Some Empirical Notes on Recent Perspectives in International Portfolio Management

Alper Ozun*, Mehmet Turk**, Umit Cetkin***

Abstract

This paper examines the impacts of volatility in high yield US corporate bond prices on US, non-US and emerging market returns within a multivariate GARCH model framework. By using daily closing values of various financial instruments in different clusters, it is empirically pointed out that the volatility spillovers from the high yield US corporate bonds to different instruments in the world markets are quite high. Furthermore, different time spans are taken into consideration to examine if these effects have been changed recently. A multivariate GARCH analysis shows that the repricing in credit has propagated largely to major fixed income markets, overnight rates, and more recently to FX. In equities however, the impact has been relatively small so far. The empirical findings show that achieving portfolio diversification is not as easy as it was in the past by using some financial instruments.

Key words: Portfolio diversification, multivariate GARCH, volatility spillovers, emerging markets, Turkey, Brazil, credit spreads, US high yield corporate bonds.
JEL Classification: C51, G15.

1. Motivation

International portfolio investments have been used as a fundamental tool for portfolio risk hedging. However, recent developments in the world economy, growth in international money and information flows have created a global financial environment where there is a high interaction and dependency among the individual markets. First of all, the Asia crisis in 1987 showed that the world economy had some common drivers such as liquidity and global risk appetite. In addition, rapid information flows, computer-based complex analysis methods and liberalization in the emerging markets have moved the economies closer. In that global climate, it is a question for the investors if international portfolio diversification is still providing risk hedging.

In this research paper, we investigate the impact of high yield US corporate bond markets on three clusters including US markets, non-US markets comprising Germany and Japan, and emerging markets comprising Brazil and Turkey with a specific focus and covering both interest rate and equity risks.

US high yield corporate bonds have taken an important part of the portfolios recently, and institutional investors have been utilizing the US high yield markets in order to actively allocate the assets. The challenging part of asset allocation using the high yield corporates is that the interest rate risk is high and the portfolio also faces credit-spread risks. While portfolio diversification could eliminate the credit spread risk of individual issues in large part, severe credit events and unfavorable shocks in economic fundamentals tend to affect credit spreads of all issuers in the same direction and could generate considerable unexpected losses on well-diversified positions. In this situation, understanding the nature of credit spread risks generated by macroeconomic shocks should be a primary focus of the corporate bond investors' attention.

On the emerging markets side, first of all, as the developing countries have matured, policy makers try to eliminate the historical mismatch between liabilities denominated in the US dollar and revenues denominated in local currency. The emerging economies have increasingly utilized their own

* Market Risk Group, Risk Management Department, Is Bank of Turkey, Turkey.
** International Markets, Treasury Department, Is Bank of Turkey, Turkey.
*** International Markets, Treasury Department, Is Bank of Turkey, Turkey.

local capital markets as a source of funding. On the other hand, international investors are comfortable with emerging markets credits, which are eager to move into the newer local markets in search of further opportunities given the economic improvements and increase in credit quality within the asset class. Those developments have created a liquid but global economy depending on local bond markets in the emerging economies. The amount of emerging market debt is about over 4 trillion USD with annual trading volumes of over 5 trillion, excluding FX and derivatives (CDS) markets. Local currency denominated bonds make up approximately 80% of all emerging market debt outstanding, a fact that is often surprising to international investors.

A simple correlation analysis reveals that the effect of US high yield corporate bonds to non-US cluster has increased in the last one year compared to the last 4 years. However, its effect on US markets and emerging markets has been somewhat more puzzling. The table below summarizes the daily price correlation between US high-grade credit and various other asset classes over the past year against a longer 4-year sample.

Table 1

Correlations against High Yield US Corporate Bond Index Price

	Last 1 Year	**Last 4 Years**
US Markets		
Short Rates O/N	0,70	0,46
10 Year Bonds	-0,08	0,38
Equities (Dow-Jones)	0,89	0,81
USD TWI	-0,64	-0,84
NON-US Markets		
German Short Rates O/N	0,94	0,24
German 10 Year Bonds	0,51	-0,13
German Equities (DAX)	0,82	0,66
Japan Short Rates O/N	0,89	0,66
Japan 10 Year Bonds	-0,15	0,60
Japan Equities (Nikkei-225)	0,70	0,57
Emerging Markets		
Turkish Lira	0,37	-0,41
Brazilian Real	-0,51	-0,62
Turkish CDS	0,16	-0,75
Brazilian CDS	-0,75	-0,84
Turkish Equities (ISE-100)	0,20	0,57
Brazilian Equities (Bovespa)	0,80	0,67

Starting with fixed income markets, it is shown in the table that over the past year the correlation between credit spreads and major yields has turned more negative compared to 4-year period except for Germany. The analysis indicates that bonds outside the US appear to be slightly more correlated to US credit worries than US treasuries. European fixed income can be assumed to be relatively more sensitive to jumps in the global bond premium.

In currency markets, the correlation between high yield credit and USD Trade Weighted Index has been negative over the past periods. That is, wider spreads are now clearly associated with a broad dollar weakness. This behavior is consistent with the significantly stronger relationship between credit and rates, and it may suggest that credit fears may have affected the dollar through lower interest rate differentials.

On the other hand, the correlation between global equities and US high yield spread has increased sharply. Brazilian equities remain sensitive to US credit markets, although Turkish equities are more driven with the hot money flows so considerably less affected by the US credit spreads in the recent months. Turkey seems to move with her own dynamics that is affected by capital flows into the financial system in last year. Non-US major equities have become more sensitive to credit spreads. Finally, US equities still seem to be quite sensitive to high yield spreads, although to a lesser extent than before.

In practice, it has been observed that emerging market CDS has a moderate spillover recently; spreads move moderately wider back to levels prevailing in early May of 2006 in which a small and short global turmoil appeared, and its correlation with US credit has moved to positive territory for Turkish CDS's whereas for Brazil the change is not significant and still it seems to be negatively correlated in spread terms.

With those observations in the markets discussed above and existing literature in finance, we are motivated to examine the volatility spillover effects of the US credit markets over the world financial markets. In order to see the effects in a unified perspective, we choose to apply multivariate GARCH methodology. In addition, we use both 1-year data and 4-year data to see if the spillover, if any, changes over time.

2. Literature Review

Empirical researches on market dependencies are motivated with the perspective of portfolio diversification. Low dependency among markets can be used as a natural hedging technique. Butler and Joaquin (2002) empirically show how the change in co-movement of financial markets influences the performance of a diversified portfolio without dynamic rebalancing.

