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INTERDEPENDENCE OF INTERNATIONAL STOCK MARKETS, EUROPEAN GOVERNMENT BOND MARKET AND GOLD MARKET

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ABSTRACT

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This thesis examines the interdependence of international stock markets (the USA, Europe, Japan, emerging markets, and frontier markets), European government bond market, and gold market during the 21st century. Special focus is on the dynamics of the correlations between the markets, as well as on, spillovers in mean returns and volatility. The mean return spillovers are examined on the basis of the bivariate VAR(1) model, whereas the bivariate BEKK-GARCH(1, 1) model is employed for the analysis of the volatility spillovers. In order to analyze the spillover effects in different market conditions, the full sample period from 2000 to 2013 is divided into the pre-crisis period (2000–2006) and the crisis period (2007–2013). The results indicate an increasing interdependence especially within international stock markets during the periods of financial turbulence, and are thus consistent with the existing literature. Hence, bond and gold markets provide the best diversification benefits for equity investors, particularly during the periods of market turmoil.

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Tutkielma tarkastelee kansainvälisten osakemarkkinoiden (Yhdysvallat, Eurooppa, Japani, kehittyvät markkinat sekä reuna-aluemarkkinat), eurooppalaisten valtionlainamarkkinoiden ja kultamarkkinoiden keskinäisriippuvuuksia 2000-luvulla. Tutkielmassa analysoidaan erityisesti tuottokorrelaatioiden vaihtelua sekä tuottojen ja volatiliteetin siirtymistä (ts. ns. spillover-ilmiöitä) edellä mainittujen markkinoiden välillä. Tuottojen siirtymistä tutkitaan kaksimuuttujaisella VAR(1) –mallilla, kun taas volatiliteetin siirtymisen analysoinnissa käytetään kaksimuuttujaista BEKK-GARCH(1, 1) –mallia. Tuottojen ja volatiliteetin siirtymistä erilaisissa markkinaolosuhteissa tutkittaessa koko tarkasteluperiodi, joka sisältää vuodet 2000–2013, jaetaan kriisiä edeltävään periodiin (2000–2006) sekä kriisin aikaiseen periodiin (2007–2013). Tulokset osoittavat keskinäisriippuvuuksien voimistuvan erityisesti kansainvälisten osakemarkkinoiden välillä epävarmoina aikoina ja ovat siten samansuuntaisia aiempien, samoista ilmiöistä raportoitujen tutkimustulosten kanssa. Valtionlainamarkkinat ja kultamarkkinat tarjoavat

näin ollen parhaat hajautushyödyt osakesijoittajille etenkin markkinaturbulensseissa.

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1 INTRODUCTION

1.1 Background and motivation

International diversification benefits seem to recede since more and more markets have become increasingly integrated with the world economy. Moreover, international capital markets, especially stock markets, tend to have increased co-movements during periods of financial turbulence despite the fact that macroeconomic fundamentals would not indicate strong interdependence. The ongoing economic crisis has witnessed that markets geographically distributed across the world cannot escape the financial contagion. As a result, diversification benefits will decrease when they are needed most.

The asset allocation is a fundamental question for portfolio managers, risk analysts and financial researchers in constructing optimal portfolios. The early studies in the late 1960s and the early 1970s marked the beginning of an extensive literature that advocates internationally diversified portfolios on the basis of the low correlation among national stock markets (see e.g. Grubel 1968; Levy and Sarnat 1970; Grubel and Fadner 1971; Agmon 1972; Lessard 1973; Solnik 1974). In addition, financial researchers have paid special attention to the linkages between the markets in terms of mean return spillovers and volatility spillovers since the 1990s (see eg. Hamao, Masulis and Ng (1990); King and Wadhwani (1990); Theodossiou and Lee (1993); Lin, Engle and Ito (1994)).

Meanwhile, many developing markets[1] have liberalized their capital markets as a part of a major reform effort resulting in an increased investment opportunity set for international investors. Despite the high returns and favorable diversification opportunities of developing markets,

[1] Developing markets are defined to consist of emerging markets and frontier markets throughout this thesis.

the research has tended to focus on developed markets. Although many researchers have contributed to literature on the interrelationship between developed and developing markets attracted by the U.S. subprime mortgage crisis and Asian financial crisis in 1997, this strand of the literature is still insufficient (see e.g. Lee (2012); Caporale, Pittis and Spagnolo (2006)). Moreover, the literature on the relationship between developing markets is limited.

The bankruptcy of Lehman Brothers, for example, showed a need for a safe haven asset that holds its value during periods of market turmoil and increases diversification benefits when other markets fall jointly. Bonds and gold are generally considered as safe haven assets but the empirical research on their efficiency for such purpose is still insufficient. Despite the importance of cross-asset relationship between stocks and bonds in asset allocation, there is no consensus among financial researchers on the peculiarities of the stock-bond co-movements (see e.g. Kwan (1996); Baur and Lucey (2009)). Moreover, the empirical research focusing on stock-gold relationship is relatively scarce.

Since the international diversification benefits within stock markets seem to decrease with globalization, there is a motivation to examine the interdependence of different asset classes. Exploiting low correlations between different asset classes in global capital markets is the primary objective of international diversification. Hence, the dynamics of international stock markets, bond markets and gold market are important to examine further. It is particularly important for portfolio managers to know if there are safe haven assets that increase diversification benefits during extreme markets conditions. Due to the limited literature on the relationship between developed and developing markets, and especially between different developing regional markets, further research is needed on these topics.

1.2 Objectives and research questions

The objective of this thesis is to analyze the interdependence of international stock markets (the USA, Europe, Japan, emerging markets, and frontier markets), European government bond market, and gold market during the 21th century. The main objective is to examine the markets from the perspective of diversification benefits. Special attention is paid to the dynamics in the correlations between the markets, as well as, mean return spillovers and volatility spillovers in different markets conditions. Therefore, the dataset is divided into two sub-samples. The pre-crisis period from 2000 to 2006 reflects a moderate era in the world economy, whereas the crisis period from 2007 to 2013 captures the influence of global recession. In this thesis, the crisis period covers the liquidity shortfall in the U.S. banking system in 2007 contributing to the global recession and the European sovereign debt crisis, whose final consequences are still unclear. All the analyses are also employed for the full sample.

The research questions are as follows:

Q1: Is there mean return linkages and/or volatility linkages between international stock markets, European government bond market and gold market?

Q2: Are the linkages between the markets magnified during the crisis period?

Q3: Is the correlation between the markets time-varying?

Q4: Are there significant diversification benefits available for international investors despite the accelerating economic and financial integration?

Q5: Do bonds and/or gold reflect properties of safe haven asset during the crisis period?

1.3 Structure

This thesis is structured as follows: The theoretical background with asset pricing theories, GARCH models and previous studies is introduced in the second section. The data and methodology are discussed in section 3. Empirical results are introduced in section 4, while the fifth section concludes the thesis.

2 THEORETICAL BACKGROUND

2.1 Asset Pricing Theory

Absolute pricing approach is a commonly used method by academics in asset pricing. The idea of absolute pricing is that the risk level and the future profits determine the price of each asset. The Capital Asset Pricing Model (CAPM) independently introduced by Sharpe (1964), Lintner (1965) and Mossin (1966) represents this approach.

The classic CAPM suggests that the expected equity returns are a function of a country-specific local risk assuming that stock markets are fully segmented. On the other hand, if international stock markets are assumed to be completely integrated, there is a motivation to apply international version of CAPM (ICAPM), where the global market risk is the only source of systematic risk. In this case, investors diversify away country-specific sources of risk. Adler and Dumas (1983) showed that the global value-weighted market portfolio is a relevant risk factor reflecting world market risk.

However, prior literature suggests that many small developed markets and emerging markets indicate partial segmentation rather than full integration or segmentation (see e.g. Bekaert and Harvey 1995; Carrieri, Errunza and Majerbi 2006). Therefore, the partially integrated ICAPM by Errunza and Losq (1985) is applied. Assuming that investors do not hedge against exchange rate risks and a risk-free asset exists, the conditional version of the ICAPM can be stated as follows:

(1)
$$E\left(r_{i,t+1}\middle|\Omega_t\right) = \lambda_{m,t+1}^{w} Cov\left(r_{i,t+1}, r_{m,t+1}^{w}\middle|\Omega_t\right) + \lambda_{m,t+1}^{l} Cov\left(r_{i,t+1}, r_{m,t+1}^{l}\middle|\Omega_t\right),$$

where Ω_t is the information set at time t, $E\left(r_{i,t+1}|\Omega_t\right)$ is conditional expected excess return on asset i, $\lambda_{m,t+1}^{w}$ is the conditional price of world market risk and $\lambda_{m,t+1}^{l}$ is the conditional price of the local market risk.

2.2 GARCH models

2.2.1 Motivation for using GARCH models

Financial time series have a number of features which cannot be captured by traditional econometric models. First, financial asset returns often exhibit leptokurtosis. This refers to the tendency for returns to have distributions with fat tails and excess peakedness. Therefore, the assumption of homoscedasticity in the Classical Linear Regression Model (CLRM) is violated and the least squares estimator is no longer the Best Linear Unbiased Estimator (BLUE). Most importantly, the standard error estimates computed for the least squares estimator could be misleading since the financial data is unlikely to have constant variance of errors. (Hill, Griffiths and Judge 2001, 238; Brooks 2008, 380, 386)

Second, volatility tends to appear in bunches, as first noted by Mandelbrot (1963). This phenomenon is known as volatility clustering or volatility pooling. More specifically, large changes in asset prices (of either sign) are followed by large changes, and small changes (of either sign) are followed by small changes. This phenomenon can be explained by the information arrivals which themselves are intermittently spaced over time. (Brooks 2008, 380)

Third, volatility seems to be affected more dramatically by a large price fall than a price rise of the same magnitude. This phenomenon refers to asymmetric effect of return shocks and it was first noted by Black (1976).

According to Black (1976), a price drop in the firm's stock increases leverage of the company and leads the stockholders to consider their future cashflows riskier. This is known as leverage effect. However, he recognized the incompleteness of the argument and the shortcomings of leverage effect have received empirical support subsequently (see e.g. Christie 1982; Schwert 1989; Bekaert and Wu 2000). In addition, the leverage effect cannot be applied to bond markets. An alternative solution is provided by the volatility feedback approach. According to this interpretation, an unexpected increase in volatility should raise the required return on equity, leading to a decline in stock price (see e.g. Campbell and Hentschel 1992; Bekaert and Wu 2000). Although the earlier studies have been primarily implemented with stock market data, the same approach is also applicable to bond markets (see Cappiello 2000). Another explanation is known as following-the-herd effect. This refers to the tendency for investors to sell their securities on the basis of other investors' behavior rather than the fundamentals during an economic turmoil. For example, Veronesi (1999) noted that stock prices overreact to bad news in good times, and conversely, underreact to good news in bad times.

Generalized Conditional Autoregressive Heteroscedasticity (GARCH) models can capture a number of features associated with financial time series. In next sections, univariate and multivariate GARCH models are introduced with some most commonly used extensions.

2.2.2 Univariate GARCH models

The conditional mean equation for univariate time series y_t can be specified as follows:

(2)
$$y_t = E\{y_t|\Omega_{t-1}\} + \varepsilon_t,$$
$$\varepsilon_t = z_t\sigma_t \qquad z_t \sim N(0,1),$$

where Ω_{t-1} is the information set at time $t-1$, ε_t is the error term, z_t is a sequence of normally distributed random variables with zero mean and unit variance, and σ_t is a time-varying function of the information set. (Tsay 2005, 100)

The Autoregressive Conditional Heteroscedasticity (ARCH) process proposed by Engle (1982) was the first model that provides volatility modeling systematically. The idea of the ARCH model is that the variance of the error term depends on the previous values of the squared errors. The variance is called conditional since it is a one-period ahead estimate based on past information. In this general case, the model is known as an ARCH(*q*) model where the conditional variance depends on *q* lags of squared errors. The model can be written as:

(3)
$$\varepsilon_t = z_t\sigma_t \qquad z_t \sim N(0,1),$$
$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i\, \varepsilon_{t-i}^2,$$

where ε_t is the error term, z_t is a sequence of normally distributed random variables with zero mean and unit variance, σ_t^2 is the estimate of the conditional variance, α_0 is the constant term, and α_i is the ARCH term. A standard normal or standardized Student-*t* distribution or a Generalized Error Distribution (GED) can also be employed for z_t. The coefficients must satisfy conditions for non-negativity to ensure that the conditional variance is positive. The non-negativity constraints are $\alpha_0 > 0$ and $\alpha_i \geq 0$ for $i > 0$. By definition, the squared errors cannot be negative. (Brooks 2008, 388–289; Tsay 2005, 102–103)

Although the ARCH model provides an applicable framework to model volatility, it has some undesirable properties. For example, the model often requires so many parameters to be estimated that the model would not be parsimonious and the violation of non-negativity constraints would be more likely. Instead, the generalized ARCH (GARCH) model by Bollerslev (1986) partially overcomes these problems and has been widely employed in volatility modeling since its introduction. The extension to the ARCH model is that it incorporates the previous own lags into the conditional variance. The general case of the model is known as GARCH(*p, q*) where the conditional variance depends on *q* lags of the squared error and *p* lags of the conditional variance. The model can be written as:

(4)
$$\varepsilon_t = z_t \sigma_t \qquad z_t \sim N(0,1),$$
$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \, \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j \, \sigma_{t-j}^2,$$

where α_0 is the constant term, α_i is the ARCH term, and β_j is the GARCH term. In this case, the non-negativity constraints are $\alpha_0 > 0$, $\alpha_i \geq 0$, $\beta_j \geq 0$. In addition, $\sum_{i=1}^{\max(p,q)}(\alpha_i + \beta_i) < 1$ is required for model to be stationary. A problem caused by violation of the former constraint can be illustrated with unconditional variance of ε_t:

(5)
$$var(\varepsilon_t) = \frac{\alpha_0}{1 - \sum_{i=1}^{\max(p,q)}(\alpha_i + \beta_i)}$$

The equation is not defined unless the denominator is positive. $\sum_{i=1}^{\max(p,q)}(\alpha_i + \beta_i) > 1$ is known as non-stationarity in variance and it has no strong theoretical argument to exist. For example, non-stationary GARCH models do not demonstrate conditional variance forecasts to converge upon the long-term average value of the variance unlike stationary GARCH models.

