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Abstract

In contrast to the existing focus on intertemporal global integration, this paper examines equity market integration from the dual perspectives of the global-regional dichotomy and the equity market regime structure. Results are obtained using an exact Kalman filter with common regimes and GARCH innovations. According to the findings, market volatility during periods of low global and European volatility tends to be dominated by idiosyncratic shocks. In contrast, common factors are generally dominant for medium-level global and European shocks. Finally, although the importance of the common factors has risen, there is no clear evidence of a global or European integration trend.

1. Introduction

A range of approaches based on market correlation coefficients, cointegration, and asset pricing theory have been used to investigate equity market co-movement and integration levels.[1] Pursuant to these approaches, researchers are able to extract information regarding the matters such as the likely response of an equity market to shocks in another market, the diversity of a global portfolio, or the success of regulatory policy aimed at increasing financial co-operation between markets.[2] Notwithstanding the extensive research on market linkages and co-movement, however, there is limited information regarding the impact of global and regional volatility regimes on co-movement levels. There is little empirical evidence, for example, concerning the contrasting current and future impact of a large global shock on European markets during periods of low European volatility versus high European volatility, or the effect of a large European-specific shock on co-movement levels given already high global volatility. In turn, little information is available regarding the relative importance of market-specific shocks on co-movement levels given particular combinations of global and European shocks.

Given the persistent nature of market volatility, a significant problem in accurately extracting such information is the difficulty in jointly estimating models with persistent regime-dependent common volatilities and persistent idiosyncratic volatilities. The problem is overcome in this paper by the construction of an augmented dynamic factor model estimated using a Metropolis-in-Gibbs sampler that effectively derives a Kalman filter with persistent common regimes and GARCH innovations (Tsiaplias, 2007).

The dynamic factor model incorporates both global and regional components. The inclusion of a regional factor in a model of asset returns provides a means for assessing regional integration by reference to the volatility attributable to the regional set and the extent to which regional volatility is priced into expected asset returns. Specifically, the

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[1] See, for example, Bekaert and Harvey (1995), Bekaert, Harvey, and Ng (2005), Longin and Solnik (1995; 2001). Kearney and Lucey (2004) provide a detailed literature review.

[2] The accuracy of the results has often been questioned. Rigobon (2003), for example, shows that the correlation coefficients predominantly used to assess co-movement or integration levels are likely to give rise to biases.

geographical nature of the factors enables consideration of both strong (global) and weak (regional) forms of integration. There is theoretical and empirical evidence supporting the hypothesis of regional integration in the European case. The establishment of the euro currency, the elimination of trade restrictions between EU members, and the delineation of EU policy regarding European financial market integration suggest the possibility of policy-driven correlation between EU markets and the associated derivation of a European (or European Union) factor set (Fratzscher, 2002). This paper assesses the co-movement impact of these structural features by jointly examining the intertemporal relevance of the European factor, and European-specific shocks, in the presence of global and idiosyncratic information.

The regime-dependent volatility of the common component provides the capacity to examine co-movement levels across the various regime combinations; including the extent to which markets are sensitive to contemporaneous and lagged regional information given shocks of a global nature. The incorporation of idiosyncratic GARCH volatility is also used to examine for co-movement and integration trends across equity markets. In this respect, output from the sampler implemented to estimate the model is used to obtain estimates of the probabilities regarding a range of hypotheses concerning (global and regional) integration trends and the strength of common co-movement during particular shocks.

The specification of time-varying idiosyncratic volatilities enables the retrieval of information regarding co-movement levels while avoiding the problem, prevalent in much of the existing research, whereby market integration (and co-movement) levels are biased by common shocks (see, for example, Rigobon, 2003). Pursuant to such criticism, an ostensible rise in the integration level may simply be a function of increased volatility in the common component. The GARCH idiosyncratic components, in addition to accounting for idiosyncratic heteroscedasticity, circumvent the possibility that a finding of increased integration is simply a consequence of a large common shock.

This paper is structured as follows. Section 2 describes the developed equity market data used for this paper, while Section 3 specifies the equity market model and estimation process. Section 4 provides an overview of the procedure adopted to evaluate market integration and co-movement levels. The relevant results concerning regime-conditional co-movement and time-varying co-movement are presented and examined in Section 5. The chapter concludes with Section 6.

2. Data

Returns data are obtained from the set of U.S.-dollar denominated MSCI Developed Country indices.[3] The indices are used to construct weekly returns during the period commencing the first week of Jan. 1980 and ending the second week of Sept. 2004 (T = 1289) for 18 of the developed countries. The 18 countries are Australia, Austria, Belgium, Canada, Denmark, France, Germany, Hong Kong, Italy, Japan, the Netherlands, Norway, Singapore, Spain, Sweden, Switzerland, the U.K., and the United States. Five of the 23 markets designated as developed are omitted due to lack of data.[4]

Excess returns are constructed by reference to the appropriately adjusted 13-week U.S. Treasury Bill such that the continuously compounded excess return (multiplied by 100) for country i at time t is:

$$r_{i,t} = 100\ln\left(1 + \tilde{r}_{i,t} - \tilde{r}_{f,t}\right), \tag{1}$$

where $\tilde{r}_{i,t} = \left(z_{i,t}/z_{i,t-1}\right) - 1$, $\tilde{r}_{f,t} = \left(1 + r_{f,t}\right)^{1/52} - 1$, $z_{i,t}$ is the index value for country i at time t, and $r_{f,t}$ is the annualized decimal yield on the 13-week (U.S.) Treasury Bill at time t.

3. Model specification and estimation

3.1. The model structure

The N-vector r_t is treated as a function of two latent factors. The first latent factor is a world (or global)) factor and is common to each market, while the second factor is common to the European markets only (i.e. the second factor's sensitivity to non-European markets is always zero). The function may be written as:

$$r_t = \left[C(L) \quad \mathrm{I}_N\right]\left[\tilde{f}_t' \quad u_t'\right]' = C(L)\tilde{f}_t + u_t, \tag{2}$$

$$\Psi(L)u_t = G^{1/2}z_t, \tag{3}$$

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[3] The indices are available at http://www.mscibarra.com/.

[4] Finland, Greece, Ireland, New Zealand, and Portugal are omitted.

$$G_{t|t-1} = diag\left(\sigma^2_{t|t-1}\right), \tag{4}$$

$$\sigma^2_{t|t-1} = \left[\sigma^2_{1,t|t-1} \quad \sigma^2_{2,t|t-1} \quad \dots \quad \sigma^2_{N,t|t-1}\right]', \tag{5}$$

$$\sigma^2_{i,t|t-1} = E\left(\sigma^2_i \left| I_{t-1}\right.\right) = \varpi_i + \sum_{p=1}^{P} \alpha_{i,p}\varepsilon^2_{i,t-p} + \sum_{q=1}^{Q} \beta_{i,q}\sigma^2_{i,t-q|t-q-1}, \tag{6}$$

where $C(L)$ is a polynomial in the lag operator L, $\tilde{f}_t$ is a $K = 2$ dimensional vector comprising the world and European factors W_t and E_t respectively, $\Psi(L) = \mathrm{I}_N - \Psi_1 L$, Ψ_1, G are diagonal matrices of order N, and z_t is a multivariate standard normal vector $z_t \sim iidMVN\left(0_N, \mathrm{I}_N\right)$. The European-specific factor is partially identified through the imposition of zero-restrictions on the European component of $C(L)$ for the non-European markets in the dataset.

The model acknowledges the potential for time-varying idiosyncratic variances through the conditionally time-varying matrix G. The diagonal elements of $G_{t|t-1}$ are modelled as GARCH processes such that, given $G_{t|t-1} \neq G$, idiosyncratic shocks are conditionally heteroscedastic. In the basic scenario $G_t = G$, idiosyncratic volatility follows the stylised constant form implying that time-varying volatility in asset returns is restricted to the common volatility component. The conditional extension to G, in addition to providing certain estimation advantages, ensures that time-varying correlation levels are not determined strictly by reference to the common component.

The diagonality of $\Psi(L)$ restricts the manner in which lagged effects may be transmitted; idiosyncratic persistence is permitted within but not between markets. Additionally, the diagonal form for G treats idiosyncratic shocks endogenously thereby restricting the transmission effects of an idiosyncratic shock to the market responsible for generating the shock. The joint diagonality of $\Psi(L)$, G has three broad implications: 1) the idiosyncratic factors do not contain information stemming from other markets, 2) lagged effects and shocks particular to market i are restricted to market i, and 3) the transmission of information across markets is restricted to lagged effects and shocks common to the market set.

The global (or world) factor is modelled as per the following:

$$\phi_w(L)\boldsymbol{f}_{w,t} = \phi_w(L)W_t = \mu_{w,t} + w_t, \tag{7}$$

$$\mu_{w,t} = \sum\nolimits_{m=1}^{M(w)} \mu_{w,m} S_{w,m,t}, \tag{9}$$

where $w_t \sim N\left(0, \sigma^2_{w,t}\right)$, $\sigma^2_{w,t} = \sum\nolimits_{m=1}^{M(w)} \sigma^2_{w,m} S_{w,m,t}$, $\sigma_{w,m+1} > \sigma_{w,m} \forall m$, $E\left(W_a u_b\right) = 0 \ \forall a,b$. The latent state variable $S_{w,m,t}$ takes the value unity if state $m = m(w)$, $m(w) \in M_w$, $M_w = \left\{m \in \mathcal{N} : m \leq M(w) \in \mathcal{N}\right\}$, and zero otherwise. The probability of state *m* prevailing is determined in accordance with the Markovian transition matrix:

$$Pr_w = \begin{bmatrix} P_{1,1,w} & \cdots & P_{M(w),1,w} \\ \vdots & \ddots & \vdots \\ P_{1,M(w),w} & \cdots & P_{M(w),M(w),w} \end{bmatrix}, \tag{10}$$

where $Pr_w' 1_{M(w)} = 1_{M(w)}$ and $1_{M(w)}$ is an *M*(*w*)-dimensional column vector of ones.[5] The $P_{a,b,w}$, $a,b \in M_w$, represent individual transition probabilities such that $P_{a,b,w} = \Pr\left(S_{w,m,t} = b \mid S_{w,m,t-1} = a\right)$ represents the probability of a transition from state *a* to state *b*.