Early research on dependency between markets concentrates on one-way and bivariate transmission of the volatility from center to the periphery, in other words, from the US markets to the emerging ones. Empirical works of Arshanapalli and Doukas (1993), King and Wadhwani (1990), Lee and Kim (1993) showing the US financial market dominance on the dependency of the global markets can be given as the main examples. In the early studies, the dependency between advanced and emerging markets is statistically significant but at low level.

On the other hand, recent empirical evidence with various methodologies has been shown that the dependency of emerging markets on the advanced markets is growing. For example, Frankel and Roubini (2003) empirically show that the IFC Global index of equities declines by 17 points and Emerging Markets Bond Index (EMBI) decreases 34% when the real G-7 interest rate increases 1 point. Dailami, Masson and Padou (2005) point out that a 200 bps increase in US short-term interest rates causes emerging market spreads to decrease between 6 bps to 65 bps, depending on debt/GDP ratios of the economies under examination. Ozun (2007a) also shows that interest rates yield curve in US Dollar has effective transitions in returns of world equity indexes. In another empirical paper, Ozun (2007b) states that volatilities in the US stock markets have strong impact on Turkish and Brazilian stock returns. Chukwuogor (2007) investigates the general patterns of recent stock market returns and the volatility of such returns using 40 global stock indexes of countries classified into developed and emerging markets. He shows that there is evidence of negative and low correlation of returns between the US stock markets and many global stock markets implying opportunities and dynamics for enhanced return through diversification in global portfolio investments.

Those researches cited above deal with one-way transmission of dependency among markets. They examine the effects of the advanced markets on the emerging markets in a sense of centralization point of view. As explained in the introduction, rapid information flow, deregulations and high liquidity in the developing countries make them be closer to the advanced markets in terms of financial climate. From that perspective, some recent researches have focused on the interdependency rather than one way dependency among the financial markets. A potential methodology to examine interdependency among selected markets is the MGARCH model.

MGARCH models can be used for dynamic asset pricing models, volatility transmission between assets and markets and futures hedging and value-at-risk. The examination of the relations between the volatilities and covolatilities of several financial markets is the most popular application of MGARCH models. According to Bauwens, Laurent and Rombouts (2006) following three questions can be answered by using the MGARCH models: i) Is the volatility of a market transmitted to another market directly (in that case, the lagged conditional variance of the market is present in the conditional variance of the other) or indirectly (in that case, it enters in the other asset equation)? ii) Does a market increase the volatility on another market, and by how much? iii) Is the impact the same for negative and positive shocks of the same amplitude?

Early examinations of the volatility transmission among the stock markets belong to Tse (1998) and Tay and Zhu (2000). Worthington and Higgs (2001) investigate the transmission of equity returns and volatility among Asian equity markets with MGARCH model to identify the source and magnitude of spillovers. The empirical findings imply the existence of large and predominantly positive mean and volatility spillovers. They also point out that mean spillovers from the developed to the emerging markets are not homogeneous across the emerging markets, and in addition, own-volatility spillovers are higher than cross-volatility spillovers especially for the emerging markets.

In spite of their usefulness, the MGARCH models have not been widely employed in the literature yet. Bivariate GARCH models are still dominant in the empirical researches. The comparative work of Goeij and Marquering (2004) is important for the methodological issues on the model. By examining and comparing MGARCH models with vector error correction, BEKK and FIGARCH, they show that there exists conditional covariance between stock and bond returns.

2. Data and Methodology

2.a. Data

Abbreviations used in this study are listed below:

HY	Active High Yield US Corporate Bond Index Price		
DAX	Dax Index	US10	US 10 Year Generic Bond
EUON	Eurozone O/N Rate	TWI	US$ Trade Weighted Index
EU10	Eurozone 10 Year Generic Bond	BOV	Bovespa Index
NKY	Nikkei Index	BRL	Brazilian Real
JPON	Japan O/N Rate	CBR	Brazil 5 yr CDS spread
JP10	Japan 10 Year Generic Bond	ISE	Istanbul Stock Exchange (ISE) Index
DJ	Dow Jones Index	TRL	Turkish Lira
USON	US O/N Rate	CTR	Turkish 5 yr CDS spread

Also for the multivariate garch model, the following parameters are utilized:

a) Constant
b) Arch (Volatility shock) coefficient
c) Garch (Persistence) coefficient

The dependent variable used in the study is the NASD-Bloomberg Active High Yield US Corporate Bond Index Price. We try to estimate the volatility spillover from this index to the other markets. This index is a measure of the average price change of all bonds in the index weighted by par amount. Individual bond prices are derived from the volume weighted average price of all trades reported by TRACE from the prior days trading. Prices calculated do not include accrued price. The NASD-Bloomberg Active US Corporate Bond Indices are comprised of the active (most frequently traded) fixed coupon bonds represented by NASD TRACE, NASD's transaction reporting facility that disseminates all over-the-counter secondary market transactions in these public bonds. The indices are rebalanced on a monthly basis. We have obtained the data from Bloomberg.

In this study, we utilized three multivariate clusters, US markets, non-US markets, and emerging markets composed of different financial instruments. By forming separate regression equations within each cluster, we have ran a multivariate GARCH analysis. The sample period is 02/01/2003 to 11/07/2007 with altogether n=1112 for 4 year period and the sample period is 03/01/2006 to 11/07/2007 with n=375 for 1 year period observations. Table 2 and Table 3 provide some simple descriptive statistics of daily returns of the independent parameters. Apparently, the empirical means of all processes are close to zero. The overnight rates exhibit high standard deviations as can be seen from the tables. The returns follow a pattern that resembles a GARCH process: there is a clustering of volatilities in all series, and the clusters tend to occur simultaneously. This motivates an application of a multivariate GARCH model.

All data are obtained from Bloomberg. Under our study's taxonomy, Turkey and Brazil are categorised as 'emerging' markets, German and Japan as 'Non-US' markets, with the remainder classified as 'US' markets.

