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The Macroeconomic Content of Equity Market Factors

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Abstract

Although existing research has examined the association between macroeconomic data and particular equity markets, little is known regarding the economic content of the latent factors common to equity markets. In this paper, several models are estimated to examine the economic composition of the common factors. A Bayesian selection process suggests that a common structure incorporating global and European factors is preferred to either the baseline case of a single global factor or the extended scenario of dual global factors. The common factors appear to be significantly associated with a small set of macroeconomic variables.

1. Introduction

This paper proposes and implements a methodology for the direct association of macroeconomic data with the latent factors common to developed equity markets, thereby providing insight into the specific macroeconomic content of the latent factors ubiquitously extracted pursuant to the Arbitrage (APT) or intertemporal CAPM (ICAPM) pricing theories. Roll and Ross commented on such a lack of economic interpretation in their seminal 1980 paper and concluded that, notwithstanding their findings concerning factor structure in equity returns, little was known regarding the economic composition of the factors that were ostensibly pricing U.S. equities.

A large number of papers have since sought to attach economic meaning to equity market common factors.[1] Although the economic datasets and the methodologies have differed, a common thread among the literature is the use of economic proxies for latent factors and the absence of any direct association between observed economic information and the underlying factor structure. Accordingly, little remains known regarding the economic composition of the unobserved factors common to equity markets.

The examination in this paper is immediately directed at attaching economic meaning to the unobserved common factors used to obtain relevant statistics such as market co-movement levels, integration levels, and expected returns. The study is augmented by the additional estimation of volatility-dependent levels of sensitivity to macroeconomic information, and the identification of geographically-dependent pricing factors. In so doing, information is also provided regarding the potentially differing

[1] See, for example, Chen, Roll, and Ross (1986), Burmeister and McElroy (1988), Cochrane (1991), Ferson and Harvey (1991), Fama and French (1992, 1993, 1995, 1996, 1998), King, Sentana, and Wadhwani (1994), Brennan, Chordia, and Subrahmanyam (1998).

relevance of macroeconomic information, and the ensuing macroeconomic interpretation of APT-type unobserved factors, during periods of low or high equity market volatility.

The estimation process is undertaken in a joint-setting pursuant to the dynamic common factor model described in Tsiaplias (2007). The joint-estimation of the factors, the common and idiosyncratic volatility levels, and the volatility-dependent economic sensitivity parameters avoids the need to obtain estimates using post-estimation extracted factors. Accordingly, the significance of any postulated economic associations, including the economic characteristics prevalent in the unobserved factors, is not rendered questionable by reference to errors-in-variables or heteroscedasticity. Formal testing is undertaken by estimating and comparing a number of non-nested models distinguished by reference to the number of equity market factors, their geographical dependence, and the type of association between the factors and the macroeconomic dataset. To facilitate the testing, a Bayesian comparison of the relative explanatory capacities of the set of factor structures and economic compositions is formulated and undertaken.

The paper is structured as follows. Section 2 provides an overview of the procedure adopted to investigate the macroeconomic composition of the common factors, and details the naive and structural forms of association pursuant to which sensitivity to macroeconomic information is constant or (volatility) regime-dependent. The macroeconomic and equity market datasets used in this paper are specified in Section 3. Model estimation and the associated convergence diagnostics for the set of models estimated are reviewed in Section 4. The model results, the model selection procedure, and model preferences are discussed in Section 5. The paper concludes with Section 6.

2. The model

This section discusses the procedure adopted to associate the equity market factors with macroeconomic data. Specifically, Section 2.1 proposes a mechanism for relating macroeconomic data to equity market common factors, while Section 2.2 defines and describes the naive and structural forms of economic association examined in this paper.

2.1. Obtaining an economic association

Consider the association of the unobserved common factors to macroeconomic data, thereby providing a direct economic interpretation for the (unobserved) factors. In this respect, this paper seeks to macroeconomically decompose the common factors, effectively evaluating the validity of the construct:

$$\boldsymbol{f}_t = \Phi \boldsymbol{f}_{t-1} + \Gamma x_t + v_t, \quad (1)$$

$$v_t = H_t^{1/2} z_{2,t}, \quad (2)$$

where $\boldsymbol{f}_t$ is a *K* by 1 vector comprising the common factors, x_t is a *P* by 1 vector of exogenous (macroeconomic) variables, Φ is a *K* by *K* matrix of coefficients on the immediate lag of the latent factors, Γ is a *K* by *P* matrix of coefficients on the exogenous variables and $z_{2,t}$ is a *K*-dimensional vector distributed as *iidMVN*.

The time *t*-1 deterministic portion of the pervasive component enters the basic return equation as per:

$$E\left(r_{i,t} \left| I_{t-1}\right.\right) = c_{i,1}{'}\boldsymbol{f}_{t|t-1} + \psi_i u_{i,t-1}, \quad (3)$$

$$u_{i,t-1} = r_{i,t-1} - c_{i,1}{'}\boldsymbol{f}_{t-1|t-1}, \quad (4)$$

therefore enabling a macroeconomic interpretation of the return structure.

For the purposes of this paper x_t is comprised of information observed at time *t*-1. The use of observed macroeconomic information enables a joint hypothesis of economic content and predictability for the common factor vector $\mathbf{f}_t$. Accordingly, the return equation may be written as:

$$\begin{aligned} E\left(r_{i,t} \left| I_{t-1}\right.\right) &= c_{i,1}{}'\mathbf{f}_{t|t-1} + \psi_i u_{i,t-1} \\ &= c_{i,1}{}'\left(\Phi \mathbf{f}_{t-1|t-1} + \Gamma x_{t-1}\right) + \psi_i u_{i,t-1} \\ &= c_{i,1}{}'\lambda_t\left(x_t, I_{t-1}\right) + \psi_i u_{i,t-1}, \end{aligned} \qquad (5)$$

Given (5), the vector $\mathbf{f}_t$ enables interpretation of the risk premia for the various factors in terms of sets of economic variables, rather than individual economic variables. In this respect, the treatment of a single variable as a common factor implicitly observes the factor space from a unidimensional perspective, and applies a treatment of the common factors that implicitly imposes the restrictions (relative to the general construct in (1) and (2)) $\Phi = 0,\ \Gamma = \mathrm{I}_P$ (I_P being an identity matrix of order *P*), and $K = P,$ such that $\mathbf{f}_t = x_t + v_t$. Where the *k*th economic variable (and pricing factor) is exactly observed the *k*th diagonal element of H_t is set to zero such that $\mathbf{f}_{k,t} = x_{k,t}$.

Compare, however the construct for the unrestricted $\mathbf{f}_t$ in which each factor is projected into the space of *P* variables to provide *P* dimensions of information (assuming that each of the *P* variables belongs to a unique space), in a potentially more realistic appraisal of the economic meaning of the risk factors. The approach explicitly circumvents Burmeister and McElroy's (1988) argument that the measured macroeconomic-factor approach enjoys a capacity for economic interpretation not available for the factor analysis approach.

2.2 Associative forms

The nature of the macroeconomic association is determined by the functional form and the arguments of the vector-valued premia term λ_t. In this paper, associative forms distinguished on the grounds of expectations regarding economic information and economic structure are evaluated. In the simplest scenario, investors determine prices in accordance with historic economic information in an economic framework where sensitivity to economic information is unconditional. Elaborations on this setting involve the consideration of historic alternative information (viz. non-macroeconomic historic information sources) and regime-conditional sensitivity to economic information.

Naive economic expectations

In the naive setting, investors determine prices by reference to observed economic information, and are either unconcerned with future economic conditions or presume that current economic conditions are sufficient indicators of future conditions. Given naive economic expectations, the factor and market return expectations are:

$$E\left(\boldsymbol{f}_{k,t} \left| I_{t-1}\right.\right) = \lambda_t\left(x_{t-1}\right) = \gamma_k{}' x_{t-1} + \phi_k \boldsymbol{f}_{k,t-1|t-1}, \tag{6}$$

$$\begin{aligned} E\left(r_{i,t} \left| I_{t-1}\right.\right) &= \theta_{i,1}{}' x_{t-1} + \theta_{i,2}{}' \boldsymbol{f}_{t-1|t-1} + \psi_i\left(r_{i,t-1} - c_{i,1}{}' \boldsymbol{f}_{t-1|t-1}\right) \\ &= \theta_{i,1}{}' x_{t-1} + \psi_i r_{i,t-1} + c_{i,1}{}'\left(\Phi - \psi_i \mathrm{I}_K\right) \boldsymbol{f}_{t-1|t-1}, \end{aligned} \tag{7}$$

where ϕ_k is the kth row of Φ.