In general, a GARCH (1, 1) adequately captures the volatility clustering and higher order models are rarely employed in practice. (Brooks 2008, 391–394; Tsay 2005, 114)

A standard GARCH model has been extended in various ways as a consequence of its inadequacy. First, artificial constraints must be placed on the coefficients in order to ensure the non-negativity conditions of the model. Second, asymmetric effects cannot be captured by a standard GARCH model. Finally, a basic GARCH model is incapable to consider direct iterations between the conditional variance and the conditional mean. Next we introduce commonly used models that overcome some of these problems. (Brooks 2008, 404)

A model that allows asymmetric effects, more specifically leverage effects, to affect the errors is the threshold GARCH (TGARCH) model. Here we introduce the GRJ model named after Glosten, Jagannathan and Runkle (1993) where the leverage effect is captured by a dummy variable (see also Zakoian 1994). The GRJ model is defined as:

(6)
$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} (\alpha_i + \gamma_i N_{t-i})\, \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j\, \sigma_{t-j}^2,$$

where N_{t-i} is a dummy variable following

(7)
$$N_{t-i} = \begin{cases} 1 \; if \; \varepsilon_{t-i} < 0, \\ 0 \; if \; \varepsilon_{t-i} \geq 0. \end{cases}$$

The conditions for non-negativity for the constant, the ARCH term and the GARCH term are similar to those of the standard GARCH model. As an additional constraint, $\alpha_i + \gamma_i \geq 0$ must be satisfied. That is, the model is acceptable although $\gamma_i < 0$ but the leverage effect occurs provided that $\gamma_i > 0$. More precisely, a larger impact is caused by a negative u_{t-i}^2 value ($(\alpha_i + \gamma_i)u_{t-i}^2$) than a positive u_{t-i}^2 value ($\alpha_i u_{t-i}^2$). The threshold of the model is considered to be zero but also other values can be applied. (Brooks 2008, 405; Tsay 2005, 130)

Most financial models assume that the return of a security depends on its risk. As a result, the investors should obtain higher returns when taking additional risk. Engle, Lilien and Robins (1987) captured this phenomenon in their ARCH-in-mean (ARCH-M) model which allows the conditional variance to enter into the conditional mean equation. Since the generalization of the ARCH model, the GARCH-M model has been more commonly employed. A GARCH(1, 1)-M model can be written as:

(8)
$$y_t = \mu + \delta\sigma_t^2 + \varepsilon_t, \qquad \varepsilon_t = z_t\sigma_t,$$
$$\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-i}^2 + \beta_1\sigma_{t-1}^2,$$

where μ is the conditional mean and δ is the risk premium parameter and they both are constants. A positive δ displays an increased mean return generated by a rise in the conditional variance. Other specifications of risk premium can also be applied by creating variable transformations, resulting the use of $\delta\sigma_t$ or $\delta\ln(\sigma_t^2)$ instead of $\delta\sigma_t^2$, for example. In addition, a lagged conditional variance rather than contemporaneous can also be observed in empirical applications. (Brooks 2008, 410; Tsay 2005, 100, 123)

2.2.3 Multivariate GARCH models

Multivariate GARCH (MGARCH) models are multivariate extensions to their univariate counterparts. However, where the univariate settings consider only the conditional variances, MGARCH models also specify equations for time-varying covariances. Therefore, these models are employed to study the volatility linkages between several assets or markets.

However, there are two major drawbacks with the MGARCH models. The main problem is to ensure that a variance-covariance matrix is positive definite at each time period. Positive definiteness ensures that the variance-covariance matrix is symmetrical about its leading diagonal (the covariance between two series is the same irrespective of the order of operations) and the leading diagonal has only positive numbers (variance can never be negative). Another problem is that the number of parameters rises rapidly as the number of assets is increased. Therefore, the estimation of MGARCH models can cause computational complexities and it can become infeasible. (Brooks 2008, 434)

A multivariate representation of GARCH can be started as follows:

(9)
$$r_t = \mu_t + \varepsilon_t,$$
$$\varepsilon_t | \Omega_{t-1} \sim N(0, H_t),$$

where r_t is an $N \times 1$ vector of returns at time t, μ_t is a mean return, and ε_t is an $N \times 1$ vector of random errors at time t with its corresponding $N \times N$ conditional variance-covariance matrix H_t. The information set Ω_{t-1} captures all the information available at time $t - 1$.

The first extension to univariate GARCH was the VECH model by Bollerslev, Engle and Wooldridge (1988). The idea of the VECH model is that each element of the conditional variance-covariance matrix H_t is a linear function of the lagged squared innovations and cross-products of the innovations and lagged values of the elements of H_t itself. They specified the VECH-GARCH(p, q) model as follows:

(10)
$$VECH(H_t) = C + \sum_{i=1}^{q} A_i\, VECH(\varepsilon_{t-i}\varepsilon'_{t-i}) + \sum_{j=1}^{p} B_j\, VECH\big(H_{t-j}\big),$$

$$\varepsilon_t | \Omega_{t-1} \sim N(0, H_t),$$

where ε_t is an $N \times 1$ innovation vector, C is a $\frac{1}{2}N(N+1) \times 1$ parameter vector, A_i and B_j for $i, j > 0$ are $\frac{1}{2}N(N+1) \times \frac{1}{2}N(N+1)$ parameter matrices, and $VECH(\cdot)$ is the operator which stacks the lower triangular portion of the symmetric matrix into vector. Unfortunately, the VECH model has both of the drawbacks discussed above. First, the estimation of the model can quickly become infeasible as the number of assets is increased. Even in the simple bivariate case, the model requires twenty-one parameters to be estimated. Second, the condition of positive definiteness is not guaranteed without imposing nonlinear inequality restrictions on the variance-covariance matrix.

In order to restrict the number of parameters to be estimated, Bollerslev et al. (1988) proposed the diagonal VECH (DVECH) model. The idea is to simplify the VECH model by assuming that each element of h_{ijt} depends only on the previous value of $\varepsilon_{it}\varepsilon_{jt}$ and on its own lag. Hence, A_i and B_j are assumed to be diagonal. The DVECH model following GARCH (1, 1) process can be written as:

(11)
$$h_{ijt} = c_{ij} + A_{ij}\varepsilon_{it-1}\varepsilon_{jt-1} + \beta_{ij}h_{ijt-1},$$

where c_{ij}, A_{ij} and β_{ij} are parameters. The conditional variances and the conditional covariances at time t are represented by h_{ijt} provided that $i,j = 1,\ldots,N$ and $i \neq j$, respectively. However, the DVECH model may produce nonpositive definite matrix. Furthermore, the dynamic dependences between volatilities are precluded by the oversimplifying restrictions. (Bauwens, Laurent and Rombouts 2006)

To overcome the positive definiteness problem of the matrix, the BEKK model (named after Baba, Engle, Kraft, and Kroner) was proposed by Engle and Kroner (1995). The conditional variance-covariance matrix can be written as:

(12)
$$H_t = CC' + \sum_{i=1}^{q} A_i \, (\varepsilon_{t-i}\varepsilon'_{t-i}) A'_i + \sum_{j=1}^{p} B_j H_{t-j} \, B'_j,$$

where C is a lower triangular portion of the matrix and A_i and B_j are $N \times N$ matrices. Based on the quadratic nature of the model, H_t is guaranteed to be positive definite provided that CC' is positive definite. However, the model has some shortcomings. First, the model cannot allow for dynamic dependences between the volatilities without increasing the number of the parameters. Second, the parameters A_i and B_j do not represent directly the impact on the lagged values of volatilities or shocks. (Tsay 451–452; Bauwens et al. 2006)

Another direction of the multivariate GARCH models is based on the Constant Conditional Correlations (CCC) model proposed by Bollerslev (1990). The foundation of the models in this category is on the decomposition of the conditional variance-covariance matrix into the conditional standard deviations and conditional correlations. These models assure the positive definiteness of the conditional variance-covariance matrices and also the conditional correlation matrix.

As the name suggests, the correlations in the CCC model are assumed to be time invariant yet the idiosyncratic variances are time varying. The CCC-GARCH can be presented as follows:

(13) $$H_t = D_t R_t D_t, \qquad D_t = diag\{\sqrt{h_{it}}\},$$

where D_t is a $k \times k$ diagonal matrix of the conditional volatility of the returns on each asset and R_t is the $k \times k$ a conditional correlation matrix. (Engle 2002)

The constant correlation assumption has been questioned leading into the development of Dynamic Conditional Correlation (DCC) model by Engle (2002). The DCC model estimates the conditional variance covariance matrix in two stages. In the first stage, the conditional variance h_{it} is estimated for each asset with univariate GARCH model in order to standardize the innovations of the assets. In the second stage, the standardized innovations are used to estimate the time varying correlation matrix R_t with multivariate GARCH (p, q) process. The process can be presented as follows:

(14) $$R_t = (diagQ_t)^{-1/2} Q_t (diagQ_t)^{-1/2},$$

$$Q_t = (1 - \alpha - \beta)\bar{Q} + \alpha \varepsilon_{t-1} \varepsilon'_{t-1} + \beta Q_{t-1},$$
$$\varepsilon_{it} = r_{it} / \sqrt{h_{it}},$$

where $\bar{Q}$ is the $k \times k$ unconditional variance matrix of standardized residuals ε_{it}, and α and β are non-negative scalar parameters satisfying the condition $\alpha + \beta < 1$.

Although the DCC model captures the dynamics of conditional correlations, it does not incorporate asymmetric effects of return shocks. To consider the asymmetries in conditional variances, covariances and correlations, an asymmetric version of Dynamic Conditional Correlations (ADCC) model proposed by Cappiello, Engle and Sheppard (2006). The ADCC-GARCH can be written as:

(15)
$$Q_t = \left(\overline{Q} - A'\overline{Q}A - B'\overline{Q}B - G'\overline{N}G\right) + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + B'Q_{t-1}B + G'n_{t-1}n'_{t-1}G,$$

where A, B and G are diagonal parameter matrices, $n_t = I[\varepsilon_t < 0]\odot\varepsilon_t$ (with $\odot$ denoting the Hadamard product), and $\overline{N} = [n_t n'_t]$.

2.3 Previous studies

2.3.1 International diversification benefits

Sharpe (1963) introduced the well-known idea of segregating the total variation of a portfolio into two components: systematic variation and unsystematic variation. Systematic risk (market risk, undiversifiable risk) results from covariance of the returns of the individual securities, whereas unsystematic risk (diversifiable risk, company specific risk, residual risk) is caused by variance of individual securities themselves. The relationship between the number of securities in a portfolio and total variation of a portfolio behaves as a rapidly decreasing asymptotic function, where the reduction in portfolio risk is attributable to the sequential addition of securities to a portfolio. That is, the decrease in portfolio risk resulting from increased diversification is caused by reduction of unsystematic portion of the total risk. Moreover, the systematic risk is driven by the average covariance between all securities in the market. (Goetzmann, Li and Rouwenhorst 2005)

The primary goal of international diversification is to exploit low correlations between national stock markets. However, the accelerating economic and financial integration have led to elevated correlations among markets reducing benefits of international diversification (see e.g. Longin and Solnik 1995; Errunza, Hogan and Hung 1999; Bekaert and Harvey 2000; Brooks and Del Negro 2004; Goetzmann et al. 2005; Driessen and Laeven 2007; Kizys and Pierdzioch 2009; Baele and Inghelbrecht 2009). Moreover, the correlations between national equity markets are magnified during turbulent periods which further decrease diversification benefits (see e.g. King Sentana and Wadhwani 1994; Longin and Solnik 1995, 2001; De Santis and Gerard 1997; Chesnay and Jondeau 2001).

Although correlations among markets have increased with globalization, the investment opportunity set has expanded at the same time. Diversification benefits can be decomposed into two components: The first component is the correlation across markets, and the second component is the number of markets available to investors. The investment opportunity set has expanded dramatically over the past few decades since many emerging markets started to liberalize their capital markets in the late 1980s (Bekaert, Harvey and Lundblad 2003). As a result, the international diversification benefits are largely dependent on emerging markets and frontier markets since they offer the most favorable diversification opportunities to investors (see e.g. Speidell and Krohne 2007; Jayasuriya and Shambora 2009; Cheng, Jahan-Parvar and Rothman 2010; Berger, Pukthuanthong and Jimmy Yang 2011). (Goetzmann et al. 2005)

The equity market integration is a gradual process which often begins with regulatory changes. Capital market liberalization is usually part of a major reform effort that can be precisely dated. Many liberalization efforts in emerging markets are clustered in the late 1980s or early 1990s but occasional reversals have also occurred. However, it is crucial to differentiate the concepts of market integration and liberalization. There are two possibilities that regulatory liberalization efforts are not effective. First, foreign investors have had the access to the market through other means, such as country funds and depositary receipts[2], and the market have been integrated before official liberalization. Second, the liberalization may have only marginal effect or no effect because foreign investors may mistrust the local government to commit to the regulatory reform in the long term. (Bekaert et al. 2003; Carrieri, Errunza and Hogan 2007)

[2] A closed-end country fund invests in a portfolio of assets in a foreign country and issues a fixed number of shares domestically. Depositary receipts represent the ownership of foreign company's stock.