A regional European factor is also introduced as a means of evaluating the impact of region-specific information. The regional component provides the capacity for the treatment of European markets in a homogeneous manner such that European market returns are determined by reference to global, idiosyncratic or regional sources. Clearly, the consideration of regional factors may be extended to the non-European case. The orthogonal European factor is modelled using the same approach adopted for the global factor.

The representation for r_t is equivalent to the variance decomposition:

$$V\left(r_t \middle| S_{w,\{t\}}, S_{e,\{t\}}, I_{t-1}\right) = \left[C(L) \quad \mathrm{I}_N\right] \tilde{P}^*_t \left[C(L) \quad \mathrm{I}_N\right]' = C^* P^*_t C^{*\prime} = \Gamma^*_t \Gamma^{*\prime}_t, \tag{11}$$

$$\tilde{P}^*_t = V\left(\left[\tilde{f}'_t \quad u'_t\right]' \middle| S_{\{t\}}, I_{t-1}\right), \tag{12}$$

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[5] *M*(*w*) = 3, whereas the corresponding value for the European factor is 2 (i.e.: *M*(*e*) = 2). The values are chosen as the minimal number of regimes required to account for heteroscedasticity in the common factors.

where $\tilde{P}_t^*$ is a block diagonal matrix containing the variance-covariance matrices for the common and idiosyncratic factors, $\Gamma_t^* = C^* P_t^{*1/2}$, and $S_{\{t\}}$ is the set of states constituting the state path to time *t*. $\tilde{P}_t^*$ depends on the entire volatility path to time *t*, $\left\{\sigma_{w,i}^2, \sigma_{e,i}^2, \sigma_{1,i}^2, \ldots, \sigma_{N,i}^2 : i = 0, 1, 2, \ldots, t\right\}$, and the common and idiosyncratic autocovariances captured through $\Phi(L)$, $\Psi(L)$. Note that P_t^* is augmented with the relevant lagged variance terms such that the lag operator in $C(L)$ is unnecessary. Consequently, and in accordance with generally observed financial market behaviour (consider, for example, King and Wadhwani, 1990; Bollerslev, Chou, and Kroner, 1992; King, Sentana, and Wadhwani, 1994), markets are presumed to covary at a level proportionate to the state of general volatility.

Constructing the factor loadings as per $c_{i,w}(L) = c_{i,w,1} + c_{i,w,2}L$ and $c_{i,e}(L) = c_{i,e,1} + c_{i,e,2}L$, the conditional volatility structure for market *i* is (assuming $\operatorname{cov}\left(f_{q,t}, u_{i,t}\right) = 0 \ \forall q, i$):

$$\begin{aligned} \mathrm{V}\left(r_{i,t} \middle| S_{w,\{t\}},\ S_{e,\{t\}},\ I_{t-1}\right) &= c_{i,1}{}' \operatorname{var}_t\left(\tilde{f}_t\right) c_{i,1} + c_{i,1}{}' \operatorname{cov}_t\left(\tilde{f}_t, \tilde{f}_{t-1}{}'\right) c_{i,2} + \\ &\quad c_{i,2}{}' \operatorname{cov}_t\left(\tilde{f}_{t-1}, \tilde{f}_t'\right) c_{i,1} + c_{i,2}{}' \operatorname{var}_t\left(\tilde{f}_{t-1}\right) c_{i,2} + \tilde{\sigma}_{i,t|t-1}^2 \qquad (13) \\ &= \gamma_{i,1,t}{}'\gamma_{i,1,t} + \gamma_{i,2,t}{}'\gamma_{i,2,t} + 2\gamma_{i,1,t}{}'\Theta_t\gamma_{i,2,t} + \tilde{\sigma}_{i,t|t-1}^2, \end{aligned}$$

$$\Theta_t = \operatorname{var}_t\left(\tilde{f}_t\right)^{-1/2} \Phi \operatorname{var}_t\left(\tilde{f}_{t-1}\right)^{1/2}, \qquad (14)$$

where $c_{i,k} = \begin{bmatrix} c_{i,w,k} & c_{i,e,k} \end{bmatrix}'$ gives the loadings on the (*k*-1)th lag of the common factors for the *i*th market, and $\operatorname{cov}_t(\cdot,\cdot)$ is an expectation taken with respect to $\mathcal{S} = \left\{S_{w,i},\ S_{e,i},\ I_{t-1} : i = 1, 2, \ldots, t\right\}$. The parameters $\gamma_{i,t}$ are determined by reference to the relevant conditioning information.

Pursuant to the specified model, volatility is determined by reference to the *i*th market's sensitivity to both contemporaneous and historic common information, the covariance structure of the common and idiosyncratic factors, the common volatility regimes and the conditional volatilities of the idiosyncratic components. It is, therefore, not assumed that the time-varying degree of influence exerted on the second moment of returns depends solely on the common regime. The adopted specification is motivated by the desire to construct a model allowing for the joint estimation and comparison of time-varying volatilities across global, regional and idiosyncratic components. In this respect, the specified common volatility structure is explicitly chosen for its ability to provide regime-dependent comparisons of common volatility levels.

3.2. The estimation procedure

The incorporation of Markovian regime switching and GARCH innovations into a model with persistent factors render maximum likelihood estimation intractable. A Metropolis-in-Gibbs sampler is therefore constructed to estimate the model. Pursuant to the sampler, draws from the full posterior $p\left(\tilde{\theta}\middle|r_1,r_2,...,r_T\right)$ are used to obtain inferences for the relevant parameters. The full posterior is given by:

$$\begin{aligned} p\left(\tilde{\theta}\middle|r_1,r_2,...,r_T\right) &= f\left(F,S,\sigma_\alpha,\sigma_\beta,\sigma_\varpi,C,\psi,\phi,\mu,\varpi,P\middle|R\right) \\ &\propto f\left(R\middle|F,C,\psi,\sigma_\alpha,\sigma_\beta,\sigma_\varpi\right) f\left(F\middle|S,\phi,\mu,\varpi\right) \\ &\quad f\left(S\middle|P\right) f\left(C,\psi,\sigma_\alpha,\sigma_\beta,\sigma_\varpi,\phi,\mu,\varpi,P\right), \end{aligned} \tag{15}$$

where *R* is the set of returns, *F* is the set of latent common factors, *S* is the set of latent common regimes, $C,\psi,\left\{\sigma_\alpha,\sigma_\beta,\sigma_\varpi\right\}$ are common factor loadings, idiosyncratic persistence, and GARCH terms respectively, ϕ,μ,ϖ are the common persistence, intercept, and volatility terms respectively, and *P* is the regime transition matrix. The prior density $f\left(C,a,\psi,\sigma_\alpha,\sigma_\beta,\sigma_\varpi,\phi,\gamma,\varpi,P\right)$ is diffuse. The sampler used to estimate the model is effectively a first-time Monte Carlo derivation of the Kalman filter with regime switching and GARCH volatilities and is detailed in Tsiaplias (2007). Essentially, the approach augments King, Sentana, and Wadhwani’s (1994) approximate Kalman filter by introducing Markovian regimes in the common component and constructing a Monte-Carlo estimation process that avoids the approximation induced by replacement of the unobserved squared innovation in the GARCH equation with its conditional expectation; an approximation that can give rise to biases (see, Tsiaplias, 2007).

4. Evaluating market integration and co-movement

Pursuant to the variance decomposition approach, general integration levels are evaluated by reference to the explanatory capacity of the common component for each market. The explanatory capacity is determined by the proportion of volatility attributable to the common component (cf. the proportion attributable to the idiosyncratic component). If the proportion of market *i*'s volatility explained by the common component rises during a given period, resulting in greater correlation with the common component, market *i*'s level of integration is deemed to have risen. In the context of the asset-pricing theory approach to integration (see, for example, Bekaert and Harvey, 1995), the size of the non-negative risk-premium is determined by reference to the non-negative volatility decomposition associated with an asset factor (ergo, a relative rise in volatility for the *k*th factor implies a greater risk-premium for the factor, represented by the greater portion of the decomposition associated with factor *k*).

The general integration level for market *i* at time *t* is evaluated by the decomposition:

$$\frac{V(C)_{i,t}}{V(C)_{i,t}+V(I)_{i,t}}=\frac{V(C)_{i,t}}{V_{i,t}}, \tag{16}$$

where $V(C)_{i,t}$ is the variance attributable to the common component at time *t*, $V(I)_{i,t}=V(\neq C)_{i,t}$ is the variance accounted for by idiosyncratic information at time *t* and $V_{i,t}$ is the time-*t* variance of market *i*.

If the inclusion of a European factor provides negligible additional explanatory capacity, the markets under consideration are deemed open to a hypothesis of strong integration. Conversely, a significant explanatory capacity associated with the European factor is deemed evidence of weak integration for European markets. Segmentation levels are inferred by reference to the complement of the proportion of volatility assigned to global and European effects.

The variance decompositions used to deduce general integration levels are:

$$\hat{D}_{i,t,general}\,|\mathcal{B}=\frac{V(C)_{i,t}}{V_{i,t}}=\frac{c_{i,w,1}^{2}\tilde{\sigma}_{w,t}^{2}+c_{i,e,1}^{2}\tilde{\sigma}_{e,t}^{2}}{\tilde{\sigma}_{i,t}^{2}}, \tag{17}$$

$$\tilde{\sigma}_{i,t}^2 = c_{i,w,1}^2 \tilde{\sigma}_{w,t}^2 + c_{i,e,1}^2 \tilde{\sigma}_{e,t}^2 + \tilde{\sigma}_i^2 + \rho_{i,t-1}^*, \quad (18)$$

$$\rho_{i,t-1}^* = c_{i,w,2}^2 \tilde{\sigma}_{w,t-1}^2 + c_{i,e,2}^2 \tilde{\sigma}_{e,t-1}^2 + 2c_{i,w,1}c_{i,w,2}\operatorname{cov}\left(W_t, W_{t-1}\right) + 2c_{i,e,1}c_{i,e,2}\operatorname{cov}\left(E_t, E_{t-1}\right), \quad (19)$$

where $\mathcal{B} = \left\{S_{w,\{t\}}, S_{e,\{t\}}, I_{t-1}\right\}$. The coefficients $c_{i,w,1} = c_{i,1,1}$, $c_{i,e,1} = c_{i,2,1}$ are the contemporaneous loadings on the global and European factors while $c_{i,w,2} = c_{i,1,2}$, $c_{i,e,2} = c_{i,2,2}$ are the loadings on the immediately lagged global and European factors. Note that the variance and covariance terms are implicitly conditional on $\mathcal{B} = \left\{S_{w,\{t\}}, S_{e,\{t\}}, I_{t-1}\right\}$.