The basic naive expectation is extended by the introduction of the common factor persistence term Φ. In the case $\Phi \neq \emptyset$ investors consider both economic data and updated information regarding the unobserved common factor path in determining future returns. The vector $f_{t-1|t-1}$ embodies revised or updated information relative to the initial estimate of common financial conditions given by $f_{t-1|t-2}$ and the result $\Phi \neq \emptyset$ establishes an active filter transferring revised estimates of common information to future prices. Given x_{t-1}, the updated factor is presumed to carry information in excess of that provided by the economic indicators (consider information outside the sphere of the observed macroeconomic set). The additional reliance on past pricing errors, pursuant to $\psi_i \neq 0$, induces pricing dependence on observed economic data, preceding returns and revised common information.

The transfer of revised common information to future prices depends on the persistence observed in the common factors and the *i*th market's sensitivity to both the common factors and historic pricing errors. In this respect, the difference term $\left(\Phi - \psi_i \mathrm{I}_K\right)$ may be interpreted as a common memory filter for the information inherent in the various sources of updated common information. The combined effect of common persistence and sensitivity to historic returns on revised common information may be offsetting or exacerbative. In the latter case, the result $\text{sign}\left(\phi_{k,m}\right) \neq \text{sign}\left(\psi_i\right) \;\middle|\; \phi_{k,m} \neq 0,\ \psi_i \neq 0$ implies that updated *m*th-order information associated with the *k*th common source exhibits a greater absolute effect on returns for the *i*th market than the effect suggested by common or idiosyncratic persistence alone.

By restricting the pricing information set to the economic indicators x_{t-1} (i.e.: $\Phi = \emptyset$), investors are assumed to determine prices in accordance with the relevant set of economic indicators. The fixed status of the pricing filter θ_i implies that investors determine prices in an unconditional economic framework where sensitivity to observed indicators is invariant across time and volatility. Notice, however, that in the case $\psi_i \neq 0$ investors consider the updated pricing error in their determination of the next period return for the *i*th asset. In the aforementioned case, the pricing error may be carried forward or corrected such that future prices are not determined solely by reference to observed economic indicators.

Structural expectations

In the naive setting investors determine prices by evaluating a factor's association with historic data and relating the factor to a given asset. The evaluation takes place in a time-invariant setting where sensitivity to factors and exogenous information is deemed constant over varying economic conditions. In the structural setting, investors construct expectations conditional on a particular economic regime or state of affairs, as per.

$$E\left(\boldsymbol{f}_{k,t} \left| I_{t-1}\right.\right) = \gamma_{k,t}{}' x_{t-1} + \phi_k \boldsymbol{f}_{k,t-1|t-1}, \tag{8}$$

$$\begin{aligned} E\left(r_{i,t} \left| I_{t-1}\right.\right) &= c_{i,1}{}'\left(\Gamma_t x_{t-1} + \Phi \boldsymbol{f}_{t-1|t-1}\right) + \psi_i\left(r_{i,t-1} - c_{i,1}{}'\boldsymbol{f}_{t-1|t-1}\right) \\ &= c_{i,1}{}'\Gamma_t x_{t-1} + c_{i,1}{}'\Phi \boldsymbol{f}_{t-1|t-1} + \psi_i\left(r_{i,t-1} - c_{i,1}{}'\boldsymbol{f}_{t-1|t-1}\right) \\ &= \theta_{i,1,t}{}' x_{t-1} + \psi_i r_{i,t-1} + c_{i,1}{}'\left(\Phi - \psi_i \mathrm{I}_K\right)\boldsymbol{f}_{t-1|t-1}. \end{aligned} \tag{9}$$

where $\gamma_{k,t} = \Gamma_k s_{k,t}$, Γ_k is a P by M matrix, $s_{k,t} = \left[s_{k,1,t} \quad \cdots \quad s_{k,M(k),t}\right]'$, and $s_{k,m,t}$ is an indicator variable taking on the value unity if the *m*th pricing structure prevails at time *t* for the *k*th common source of information and zero otherwise.

The pricing framework continues to assume that a particular asset's sensitivity to a given information structure is constant such that time-variation in the construction of expectations is induced by conditional factor sensitivity to macroeconomic information. Investors, however, are not restricted to a common state of affairs and are allowed to associate a particular state (or level of sensitivity) to a given source of (non-idiosyncratic) information at time *t*. Such associations are determined independently of the states (or regimes) accorded to other factors.[2] It is clear, therefore, that topical or regional information needn't follow the same state path as global information.

3. Data

In accordance with previous research variables pertaining to short-term interest rates, interest rate spreads, commodity and consumer prices, trade, employment, investment, and production levels are considered.[3] Where necessary, variables have been converted to their growth rates (refer to Appendix A). Given the large number of variables, a basic explanatory set of eight plausible variables was created for estimation purposes. Any insignificant variables were replaced such that all stationary variables are considered. The results are, therefore, robust to different compositions of the explanatory set. To offset multicollinearity issues, the incremental component was used for variables

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[2] This is essentially a simplifying assumption and may be interpreted as a corollary of the orthogonality assumption on the common factors.
[3] For previous research see, for example, Chen, Roll, and Ross (1986), Burmeister and McElroy (1988), Chen (1991), Cochrane (1991, 1996), Ferson and Harvey (1991), Glosten, Jagannathan, and Runkle (1993), Flannery and Protopapadakis (2002), Connolly and Wang (2003), and Rapach, Wohar, and Rangvid (2005).

exhibiting high levels of correlation with existing panel members.[4] The explanatory panel settled upon comprises the centered and standardised growth rates of: 1) monthly U.S. deposit rates, 2) the spot price of lead, 3) industrial country imports, 4) industrial country consumer prices, 5) the spot price of oil (spot oil, WTI), 6) the value of U.S. government securities issued, 7) the number of professional employees, and 8) the incremental component of industrial production. [5]

Pursuant to the monthly frequency of the macroeconomic dataset, monthly national market returns are used to estimate the models. A set of $N = 15$ national market (Australia, Belgium, Canada, France, Germany, Hong Kong, Italy, Japan, Netherlands, Singapore, Spain, Sweden, Switzerland, U.K., and the U.S.) excess (percentage) returns obtained from the U.S.-dollar denominated MSCI developed country indices is used to obtain model inferences. The monthly returns span $T = 415$ observations over the period January, 1970 to July, 2004.

4. Estimation and diagnostics

Four basic models conforming to the naive and structural forms are constructed and estimated. The basic estimated return structure is given by:

$$r_t = \alpha + c_1 \boldsymbol{f}_{world,t} + c_2 \boldsymbol{f}_{Europe,t} + u_t \,, \tag{10}$$

$$\Psi\left(L\right) u_t = G_t^{1/2} z_t \,, \tag{11}$$

$$G_t = diag\left(\left[\sigma^2_{1,t|t-1} \quad \sigma^2_{2,t|t-1} \quad \ldots \quad \sigma^2_{N,t|t-1}\right]'\right), \tag{12}$$

[4] The incremental (or unexpected) component is taken as the vector of residuals from an OLS regression of the relevant variable on the remaining members of the macroeconomic panel.
[5] The condition number for the panel of explanatory variables is 1.35 providing no indication of a multicollinearity issue.

$$\sigma_{i,t|t-1}^2 = E\left(\sigma_i^2 \left| I_{t-1}\right.\right) = \varpi_i + \sum_{p=1}^{P} \alpha_{i,p} \varepsilon_{i,t-p}^2 + \sum_{q=1}^{Q} \beta_{i,q} \sigma_{i,t-q|t-q-1}^2 , \quad (13)$$

$$\phi_k\left(L\right) f_{k,t} = \mu_{k,t} + \sigma_{k,t} e_{k,t} , \quad (14)$$

$$\mu_{k,t} = \gamma_{k,t}{}' x_{t-1} = s_{k,t}{}' \Gamma_k{}' x_{t-1} , \quad (15)$$

$$\sigma_{k,t}^2 = \sigma_k^{2\prime} s_{k,t} , \quad (16)$$

where $z_t \sim iidN\left(0, \mathrm{I}_N\right)$, $P = Q = 1$, k pertains to the world or European factor, $e_{k,t} \sim iidN\left(0,1\right)$, and $\Psi\left(L\right)$, $\phi_k\left(L\right)$ are first-order processes in the lag operator L. The path of the discrete Markovian regime $s_{k,t}$ is determined by a constant transition matrix and identified by reference to σ_k^2. The structure incorporates persistent common and idiosyncratic factors, and accommodates heteroscedasticity via common Markovian regimes and GARCH innovations. All parameters are jointly estimated and the estimation process is detailed in Tsiaplias (2007).