Table 2

Summary Statistics of daily returns for 3 market groups (4-year period)

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Probability
HY	0,02	0,03	1,71	-1,52	0,29	-0,06	6,10	444,9	0,00
US Markets									
DJ	0,04	0,05	3,53	-3,67	0,75	-0,05	4,95	176,0	0,00
USON	0,12	0,00	27,70	-19,54	2,44	1,21	30,82	36137,9	0,00
US10	0,02	0,00	6,67	-4,22	1,28	0,46	5,26	275,8	0,00
TWI	-0,02	-0,01	1,67	-1,32	0,45	0,05	3,28	4,2	0,12
Non-US Developed Markets									
DAX	0,08	0,12	6,64	-6,34	1,22	-0,20	6,41	545,6	0,00
EUON	0,02	0,00	37,81	-35,35	4,09	1,24	34,85	47279,9	0,00
EU10	0,00	-0,02	4,21	-3,04	0,96	0,33	4,06	71,6	0,00
NKY	0,07	0,01	3,52	-5,23	1,15	-0,45	4,42	131,3	0,00
JPON	0,24	0,00	58,53	-29,60	4,60	3,87	54,48	125555,0	0,00
JP10	0,08	0,00	26,06	-14,58	2,61	1,83	20,12	14197,0	0,00
Emerging Markets									
BOV	0,14	0,19	5,16	-6,86	1,60	-0,28	3,77	41,9	0,00
BRL	-0,05	-0,09	5,45	-2,95	0,82	0,91	8,07	1343,6	0,00
CBR	-0,29	-0,29	14,84	-23,79	2,99	0,18	8,42	1367,1	0,00
ISE	0,13	0,20	10,96	-13,34	1,93	-0,43	8,17	1270,7	0,00
TRL	-0,02	-0,06	5,42	-4,42	0,88	0,78	8,86	1704,1	0,00
CTR	**-0,14**	**-0,27**	**21,45**	**-12,21**	**3,03**	**1,03**	**8,23**	**1463,5**	**0,00**

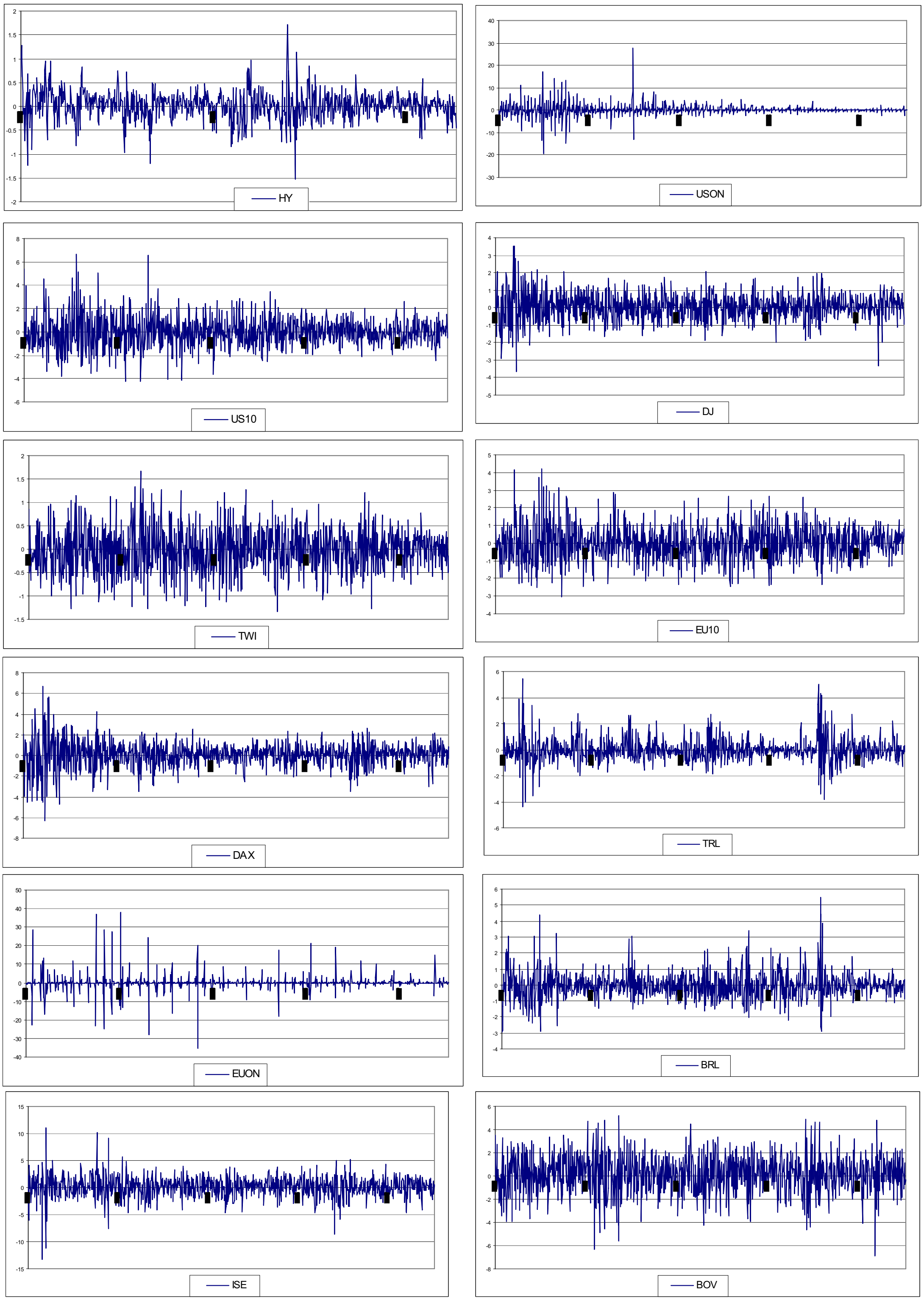
Table 3

Summary Statistics of daily returns for 3 market groups (1-year period)

	Mean	Me-dian	Maxi-mum	Mini-mum	Std. Dev.	Skew-ness	Kurto-sis	Jarque-Bera	Probability
HY	0,02	0,02	0,84	-0,68	0,22	0,00	3,85	11,3	0,00
US Markets									
DJ	0,06	0,06	1,96	-3,35	0,61	-0,59	6,18	180,3	0,00
USON	0,05	0,00	3,75	-2,54	0,56	0,93	11,45	1168,9	0,00
US10	0,01	0,00	2,60	-2,50	0,82	0,01	3,01	0,0	1,00
TWI	-0,02	0,00	1,20	-1,26	0,36	-0,11	3,55	5,5	0,06
Non-US Developed Markets									
DAX	0,10	0,17	2,61	-3,46	0,92	-0,49	4,10	33,9	0,00
EUON	0,16	0,00	21,38	-9,32	2,33	4,42	40,32	22979,8	0,00
EU10	0,05	0,05	2,67	-2,42	0,81	-0,05	3,24	1,0	0,59
NKY	0,03	0,02	3,52	-4,23	1,14	-0,38	4,12	28,7	0,00
JPON	0,70	0,00	58,53	-29,60	6,96	3,16	29,72	11779,4	0,00
JP10	0,07	0,00	5,03	-5,29	1,62	-0,09	3,27	1,7	0,42
Emerging Markets									
BOV	0,13	0,16	4,84	-6,86	1,51	-0,26	4,68	48,4	0,00
BRL	-0,03	-0,09	5,45	-2,90	0,81	1,61	12,45	1557,3	0,00
CBR	-0,29	-0,01	12,19	-2,38	3,45	-0,45	9,38	648,1	0,00
ISE	0,05	0,08	5,10	-8,67	1,73	-0,56	4,81	71,1	0,00
TRL	0,00	-0,02	5,02	-3,85	0,92	0,96	9,37	691,7	0,00
CTR	**-0,02**	**0,00**	**12,62**	**-8,42**	**2,91**	**0,65**	**4,72**	**72,9**	**0,00**