Strong and weak integration levels ($\hat{D}_{strong}$ and $\hat{D}_{weak}$ respectively) are deduced in an analogous fashion to (17) by reference to the variance decompositions associated with the global and European factors respectively.

The time-dependent integration assessment framework adopted in the paper is defined by hypotheses framed in terms of A_0, B_0:

A_0: The probability of market *i*, $i \in C$ where *C* represents some criterion set, exhibiting greater integration with the *k*th, $k \in \left\{w, e, \left\{w, e\right\}\right\}$, component than the *j*th component, $j \in \left\{w, e, \left\{w, e, i\right\}\right\}$ and $j \neq k$, during period t_1, t_2, $1 \leq t_1 \leq t_2 \leq T$, exceeds $100(1-a_0)$ for some critical value a_0.

B_0: The probability of market *i*, $i \in C$ where *C* represents some criterion set, exhibiting greater integration with the *k*th, $k \in \left\{w, e, \left\{w, e\right\}\right\}$, component during period t_1, t_2, $1 \leq t_1 \leq t_2 \leq T$, than during period t_3, t_4, $1 \leq t_3 \leq t_4 \leq T$ and $t_3, t_4 \neq t_1, t_2$, exceeds $100(1-b_0)$ for some critical value b_0.

The supporting probability for a given hypothesis is determined by computing the $\hat{D}$ ($\hat{D}_{general}$, $\hat{D}_{strong}$, and $\hat{D}_{weak}$) statistics at each pass of the MCMC sampler used to estimate the model. If the condition defined by the hypothesis is satisfied at the *m*th pass of the sampler the *m*th element of the binary vector $d_m\left(A_0\right)$ $\left(d_m\left(B_0\right)\right)$ is set to unity, otherwise the element is set to zero. The expected probability associated with A_0 $\left(B_0\right)$ is given by the mean of $d_m\left(A_0\right)$ $\left(d_m\left(B_0\right)\right)$. The use of the MCMC draws obviates any need to evaluate hypotheses using estimates of $\hat{D}$ obtained from smoothed volatility decompositions (constructed using the posterior expected values of the estimated parameters). In this respect, the use of $\hat{D}$ obtained from smoothed volatility decompositions to investigate integration levels is problematic from both an errors-in–variables (EIV) perspective and the potentially non-stationary nature of $\hat{D}$. The relevant hypotheses and associated results are presented in Section 5.3.

5. Results and discussion

This section commences by reviewing the model's regime and decompositional dynamics. Following the general review in Section 5.1, Section 5.2 examines the volatility associated with the global, European, and idiosyncratic factors in the regime-dependent context. Finally, Section 5.3 evaluates the time-varying co-movement structure, and presents probabilities regarding hypotheses concerning the prevalence of the global, European, and idiosyncratic components across a range of time periods and events.

5.1. The global and European regime dynamics

Section 5.1.1 reviews the regime dynamics associated with the global and European factors. The regime dynamics are responsible, in conjunction with the idiosyncratic volatilities, for determining the level of co-movement observed among developed equity markets. A discussion on the global and European volatility decompositions takes place in Sections 5.1.2 and 5.1.3.

5.1.1. Regime dynamics

Volatility for the first two regimes is similar for both the global and European innovations, albeit slightly larger in the European case (Table 1). The estimates suggest that shocks in the second regime are approximately four times greater than those for the first regime. Given the comparability of the first two regimes for the world and regional factors, it is reasonable to conclude that the regimes correspond generally to the low and high (or low and medium) volatility levels respectively. Switching between the first two regimes may, therefore, be interpreted as movement across the polars of the ordinary (cf. extreme) volatility spectrum.

Table 1 *Regime-dependent volatility for the world and European factors*

Regime	*Median*	*Mean*	*95% HPD*		*95% BCI*	
World						
1	1.419	1.423	1.139	1.699	1.153	1.715
2	5.401	5.450	4.150	6.860	4.212	6.943
3	59.391	96.176	10.864	265.182	19.009	381.477
Europe						
1	1.816	1.821	1.285	2.364	1.297	2.379
2	7.192	7.440	4.921	10.522	5.201	11.124

The third volatility regime identified for global innovations is approximately eleven times greater than volatility for the second global regime and represents an extreme shift relative to the alternative regimes. The size of the volatility in the third state appears to capture (negative) outliers or extreme global shocks such as the October, 1987 crash. Accordingly, the third state may be interpreted as corresponding to the extreme negative shocks partially responsible for skewness in the returns data. The inability to accurately identify an analogous form of volatility for the regional factor may be related to the paucity of severe European-specific shocks. It is possible, for example, that severe European shocks are part of a transfer system whereby extreme volatility in (developed) European markets is contemporaneously transferred to the global innovation, as opposed to taking the insulated form of a regional-specific shock.

Persistence for the high and low global volatility states is slightly higher than in the European case, implying that the average duration of the states is greater in the global case. In a similar manner to the European regime dynamics, the probability of a high-to-low volatility transition is greater than its converse. The probability of a shift to an extreme state of volatility, although relatively small, is greater for the high volatility state (1.1%) than for its low volatility counterpart. Expected durations for the low and high global volatility regimes are approximately 57 and 22 weeks respectively. A comparison with European equivalents suggests that global regimes generally endure for approximately twice the period of their regional counterparts.

The persistence (or transition) probabilities for the global and European regimes are presented in Table 2. Persistence for European-specific volatility is greater for the first of the two possible regimes, corresponding to the low state of volatility. Estimates of the probability of remaining in the low-volatility state are also more precise than that of the high volatility state. The European transition terms, nevertheless, imply a high probability of remaining in either of the two states. In this respect, the expected duration of the European low-volatility state is approximately 28 weeks, compared to 10 weeks for the high-volatility state.

Table 2 *Persistence probabilities for the World and European regimes*

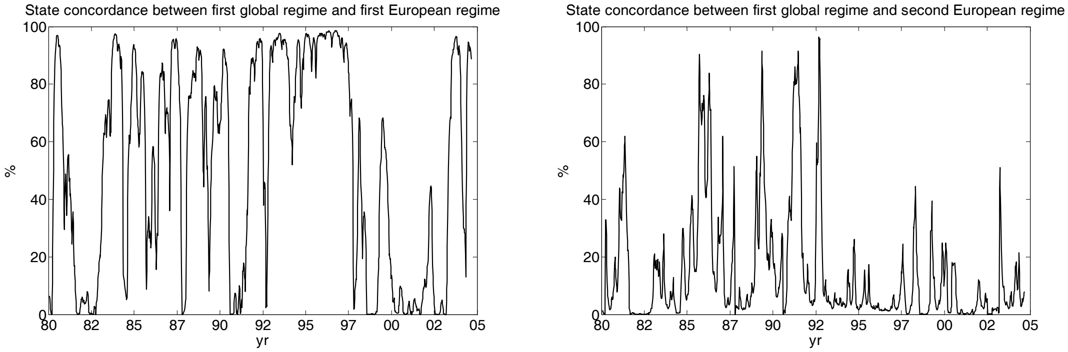
Transition Parameters	*Mean*	*Std. Dev.*	*95% BCI*		*Exp. Duration*
World					
1,1	0.982	0.007	0.967	0.993	56.5
1,2	0.014	0.007	0.003	0.029	
1,3	0.004	0.003	0.000	0.012	
2,1	0.034	0.015	0.011	0.069	
2,2	0.955	0.019	0.912	0.982	22.3
2,3	0.011	0.013	0.000	0.044	
3,1	0.195	0.163	0.006	0.600	
3,2	0.437	0.198	0.079	0.821	
3,3	0.368	0.185	0.065	0.755	1.6
Europe					
1,1	0.964	0.019	0.916	0.989	27.5
2,2	0.900	0.052	0.767	0.967	10.0

x,*y* is a transition from regime *x* to regime *y*.

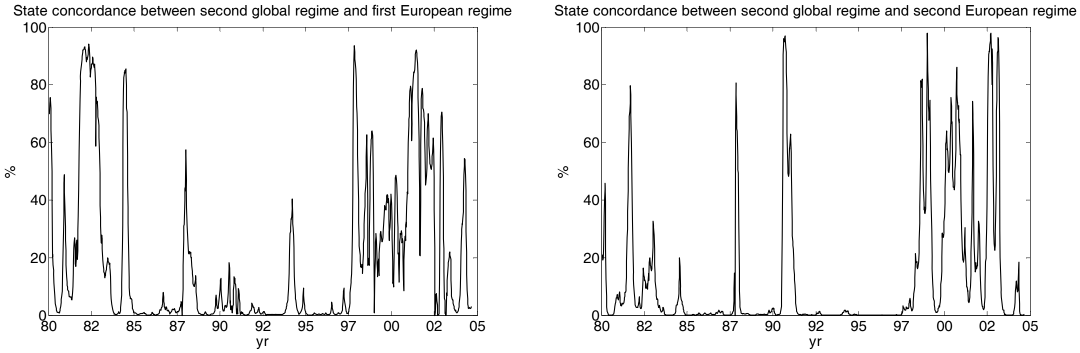
The expected duration of the extreme volatility regime is significantly shorter than that of the other global regimes, with an average length of just over 1.5 weeks. Given an extreme state of volatility, the probability of a transition to the state of high volatility is clearly greater than a transition to the low volatility state, in addition to being mildly greater than the probability of remaining in the extreme state. In this respect, the estimates appear to acknowledge the closer theoretic proximity between the extreme and high volatility states and suggest that the greater jump from extreme to low volatility is the least likely of the three transition possibilities. Accordingly, the model suggests that the extreme volatility regime, activated pursuant to an excessive global shock, ordinarily adopts a transient short-lived form followed by a shift to a persistent state of high global volatility in which it generally remains for a significant period of time (viz. the expected duration of approximately 22 weeks).

Evidence regarding the state concordance dynamics is obtained using the joint posterior density of the various combinations of the world and European regime sets. Given a set of draws from the Metropolis-in-Gibbs sampler, the exact time-t state concordance is determined by reference to the prevailing states at time t for the two state variables drawn at each pass of the sampler.

The couple $\{a=b=1\}$ may be defined as the case of lower general volatility, while $\{a=b=2\}$ constitutes the higher general volatility case.[6] Variants of the form $\{a=2,b=1\}$, $\{a=1,b=2\}$ capture the situation where global and European volatilities co-behave in an antithetic manner, while the couple $\{a=3,b\}$ is associated with extreme global shocks. The concordance probabilities are presented in Figures 1-3.



