

Dynamic inter-relationships among national equity markets

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Early studies

- Granger and Morgenstern (1970), Grubel and Fadner (1971), Ripley (1973), Lessard (1976), Panton et al. (1976) and Hilliard (1979).
 - Studied the gains from diversifying internationally.
 - focused their analysis on the correlation matrix of a set of national equity indices
 - unconditional second moments
 - Constant correlation coefficients

- A growing integration of financial markets in the 1980s
- Fama (1981, 1990), Kaul (1987), Schwert (1990), Chen et al. (1986) and Chen (1991),
- linked stock market behaviour with fundamentals;
- shocks in the latter should exert a predictable influence on stock market prices

Market interdependencies

- Jeon and Chiang (1991)
 - World market prices are linked so closely
 - “movements in prices in one national market immediately affect stock prices in foreign markets through efficient information sharing and free accessibility to markets by domestic as well as foreign investors”

- Eun and Shim (1989) and Von Furstenberg and Jeon (1989),
 - have investigated the short-run interdependence on daily equity returns using VAR.
 - “innovations in the U.S. are rapidly transmitted to the other markets in a clearly recognisable fashion...no single foreign market can significantly explain the U.S. market movements”

Financial crises

- seem to strengthen international stock market interlinkages
- Von Furstenberg & Jeon use VAR and principal components analysis on four major markets
 - “correlations among these markets increase substantially after October 1987 “

- Calvo and Reinhart (1996) investigate international correlations among emerging markets markets,
 - they found a tendency for higher correlations during the Mexican 1995 crisis period.

- Baig and Goldfajn (1998) used correlation indexes and VAR
- return inter linkages across six Asian stock markets loom larger when analysis encompasses the Asian crisis period

- the above studies do not usually recognise that national market movements may be linked via their variances and covariances (as well as through their means)

Higher moment dependency

- Being linked by their second moments, implies that markets do not necessarily have to react always in the same direction to “news” from a leading market.

- Secondly, they do not easily account for a change over time of international stock market interdependence
- NB: if markets are linked through their second moments and if those moments are time-varying, then this market dependence may change over time

- Indeed during and immediately after stock market crises correlation coefficients may well rise above historical levels

Volatility spillovers

- by treating the volatilities as time series, it will be possible to reveal any existing non-synchronous patterns in the way shocks are transmitted among markets

- Hamao et al. (1990) and Bae and Karolyi (1994) used univariate GARCH to study the transmission of volatility across international stock markets
 - current volatilities in a single market are linked to the volatility surprises in a previously open foreign market

- Theodossiou and Lee (1993) and Koutmos and Booth (1995) have extended this approach to multivariate symmetric and asymmetric GARCH

- However, it is important to distinguish between two broad sources of stock market risk associated, respectively, with **global** and **local** news (King and Wadhwani (1990), Lin et al. (1994) and Peirò et al. (1998)).

- Giannopoulos & Cifarelli (1999) studied national stock market interdependencies through the changes in their time-varying *beta* against the world index
 - price interdependence is assumed to operate via stock market **systematic volatility** rather than overall volatility
 - Only global news is responsible for cross-country price movements.

- $$\beta_t^{US} = k_1 + a_{11} \beta_{t-1}^{US} + a_{12} \beta_t^J + a_{13} \beta_{t-1}^{UK} + a_{14} \beta_{t-1}^{Fr} + a_{15} \beta_{t-1}^{Sw} + a_{16} \beta_t^{HK} + e1_t$$
- $$\beta_t^J = k_2 + a_{21} \beta_{t-1}^{US} + a_{22} \beta_{t-1}^J + a_{23} \beta_{t-1}^{UK} + a_{24} \beta_{t-1}^{Fr} + a_{25} \beta_{t-1}^{Sw} + a_{26} \beta_{t-1}^{HK} + e2_t$$

Dynamic VAR

$$R_{i,t} = \mu_{i,1}R_{i,t-1} + \sum_{j \neq i} \mu_{i,j}R_{j,t-1} + \varepsilon_{i,t}$$

$$i, j = 1, 2, 3, 4$$

$$\varepsilon_{i,t} \text{ is } N(0, h_{i,t})$$

$$h_{i,t} = \omega_i + \beta_i h_{i,t-1} + \alpha_i \varepsilon_{i,t-1}^2$$

Standardized Residuals

$$z_{i,t} = \varepsilon_{i,t} / h_{i,t}$$

To account for correlation between the standardized innovations, we adjust the innovations with the correlations by using a nonparametric estimation (Nadaraya Watson) of the conditional covariance matrix.

