STOCK AND BOND RELATIONSHIPS IN ASIA

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Abstract

This paper analyzes the relationship between stocks and bonds in nine Asian countries. Using a bivariate stochastic volatility model, we show that there are significant volatility spillover effects between stock and bond markets in several of the countries. Furthermore, dynamic correlation patterns show that the relationship between stock and bond markets changes considerably over time in all countries. Stock-bond correlation increases during periods of turmoil in several countries, indicating that there is a cross-asset contagion effect. Therefore, if there is a flight to quality effect in Asian markets, it seems to occur across countries or regions rather than across domestic assets. The results have direct and important implications for regional policy makers as well as domestic and international investors that invest in multiple asset classes.

Keywords: Asia; stock markets; bond markets; stochastic volatility; Markov Chain Monte Carlo; spillover effects; dynamic correlation

JEL Classification: C32; F30; G12; G15

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1 Introduction

The relationship between different asset classes is a fundamental and important issue for portfolio managers. The relative risk between assets such as stocks and bonds is perhaps especially important, since it likely changes over time, and thus creates a need to update investment portfolios so that they exhibit the desired risk level. From a theoretical perspective, the relationship between stocks and bonds can be seen in the light of present value. An increase in future discount rates results in a fall in the present value of stocks and bonds, thus causing prices for both assets to fall. This reasoning indicates a positive correlation between stocks and bonds. There are also other arguments for why moves in stocks and bonds should be positively correlated. For instance, macroeconomic variables may affect them in a similar fashion, thus causing positively correlated movements in the two different assets. Besides macroeconomic factors such as future inflation, the correlation structure can also be dependent on the lead-lag nature between stocks and bonds, something that may change over time. There are also arguments in the literature on stocks and bonds for why the movements in the two assets should be negatively correlated. For instance, the so-called "flight to quality" arguments says that investors tend to move in and out of asset classes partially as a result of the current market situation and updated risk assessments. As the general risk level in the market changes, investors can be expected to change portfolio weights of assets with different risk characteristics.

Even though the understanding of the relationship between different asset classes such as stocks and bonds is imperative for portfolio managers, this subject has received surprisingly little attention in the research literature. To the best of our knowledge, this study differs from earlier studies on stock and bond relationship in at least two important ways. First, this is the first study that uses a bivariate stochastic volatility model to analyze the relationship between domestic stock and bond markets. Second, we have yet to see a comprehensive study on how bond and stock markets relate to each other in Asia. This paper attempts to answer the question of how Asian stock and bond markets are related to each other over time. The focus is on stocks and bonds within the same country, thus limiting the study of the dependency structure to the national arena. This approach enables us to focus on how the two different assets are related from the view of domestic investors as well as international investors that want to invest in a specific market but still have to decide which asset class to invest in. The complex relationship between different assets across national borders is of great interest to market participants with international portfolios, but we leave that analysis to future research.

As mentioned, to understand how bonds and stocks behave in Asia, we apply a bivariate stochastic volatility model that incorporates volatility spillover effects (Johansson, 2009). We also let the correlation structure be time varying. This way, we can see how the co-movements between the two asset classes change over time. Our results show that the correlation between Asian stock and bond markets is indeed time varying in nature. In some of the markets, the correlation between the two assets moves between positive and negative values. Also, stock-bond correlation tends to increase during periods of market turmoil for most countries. The results show the importance for portfolio and risk managers to understand the current market environment when deciding on allocations and risk management strategies. They also have implications for regional policy makers, e.g. when issuing new government bonds.

The rest of the paper is structured as follows: Section 2 discusses the theoretical as well as empirical literature on stocks and bonds. Section 3 then explains the methodology, while Section 4 introduces the data and presents the results of the empirical estimations, focusing on volatility spillover effects, time-varying volatility, and dynamic correlation patterns. This section also briefly discusses the relationship between periods of increasing market risk, as measured by the increases in volatility, and the time-varying nature of stock-bond correlations. Finally, section 5 concludes the study.

2 Stock and Bond Markets

It is commonly argued that stocks and bonds complement each other and that investors should combine the two different kinds of assets to form portfolios that fit their desired level of risk exposure. The risk-return characteristics of stocks and bonds most usually differ in the sense that stocks exhibit higher level of volatility and are expected to yield higher returns relative to bonds. However, this view is most often too simplified and also gives at best a part of the whole picture when it comes to understanding and combining the two asset classes. First, as we shall see later on, bonds may exhibit very high levels of volatility, at least during shorter time periods. Second, and more importantly, even though the two forms of assets differ in their risk-return profiles, their interdependence is important when designing an optimal portfolio. The relationship between stocks and bonds has been studied and used in different settings. For example, the so-called "Fed Model" uses the relationship between the stock market and the 10-year U.S. Treasury Bond to identify whether stocks are under- or overvalued.[1] According to proponents of this valuation approach, stocks should deliver lower returns and be more costly when bond yields are relatively low, as the two assets are competing assets. Here, we present and discuss theoretical arguments as well as empirical studies on the relationship between stocks and bonds found in the literature.

Arguably the most common way of looking at stocks and bonds is by using a standard present value approach. From a present value perspective, both stocks and bonds are claims to future cash flows. Their present value should thus be equal to the sum of future cash flows discounted by a suitable discount rate. This means that both stocks and bonds are

[1] The "Fed Model" has received critique due to the fact that it compares the real number of the valuation of a stock (e.g. a price/earnings ratio) with that of the nominal number of a bond yield and thus ignores that companies' long-run earnings move with inflation.

affected similarly to a change in the expected future discount rates and that the two should exhibit positive correlation patterns. However, this argument rests on a ceteris paribus assumption that most probably does not hold in practice. One problem is that the discount rate for the two assets should differ if their risk profiles differ, a very likely scenario. Also, the dividend streams from stocks and bond differ significantly. Bond yields are nominal, which means that if an inflationary shock occurs, the bond yields are affected significantly. However, the price of a stock is much less affected, since the nominal value of the dividend stream of the stock goes up in response to an inflationary shock. The response to a fall in interest rates also differs between stock and bonds. A fall in interest rates indicates an expected slowdown in future economic activity, which means that stock prices are negatively affected, since the expected future dividend stream from companies is decreasing. It can be expected that bond prices, on the other hand, reacts in an opposite direction since the dividend stream of a bond will be discounted at a lower rate, thus increasing the present value of all future dividends. One important contribution to research on the relationship between stocks and bonds from a present value perspective is that of Shiller and Beltratti (1992). They argue that stock prices and long-term bond yields should be negatively correlated, since the discount rate has opposite effects on them. They use time series econometric methods to estimate a theoretical correlation level between stocks and bonds in the U.S. and the U.K. if the present value model holds. Shiller and Beltratti (1992) show that the positive correlation between stock and bond prices (or the negative correlation between stock prices and bond yields) is actually higher than it should be based on the present value model. In a related study, Campbell and Ammer (1993) break down excess returns into components that are associated with future cash flows and future discount rates. By extracting news about dividends and real interest rate, expected inflation and risk premiums for stocks and bonds, they study the effects of these different components on assets and how stocks and bond move over time.