Moreover, there are a number of factors that may obscure the impact of the regulatory changes. First, the investment restrictions may have not been binding before the liberalization. Second, liberalizations can be executed in many different forms, such as relaxing currency controls and reducing foreign ownership restrictions, and not all reforms take place simultaneously. Third, despite countries undertake official regulatory changes, there are numerous impediments that discourage foreign investors to invest in emerging markets, for example home bias or other market imperfections.[3] However, in general, *"opening the market to foreign investors should lead to increased integration if it generates foreign portfolio investments that did not occur before such liberalization."* (Carrieri et al. 2007, p. 936). (Bekaert and Harvey 2000; Bekaert et al. 2003)

Capital market liberalization, if effective, has several impacts on both financial and real sectors. The cost of capital falls since foreign investors that are permitted to access domestic equity markets reap the international diversification benefits and will drive up domestic equity market values (Bekaert and Harvey 2000; Henry 2000a). Aggregate domestic investment has also documented to increase after liberalization (Henry 2000b). Finally, foreign investors may enhance the development of corporate governance and transparency which stimulates corporate investment. In summary, market integration promotes economic growth through enhanced financial development and improved liquidity. (Bekaert et al. 2003)

Although geographical diversification benefits have decreased with globalization, the increase of correlation following capital market liberalization is relatively small and international diversification still

[3] The three categories of barriers to foreign participation in emerging markets according to Bekaert (1995) are: 1) legal barriers, 2) indirect barriers arising from information asymmetry, accounting standards, and investor protection, and 3) risks that must be considered especially in emerging markets such as poor liquidity, uncertain political conditions, and currency risk.

overcomes industry diversification. (Bekaert and Harvey 2000; Baele and Inghelbrecht 2009)

2.3.2 Spillovers between international capital markets

Financial researchers have paid special attention to the linkages, more specifically mean return spillovers, volatility spillovers and financial contagion[4], between the markets since the 1990s. A majority of the research focus on stock market linkages between developed markets, such as USA, Japan, UK, Canada, and Germany. Theodossiou and Lee (1993) found that USA is a major source of transmission mechanism of mean return and risk across developed stock markets. They found that the conditional mean and volatility appear to be causal from USA to UK, Canada, Japan, and Germany (with the exception of mean return spillovers to Japan). In addition, they report significant mean return spillovers from Japan to Germany, as well as significant volatility spillovers from UK to Canada, from Japan to Germany, and from Germany to Japan. King and Wadhwani (1990) found clear contagion effects between USA, UK and Japan. Consistent evidence is shown by Lin et al. (1994) who found bidirectional mean return spillovers and volatility spillovers between USA and Japan. Hamao et al. (1990) examined the U.S., the U.K. and Japanese stock markets by GARCH(1, 1)-M model. They found that volatility spillover effect from Japan to USA and UK is much weaker than volatility spillover effect from USA and UK to Japan.

Bae and Karolyi (1994) incorporated the asymmetric effects in their analysis revealing the importance of both the magnitude and the sign of the shocks for volatility spillovers across the U.S. and Japanese stock markets. Further, Koutmos and Booth (1995) expanded the former study

[4] Volatility spillover refers to the risk transmission mechanism across economies, whereas financial contagion refers to the negative effect of a distressed economy on otherwise healthy economy during the crisis period (Forbes and Rigobon 2002).

by adding the U.K. stock markets in their multivariate EGARCH model. They found significant volatility spillovers from USA and UK to Japan, from UK and Japan to USA, and from Japan and UK to USA. They also support the existence of asymmetric effects in volatility spillovers. Savva (2009) also found clear evidence of asymmetric effects across the U.S. and major European stock markets (UK, Germany, France, Italy, and Spain) in terms of volatility spillover.

In contrast with the previous studies, Susmel and Engle (1994) found only weak bidirectional volatility spillovers between USA and UK. In addition, Karolyi (1995) examined the dynamic relationship between the U.S. and Canadian stock markets by bivariate BEKK-GARCH model and he reports only moderate volatility spillover effects from USA to Canada.

In contrast, the literature on the relationship between emerging markets is limited. For example, Kasch-Haroutounian and Price (2001) investigated the linkages in Central Europe, while Li and Majerowska (2008) examined Eastern European markets. Similarly, the literature on the interrelationship between developed and emerging markets is rather scarce granted that the U.S. subprime mortgage crisis and the Asian financial crisis in 1997 have inspired researchers to contribute to this strand of literature. Most of the studies in this category employ USA, Western Europe and Japan as benchmarks for developed countries while emerging markets usually comprise Pacific Basin countries, Latin American countries and Eastern Europe countries. For example, Worthington and Higgs (2004) examined the spillovers of returns and volatilities in Asian developed (Hong Kong, Japan and Singapore) and emerging markets (Indonesia, Korea, Malaysia, the Philippines, Taiwan and Thailand) by multivariate GARCH model. Their results generally indicate positive mean return spillovers and volatility spillovers but the impacts vary from country to country. Caporale et al. (2006) explored the transmission of Asian crisis using a bivariate BEKK- GARCH model between the USA, Europe, Japan and South East Asia, and they report volatility spillovers in all pairwise markets. A more recent study by Baur and Fry (2009) demonstrated that Hong Kong was the main driver in the Asian crisis. Ng (2000) showed that shocks from the USA are more prominent than shocks from Japan in the Pacific Basin region, although both are important. Liu and Pan (1997), Liu, Pan and Shieh (1998), and Cheung, Cheung and Ng (2007) have also contributed this strand of literature.

Dooley and Hutchison (2009), Lee (2012) and Bouaziz, Selmi and Boujelbene (2012) are among those who examined the contagion during the U.S. subprime mortgage crisis. Dooley and Hutchison (2009) focused on Russian, South African and Turkish markets, as well as, emerging markets locating in Latin America, Asia, and Central Europe. Using 5-year credit default swap spreads on sovereign bonds, they showed that emerging markets appeared to be relatively isolated from the impacts of the crisis until the bankruptcy of Lehman Brothers. Lee (2012) examined both developed and emerging markets geographically distributed across the world. He found that out of twenty international stock markets Hong Kong, Taiwan, Australia and New Zealand suffered the most severe effects of contagion. Bouaziz et al. (2012) employed the DCC multivariate GARCH model to analyze the contagion effect from USA to UK, Japan, Germany, France, and Italy, and they found clear evidence of volatility spillovers and contagion.

The literature of financial linkages indicates several regularities. First, volatility spillovers occur at least between major stock markets. Second, the correlations among stock markets have a tendency to increase when volatility is high showing a strong evidence of financial contagion in crisis periods. Third, bad news arriving from one market seems to have stronger impact on other market’s volatility than good news demonstrating the existence of asymmetric effects.

Understanding the correlation between stock and bond markets is a fundamental question in constructing of the optimal portfolio. Despite its importance, there is no consensus among financial researchers on the peculiarities of the stock-bond co-movements. Keim and Stambaugh (1986) were the first to investigate the stock-bond relationship and they found positive correlations between stocks and bonds. For example, Campbell and Ammer (1993) and Kwan (1996) support the same argument of positive correlation between the two assets.

Flight-to-quality and flight-from-quality represent another strand of the stock-bond literature. Flights reflect a temporary negative correlation between stocks and bonds during crisis periods. More specifically, flight-to-quality refers to the flight from stocks to bonds during stock market crashes, and flight-from-quality refers to the flight from bonds to stocks during bond market collapses. (Baur and Lucey 2009) For example, Gulko (2002), Connolly, Stivers and Sun (2005), and Baur and Lucey (2009) advocate negative correlations between the two assets during periods of market turmoil.

Moreover, the prior literature shows conflicting results regarding the variation of stock-bond correlation. For example, Shiller and Beltratti (1992) and Campbell and Ammer (1993) have shown that the correlation between stocks and bonds is time invariant. On the other hand, there is a lot of evidence that the stock-bond correlations fluctuate over time. For example, Gulko (2002), Li (2002), Scruggs and Glabadanidis (2003), Ilmanen (2003), Jones and Wilson (2004), Connolly et al. (2005), and Cappiello et al. (2006) are among those who advocate time-varying correlation of the two assets. In addition, Alexander, Edwards and Ferri (2000) found mixed sign correlations between stocks and bonds.

A safe haven asset can be defined as an asset that consistently displays uncorrelated or negatively correlated properties with other assets during periods of financial turmoil. That is, a safe haven asset holds its value while other assets' values fall jointly. Safe haven assets are needed especially during extreme negative shocks, defined as black swan events[5]. Bonds are considered as safe haven assets since they offer a fixed return if held to maturity. In addition, the secondary market for deep bond markets is highly liquid. Even though gold is more volatile and less liquid than bonds, it avoids some attributes that bonds are prone to. These are inflation, currency risk and default risk. Few studies have shown that gold empirically support the argument of save haven asset (see e.g. Baur and Lucey 2010).

[5] Black swan events are unpredictable events that induce extreme impacts (Taleb 2010). The September 11 attacks and the bankruptcy of Lehman Brothers in September 2008 are examples of black swan events.

3 DATA AND METHODOLOGY

3.1 Data

The chosen eQ mutual funds seek to invest their assets in Vanguard index funds, which in turn, seek to track the performance of benchmark stock and bond indices. In order to achieve as comprehensive data as possible, the benchmark indices in US dollars from DataStream are preferred over eQ mutual funds and Vanguard index funds. The data consists of total return indices for stock markets in the USA (S&P 500), Europe (MSCI Europe), Japan (MSCI Japan), emerging markets (EM, MSCI Emerging Markets), and frontier markets (FM, MSCI Frontier Markets). In addition, European Government Bond (Bond, Barclays Capital Global Aggregate Euro Government Float Adjusted Bond Index) and Gold[6] (Gold Bullion ETF) are chosen as safe haven assets. The sample period starts from January 2000 and ends in July 2013 except for FM, Bond and Gold whose start dates reflect their availability in DataStream. More detailed information about the markets under investigation is provided in Table 1. Weekly data is preferred over daily data because of the trading-hour differences in different markets.

The dataset is divided into two sub-samples in order to analyze the spillovers in terms of mean returns and volatilities in different market conditions. The pre-crisis period from 2000 to 2006 reflects moderate period in the world economy, whereas the crisis period from 2007 to 2013 includes global recession. In this thesis, the crisis period covers the liquidity shortfall in the U.S. banking system in 2007 contributing to the global recession and the European sovereign debt crisis, whose final

[6] FM and Gold are not included in the selection of eQ mutual funds but they are incorporated into the dataset in order to expand the investment opportunities.

consequences are still unclear. All the analyses are employed also for the full sample.

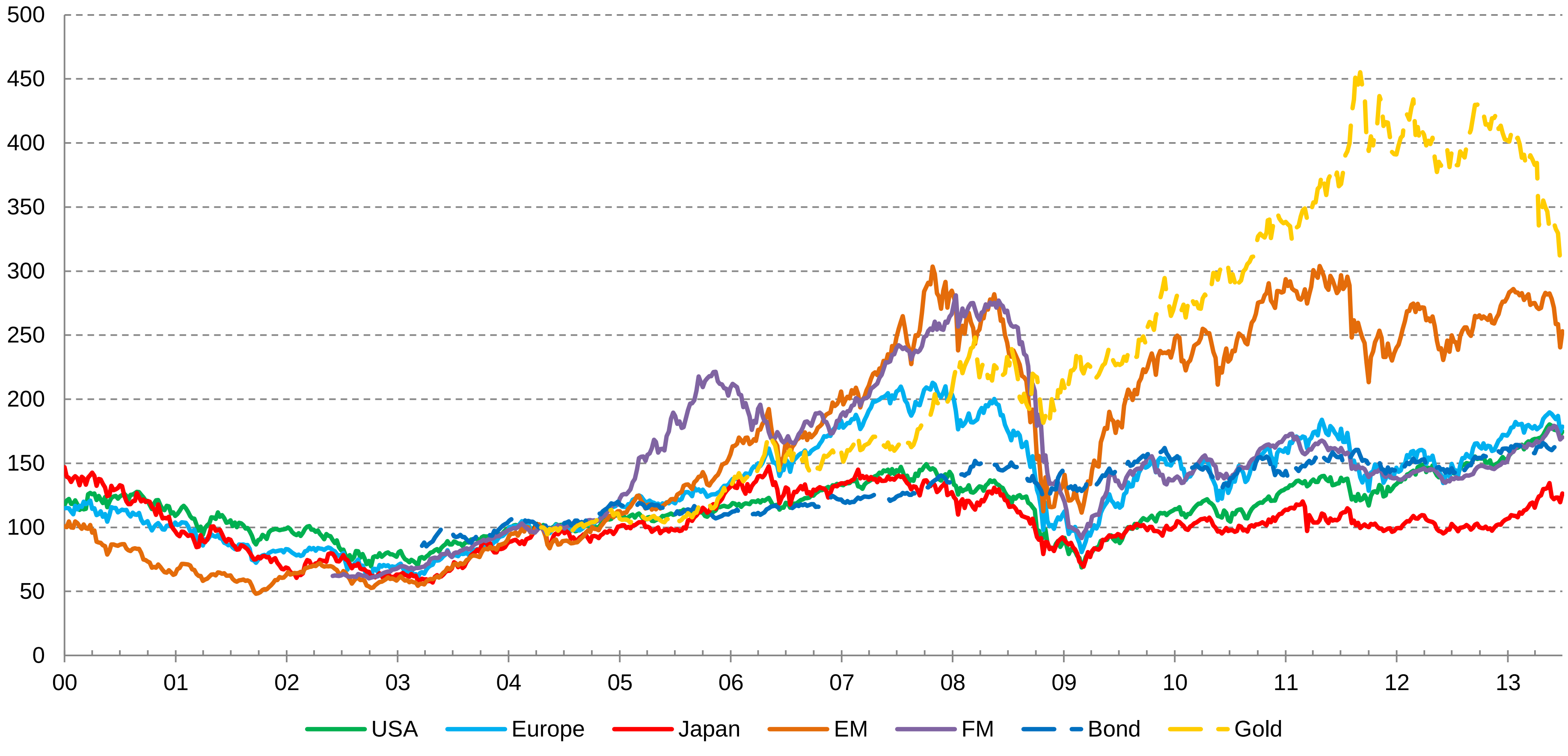
Table 1. The description of the markets under investigation.

