The Financial Crisis of 2008: Modelling the Transmission Mechanism Between the Markets

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Outline

1. Introduction & Objectives

2. Data

3. Methodology and Results

4. Conclusions

5. Some references

1. Introduction & Objectives

- Recently we have seen how different **financial crises**, having originated in particular regions and countries, have extended geographically.

- It is important to distinguish between **interdependence** and **contagion** (Forbes and Rigobon, 2002)

- Some **definitions of contagion**:

    - "**Contagion**" refers to that part of the transmission of shocks to other countries (cross-country correlation), which is due to factors other than common shocks (Cheung, Fung and Tam (2008))

    - "**Contagion**" occurs when cross-country correlations increase during "crisis times" relative to correlations during "tranquiltimes". (World Bank definition)

Objective:

- To **model the transmission mechanism** between the most important financial markets in order to **detect** if there is **contagion** caused by the **financial crisis of 2008**

2. Data

Daily stock-price indexes of nineteen markets, from December 31, 1994 to September 30, 2009

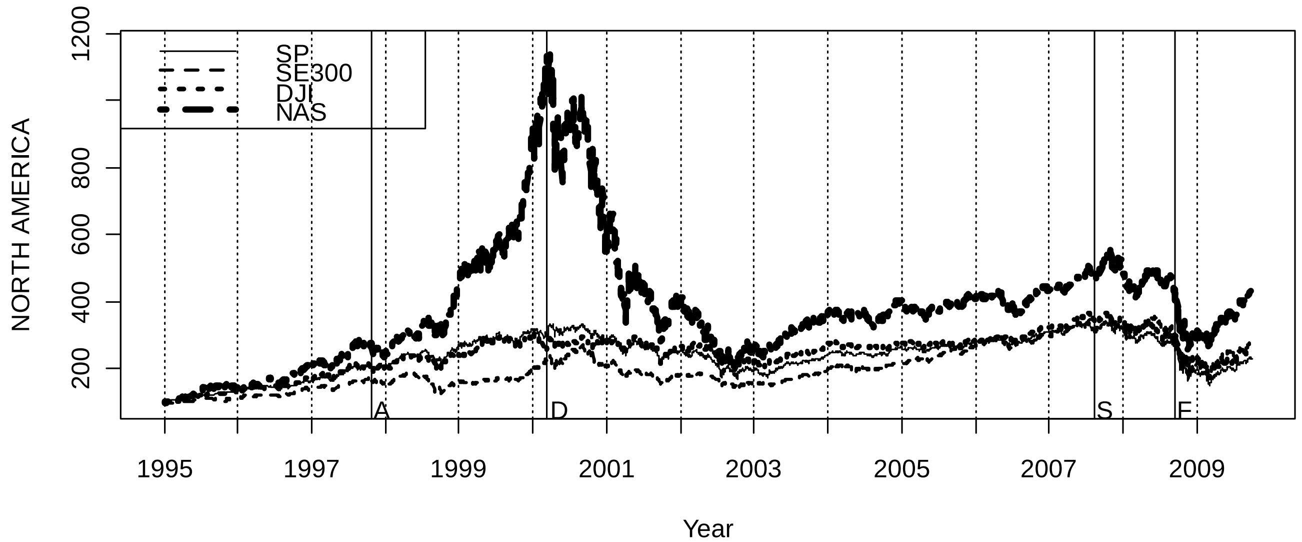
North American Indexes: Standard and Poor's 500 (SP), Dow Jones Industrial Index JONES (DJI), Nasdaq (NAS) and the Canadian Toronto Index SE300 (SE300)

European Indexes: Germany (DAX), France (CAC40), Italy (MIB30), UK (FTSE) and Spain (IBEX35)