The first (baseline) model adopts a single global factor and two common regimes in the vein of the global CAPM, while the remaining models incorporate additional layers of complexity by adding further regimes and factors to the baseline scenario (see Table 1). In this respect, model 2 implements three common regimes (versus the two regimes for the baseline scenario), model 3 adds a European factor with two independent (i.e. European specific) regimes, whereas the fourth model identifies two global factors in addition to a European factor. All three factors for model four are subject to independent two-regime processes for a total of six regimes. The estimation results, including the significance of the macroeconomic data, are presented in Section 5. A formal model selection process, outlined and implemented in Section 5.3, is used to deduce whether the additional layers of complexity better explain developed equity market returns.

The single factor models (models 1 and 2) are identified by a unity restriction on the U.S. factor loading term. The third model's global factor is identified in the same manner as the first two models, whereas the European factor is identified by a unity restriction on Germany's European factor loading (in addition to the zero European factor restriction for the non-European markets). Two identification approaches are used to identify the three factors associated with the fourth model.

Table 1 *Overview of model structures*

Model	Association	Factor structure
1	Naive & structural	Single global factor (2 regimes)
2	Naive & structural	Single global factor (3 regimes)
3	Naive & structural	• Global factor (2 regimes) • European factor (2 regimes)
3b	Structural (in the global component)	• Global factor (2 regimes) • European factor (2 regimes) • European sensitivity to economic information treated as constant over both regimes
4	Naive & structural	• Global factor 1 (2 regimes) • Global factor 2 (2 regimes) • European factor (2 regimes)

Pursuant to the first approach, the U.S. market loadings on the second global and European factors are restricted to zero while sensitivity to the first global factor is set to unity. Further, Japanese and German sensitivity to the second global and European factors respectively are set to unity. Under the second approach, German sensitivity to the European factor, U.S. sensitivity to the first global factor, and U.K. sensitivity to the second global factor are set to unity, while U.S. sensitivity to the second global factor is unrestricted. The first and second global factors are distinguished via the imposition of zero restrictions on the Swiss and French markets respectively. The results presented for the fourth model pertain to the second identification approach. In this respect, the model rankings determined in Section 5.3 remain the same regardless of the identification approach adopted for the fourth model.

The convergence statistics for the naive structures are similar to or better than their structural counterparts. The autocorrelation coefficients for the γ terms under the naive assumption are also similar to or smaller than their equivalents under the structural hypotheses. Accordingly, discussion of the convergence statistics is restricted to the more complicated structural models.[6]

Gelman-Rubin convergence statistics (R statistics) are obtained from two runs of the sampler using dispersed initial values.[7] The convergence statistics are at or extremely close to unity for all parameters and suggest convergence to the posterior density for all the structural models. Autocorrelation coefficients for the first model's common component parameters are close to zero by the tenth lag suggesting that the sampler mixes fairly rapidly in the base structural scenario. The introduction of a third regime increases the autocorrelation observed in the common component parameters, especially in the case of the first regime where autocorrelation coefficients for the economic parameters $\gamma_{.,1}$ (representing sensitivity to macroeconomic conditions in the first regime) taper off slowly. The autocorrelation appears to be associated with difficulties regarding the clear identification of a third regime.

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[6] The convergence statistics are available on request.

[7] Each run provided 100,000 draws minus a burn-in of 5000 draws.

The autocorrelation coefficients for the first variant of the third model's $\gamma_{\cdot,\cdot,2}$ parameters (model 3a), representing the economic coefficients for the European factor, require several hundred observations before tapering off towards zero. Similarly high autocorrelation levels are observed over several sets of dispersed initial conditions, suggesting weak identification of the conditional expectation of the European factor. The autocorrelation levels also induce difficulties regarding the estimation of accurate standard errors for the $\gamma_{\cdot,\cdot,2}$ parameters. To alleviate the problem, the model is re-estimated with the restriction $\gamma_{\cdot,\cdot,2} = 0$. The convergence and mixing properties of the restricted model are greatly improved with R-statistics at unity, and autocorrelation levels tapering off to zero at rates similar to those observed for the first model. The mixing difficulties encountered for model 3a do not appear present in the fourth model, which introduces an additional global factor. Although the autocorrelation coefficients $\gamma_{\cdot,\cdot,3}$ for the European factor taper off towards zero at a slower rate than for the two global factors, the mixing rate is clearly better than in the case of model 3a. The improved mixing rates for model 4 relative to model 3a may be associated with the presence of common information among the global and European components alleviated by the fourth model's inclusion of an additional global factor.

The presence of heteroscedasticity is examined using Lagrange multiplier tests for ARCH effects on the idiosyncratic residuals. Test results for the single global factor models (models 1 and 2) indicate that no significant ARCH effects remain in the idiosyncratic residuals and suggest that the GARCH (1,1) process adequately accounts for the conditional volatility observed in the idiosyncratic components. The results are extremely similar for both models 1 and 2 given the naive or structural cases. Significant residual ARCH effects are only observed in one of the fifteen markets (Germany) for the third model and in two of the 15 markets (Singapore and Australia) for model 4. [8]

The ARCH tests are also undertaken on the common factor residual components to determine whether the specified volatility processes adequately account for common volatility.[9] The first model's pervasive factor, for both the naive and structural hypotheses, exhibits no significant remaining ARCH effects given the estimation of pervasive volatility as a two-regime Markovian switching process. The result suggests that a third volatility regime for the global factor is unnecessary. In any case, the ARCH tests on the global factor residuals for both the naive and structural variants of the second model find no significant evidence of ARCH-type heteroscedasticity. Similarly, tests on the common component residuals for models 3 and 4 find little evidence of any remaining ARCH effects.

It appears that augmentation of the single global factor model introduces autocorrelation in the squared residuals of some of the idiosyncratic components. Although evidence of conditional heteroscedasticity is negligible for all common components and nearly all idiosyncratic components, the evidence suggests that idiosyncratic conditional heteroscedasticity may be better accounted for by limiting the unobserved global component to a single factor.

5. Results

The model results are divided into three components covering the macroeconomic sensitivity of the common factors, common factor sensitivity to non-macroeconomic

[8] The fourth and fifth lags of the German idiosyncratic residuals, however, also exhibit significant ARCH effects (p-values 0.049 and 0.045) for the naive variant of model four.
[9] The heteroscedasticity diagnostics are available upon request.

sources of information, and model selection. Section 5.1 examines the explanatory capacity of the economic variables across the common factors, and across volatility regimes. Next, Section 5.2 considers the significance of alternative sources of information captured through the common and idiosyncratic persistence terms. Section 5.3 defines a model selection procedure pertaining to the econometric specification in Section 4 and uses it to undertake a comparison across the various factor and regime combinations adopted.

5.1. Economic sensitivity

In the case of the basic structural model, model 1, four economic variables are clearly significant in the first economic regime (identified by low global volatility): U.S. deposit rates, spot lead, industrial country imports, and industrial country consumer prices (Table B1). U.S. interest rate changes impact negatively on equity markets such that the marginal impact of a 1% rise in U.S. rates on an equity market with unit sensitivity to the global factor is a drop in next period prices of about 0.4%. The negative association with U.S. deposit rates is consistent with earlier evidence regarding a negative association between equity returns and short-term interest rates [Glosten, Jagannathan, and Runkle (1993)]. The result also contradicts evidence regarding the existence of a positive relationship between short-term interest rates and equity returns [see, for example, Ferson (1989)].