Market	Index	Content	Coverage	Time Span
USA	S&P 500 Total Return	500 large cap companies in the U.S. market.	Approximately 75% of the U.S. equity universe.	January 2000–July 2013
Europe	MSCI Europe Total Return	Large and mid cap companies across Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the UK.	Approximately 85% of equity universe in developed European countries.	January 2000–July 2013
Japan	MSCI Japan Total Return	Large and mid cap companies in the Japanese market.	Approximately 85% of Japanese equity universe.	January 2000–July 2013
Emerging Markets	MSCI Emerging Markets Total Return	Large and mid cap companies across Brazil, Chile, China, Colombia, Czech Republic, Egypt, Hungary, India, Indonesia, Korea, Malaysia, Mexico, Morocco, Peru, Philippines, Poland, Russia, South Africa, Taiwan, Thailand and Turkey.	Approximately 85% of equity universe in Emerging Markets.	January 2000–July 2013
Frontier Markets	MSCI Frontier Markets Total Return	Large and mid cap companies across Argentina, Bahrain, Bangladesh, Bulgaria, Croatia, Estonia, Jordan, Kazakhstan, Kenya, Kuwait, Lebanon, Mauritius, Nigeria, Oman, Pakistan, Qatar, Romania, Serbia, Slovenia, Sri Lanka, Tunisia, Ukraine, United Arab Emirates and Vietnam.	Approximately 85% of equity universe in Frontier Markets.	June 2002–July 2013
Bond	Barclays Capital Global Aggregate Euro Government Float Adjusted Bond Index	Euro-denominated eurozone treasury and eurozone government-related securities with maturities greater than one year.	The total universe of the euro-denominated government fixed income securities.	March 2003–July 2013
Gold	Gold Bullion ETF	Spot price of gold bullion.	Gold market.	April 2004–July 2013

Graph 1 illustrates the development of the benchmark indices in US dollars. The series are scaled to 100 on the basis of gold index availability (April 2004) in order to make them comparable. The stock market crash in autumn 2008 is obvious.

International trade measured by exports of goods is applied in order to capture the macroeconomic fundamentals between the markets. The data is collected from IMF online data source Direction of Trade Statistics (DOTS). The data source does not provide market classification according to the MSCI but the aggregate measures for Europe, EM and FM could be constructed from country-level data.

Weekly logarithmic returns are applied in the analyses. Descriptive statistics for the full sample are presented in Table 2. Mean is multiplied by 52 and standard deviation by square root of 52 in order to show them in annual terms. Minimum and maximum indicate the range of the weekly data. Gold exhibits the highest returns followed by FM and EM. The standard deviation of FM is the lowest among stock markets since the index includes a wide variety of equity markets from different regions and different levels of development. As a consequence, the returns of equity markets included in FM index partially offset each other indicating relatively low volatility. All the return series are skewed to the left and exhibit leptokurtosis. The Jarque-Bera test is employed to check statistically whether the return series are normally distributed. The null of normality is rejected at 1% risk level in all cases. Finally, the Engle test for five lags is applied to test the presence of the ARCH effects in squared residuals. All the ARCH-LM statistics are significant at 1% risk level indicating a clear pattern of autocorrelation in squared residuals. Therefore, GARCH-type parameterization is appropriate method for modeling the conditional variances and covariances. Descriptive statistics for the pre-crisis period and crisis period are presented in Appendix 1.



Graph 1. Development of the benchmark indices in USD from January 2000 to July 2013. Indices are scaled to 100 on the basis of gold index availability (April 2004).

Table 2. Descriptive statistics for the full sample (2000–2013).
Three asterisks (***) indicates the significance at 1% risk level.

Market	Mean (%)	Max (%)	Min (%)	Std. Dev. (%)	Skewness	Kurtosis	Jarque-Bera	ARCH-LM
USA	2,94	12,39	-15,73	18,61	-0,53	7,23	558,91***	66,93***
Europe	3,27	19,64	-15,93	22,87	-0,29	6,77	425,96***	182,91***
Japan	-1,10	12,12	-17,92	21,77	-0,40	6,36	349,45***	38,03***
EM	6,80	21,28	-17,96	24,38	-0,62	8,35	885,39***	158,33***
FM[a]	9,09	9,22	-16,58	16,93	-1,62	12,30	2338,40***	125,90***
Bond[b]	6,07	6,62	-6,24	11,23	-0,13	3,80	15,81***	45,05***
Gold[c]	11,98	13,74	-13,59	19,83	-0,29	5,68	149,90***	15,34***

Notes: [a] Data for FM is available from June 2002.
[b] Data for Bond is available from March 2003.
[c] Data for Gold is available from April 2004.

3.2 Methodology

Moving window correlation of six months is employed in order to capture the dynamic features of correlation between the markets. International trade measured by exports of goods is applied in order to capture the macroeconomic fundamentals between the markets.

Bivariate representation is adopted in order to analyze the interdependences among the markets. Hence, there are six pairwise markets to be analyzed. The conditional mean returns of the pairwise markets are estimated with first order bivariate vector autoregressive (VAR(1)) model. The bivariate VAR(1) model can be written as:

(16)
$$y_{1t} = \beta_{10} + \beta_{11} y_{1t-1} + \alpha_{11} y_{2t-1} + u_{1t},$$
$$y_{2t} = \beta_{20} + \beta_{21} y_{2t-1} + \alpha_{21} y_{1t-1} + u_{2t},$$

where u_{it} is an error term with $E(u_{it}) = 0$, and $E(u_{1t}u_{2t}) = 0$. Hence, y_{it} depends on immediately previous values of both variables y_{1t-1} and y_{2t-1}, and an error term. (Brooks 2008, 290)

Many researchers have adopted a bivariate BEKK-GARCH model to estimate volatility spillovers between stock markets (see e.g. Karolyi 1995; Caporale et al. 2006). Hence, the volatility linkages between each pairwise market are analyzed with the bivariate BEKK-GARCH(1, 1) model which can be stated as:

(17) $$H_t = C_0 C_0' + A_{11}\varepsilon_{t-1}\varepsilon_{t-1}' A_{11}' + G_{11} H_{t-1} G_{11}',$$

where $C_0$is a 2×2 lower triangular portion of the matrix and A_{11} and G_{11} are 2×2 matrices. The A_{11} matrix elements capture the effects of shocks (ARCH effects), while the G_{11} matrix elements capture the information of past volatility effects (GARCH effect). More specifically, the diagonal elements in matrices A_{11} and G_{11} capture their own ARCH and GARCH effects, respectively. Moreover, the off-diagonal elements of A_{11} capture the shock transmissions between the markets, whereas the off-diagonal elements of G_{11} capture the volatility spillovers between the markets. (Tsay 2005, 451–452; Bauwens et al. 2006).

The second moment with individual elements can be written as:

(18) $$H_t = C_0 C_0' + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} \varepsilon_{1t-1}^2 & \varepsilon_{1t-1}\varepsilon_{2t-1} \\ \varepsilon_{2t-1}\varepsilon_{1t-1} & \varepsilon_{2t-1}^2 \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}' + \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix} H_{t-1} \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix}'$$

Each element of the BEKK model can be further expanded by matrix multiplication as follows:

(19) $$h_{11t} = c_{11}^2 + a_{11}^2\varepsilon_{1t-1}^2 + 2a_{11}a_{21}\varepsilon_{1t-1}\varepsilon_{2t-1} + a_{21}^2\varepsilon_{2t-1}^2 + g_{11}^2 h_{11t-1} + 2g_{11}g_{21}h_{12t-1} + g_{21}^2 h_{22t-1},$$

(20) $$h_{12t} = c_{11}c_{21} + a_{11}a_{12}\varepsilon_{1t-1}^2 + (a_{21}a_{12} + a_{11}a_{22})\varepsilon_{1t-1}\varepsilon_{2t-1} + a_{21}a_{22}\varepsilon_{2t-1}^2 + g_{11}g_{12}h_{11t-1} + (g_{21}g_{12} + g_{11}g_{22})h_{12t-1} + g_{21}g_{22}h_{22t-1},$$

(21) $$h_{22t} = c_{21}^2 + c_{22}^2 + a_{12}^2\varepsilon_{1t-1}^2 + 2a_{12}a_{22}\varepsilon_{1t-1}\varepsilon_{2t-1} + a_{22}^2\varepsilon_{2t-1}^2 + g_{12}^2h_{11t-1} + 2g_{12}g_{22}h_{12t-1} + g_{22}^2h_{22t-1}.$$

To test for a causality effect between the markets, the specific off-diagonal elements of matrices A_{11} and G_{11} must be set equal to zero. A causality effect from the first market to the second market can be tested by setting a_{12} and g_{12} to zero. Similarly, a_{21} and g_{21} must be set to zero to test causality effects from the second market to the first market. The former case can be represented as follows:

(22) $$h_{11t} = c_{11}^2 + a_{11}^2\varepsilon_{1t-1}^2 + 2a_{11}a_{21}\varepsilon_{1t-1}\varepsilon_{2t-1} + a_{21}^2\varepsilon_{2t-1}^2 + g_{11}^2h_{11t-1} + 2g_{11}g_{21}h_{12t-1} + g_{21}^2h_{22t-1},$$

(23) $$h_{12t} = c_{11}c_{21} + a_{11}a_{22}\varepsilon_{1t-1}\varepsilon_{2t-1} + a_{21}a_{22}\varepsilon_{2t-1}^2 + g_{11}g_{22}h_{12t-1} + g_{21}g_{22}h_{22t-1},$$

(24) $$h_{22t} = c_{21}^2 + c_{22}^2 + a_{22}^2\varepsilon_{2t-1}^2 + g_{22}^2h_{22t-1}.$$

4 EMPIRICAL RESULTS

4.1 Correlation analysis

Table 3 exhibits the average correlation coefficients across the markets. The highest correlations are reported between Europe and EM (0,761), and between USA and Europe (0,740). The interrelationship between stock markets and safe haven assets generally indicates lower correlations than the correlations among stock markets. The lowest correlations are reported between FM and Gold (0,124), and USA and Bond (0,129) indicating only minor interdependence. However, none of the markets demonstrate negative average correlation.

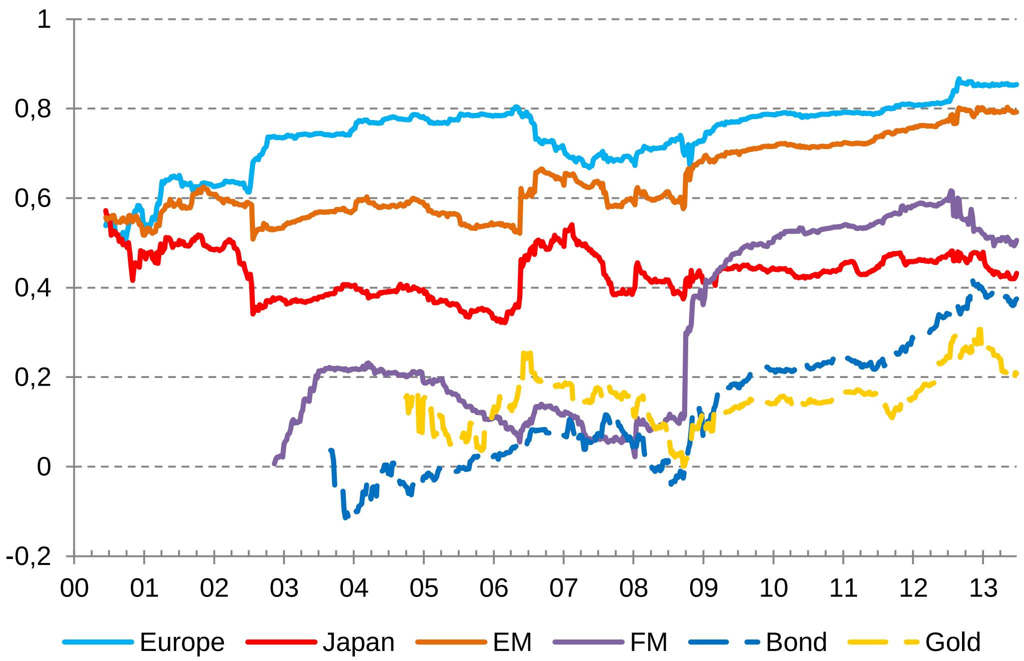
Table 3. Average cross-market correlations during the 2000–2013 period.

	USA	Europe	Japan	EM	FM	Bond	Gold
USA	1,000						
Europe	0,740	1,000					
Japan	0,432	0,519	1,000				
EM	0,637	0,761	0,600	1,000			
FM[a]	0,306	0,407	0,304	0,465	1,000		
Bond[b]	0,129	0,462	0,227	0,270	0,187	1,000	
Gold[c]	0,150	0,379	0,294	0,356	0,124	0,499	1,000

Notes: [a] *Data for FM is available from June 2002.*
[b] *Data for Bond is available from March 2003.*
[c] *Data for Gold is available from April 2004.*

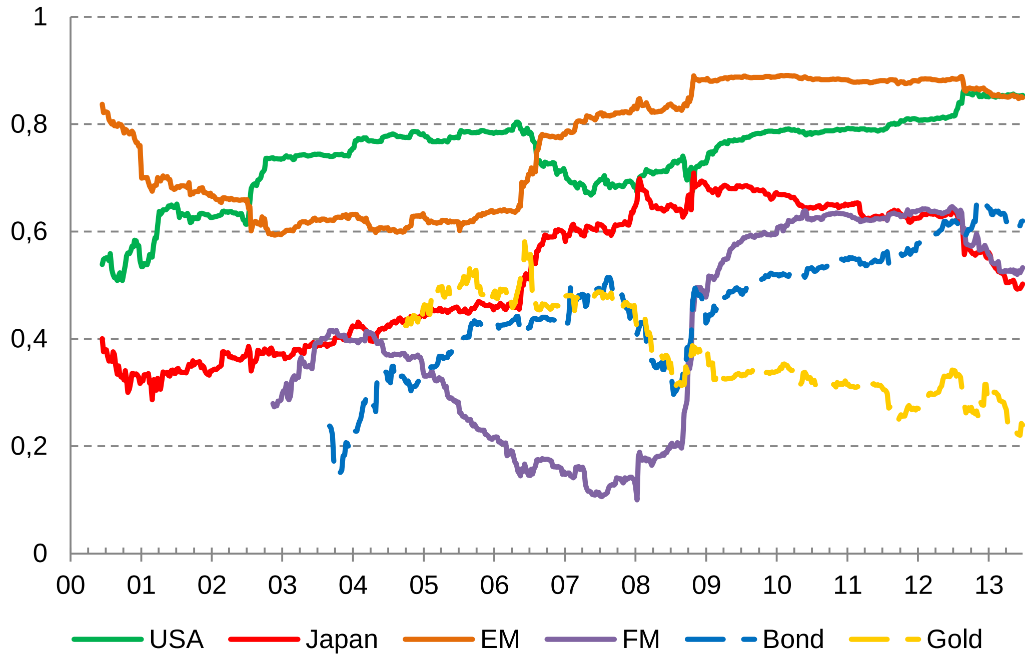
Graph 2 exhibits the 6-month moving window correlation between USA and the other markets. Correlation between USA and Europe jumped from the level of 0,63 to 0,73 in couple of months during the bear markets of 2002. Meanwhile, the correlations between USA and Japan, as well as, USA and EM diminished to 0,35 and 0,53, respectively. The stock market downturn was not as severe in Japan and EM as it was in the USA and

Europe which explains the opposite behavior of correlations. In May 2006, investors reassessed their projections in the uncertain market condition resulting in the sell-offs of risky assets, especially equities in developing markets. A sharp decline of May 2006 brought the correlation of Japan and EM to the level before the 2002 meltdown. Since 2008, Europe and EM have evolved in tandem and increased gradually to 0,85 and 0,8 respectively, whereas Japan has remained between 0,4 and 0,5. FM generally exhibit low correlation with any other market till the collapse of Lehman Brothers and that is why FM is considered separately in subsequent section. Similarly, Bond indicates minor, even negative, correlations with the USA until the Lehman Brothers bankruptcy and hence, Bond is also considered on its own section. However, correlation of Bond, as well as that of Gold, with USA during the most severe stock market crash in the 21th century was close to zero reflecting the properties of safe haven assets. Otherwise, Gold has been relatively stable around its low mean of 0,150 with the exception of peaks during market correction of 2006 and the year 2012.