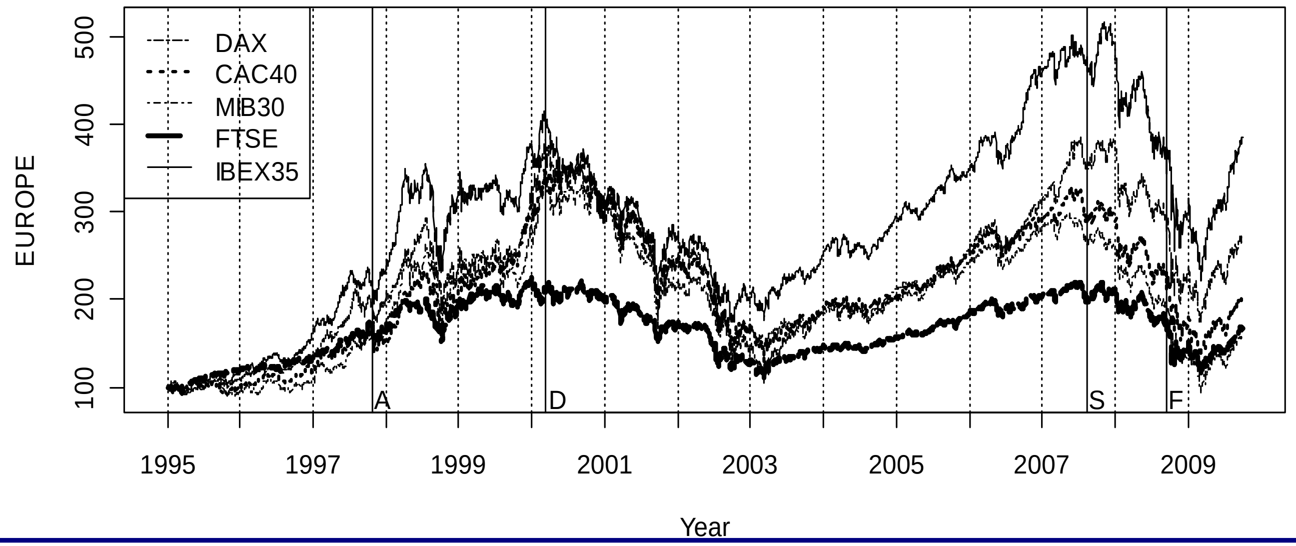
Japanese Indexes: Nikkei (NIK) and Topix (TOPX)

Southeast Asian Indexes: Hong Kong (Hang Seng Index HSI), Philippines (IPSE), Korean (KS11), Singapore (STI), Taiwan (TWII), Indonesia (JKSE), Malaysia (KLCI) and Thailand (SET)