The first structural model also suggests that an observed rise in the price of lead impacts negatively on equity prices. In a similar vein, an observed rise in consumer prices, with the possibility of flow-on interest rate effects, tends to dampen equity returns. In contrast, observed industrial country imports impact positively on global equity returns, suggesting that a rise in international trade has a positive marginal effect on future equity returns. The positive and negative signs for the import and consumer price variables respectively are consistent with a priori expectations. A similar significance for consumer prices is observed in earlier research [see, for example, Chen, Roll, and Ross (1986), Cochrane (1996), Flannery and Protopapadakis (2002)]. The importance of international trade on equity returns is also highlighted in Forbes and Chinn (2004). The salient difference between earlier results and those herein is that the results for this model pertain to a global factor common to developed equity markets as opposed to the equity markets themselves. Insight is, therefore, provided into the composition of a global portfolio akin to that implied by the global APT. Observed changes to the oil price, the level of U.S. government securities, professional employment or incremental industrial production provide no pricing information for the first economic regime. In terms of the naive variant of model 1, macroeconomic sensitivity appears to accord with the sensitivity observed for the first structural model's low volatility regime (Table C1).[10]

The research summarised in Section 1 highlights a market-specific (esp. the U.S. equity market) significance for a large number of macroeconomic variables. Model 1, however, appears to contradict such suggestions given that the remaining variables in the macroeconomic set (oil prices, U.S. government securities issued, professional employment, and incremental industrial production) are insignificant at the 5% level as are the variables defined in Appendix A that are excluded from the current set. Instead, model 1 suggests that developed equity markets exhibit sensitivity to a small set of

[10] The model estimated with U.S. unemployment replacing the professional employment variable yields similar results.

important economic variables pertaining to interest rates, import levels, and consumer and commodity price levels.

The macroeconomic parameters for the second regime, $\gamma_{\cdot,2}$, estimate common sensitivity to the economic information set in a state of higher volatility such that the differential pricing impact of the second regime is given by $\gamma_{\cdot,2,inc} = \gamma_{\cdot,2} - \gamma_{\cdot,1}$. The impact of the oil price, U.S. government security, and professional employment variables remains insignificant in the second regime. In contrast, the impact of the incremental component of industrial production, although negligible in low volatility conditions, exhibits a significant negative shift. There are no substantive differential effects for the four significant variables in the first regime, implying that the variables remain significant notwithstanding a positive shift in volatility.

The absence of any shift in significance for seven of the eight variables in the panel suggests that the expected factor component for the structural model does not deviate greatly from its naive counterpart. Accordingly, any explanatory capacity of the four significant variables in the first regime is retained following a shift to the higher volatility regime. The estimates also suggest that significant information may be extracted from the observed incremental component of industrial production but only preceding a period of higher volatility. Consequently, a high probability of a positive volatility shift dampens returns given the negative association between the expected global factor and incremental industrial production in the high volatility regime.

The second structural model introduces a third economic state (or regime) to the global factor. None of the variables in the lowest volatility regime differ significantly from their medium volatility counterparts, which appear to be associated with the first structural model's low-volatility regime (Table B2). Furthermore, the coefficients for the second regime are almost identical to those of its naive variant with the U.S. deposit rate, lead price, industrial country imports, and industrial country consumer price variables significant at the 5% level (Table C2). All eight parameters corresponding to the third economic regime also fail to deviate significantly from their values in the second regime. Although the direction of the incremental industrial production variable remains negative, the variable fails to retain its significant status observed for the first structural model. The negligible differential impact of the economic parameters across regimes implies that the economic predictability of the global factor coincides with its naive variant.

A second, European specific, factor complements the global factor for the first variant of the third structural model (model 3a). Both factors incorporate two distinct economic regimes. The spot price of lead, and industrial country imports and prices variables remain significant for the global factor's first regime as is the case for the first and second models (Table B3). The U.S. deposit rate, however, although maintaining its negative sign, fails to differ significantly from zero. The presence of a European factor, therefore, appears to reduce the global significance of U.S. deposit rates, whereas observed changes in consumer and commodity prices, and industrial country imports retain their significance. As is the case for structural models 1 and 2, economic sensitivity for the third naive model's global factor accords with the sensitivity observed for its structural counterpart in the low-volatility regime (Table C3).

In the case of the second global regime, the differential effect for the first seven variables in the explanatory set is clearly insignificant. As a result, the price of lead, industrial country imports, and industrial country prices provide an explanatory capacity across periods corresponding to either regime. As is also the case for the first two models, the explanatory capacity of the incremental component of industrial production exhibits a negative shift, albeit at a smaller significance level (incremental industrial production is significant at the 10% level rather than the 5% level).

No variable in the panel exhibits any significant effects for model 3a's European factor in its low-volatility regime suggesting that expectations regarding the European specific component are little affected by U.S. economic data, industrial country trade, or global commodity levels during periods of low European volatility.[11] Although, the differential effects of the economic variables for the European factor lack significance at the 5% level, sensitivity to the observed changes in oil prices and U.S. government securities on issue appears to shift in the negative direction following a jump towards higher European volatility. In contrast to the structural variant, oil prices and incremental U.S. industrial production levels provide significant explanatory information for the third naive model's European factor. As expected, the direction of the European portfolio's association with oil prices is negative. As such, the introduction of a second European regime obfuscates the significance observed for the naive variant and suggests that regime-dependence for the economic sensitivity specification may be unnecessary.

The insignificant economic parameters in the structural scenario, and the negligible value for the European persistence term ϕ_{Europe}, tend to the conclusion that no historic information may be used to explain the path of the European factor. Accordingly, the factor may be interpreted as comprising no more than the set of European-specific shocks. The latter interpretation is adopted for model 3b where the European economic

[11] The estimation was repeated with alternative explanatory sets including variables pertaining to European consumer prices and German imports with similarly insignificant results.

coefficients for both the first and second regimes, $\gamma_{\cdot,1,2}$ and $\gamma_{\cdot,2,2}$, are set to zero (Table B4). The global component parameters for model 3b fail to differ substantively from those of the first variant and the interpretation provided for model 3a remains applicable.

The final structural model extends model 3 by adding a second global factor. For the fourth model, observed changes in industrial country imports and consumer price levels impact significantly on the next period value of the first of the two global factors in the low volatility regime (Table B5). In this respect, the first global factor for the fourth naive model also appears to be weakly associated with industrial country consumer price levels (Table C4). The nature of the impact accords with previous models, such that the marginal impact of a rise in import levels is positive while the marginal impact of a rise in consumer prices is negative. The economic variables are all insignificant for the second global factor's low-volatility regime, although the significance level of the observed change in the spot price of lead is extremely close to 5%. Similarly, the price of lead is significant for the second global factor under the naive variant.

In contrast to the results for the first three structural models, two observed economic variables impact significantly on the next period value of the European factor in the low volatility regime: U.S deposit rates and industrial country consumer prices. The impact of both variables is negative and the significance of consumer prices for both the first global factor and the European factor indicates a general explanatory relevance of the consumer price variable for developed European markets specifically and developed markets generally (during periods of low volatility). The results appear to distribute the four significant parameters observed for the sole pervasive factor in model 1 across the three common factors. The European factor for the fourth naive model also exhibits a significant association with industrial country consumer price levels, in addition to oil prices. The association is negative for both variables implying that hikes in consumer and oil prices push European markets downwards. In this respect, the expected marginal response for a European market (with unit sensitivity to the European factor) to a percentage point fall in industrial country consumer prices or oil prices is a rise of 0.64% and 0.74% respectively.[12]

Significant shifts across economic regimes are observed for the professional employment and incremental industrial production variables in the case of the first global factor's second regime. The shifts suggest that observed changes in professional employment and incremental industrial production, albeit irrelevant during periods of low volatility, provide information regarding the path of the first global factor during periods of higher volatility. The direction of the parameters implies that an increase in professional employment produces a positive marginal effect while the marginal effect of incremental industrial capacity is negative. The absence of any significant (at the 5% level) shift for industrial country imports and industrial country consumer prices implies that sensitivity to the variables is similar across regimes. It should be noted, however, that a significant negative shift at the 10% level is observed for industrial country imports.

The differential effects of the second European regime are insignificant for all variables. Consequently, U.S. deposit rates and industrial country consumer prices retain a similar association to the European factor even where the second European regime prevails. The differential impact of the second global factor's higher volatility regime is also negligible for all economic variables; as such the observed information fails to

[12] Interestingly, the replacement of industrial country consumer prices and imports with their European equivalents fails to increase the explanatory capacity of the economic dataset.

exhibit a significant (at the 5% level) predictive capacity for either regime. It appears, therefore, that the second global factor adds little to the third model's capacity to explain expected market returns.