Figures 1a-b. *State concordance across first global regime*.



Figures 2a-b. *State concordance across second global regime*.

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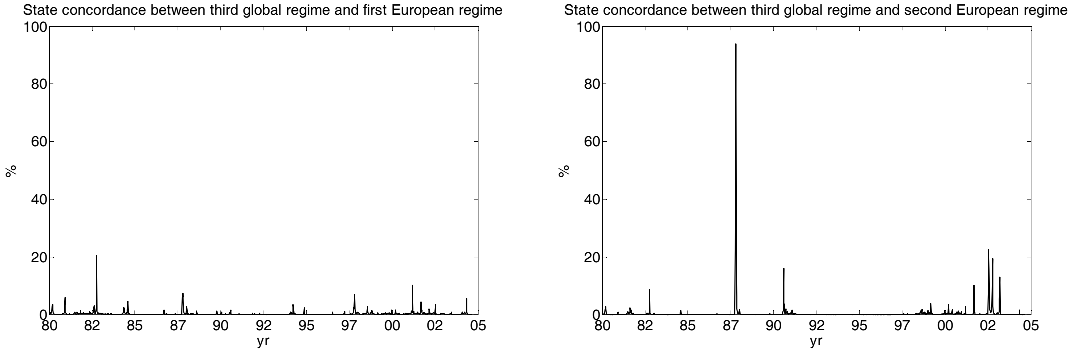
[6] The structure $\{a,b\}$ identifies the global regime by a, and the European regime by b.



Figures 3a-b. *State concordance across third global regime*.

The general lower volatility characteristic dominates for the greater portion of the period under study. Three short-lived spikes towards a state of general higher volatility are evident in the pre-1997 period during 1981, 1987 and 1990/91. The lower general volatility status is clearest in the six-year period spanning 1991-1997 where the probabilities associated with the higher volatility characteristic approach zero. A clear shift towards higher general volatility emerges post-1997 giving ground, however, to the lower general volatility state in the period 2003-2004.

The probability associated with the {1,2} regime combination, identified by periods where low global volatility is coupled with higher Euro-specific volatility, appears significant in four periods covering 1985 to 1992. The probability of the {1,2} couple tapers off in the latter portion of the period under study given the dominance of low general volatility during 1992-1997 and the higher global volatility associated with the period 1998 to 2002. The years 1997 and 2001, associated with the higher (cf. extreme) global, lower European volatility combination given by the {2,1} couple, precede spikes characterized by higher general volatility. Consequently, it appears that European volatility is drawn towards the greater volatility observed at the global level in the aforementioned instances.

In terms of the volatility couples identified by the presence of extreme global volatility, the 1987 crash is clearly characterised by the {3,2} couple. The probabilities associated with other periods of extreme global volatility, in combination with either lower or higher European volatility, are generally small. The presence of five smaller spikes during the period 2001 to 2003, however, four of which are defined by higher European volatility, provides further indication of an unusually heightened level of common volatility for the relevant period.

5.1.2. The global factor decomposition

The time varying volatility decompositions $\hat{D}$ for the eighteen markets applicable to the weekly data set are presented in Appendix A.[7] The decompositions are estimated using the process described in Section 4.1. In this respect, given GARCH idiosyncratic volatilities, the volatility decomposition for any given period and market is a function of three time-varying processes: the global regime path, the European regime path (if applicable), and the market's idiosyncratic volatilities.

A surge in the volatility associated with the global factor is observed across the market set in the years 1982 and 1987. The latter year clearly depicts the global volatility ramifications of the 1987 U.S. stockmarket crash while the period October, 1982 is associated with a sharp spike to U.S. returns driven by the belief that U.S. rates would continue to fall. While the effects of the 1987 crash are clear across all markets, the 1982 spike appears less pronounced for the U.S. market. The smaller impact of the 1982 spike for the U.S. may be related to the relatively strong impact of the global component on the U.S. market in the period preceding October, 1982 and/or the treatment of aspects of the shock as endogenous or idiosyncratic. A smaller common shock observed during 1984 appears to be related to a surge in institutional and pension fund investment for the U.S. market. A fourth major jump in the volatility associated with the global component is observed in August, 1990 amid fears that the tension in Iraq would lead to a sustained rise in oil prices and a U.S. recession. Although the rising impact of the global component in August, 1990 is clear for the majority of markets, its impact on the Austrian market is relatively minor suggesting that some of the smaller central European markets were relatively insulated against the effects of the Iraqi crisis.

In March, 1994 a spike (in the volatility attributed to the global factor) is observed and concentrated in the non-Asian markets in the study. The spike appears to be related to the possibility of rising U.S. interest rates leading to a general downturn in global equity markets. The minor impact of the spike for the Asian markets indicates that idiosyncratic

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[7] To save space, presentation is restricted to the global and European decompositions ($\hat{D}_{strong}$ and $\hat{D}_{weak}$, respectively). The decomposition $\hat{D}_{general}$ is the sum of the two aforementioned decompositions, while its complement is the idiosyncratic decomposition.

volatility is significant and dominant during the relevant period. In this respect, consider the post-1990 collapse of the Nikkei index following successive interest rate hikes by the Bank of Japan. Given the idiosyncratically-driven collapse, fears of rising U.S. rates exhibit relatively little effect on Japan and nearby markets. Another spike appears during October, 1997 for all but the Hong Kong and Singapore markets. The impact pertains to the 1997 East Asian financial crisis and is clear for the European and North-American markets, suggesting a general downward trend across markets as a function of economic information originating in Asia. The absence of a significant global impact for the Hong Kong and Singapore markets suggests that idiosyncratic information is dominant during the relevant period. The significant impact of idiosyncratic information during the period for the aforementioned two markets is better understood given that the October 27, 1997 surge in global volatility was precipitated by a significant negative shock to the Hong Kong market. The negligible impact of the global component for Hong Kong and Singapore suggests that information emanating from these two markets acted as a catalyst for the volatility spike observed in the global factor and the associated equity market co-movement.

A successive number of spikes in the volatility attributed to the global factor are apparent in the period 1998 to the earlier part of 2003. The period to 1998 is associated with a general fall in U.S. interest rates to 4.75% (cf. 6% in 1995). Following 1998, U.S. rates rise to 5.5% in 1999 and 6.5% in 2000, before a reversal sees U.S. rates fall to 1% in June, 2003. The high level of volatility associated with the global component during the aforementioned period (and the associated strong levels of co-movement) detracts from the ability to clearly observe a global spike during the Sept. 11, 2001 World Trade Center attack. The final spike in the global decomposition is observed in May, 2004 and is common to all markets (i.e. no idiosyncratic component acts to offset it). The spike appears to be the result of a global fall in markets proceeding a sharp rise in oil prices and conflict in Iraq.

5.1.3. The European factor decomposition

In comparison to the evident spikes observed for the global factor volatility decomposition, the spikes in the European volatility decomposition and European co-movement are less pronounced. Two sets of major surges in the explanatory capacity of the European factor are evident in (May) 1989 and (April, July) 1991. The surges are least evident in the Norwegian market and their effects also appear weak for Sweden and the United Kingdom. Accordingly, the influence of European-specific information leading to increased European co-movement appears to be limited to mainland Europe. The stronger decompositional capacity of the non-European components for Norway, Sweden and the U.K. also suggests that all three markets are less integrated with the general European factor relative to the mainland European markets in the panel. The 1989 surge appears to be related to political reform in Eastern Europe with the collapse of communist regimes in Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, and Romania. The maximal level of European co-movement in 1989, during May, follows the visit of Soviet president Mikhail Gorbachev to China and the ensuing Tiananmen Square protests.

Although unclear, the volatility spike in April, 1991 appears to be centered on European uncertainty regarding the welfare of the U.S. economy. In turn, uncertainty regarding German interest rates and increased tension in the former Yugoslavia appear to be the catalyst for the common shock across (generally mainland) European markets in July of 1991. A third European shock, in October, 1992, is strongest for Belgium, France, Germany, the Netherlands, Spain, and Switzerland. The common fall in the aforementioned European markets coincides with fears of a continued downturn across the major European economies.

In 1999 the euro was adopted as the official currency for Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain. National currencies, however, remained in circulation. Increased financial integration among EU members is cited as a major determinant underlying the introduction of the common currency (see, for example, Fratzscher, 2002). Save in the case of Italy, however, the level of co-movement observed among European equity markets in the post-1999 period does not appear to have risen or adjusted in any significant manner. In turn, there appear to be no positive trends regarding the significance of the European factor over the time period investigated. Formal tests regarding the prevalence of the European factor are undertaken in Section 5.3.

5.2. Regime-dependent market co-movement

This section considers the co-movement impact of the various volatility regimes for the global and European factors. In this respect, the impact of global shocks on equity markets and the effects of European-specific shocks on European co-movement are considered. The state-conditional examination is facilitated by the variance-covariance form for the returns:

$$V\left(r_t \middle| S_t, S_{\{t-1\}}, I_{t-1}\right) = BP_{t|t-1}B' + G_t = \Gamma_t \Gamma_t{}' + \Sigma_{t|t-1}, \tag{20}$$

where $\Gamma_t = f\left(S_{w,\{t\}}, S_{e,\{t\}}\right)$, S_w, S_e are discrete hidden Markov-chains for the global and European factors respectively, and $S_{\cdot,\{k\}} = \left\{S_{\cdot,1}, S_{\cdot,2}, ..., S_{\cdot,k}\right\}$.

Given the adopted variance-covariance structure, state patterns produce covariance effects through the Γ_t term. Assuming the identification condition $P_{t|t-1}\left(S_{w,m+1}\right) \gg P_{t|t-1}\left(S_{w,m}\right) \forall m$ (with an analogous condition for S_e) a positive switch to $S_{w,m+1}$ (after integrating out S_e) will shift $\Gamma_t \Gamma_t{}'$ in the same direction. The effect of such a switch for the variance-covariance matrix of r_t depends on $\Sigma_{t|t-1}$. Removing the conditioning on I_{t-1} leads to the unconditional idiosyncratic covariance form such that:

$$V\left(r_t \middle| S_t, S_{\{t-1\}}, I_{t-1}\right) = \Gamma_t \Gamma_t{}' + \Sigma. \tag{21}$$

In this case, the model fails to consider idiosyncratic time-effects and the switch $m \xrightarrow{t} m+1$ shifts the variance-covariance level in the positive direction.