2. Data

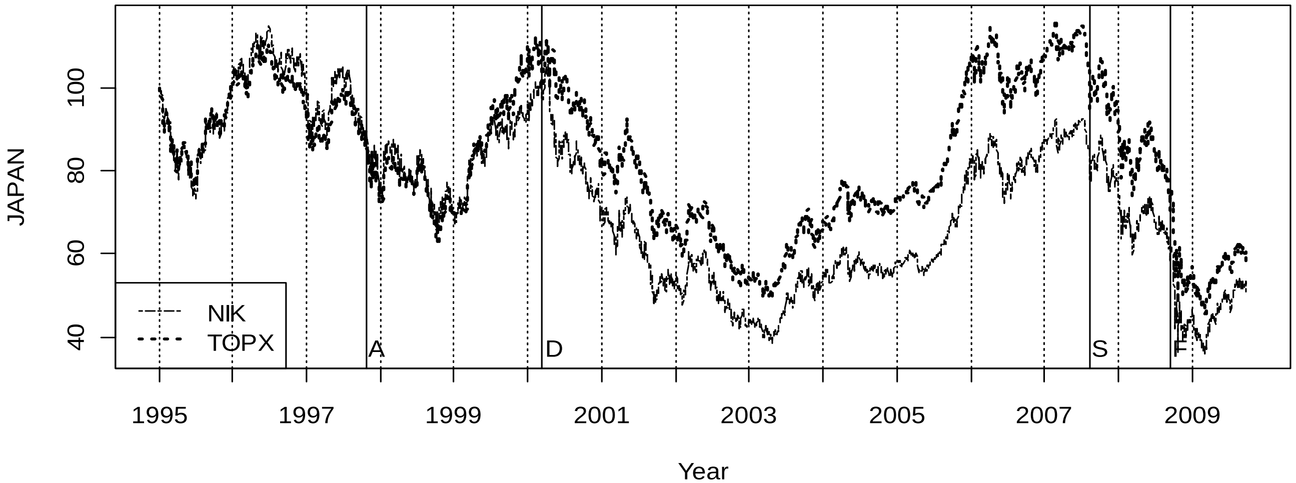


Evolution of North American stock price indexes

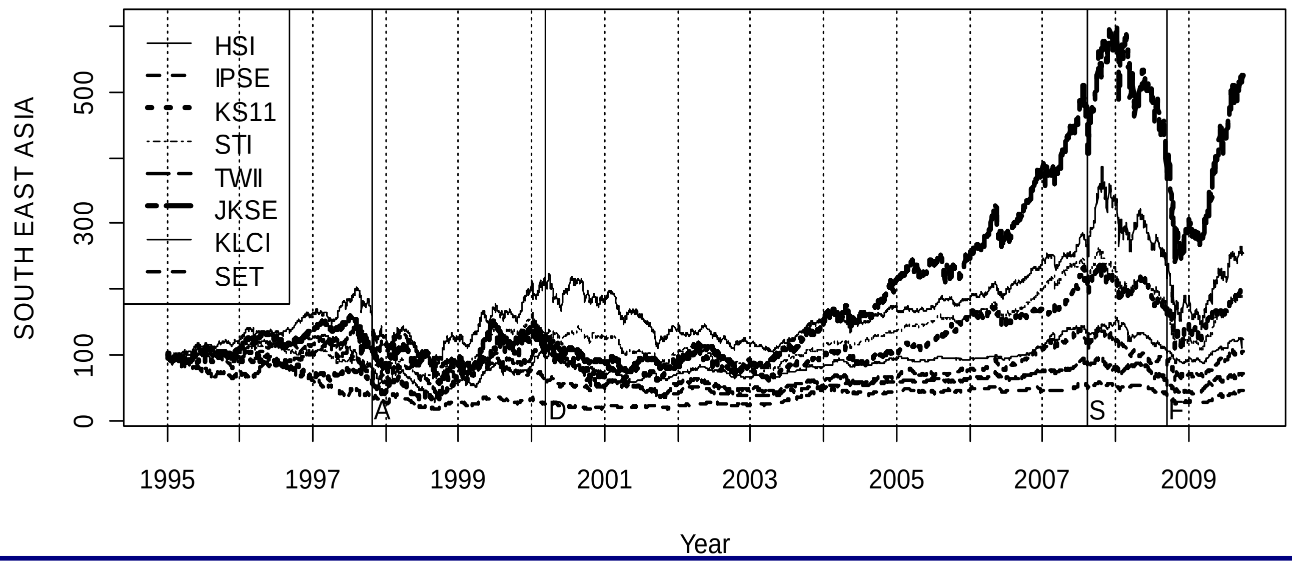


Evolution of European stock price indexes

2. Data



Evolution of Japanese stock price indexes



Evolution of Southeast Asian stock price indexes

Some exploratory results

- **Dynamics of most of the time series are similar,** except in the group of Southeast Asian Markets, where different patterns are observed at the beginning and until 2002

- **Contemporaneous Correlation:**
    - o **High correlations within** the European, North American, Japanese and Southeast Asian indexes returns
    - o **High correlations across** the European and North American markets
    - o **Truly low correlations** within the Southeast Asian index returns and across the other markets

- **Stock returns** are calculated as the first difference of the natural log of each stock price index (they are expressed as percentages)
    - They present the usual features of financial time series: non-normality, skewness and high kurtosis

3. Methodology & Results

- Time series factors analysis (**TSFA**, introduced by Gilbert and Meijer, 2005 and implemented in the TSFA CRAN package) **in order to reduce the dimensionality** (Our analysis uses nineteen series!)