Besides the present value approach to stocks and bonds, there is a growing literature on the so-called flight-to-quality phenomenon that many argue has a direct impact on the relationship between the two asset classes. In an early article, Barsky (1989) discusses the relationship between stocks and bonds in the framework of a consumption-based asset pricing model. He analyzes the effects of changes in risk and real economic productivity growth and their impact on the stock-bond joint behavior. Barsky's main conclusion is that stocks and bonds may or may not move together and that the outcome is dependent on economic agents’ general level of risk aversion. Barsky begins his article with a quote from a Federal Reserve letter, stating that investors tend to look for safety and thus move from stocks to relatively safer bonds, with falling stock prices and rising government bond prices as a result. Connolly, Stivers and Sun (2005) show that uncertainty in the stock markets is a significant determinant of stock-bond correlation. Other studies that look at the relationship between stocks and bonds during periods of crisis include Hartmann, Straetmans and De Vries (2001), Gulko (2002), and Baur and Lucey (2009). Several of these studies take a similar approach, focusing on the time-varying correlation structure between stocks and bonds and how it behaves during periods of financial turmoil.

Focusing instead on general cross-asset studies, Fleming, Kirby and Ostdiek (1998) develop a model that predicts volatility linkages in the stock, bond, and money markets. Using a stochastic volatility framework, they show that there are strong spillover effects among the different asset classes. Similarly, Lim, Gallo, and Swanson (1998) use two world indices for stock and bonds to study possible causal effects and long-run relationships between the two assets. They find a significant feedback relationship between the two markets. Also, Steeley (2006) looks at the volatility transmission between stocks and bonds.

While several early studies used a constant correlation framework to analyze the relationship between stocks and bonds, Scruggs and Glabadanidis (2003) use a dynamic covariance approach to study the co-movements between an equity index and a portfolio of long-term government bonds. Their results reject models that impose a constant correlation structure between the two assets. Ilmanen (2003) also recognizes the fact that the correlation between stocks and bonds has not been stable over time. He shows that the correlation is low when inflation and growth is low and when equities are volatile (again supporting the flight-to-equity argument). Ilmanen (2003) also shows that the stock-bond correlation is lower near business cycle peaks and when the monetary authorities impose tightening policies. Other studies supporting a time-varying correlation between stock and bond markets include Connolly, Stivers and Sun (2005), Li (2004) and Jones and Wilson (2004). Also, Cappiello, Engle and Sheppard (2006) focus on the dynamic correlation between different stock and bond markets in Europe before and after the introduction of the Euro. Besides looking at dynamic correlation patterns among stock markets as well as the dynamic correlation patterns among bond markets, the authors show that the correlation between stocks and bonds in EMU, U.S. and Australasian markets is time varying and shifts between positive and negative values. Christiansen (2008) uses a multivariate volatility model to study how bonds and stocks in the U.S. and Europe relate to each other. Kim, Moshirian, and Wu (2006) also look at the dynamic correlation between stocks and bonds in Europe. They find a downward trend in the correlation between stock and bond returns over the last decade. De Goeij and Marquering (2005) apply a multivariate GARCH model to show that the covariance between stocks and bonds depends on the type of shocks. Bad news in the two markets is usually followed by a higher covariance between them. They also show that portfolio management is significantly affected by the shifting pattern between the two assets. Dopfel (2003) focuses on the fact that the dynamic correlation between stocks and bonds decreases in a certain period and the effect it has for investors. Finally, d'Addona and Kind (2006) use an affine asset pricing framework to model stocks and bonds. Focusing on the markets in the G7 countries, their model incorporates the influence of economic fundamentals on the stock-bond correlation structure.

Besides studies on stock-bond relationships, this study is also related to a large literature that focuses on the dynamic interactions between assets that belong to the same asset class. Most of these studies are focusing on time-varying stock co-movements and/or spillover effects among different stock markets. Examples of studies that focus on international markets include Bekaert and Harvey (1995), Bekaert (1995), Forbes and Rigobon (2002) and Johansson and Ljungwall (2009). A much smaller literature focuses on co-movements in international bond markets. For instance, Johansson (2008) analyzes the short- and long-run relationship between four emerging Asian bond markets as well as their dynamic correlation structure. Other studies have analyzed the relationship between bonds in more developed markets. For example, Skintzi and Refenes (2006) look at spillover effects from the Euro and US markets to individual European markets.

3 Methodology

3.1 The Bivariate Stochastic Volatility Model

We now introduce the model that will be used to estimate volatility spillover effects and dynamic correlation structures in the markets included in this paper. As we will see in the following section, all nine stock markets as well as all nine bond markets exhibit significant heteroscedastic features. We will therefore use a model that takes time-varying volatility into account. The model incorporates time-varying volatilities and correlation in a stochastic volatility framework. The model is from Johansson (2009) and can be written as follows:

$$y_t = \Omega_t \varepsilon_t, \qquad \varepsilon_t \sim N(0, \Sigma_{\varepsilon,t}), \tag{1}$$

$$\Sigma_{\varepsilon,t} = \begin{pmatrix} 1 & \rho_t \\ \rho_t & 1 \end{pmatrix}, \tag{2}$$

$$h_{t+1} = \gamma_0 + \Gamma\left(h_t - \gamma_0\right) + \eta_t, \qquad \eta_t \sim N\left(0, \operatorname{diag}\left(\sigma^2_{\eta_1}, \sigma^2_{\eta_1}\right)\right), \tag{3}$$

$$z_{t+1} = \delta_0 + \delta_1\left(z_t - \delta_0\right) + \sigma_\rho \vartheta_t, \quad \vartheta_t \sim N\left(0,1\right), \quad \rho_t = \frac{\exp\left(z_t\right) - 1}{\exp\left(z_t\right) + 1}. \tag{4}$$

Here, $h_0 = \gamma_0$. Since we are using a bivariate structure, log-returns at time t are denoted $y_t = (y_{1t}, y_{2t})'$ for $t = 1,\ldots,T$. Furthermore, $\varepsilon_t = (\varepsilon_{1t}, \varepsilon_{2t})'$, $h_t = (h_{1t}, h_{2t})'$, $\eta_t = (\eta_{1t}, \eta_{2t})'$, $\gamma_0 = (\gamma_{10}, \gamma_{20})'$, and

$$\Gamma = \begin{pmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{pmatrix}, \quad \Sigma_\varepsilon = \begin{pmatrix} 1 & \rho_\varepsilon \\ \rho_\varepsilon & 1 \end{pmatrix}, \quad \Sigma_\eta = \begin{pmatrix} \sigma^2_{\eta_1} & \rho_\eta \sigma_{\eta_1} \sigma_{\eta_2} \\ \rho_\eta \sigma_{\eta_1} \sigma_{\eta_2} & \sigma^2_{\eta_2} \end{pmatrix}.$$

Equation (2) shows that we allow for the correlation between the two log-returns to vary over time. We follow the same approach as in Yu and Meyer (2006) and Johansson (2009) and model the correlation as an AR(1)-process in which we bound correlation between -1 and 1. To do this, we apply a Fischer transformation with the correlation process defined as in Equation (4), where $z_0 = \delta_0$. For this approach to work, we are limited to the bivariate case.[2] Equation (3) shows that we allow for volatility in one asset to spill over into the other asset in the following period. Γ is therefore a matrix that combines volatility persistence parameters (γ_{11} and γ_{22}) and volatility spillovers (γ_{12} and γ_{21}). While the spillover effects are interesting and therefore included in this study, our main focus is on the potentially time-varying nature of the correlation between stocks and bonds in the different Asian countries.