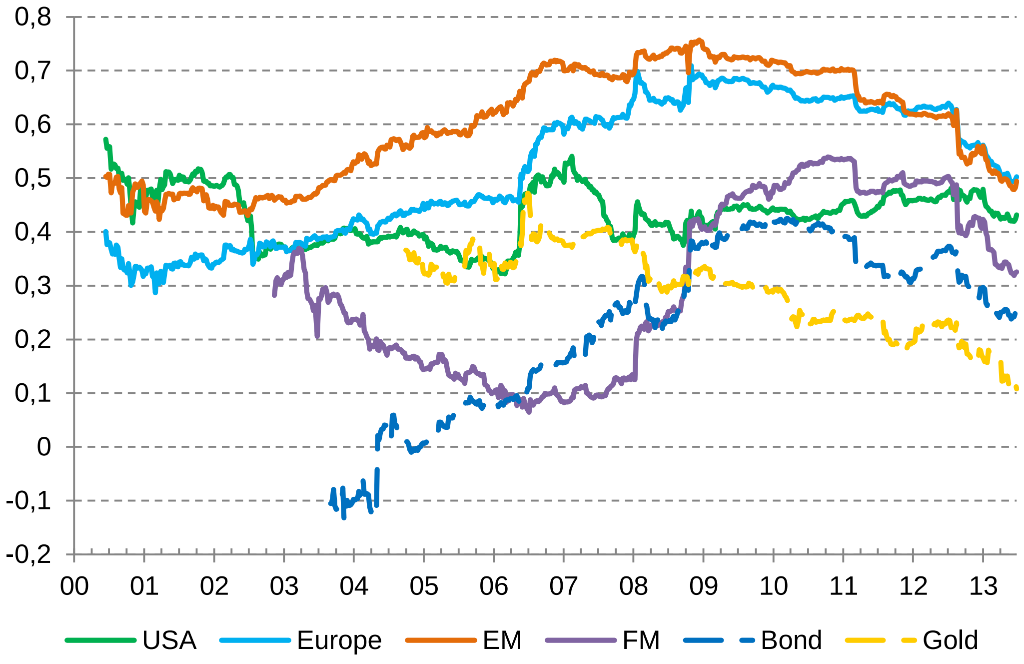
Graph 2. 6-month moving window correlation between the U.S. stock market and the other markets.

Graph 3 presents the 6-month moving window correlation between Europe and the other markets. The only period when Europe had the greatest correlation with the USA takes place between market dips of 2002 and 2006. Otherwise, EM exhibit very high correlations with Europe since 2006 market decline, peaked in autumn 2008 (0,89). However, the USA and EM result in the same level of 0,85. Japan exhibits upward trend from its lowest value (0,29) in February 2001 to its peak (0,71) in October 2008, and downward trend ever since ending up to the level of 0,5. Gold has the highest correlation with Europe among all the stock markets. The correlation between Europe and Gold was approximately 0,38 during the end of year 2008. Therefore, there is no evidence that Gold is a safe haven asset to the European stock investor. Nevertheless, the correlation between Europe and Gold has decreased since the market crash of 2008 and since then, Gold has been an ultimate diversifier within the assets and markets being examined.



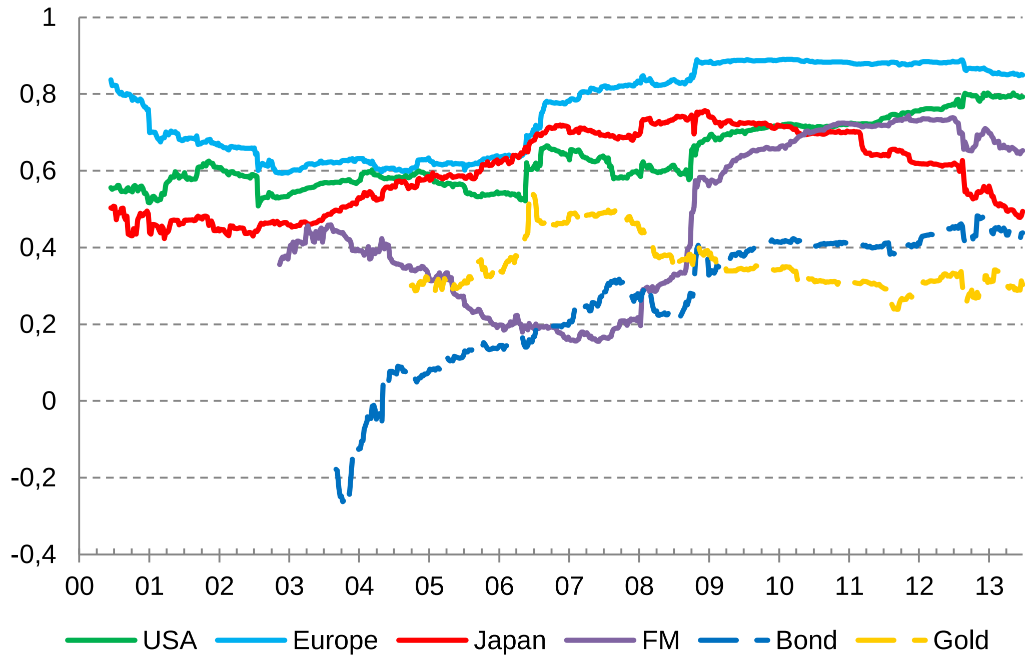
Graph 3. 6-month moving window correlation between European stock markets and the other markets.

Graph 4 exhibits correlation of Japan with the other markets. Japan exhibits relatively low correlations with other stock markets, especially with the USA. For example, Japan is less correlated with the USA and Europe than the USA and Europe are correlated with EM. In addition, both the USA and FM had correlation with Japan just over 0,4 in autumn 2008 and those are the lowest values of correlations among stock markets at that period of time. The correlation of Japan has been the highest with EM most of the time, peaked at 0,76 at the end of 2008. However, all the markets show downward trend compared to Japan in recent years with the exception of the USA, whose correlation has persisted between 0,4 and 0,5 from 2008 crash. Japanese peculiarities are highlighted by the impact of Fukushima nuclear disaster in March 2011, when stock market plummeted in Japan but other markets were almost unaffected. As a consequence, we can see an abrupt decline in correlations with other markets except Gold.



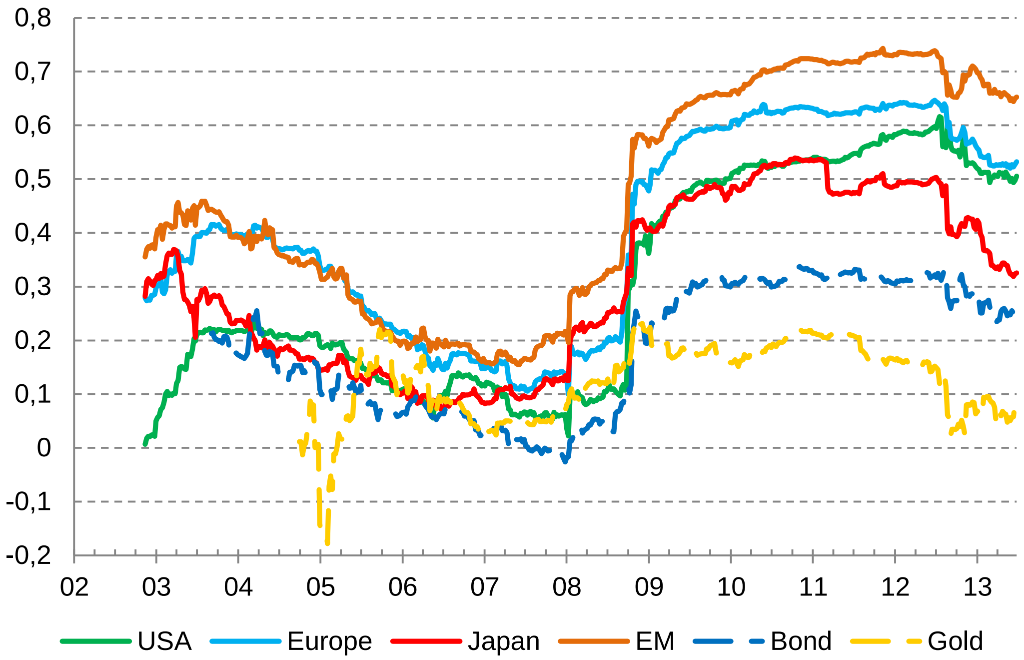
Graph 4. 6-month moving window correlation between Japanese stock market and the other markets.

Graph 5 indicates the correlation between EM and the other markets. The correlation of EM with developed stock markets increased during May 2006 correction and the 2008 crash, but correlation between EM and Japan has returned its original level, approximately 0,5. Japan and Gold are the only markets that do not indicate increased level of dependence with EM.



Graph 5. 6-month moving window correlation between emerging markets equity markets and the other markets.

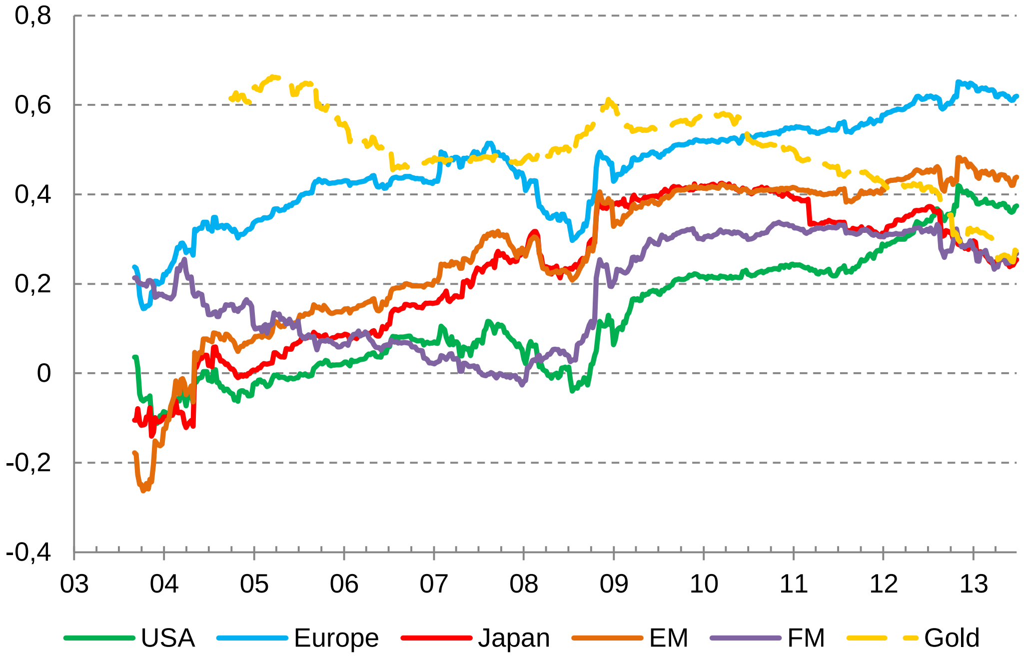
Graph 6 demonstrates the correlation between FM and the other markets. There is a clear evidence of soaring correlations due to the Lehman Brothers bankruptcy. The correlations continued to rise and exhibited elevated levels for many years after the crash, though the levels have recently declined from their peaks. In addition, correlations started to diverge during the crash 2008, as they were closely together couple of years prior to that. Recently, FM has had the highest correlation with EM followed by Europe, USA, Japan, Bond and Gold. Before 2008 crash, FM indicated only moderate levels of correlation with all markets, especially at the beginning of 2008, when the highest correlation was only 0,21 (EM) and the lowest -0,02 (Bond) . There was a downward trend in correlation with stock markets and Bond, while Gold exhibited a sharp dip in the beginning of 2005 the lowest value being -0,18.



Graph 6. 6-month moving window correlation between frontier markets equity markets and the other markets.