- Multivariate GARCH model with dynamic conditional correlation (**DCC-GARCH**) introduced by Engel (2002) **for measuring time-varying conditional correlations**

- Detection of **changes** in the **dynamic correlations** across the markets **due to the financial crisis of 2008** by means of a dummy variable. The model is adjusted by autocorrelation coefficient and conditional heteroscedasticity,

- **Our contagion definition**: there is contagion between markets when the **dummy variable is significant and positive in the mean and/or variance of the pair-wise correlation coefficients**. Thus, contagion exists when pair-wise correlations increase during crisis times relative to correlations during peaceful times and/or are more volatile

3. Methodology & Results

- **Time series factors analysis (TSFA)** (1/3)

  - Unlike Dynamic Factor Analysis, **TSFA** obviates the need for explicitly modelling the dynamics of the process and **estimates a model** for the time series with **as few observations as possible**

  - The observations don’t need to be independent and identically distributed and the data don't need to be covariance stationary.

  - The **relationship between** the **observed time series** Y_t (M-vector of length T) **and the unobserved factors** f_t (k-vector, k<<M) is explained by the model

$$Y_t = a_t + Bf_t + e_t \qquad (1)$$

Where a_t is the M-vector of intercept parameters, B is a Mxk matrix parameters of loadings and e_t is a random M-vector of measurement errors.

3. Methodology & Results

•**Time series factors analysis (TSFA)** (2/3)

Statistics used for measuring models with varying number of factors (Wansbeek and Meijer (2000)):

- In factor analysis, the usual null model is the same as the **zero-factor model**, i.e., the model that specifies that **all observed variables are independently distributed.**

- The **comparative fit index (CFI):** It's a pseudo-R^2, based on the χ-squared statistic that compares a model to the null model. Its value is always between 0 and 1. A general rule is that CFI should be greater than 0.9 for the model containing all the representative factors.

- The **root mean square error of approximation (RMSEA).** It's a non-negative number, based also on the χ-squared statistic, that measures the lack of fit per degree of freedom. Usually a RMSEA less than 0.05 for the model containing all the factors is considered a well-fitting model.

- **Communality**: is the ***squared multiple correlation*** for the variable as dependent using the factors as predictors

3. Methodology & Results

•Time series factors analysis (TSFA) (3/3)

	Factor 1	*Factor 2*	*Factor 3*	*Factor 4*	*Communality*
SP	**0.689**	-0.016	-0.008	-0.009	**0.995**
SE300	**0.382**	0.041	0.123	0.047	0.472
NIK	-0.006	**0.668**	0.010	0.009	**0.938**
DAX	0.071	-0.008	**0.570**	0.009	**0.766**
CAC40	-0.016	0.003	**0.681**	-0.018	**0.908**
MIB30	-0.024	-0.004	**0.626**	-0.011	**0.748**
FTSE	0.013	0.013	**0.593**	0.025	**0.775**
IBEX35	-0.015	-0.006	**0.635**	0.005	**0.778**
DJI	**0.658**	-0.011	0.005	-0.006	**0.918**
NAS	**0.583**	-0.011	-0.040	-0.013	0.663
TOPX	-0.007	**0.678**	-0.001	0.019	**0.931**
HIS	0.024	0.090	0.059	**0.446**	0.573
IPSE	-0.005	0.010	-0.032	**0.394**	0.251
KS11	0.033	0.109	0.015	**0.307**	0.291
STI	0.031	0.002	0.039	**0.516**	0.563
TWII	0.008	0.075	-0.004	**0.298**	0.232
JKSE	-0.015	-0.024	-0.008	**0.474**	0.350
KLCI	-0.037	-0.037	-0.003	**0.386**	0.254
SET	0.020	-0.049	0.010	**0.453**	0.349
CFI	0.431	0.727	0.930	**0.984**	
RMSEA	0.222	0.163	0.089	**0.045**	

