, we determine whether there exists the co-movement by applying one-sample t-test on mean of covariance. One sample t-test is performed separately in US, Japan and Thailand.

Our study covers the long period from April 1999 to September 2018, 19 years in total, thus, it is likely that US, Japan and Thailand encounter the structural changes of the economies. We perform the unit root with break test, following Perron (1989), on monetary policy stance to obtain the break dates for three countries. We choose to find break dates,

based on interest rate, since monetary policy stance is the good economic indicators that response quickly to structural change. In addition, it also reflects the policy made by the government in that country.

Table 1 Unit root with break date

Country	Break Date	ADF (t-statistics)	p-value
US	July 2007	-4.789	0.0184
Japan	October 2008	-2.994	0.6896
Thailand	October 2008	-2.980	0.6972

The break dates in 3 countries associate with the financial crisis that first occurred in US in 2007 and then spread to Asian countries such as Japan and Thailand in 2008. We divide the analysis into 2 panels: before crisis and after crisis.

To check for the stationarity of the variables, we perform Augmented Dickey-Fuller (ADF) to test for unit root test. We test for I(1) if the series is not I(0). The lag length criterion for the unit root tests is based on the Schwarz information criterion. We conduct ADF in 2 panels, for each country, before and after global financial crisis, following the break dates.

The result shows that the series have the mix of I(0) and I(1). Co-movement, inflation and market uncertainty are I(0), whereas monetary policy stance, state of the economy are I(1). Thus, ordinary least squares (OLS) cannot be applied since all variables need to be stationary. Using OLS can produce spurious result. Johansen cointegration test cannot be applied as well if variables are not integrated in the same order (Pesaran, et al., 1996). Consequently, Autoregressive Distributed Lag model (ARDL) is preferable model since it is able to cope with variables with different orders, I(0), I(1) or combination of both. According to the result of unit root test, none of the series is I(2), thus we can implement ARDL model.

In order to determine factors affecting the co-movement between shock of stock and bond index return, we then estimate the monthly[1] covariance equation model based on four

[1] In order to form the monthly model, we use the day 15th of each month as the representative of the covariance of that month.

independent variables, including monetary policy stance (IR), inflation (INF), state of the economy (IP), and global market uncertainty (VIX). The monthly covariance model can be stated as:

$$\sigma_{12t} = \beta_0 + \beta_1 IR_t + \beta_2 INF_t + \beta_3 IP_t + \beta_4 VIX_t + u_t \quad (4)$$

According to the above mentioned, since the series are either I(0) or I(1), this study applies Autoregressive Distributed Lag model (ARDL) developed by Pesaran and Shin (1995), Pesaran et al. (1996) and Pesaran (1997). Dependent variable is σ_{12t} from dynamic conditional correlation model (DCC). Three separate models are conducted using US, Japan and Thailand data. We use σ_{12t}, covariance of residuals of stock and bond index returns on the 15th day of each month. Since monetary policy stance (3-month government bond bid yields) and market uncertainty (VIX) are available in daily, data on the 15th day are used as monthly data, to be consistent with the dependent variable.

We first specify bound test cointegration (Pesaran, et al., 1996) as follows:

$$\Delta\sigma_{12t} = a_0 + \sum_{i=1}^{p} b_i \Delta\sigma_{12t-i} + \sum_{i=1}^{q_1} c_i \Delta IR_{t-i} + \sum_{i=1}^{q_2} d_i \Delta INF_{t-i} + \sum_{i=1}^{q_3} e_i \Delta IP_{t-i} + \sum_{i=1}^{q_4} f_i \Delta VIX_{t-i} + \lambda_1 \sigma_{12t-1} + \lambda_2 IR_{t-1} + \lambda_3 INF_{t-1} + \lambda_4 IP_{t-1} + \lambda_5 VIX_{t-1} + v_t \quad (5)$$

Where σ_{12t} is co-movement of the residuals between stock and bond index returns. IR_t is monetary policy stance. INF_t is inflation. IP_t is state of the economy. VIX_t is global market uncertainty. a_0 is the constant. $b_i \ldots f_i$ are coefficients. i =1,...,k. p is optimal lag order for dependent variable and q_1, q_2, q_3, q_4 are optimal lag orders for

independent variables. p and $\mathbf{q_1 \dots q_4}$ are not necessarily be the same. $\boldsymbol{\lambda_1, \dots, \lambda_5}$ are coefficients of the long run relationship.