[2] For a discussion on potential alternative solutions that allow for higher dimensions, see Yu and Meyer (2006).

3.2 Estimation Procedure

Stochastic volatility models have no closed-form solutions, meaning that straightforward maximum likelihood estimation is not applicable. There are several different approaches for estimating the parameters in a stochastic volatility model, including quasi-maximum likelihood, general method of moments (GMM), spectral GMM, efficient method of moments, simulated maximum likelihood, and Markov chain Monte Carlo (MCMC) simulation. Studies have shown that the MCMC approach is a good alternative to other models.[3] We will therefore use the MCMC estimation procedure to estimate the bivariate stochastic volatility model introduced above. The following brief introduction to MCMC simulation of stochastic volatility models is based on Yu and Meyer (2006) and Johannes and Polson (2004).

The vector θ comprises the unknown parameters, essentially combining the vector c of unknown parameters and the vector l of latent volatilities and correlation, i.e. $\theta = (c, l_1, \ldots, l_T)$. If we let $p(.)$ denote the probability density function of a random variable, we can use independent prior distributions for the parameters and condition on the sequence of latent states. This gives us the joint prior density of vector θ:

$$\begin{aligned} & p(l)\,p(h_0)\prod_{t=1}^{T} p(l_t|c) \\ & = p(\gamma_{10})\,p(\gamma_{20})\ldots p(l_0)\prod_{t=1}^{T} p(l_t|c). \end{aligned} \tag{5}$$

Utilizing the data, the joint prior is updated to the joint posterior of the unknown quantities, $p(\theta|y)$, by way of multiplying the prior $p(\theta)$ with the likelihood $p(y|\theta)$. This can be written as:

$$p(\theta|y) \propto p(\theta)\,p(y|\theta) \propto p(c)\,p(l_0)\prod_{t=1}^{T} p(l_t|c)p(y_t|l_t). \tag{6}$$

[3] See Jacquier, Polson and Rossi (1994) and Andersen, Chung and Sorensen (1999) for more detailed discussions on alternative estimation approaches.

Here, $\propto$ means "proportional to". MCMC estimation is then based on the creation of a Markov chain with a stationary distribution that equals the target density. The Markov chain is used to simulate samples from the target density, i.e. $p(\theta|y)$. It is important that the Markov chain is long enough so that it has reached equilibrium before inference is done based on it.[4]

4 Data and Empirical Results

In this section, we first introduce the data from the nine East Asian countries' stock and bond markets. The data is then used in the estimation of the bivariate stochastic volatility model described above. The discussion of the results begins with the estimated time-varying volatility and volatility spillover effects and then continues with the dynamic correlation structure between the stock and bond markets.

4.1 Data and Summary Statistics

The data used in this study is comprised of indices for national stock and bond markets. The stock market data is composed by commonly used stock indices for each of the nine Asian countries. The bond market data is from the J.P. Morgan Emerging Local Markets Index Plus (ELMI+) series. We use local currency stock and bond indexes because we want to focus on the relationship between the two assets without having to take the exchange rate into consideration. This focus applies not only to domestic investors, but also to international investors. If international investors are considering investing in different countries, they want to separate the issues of which assets to invest in and whether or not to take on exchange rate risk. The data are sourced from Datastream and are gathered at a weekly frequency from December 31, 1993 to December 31, 2008 resulting in a total number of 783 observations. The continuously compounded percentage return of each index series is calculated as the log

[4] The software package WinBUGS is used for the posterior simulation of the stochastic volatility model. For more details on the software and how it can be used to estimate univariate and multivariate stochastic volatility models, see Meyer and Yu (2000) and Yu and Meyer (2006).

of the price differences (R_{it} = 100*log[P_{it}/P_{it-1}]), resulting in 782 final log-return observations. The maximum number of observation is available only for three of the nine countries. The restriction on the other countries is due to the fact that the J.P. Morgan ELMI+ bond indices vary in length. The time series for each of the assets and the nine countries are shown in Figure 1 and Figure 2. The two figures show signs of strong volatility clustering, indicating that both national stock and bond indices exhibit heteroscedasticity.

[FIGURE 1]

[FIGURE 2]

Table 1 presents descriptive statistics for each of the eighteen index series. Looking first at the descriptive statistics for the stock market log returns, all series have a mean that is relatively close to zero, although the Chinese and Indonesian markets have relatively high weekly mean returns of 0.115 and 0.288 percent, respectively. Thailand, being at the epicenter of the severe Asian financial crisis in 1997-1998 has a negative average weekly return of -0.170. Overall, four of the markets exhibit positive mean values, while the other five have negative weekly averages. The maximum and minimum returns together with the unconditional standard deviation numbers indicate that the nine markets are quite volatile. The most extreme positive one-week return is that of Thailand, with a maximum return of close to 22 percent. Similarly, Thailand exhibits the largest negative weekly return of -26.661 percent. The standard deviation is high in all markets, with South Korea showing the highest value of 4.676. Skewness and kurtosis differ considerably among the nine markets and the Jarque-Bera test rejects normality in all nine cases.

The bond returns exhibit somewhat different patterns when compared to those of the stock markets. All nine bond markets have positive means and much lower maximum and minimum values compared to the stock index returns. The standard deviations show that all bond markets are considerably less volatile than their stock market counterparts. This supports the general view that stock markets are riskier than bond markets. Most of the series are positively skewed and show high levels of excess kurtosis, features that are also evident in the Jarque-Bera test statistic that again rejects normality in all nine cases.

[TABLE 1]

4.2 Empirical Analysis

We now turn to the estimation of the bivariate stochastic volatility model for the nine Asian countries. First, we specify the prior distributions for the parameters. The different priors are closely related to those in earlier studies that estimate similar models (e.g. Yu and Meyer, 2006; Johansson, 2009). The priors are chosen to be somewhat informative. However, they are still quite general and do not constrain the results of the estimation very much. The prior distributions for each of the eleven parameters in the bivariate stochastic volatility model are:

$$\begin{aligned}
&\gamma_{10} \sim N(0,100) \\
&\gamma_{10} \sim N(0,100) \\
&\gamma_{11}^{*} \sim \text{beta}(20,1.5), \text{ where } \gamma_{11}^{*} = (\gamma_{11}+1)/2 \\
&\gamma_{22}^{*} \sim \text{beta}(20,1.5), \text{ where } \gamma_{22}^{*} = (\gamma_{22}+1)/2 \\
&\sigma_{1}^{2} \sim \text{Inverse-Gamma}(2.5, 0.025) \\
&\sigma_{2}^{2} \sim \text{Inverse-Gamma}(2.5, 0.025) \\
&\delta_{0} \sim N(0.7,10) \\
&\delta_{1}^{*} \sim \text{beta}(20,1.5), \text{ where } \delta_{1}^{*} = (\delta_{1}+1)/2 \\
&\sigma_{\rho}^{2} \sim \text{Inverse-Gamma}(2.5, 0.025)
\end{aligned}$$

The MCMC simulation procedure is initiated with 10,000 burn-ins. These initial samples are then thrown away and the following 40,000 draws are used for inference. To show how the simulation behaves over time, the trace plots for the model parameters from the estimation for the Indonesian stock and bond markets are presented in Figure 3. The convergence of the MCMC simulation is also tested using Geweke *Z*-Score tests. The results of these tests are shown in Table 2. The *Z*-scores are either smaller than the critical values or close to them for all but a few cases (2.56 is the 1% critical value and 1.96 is the 5% critical value). We thus conclude that the MCMC simulation gives us reasonable estimates.