3. Methodology & Results

•**DCC-AGARCH model (1/3)**, fitted to the factors obtained from TSFA:

•Fit an AR(1) model to account for possible autocorrelation plus two one day-lagged factors in the mean equation (Chiang et al., 2007):

$$\mathbf{factor_{i,t} = \gamma_0 + \gamma_1 factor_{i,t-1} + \gamma_2 factor_{j,t-1} + \gamma_3 factor_{k,t-1} + \varepsilon_{i,t}} \qquad (2)$$

$t=1,\ldots,n,$ $i=1,\ldots,4,$ $\varepsilon_t|F_{t-1}\sim N(0,H_t),$ $F_t=\{factor_{i,t},\ldots,factor_{i,t-1}\}$

• $H_t=D_tR_tD_t$: conditional matrix. R_t (nxn) time varying correlation matrix, D_t (nxn) diagonal matrix of time-varying standard deviations $(h_{ii,t})^{1/2}$ obtained from the asymmetric univariate GARCH(1,1)model:

$$h_{ii,t} = c_i + a_i \varepsilon_{i,t-1}^2 + b_i h_{ii,t-1} + d_i \eta_{i,t-1}^2 \qquad (3)$$

Where $\eta_{i,t} = \max[0, -\varepsilon_{i,t}]$ picks up the asymmetric effect

3. Methodology & Results

- **DCC-AGARCH model (2/3)**, fitted to the factors obtained from TSFA:

  - The residuals $\varepsilon_{ii,t}$ have been standardized as $u_{ii,t} = \varepsilon_{ii,t} / \sqrt{h_{ii,t}}$ and employed to develop the DCC correlation specification

$$Q_t = (1-\alpha-\beta)\overline{Q} + \alpha u_{t-1}u'_{t-1} + \beta Q_{t-1} \quad (4)$$

where

$$R_t = (diag(Q_t))^{-1/2} Q_t (diag(Q_t))^{-1/2} \quad (5)$$

and

$$\overline{Q} = E[u_t u_t^{'}]$$

is the unconditional covariance of the standardized residuals

and $Q_t = (q_{ij,t})$

is the time-varying covariance matrix of the standardized residuals

The correlation estimators of Eq. (5) are of the form:

$$\rho_{ij,t} = q_{ij,t} / \sqrt{q_{ii,t} q_{jj,t}}, \qquad i, j = 1, 2, \ldots, n, \quad (6)$$

3. Methodology & Results

- **DCC-AGARCH model (3/3)**, fitted to the factors obtained from TSFA:

	Mean equation				Variance equation			
	γ_0	γ_1	γ_2	γ_3	**c**	**a**	**b**	**d**
Factor 1: North America	**0.017*** (1.86)	-0.021 (-1.26)		**0.053***** (3.66)	**0.010***** (9.32)	**0.139***** (14.37)	**0.922***** (165.03)	**-0.151***** (-14.41)
Factor 2: Japan	**-0.021*** (-1.82)	**-0.052***** (-3.65)	**0.318***** (19.80)	**0.182***** (11.14)	**0.015***** (6.77)	**0.106***** (10.75)	**0.9165***** (139.46)	**-0.078***** (-7.43)
Factor 3: Europe	**0.017*** (1.73)	**-0.178***** (-11.49)	**0.365***** (23.52)		**0.009***** (8.23)	**0.114***** (12.12)	**0.921***** (135.35)	**-0.099***** (-9.93)
Factor 4: Southeast Asia	0.008 (0.70)	**0.076***** (5.62)	**0.393***** (23.56)	**0.0852***** (5.22)	**0.019***** (15.48)	**0.130***** (24.30)	**0.880***** (187.97)	**-0.057***** (-8.29)
	Conditional correlation equation							
	α		β					
	0.007*** (9.09)		**0.991***** (919.39)					

*Note: The t-statistics are in parenthesis. ***, ** and * denote statistical significance at the 1%, 5% and 10% level.*
Mean equation: factt= γ0 + γ1factt-1 + γ2fact_Zone1,t-1 +γ3fact_Zone2,t-1 + et,
where et|Ft-1 ~N(0,Ht) and Zone1 and Zone2 refers to the North American and European effect, respectively.