The order of lags is selected base on Schwarz Bayesian Information Criterion (SBIC), since it produces the parsimonious model, by selecting the small lag length. The maximum lag is 3 months or 1 quarter.

From the bound test, null hypothesis cannot be rejected, long run relationship does not exist. The short-run specification model or error correction model can only be estimated as follows:

$$\Delta\sigma_{12t} = a_1 + \sum_{i=1}^{p} b_{1i}\Delta\sigma_{12t-i} + \sum_{i=1}^{q_1} c_{1i}\Delta IR_{t-i} + \sum_{i=1}^{q_2} d_{1i}\Delta INF_{t-i} + \sum_{i=1}^{\mathbf{q_3}} \mathbf{e_{1i}}\Delta\mathbf{IP_{t-i}} + \sum_{i=1}^{\mathbf{q_4}} \mathbf{f_{1i}}\Delta\mathbf{VIX_{t-i}} + \boldsymbol{\mu_t} \quad (6\text{-}1)$$

If the null hypothesis is rejected, there exists the long run relationship. Then, both long-run relationship and short-run adjustment equations can be estimated through the error correction model, which can be stated as follows:

$$\Delta\sigma_{12t} = a_3 + \sum_{i=1}^{p} b_{3i}\Delta\sigma_{12t-i} + \sum_{i=1}^{q_1} c_{3i}\Delta IR_{t-i} + \sum_{i=1}^{q_2} d_{3i}\Delta INF_{t-i} + \sum_{i=1}^{\mathbf{q_3}} \mathbf{e_{3i}}\Delta\mathbf{IP_{t-i}} + \sum_{i=1}^{\mathbf{q_4}} \mathbf{f_{3i}}\Delta\mathbf{VIX_{t-i}} + \boldsymbol{\psi}\mathbf{CE_{t-1}} + \boldsymbol{\xi_t} \quad (6\text{-}2a)$$

where $\mathbf{CE_{t-1}}$ represents Cointegrating Equation or long-run relationship. Then, long-run equation model can be derived from this cointegrating equation as:

$$\mathbf{CE_t = \sigma_{12t} - a_2 + \sum_{i=1}^{p} b_{2i}\sigma_{12t-i} + \sum_{i=1}^{q_1} c_{2i}IR_{t-i} + \sum_{i=1}^{q_2} d_{2i}INF_{t-i}}$$

$$+\sum_{i=1}^{q3} e_{2i} IP_{t-i} + \sum_{i=1}^{q4} f_{2i} VIX_{t-i} = 0 \qquad (6\text{-}2b)$$

The coefficients in error correction model (6-2a) relate to the short run dynamic, converging to equilibrium. ψ represents the speed of adjustment to equilibrium in every period.

Co-movements between stock and bond are computed by using daily data of stock and bond index returns in US, Japan and Thailand. The sample period starts from 16th March 1999 to 28th September 2018. Stock returns of US, Japan and Thailand are extracted from the S&P500 index, Tokyo Stock Exchange price Index and Stock Exchange of Thailand price index respectively. Bond index returns are retrieved from US benchmark 10-year government bond index, Japan benchmark 10-year government bond index and Thailand government bond index with maturity of 7-10 years (Clean Price). All indices, except Thailand government bond index are sourced from Thompson Datastream. Thailand government bond index with maturity of 7-10 years (Clean Price) is obtained from ibond database provided by ThaiBMA. Since 10-year government bond index benchmark is not available for Thailand, we choose government bond index with maturity of 7-10 years (Clean Price) as it includes 10-year government bond and it is consistent with bond indices of US and Japan.