$$H_{i,t} = \frac{\sum_{\tau=1}^T z_{i,t} z'_{i,t} K_{\lambda}(s_{\tau} - s_t)}{\sum_{\tau=1}^T K_{\lambda}(s_{\tau} - s_t)}$$

T is the sample size

s_t is a conditioning variable

$K_{\lambda}(\cdot) = K(\cdot / \lambda) / \lambda$, with λ as the bandwidth

and $K(\cdot)$ is a kernel function

Adjusted Standardized Residuals

We decompose the conditional covariance into conditional standard deviations and correlations, and then we adjust the standardized innovations.

$$H_{ij,t} = h_{i,t}^{1/2} h_{j,t}^{1/2} \rho_{ij}, i \neq j, 1 \leq i, j \leq T$$

We obtain, $z_{i,t}^*$

Impulse Response Function

$$R_{i,t+1} = A_{i,1}R_{i,t} + \sum_{j \neq i} A_{i,j}R_{j,t} + z_{i,t}^*$$

$A_{i,j}$ are interpreted as impulse responses of the system

$z_{i,t}^*$ are the adjusted standardized residuals

The standardized residuals are orthogonalized to accommodate for a contemporaneous independence.

- Historical patterns are removed
- Allows for both volatility persistence and transmission between different markets

- The non parametric specification
 - accounts for dynamic changes in conditional covariances
 - captures what anything not explained by the GARCH
 - Ensures the H_t is always positive semidefinite
 - NB: the choice of the kernel is not so important

- The impulse response is done on the adjusted (for current market conditions) non parametric std residuals
 - Enable us to study inter linkages during volatility scenarios

Figure 1: Daily returns of equity indices (DJIA, FTSE100, NIKKEI225, and DAX) from January 1st, 1997 to January 1st, 2007.