3. Methodology & Results

Financial crisis of 2008 (1/3):

• The effect of the financial crisis on the DCC has been studied introducing a dummy variable for the financial crisis of 2008.

•The applied equations system is described as:

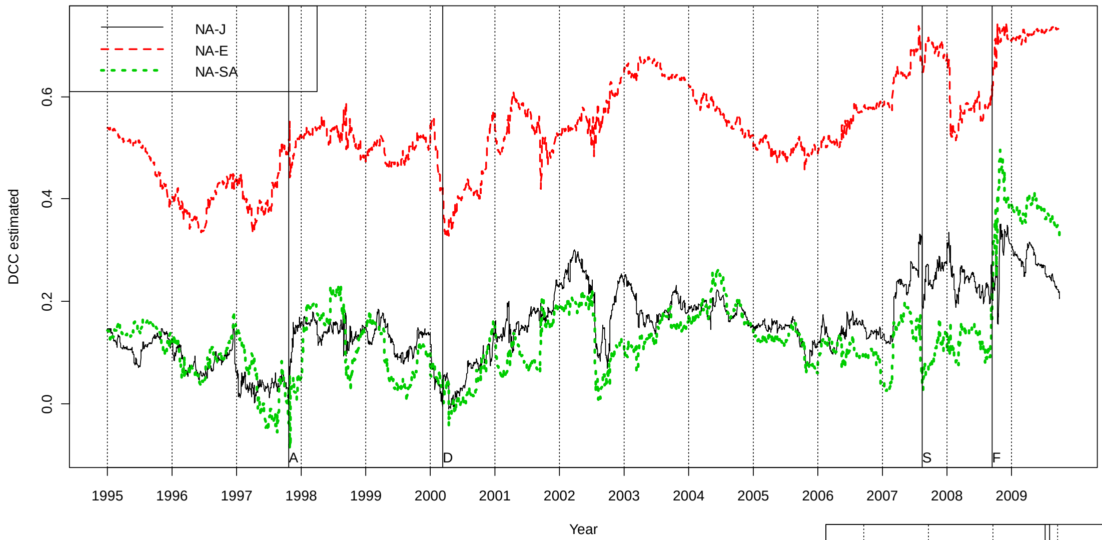
$$\rho_{ij,t} = \mu + \sum_{p=1}^{P} \phi_p \rho_{ij,t-p} + \alpha Crisis_t + e_{ij,t} \qquad (7)$$

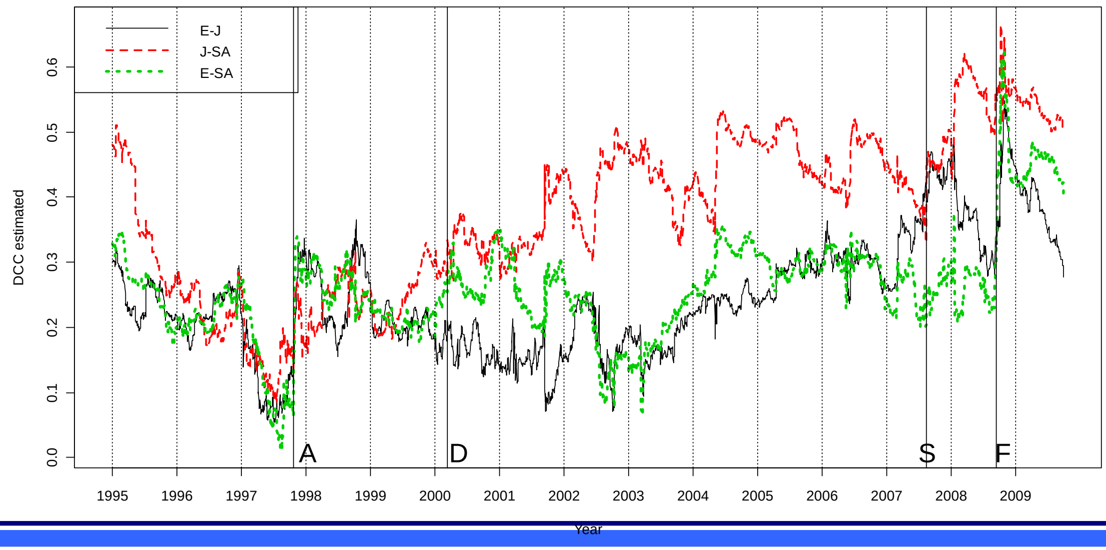
$$h_{ij,t} = \varpi_0 + \varpi_1 \varepsilon_{ij,t-1}^2 + \beta_1 h_{ij,t-1} + \delta Crisis_t \qquad (8)$$