The impact of market uncertainty and macroeconomic factors is examined by using both daily and monthly data, starting from 15th March 1999 to 15th November 2018. Monetary policy stance is three-month government bond bid yields for US and Japan, and three-month Thailand reference rate (offered rate) for Thailand. We compute log difference of CPI as a proxy of inflation from domestic consumer price index. State of the economy is domestic industrial production index. Global market uncertainty is Chicago board options exchange implied volatility index. All macroeconomic data are retrieved from Thompson Datastream.

Results and Discussion

In order to answer whether there is co-movement between stock and bond index returns, we perform one sample t-test on daily co-movement (σ_{12t}) obtained from the DCC-GARCH models. We divide samples into two panels, before crisis and after crisis. From Table 2, we can reject the null hypothesis of mean equals zero in every panel, which means that co-movement between stock and bond exists in US, Japan and Thailand. For US, co-movement is strongly negative at -0.17. Co-movement is more negative after crisis. For Japan, the co-movement between stock and bond is negative, similar to US, but the degree is weaker than US. Co-movements during before crisis and after crisis are not significantly different. For Thailand, the co-movement is positive and absolute value is close to zero.

Table 2 One sample t-test on mean of co-movements between stock and bond index returns

Country	All samples	Before crisis	After crisis
US	-0.1768***	-0.1115***	-0.2245***
Japan	-0.0812***	-0.0961***	-0.0671***
Thailand	0.0162***	0.0266***	0.0065***

Note: *** significant at the 0.01 level
** significant at the 0.05 level
* significant at the 0.1 level

In order to answer what the determinants driving the level of co-movement between stock and bond index returns are, we perform three ARDL models on US, Japan and Thailand. For US and Thailand. From Table 3, we can reject null hypothesis of no long run relationship in both before crisis and after crisis periods. F-statistics are above the critical value I(1) at 1% significant level. However, for Japan, we can reject null hypothesis only in after crisis period.

Table 3 Bound test cointegration

Country	F-statistics	
	Before Crisis	After Crisis
US	5.637***	43.586***
Japan	3.393	21.266***
Thailand	14.081***	19.741***

Note: *** significant at the 0.01 level

** significant at the 0.05 level

* significant at the 0.1 level

Table 4 Short run relationship and error correction models for US, Japan and Thailand

$\Delta\sigma_{12t}$	US		Japan		Thailand	
Variables	Before Crisis	After Crisis	Before Crisis	After Crisis	Before Crisis	After Crisis
$\Delta\sigma_{12t-1}$	0.1419	0.1404	-0.4170***	0.1578**	0.1657	0.1135
$\Delta\sigma_{12t-2}$	0.1866		-0.0389			
$\Delta\sigma_{12t-2}$	0.4515***					
ΔIR_t	-0.0071	0.0361	-0.0056	-0.2801***	-0.0120	0.0334**
ΔINF_t	-0.0627*	0.0102	-0.0164	0.0143	-0.0135	0.0182*
ΔINF_{t-1}						-0.0438***
ΔINF_{t-2}						-0.0199**
ΔINF_{t-3}						-0.0157*
ΔIP_t	-0.0233	-0.0237	0.0039	0.0135***	0.0002	-0.0000
ΔIP_{t-1}				-0.0191***		
ΔVIX_t	-0.0094***	-0.0190***	-0.0016	-0.0015	0.0003	-0.0000
ΔVIX_{t-1}	-0.0111***			0.0039***		-0.0030***
ΔVIX_{t-2}				0.0026***		
Constant	0.0016	0.0016	-0.0009	0.0043	-0.0014	-0.0017

CE_{t-1}	-0.7915***	-1.0514***		-0.8029***	-0.9535***	-0.9221***
R-squared	0.5125	0.6329	0.1975	0.5942	0.4034	0.5604
Adjusted R-squared	0.4609	0.6156	0.1512	0.5607	0.3694	0.5197
F-statistic	9.9303	36.4943	4.2649	17.7353	11.8351	13.7661
Prob(F)	0.0000	0.0000	0.0007	0.0000	0.0000	0.0000