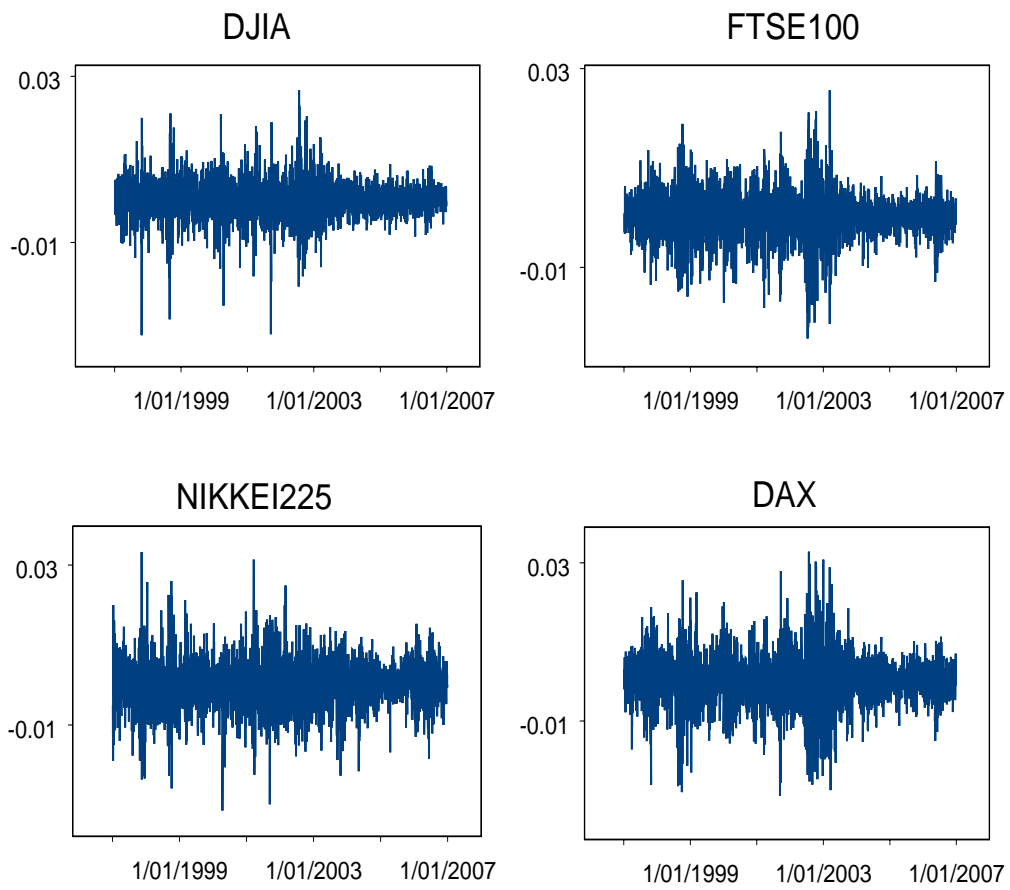
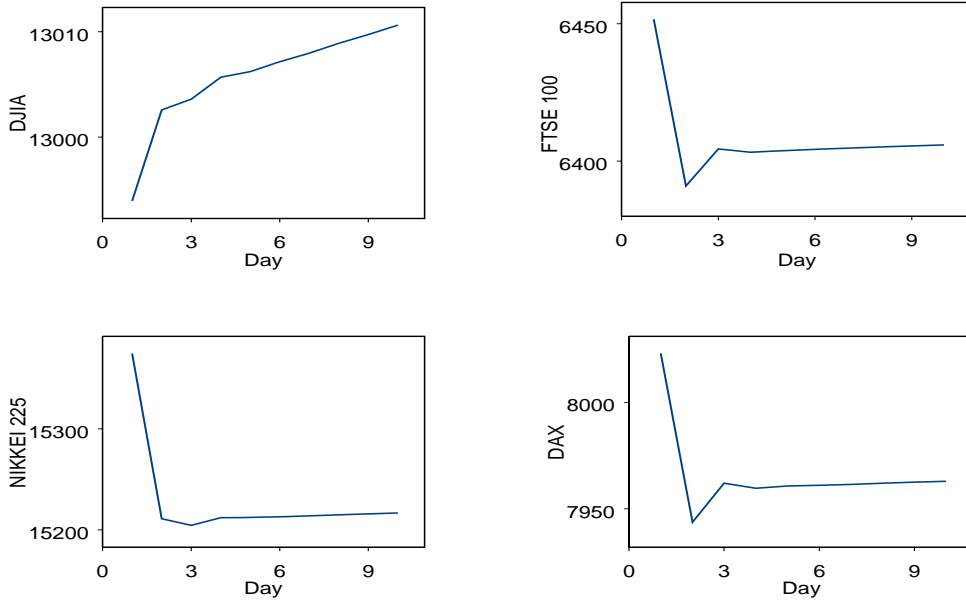