The data used in the analysis are daily log-returns of each variable calculated from close-to-close values. In literature the higher frequency daily return data are preferred to the lower frequency data such as weekly and monthly returns. The reason for this is that longer horizon returns can obscure transient responses to innovations which may last for a few days only (Elyasiani *et al*., 1998: 94).

Table 2 and 3 present descriptive statistics for each return series for the 4-year period and 1-year period. Sample means, medians, maximums, minimums, standard deviations, skewness, kurtosis, the Jacque-Bera statistics and p-values are reported for the daily dollar returns. Over the 4-year calculation period the highest mean returns are in Japanese overnight rates (0.24%) and Bovespa (0.14%) while the lowest mean returns are in Brazil CDS spreads (-0.29%), and Turkish CDS spreads (-%0.14). Daily returns are higher across the Non-US developed markets than the other clusters.


HY
USON
US10
DJ
TWI
EU10
DAX
TRL
EUON
BRL
ISE
BOV

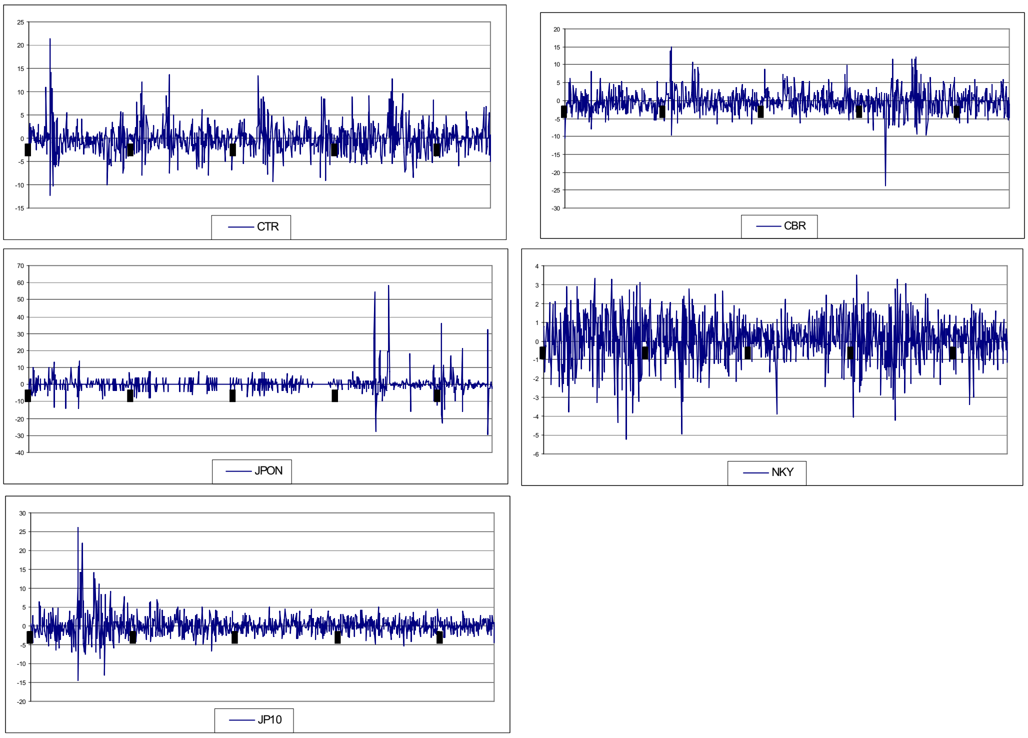


Fig. 1. US markets, Non-US markets and Emerging Markets daily returns (2003 to July 2007)

As anticipated, volatility (as measured by standard deviation) has dropped in the last year compared to previous 4 years except for the three following financial instruments: Japanese overnight rates, Brazilian CDS's and Turkish Lira. Volatility is higher in the Non-US and emerging markets against the US markets. The three markets display volatility ranging from 0.36 (US$ TWI) to 6.96 (Japanese overnight rates). The standard deviations for the emerging markets on the other hand range from 0.81 (Brazilian Real) to 3.45 (Brazilian CDS). The volatility of returns can be observed from the plots of daily returns for each series in Figure 1.

The distributional properties of the return series generally appear to be non-normal. All the stock indices have negative skewness, while in contrast the overnight indices are positively skewed. The kurtosis in all markets, both US, non-US and emerging, exceeds 3 and exhibits leptokurtic distribution.

The Jarque-Bera statistic and corresponding *p*-value are used to test the null hypotheses that the daily returns are normally distributed. With most *p*-values equal to zero at four decimal places, we reject the null hypothesis that returns for developed and emerging Asian markets are well approximated by the normal distribution. The exceptions for these being US 10 year bond, Eurozone 10 year bond, Japanese 10 year bond and US$ TWI.

2.b. Multivariate GARCH Methodology

Time dependency in financial time series is in general modelled with derivatives of ARCH process of Engle (1982). ARCH process models a time-varying conditional variance as a linear function of past squared residuals and of its past values. The Generalized ARCH known as GARCH model introduced by Bollerslev (1986) captures the additional probability mass in the tails within the distributions. The GARCH models have been reshaped under additional assumptions. Exponential GARCH (Nelson, 1991), GJR GARCH (Glosten, Jagannathan, and Runkle, 1993), IGARCH (Engle and Bollerslev, 1986), FIGARCH (Baillie, Bollerslev and Mikkelsen, 1996) and HY-

GRACH (Davidson, 2001), have been employed for the volatility modelling of financial time series. In general, empirical findings in the literature support the argument that the GARCH models are successfully able to capture the volatility in the financial time series (Darrat and Benkato, 2003; Ameer, 2005).