Estimates of the state-conditional variance decompositions are obtained using Eq. (21) and the average of the state-dependent decompositions obtained at each pass of the sampler used to estimate the model. Estimates pursuant to Eq. (20) are considered in Section 5.3.

5.2.1. European markets

In the low general volatility case (Table 3a), where common innovations are determined according to the first global and European regimes, the common component is less significant and country-specific information plays a more important role in setting market volatility levels. This scenario may be interpreted as accommodating the state of lowest-level integration among a discrete set of integration levels. Given low common volatility, common information is at least as important as idiosyncratic information for only four of the twelve European markets (France, Germany, the Netherlands, and Switzerland). European volatility is more important in the German case, global volatility for the Netherlands, while neither source of low-level volatility clearly dominates in the French or Swiss cases.

Table 3a *Variance decompositions given low general volatility (the (1,1) state-conditional case)*

Market	*World(1)*	*Europe(1)*	*Idiosyncratic*
Austria	0.07	0.25	0.68
Belgium	0.16	0.28	0.56
Denmark	0.11	0.15	0.74
France	0.28	0.25	0.47
Germany	0.26	0.35	0.40
Italy	0.11	0.14	0.75
Netherlands	0.38	0.20	0.42
Norway	0.15	0.08	0.78
Spain	0.18	0.18	0.64
Sweden	0.23	0.09	0.68
Switzerland	0.26	0.25	0.49
U.K.	0.28	0.09	0.63
Canada	0.41	0.00	0.59
U.S.	0.46	0.00	0.54
Australia	0.22	0.00	0.78
Hong Kong	0.18	0.00	0.81
Japan	0.10	0.00	0.90
Singapore	0.22	0.00	0.78

World(1), *Europe(1)* represent contemporaneous sensitivity to the world and European factors respectively.

World low-level volatility accounts for at least 25% of market volatility for France, Germany, the Netherlands, Switzerland, and the United Kingdom. In contrast, low-level world volatility accounts for less than 10% of volatility in the Austrian case and approximately 10% of total volatility in the Italian and Danish cases. European effects represent 25% or more of the volatility decomposition for Germany, Belgium, Switzerland, France, and Austria while idiosyncratic volatility is above 70% of total volatility for Italy, Denmark, and Norway.

The switch to the medium general volatility scenario, pursuant to which the variance of common innovations is determined by the second global and European regimes, accommodates a greater level of (strong or weak) integration. In this scenario, with the exception of Norway, the common sources of volatility are dominant for every European market under consideration (see Table 3b). Integration with the world factor is strongest for the U.K. and the Netherlands at almost 50% while weak-form integration is best supported for Germany and Belgium with 48% and 45% of total volatility respectively. With respect to the remaining markets, the global volatility source dominates the common volatility spectrum for Sweden and Norway while the converse holds for Austria, Denmark, and Italy. Neither common volatility-composite clearly dominates for France, Spain, or Switzerland.

Table 3b *Variance decompositions given medium general volatility (the (2,2) state-conditional case)*

Market	*World(1)*	*Europe(1)*	*Idiosyncratic*
Austria	0.10	0.40	0.49
Belgium	0.24	0.45	0.31
Denmark	0.21	0.32	0.47
France	0.39	0.38	0.23
Germany	0.34	0.48	0.18
Italy	0.27	0.36	0.38
Netherlands	0.49	0.28	0.23
Norway	0.30	0.17	0.53
Spain	0.31	0.34	0.35
Sweden	0.39	0.17	0.44
Switzerland	0.38	0.40	0.23
U.K.	0.49	0.17	0.34
Canada	0.64	0.00	0.36
U.S.	0.73	0.00	0.27
Australia	0.52	0.00	0.48
Hong Kong	0.41	0.00	0.59
Japan	0.27	0.00	0.73
Singapore	0.38	0.00	0.62

The case of high (or extreme) general volatility is associated with maximal global volatility. In this case, the additional volatility dimension available for shocks to the global factor provides the capacity for examining market behaviour following a severe global shock. In the European case, the model provides the capacity for quantifying the existence and extent of a temporal reduction in the importance of common European shocks in the presence of a severe global shock.

Country-specific volatility during a period of extreme general volatility accounts for 10% or less of total volatility for seven of the twelve European markets (Table 3c). The five markets for which country-specific volatility exceeds 10% of total volatility are Austria, Denmark, Italy, Norway, and Spain. The proportion of volatility attributable to global shocks during a period of maximal volatility ranges from approximately 90% for France, Germany, the Netherlands, Sweden, Switzerland, and the U.K. to around 60% for Austria. Global shocks account for at least 70% of total volatility for eleven of the twelve European markets, signifying a clear pattern of co-movement among the European markets in response to a severe global shock.

Table 3c *Variance decompositions given extreme global volatility (the (3,any) state-conditional case)*

Market	*World(1)*	*Europe(1)*	*Idiosyncratic*
Austria	0.61	0.15	0.25
Belgium	0.80	0.10	0.09
Denmark	0.75	0.08	0.17
France	0.86	0.06	0.09
Germany	0.87	0.09	0.04
Italy	0.77	0.07	0.15
Netherlands	0.92	0.04	0.04
Norway	0.81	0.03	0.16
Spain	0.82	0.06	0.12
Sweden	0.88	0.03	0.09
Switzerland	0.88	0.07	0.05
U.K.	0.90	0.02	0.08
Canada	0.95	0.00	0.05
U.S.	0.96	0.00	0.04
Australia	0.87	0.00	0.13
Hong Kong	0.82	0.00	0.18
Japan	0.77	0.00	0.23
Singapore	0.77	0.00	0.23

Austria, Denmark, and Italy appear to be the least responsive (of the developed European markets) to an extreme global shock. The lower level of responsiveness to the third global volatility regime suggests a relatively greater level of insulation to global shocks. In this respect, it is important to note that the volatility attributable to the

European composite is at or below 10% for all the European markets, with the exception of Austria (approximately 15%). The results, therefore, imply that European volatility is largely irrelevant in the presence of a severe universal shock. In turn, the three largest European markets (France, Germany, and the U.K.) respond in a similar fashion with around 90% of volatility attributable to the severe global shock. Accordingly, it is clear that European markets tend to exhibit high levels of co-movement, dominated by the global factor, given an extreme global shock.

5.2.2. Non-European markets

The model suggests that a single global composite is responsible for over 40% of U.S. and Canadian market volatility in the low common volatility scenario. This value rises to over 60% for the second common regime structure and peaks at over 90% following an extreme shock. In terms of the Asian markets and Australia, the global composite is responsible for between 10% (Japan) and 22% (Australia and Singapore) of regime-conditional volatility in the low common volatility scenario. In the medium-volatility case, about 30% of Japanese volatility is attributable to the global factor for Japan, rising to approximately 40% for Singapore and Hong Kong and slightly over 50% for Australia. Consequently, Asian market volatility continues to be dominated by idiosyncratic information following a positive volatility shift. The third regime structure, identifying extreme global shocks, represents an exception to the dominance of idiosyncratic volatility given that shocks to the global composite are clearly responsible for the greater portion of Asian market volatility (common volatility accounts for nearly 90% of Australian volatility and approximately 80% of the Asian market volatilities). The impact of idiosyncratic volatility is clearly smallest, however, for the North American markets where only 4% and 5% of U.S. and Canadian volatility (respectively) is attributed to idiosyncratic information during periods of extreme global volatility. Consequently, although the association between the Asian markets and the global factor is weaker than that for the North American markets, the results indicate that the effect of an extreme shock to the global factor tends to dominate all developed markets.

5.3. The case of conditional idiosyncratic volatility

Section 5.3 presents evidence concerning two sets of hypotheses. The first set, in Section 5.3.1, covers the idiosyncratic decompositions and examines whether volatility attributed to idiosyncratic factors declines over time for developed markets. The second set of hypotheses are defined in Section 5.3.2 and examine the time-varying prevalence of the global factor relative to the European factor.

5.3.1. Hypotheses regarding the idiosyncratic decompositions

The first set of hypotheses is designed to investigate the idiosyncratic patterns observed for the 18 markets over the period 1980-2004. The probabilities associated with the hypotheses are constructed using the method outlined in Section 4.1. The hypotheses pertaining to the idiosyncratic composition are presented in Table 4. Hypothesis *A1* asserts that the volatility attributable to the idiosyncratic component for market *i* in the third period is smaller than that for the first two periods. Hypotheses *A2* and *A3* extend hypothesis *A1* by examining whether the proportion of volatility attributed to idiosyncratic sources declines in each half (third) of the period under study. The hypotheses are designed to evaluate the validity of an increased integration hypothesis. In this respect, there is a large volume of literature devoted to the examination of integration trends, coupled with the common suggestion of increased integration over time. Under the assumption of a positive integration trend, it follows that the evidence in support of all three hypotheses will be convincing, with similar evidence for hypotheses *A2* and *A3* (disparate evidence for hypotheses *A2* and *A3* contradicts the linearity assumption).

The probabilities associated with hypothesis *A1* are greater than 95% for fifteen of the eighteen markets, while probabilities for two of the remaining three markets, namely Belgium and Switzerland, are above 90% (Table 5). The sole exception is that of Austria, where the evidence is strongly against the *A1*th hypothesis; the probability in support of the hypothesis is less than 1%. With the exception of the Austrian market, the decline in the volatility contribution of the idiosyncratic component in the third period suggests that the importance of common sources of volatility rose towards the latter third period of the study for developed financial markets.

The evidence is clearly in favour of hypothesis *A2* for all markets except Austria and Switzerland suggesting that the importance of the common variance rose during the latter half of the study. The results change significantly for several markets when the relevant time period is partitioned into three periods in accordance with hypothesis *A3*, with the number of markets contradicting the hypothesis increasing from two to seven. In this respect, the probability of a period by period decline in the volatility attributed to the idiosyncratic component falls to below 50% for Australia, Canada, Japan, Norway, and the United States. The switch for the aforementioned markets suggests that the volatility accounted for by the common component has failed to rise steadily (or linearly) for the relevant markets. The majority of European markets, with the exceptions of Austria, Norway and Switzerland, continue to exhibit increasingly integrated behaviour, with the strongest evidence of rising integration available for Italy, the Netherlands, Spain, and the United Kingdom. There is similarly strong evidence in favour of rising integration for Hong Kong. Finally, the evidence regarding Austria and Switzerland remains consistent with that of hypothesis *A2* and raises no suggestion that the idiosyncratic proportion of volatility declines over time, thereby favouring the conclusion that the two markets have become increasingly segmented over time. Accordingly, although evidence of a linear integration trend across developed markets is varying, there is little evidence of the converse situation of increased segmentation.