Table 5 Long-run (Cointegrating Equation) models for US, Japan and Thailand

σ_{12t}	US		Japan	Thailand	
Variables	Before Crisis	After Crisis	After Crisis	Before Crisis	After Crisis
σ_{12t-1}	0.2119**	0.1387**	0.1702**	0.2136**	0.1336
σ_{12t-2}	0.1094				
σ_{12t-2}	0.2435**				
IR_t	0.0137*	0.0191	-0.1560***	0.0018	0.0136**
INF_t	-0.0351	0.0211	0.00985	-0.0133	0.0147
INF_{t-1}					-0.0301***
INF_{t-2}					-0.0364***
INF_{t-3}					-0.0221**
IP_t	-0.0157***	-0.0052*	0.0127**	0.0001	-0.0001
IP_{t-1}			-0.0146***		
VIX_t	-0.0086***	-0.0207***	-0.0070***	-0.0011	0.0017**
VIX_{t-1}	-0.0074**		0.0025*		-0.0023***
VIX_{t-2}			0.0027**		
Constant	1.7346***	0.7289**	0.1684	0.0307	0.0154
R-squared	0.6616	0.7585	0.6201	0.0773	0.4488
Adjusted R^2	0.6305	0.7492	0.5927	0.0342	0.4037
F-statistic	21.2612	81.0409	22.6460	1.7936	9.9519
Prob(F)	0.0000	0.0000	0.0000	0.1203	0.0000

Note: *** significant at the 0.01 level

** significant at the 0.05 level

* significant at the 0.1 level

US

According to bound test for both before and after crisis, there exists long-run relationship. Then, estimate error correction models with Cointegrating Equation (CE) term for before and after crisis periods are estimated. Table 4 presents that lagged error correction term of two panels are highly significant, indicating that the speed of adjustment is fast. Before crisis, CE_{t-1} carry negative value of -0.79 which means that last period equilibrium is corrected by 79% in the following month. After crisis, the CE_{t-1} is higher at -1.05 or 105%. Market uncertainty is the main factor in short-run dynamic and it is more significant after 2008.

In terms of long run relationship (Table 5), during before crisis period, monetary policy stance (IR), state of the economy (IP) and global market uncertainty (VIX) are the main drivers, influencing stock-bond co-movement. Monetary policy stance (IR) is significant at 10% level and has positive impact on co-movement. Higher monetary policy stance leads to higher discount rate, causing positive relationship. State of the economy and market uncertainty have negative impact on correlation. Economy of US, during 1999-2007 has grown consistently, this leads to cash flow effect on stock, which means that growth in economy makes stock become more attractive than bond. As a result, state of the economy has negative impact on co-movement. Negative coefficient of market uncertainty indicates flight-to-quality phenomenon.

After crisis period, interest rate is no longer the factor that affects stock-bond correlation significantly. State of the economy and market uncertainty still play important roles in co-movement. Market uncertainty becomes more important since the absolute value of coefficient is larger. Adjusted R-squared improve in the second panel from 63% to 75%, mainly due to market uncertainty. Negative coefficient of market uncertainty indicates that investors view stock and bond as two choices of investments. If stock market is volatile, investors fly to bond market as

bond is safer than stock. Investors do not pull money out of two markets at the same time but simply adjust asset allocation between stock and bond.

Japan

Since there is no cointegration in the first panel, we then perform long run relationship model and estimate residual or error correction model with Cointegrating Equation (CE) only in the after-crisis panel only. For before-crisis, we estimate short run dynamic without Cointegrating Equation (CE) term.

Table 4 reports the result of short run dynamic model for before crisis and error correction model for after crisis. Since before crisis period has no long-run cointegtration, we estimate short run model without Cointegrating Equation (CE) term. The result shows that all independent variables are unable to explain movement of correlation, and adjusted R-squared is low. For after crisis period, monetary policy stance, state to the economy and market uncertainty can explain co-movement significantly. The lagged error correction term is highly significant at 80%. To conclude, our model has more power to explain the after-crisis period than before-crisis period for Japan.