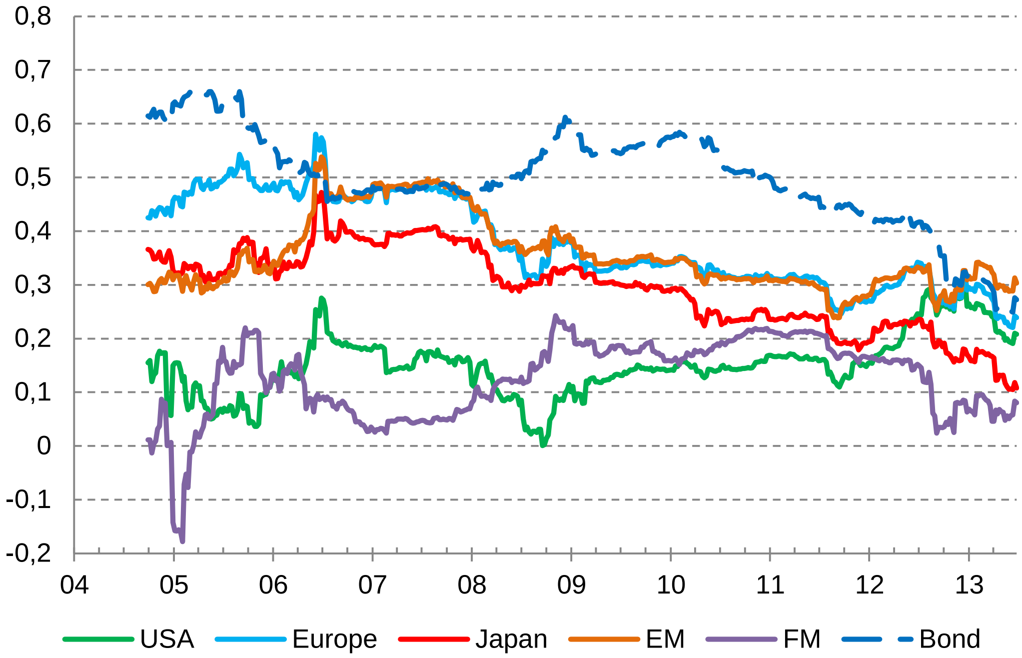
Graph 7 introduces the correlation between Bond and the other markets. The pre-crisis period reflects a steady era of Economic and Monetary Union (EMU) as the sovereign bond yields of the member states converged due to the elimination of exchange rate and inflation risk. In addition, the Maastricht criteria contributed to the convergence of the euro area. In the pre-crisis period, Bond correlation was very low with the stock markets outside the Europe, although increasing correlations with EM and Japan were evidenced till the end of 2007. Instead, the correlation between Bond and FM decreased, whereas the correlation between Bond and USA varied close to zero. In addition to the U.S. stock investor, Bond indicates the properties of safe haven asset also for FM stock investor in the 2008 crash.

European government bond yields started to diverge since autumn 2008 as the pricing of the sovereign credit risk was reassessed after the Lehman Brothers collapse. As a result, correlations jumped in autumn 2008 and indicated upward trend for the USA and Europe ever since. That is, the European sovereign debt crisis has increased the correlation of Bond between USA and Europe, and hence, the diversification benefits have diminished. On the other hand, there is no significant variation in the correlation of developing markets. The most prominent change is shown by Gold that exhibited the highest correlation during its earliest years (over 0,6) but declined to the same level of Japan and FM at the end of the period (0,25).



Graph 7. 6-month moving window correlation between European Government Bond market and the other markets.

Finally, Graph 8 indicates the correlation between Gold and the other markets. The correlations of Gold with Europe, EM and Japan peaked during the May 2006 decline and have gradually decreased towards to the present, Europe and EM jointly. The USA and FM, in turn, exhibited considerably lower correlations with Gold compared to the other markets till the Lehman Brothers bankruptcy but all correlations indicate convergence in recent years.



Graph 8. 6-month moving window correlation between gold market and the other markets.

4.2 Trade linkages

Table 4 indicates the proportional exports of goods from each market to partner markets from 2000 to 2012. There is a clear trend in the direction of international trade: Developing markets indicate growing importance in the global economy whereas developed markets are becoming less important. The developed markets exhibit increasing exports to the developing markets, and the global recession in 2009 has further strengthened the phenomena.

The trade linkages between EM and Europe appear to become more intense than linkages between EM and the USA. The proportional exports from Europe to EM have increased from 42,4% (2000) to 58,6% (2012),

Table 4. Proportional exports of goods from each market to partner markets from 2000 to 2012 (%).

Market	Partner	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
USA														
	Europe	36,8	37,6	36,2	36,3	36,0	35,4	35,0	35,6	35,1	34,5	31,2	30,2	28,9
	Japan	13,6	12,7	12,2	11,7	10,9	10,1	9,3	8,7	8,1	7,6	7,4	7,0	7,1
	EM	46,9	46,6	48,6	48,6	49,3	49,8	50,5	50,3	50,6	51,9	55,6	56,6	57,5
	FM	2,7	3,1	3,1	3,4	3,8	4,7	5,2	5,4	6,2	6,0	5,7	6,1	6,5
Europe														
	USA	37,3	36,6	36,2	33,7	31,7	30,2	28,5	25,7	23,4	23,8	21,4	20,6	21,1
	Japan	7,4	7,1	6,6	6,3	6,1	5,5	5,0	4,5	4,2	4,5	4,2	4,1	4,3
	EM	42,4	42,6	43,6	45,5	47,2	48,2	49,9	52,6	54,6	54,7	58,1	59,2	58,6
	FM	12,8	13,7	13,6	14,6	15,0	16,1	16,6	17,2	17,8	17,0	16,3	16,1	16,1
Japan														
	USA	40,1	39,9	38,1	32,7	30,2	30,3	29,8	26,6	23,2	21,8	20,8	20,3	23,1
	Europe	22,6	21,8	20,1	20,9	20,6	18,8	18,5	18,4	17,7	16,9	15,2	15,6	13,0
	EM	34,6	35,3	38,6	42,8	45,6	46,9	47,4	49,9	52,8	55,8	59,1	59,1	58,0
	FM	2,7	3,0	3,2	3,5	3,6	4,0	4,4	5,1	6,3	5,5	5,0	4,9	5,8
EM														
	USA	42,7	41,7	41,4	38,1	36,6	35,4	34,5	31,7	29,4	31,1	31,5	30,9	32,6
	Europe	35,0	35,6	36,8	39,2	40,3	41,5	42,3	44,1	44,8	43,5	42,6	41,7	39,4
	Japan	14,7	14,6	13,5	13,4	13,1	12,2	11,4	10,9	10,8	11,0	11,5	12,0	12,0
	FM	7,6	8,1	8,2	9,3	10,1	10,9	11,8	13,2	15,0	14,4	14,5	15,4	16,0
FM														
	USA	15,9	14,0	13,5	13,9	14,7	15,1	13,6	12,6	11,3	10,8	10,7	9,6	8,4
	Europe	32,7	34,7	37,1	37,5	37,0	36,3	34,8	34,6	33,1	35,6	32,3	32,4	30,2
	Japan	16,2	15,9	14,7	13,9	13,2	13,7	13,9	12,9	13,3	11,5	11,2	11,5	12,8
	EM	35,2	35,4	34,7	34,8	35,1	34,9	37,7	39,9	42,3	42,2	45,7	46,6	48,7

whereas the corresponding figures for the USA are 46,9% and 57,5%. Moreover, the proportional exports from EM to Europe has increased from 35,0% (2000) to 39,4% (2012), while the U.S. share has decreased from 42,7% (2000) to 32,6% (2012). However, the global recession seems to change the trend since the difference reached its peak in 2008 when the share for Europe and the USA was 44,8% and 29,4%, respectively. That is, the U.S. economic recovery has been faster than European since 2008 and the USA has partially regained the share back from Europe. Nevertheless, the relatively strong dependence between Europe and EM is partly explained by intense trade linkages.

Japan indicates similar trend than the USA and Europe but the magnitude is more dramatic. The proportion of exports from the USA and Europe to Japan have been reducing nearly by half in the 21^{st} century, and the same applies to exports from Japan to the USA and Europe. EM, on the other hand, has increased its proportion of Japanese exports from 34,6% (2000) to 58,0% (2012).

FM represent a minor percentage of the other markets' exports despite the fact that FM have increased their shares more than EM. FM appeared to be equally important destination to Europe (16,1%) and EM (16,0%) in 2012 although EM is expected to overtake Europe in proportional exports next year. However, EM is the major trade partner for FM since the proportional exports from FM to EM increased from 35,2% (2000) to 48,7% (2012), while the exports to Europe decreased from 32,7% (2000) to 30,2% (2012). On the other hand, Japan, and especially the USA, have lost their shares from 16,2% and 15,9% in 2000 to 12,8% and 8,4% in 2012, respectively. The loose trade linkages between FM and USA partially explain the weak dependence. As a result, markets are essentially driven by investor sentiment rather than economic fundamentals, especially during market turbulence. This is in line with King et al. (1994).

4.3 Spillovers

4.3.1 The full sample period (2000–2013)

Table 5 introduces the mean return spillovers (Panel A), ARCH effects (Panel B), and GARCH effects (Panel C) among the markets for the full sample. The predominance of the U.S. market is obvious in terms of mean return spillovers among the stock markets. There are very significant (1%) positive unidirectional mean return spillovers causal from USA to all the

Table 5. Mean return spillovers, ARCH effects, and GARCH effects from 2000 to 2013.

Panel A reports mean return spillovers, Panel B ARCH effects, and Panel C GARCH effects between the USA, Europe, Japan, emerging markets (EM), frontier markets (FM), Bond (European government bond market), and gold market. Parameter estimates for mean return spillovers are estimated with bivariate VAR(1) model, whereas the off-diagonal parameters for ARCH effects (shock transmissions) and GARCH effects (volatility spillovers) are estimated with bivariate BEKK-GARCH(1, 1) model. In addition, the parameters on the leading diagonals in Panel B and C captures the markets' own ARCH effect and GARCH effect, respectively, estimated with GARCH(1, 1) model.

Each panel reports the parameter estimates with asterisks indicating the significance at 1% (***), 5% (**), and 10% (*) risk levels. Unlike the correlation matrices, the matrices showing cross-effects between the markets are not exactly symmetric about their leading diagonals, and therefore, both upper and lower portions of the matrices are demonstrated in order to clarify the interpretation. Each pairwise market reports two parameters. The first parameter indicates the effect of the market locating in the leftmost column to its pairwise market, and the second parameter indicates the effect of pairwise market to the market locating in the leftmost column. The parameters are interpreted as absolute values.

	USA		**Europe**		**Japan**		**EM**		**FM**		**Bond**		**Gold**	
Panel A: Mean return spillovers														
USA			0,2478***	-0,063	0,1813***	0,0052	0,1433***	0,0139	0,1023***	0,0068	-0,000	-0,008	-0,074	-0,016
Europe	-0,063	0,2478***			0,1323***	-0,014	0,1548***	0,0532	0,1052***	-0,049	-0,029	0,0256	-0,061*	-0,037
Japan	0,0052	0,1813***	-0,014	0,1323***			-0,024	0,0825**	-0,004	0,0490	-0,079***	0,1478**	-0,163***	-0,014
EM	0,0139	0,1433***	0,0532	0,1548***	0,0825**	-0,024			0,0812***	-0,093*	-0,010	0,0265	-0,009	-0,040
FM[a]	0,0068	0,1023***	-0,049	0,1052***	0,0490	-0,004	-0,093*	0,0812***			-0,032	0,0607	-0,121**	-0,003
Bond[b]	-0,008	-0,000	0,0256	-0,029	0,1478**	-0,079***	0,0265	-0,010	0,0607	-0,032			-0,127	0,0218
Gold[c]	-0,016	-0,074	-0,037	-0,061*	-0,014	-0,163***	-0,040	-0,009	-0,003	-0,121**	0,0218	-0,127		

(continued on next page)

(Table 5 continued)

	USA		**Europe**		**Japan**		**EM**		**FM**		**Bond**		**Gold**	
Panel B: ARCH effects														
USA	0,159***		0,327***	-0,236***	-0,391***	0,0566	-0,215***	0,1125***	-0,042	0,1355***	-0,051	0,1774	-0,100	-0,260***
Europe	-0,236***	0,327***	0,182***		0,0056	0,0846	-0,006	0,1342***	0,0091	0,0395	0,0490	-0,368***	-0,043	-0,056
Japan	0,0566	-0,391***	0,0846	0,0056	0,129***		0,1081*	-0,033	-0,047	0,0859	-0,014	-0,037	-0,169**	0,1162
EM	0,1125***	-0,215***	0,1342***	-0,006	-0,033	0,1081*	0,195***		0,0428	0,0618	0,1178***	0,1364	-0,067	-0,052
FM[a]	0,1355***	-0,042	0,0395	0,0091	0,0859	-0,047	0,0618	0,0428	0,216***		0,0994***	0,0284	-0,381***	0,1163***
Bond[b]	0,1774	-0,051	-0,368***	0,0490	-0,037	-0,014	0,1364	0,1178***	0,0284	0,0994***	0,064***		-0,249***	0,0349
Gold[c]	-0,260***	-0,100	-0,056	-0,043	0,1162	-0,169**	-0,052	-0,067	0,1163***	-0,381***	0,0349	-0,249***	0,065**	
Panel C: GARCH effects														
USA	0,826***		-0,048	0,0559*	0,3547***	-0,305***	0,1030***	-0,063***	0,0106	-0,043***	0,1467***	-0,293***	0,2500***	-0,165***
Europe	0,0559*	-0,048	0,752***		0,0105	-0,092***	0,0284	-0,082***	-0,005	-0,012	0,1401***	-0,576***	-0,023	0,1186***
Japan	-0,305***	0,3547***	-0,092***	0,0105	0,715***		-0,122***	0,0360	0,0475	-0,026	0,0559***	-0,241***	0,0256	0,0359
EM	-0,063***	0,1030***	-0,082***	0,0284	0,0360	-0,122***	0,745***		-0,025*	-0,011	-0,060***	0,2174***	-0,005	0,1712***
FM[a]	-0,043***	0,0106	-0,012	-0,005	-0,026	0,0475	-0,011	-0,025*	0,769***		-0,042	0,1096**	0,3227***	-0,222***
Bond[b]	-0,293***	0,1467***	-0,576***	0,1401***	-0,241***	0,0559***	0,2174***	-0,060***	0,1096**	-0,042	0,903***		0,0560	-0,008
Gold[c]	-0,165***	0,2500***	0,1186***	-0,023	0,0359	0,0256	0,1712***	-0,005	-0,222***	0,3227***	-0,008	0,0560	0,879***	

Notes: [a] Data for FM is available from June 2002.
[b] Data for Bond is available from March 2003.
[c] Data for Gold is available from April 2004.

other stock markets and the magnitude of spillovers is descending to Europe, Japan, EM, and FM. In contrast, there are no linkages between USA and safe haven assets which are the most segregated markets under investigation. Japan is the only market that has spillovers between Bond. More specifically, there is a very significant (1%) but small negative spillover from Japan to Bond and a significant (5%) relatively large positive spillover from Bond to Japan. In addition, there are negative unidirectional spillovers from Japan (1%), FM (5%), and Europe (10%) to Gold, most prominent from Japan. Mean return spillovers from developing markets to other markets are limited. In addition to the spillover from FM to Gold, there is only a weak (5%) positive unidirectional spillover from EM to Japan. Developing markets themselves show interrelationship since there is a highly significant (1%) positive spillover from EM to FM, and a negative (10%) spillover from FM to EM granted that the impacts are minor. Europe has a very clear (1%) positive unidirectional impact on Japan, EM and FM. As a result, Japan and FM are the only stock markets that appear to be independent of one another in terms of mean return spillover.