Table 4 *The first set of hypotheses for the conditional idiosyncratic volatility scenario*

Hypothesis *A1*	The average volatility attributable to the idiosyncratic component for market *i*, *i* = 1 to 18, in the third period is smaller than that for the first two periods.[#]
Hypothesis *A2*	The average proportion of volatility attributed to idiosyncratic sources declines in the second half of the timeframe under study.
Hypothesis *A3*	The average proportion of volatility attributed to idiosyncratic sources declines successively across the three periods.

[#] Denote period 1 as the period commencing 9/1/1980 and ending 23/3/1988, period 2 as the period 30/3/1988 to 12/6/1996 and period 3 as the period 19/6/1996 to 1/9/2004.

Table 5 *Probabilities associated with the idiosyncratic decomposition hypotheses (defined in Table 4)*

Market/Hypothesis	*A1*	*A2*	*A3*
Austria	0.001	0.044	0.000
Belgium	0.928	0.988	0.914
Denmark	1.000	0.958	0.760
France	1.000	1.000	1.000
Germany	1.000	0.998	0.782
Italy	1.000	1.000	0.979
Netherlands	0.985	1.000	0.985
Norway	1.000	1.000	0.028
Spain	1.000	1.000	0.998
Sweden	1.000	0.994	0.721
Switzerland	0.927	0.249	0.000
U.K.	1.000	1.000	0.992
Canada	1.000	0.993	0.205
U.S.	0.999	0.996	0.030
Australia	1.000	1.000	0.160
Hong Kong	1.000	1.000	0.988
Japan	0.970	0.906	0.000
Singapore	0.983	0.984	0.678

5.3.2. Hypotheses regarding the common decomposition

The second set of hypotheses examines the manner in which volatility is distributed across the two sources of common volatility. In the context of the adopted model, the hypotheses are meaningful only for the European market set. The hypotheses examine the relative dominance of the European factor, as well as the extent to which European volatility levels change over the periods 19/6/1996 to 27/12/2000 and 6/1/1999 to 15/3/2000. In the latter sense, the hypotheses examine the response of European markets to both growth in the U.S. and the introduction of the common euro currency.

Hypotheses *B1* to *B3* assert that the volatility attributable to the global component for market *i* is greater than that of the European component for period j, $j = \{1, 2, \text{or } 3\}$. The hypotheses provide an assessment of the relative importance of the global and European components over the three periods in terms of distinct volatility contribution. For the *i*th European market, the dominance of the European component in the *j*th period suggests that regional-specific volatility is the dominant source of common volatility in the relevant period. The hypotheses *B1* to *B3* (and *B4* to *B7*) are presented in Table 6.

Table 6 *The second set of hypotheses regarding the common decomposition*

Hypotheses *B1-B3*	The volatility attributable to the global component for market *i* is greater than that of the European component for period *j* = 1, 2, or 3.
Hypothesis *B4*	The proportion of common volatility explained by the European factor rises in the second half of the timeframe under study.
Hypothesis *B5*	The proportion of common volatility explained by the European factor rises successively in the second and third time periods.
Hypotheses *B6-B7*	Ordinary time volatility attributed to the European factor (for market *i*) exceeds European volatility levels for the period 19/6/1996 to 27/12/2000 (6/1/1999 to 15/3/2000). Ordinary time volatility is determined as the average volatility associated with the European component for the 52 week period preceding 19/6/1996 (6/1/1999).

The world source of common volatility is clearly dominant across all three time periods for the Netherlands, Norway, Sweden, and the U.K., while the converse holds true for Austria and Belgium (Table 7). Several markets exhibit a transition between dominant global and dominant regional common volatility effects. In this respect, a pattern of strong global effects in the first and third periods coupled with dominant European effects in the second period is observed for France, Spain, and Switzerland. The results for Denmark, Germany, and Italy suggest that the regional component of common volatility dominates in the first two periods, with the proportion of volatility associated with the European component rising in period two before declining sharply in favour of the global composite. Figure 4 plots the probabilities associated with hypotheses *B1-B3*.

Pursuant to hypotheses *B4* and *B5*, the percentage of common volatility explained by the European factor rises across each half (third) of the timeframe under study. The relative growth of the regional volatility source provides an assessment regarding the extent to which European markets are increasingly susceptible to regional information. The evidence for both hypotheses is unambiguous and fails to suggest that growth in volatility attributed to the European factor exceeds that of its global counterpart. In fact, the probabilities indicate that the proportion of common volatility explained by global sources grew in the second half of the study suggesting that European markets are becoming increasingly integrated with the global factor.

Table 7 *Probabilities associated with the common decomposition hypotheses (defined in Table 6)*

Market/Hypothesis	*B1*	*B2*	*B3*	*B4*	*B5*	*B6*	*B7*
Austria	0.000	0.000	0.000	0.245	0.000	0.564	0.388
Belgium	0.009	0.000	0.113	0.028	0.000	0.592	0.699
Denmark	0.236	0.005	0.471	0.035	0.000	0.655	0.399
France	0.913	0.176	0.996	0.008	0.000	0.148	0.320
Germany	0.144	0.001	0.611	0.029	0.000	0.640	0.466
Italy	0.333	0.004	0.694	0.003	0.000	0.002	0.104
Netherlands	1.000	0.992	1.000	0.006	0.000	0.693	0.481
Norway	0.999	0.952	1.000	0.015	0.000	0.329	0.322
Spain	0.734	0.062	0.931	0.011	0.000	0.103	0.310
Sweden	1.000	0.998	1.000	0.014	0.000	0.111	0.710
Switzerland	0.763	0.089	0.980	0.017	0.000	0.251	0.355
U.K.	1.000	1.000	1.000	0.010	0.000	0.383	0.435

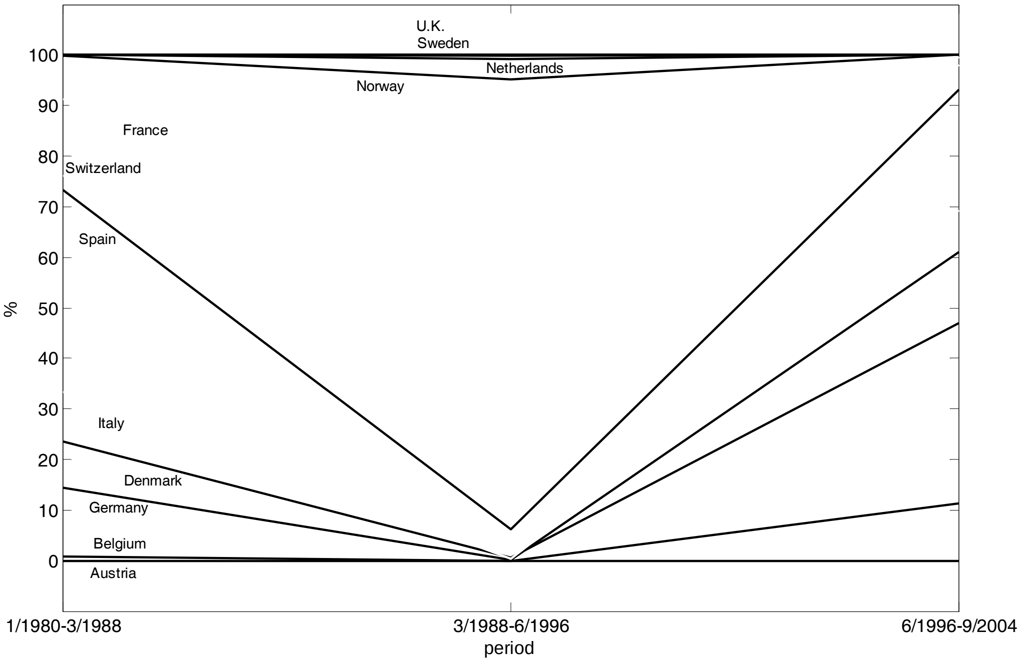


Figure 4. *The probabilities associated with the common decomposition hypotheses B1-B3 defined in Table 6.*

To better examine the possibility of regionally dependent co-movement among the European markets, hypotheses *B6* and *B7* examine whether the ordinary-time volatility attributed to the European factor exceeds the volatility observed during the two relevant periods. The two periods are associated with abnormal growth and a significant correction in the NASDAQ, as well as the introduction of the euro currency in January, 1999. With the exception of Italy (in the period 6/1996 to 27/12/2000), there is little evidence to suggest that the volatility attributed to the European component rises for either the subsuming period 19/6/1996 to 27/12/2000 or the sub-period 6/1/1999 to 15/3/2000. In fact, the probabilities tend to the conclusion that European volatility decomposition levels fail to increase or decrease over both the specified periods. The results for the *B8*th hypothesis, coupled with the common fall in country-specific volatility pursuant to the evidence in favour of hypothesis *A8*, imply that integration with the global factor tends to rise during the period 19/6/1996 to 27/12/2000. Accordingly, there is little evidence supporting a hypothesis of rising European-specific integration across the period 19/6/1996 to 27/12/2000 (or the sub-period 6/1/1999 to 15/3/2000).