From Table 5, after late 2008, the main factors affecting relationship between stock and bond are monetary policy stance, state of the economy and market uncertainty. Monetary policy stance shows negative coefficient which contradicts to the pricing theory. This phenomenon can be explained by Andersen et al. (2007). They state that interest rate can promote negative relationship during recession. After 2008, Japan economy still suffers from huge amount of debt. The government controls the rate close to zero and lowered the rate further in 2014. The lower interest rate has positive impact on bond price. However, lower interest rate has negative impact on stock, since it can be viewed that economy still cannot pick up and performance of stock market is in downward trend. This explanation is consistent with state of the economy, sum of coefficient is negative, which means that state of the economy promotes negative co-movement. When economy is not doing well, interest rate is

usually low which has a good impact on bond price. However, sluggish economy has negative cash flow effect on stock, causing lower stock return. As a result, state of the economy has negative impact on stock-bond co-movement. Current VIX and lagged VIX are the most influential factors in long run model for Japan. The sum of coefficient is -0.0018, implying the flight-to-quality, similar to US.

Thailand

According to bound test for both before and after crisis, there exists long-run relationship. Then, estimate error correction models with Cointegrating Equation (CE) term for before and after crisis periods are estimated. Table 4 reports the error correction model result. The coefficients of lagged error correction term are highly significant. CE for before and after crisis are -95% and -92% respectively. Short run dynamic for before crisis still cannot be explained by the macroeconomic factors. However, the model shows improvement in after crisis. Higher interest rate produces more positive correlation, while inflation and lag of market uncertainty produce negative correlation.

From Table 5, in before-crisis period, although bound test cointegration can reject the null hypothesis. However, the F-statistic is not significant, thus we first conclude that there is no long run relationship among variables in this panel. During 1999 to 2003, Thai economy was in recovery stage due to Asian financial market in 1997. Bond and stock markets were still in the early stage of development. Thus, foreign investors may not be able to invest in Thai markets. In addition, compared to stock market, which is easier to invest, Thai retail investors may not have access to bond market. As a result, the relationship between stock and bond index returns are still close to zero.

After crisis period, monetary policy stance, inflation and market uncertainty are the main factors, affecting correlation. The effect of monetary policy stance is positive, while effects of inflation and market uncertainty are negative. Inflation is the most influential factors for Thailand. The higher inflation has negative impact on bond price, however, it has cash flow

effect on stock since it can boost expected dividend. In addition, higher inflation is often in accordance with expansion periods. Wealth effect can make stock become more attractive than bond. Consequently, inflation produces negative relationship between stock and bond index returns.

In terms of market uncertainty, after 2008, Thai bond and stock markets became one of the choices of investments for international investors. Foreign investors play a big role in Thai markets. In Table 5, Current VIX promotes positive stock-bond co-movement, this indicates contagion effect, when global market is volatile, international investors will shift investment to developing markets, including Thailand. However, we can observe that lag of VIX promotes negative relationship. The sum of coefficient is -0.00065, close to zero. This implies that, global market uncertainty promotes contagion effect on Thai market, however, the phenomenon lasts in a short period, since foreign investors will move fund back when global market is more stable in the next period.

Conclusion and Recommendations

This paper attempts to determine whether co-movement between stock and bond index returns exists in US, Japan and Thailand. If co-movement exists, we investigate further the determinants, driving the level of co-movement. Our analysis covers the long period from April 1999 to September 2018. Thus, we perform unit root test with break date on monetary policy stance to obtain the break date. The break date for US is July 2007 and for Japan and Thailand is October 2008. The dates are related to global financial crisis in 2008, consequently, we divide the analysis in 2 panels: before and after crisis.

We expect to see significant negative co-movement between stock and bond index returns. When stock market performs well, investors will move fund to stock. However, if stock returns declined, investors will invest more in bond. We define co-movements of stock and bond as the dynamic covariances of residuals between stock and bond index returns from DCC GARCH (1,1) model. To determine whether co-movements between stock and bond index returns exist we employ one sample t-test on covariance.