Crisis variables are defined as **dummy variables**, indicators that take the **value 1** during the **crisis period** and **0 otherwise**. For the Global Financial crisis, $Crisis_t$ take the value 1 from 9/15/2008 to 10/14/2008.

3. Methodology & Results

Financial crisis of 2008 (2/3):





3. Methodology & Results

• Financial crisis of 2008 (3/3):

	North America/Japan	North America/Europe	North America/ Southeast Asia	Europe/Japan	Japan/ Southeast Asia	Europe/ Southeast Asia
Mean Equation						
Constant	**6.08e-04***** (2.87)	1.95e-04 (0.44)	**18.85e-04***** (6.10)	**0.001***** (4.29)	**6.18e-04**** (2.00)	**5.23e-04*** (1.92)
ρ_{t-1}	**0.996***** (865.23)	**0.999***** (1252.22)	**0.995***** (980.44)	**0.995***** (1043.36)	**0.998***** (1354.23)	**0.998***** (976.21)
Crisis$_t$	2.93e-03 (0.06)	**0.008**** (2.35)	**0.013*** (1.74)	0.006 (0.275)	0.004 (1.158)	**0.016**** (2.06)
Variance Equation						
Constant	**1.81e-06***** (24.86)	**1.49e-06***** (26.18)	**7.08e-06***** (31.83)	**3.95e-06***** (24.15)	**4.32e-06***** (10.60)	**2.73e-06***** (32.38)
ε_{t-1}^2	**0.094***** (35.88)	**0.162***** (30.62)	**0.265***** (31.91)	**0.140***** (26.12)	**0.223***** (9.69)	**0.182***** (39.29)
h$_{t-1}$	**0.885***** (344.82)	**0.828***** (176.50)	**0.692***** (108.62)	**0.800***** (120.67)	**0.764***** (51.78)	**0.801***** (216.36)
Crisis$_t$	**3.42e-05*** (1.72)	4.08e-05 (1.46)	**1.883e-04*** (1.94)	5.70e-05 (1.59)	2.86e-05 (1.51)	**1.34e-04*** (1.74)
Q(20)	22.743	30.20*	15.136	12.139	15.804	29.751*
Q^2(20)	221.699**	4.786	2.139	7.743	3.095	10.057

Note: The t-statistics are in parenthesis. ***, ** and * denote statistical significance at the 1%, 5% and 10% level.

4. Conclusions

- After applying **Time Series Factor Analysis** we find that the **nineteen stock indexes** can be **grouped** into **four regions: North-America, Japan, Europe and Southeast Asian.**

- During the Global Financial crisis, there is **contagion between** most of the regions (**North America with Japan, Europe and Southeast Asia, Europe with Southeast Asia**) but not between Japan and the rest of the geographical regions.

- Our results suggest that **Southeast Asian markets are influenced by European and North American markets** due to their size and world economic importance

- The finding that in most cases **pair-wise correlation coefficients are more volatile** and increase **during this crises** suggest that the gain from **international diversification investment** in multiple markets **is likely to be lowest** when it is more desirable.

5. Some References

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Thank you!

Merci!