[FIGURE 3]

[TABLE 2]

The results for each country are shown in Table 3, where 1 signifies the domestic stock market and 2 signifies the domestic bond market. The estimated parameters are presented in terms of their location and dispersion measures, i.e. mean, standard deviation, and 95% credible intervals. Focusing first on the volatility in Table 3, the parameters γ_{11} and γ_{22} show how persistent volatility is in the local stock and bond markets, respectively. Both assets exhibit very persistent volatility, with parameters close to, but smaller than, one. For five countries, the volatility persistence is larger in the bond market compared to the stock market. The results indicate that bond markets in general exhibit very persistent volatility and corroborate the findings on Asian bond markets in Johansson (2008, 2010a). The parameters γ_{12} and γ_{21} show how volatility in the bond market spill over into the stock market and vice versa. There is a unidirectional spillover effect from the bond market to the stock market in Hong Kong and Taiwan. There is also a unidirectional spillover effect from the stock market to the bond market in Indonesia. Finally, there is a feedback relationship between the two asset classes in Korea and the Philippines. These results indicate that there are significant volatility spillover effects between stocks and bonds in a majority of the Asian countries analyzed in this study.

Moving on to the correlation function, the estimated values for δ_1 indicate that the correlation patterns are persistent as well. The posterior mean of the parameter δ_1 is between 0.825 and 0.952 for the nine countries. This supports the use of a dynamic correlation structure when analyzing the relationship between stock and bond markets in these countries.

[TABLE 3]

The time-varying volatility patterns for the nine stock markets are shown in Figure 4. For those markets with time series going back to the Asian financial crisis in 1997-1998, there is as expected a strong increase in volatility during that period. Most of the countries show signs of very significant increases in volatility during the second half of 2008. This is to be expected as the subprime crisis in the U.S. escalated during this period and the Lehman Brothers bankruptcy fueled a contagion in global stock markets.[5] Figure 5 presents the time-varying volatility in each of the nine bond markets. For most countries, the Asian financial crisis resulted in the highest level of bond market volatility in the sample. This is true also for China, whose financial markets are commonly seen as being insulated from the rest of the world. Overall, the volatility patterns in the two different asset classes show some resemblance, with spikes typically occurring in the same periods. However, it is clear that there are factors that affect the two assets differently, since the patterns diverge considerably for all nine countries.

[FIGURE 4]

[FIGURE 5]

[5] See Johansson (2010b) for a detailed analysis on regional volatility in East Asia during the recent global financial crisis.

Figure 6 shows the time-varying correlation structure between stock and bond markets in the nine Asian countries. For China, the correlation is mostly positive, albeit at low levels. For Hong Kong, correlation between stock and bond markets are always positive, with relatively high levels (up to 0.3) occurring at the time of the Asian financial crisis and an additional increase in the period 2003-2006. For Indonesia, the correlation is considerably higher, reaching approximately 0.45 during 2007. In the case of Korea, on the other hand, the correlation is quite stable and stays close to zero for most of the sample period. The available data for Malaysia is very short, but the correlation pattern indicates that the relationship between the two asset classes is dynamic in nature with changes from 0.3 down to close to 0.05 in 2007-2008. For the Philippines, Taiwan and Thailand, the correlation between stock and bond markets is also relatively stable, but at different average levels. Finally, Singapore exhibits considerable volatility in its stock-bond correlation process, with spikes well above 0.3 followed by negative levels of correlation.

[FIGURE 6]

Overall, the Asian countries included in this study exhibit positive correlation between stocks and bonds, except for short periods in China, Korea, and Singapore, during which the stock-bond correlation is somewhat below zero. Correlation seems to be increasing during times of financial crisis in several countries, indicating that the possibility of diversification across assets in the same country decreases during such episodes. It should be noted that the general level of correlation is relatively modest over the sample period, with maximum levels of around 0.45 occurring in Indonesia in 2006-2007. However, the considerable changes in stock-bond correlation over time, combined with the volatility spillover effects between the two asset classes in several of the countries included in this study indicate that there is an important relationship between stocks and bonds in Asia.

One way to interpret our results is that contagion brings with it a flight to quality in the sense that international investors see other countries as being of higher quality and that risk in different asset classes in the same Asian country is originated not primarily from asset risk but instead from country risk. One hypothesis that can be derived from this is that the issue of contagion versus flight to quality may differ due to the general level of market development or other country-specific factors. Future research that focuses on possible simultaneous transmissions between domestic and international financial markets shock is therefore needed. One recent contribution in this area is that of Ehrmann, Fratzscher, and Rigobon (2005). They look at transmission effects among money, bond and equity markets within and between the U.S. and the Euro area. However, the results in this paper indicate that movements in Asian markets seem to differ from those in the European markets. One area for future research is thus to try to understand possible transmission effects and take domestic transmission as well as transmissions across markets that are in different stages of development into account. Such a framework may increase our understanding of the movements in asset classes such as stocks and bonds in domestic and international markets as well as the general behavior of international investors.

5 Conclusions

There are different theories for how stock and bond markets should relate to each other. However, there are still relatively few studies that actually look at regional set of countries, and especially so when it comes to Asia. This paper has focused on the relationship between stock and bond markets in nine Asian countries. It is, to our, knowledge, the first study that addresses how the two asset classes are related to each other in this set of countries. We use a bivariate stochastic volatility model that allows for spillover effects in volatility and a time-varying correlation structure between the two asset classes. Our findings show that there are significant volatility spillover effects in most of the nine countries. This means that the volatility processes in the two asset classes are linked to each other. Furthermore, the dynamic correlation series shows that the stock-bond correlation in the nine Asian countries varies considerably over time. For the sample used in this paper, correlation is mostly positive. However, it also reaches negative levels in three of the nine countries.

The different results in this study have important implications for international investors as well as policy makers. The finding that the nine emerging markets exhibit significant volatility spillover effects has an effect on investors who use a mean-variance framework in their portfolio strategy. Furthermore, the dynamic correlation patterns indicate that correlation vary considerably over time, something that again affects portfolio allocation. Several of the countries exhibit both high and low correlation levels between the two asset classes during different periods. This result, combined with the volatility patterns and the fact that bond volatility can be significant during times of turmoil, has a significant impact on the risk-return behavior of investment portfolios that combine different asset classes. The correlation between stocks and bonds seems to increase during periods of turmoil in several of the markets, indicating a contagion effect that transmits across assets in some Asian countries. If there is a flight to quality effect, it seems to be in the form of capital moving away from a certain country rather than into a relatively safer asset in the same country. However, this study has not focused on international cross-asset relationships in Asia and thus leaves that topic for future research.