The multivariate GARCH (MGARCH) models, on the other hand, are used to parameterize the conditional cross-moments. In this research paper we use MGARCH model to see the conditional cross-moments of selected financial markets by taking into account time-varying volatility spillover effect. The following conditional expected return equation, which models each market's own returns and the returns of other markets lagged in one day is used by following (Worthington and Higgs, 2001). In fact, the equation is derived from random walk with noise model but deals with cross-markets interaction.

$$R_t = \alpha + AR_{t-1} + \varepsilon_t \tag{1}$$

In Equation (1), R_t is an $n \times 1$ vector of daily returns at time t for each market and $\varepsilon_t / I_{t-1} \sim N(0, Ht)$. The vector of random errors in the equation, namely ε_t, is the innovation for each market at time t with its corresponding $n \times n$ conditional variance-covariance matrix, namely, H_t. The information set, I_{t-1}, is the information in the market place at time $t-1$. The $n \times 1$ vector labelled with α represents long-term drift coefficients. From that notation, a_{ij} of the matrix A shows the degree of mean spillover effect across markets. In financial words, it represents today's return in market i that is used to predict tomorrow's returns in market j. The estimates of the elements of A provide measures of the significance of the own and cross-mean spillovers. That multivariate process enables the measurement of the effects of the innovations in the mean market returns of one financial time series on its own lagged returns and those of the lagged returns of other markets (Worthington and Higgs, 2001).

We can use various models to estimate the conditional variance-covariance matrix of equations. By following Worthington and Higgs (2001), we choose BEKK model, which employs variance-covariance matrix of equations depending on the squares and cross products of innovation ε_t and volatility H_t for each market lagged one period. The BEKK model enables the conditional variances and covariances of the financial markets to influence each other. Its advantages can be listed as i) not requiring the estimation of a large number of parameters, ii) ensuring the condition of a positive semi-definite conditional variance-covariance matrix in the optimisation process, iii) being a necessary condition for the estimated variances to be zero or positive (Karolyi, 1995; Worthington and Higgs, 2001).

The BEKK parameterization for the MGARCH model can be explained as in Equation (2):

$$Ht = B'B + C'\varepsilon_t \, \varepsilon_{t-1}C + G'H_{t-1}G \,. \tag{2}$$

In the equation, b_{ij} are elements of an $n \times n$ symmetric matrix of constants B, the elements c_{ij} of the symmetric $n \times n$ matrix C measure the degree of innovation from market i to market j, and the elements g_{ij} of the symmetric $n \times n$ matrix G indicate the persistence in conditional volatility between market i and market j. This can be expressed for the bivariate case of the BEKK as:

$$\begin{bmatrix} H_{11t} & H_{12t} \\ H_{21t} & H_{22t} \end{bmatrix} = B'B + \begin{bmatrix} H_{11t} & H_{12t} \\ H_{21t} & H_{22t} \end{bmatrix}' \begin{bmatrix} \varepsilon^2{}_{1t-1} & \varepsilon_{1t-1} & \varepsilon_{2t-1} \\ \varepsilon_{2t-1} & \varepsilon_{1t-1} & \varepsilon^2{}_{2t-1} \end{bmatrix} \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} + \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix}' \begin{bmatrix} H_{11t-1} & H_{12t} \\ H_{21t-1} & H_{22t-1} \end{bmatrix} \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix}. \tag{3}$$

In Equation (3), instead of examining b_{ij}, c_{ij} and g_{ij} individually, the functions of the parameters constituting the intercepts and the coefficients of the lagged variance, covariance, and error terms are under co-examination (Kearney and Patton, 2000; Worthington and Higgs, 2001). Under the assumption of normally distributed random errors, the log-likelihood function for the MGARCH model can be written as in Equation (4):

$$L(\theta) = -\frac{Tn}{2} + \ln(2\pi) - \frac{1}{2}\sum_{t=1}^{T} (\ln|H_t| + \varepsilon'_t |H^{-1}{}_t| \varepsilon_t) \,. \tag{4}$$

In Equation 4, T is the number of observations, n is the number of financial time series, θ is the vector of parameters that should be estimated.

The Ljung-Box Q statistic is employed to test for randomness in the noise terms for the estimated MGARCH model. The Ljung-Box Q statistic is shown in Equation (5) where $r(j)$ is the sample autocorrelation at lag j received from the noise terms and T is the number of observations. Q is asymptotically distributed as χ^2 with (p - k) degrees of freedom and k is the number of explanatory variables.

$$Q = T(T+2)\sum_{j=1}^{P}(T-j)^{-1}r^2(j)\,. \tag{5}$$

The next part discusses the empirical findings in terms of both theoretical and portfolio management perspectives.

3. Empirical Evidence

In terms of volatility spillover from US corporate high yield sector to other markets, the most striking evidence is that the spillover effect has increased in most of the sectors which indicates that the portfolio diversification benefits has been decreasing. The spillover has increased most in the US 10 year bond among the US markets in the last year (0.51) compared to 4 year average (0.01), and its persistency has increased to 0.66 from almost zero levels. Also in terms of persistency of volatility the US high yield sector has gained importance for the overnight rates, which has reached to 0.51 in the last year.

Table 3

Estimated Coefficients for variance covariance equations (US markets)

	1 YEAR					4 YEARS				
	HY (i=1)	DJ (i=2)	USON (i=3)	US10 (i=4)	TWI (i=5)	HY (i=1)	DJ (i=2)	USON (i=3)	US10 (i=4)	TWI (i=5)
b(i1)	-0,02					0,05				
b(i2)	-0,10	0,17				-0,03	-0,02			
b(i3)	0,57	-0,02	0,00			0,03	-0,04	0,09		
b(i4)	0,00	0,00	0,00	0,00		-0,01	0,01	0,02	-0,05	
b(i5)	0,00	0,00	0,00	0,00	0,00	0,00	-0,01	0,01	0,00	0,00
c(i1)	0,30	0,14	0,29	0,51	0,15	0,29	0,04	0,00	0,01	0,03
c(i2)	0,00	0,14	0,15	0,08	0,00	0,09	0,08	0,00	0,03	0,04
c(i3)	0,01	0,03	0,95	0,08	0,05	0,05	0,04	0,36	0,05	0,02
c(i4)	0,00	0,02	0,04	0,06	0,01	0,02	0,02	0,00	0,10	0,08
c(i5)	0,04	0,14	0,45	0,53	0,04	0,02	0,03	0,01	0,02	0,13
g(i1)	0,83	0,31	0,51	0,66	0,09	0,93	0,01	0,00	0,00	0,02
g(i2)	0,02	0,87	0,12	0,53	0,02	0,09	0,98	0,00	0,01	0,03
g(i3)	0,03	0,15	0,11	0,02	0,10	0,04	0,00	0,95	0,00	0,02
g(i4)	0,10	0,30	0,17	0,48	0,11	0,02	0,02	0,00	0,99	0,00
g(i5)	0,05	0,13	0,12	0,34	0,96	0,01	0,00	0,00	0,01	0,98

The effect of US corporate high yield sector on the non-US markets has increased in the last year as well, especially on the Eurozone overnight rates (1.87) and Nikkei index (0.83). One of the surprising results is that the persistency levels for all these sectors have increased except Eurozone overnight rates. So when evaluating the effect, it can be suggested that however the high yield sector price volatility effects the eurozone overnight rates highly, the effect for this is proved to be temporary for this index. While Japanese market has been more affected by the volatility changes in high yield bonds in the last year in both equity and bond markets, the volatility persistence of German market increased in equity and bond markets, and slightly decreased from 0,23 to 0,15 in interest rates.