5.2. Alternative sources of information

The unrestricted nature of the common and idiosyncratic persistence terms, ϕ and ψ, implies that equity markets are susceptible to alternative (to macroeconomic) sources of information. Given that the results are similar across the naive and structural variants, discussion is limited to the estimates observed for the naive set of models. The statistics describing the ϕ term for the naive models are presented in Tables C1-C4. The corresponding statistics for the idiosyncratic persistence ψ are presented collectively in Table C5. Common persistence for the first two models is not significantly different to zero, implying that the macroeconomic set is solely responsible for determining the expected value of the global reference portfolio. All three persistence parameters for the fourth model are similarly insignificant, as is the European factor for model 3. The third model's global persistence parameter is significant at the 10% level and indicates (albeit weakly) that an alternative source of information is pertinent in determining the expected value of its global portfolio. Recall that, in the naive case, the expected returns are given by equation (7) (suppressing the intercept α_i):

$$E\left(r_{i,t}\left|I_{t-1}\right.\right)=\theta_{i,1}{}'x_{t-1}+\theta_{i,2}{}'\mathbf{f}_{t-1|t-1}+\psi_i\left(r_{i,t-1}-c_{i,1}{}'\mathbf{f}_{t-1|t-1}\right).$$

The result $\phi=0$ renders $\theta_{i,2}$ irrelevant such that expected returns are no longer dependent on the updated expectation of the common component except indirectly through the idiosyncratic persistence term ψ. The idiosyncratic persistence parameters are negligible for all European and North American markets across each of the four models. Idiosyncratic persistence is also negligible for Japan and Hong Kong. Singapore exhibits non-negligible positive idiosyncratic persistence for the single global factor scenario, while Australian idiosyncratic persistence is significant and negative in all but the fourth case. In 13 of the 15 markets (i.e. all markets except Australia and Singapore), the expected return structure appears to collapse to its simple form (again, suppressing the intercept α_i), $E\left(r_{i,t} \left| I_{t-1}\right.\right) = \theta_{i,1}{}' x_{t-1}$, whereby expected market values are determined by reference to the non-negligible components of the macroeconomic dataset.

5.3. Model Selection

The estimated models rely on several non-nested assumptions regarding factor structure and lead to alternative schools of thought regarding the composition of the common factors observed among national equity markets. The assumptions vary across matters such as the number of factors, the volatility structure of the factors and the construction of the expected components. A common thread across all models is the modelling of idiosyncratic volatilities as GARCH(1,1) processes. As discussed in Tsiaplias (2007), the latent nature of the extracted factors and their regimes leads to an intractable likelihood function. In any case, observation of the likelihood function fails to provide a valid mechanism for comparison of the estimated models given the non-nested nature of the various assumptions. To overcome this difficulty, approximations to the marginal likelihoods are obtained and used to undertake comparisons across the structural and naive hypotheses and between the various structural and naive models.

The goal is to obtain $f\left(Y\middle|M_i\right)$ which may then be used to undertake comparisons across models, obtain Bayes factors, and determine posterior probabilities for the models. Given $f\left(Y\middle|M_i\right)$, the posterior probability for the *i*th model is straightforward to obtain.

Conditional on the common factor draw F and the regime process S we can obtain $f\left(Y\middle|\Theta,F,S,M\right)$. The goal, however, is to obtain:

$$f\left(Y\middle|M\right)=\int_{\theta}\int_{s}\int_{f} f\left(Y\middle|\Theta,F,S,M\right)df\,ds\,d\theta\,. \qquad (17)$$

There is no analytical solution for integrating out the relevant parameters and an approximation is necessary. The integration process is undertaken in three steps. The Kalman filter may be used to obtain the (conditional on $S_{<=t}$, Θ) one-step ahead density $f\left(y_t\middle|\Theta,\ S_1,S_2,...,S_t,I_{t-1},M\right)$. The reliance on the entire state history to time *t*, $S_{<=t}$, is a corollary of the persistent nature of F in accordance with $\phi\neq 0$. Given the failure to reject the null hypothesis $\phi=0$, however, the history of the state becomes irrelevant. At the first step, then, the Kalman filter is used to obtain $f\left(y_t\middle|\Theta,S_t,I_{t-1},M\right)$ and therefore $f\left(Y\middle|\Theta,S,M\right)$. There are a range of values of Θ at which the Kalman filter may be evaluated. One possibility is to evaluate $f\left(Y\middle|\Theta,S,M\right)$ at each draw of Θ from its posterior density $f\left(\Theta\middle|Y\right)$ and take the value for which $f\left(Y\middle|\Theta,S,M\right)$ is maximized as an estimate of the mode. Another is to use multivariate or piecewise medians. The piecewise median is found to provide the most stable estimate of $f\left(Y\middle|\Theta,S,M\right)$ and is therefore adopted. A difficulty in the extraction of $f\left(Y\middle|\Theta,S,M\right)$ is that Θ comprises the estimated parameters and the idiosyncratic GARCH volatilities. The need to condition on idiosyncratic conditional variances is a consequence of the intractability of integrating out the GARCH volatilities from $f\left(Y \middle| \Theta, S, M\right)$ in the presence of the regime structure S. The idiosyncratic volatilities are constructed relying on two ramifications: 1) given observation of F and the parameter set θ, the residuals are observed, and 2) for fixed initial conditions, observation of the residuals ensures that the idiosyncratic volatilities may be determined exactly. Given the preceding ramifications, the average across all draws of the idiosyncratic conditional volatilities is adopted as the estimate of the idiosyncratic volatility.

The regime process S can be integrated out of $f\left(y_t \middle| \Theta, S_t, I_{t-1}, M\right)$ pursuant to $f\left(Y \middle| \Theta, M\right) = \int_S f\left(Y, S \middle| \Theta, M\right) ds$. Consider the availability of $f\left(S_t \middle| \Theta, I_{t-1}, M\right)$ and the consequent derivation of $f\left(y_t \middle| \Theta, I_{t-1}, M\right)$ as per:

$$f\left(y_t \middle| \Theta, I_{t-1}, M\right) = \int_S f\left(y_t \middle| \Theta, S_t, I_{t-1}, M\right) f\left(S_t \middle| \Theta, I_{t-1}, M\right) ds. \tag{18}$$

The desired density $f\left(Y \middle| \Theta, M\right)$ is then given by the product of each of the T densities $f\left(y_t \middle| \Theta, I_{t-1}, M\right)$. Given the discrete nature of the regime process, the integration may be undertaken as a summation over the state probabilities. Hamilton's Markovian filter is used to retrieve $f\left(S_t \middle| \Theta, I_{t-1}, M\right)$ and thereby complete the second step to obtain $f\left(Y \middle| \Theta, M\right)$ [Hamilton (1989, 1990)]. An approximation to the marginal likelihood $f\left(Y \middle| M\right)$ is finally obtained using the Laplace method on the parameter set θ (i.e. the set of estimated parameters net of the latent components) [see DiCiccio et al. (1997) regarding the Laplace approximation].

The approximate marginal likelihoods for the naive and structural models are presented in Tables 2 and 3. The final row of each table represents twice the absolute value of the natural logarithm of the approximate Bayes factor across two runs of the same model. The theoretical value should be zero given that both models are the same. The magnitude of the value of $2\left|\ln B\right|$ provides information regarding the stability of the marginal likelihood derivation across samples initiated using dispersed initial values. Clearly, an absolute difference across models that fails to exceed the within-model differences suggests that the informational qualities of competing hypotheses are indistinguishable. The differences across the naive (and structural) set of models, however, are substantially larger than the within model differences indicating a clear model preference structure. The log densities across the various conditional forms indicate the approximate impact of the stepwise integrations. Clearly, the full conditional densities favour the increasingly augmented models as expected. The relevant values for undertaking cross-model comparisons are the logarithm of $f\left(Y\middle|M\right)$ and its volume corrected variant $f\left(Y\middle|M\right)^{C}$ [DiCiccio et al. (1997)].

In terms of the naive set of models, the marginal likelihood associated with the third model is clearly the greatest of the four marginal likelihoods; thereby encouraging the proposition of an independent European specific component across developed equity markets and tending against the hypothesis of a single pervasive factor. The approximate marginal likelihood for the first model is the next largest, followed by model 2. The weak preference for model 1 over model 2 is consistent with the observation that conditional volatility in the global factor is adequately accounted for by two Markovian regimes. The posterior probability (always assuming uniform model priors) of the augmented global structure identified by the fourth model is the smallest of the four naive models, suggesting that the addition of a second global factor adds little to the basic hypothesis of a single pervasive factor.