The results show that US and Japan exhibit negative relationship between stock and bond index returns. The covariance in US is stronger than Japan and is more negative. Co-movement in Thailand on the other hand is positive but close to zero. The result is consistent with Andersson et al. (2008), Baur and Lucey (2009), Dimic et al. (2016), Johansson (2010) and Saengchan (2018).

Since there exists the significant relationship between stock and bond index returns in US, Japan and Thailand, we investigate further the determinants, driving the level of co-movement between stock and bond index returns. The determinants consist of monetary policy stance, inflation, state of the economy and global market uncertainty. From theoretical framework, monetary policy stance should promote positive relationship, since interest rate has discount rate effect on stock and bond prices. The higher interest rate, the lower stock and bond prices and vice versa. Inflation and state of the economy have negative relationship with bond price. However, the effect on stock return is ambiguous. When inflation increases, it may boost the discount rate, at the same time it can increase the expected dividend of stock. Similar to state of the economy, if economy expands, the demand of money is high, economic expansion may induce higher inflation and interest which cause the higher discount rate, however, economic expansion can help boost dividend and growth of the firm in the future, thus it has both cash flow and discount rate effects on stock. The last factor is global market uncertainty, the negative coefficient of global market uncertainty implies flight-to-quality. Flight-to-quality occurs when investors sell stocks to buy bonds, or sell bonds to buy stocks. and positive coefficient means contagion where investors move funds out of both stock and bond markets.

For US, there exists long run relationship before and after crisis periods. Before crisis period, monetary policy stance, state of the economy and market uncertainty are the main drivers, influencing stock-bond co-movement. Monetary policy stance promotes positive co-movement which is consistent with the theory and empirical findings of Li (2002) and Yang et al. (2009). Yang et al. (2009) and Dimic et al. (2016) address that inflation also promotes positive

stock-bond relationship. However, in this study we cannot detect the significant relationship between inflation and stock-bond co-movement. In terms of state of the economy, economy of US grew consistently and reached its peak in 2007, and from the result, state of the economy causes the negative relationship, which implies that economic expansion boosts expected dividend more than discount rate, thus it produced the negative co-movement. Global market uncertainty produces negative relationship, showing flight-to-quality which is consistent with Connolly, et al. (2005), Baur and Lucey (2009) and Dimic et al. (2016). After crisis, co-movement is mainly explained by global market uncertainty and coefficient remains negative. The error correction model shows negative coefficient of error correction term which means that short term dynamic will converge to long run relationship.

For Japan, from bound test cointegration, there only exits the long run relationship in after crisis period. Monetary policy stance, state of the economy and market uncertainty significantly promote negative co-movement. Monetary policy stance shows negative coefficient which contradicts to the pricing theory. Andersen et al. (2007) also find that monetary policy stance can promote negative relationship during recession. After 2008, Japan economy is in decline stage and government faces difficulty to stimulate the economy even if the interest rate remains very low and negative. Thus, it is likely that, in the case of Japan, interest also has cash flow effect on stock, consequently, interest rate has positive relationship on stock price. If the interest rate declines further, it is the bad sign of the economy which can lower the stock return. As a result, interest rate promotes negative relationship between stock and bond. This explanation is consistent with state of the economy. The coefficient is negative, meaning that state of the economy has effect on cash flow of stock more than discount rate. In terms of market uncertainty, the impact is similar to US, showing flight-to-quality phenomenon.

For Thailand, we can detect long run relationship in both before and after crisis period. However, our model can explain co-movement significantly only in after crisis period. The main factors influencing co-movement are monetary policy stance, inflation and global market

uncertainty. Monetary policy stance promotes positive relationship which is similar to US. Inflation produces negative co-movement. The higher inflation has negative impact on bond price, however, it has cash flow effect on stock since it can boost expected dividend. In addition, higher inflation is often in accordance with expansion periods. Wealth effect can make stock become more attractive than bond. The result is consistent with Saengchan (2018) but different from Dimic et al. (2016). Dimic et al. (2016) find that inflation produces positive correlation in most emerging countries. In terms of global market uncertainty, current market uncertainty promotes positive co-movement, implying contagion effect. The result is consistent with Saengchan (2018). However, we can observe that lag of VIX promotes negative relationship. The sum of coefficient is -0.00065, close to zero. This implies that global market uncertainty promotes contagion effect on Thai market, however, the phenomenon lasts in a short period, since foreign investors will move fund back when global market is more stable in the next period.