Besides direct effects on international investors and their portfolio management, the results also have an impact on policy makers in these countries. The time-varying relationship between the domestic stock and bond markets affects how governments can build up diverse domestic financial markets and their ability to issue debt. If the domestic debt market is directly related to that of the domestic equity market, it will affect the pricing of sovereign and quasi-sovereign bonds. This will thus influence the ability to conduct fiscal policy and the general welfare of the country. Possible future topics related to this study include a more detailed analysis of different macroeconomic variables and their potential influence on the correlation structure of stocks and bonds. For instance, the present value approach clearly tells us that the stock-bond correlation structure is directly dependent on inflation. Also, there is room for future research that compares pattern of contagion and flight to quality in countries with different level of economic and market development. There is a possibility that contagion and flight to quality may be dependent on the general level of market development in a country. Or, the existence of cross-asset contagion and flight to quality may be a result of the severeness of the general market situation, with extreme financial crises resulting in an overall capital flight from all domestic assets. A better framework for analyzing the simultaneous transmission between domestic and international financial market shocks is thus needed.

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Table 1. Descriptive Statistics for Weekly Returns

	China	**Hong Kong**	**Indonesia**	**Korea**	**Malaysia**	**Philippines**	**Singapore**	**Taiwan**	**Thailand**
Stock Markets									
Mean	0.115	0.023	0.288	0.035	-0.041	-0.048	-0.001	-0.023	-0.170
Median	0.007	0.176	0.746	0.296	0.352	0.109	0.081	0.189	-0.026
Maximum	13.945	13.917	11.587	17.436	6.653	16.185	13.678	18.318	21.838
Minimum	-14.898	-19.921	-23.297	-22.929	-9.712	-21.985	-16.883	-14.292	-26.661
Std. Dev.	3.504	3.641	3.622	4.676	2.622	3.700	2.919	3.596	4.094
Skewness	0.008	-0.468	-1.381	-0.415	-0.997	-0.506	-0.400	-0.136	-0.157
Kurtosis	5.082	6.090	9.320	6.122	5.044	8.077	6.439	5.158	7.037
JB	112.936	339.584	671.950	294.798	44.182	757.187	406.102	133.691	534.147
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Bond Markets									
Mean	0.073	0.084	0.224	0.139	0.063	0.218	0.052	0.072	0.139
Median	0.052	0.084	0.200	0.091	0.051	0.181	0.048	0.075	0.103
Maximum	1.467	1.379	9.282	5.693	2.112	4.510	1.130	1.143	7.139
Minimum	-1.450	-1.248	-5.497	-2.919	-1.576	-4.122	-1.342	-2.065	-3.813
Std. Dev.	0.236	0.121	0.802	0.469	0.274	0.591	0.092	0.208	0.492
Skewness	0.515	0.378	3.574	4.400	1.721	0.501	-2.251	-1.282	4.216
Kurtosis	12.226	54.543	69.384	54.168	34.959	21.758	97.116	22.757	72.054
JB	2244.316	86583.320	62967.910	76149.990	5596.533	9968.095	289277.900	11212.250	157687.300
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	625	782	339	678	130	678	782	678	782

Note: The table presents preliminary summary statistics for weekly log returns for the stock and bond markets in each of the nine countries. JB is the Jarque-Bera statistic for normality and p-values for the test are given in parentheses.

Table 2. Geweke Z-Score Test Results

	China	Hong Kong	Indonesia	Korea	Malaysia	Philippines	Singapore	Taiwan	Thailand
γ_{10}	0.966	-1.764	1.185	-0.849	-1.191	0.121	0.445	0.439	0.593
γ_{20}	-0.504	-1.352	0.653	-1.132	2.250	-0.405	0.459	1.849	0.194
γ_{11}	1.202	-0.373	0.023	-0.295	0.562	-0.278	-0.182	-0.094	0.180
γ_{12}	-1.497	0.099	-0.202	0.362	-1.195	0.508	0.415	0.401	0.286
γ_{21}	0.864	-2.087	1.203	0.096	-2.728	0.019	-1.515	0.829	1.763
γ_{22}	0.239	1.696	-1.082	-0.108	1.536	0.211	2.221	-0.914	-1.895
δ_0	-1.841	1.388	-1.081	1.835	-0.120	-0.027	3.253	0.221	1.791
δ_1	-3.021	-1.313	0.177	-0.910	2.294	0.227	0.605	0.606	-0.649
σ_ρ	0.592	-2.868	0.564	0.437	0.267	-1.098	-0.817	0.708	1.054
$\sigma_{\eta 1}$	-0.889	0.900	-0.977	0.139	-0.788	-1.310	0.493	0.458	-0.755
$\sigma_{\eta 2}$	-0.119	0.141	0.818	-0.462	1.505	1.062	-2.314	0.123	1.738

Note: Geweke Z-score test statistics for each model parameter.