The parameter estimates on the leading diagonals of Panels B and C indicate that the conditional variance of each market depends very significantly on their own past shocks and variances, respectively. More specifically, stock markets appear to be more prone to shock effects than bond or gold. Nevertheless, the U.S. market appears to be the main driver of risk transfer although the influence of ARCH and GARCH effects are not coherent. The shock transmission is bidirectional between USA and Europe, as well as, between USA and EM, but the U.S. impact is greater in both cases. In addition, there is unidirectional shock transmission from USA to Japan, and surprisingly, from FM to USA. Europe appears to be susceptible to risk transfer from all the other markets, and moreover, the relationship is solely unidirectional from other market to Europe in most cases. This is true with the exception of FM which, in turn, is the most isolated market among stock markets. However, FM has clear volatility linkages between safe haven assets. In addition, there is a very weak (10%) unidirectional contagion effect causal from EM to FM, as well as, a unidirectional shock transmission from Japan to EM. Bond exhibits very significant (1%) and dominant bidirectional contagion effect between the developed stock markets and EM, whereas the impact on FM is solely unidirectional.

In general, less correlated stock markets exhibit also fewer spillovers in terms of mean returns and volatilities. For example, FM have only few spillovers between developed stock markets. Moreover, there are no linkages documented between FM and Japan indicating that the two markets are segregated. As a consequence, FM provide the most attractive diversification opportunities for investors within the stock markets examined. On the other hand, there are many volatility spillovers between safe haven assets and the stock markets although the correlations between them do not indicate strong interdependence. For example, there are prominent volatility spillovers between Bond and the stock markets. This may be due to the European sovereign debt crisis which has raised the global uncertainty resulting in increased contagion effects. Despite the numerous volatility spillovers, the mean return spillovers between safe haven assets and stock markets are still relatively scarce. This implies that the cross-asset allocation provides significant diversification benefits.

4.3.2 The pre-crisis period (2000–2006)

Table 6 introduces the mean return spillovers, ARCH effects, and GARCH effects among the markets for the pre-crisis period. Panel A indicates that the mean return spillovers are relatively scarce and weak in the pre-crisis period. There is some evidence of positive mean return spillovers causal from USA to Japan, EM, and FM. On the other hand, developing markets are affected positively and very significantly (1%) by Europe. There are

Table 6. Mean return spillovers, ARCH effects, and GARCH effects from 2000 to 2006.

Panel A reports mean return spillovers, Panel B ARCH effects, and Panel C GARCH effects between the USA, Europe, Japan, emerging markets (EM), frontier markets (FM), Bond (European government bond market), and gold market. Parameter estimates for mean return spillovers are estimated with bivariate VAR(1) model, whereas the off-diagonal parameters for ARCH effects (shock transmissions) and GARCH effects (volatility spillovers) are estimated with bivariate BEKK-GARCH(1, 1) model. In addition, the parameters on the leading diagonals in Panel B and C captures the markets' own ARCH effect and GARCH effect, respectively, estimated with GARCH(1, 1) model.

Each panel reports the parameter estimates with asterisks indicating the significance at 1% (***), 5% (**), and 10% (*) risk levels. Unlike the correlation matrices, the matrices showing cross-effects between the markets are not exactly symmetric about their leading diagonals, and therefore, both upper and lower portions of the matrices are demonstrated in order to clarify the interpretation. Each pairwise market reports two parameters. The first parameter indicates the effect of the market locating in the leftmost column to its pairwise market, and the second parameter indicates the effect of pairwise market to the market locating in the leftmost column. The parameters are interpreted as absolute values.

	USA		**Europe**		**Japan**		**EM**		**FM**		**Bond**		**Gold**	
Panel A: Mean return spillovers														
USA			0,1080	-0,018	0,1110*	-0,018	0,1443**	0,0151	0,0803**	-0,027	0,0585	-0,041	0,0550	-0,064
Europe	-0,018	0,1080			-0,001	-0,008	0,1675***	0,0542	0,0959***	-0,075	0,0298	0,0757	0,0652	0,0005
Japan	-0,018	0,1110*	-0,008	-0,001			0,0010	0,0226	0,0344	-0,036	-0,060*	-0,009	-0,049	0,0520
EM	0,0151	0,1443**	0,0542	0,1675***	0,0226	0,0010			0,0728	-0,088	-0,033	-0,086	0,1526*	-0,045
FM[a]	-0,027	0,0803**	-0,075	0,0959***	-0,036	0,0344	-0,088	0,0728			-0,081*	0,1144	0,0166	0,0543
Bond[b]	-0,041	0,0585	0,0757	0,0298	-0,009	-0,060*	-0,086	-0,033	0,1144	-0,081*			-0,127	0,0450
Gold[c]	-0,064	0,0550	0,0005	0,0652	0,0520	-0,049	-0,045	0,1526*	0,0543	0,0166	0,0450	-0,127		

(continued on next page)

(Table 6 continued)

	USA		Europe		Japan		EM		FM		Bond		Gold	
Panel B: ARCH effects														
USA	0,173***		0,2007***	0,4320***	-0,313***	-0,047	-0,296***	0,0950**	-0,024	0,0872*	0,1594***	-0,131**	0,0851	0,1274***
Europe	0,4320***	0,2007***	0,191***		-0,179***	0,0434	-0,123	0,1190**	-0,053	-0,003	0,1055	-0,340***	-0,409***	0,2138***
Japan	-0,047	-0,313***	0,0434	-0,179***	0,029		-0,154***	0,3753***	-0,009	-0,236*	0,0586**	-0,413***	0,1268*	0,3113**
EM	0,0950**	-0,296***	0,1190**	-0,123	0,3753***	-0,154***	0,137***		0,0776	-0,102	0,0499*	-0,073	0,0643	0,1597*
FM[a]	0,0872*	-0,024	-0,003	-0,053	-0,236*	-0,009	-0,102	0,0776	0,167***		-0,014	-0,071	-0,164	0,0479
Bond[b]	-0,131**	0,1594***	-0,340***	0,1055	-0,413***	0,0586**	-0,073	0,0499*	-0,071	-0,014	-0,076		-0,532***	0,0247
Gold[c]	0,1274***	0,0851	0,2138***	-0,409***	0,3113**	0,1268*	0,1597*	0,0643	0,0479	-0,164	0,0247	-0,532***	0,118	
Panel C: GARCH effects														
USA	0,820***		-0,108***	0,1422**	0,6557***	-0,106	0,2212***	-0,109***	0,0109	-0,042*	-0,127***	0,1368***	-0,552	-0,217
Europe	0,1422**	-0,108***	0,710***		0,0976**	-0,142***	0,0731*	-0,126***	0,0236	0,0104	0,2635***	-0,579***	0,0061	0,0008
Japan	-0,106	0,6557***	-0,142***	0,0976**	0,867***		-0,050***	-0,028	-0,079***	0,1862***	-0,029**	0,0397	0,7594***	0,5992
EM	-0,109***	0,2212***	-0,126***	0,0731*	-0,028	-0,050***	0,736***		-0,060	0,1162	0,0051	-0,053	-0,263	-0,757***
FM[a]	-0,042*	0,0109	0,0104	0,0236	0,1862***	-0,079***	0,1162	-0,060	0,804***		0,0080	0,0236	0,1529**	-0,101
Bond[b]	0,1368***	-0,127***	-0,579***	0,2635***	0,0397	-0,029**	-0,053	0,0051	0,0236	0,0080	1,032***		-0,230	0,0728
Gold[c]	-0,217	-0,552	0,0008	0,0061	0,5992	0,7594***	-0,757***	-0,263	-0,101	0,1529**	0,0728	-0,230	0,834***	

Notes: [a] *Data for FM is available from June 2002.*
[b] *Data for Bond is available from March 2003.*
[c] *Data for Gold is available from April 2004.*

also weak (10%) negative spillovers from Japan and FM to Bond, as well as, positive spillovers from EM to Gold. The analysis shows only little evidence of interdependences among the markets in terms of mean return spillovers during the pre-crisis period.

The leading diagonal of Panel B in Table 6 indicates that Japan, Bond, and Gold are not driven by their own past shocks, and the results are also supported by the Engle test (see Appendix 1). However, Panel C demonstrates that the own GARCH terms of each market are very significant (1%). When it comes to risk transmission, the U.S. markets exhibit significant bidirectional linkages between Europe, EM and Bond. USA dominates EM but Europe dominates USA. In addition, there is a very significant (1%) unidirectional volatility linkage causal from USA to Japan and rather weak (10%) unidirectional linkage causal from FM to USA. All these results are significant in both ARCH and GARCH terms. Europe is not so clearly affected by other markets than it is in full period: Europe has unidirectional and bidirectional volatility linkages between all the markets with the exception of FM, and it is dominated only by EM and Bond. Japan appears to be the most vulnerable market in this period since it is dominated by USA and FM, and it is clearly affected by all the other markets too. FM is clearly the most isolated market since there are no volatility linkages between FM and Europe, FM and EM or FM and Bond. There is a unidirectional volatility spillover from Gold to EM and little evidence (10%) of unidirectional shock effect from EM to Bond which is the only linkage between developing markets and Bond. Instead, there are clear bidirectional volatility linkages between Bond and developed stock markets.

The results do not support any mean return spillover or risk transmission between EM and FM, and hence, they are the most segregated markets under investigation in the pre-crisis period. In addition, there is no risk transmission documented between FM and Europe or between FM and Bond. Although Japan is the most vulnerable market in the pre-crisis period, the Japanese returns are weakly driven only by the U.S. market. As a result, substantial diversification benefits are available as long as there are no mean returns spillovers reported.

4.3.3 The crisis period (2007–2013)

Table 7 shows that the crisis period indicates many spillovers in terms of both mean returns and volatilities. Europe (at 5% risk level) and Japan (1%) returns are strongly positively driven by the U.S. returns. In addition, there is some evidence (at 10% level) of spillovers from USA to FM and Gold, as well as, from Japan and Bond to USA. Gold is negatively driven by all the other markets except EM and Bond which do not support any mean return spillovers with Gold. Japan is the most clearly linked market with safe haven assets since there are very clear (1%) and strong mean return spillovers between them. FM and Japan are again the only stock markets without any mean return spillovers, whereas FM and EM have very clear (1%) bidirectional mixed sign spillovers. Europe has positive and large unidirectional mean return spillovers to Japan, EM, and FM. Finally, Japan is clearly (1%) and positively driven by EM returns.

Table 7 Panel B shows that Gold appears to be the only market that is not affected by its own past shocks, although the Engle test supported the ARCH effects at the 10% risk level for gold (see Appendix 1). However, all the markets are highly (1%) dependent on their own past volatilities. The crisis period revealed the vulnerability of developing markets. Both EM and FM exhibit very significant (1%) bidirectional volatility linkages in almost all cases. More specifically, EM is dominated by USA, Europe, Japan, and there is highly significant (1%) bidirectional contagion effect between EM and FM, as well as between, EM and Bond. However, EM exhibit strong volatility spillovers to Gold whereas Gold respond only partially (10%) in terms of shock effect to EM. FM, on the other hand, is

Table 7. Mean return spillovers, ARCH effects, and GARCH effects from 2007 to 2013.

Panel A reports mean return spillovers, Panel B ARCH effects, and Panel C GARCH effects between the USA, Europe, Japan, emerging markets (EM), frontier markets (FM), Bond (European government bond market), and gold market. Parameter estimates for mean return spillovers are estimated with bivariate VAR(1) model, whereas the off-diagonal parameters for ARCH effects (shock transmissions) and GARCH effects (volatility spillovers) are estimated with bivariate BEKK-GARCH(1, 1) model. In addition, the parameters on the leading diagonals in Panel B and C captures the markets' own ARCH effect and GARCH effect, respectively, estimated with GARCH(1, 1) model.

Each panel reports the parameter estimates with asterisks indicating the significance at 1% (***), 5% (**), and 10% (*) risk levels. Unlike the correlation matrices, the matrices showing cross-effects between the markets are not exactly symmetric about their leading diagonals, and therefore, both upper and lower portions of the matrices are demonstrated in order to clarify the interpretation. Each pairwise market reports two parameters. The first parameter indicates the effect of the market locating in the leftmost column to its pairwise market, and the second parameter indicates the effect of pairwise market to the market locating in the leftmost column. The parameters are interpreted as absolute values.