Table 6 Summary of sign of σ_{12} and significant factors, influencing co-movement

Country	Sign of σ_{12}	Significant factors	
		Before crisis	After crisis
US	Negative	Monetary Policy Stance (+) State of the economy (-) Market uncertainty (-)	State of the economy (-) Market uncertainty (-)
Japan	Negative	-	Monetary Policy Stance (-) State of the economy (-) Market uncertainty (-)
Thailand	Positive	-	Monetary Policy Stance (+) Inflation (-) Market uncertainty (-)

The evidences of three countries indicate that each country has different patterns of dynamic stock-bond co-movement. In addition, factors driving co-movement are also different.

Market uncertainty plays the big role in three countries. In US and Japan, which are developed countries, market uncertainty has negative relationship with co-movement. We can conclude that flight-to-quality exists in these countries. Good financial market requires depth and access. Depth means that financial market has sufficient size and access means the economic participants are able to use financial services.

In terms of market capitalization of stock markets, US and Japan ranked first and third. While bond market, US and Japan ranked first and second. Investors from these countries are also the main players of global market, when stock market is uncertain, they liquidate position in stock market and move to bond. Domestic investors have large investment so they still need to maintain some position in their markets.

For Thailand, before 2008, outstanding value of Thai bond market is around 5 trillion while market capitalization of stock market is 6 trillion. Size of the markets are small and investors may not have access to both markets, especially bond market. After crisis, Thai financial markets became one of the investment destinations for international investors. Stock and bond markets in Thailand have grown rapidly. However, compared with global financial market, size of Thai market is still small and foreign investors are able to influence the market significantly. Foreign investors view Thai market and stock market as a whole, thus when their home markets crash, they shift investment to emerging markets, including Thailand, leading to positive co-movement.

Another explanation driving the difference patterns of co-movement is financial literacy of investors in three countries. Klapper et al. (2015) study financial literacy around the world. They measure financial literacy of adults by interviewing concepts in finance such as knowledge of interest rates, interest compounding, inflation, and risk diversification and reports the percentage of adults who are financially literate. The evidence shows that there is huge difference among countries. Percentage of adults who are financially literate in US, Japan and Thailand are 57, 43 and 27 respectively. Since putting money in multiple investment is safer than investing in single asset, bond should be a hedge for stock during stock market crisis and

they should be negatively correlated. US and Japan investors with relatively high financial literacy may put money in two assets in order to diversify risk and adjust portfolio when market changes, causing negative co-movement. Financial literacy in Thailand is lower than Japan and US, this implies that investors may not diversify well enough or they do not adjust their portfolios, according to change in markets. As a result, low financial literacy leads to close-to-zero co-movement of stock and bond index returns and weak flight-to-quality.

The empirical findings provide the insights how stock and bond dynamic co-movements in US, Japan and Thailand behave and factors, influencing relationship. Since stock and bond are the main asset classes, covariance among asset classes is crucial element in asset allocation. Understanding stock-bond co-movement can help investors and firms in portfolio optimization and risk management. In addition, policy makers can use the relationship between co-movement and macroeconomic factors to gauge how stock and bond markets behave in accordance with change in policy.

Our dependent variable, co-movement, is available in daily. However, highest frequency of macroeconomic variables is monthly. Thus, performing ARDL using monthly data, made us lose the information at the daily level. Therefore, further research may use the model with mixed frequency data to capture daily movement. More independent variables can be included in order to gain more insights. In addition, since covariance measures the linear relationship between residuals of stock and bond index returns, further research can use other non-linear methods to measure how stock and bond comove.

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