Table 2 *The log-densities for the set of naive models*

	Model 1	Model 2	Model 3	Model 4
First run				
Ln $f(Y \mid \Theta, F, S, M)$	-17829.1	-17828.8	-17193.9	***-16998.1***
Ln $f(Y \mid \Theta, S, M)$	-18568.7	-18576.4	-18351.6	***-18304.5***
Ln $f(Y \mid \Theta, M)$	-18721.5	-18722.1	***-18579.4***	-18754.9
Ln $f(Y \mid \Theta, M) f(\Theta)$	-18945.9	-18949.8	***-18847.4***	-19074.3
$f(Y \mid M)$	-19069.2	-19070.9	***-18986.0***	-19232.4
$f(Y \mid M)^{C,1}$	-19069.6	-19071.3	***-18986.5***	-19233.0
Second run				
Ln $f(Y \mid \Theta, F, S, M)$	-17829.8	-17829.2	-17193.3	***-16999.0***
Ln $f(Y \mid \Theta, S, M)$	-18568.6	-18576.6	-18350.1	***-18306.6***
Ln $f(Y \mid \Theta, M)$	-18721.5	-18722.8	***-18581.2***	-18755.6
Ln $f(Y \mid \Theta, M) f(\Theta)$	-18945.8	-18950.7	***-18849.2***	-19074.9
$f(Y \mid M)$	-19068.7	-19072.0	***-18987.7***	-19232.7
$f(Y \mid M)^{C,2}$	-19069.1	-19072.5	***-18988.1***	-19233.3
2ln|B|	1.0	2.3	3.4	0.7

1. $f(Y \mid M)^{C,1}$ is the volume-corrected Laplace approximation.
2. B is constructed as $f(Y \mid M)^{C,1} / f(Y \mid M)^{C,2}$.
3. The maximal value across each density level is highlighted.

Table 3 *The log-densities for the set of structural models*

	Model 1	Model 2	Model 3a	Model 3b	Model 4
First run					
ln $f(Y \mid \Theta, F, S, M)$	-17829.4	-17836.4	-17196.6	-17194.6	***-17006.2***
ln $f(Y \mid \Theta, S, M)$	-18547.8	-18555.9	-18324.7	-18349.5	***-18265.7***
ln $f(Y \mid \Theta, M)$	-18749.4	-18754.7	-18601.1	***-18594.0***	-18818.8
ln $f(Y \mid \Theta, M) f(\Theta)$	-18991.1	-19017.2	-18903.5	***-18862.6***	-19190.4
$f(Y \mid M)$	-19105.7	-19117.8	-19020.5	***-18985.5***	-19315.4
$f(Y \mid M)^{C,1}$	-19106.2	-19118.3	-19021.3	***-18986.0***	-19316.2
Second run					
ln $f(Y \mid \Theta, F, S, M)$	-17829.7	-17836.1	-17196.9	-17194.7	***-17006.4***
ln $f(Y \mid \Theta, S, M)$	-18546.9	-18557.2	-18302.1	-18349.8	***-18264.7***
ln $f(Y \mid \Theta, M)$	-18746.6	-18755.6	-18603.7	***-18593.9***	-18817.2
ln $f(Y \mid \Theta, M) f(\Theta)$	-18986.3	-19018.1	-18905.9	***-18862.7***	-19188.8
$f(Y \mid M)$	-19108.6	-19118.6	-19024.5	***-18985.4***	-19313.4
$f(Y \mid M)^{C,2}$	-19109.1	-19119.1	-19025.2	***-18985.9***	-19314.3
2ln|B|	5.7	1.6	7.8	3.8	7.8

The order of the marginal likelihoods for the structural variants is consistent with that observed for the naive counterparts, adding weight to the conclusion of a significant European-specific component and tending to reject the hypothesis of two global factors.

Under the structural hypothesis, model 3 is estimated in two forms: 1) using regime-dependent coefficients across the economic parameters for both factors (model 3a), and 2) restricting the European factor's macroeconomic coefficients to zero (model 3b). Both variants of the third approach produce marginal likelihoods exceeding those of the other structural forms, with the marginal likelihood associated with the second variant clearly greater than that of its less parsimonious alternative.

The expected value of the third model's global factor during conditions of low-volatility is similar under both variants (models 3a and 3b) and almost identical to its naive counterpart. In turn, expectations concerning the global factor during periods of high-volatility do not differ significantly from their values in the first regime. Global factor expectations during periods of higher global volatility therefore continue to depend largely on international trade and consumer prices, in addition to exhibiting weak sensitivity to incremental U.S. production growth. The continued significance of the trade and consumer price variables in the higher volatility regime encourages the conclusion that markets are influenced by observed economic data irrespective of the presence of small or large global shocks.

The greater marginal likelihood associated with model 3b, where the macroeconomic coefficients for the European factor are restricted to zero, also suggests that the macroeconomic panel fails to adequately define the path of the European factor or that European markets fail to price any exposure to a distinct European specific volatility source. Consequently, evidence in favour of model 3b identifies a preference for pricing in the vein of the conditional global CAPM given the model's consequence that the common expected return is determined solely by reference to the global factor.

In terms of a relative comparison across the naive and structural hypotheses, the marginal likelihoods indicate a clear preference for the naive versions of models 1, 2, 3a and 4. Pursuant to such a preference, the derivation of a common factor path based on the assumption of regime-invariant sensitivity to the macroeconomic panel appears to dominate its volatility-dependent counterpart. The two largest marginal likelihoods are associated with (structural) model 3b and naive model 3. Although the volatility structures for both models are identical, the derivation of the common path differs across both models. The slightly higher marginal likelihood for model 3b differs negligibly from its counterpart for the third naive model indicating (given uniform priors) that neither model is preferred relative to the other.

6. Conclusion

Little is known regarding the economic content of the unobserved factors common to national equity markets. This paper helps to address the void by constructing a framework for directly associating common equity market factors with macroeconomic data. Accordingly, the results provide an economic interpretation for the latent factor structures used to model equity returns pursuant to pricing theories such as the APT.

Several models were estimated to examine both the common factor structure of developed equity markets and the macroeconomic composition of their common factors. All parameters were jointly estimated to avoid errors-in-variables issues, and idiosyncratic heteroscedasticity was explicitly accounted for. The economic composition of the common factors was first derived pursuant to the assumption that the common paths are not dependent on common volatility levels (the 'naive' approach). The initial assumption was then widened to examine the manner in which the economic composition changes across financial market regimes (the ‘structural’ approach). Unrestricted persistence was also incorporated in the common and idiosyncratic components to evaluate the existence of any feedback and jointly assess the relevance of any non-macroeconomic sources of information.

Given the non-nested model assumptions, approximate marginal likelihoods were estimated for each model to enable evaluation of the various approaches in a Bayesian context. Pursuant to the marginal likelihoods, a common structure incorporating global and European factors is preferred to either the baseline case of a single global factor or the extended scenario of dual global factors. Accordingly, the results suggest the existence of significant European-specific effects not captured by the traditional single global factor hypothesis. The two overall preferred models identify global and European factors and cover both the naive and structural specifications.

The global factor for the naive preferred model is significantly associated with industrial country consumer prices, industrial country trade levels, and the price of lead, while oil prices and incremental U.S. industrial production levels explain the path of the European factor. As such, the model identifies a significant relationship between the U.S. economy and the orthogonal European factor common to European equity markets. Given the aforementioned variables, the other macroeconomic variables considered, including short-term interest rates frequently deemed significant in existing research, exhibit a negligible explanatory capacity for the common factors. The economic composition of the global factor for the (equally) preferred structural model is almost identical to that of the preferred naive model’s global factor. Consequently, the significance of the macroeconomic variables for the global factor does not appear to depend on global volatility levels.

The marginal likelihoods for the naive scenarios are typically greater than their structural counterparts, suggesting that common factor paths are better derived using regime-invariant coefficients on macroeconomic data. The general preference in favour of models incorporating volatility-invariant sensitivity to macroeconomic information suggests that the significant macroeconomic content of the common factors is not limited to periods of low volatility. This result is important given its implication that, during periods where large common shocks are observed, the behaviour of national equity markets is significantly associated with prevailing economic conditions as opposed to a financial agent response to endogenous (or non-economic) information.