Table 3. Posterior Quantities for Model Parameters

	China				Hong Kong				Indonesia			
	Mean	**Std. Dev.**	**2.50%**	**97.50%**	**Mean**	**Std. Dev.**	**2.50%**	**97.50%**	**Mean**	**Std. Dev.**	**2.50%**	**97.50%**
γ_{10}	2.251	0.233	1.802	2.738	2.673	0.290	2.190	3.339	2.327	0.168	2.017	2.686
γ_{20}	-3.786	0.477	-4.708	-2.801	-4.764	0.445	-5.613	-3.851	-2.151	0.391	-2.845	-1.261
γ_{11}	0.952	0.024	0.896	0.988	0.981	0.010	0.957	0.996	0.870	0.094	0.635	0.988
γ_{12}	0.002	0.007	-0.012	0.017	0.008	0.005	0.000	0.018	0.005	0.038	-0.054	0.099
γ_{21}	0.019	0.025	-0.030	0.069	0.000	0.010	-0.020	0.022	0.441	0.145	0.225	0.793
γ_{22}	0.975	0.010	0.952	0.992	0.992	0.005	0.981	0.999	0.833	0.068	0.671	0.939
δ_0	0.090	0.093	-0.078	0.269	0.282	0.125	-0.015	0.484	0.807	0.218	0.386	1.097
δ_1	0.837	0.106	0.568	0.976	0.904	0.085	0.668	0.990	0.844	0.107	0.577	0.987
σ_ρ	0.101	0.030	0.059	0.179	0.105	0.036	0.061	0.188	0.105	0.036	0.059	0.199
$\sigma_{\eta 1}$	0.230	0.055	0.135	0.349	0.124	0.025	0.084	0.180	0.300	0.085	0.170	0.499
$\sigma_{\eta 2}$	0.345	0.045	0.265	0.438	0.177	0.023	0.135	0.225	0.123	0.046	0.064	0.242
	Korea				**Malaysia**				**Philippines**			
	Mean	**Std. Dev.**	**2.50%**	**97.50%**	**Mean**	**Std. Dev.**	**2.50%**	**97.50%**	**Mean**	**Std. Dev.**	**2.50%**	**97.50%**
γ_{10}	2.215	0.250	1.705	2.689	1.292	0.748	-0.517	2.103	2.284	0.193	1.891	2.655
γ_{20}	-4.328	0.558	-5.464	-3.260	-3.462	0.519	-4.282	-2.260	-2.178	0.424	-3.036	-1.349
γ_{11}	0.840	0.102	0.584	0.964	0.885	0.104	0.616	0.993	0.817	0.095	0.594	0.959
γ_{12}	0.063	0.041	0.011	0.169	-0.040	0.041	-0.128	0.036	0.058	0.038	0.001	0.148
γ_{21}	0.130	0.092	0.016	0.388	0.503	0.720	-0.072	2.571	0.333	0.305	0.022	1.026
γ_{22}	0.938	0.039	0.831	0.987	0.897	0.087	0.655	0.991	0.848	0.125	0.555	0.976
δ_0	0.080	0.094	-0.112	0.256	0.503	0.308	-0.014	1.244	0.433	0.099	0.241	0.614
δ_1	0.850	0.105	0.580	0.979	0.892	0.099	0.625	0.993	0.846	0.096	0.600	0.970
σ_ρ	0.111	0.039	0.061	0.214	0.123	0.047	0.065	0.245	0.107	0.030	0.064	0.179
$\sigma_{\eta 1}$	0.261	0.077	0.139	0.438	0.239	0.126	0.079	0.527	0.281	0.081	0.149	0.462
$\sigma_{\eta 2}$	0.237	0.044	0.122	0.316	0.326	0.215	0.071	0.792	0.248	0.095	0.073	0.393
	Singapore				**Taiwan**				**Thailand**			
	Mean	**Std. Dev.**	**2.50%**	**97.50%**	**Mean**	**Std. Dev.**	**2.50%**	**97.50%**	**Mean**	**Std. Dev.**	**2.50%**	**97.50%**
γ_{10}	1.726	0.297	1.023	2.241	2.339	0.264	1.828	2.887	2.615	0.245	2.162	3.134
γ_{20}	-5.372	0.419	-6.146	-4.478	-3.663	0.299	-4.256	-3.061	-3.289	0.512	-4.307	-2.280
γ_{11}	0.963	0.020	0.914	0.994	0.957	0.018	0.913	0.985	0.968	0.016	0.929	0.992
γ_{12}	0.009	0.008	-0.005	0.027	0.024	0.013	0.002	0.053	0.008	0.006	-0.001	0.021
γ_{21}	0.004	0.013	-0.020	0.031	0.028	0.026	-0.018	0.086	0.045	0.031	-0.010	0.113
γ_{22}	0.986	0.007	0.970	0.997	0.941	0.024	0.886	0.980	0.964	0.014	0.934	0.987
δ_0	0.136	0.174	-0.287	0.429	0.317	0.100	0.130	0.509	0.251	0.085	0.074	0.405
δ_1	0.952	0.041	0.841	0.994	0.850	0.087	0.633	0.962	0.825	0.106	0.563	0.966
σ_ρ	0.116	0.039	0.063	0.219	0.140	0.060	0.065	0.297	0.110	0.036	0.063	0.206
$\sigma_{\eta 1}$	0.216	0.055	0.126	0.337	0.197	0.041	0.128	0.289	0.159	0.037	0.103	0.247
$\sigma_{\eta 2}$	0.213	0.027	0.165	0.270	0.333	0.053	0.242	0.450	0.396	0.045	0.313	0.489

Note: The table presents results for the bivariate stochastic volatility model with dynamic correlation and volatility spillover effects. Mean, standard deviation, and 95% credible intervals of the posterior distributions are showed for each parameter.