Table 4

Estimated Coefficients for variance covariance equations (Non-US markets)

	1 YEAR							4 YEARS						
	HY (i=1)	DAX (i=2)	EUON (i=3)	EU10 (i=4)	NKY (i=5)	JPON (i=6)	JP10 (i=7)	HY (i=1)	DAX (i=2)	EUON (i=3)	EU10 (i=4)	NKY (i=5)	JPON (i=6)	JP10 (i=7)
b(i1)	0,00							0,03						
b(i2)	-0,02	0,00						0,05	0,11					
b(i3)	-0,02	0,03	-0,50					-0,10	0,01	-0,07				
b(i4)	0,60	0,00	-0,03	0,00				-0,12	-0,04	0,09	0,01			
b(i5)	0,01	-0,13	-0,05	0,57	0,07			-0,02	-0,06	0,05	1,09	0,11		
b(i6)	-0,03	0,29	0,35	0,00	-0,01	-0,02		0,04	0,11	0,04	0,03	-0,02	-0,01	
b(i7)	-0,16	0,00	-0,12	0,34	2,63	-0,02	0,68	0,07	0,00	0,03	0,00	2,07	-0,06	0,00
c(i1)	0,19	0,22	1,87	0,05	0,83	0,10	0,01	0,21	0,25	0,77	0,12	0,40	0,15	0,11
c(i2)	0,01	0,09	0,27	0,01	0,02	0,26	0,12	0,00	0,15	0,34	0,05	0,02	0,31	0,04
c(i3)	0,00	0,02	1,38	0,07	0,08	0,00	0,04	0,00	0,01	2,05	0,04	0,00	0,11	0,02
c(i4)	0,00	0,07	0,11	0,04	0,08	0,04	0,05	0,01	0,03	0,34	0,09	0,04	0,14	0,16
c(i5)	0,02	0,05	0,56	0,07	0,01	0,53	0,10	0,02	0,01	0,30	0,04	0,09	0,38	0,10
c(i6)	0,00	0,00	0,00	0,01	0,02	0,76	0,01	0,00	0,00	0,01	0,00	0,01	0,71	0,01
c(i7)	0,00	0,05	0,23	0,01	0,01	0,30	0,12	0,00	0,01	0,03	0,02	0,00	0,10	0,12
g(i1)	0,99	0,10	0,15	0,23	0,32	0,31	0,05	0,96	0,08	0,23	0,08	0,10	0,02	0,02
g(i2)	0,01	0,99	0,03	0,05	0,03	0,13	0,02	0,00	0,98	0,09	0,01	0,01	0,03	0,03
g(i3)	0,00	0,00	0,21	0,07	0,02	0,05	0,02	0,00	0,00	0,25	0,01	0,00	0,02	0,01
g(i4)	0,01	0,08	0,05	0,96	0,02	0,14	0,10	0,00	0,02	0,17	0,98	0,00	0,05	0,04
g(i5)	0,01	0,05	0,03	0,01	0,96	0,43	0,15	0,00	0,00	0,01	0,01	0,98	0,08	0,01
g(i6)	0,00	0,00	0,02	0,01	0,01	0,64	0,04	0,00	0,00	0,01	0,00	0,00	0,59	0,00
g(i7)	0,00	0,01	0,09	0,00	0,01	0,67	0,68	0,00	0,00	0,02	0,00	0,01	0,04	0,99

In mean spillover terms, spillovers from US High Yield Bonds to Brazilian Real, Brazil CDS and Japanese Nikkei Index are statistically significant at 1% significance level over 4-year period. The biggest change over time has been observed from High Yield Bonds to Brazilian Real, which has increased from 0.09 to 0,39 and for Brazil CDS from 0.05 to 0.34. The persistency effect has increased for Bovespa index and Turkish CDS dramatically, though it is not very significant in short term, if there is any volatility that is sustained over the long term. The effects of lagged volatility persistence of US high yield bond indices over emerging markets have increased significantly in the last year compared to the last 4 years. That is, the volatility transition over long term has become more important last year with the increase of hedge funds or financial institutions heavy investments on high yielding and more risky assets with high liquidity of funds over the world capital markets.

Table 5

Estimated Coefficients for variance covariance equations (Emerging markets)