6. Conclusion

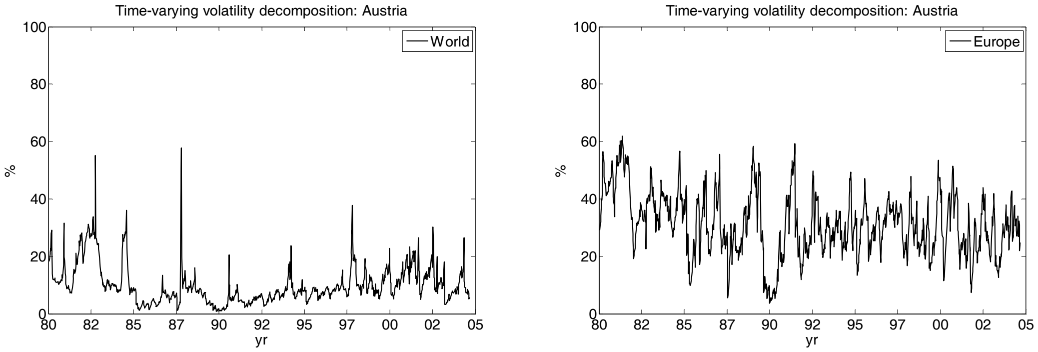
Much of the existing research on the topic of market integration relies on straightforward correlations between markets or market cointegration levels to determine the strength of co-movement between equity markets (see Kearney and Lucey, 2004). Alternatively, factor-based approaches generally assume that integration levels may be determined by a market's association with a single pervasive factor in the (global) CAPM sense (see, for example, Bekaert and Harvey, 1995). In this paper, a model is constructed to obtain inferences regarding co-movement levels and market integration for 18 developed equity markets. The model combines distinct forms of time-varying volatility across the common and idiosyncratic components, with the common component divided into global and European factors to enable investigation of the regional integration properties of the developed European markets. In this respect, independent global and European (Markovian) regimes are used to consider the manner in which market integration levels change across the various global-European regime combinations. In addition, the time-varying volatility in the idiosyncratic components is exploited to obtain inferences regarding global and European market integration levels in the time domain. The model is estimated using MCMC methods that effectively construct, for the first time, a Kalman filter with common Markovian regimes and GARCH innovations (Tsiaplias, 2007).

According to the results, market co-movement levels during periods of low common volatility are dominated by idiosyncratic shocks for the majority of developed markets (France, Germany, the Netherlands, and Switzerland constituting the exceptions). The results change significantly given medium-level global shocks and the majority of markets exhibit greater sensitivity to common rather than idiosyncratic information. Specifically, volatility in 15 of the 18 markets is dominated by common shocks, and only the three Asian markets (Hong Kong, Japan, and Singapore) continue to be dominantly influenced by idiosyncratic information. In the case of an extreme global shock, however, all markets co-move strongly and idiosyncratic shocks account for a quarter or less of volatility in all markets. With respect to the global-European dichotomy, mainland European markets tend to exhibit greater susceptibility to European shocks than Norway, Sweden, or the U.K., suggesting a (geographically-dependent) dichotomous sensitivity to European shocks.

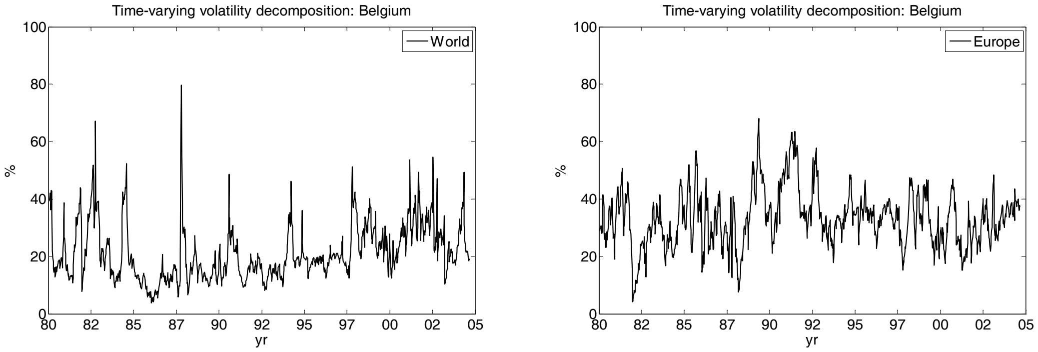
Regarding the question of time-varying integration, the proportion of volatility attributed to the common component is greater in the final third period of the study than in the preceding two periods. There is, however, no clear evidence of a linear integration trend across the developed market set. In this respect, evidence of the falling significance of idiosyncratic shocks over time is strongest for Belgium, France, Hong Kong, Italy, the Netherlands, Spain, and the United Kingdom.

In terms of the prevalence of the European factor, the global source of volatility dominates the European source across each third of the period 1980-2004 for the Netherlands, Norway, Sweden, and the U.K., while the converse holds true for Austria and Belgium. Finally, there is little evidence suggesting a positive trend in European integration levels, notwithstanding attempts to increase European financial integration.

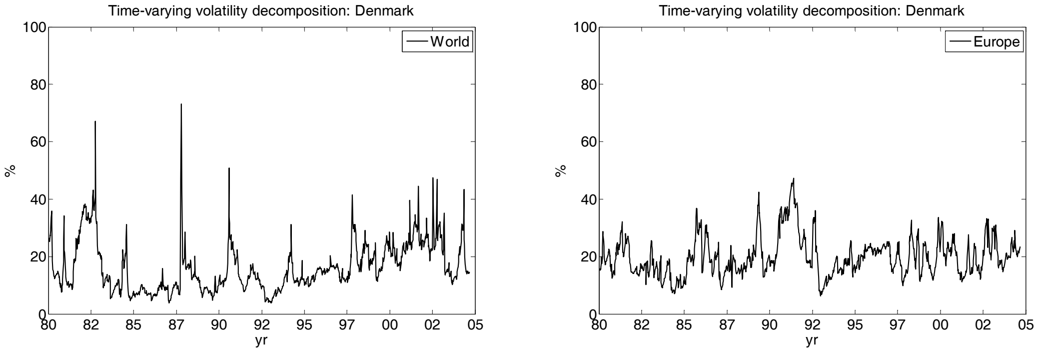
Appendix



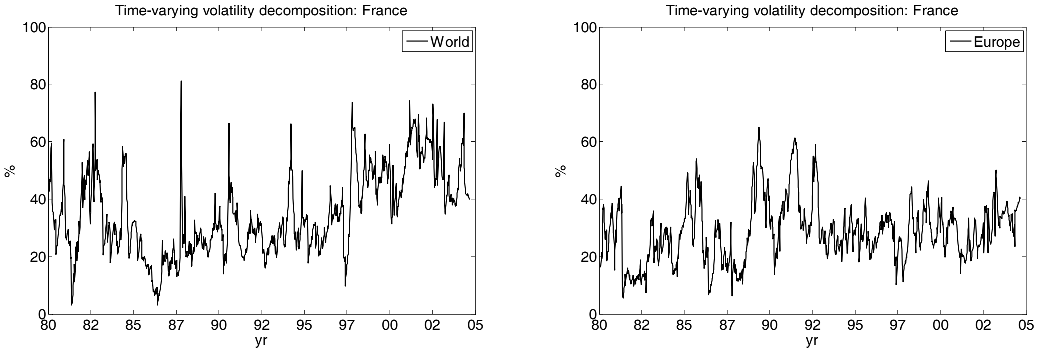
Figures A.1. *Volatility decomposition for Austria.*



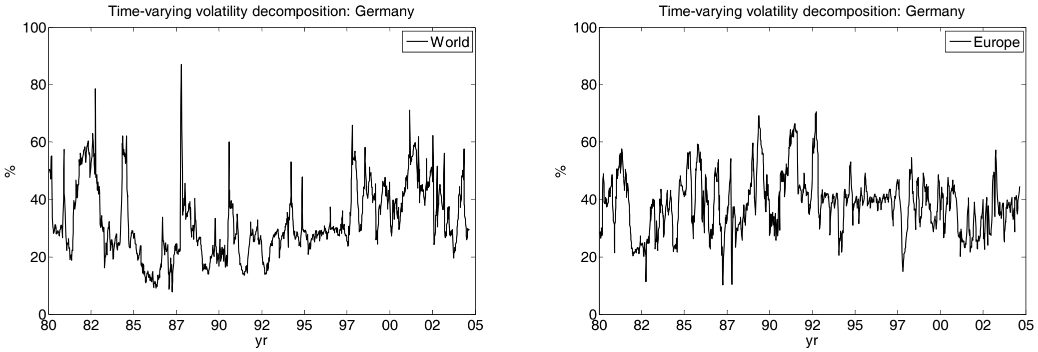
Figures A.2. *Volatility decomposition for Belgium.*



Figures A.3. *Volatility decomposition for Denmark.*



Figures A.4. *Volatility decomposition for France*.



Figures A.5. *Volatility decomposition for Germany*

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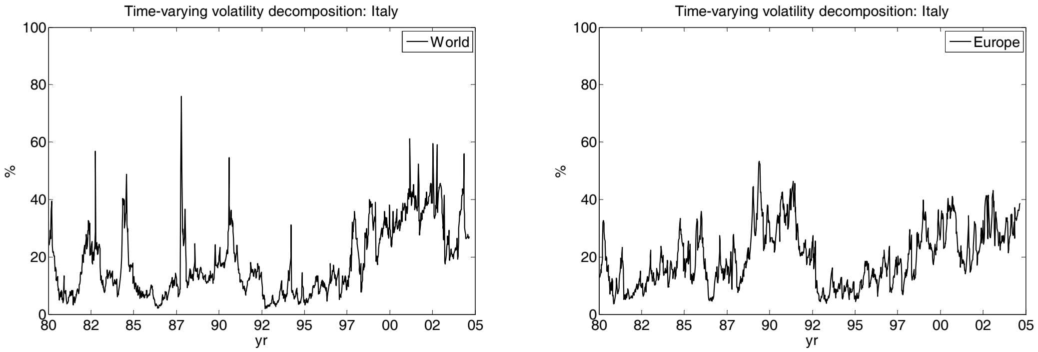
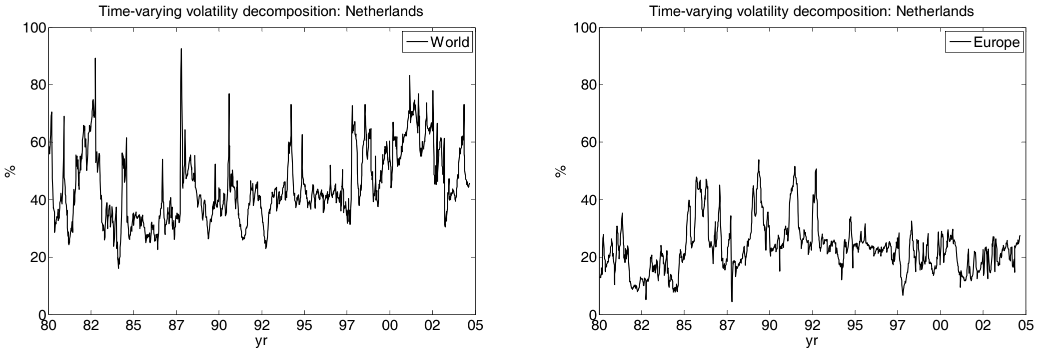
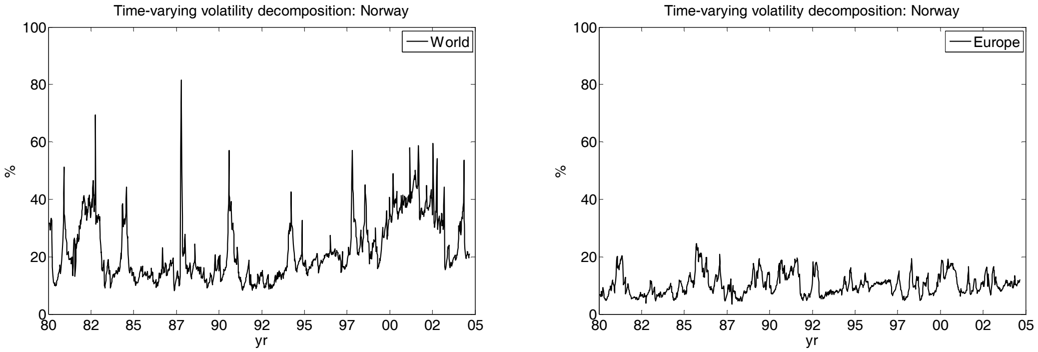