Figure 2: Impulse responses of a shock in US market on major markets

(a) Shock as 1% percentile of past conditional volatility



(b) Shock as 99% percentile of past conditional volatility

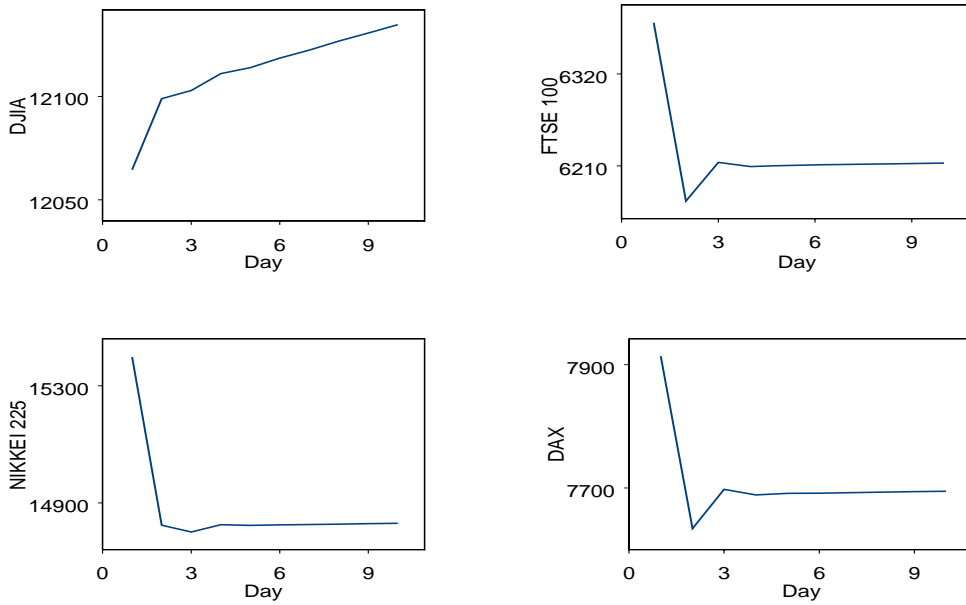


Table 1: GARCH VAR estimation results

$$R_{US,T+1} = \mu_{US}R_{US,T} + \mu_{UK}R_{UK,T} + \mu_{JP}R_{JP,T} + \mu_{BD}R_{BD,T} + \sqrt{h_{US,T+1}} z_{US,T+1}^*$$

$$h_{US,T+1} = \omega_{US} + \beta_{US}h_{US,T} + \alpha_{US}(\sqrt{h_{US,T}} z_{US,T}^*)^2$$

Coefficient	Value	Std. Error
μ_{US}	-0.0315	0.0022*
μ_{UK}	-0.0067	0.0026*
μ_{JP}	-0.0293	0.0014*
μ_{BD}	0.0368	0.0020*
ω_{US}	0.865	1.0000
β_{US}	0.929	0.0162*
α_{US}	0.064	1.4732

$$R_{UK,T+1} = \mu_{UK}R_{UK,T} + \mu_{US}R_{US,T} + \mu_{JP}R_{JP,T} + \mu_{BD}R_{BD,T} + \sqrt{h_{UK,T+1}} z_{UK,T+1}^*$$

$$h_{UK,T+1} = \omega_{UK} + \beta_{UK}h_{UK,T} + \alpha_{UK}(\sqrt{h_{UK,T}} z_{UK,T}^*)^2$$

Coefficient	Value	Std. Error
μ_{UK}	-0.108	0.0027*
μ_{US}	0.349	0.0023*
μ_{JP}	-0.0528	0.0014*
μ_{BD}	-0.0214	0.0020*
ω_{UK}	1.426	0.398*
β_{UK}	0.9036	0.0136*
α_{UK}	0.083	0.0119*

* = 5% significance level.

Table 2: GARCH VAR estimation results

$$R_{JP,T+1} = \mu_{JP}R_{JP,T} + \mu_{US}R_{US,T} + \mu_{UK}R_{UK,T} + \mu_{BD}R_{BD,T} + \sqrt{h_{JP,T+1}} z_{JP,T+1}^*$$

$$h_{JP,T+1} = \omega_{JP} + \beta_{JP}h_{JP,T} + \alpha_{JP}(\sqrt{h_{JP,T}} z_{JP,T}^*)^2$$

Coefficient	Value	Std. Error
μ_{JP}	-0.106	0.0015*
μ_{US}	0.334	0.0022*
μ_{UK}	0.099	0.0027*
μ_{BD}	0.0872	0.0020*
ω_{JP}	0.680	0.323*
β_{JP}	0.9262	0.024*
α_{JP}	0.0688	0.0050*

$$R_{BD,T+1} = \mu_{BD}R_{BD,T} + \mu_{US}R_{US,T} + \mu_{UK}R_{UK,T} + \mu_{JP}R_{JP,T} + \sqrt{h_{BD,T+1}} z_{BD,T+1}^*$$

$$h_{BD,T+1} = \omega_{BD} + \beta_{BD}h_{BD,T} + \alpha_{BD}(\sqrt{h_{BD,T}} z_{BD,T}^*)^2$$

Coefficient	Value	Std. Error
μ_{BD}	-0.091	0.0021*
μ_{US}	0.378	0.0022*
μ_{UK}	-0.080	0.0028*
μ_{JP}	-0.032	0.0015*
ω_{BD}	1.986	0.573*
β_{BD}	0.9167	0.0109*
α_{BD}	0.072	0.096*

* = 5% significance level.