Figure 1. Stock Market Returns

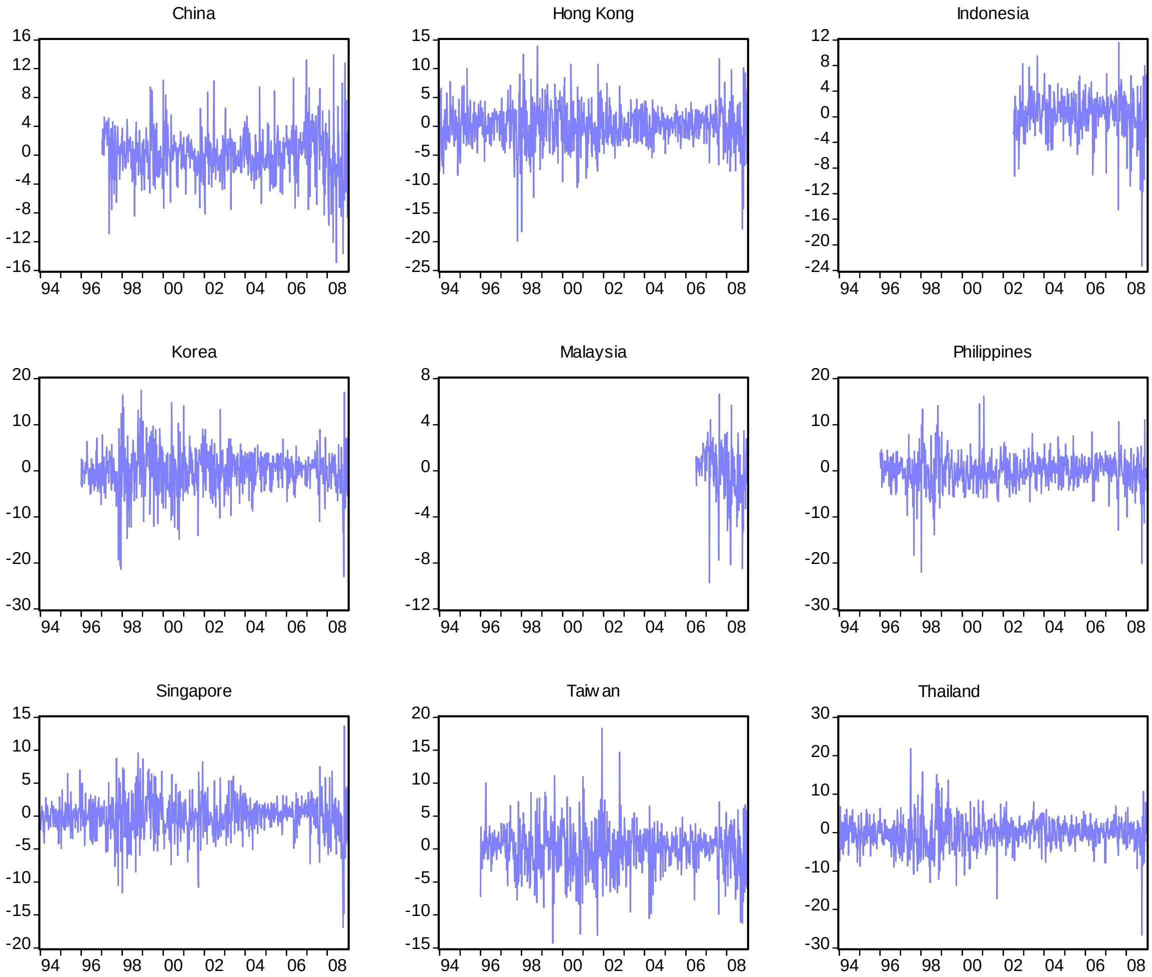

Figure 2. Bond Market Returns

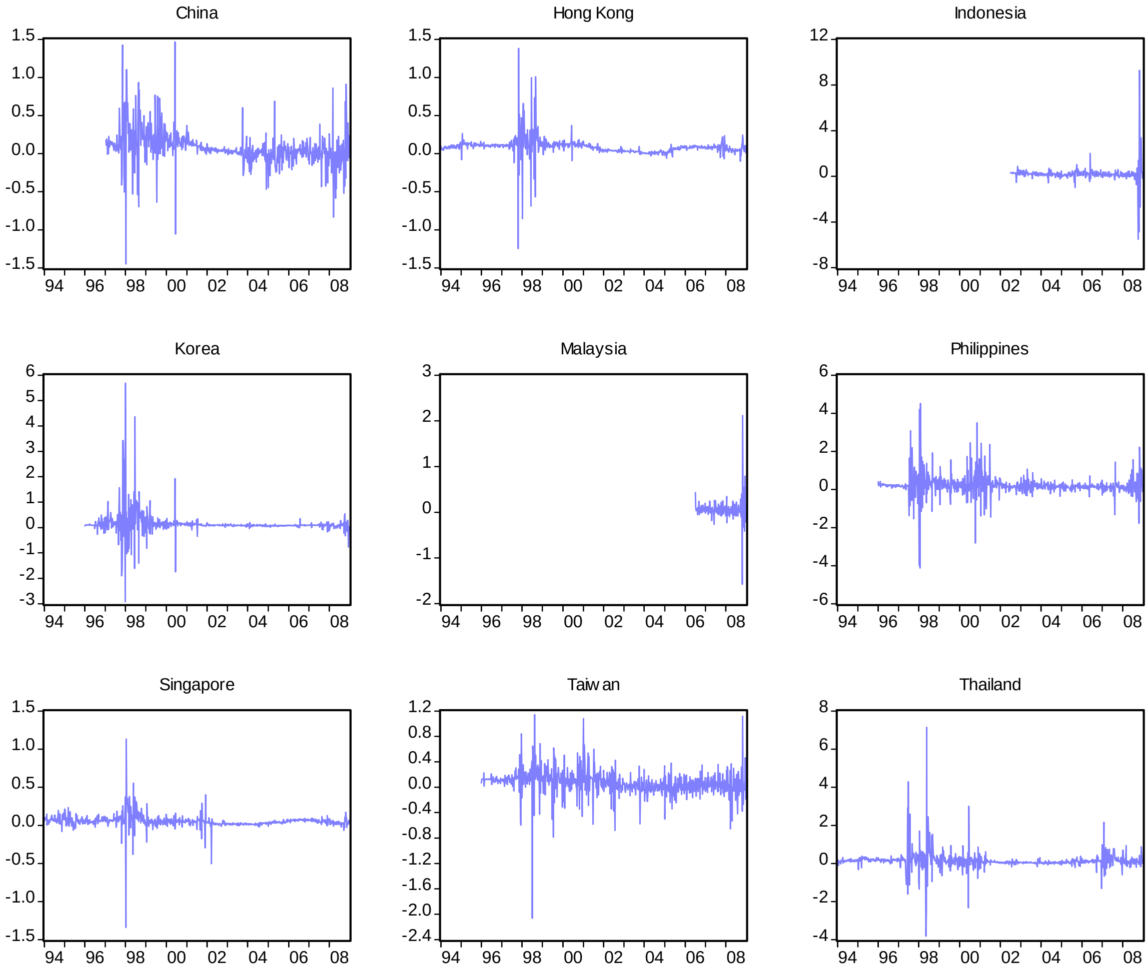

Figure 3. Trace Plots for Selected Model Parameters – Indonesia