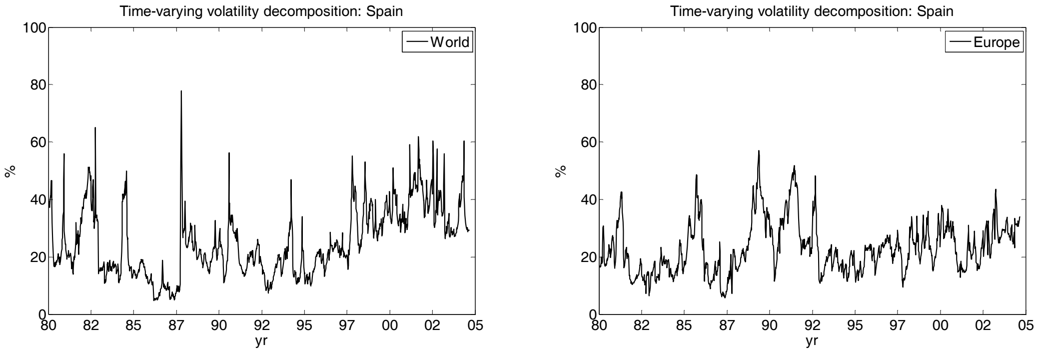
Figures A.6. *Volatility decomposition for Italy*.



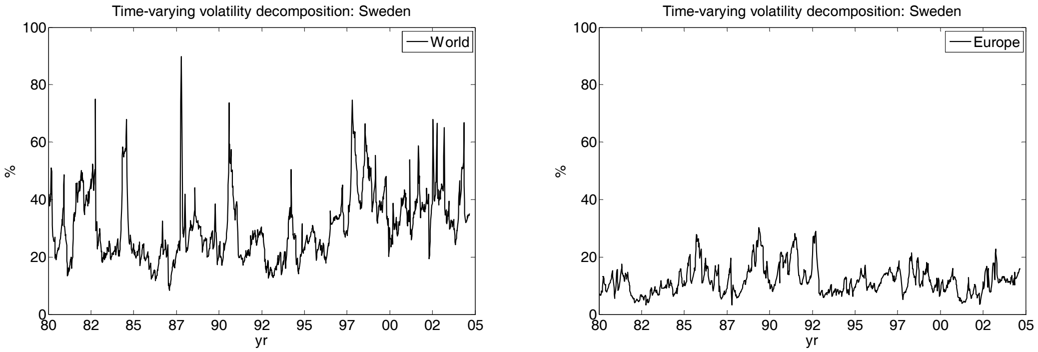
Figures A.7. *Volatility decomposition for the Netherlands.*



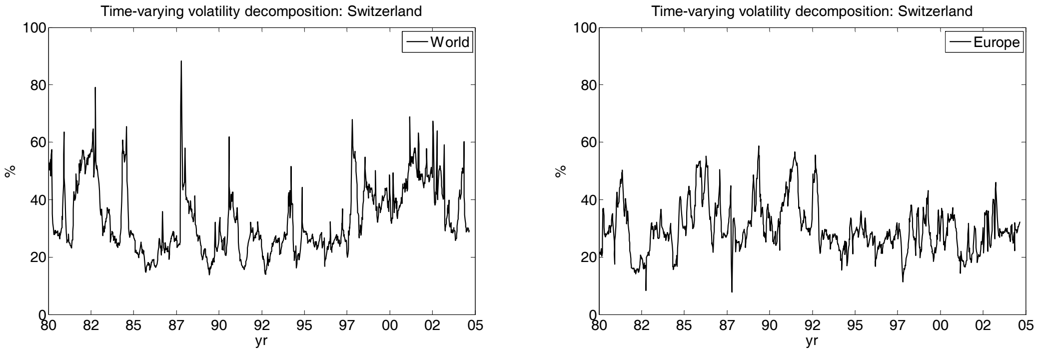
Figures A.8. *Volatility decomposition for Norway.*



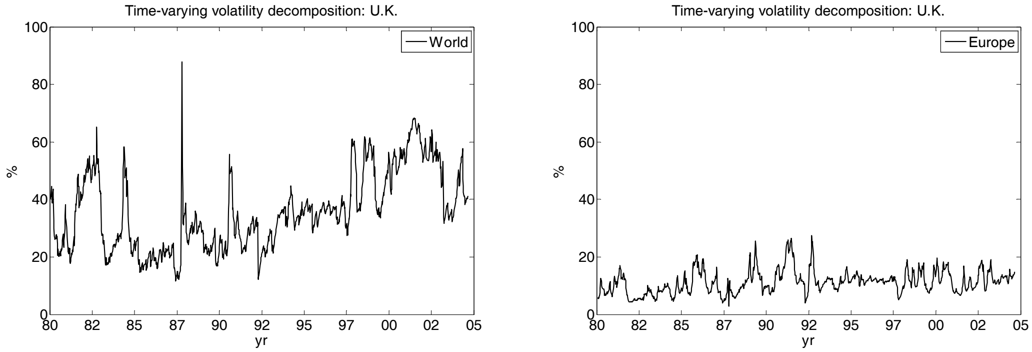
Figures A.9. *Volatility decomposition for Spain.*



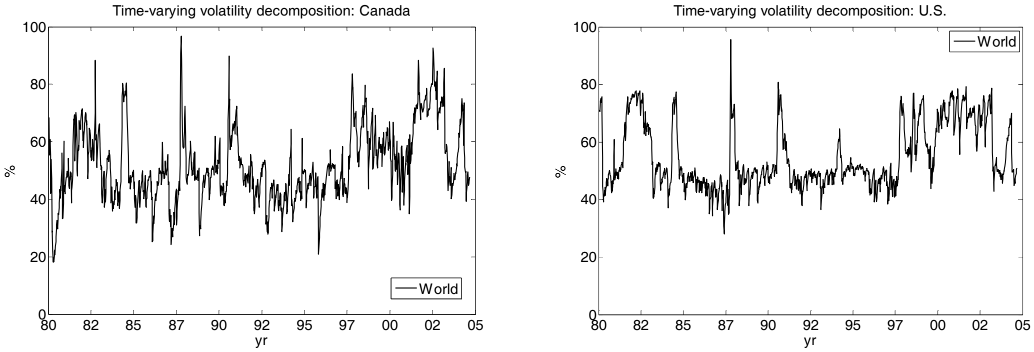
Figures A.10. *Volatility decomposition for Sweden.*



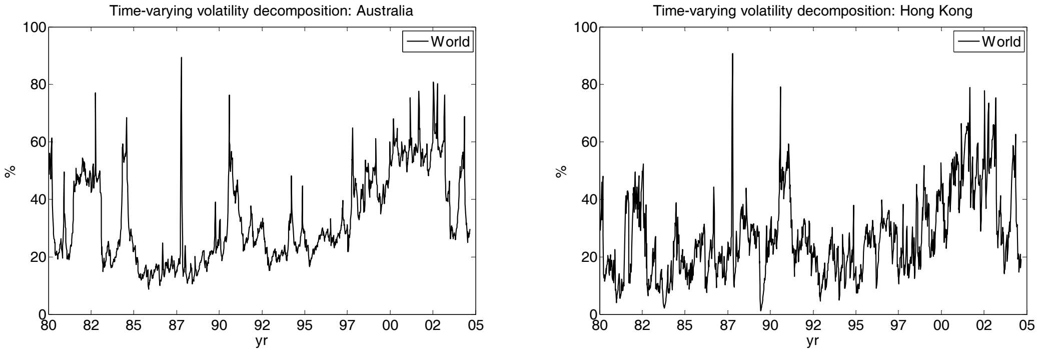
Figures A.11. *Volatility decomposition for Switzerland.*



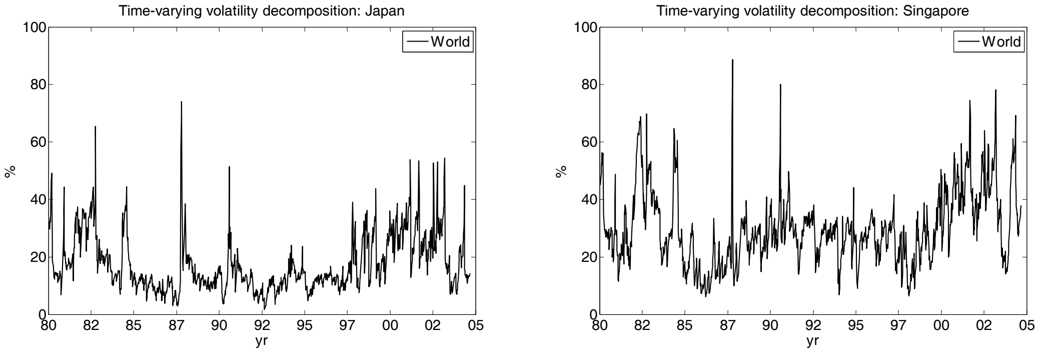
Figures A.12. *Volatility decomposition for the U.K.*



Figures A.13. *Volatility decompositions for Canada and the U.S.*



Figures A.14. *Volatility decompositions for Australia and Hong Kong.*



Figures A.15. *Volatility decompositions for Japan and Singapore.*

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