	USA		**Europe**		**Japan**		**EM**		**FM**		**Bond**		**Gold**	
Panel A: Mean return spillovers														
USA			0,2785**	-0,030	0,2230***	0,0929*	0,1413	-0,076	0,0830*	0,1065	-0,022	0,1330*	-0,106*	-0,019
Europe	-0,030	0,2785**			0,2165***	-0,003	0,2484**	0,0033	0,1369***	-0,047	-0,041	0,0842	-0,083**	-0,061
Japan	0,0929*	0,2230***	-0,003	0,2165***			-0,024	0,1266***	-0,057	0,0784	-0,093***	0,3007***	-0,167***	-0,023
EM	-0,076	0,1413	0,0033	0,2484**	0,1266***	-0,024			0,1015***	-0,329***	0,0076	0,1045	-0,032	-0,046
FM	0,1065	0,0830*	-0,047	0,1369***	0,0784	-0,057	-0,329***	0,1015***			0,0124	-0,008	-0,144*	0,0030
Bond	0,1330*	-0,022	0,0842	-0,041	0,3007***	-0,093***	0,1045	0,0076	-0,008	0,0124			-0,091	0,0230
Gold	-0,019	-0,106*	-0,061	-0,083**	-0,023	-0,167***	-0,046	-0,032	0,0030	-0,144*	0,0230	-0,091		

(continued on next page)

(Table 7 continued)

	USA		Europe		Japan		EM		FM		Bond		Gold	
Panel B: ARCH effects														
USA	0,135***		0,6708***	-0,415***	-0,410***	0,1223*	0,8510***	-0,469***	-0,318***	0,4866***	-0,131***	0,4352***	-0,089	-0,317***
Europe	-0,415***	0,6708***	0,188***		0,0132	0,0952	-0,705***	0,6816***	-0,008	0,3468***	0,0316	-0,092	-0,057	-0,090
Japan	0,1223*	-0,410***	0,0952	0,0132	0,372***		0,3232***	-0,163***	-0,008	-0,008	-0,020	-0,057	0,0498	-0,570***
EM	-0,469***	0,8510***	0,6816***	-0,705***	-0,163***	0,3232***	0,250***		-0,062	-0,239	0,1467***	0,1985	-0,343***	-0,248*
FM	0,4866***	-0,318***	0,3468***	-0,008	-0,008	-0,008	-0,239	-0,062	0,264***		0,2079***	0,2545***	-0,500***	0,0924**
Bond	0,4352***	-0,131***	-0,092	0,0316	-0,057	-0,020	0,1985	0,1467***	0,2545***	0,2079***	0,075**		-0,216**	0,0704*
Gold	-0,317***	-0,089	-0,090	-0,057	-0,570***	0,0498	-0,248*	-0,343***	0,0924**	-0,500***	0,0704*	-0,216**	0,059	
Panel C: GARCH effects														
USA	0,816***		0,0625	0,0719	0,0564***	0,0186	-0,608***	0,2377***	0,1179***	-0,249***	0,2836***	-0,785***	0,2513***	-0,174***
Europe	0,0719	0,0625	0,738***		0,0055	-0,003	0,3148***	-0,259***	-0,466***	0,8081***	0,1242***	-0,547***	-0,019	0,1639***
Japan	0,0186	0,0564***	-0,003	0,0055	0,551***		-0,179***	0,0719***	0,0605**	-0,025	0,0815*	0,1335	-0,216***	0,1057***
EM	0,2377***	-0,608***	-0,259***	0,3148***	0,0719***	-0,179***	0,730***		-0,258***	0,8388***	-0,073***	0,4350***	0,2013**	-0,174
FM	-0,249***	0,1179***	0,8081***	-0,466***	-0,025	0,0605**	0,8388***	-0,258***	0,735***		-0,130***	0,2863***	0,3312***	-0,212***
Bond	-0,785***	0,2836***	-0,547***	0,1242***	0,1335	0,0815*	0,4350***	-0,073***	0,2863***	-0,130***	0,890***		0,0759	-0,027
Gold	-0,174***	0,2513***	0,1639***	-0,019	0,1057***	-0,216***	-0,174	0,2013**	-0,212***	0,3312***	-0,027	0,0759	0,867***	

not affected to the extent of EM but it still has more volatility linkages than in the pre-crisis period. For example, FM has highly significant bidirectional ARCH and GARCH effects with safe haven assets dominating Gold and being dominated by Bond. Japan appears to be the most segregated market in the crisis period, since it has no volatility linkages between Europe, and there is only minor unidirectional contagion effect causal from Japan to FM and Bond. Hence, Japan has bidirectional volatility linkages only with EM and Gold. In addition, Japan is strongly (1%) affected by the U.S. shocks, whereas USA is only partially (10%) affected by Japanese shocks. The predominance of the U.S. markets is indeed apparent in the crisis period. There are highly significant (1%) bidirectional volatility linkages between USA and the other market in almost every case. Surprisingly, the model does not support GARCH effect between USA and Europe, although there are highly significant (1%) bidirectional ARCH effects between these two markets. This may be due to ongoing financial and economic problems in Europe that emerged as a consequence of the European sovereign debt credit crisis. Meanwhile, the USA has demonstrated faster economic growth than Europe, and hence, there is no contagion effect between the two markets.

The most obvious difference between the two sub-samples is increased integration in the crisis period. In general, the mean return spillovers and the volatility spillovers are more significant and larger in magnitude in the crisis period. The mean return spillover in the crisis period (pre-crisis period) is significant in nine (two) cases at 1% risk level, in three (two) cases at 5% risk level, and in five (four) cases at 10% risk level. When it comes to shock transmission, the ARCH effect is significant in twenty-one (fourteen) cases at 1% risk level, in two (five) cases at 5% risk level, and in three (five) cases at 10% risk level. The difference is more dramatic for the volatility spillovers since GARCH term indicates twenty-eight (fifteen) cases significant at 1% risk level, two (four) cases at 5% risk level, and one (two) cases at 10 % risk level.

The results show a clear evidence of increased interdependence of capital markets during the market turbulence leading to decreased diversification benefits. Although safe haven assets show significant contagion effects between the stock markets in the crisis-period, Bond and Gold still provide attractive diversification benefits for stock investors. FM exhibit very significant bidirectional volatility spillovers with all the other markets except Japan. Despite the contagion between FM and the other markets, FM are still favorable diversifier within the markets examined.

The results indicating increasing interdependence within international stock markets during turbulent periods are consistent with the earlier studies (see e.g. King et al. 1994; Longin and Solnik 1995, 2001; De Santis and Gerard 1997; Chesnay and Jondeau 2001). Our findings of the contagion effects originated from the U.S. subprime mortgage crisis are also consistent with the existing literature (see e.g. Lee (2012); Bouaziz et al. (2012)).

5 CONCLUSIONS

This thesis analyzed the interdependences of international stock markets (the USA, Europe, Japan, emerging markets, and frontier markets), European government bond market, and gold market during the 21st century. Mean return spillovers were examined by bivariate VAR(1) model, whereas volatility spillovers were examined by bivariate BEKK-GARCH(1, 1) model. In addition, six-month moving window correlation was employed in order to capture the dynamic features of correlations.

In order to capture the influence of ongoing financial crisis, the dataset was divided into two sub-samples. The pre-crisis period from 2000 to 2006 reflects a moderate period, whereas the crisis period from 2007 to 2013 captures the impact of the ongoing economic crisis. All the analyses were employed also with the full sample. Weekly logarithmic returns were applied in the analyses.

In general, correlations have slightly increased among the stock markets during the 21th century. At the same time, the correlations between stock and bond markets have also increased leading to decreasing diversification benefits. This is at least to some extent due to the European sovereign debt crisis which has raised the global uncertainty. However, the correlation between stocks and gold has slightly decreased indicating better diversification opportunities. As a consequence, the correlation between bond and gold markets has also declined. The correlations between the USA, Europe, and EM were relatively high. In contrast, Japan demonstrated moderate correlations with the USA and Europe, especially with the USA. FM exhibited the lowest correlations with other stock markets, whereas bond and gold markets demonstrated low correlations with stock markets.

However, the correlations exhibited considerable time-variation and the impacts of market crashes were not necessarily coherent in all the markets. For example, the bankruptcy of Lehman Brothers caused an abrupt increase in the correlations between FM and the other markets which is a clear evidence of contagion. What can be considered as a safe haven asset is determined by asset to which a safe haven asset is compared to. Both gold and bond market indicated the properties of safe haven asset for the U.S. stock markets, and gold market reflected the same properties also for FM during the stock market crash of 2008. Finally, the cross-asset correlations between bond and the stock markets varied over time. These results are consistent with the mainstream of the existing literature (see e.g. Gulko (2002); Li (2002); Scruggs and Glabadanidis (2003); Ilmanen (2003); Jones and Wilson (2004); Connolly et al. (2005); Cappiello et al. (2006)).

The full period indicated several mean return spillovers among stock markets and the influence of the USA was prominent. In contrast, Bond and Gold appeared to be the most segregated markets in terms of mean return spillovers. In addition, mean return spillovers were limited from developing markets to the other markets. Japan and FM were the only stock markets that did not support any mean return spillovers among themselves. The USA was also the main driver of volatility spillovers, whereas Europe was susceptible to risk transfer from all the other markets. FM was the most isolated market, although it indicated clear volatility linkages between bond and gold. Finally, there were significant linkages between Bond and the stock markets.

The linkages were relatively weak in the pre-crisis period, especially in terms of mean return spillovers. Evidence of positive mean return spillovers causal from Europe and the USA to the developing markets, as well as, from the USA to Japan was documented. The U.S. market exhibited significant unidirectional volatility linkage to Japan, as well as, bidirectional volatility linkages between Europe, EM, and Bond. Japan appeared to be the most vulnerable market since it was susceptible to risk transfer from all the other markets. In contrast, FM was the most segregated market. In addition, Bond exhibits clear bidirectional volatility linkages between developed markets.

The mean return spillovers and volatility spillovers were more prominent in the crisis period. There were clear positive unidirectional mean return spillovers from Europe to Japan, EM, and FM. On the other hand, European and Japanese returns were strongly driven by the U.S. returns. Bond and Gold had the most prominent mean return spillovers with Japan, whereas FM and Japan were the only stock markets without any mean return spillover. Gold was negatively driven by the USA, Europe, Japan, and EM. When it comes to the volatility spillovers, there were highly significant bidirectional volatility spillover between the USA and all the other markets. Japan appeared to be the most segregated market from the volatility spillovers. In addition, the crisis period revealed the vulnerability of developing markets since they exhibited highly significant bidirectional volatility spillovers with almost every market.

In summary, the spillovers in terms of both mean returns and volatilities were magnified in the crisis period compared to the pre-crisis period. The predominance of the U.S market is obvious during all periods. Previously, Theodossiou and Lee (1993) got similar results that advocate the USA as a major source of spillovers. Japan was shifted from the most vulnerable market of the pre-crisis period to the most segregated market of the crisis period in terms of volatility spillovers. On the other hand, FM was the most isolated market of the pre-crisis period but it was prone to significant volatility spillovers during the crisis period. In addition, FM and Japan were the only stock markets that did not indicate mean return spillovers in any period. The results indicate that markets are essentially driven by investor sentiment rather than economic fundamentals, especially during market turbulence. This is in line with King et al. (1994).

The results indicating increasing interdependence within international stock markets during periods of financial turbulence are consistent with the existing literature (see e.g. King et al. 1994; Longin and Solnik 1995, 2001; De Santis and Gerard 1997; Chesnay and Jondeau 2001). In addition, the results of the contagion effects originating from the U.S. subprime mortgage crisis are also consistent with the earlier studies (see e.g. Lee (2012); Bouaziz et al. (2012)).

Although considerable risk transfers were reported between FM and the other markets in the crisis-period, FM provide the best diversification opportunities within the stock markets. This trend appears to remain since MSCI regularly reviews potential markets to include in its frontier markets index. Japan indicates good diversification opportunities since it has relatively low correlations between other developed stock markets. In addition, Japan and FM indicated only marginal impact on each other in terms of mean return spillover and risk transfer. However, investors must consider that historical returns of Japanese stock market have been low. Nevertheless, bond and gold market provide the best diversification benefits for stock investors, especially during periods of market turmoil.

The results of this thesis have implications for both academics and practitioners. This thesis has contributed to the scarce literature on the interdependence between stock, bond, and gold markets, as well, as the limited literature on the linkages between developed and developing stock markets. The results are applicable for portfolio managers in asset allocation purposes.

For future research it would be interesting to employ country-level data in order to distinguish the increasing impact of China, and India, for example. In addition, the future research could examine the properties of different bond markets in relation to stock and gold markets.

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APPENDIX

Appendix 1. Descriptive statistics for the pre-crisis period (2000-2006) and the crisis period (2007-2013).

The pre-crisis period.

Market	**Mean** (%)	**Max** (%)	**Min** (%)	**Std. Dev.** (%)	**Skewness**	**Kurtosis**	**Jarque-Bera**	**ARCH-LM**
USA	1,81	12,39	-12,17	17,77	0,12	7,02	247,24***	66,84***
Europe	6,67	10,64	-10,87	18,30	-0,51	5,57	116,84***	45,52***
Japan	-1,26	10,43	-11,53	21,87	-0,04	3,80	9,89***	1,76
EM	10,18	7,49	-10,90	19,45	-0,76	4,22	57,21***	15,15***
FM	24,12	6,71	-5,77	14,17	-0,01	3,99	9,84***	37,34***
Bond	9,28	4,04	-3,43	10,02	-0,05	2,83	0,3	9,54*
Gold	17,19	5,72	-8,63	17,53	-0,49	4,02	11,68***	6,96

The crisis period.

Market	**Mean** (%)	**Max** (%)	**Min** (%)	**Std. Dev.** (%)	**Skewness**	**Kurtosis**	**Jarque-Bera**	**ARCH-LM**
USA	4,15	7,88	-15,73	19,50	-1,06	7,33	328,12***	34,22***
Europe	-0,39	19,64	-15,93	26,95	-0,17	6,02	130,72***	101,66***
Japan	-0,93	12,12	-17,92	21,70	-0,80	9,19	578,12***	21,29***
EM	3,15	21,28	-17,96	28,78	-0,50	7,99	366,48***	77,81***
FM	-1,50	9,22	-16,58	18,51	-2,02	13,04	1653,68***	78,63***
Bond	4,21	6,62	-6,24	11,88	-0,14	3,96	14,08***	36,13***
Gold	9,82	13,74	-13,59	20,74	-0,22	5,89	121,12***	9,86*