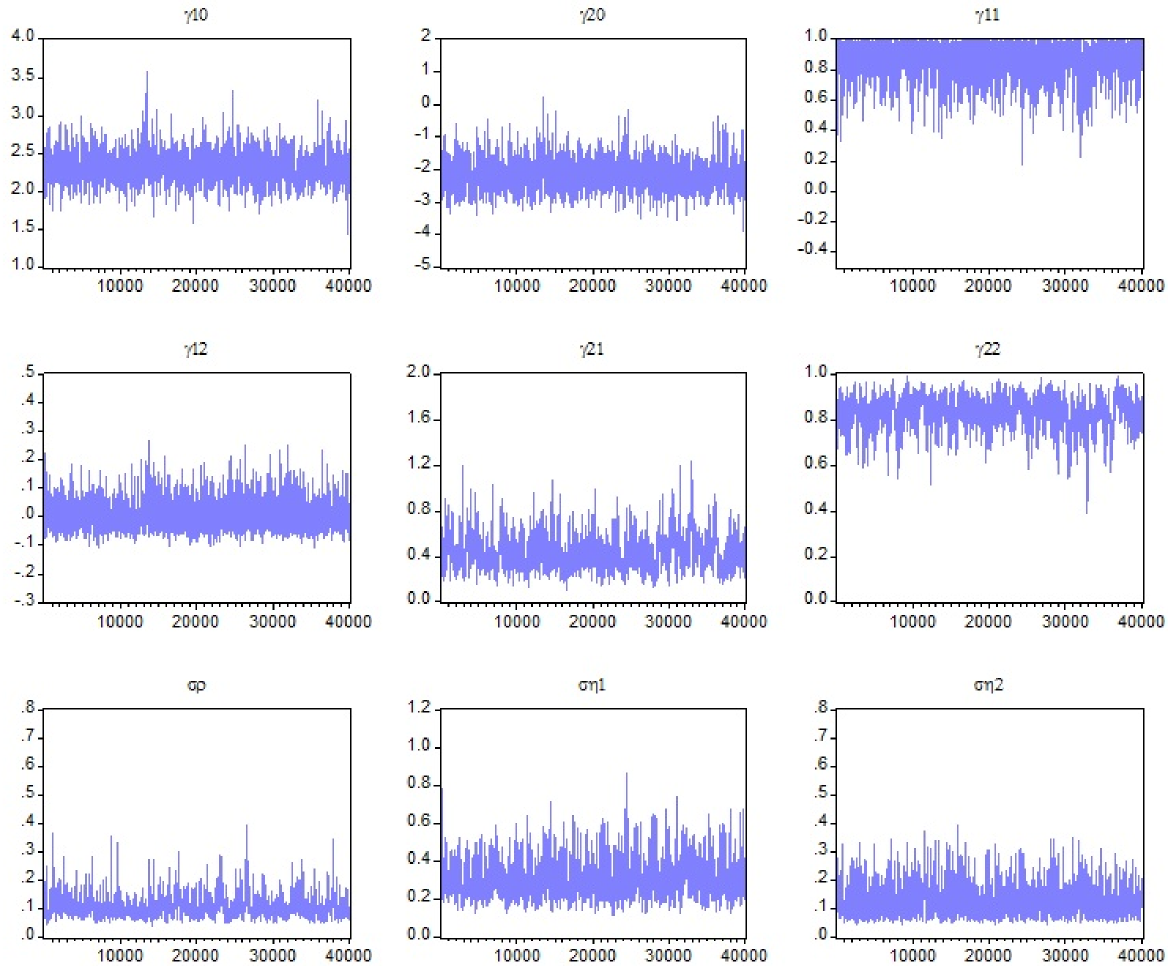

Figure 4. Stock Market Volatility

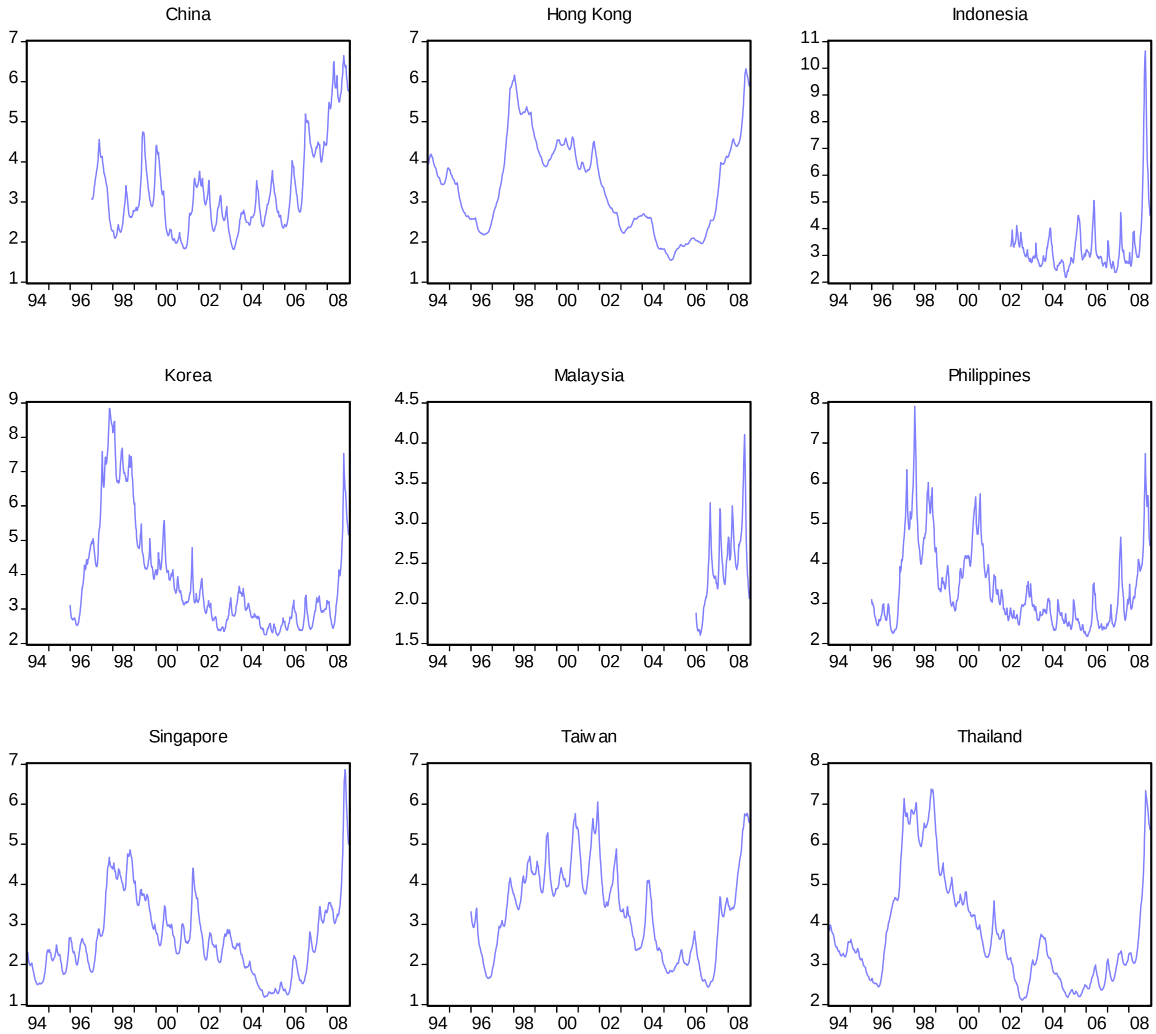

Figure 5. Bond Market Volatility

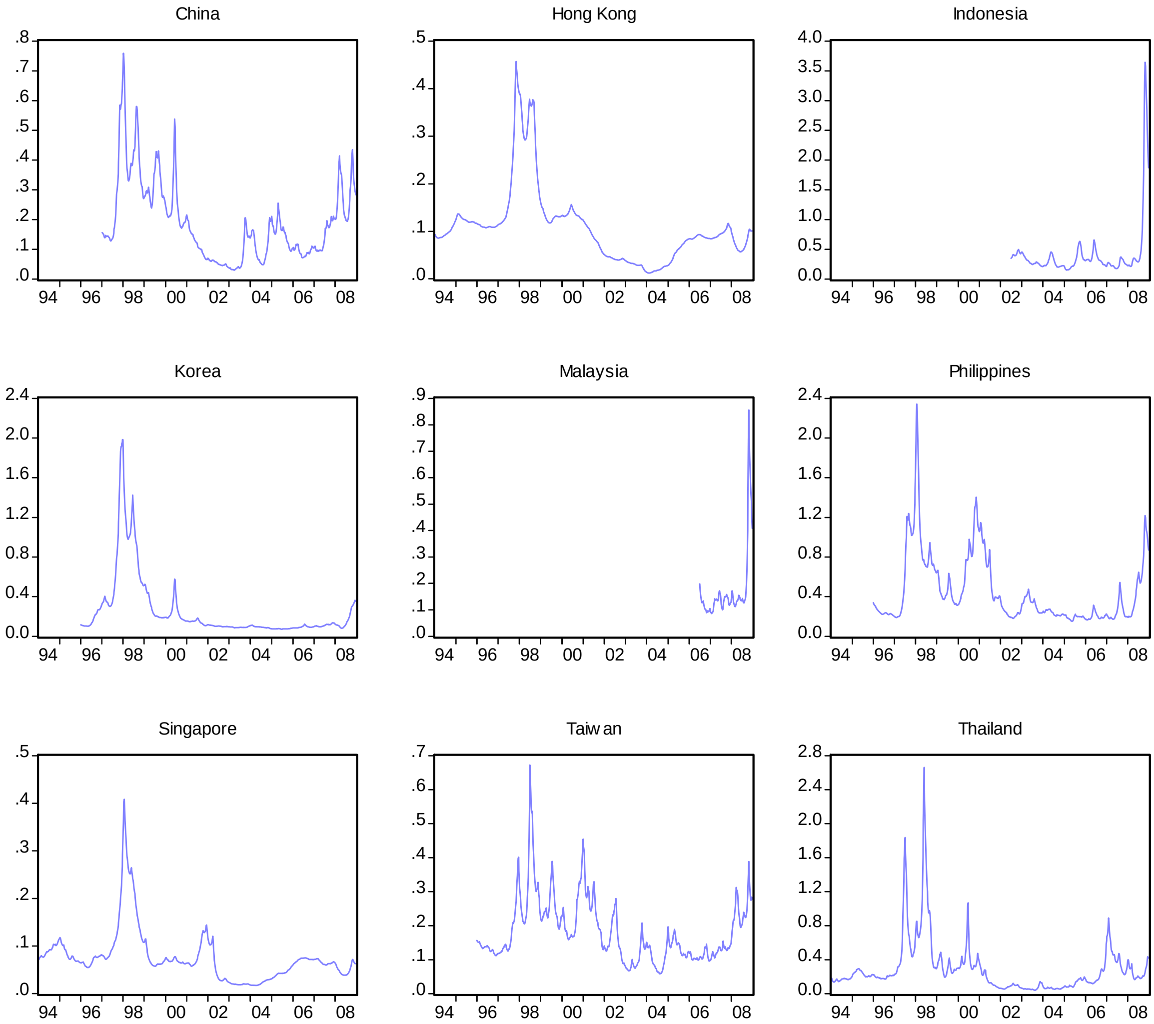

Figure 6. Stock-Bond Market Correlation