Appendix A

Taxonomy: variable (series code) [transformation][13]

Source: International Financial Statistics (International Monetary Fund)

One-month U.S. Deposits, London offer (11160LDCZF) [monthly spread]
Copper, London offer (11276C.DZF) [continuous growth rate]
Lead, London offer (11276V.DZF) [continuous growth rate]
Oil, average spot price index (00176AADZF) [continuous growth rate]
Imports, Asia (50571..DZF...) [continuous growth rate]
Imports, Industrial countries (11071..DZF...) [continuous growth rate]
Imports, Germany (13471..DZF...) [continuous growth rate]
Imports, Oil exporting countries (99971..DZF...) [continuous growth rate]
Consumer prices, Industrial countries (11064...ZF...) [continuous growth rate]
Consumer prices, Middle East (40564...ZF...) [continuous growth rate]
Consumer prices, Asia (50564...ZF...) [continuous growth rate]
Consumer prices, Africa (60564...ZF…) [continuous growth rate]
Consumer prices, Europe (17064...ZF...) [continuous growth rate]

Second Source: St. Louis Federal Reserve (U.S. data)

Commercial and Industrial Loans (BUSLOANS) [continuous growth rate]
Civilian Employment-Population Ratio (EMRATIO) [first difference]
New One Family Houses Sold (HSN1F) [continuous growth rate]
Industrial Production Index (INDPRO) [continuous growth rate]
Spot Oil, West Texas Intermediate (OILPRICE) [continuous growth rate]
Total Capacity Utilization (TCU) [continuous growth rate]
Total Consumer Credit Outstanding (TOTALNS) [continuous growth rate]
Civilian Unemployment Rate (UNRATE) [first difference]
U.S. Government Securities at all Commercial Banks (USGSEC) [continuous growth rate]
All Employees: Professional & Business Services (USPBS) [continuous growth rate]
Moody's Seasoned Aaa Corporate Bond Yield (AAA) [quality spread]
Moody's Seasoned Baa Corporate Bond Yield (BAA) [quality spread]
10-Year Treasury Constant Maturity Rate (GS10) [term spread]
3-Month Treasury Bill: Secondary Market Rate (TB3MS) [term spread]
University of Michigan: Consumer Sentiment (UMCSENT) [logarithm]
M2 Money Stock (M2SL) [continuous growth rate]

[13] The transformed variables span the period December, 1969 to June, 2004.

Appendix B

Table B1 *Parameter statistics regarding global sensitivity to macroeconomic variables and global persistence (Structural model 1)*

Variable	*Median*	*Mean*	*Std. Dev.*	*95% BCI*		*Pr>0*
$\gamma_{1,1}$	-0.422	-0.422	0.171	-0.759	-0.086	0.007
$\gamma_{2,1}$	-0.337	-0.338	0.159	-0.652	-0.029	0.017
$\gamma_{3,1}$	0.552	0.553	0.167	0.223	0.878	0.999
$\gamma_{4,1}$	-0.636	-0.637	0.172	-0.972	-0.298	0.000
$\gamma_{5,1}$	-0.120	-0.124	0.180	-0.478	0.231	0.244
$\gamma_{6,1}$	0.009	0.009	0.166	-0.322	0.328	0.521
$\gamma_{7,1}$	0.173	0.175	0.179	-0.175	0.530	0.837
$\gamma_{8,1}$	-0.015	-0.015	0.169	-0.353	0.312	0.464
$\gamma_{1,2,inc}$	0.138	0.068	1.390	-2.895	2.668	0.544
$\gamma_{2,2,inc}$	-0.973	-0.971	1.597	-4.161	2.241	0.255
$\gamma_{3,2,inc}$	-1.322	-1.331	1.286	-3.921	1.203	0.140
$\gamma_{4,2,inc}$	-0.741	-0.757	1.318	-3.410	1.864	0.272
$\gamma_{5,2,inc}$	-0.567	-0.580	1.185	-2.952	1.717	0.299
$\gamma_{6,2,inc}$	-0.858	-0.998	1.508	-4.389	1.647	0.255
$\gamma_{7,2,inc}$	1.395	1.370	1.242	-1.179	3.747	0.876
$\gamma_{8,2,inc}$	-3.705	-3.798	1.551	-7.076	-0.984	0.004
φ	0.064	0.063	0.056	-0.049	0.172	0.870

$\gamma_{\cdot,j}$ represents sensitivity to the *j*th regime.

Table B2 *Parameter statistics regarding global sensitivity to macroeconomic variables and global persistence (Structural model 2)*

Variable	*Median*	*Mean*	*Std. Dev.*	*95% BCI*		*Pr>0*
$\gamma_{1,1}$	0.765	0.651	2.696	-4.761	5.735	0.631
$\gamma_{2,1}$	-0.191	-0.210	2.021	-4.376	3.880	0.455
$\gamma_{3,1}$	-0.333	-0.164	2.279	-4.486	4.948	0.440
$\gamma_{4,1}$	-0.177	-0.266	2.274	-5.084	4.197	0.462
$\gamma_{5,1}$	-0.858	-0.820	1.485	-3.753	2.506	0.223
$\gamma_{6,1}$	0.062	-0.055	1.922	-4.470	3.639	0.516
$\gamma_{7,1}$	1.769	1.272	2.676	-3.661	5.304	0.664
$\gamma_{8,1}$	-2.623	-2.639	2.848	-7.680	3.337	0.170
$\gamma_{1,2,inc}$	-1.205	-1.080	2.717	-6.177	4.399	0.308
$\gamma_{2,2,inc}$	-0.152	-0.133	2.045	-4.260	4.077	0.466
$\gamma_{3,2,inc}$	0.913	0.724	2.308	-4.405	5.072	0.649
$\gamma_{4,2,inc}$	-0.497	-0.399	2.312	-4.906	4.504	0.399
$\gamma_{5,2,inc}$	0.776	0.725	1.515	-2.707	3.691	0.744
$\gamma_{6,2,inc}$	-0.058	0.057	1.955	-3.677	4.501	0.484
$\gamma_{7,2,inc}$	-1.642	-1.119	2.717	-5.198	3.905	0.348
$\gamma_{8,2,inc}$	2.649	2.648	2.867	-3.433	7.702	0.828
$\gamma_{1,3,inc}$	0.013	-0.048	1.947	-4.096	3.746	0.503
$\gamma_{2,3,inc}$	-0.612	-0.565	2.023	-4.531	3.638	0.372
$\gamma_{3,3,inc}$	-1.515	-1.495	1.858	-5.148	2.287	0.197
$\gamma_{4,3,inc}$	-0.688	-0.647	1.879	-4.254	3.266	0.347
$\gamma_{5,3,inc}$	-0.718	-0.693	1.737	-4.167	2.993	0.312
$\gamma_{6,3,inc}$	-0.840	-0.939	1.975	-5.096	2.780	0.320
$\gamma_{7,3,inc}$	0.956	0.820	2.175	-3.777	4.717	0.669
$\gamma_{8,3,inc}$	-3.361	-3.279	2.153	-7.318	1.290	0.067
φ	0.065	0.064	0.059	-0.053	0.177	0.862

a. $\gamma_{\cdot,j}$ represents sensitivity to the *j*th regime.
b. $\gamma_{\cdot,j,inc}$ compares incremental coefficients in regime *j* (relative to regime *j*-1).