	1 YEAR							4 YEARS						
	HY (i=1)	BOV (i=2)	BRL (i=3)	CBR (i=4)	ISE (i=5)	TRL (i=6)	CTR (i=7)	HY (i=1)	BOV (i=2)	BRL (i=3)	CBR (i=4)	ISE (i=5)	TRL (i=6)	CTR (i=7)
b(i1)	0,04							0,06						
b(i2)	-0,23	0,04						-0,01	0,04					
b(i3)	-0,14	0,03	0,05					-0,03	-0,01	0,02				
b(i4)	0,28	0,20	0,00	0,29				0,03	0,41	0,10	0,07			
b(i5)	0,23	0,01	-0,58	0,00	-0,05			-0,03	0,09	-0,10	0,00	0,04		
b(i6)	-0,15	-0,02	0,12	0,03	0,00	0,00		-0,06	-0,02	-0,08	0,76	0,03	-0,10	
b(i7)	-0,01	0,44	0,07	-0,39	0,00	0,00	-0,02	-0,05	0,22	0,05	0,18	0,00	0,01	0,78
c(i1)	0,25	0,07	0,39	0,34	0,05	0,21	0,02	0,27	0,03	0,09	0,05	0,14	0,10	0,01
c(i2)	0,01	0,04	0,02	0,03	0,26	0,00	0,04	0,00	0,11	0,02	0,08	0,05	0,01	0,10
c(i3)	0,05	0,08	0,04	0,33	0,30	0,05	0,17	0,00	0,05	0,25	0,06	0,02	0,03	0,02
c(i4)	0,00	0,03	0,03	0,00	0,03	0,02	0,18	0,00	0,03	0,02	0,14	0,04	0,01	0,07
c(i5)	0,02	0,01	0,00	0,06	0,12	0,02	0,01	0,00	0,03	0,01	0,05	0,15	0,01	0,27
c(i6)	0,02	0,23	0,11	0,13	0,18	0,25	0,49	0,00	0,09	0,05	0,03	0,02	0,25	0,06
c(i7)	0,00	0,02	0,04	0,13	0,00	0,05	0,12	0,00	0,01	0,00	0,07	0,02	0,02	0,29
g(i1)	0,93	0,56	0,17	0,24	0,14	0,19	0,32	0,94	0,04	0,09	0,05	0,17	0,05	0,02
g(i2)	0,01	0,96	0,00	0,09	0,07	0,02	0,04	0,00	0,96	0,02	0,01	0,04	0,01	0,05
g(i3)	0,00	0,06	0,97	0,19	0,12	0,02	0,08	0,00	0,02	0,95	0,03	0,02	0,00	0,04
g(i4)	0,00	0,00	0,00	0,98	0,02	0,00	0,05	0,00	0,01	0,01	0,94	0,03	0,01	0,03
g(i5)	0,01	0,07	0,02	0,02	0,88	0,01	0,04	0,00	0,02	0,01	0,08	0,97	0,00	0,06
g(i6)	0,00	0,12	0,01	0,08	0,00	0,95	0,17	0,00	0,04	0,02	0,01	0,00	0,94	0,07
g(i7)	0,00	0,03	0,01	0,01	0,06	0,01	0,90	0,00	0,01	0,00	0,05	0,00	0,01	0,89

With the exception of ISE index, the analysis of volatility spillover effects in emerging markets shows that US high yield bond has more explanatory effects over the future volatility shocks for the last year. Own-volatility spillover, on the other hand, decreased for all the asset classes in the last year. The increase of interaction of emerging markets and higher capital mobility may be one reason of own-volatility spillover decrease and more volatility transition among the markets.

The own-volatility persistence that is examined by observation of the diagonal values of GARCH effects indicates that the most consistent effect is on the emerging markets with the lowest in ISE (0,88) in 1 year period, and Turkey CDS (0,89) in 4 year period. All other emerging market assets have more than 0,90 own-volatility persistence, which can be concluded as emerging markets sustain the past volatility changes to the volatility in the future periods. Non-US markets, on the other hand, have some exceptions for own-volatility persistence, such as it is only 0,21 for Euro O/N rate in 1 year period, and 0,25 in 4 years. The own-volatility persistence in US market decreased in last year especially in US overnight interest rates, from 0,95 to 0,11.

Other than these, it seems that some other markets have been integrated more over the last couple of years. For instance Nikkei has more spillover to Eurozone overnight rates (0.56) and Japanese overnight rates (0.53), whereas Turkish lira spillover has increased to Turkish CDS levels (0.49).

A multivariate GARCH analysis shows that the repricing in credit over the last year has propagated largely to major overnight rates especially Japanese and Eurozone overnight rates, more recently to Nikkei and Bovespa. In FX markets until recently the impact has been minimal.

Table 6

Tests for standardized residuals

		HY	BOV	BRL	CBR	ISE	TRL	CTR
1-Year Sample	**Q-Stat**	0,303	0,010	0,109	0,333	0,100	0,049	1,665
	Prob	0,582	0,920	0,741	0,564	0,752	0,825	0,197
4-Year Sample	**Q-Stat**	0,802	0,035	0,010	0,021	0,019	0,067	0,696
	Prob	0,370	0,852	0,922	0,886	0,889	0,795	0,404
		HY	**DJ**	**USON**	**US10**	**TWI**		
1-Year Sample	**Q-Stat**	0,455	0,053	0,000	0,014	0,143		
	Prob	0,500	0,818	0,999	0,907	0,705		
4-Year Sample	**Q-Stat**	0,832	0,006	0,158	0,037	0,000		
	Prob	0,362	0,941	0,691	0,847	0,990		
		HY	**DAX**	**EUON**	**EU10**	**NKY**	**JPON**	**JP10**
1-Year Sample	**Q-Stat**	0,271	0,007	0,445	0,010	0,064	0,002	0,007
	Prob	0,603	0,934	0,505	0,922	0,800	0,966	0,933
4-Year Sample	**Q-Stat**	0,971	0,000	3,495	0,117	0,026	0,000	0,000
	Prob	0,324	0,990	0,062	0,733	0,873	0,988	0,984

Regarding the Ljung-Box Q statistics in Table 6, we can reject the null hypothesis that there is autocorrelation in the standardised residuals with all of the p-values are greater than 0,05. It can be concluded that the mean return equations for all market sections, and for both 1-year period and 4-year period, are correctly specified and there remain no residuals out of the model to be characterized in the mean equations.

4. Concluding Remarks

In this research paper we examine the transmission of daily returns and volatility from US high yield sector to global markets for time period from 2003 to 2007. A multivariate generalised autoregressive conditional heteroskedasticity (MGARCH) model is used to identify the magnitude of spillovers. The whole period is divided into two sub-categor-iesy; one-year and 4-year periods to analyze if the volatility spillovers have changed in last one-year in which high liquidity and increased international portfolio investments might create dependency among market returns.

We argue that returns in high yield US corporate bonds have significant effect on the returns in the global financial markets. With that motivation, we estimate the volatility spillover from the NASD-Bloomberg Active High Yield US Corporate Bond Index Price to returns in different financial instruments within three multivariate clusters; namely US markets, non-US advanced markets, and emerging markets.

The empirical results show that not only markets but also financial instruments within the same economy have become more dependent on each other. For example, the spillover has increased most in the US 10-year bond among the US markets in the last year (0.51) compared to 4-year average (0.01), and its persistency has increased to 0.66 from almost zero levels. What is more, the effect of US corporate high yield sector on the non-US markets has increased in the last year as well. For example, for the Eurozone overnight rates, the spillover is 1.87 and it is 0.83 for the Nikkei.

The most interesting results in terms of portfolio diversification come from the emerging markets. Spillovers from US High Yield Bonds to Brazilian Real and Brazil CDS are persistent over the 4-year period. More importantly, the effects of lagged volatility persistence of US high yield bond indices over emerging markets have increased significantly in the last year compared to the last 4 years. For example, for the Brazilian Real it has increased from 0.09 to 0,39 and for Brazil CDS it has increased from 0.05 to 0.34. The ISE seems to be the least integrated market. The possible reason for that might have developments in Turkey's integration process with the EU and recent political stability, which have caused increase of hedge funds, portfolio investments and risk appetites of the global investors on Turkey.

The empirical findings have important conclusions in terms of both methodological and practical goals for portfolio risk managers. On the methodological side, it is shown that with proper methodology, it is possible to capture the integration among the markets even the instruments and markets are multidimensional and complicated. Though it has been not employed enough in the literature, the multivariate GARCH model has a proper algorithm for estimating volatility spillovers and integration of the markets. On the practical side, it is statistically shown that the markets have become more dependent on each other over the world. Even with instruments from an emerging market, if it does not have an internal dynamic as Turkey has recently had, it is not so easy to decrease portfolio risk just by using instruments from emerging markets. Due to high correlation and volatility spillovers among the markets, portfolio managers should use hedging strategies based on derivative instruments rather than diversification among different spot markets. There seems to be a domino effect among the global financial markets that makes hard to create diversified portfolios by putting eggs in different baskets.

Our research might be extended in both methodological and empirical frameworks. On the methodological side, timescale effects among the markets might be examined to see the long-run dependency among them. On the empirical side, asymmetric volatility can be modelled to find out the cross volatility stemming from the asymmetric information flows among the participants in different markets.

References

1. Ameer, R. (2005), "Integration of the South and East Asian Stock Markets, Return and Volatility Spillover from US, UK, Singapore and Hong Kong using EGARCH Model" www.papers.ssrn.com/sol3/papers.cfm?abstract_id=755071
2. Arshanapalli B. and J. Doukas (1993), "International Stock Market Linkages: Evidence from the Pre- and Post-October 1987 Period", Journal of Banking and Finance, 17, pp. 193-208.
3. Baillie, R., Bollerslev, T. and Mikkelsen, H.O. (1996) "Fractionally Integrated Generalized Autoregressive Conditional Heteroskedasticity", Journal of Econometrics, 74, pp. 3-30.
4. Bauwens, L., Laurent, S., and Rombouts, J. (2006), "Multivariate GARCH Models: A Survey", Journal of Applied Econometrics, 21, pp. 79-109.
5. Bollerslev T. (1986), "Generalized Autoregressive Conditional Heteroskedasticity", Journal of Econometrics, 31, pp. 307-327.
6. Butler, K.C. and Joaquin, D.C., (2002), "Are The Gains From International Portfolio Diversification Exag-Gerated? The Influence of Downside Risk in Bear Markets", Journal of International Money and Finance, 21, pp. 981-1011.
7. Chukwuogor, C. (2007), "Stock Markets Returns and Volatilities: A Global Comparison", Global Journal of Finance and Banking Issues, 1 (1), pp. 1-27.

8. Dailami, M. and Padou, M. (2005), "*Global Monetary Conditions Versus Country-Specific Factors In The Determination Of Emerging Market Debt Spreads*", Policy Research Working Paper Series 3626, The World Bank.
9. Darrat, A.F. and Benkato, O.M. (2003), "Interdependence and Volatility Spillovers under Market Liberalization: The Case of Istanbul Stock Exchange". Journal of Business, Finance & Accounting, 30, pp. 1089-1114.
10. Davidson, J. (2001), "Moment and Memory Properties of Linear Conditional Heteroskedasticity Models". Manuscript, Cardiff University.
11. Elyasiani, E., Perera, P., Puri, T.N., (1998), "Interdependence and dynamic linkages between stock markets of Sri Lanka and its trading partners", Journal of Multinational Financial Management, 8, pp. 89-101.
12. Engle R.F. (1982), "Autoregressive Conditional Heteroscedasticity with Estimate of the Variance of United Kingdom Inflation", Econometrica, 50, pp. 987-1007.
13. Engle, R.F. and Bollerslev, T. (1986), "*Modelling The Persistence of Conditional Variance"*, Econometric Review, 5, pp. 1-87.
14. Frankel J., and Roubini N. (2003) *"The Role of Industrial Country Policies in Emerging Market Crises"*, NBER W P No. 8634. In Economic and Financial Crises in Emerging Market Economies, edited by Martin Feldstein (University of Chicago Press: Chicago).
15. Glosten, L., Jagahannathan, R. and Runkle, R., (1993), "On the Relationship between the Expected Value and The Volatility of the Nominal Excess Return on Stocks", Journal of Finance, 48, pp. 1779-1801.
16. Goeij, P. and Marquering, W. (2004), "Modeling the Conditional Covariance Between Stock and Bond Returns: A Multivariate GARCH Approach", Journal of Financial Econometrics 2, 531-564.
17. Karolyi, G.A. (1995), A Multivariate GARCH Model of International Transmissions of Stock Returns and Volatility: The Case of the United States and Canada. Journal of Business & Economics Statistics. Vol. 13, No. 1, 11-25
18. Kearney, C. and Patton, A.J, 2000, "Multivariate GARCH Modeling of Exchange Rate Volatility Transmission in the European Monetary System", The Financial Review, Eastern Finance Association, vol. 35 (1), pages 29-48.
19. King, M.A., Wadhwani, S., (1990), "Transmission of Volatility Between Stock Markets". Review of Financial Studies, 3, pp. 5-33.
20. Lee, T.-H. and Long, X. (2005), "Copula-based Multivariate GARCH Model with Uncorrelated Dependent Errors", UCR Working Paper 2005-16. http://economics.ucr.edu/papers/
21. Nelson, B. (1991), "Conditional Heteroskedasticity in Asset Returns: A New Approach", Econometrica, 59, pp. 347-370.
22. Ozun, A. (2007a), "International Transmission of Volatility in the US Interest Rates to The Stock Returns: Some Comparative Evidence From World Equity Markets", International Research Journal of Finance and Economics, Issue 10.
23. Ozun, A. (2007b), "Are The Reactions of Emerging Equity Markets to The Volatility in Advanced Markets Similar?: Comparative Evidence From Brazil and Turkey", International Research Journal of Finance and Economics, Issue 9, pp. 220-230.
24. Tse Y. (1998), "The Conditional Heteroscedasticity of the Yen-Dollar Exchange Rate", Journal of Applied Econometrics, 193, pp. 49-55.
25. Nicholas T. and Zhen Z. (2000), "*Correlations in Returns and Volatilities in Pacific-Rim Stock Markets*", Open Economies Review, 11 (1), pp. 27-47.
26. Worthington, A. and Higgs, H. (2001) "*A multivariate GARCH analysis of equity returns and volatility in Asian equity markets*", School of Economics and Finance Discussion Papers and Working Papers Series 089, School of Economics and Finance, Queensland University of Technology.