Table B3 *Parameter statistics regarding common sensitivity to macroeconomic variables and common persistence (Structural model 3a)*

Variable	*Median*	*Mean*	*Std. Dev.*	*95% BCI*		*Pr>0*
Regime 1						
$\gamma_{1,1,1}$	-0.266	-0.266	0.194	-0.647	0.114	0.086
$\gamma_{2,1,1}$	-0.413	-0.413	0.175	-0.758	-0.071	0.009
$\gamma_{3,1,1}$	0.588	0.590	0.182	0.233	0.950	0.999
$\gamma_{4,1,1}$	-0.565	-0.566	0.199	-0.958	-0.181	0.002
$\gamma_{5,1,1}$	0.158	0.157	0.189	-0.213	0.528	0.796
$\gamma_{6,1,1}$	0.211	0.211	0.185	-0.149	0.574	0.874
$\gamma_{7,1,1}$	0.086	0.086	0.242	-0.382	0.555	0.636
$\gamma_{8,1,1}$	0.045	0.044	0.203	-0.353	0.444	0.586
$\gamma_{1,1,2}$	-0.165	-0.262	0.659	-1.744	0.787	0.390
$\gamma_{2,1,2}$	-0.373	-0.402	0.554	-1.627	0.628	0.201
$\gamma_{3,1,2}$	-0.659	-0.383	1.090	-1.852	2.396	0.216
$\gamma_{4,1,2}$	-1.378	-1.082	1.179	-2.621	2.081	0.153
$\gamma_{5,1,2}$	0.003	-0.361	1.137	-3.405	0.837	0.502
$\gamma_{6,1,2}$	-0.325	-0.380	0.557	-1.675	0.578	0.230
$\gamma_{7,1,2}$	0.018	0.145	0.775	-1.035	2.145	0.514
$\gamma_{8,1,2}$	-0.659	-0.630	0.587	-1.717	0.651	0.127
Regime 2						
$\gamma_{1,2,1,inc}$	0.279	0.233	1.626	-3.198	3.385	0.576
$\gamma_{2,2,1,inc}$	-0.893	-0.934	2.016	-5.067	3.011	0.314
$\gamma_{3,2,1,inc}$	-2.002	-2.070	1.672	-5.534	1.052	0.098
$\gamma_{4,2,1,inc}$	-0.801	-0.830	1.533	-3.990	2.174	0.283
$\gamma_{5,2,1,inc}$	0.033	0.140	1.868	-3.351	4.357	0.509
$\gamma_{6,2,1,inc}$	-0.464	-0.493	1.758	-4.072	2.967	0.388
$\gamma_{7,2,1,inc}$	1.307	1.072	1.914	-3.420	4.244	0.755
$\gamma_{8,2,1,inc}$	-2.560	-2.748	1.825	-6.881	0.402	0.045
$\gamma_{1,2,2,inc}$	-0.474	-0.321	1.312	-2.513	2.166	0.397
$\gamma_{2,2,2,inc}$	0.339	0.297	0.984	-1.686	2.135	0.643
$\gamma_{3,2,2,inc}$	2.257	1.619	1.949	-3.146	3.842	0.828
$\gamma_{4,2,2,inc}$	2.254	1.616	2.035	-3.420	4.002	0.827
$\gamma_{5,2,2,inc}$	-2.347	-1.652	2.055	-3.846	3.406	0.167
$\gamma_{6,2,2,inc}$	-0.474	-0.437	1.029	-2.366	1.665	0.317
$\gamma_{7,2,2,inc}$	0.940	0.736	1.410	-2.491	3.022	0.756
$\gamma_{8,2,2,inc}$	0.305	0.252	1.063	-2.016	2.216	0.619
φ_{world}	0.108	0.107	0.059	-0.013	0.220	0.962
φ_{Europe}	0.007	0.007	0.069	-0.127	0.145	0.539

a. $\gamma_{\cdot,j,k}$ indicates parameter value in the *j*th regime for the *k*th common factor (*k*=1 for global factor, *k*=2 for European factor).

b. $\gamma_{\cdot,j,inc}$ is the incremental parameter for factor *k* (*k*=1 for global factor, *k*=2 for European factor).

Table B4 *Parameter statistics regarding common sensitivity to macroeconomic variables and common persistence (Structural model 3b)*

Variable	*Median*	*Mean*	*Std. Dev.*	*95% BCI*		*Pr>0*
Regime 1						
$\gamma_{1,1,1}$	-0.291	-0.291	0.191	-0.666	0.083	0.062
$\gamma_{2,1,1}$	-0.424	-0.425	0.174	-0.766	-0.085	0.007
$\gamma_{3,1,1}$	0.618	0.620	0.181	0.269	0.976	1.000
$\gamma_{4,1,1}$	-0.593	-0.594	0.196	-0.982	-0.211	0.001
$\gamma_{5,1,1}$	0.091	0.090	0.188	-0.285	0.455	0.687
$\gamma_{6,1,1}$	0.170	0.171	0.182	-0.187	0.529	0.827
$\gamma_{7,1,1}$	0.089	0.091	0.238	-0.368	0.556	0.642
$\gamma_{8,1,1}$	-0.008	-0.008	0.200	-0.398	0.382	0.484
$\gamma_{\cdot,1,2}$	-	-	-	-	-	-
Regime 2						
$\gamma_{1,2,1,inc}$	0.264	0.221	1.604	-3.147	3.346	0.573
$\gamma_{2,2,1,inc}$	-0.919	-0.952	1.989	-5.002	2.964	0.307
$\gamma_{3,2,1,inc}$	-1.989	-2.068	1.662	-5.562	1.005	0.096
$\gamma_{4,2,1,inc}$	-0.774	-0.788	1.517	-3.869	2.265	0.283
$\gamma_{5,2,1,inc}$	0.005	0.099	1.796	-3.246	4.162	0.502
$\gamma_{6,2,1,inc}$	-0.441	-0.474	1.730	-4.021	2.924	0.391
$\gamma_{7,2,1,inc}$	1.413	1.200	1.853	-3.161	4.306	0.777
$\gamma_{8,2,1,inc}$	-2.494	-2.703	1.815	-6.910	0.400	0.045
$\gamma_{\cdot,2,2}$	-	-	-	-	-	-
φ_{world}	0.108	0.107	0.060	-0.013	0.222	0.960
Φ_{Europe}	0.074	0.075	0.070	-0.063	0.213	0.856

$\gamma_{\cdot,j,k}$ indicates parameter value in the *j*th regime for the *k*th common factor (*k*=1 for global factor, *k*=2 for European factor).

Table B5 *Parameter statistics regarding common sensitivity to macroeconomic variables and common persistence (Structural model 4)*

Variable	*Median*	*Mean*	*Std. Dev.*	*95% BCI*		*Pr>0*
Regime 1						
$\gamma_{1,1,1}$	-0.094	-0.095	0.185	-0.460	0.268	0.304
$\gamma_{2,1,1}$	-0.154	-0.156	0.177	-0.505	0.189	0.186
$\gamma_{3,1,1}$	0.460	0.458	0.200	0.057	0.846	0.987
$\gamma_{4,1,1}$	-0.574	-0.575	0.203	-0.978	-0.177	0.003
$\gamma_{5,1,1}$	0.084	0.081	0.199	-0.320	0.463	0.666
$\gamma_{6,1,1}$	0.199	0.202	0.183	-0.148	0.567	0.866
$\gamma_{7,1,1}$	-0.130	-0.128	0.214	-0.546	0.302	0.268
$\gamma_{8,1,1}$	0.085	0.084	0.188	-0.287	0.451	0.677
$\gamma_{1,1,2}$	-0.189	-0.189	0.228	-0.631	0.263	0.200
$\gamma_{2,1,2}$	-0.399	-0.398	0.209	-0.809	0.017	0.030
$\gamma_{3,1,2}$	0.301	0.305	0.207	-0.093	0.720	0.932
$\gamma_{4,1,2}$	-0.277	-0.277	0.208	-0.686	0.131	0.090
$\gamma_{5,1,2}$	0.276	0.275	0.196	-0.113	0.658	0.919
$\gamma_{6,1,2}$	-0.046	-0.048	0.188	-0.422	0.317	0.402
$\gamma_{7,1,2}$	0.051	0.053	0.187	-0.311	0.426	0.608
$\gamma_{8,1,2}$	-0.030	-0.031	0.223	-0.467	0.408	0.444
$\gamma_{1,1,3}$	-0.796	-0.801	0.393	-1.589	-0.009	0.024
$\gamma_{2,1,3}$	-0.006	-0.027	0.355	-0.758	0.581	0.493
$\gamma_{3,1,3}$	0.125	0.108	0.451	-0.840	0.928	0.623
$\gamma_{4,1,3}$	-0.855	-0.904	0.510	-2.081	-0.090	0.017
$\gamma_{5,1,3}$	-0.260	-0.312	0.505	-1.595	0.528	0.253
$\gamma_{6,1,3}$	-0.085	-0.097	0.366	-0.860	0.595	0.399
$\gamma_{7,1,3}$	0.301	0.296	0.378	-0.459	1.026	0.798
$\gamma_{8,1,3}$	-0.074	-0.077	0.432	-0.913	0.748	0.430
Regime 2						
$\gamma_{1,2,1,inc}$	1.099	1.108	1.895	-2.761	4.804	0.735
$\gamma_{2,2,1,inc}$	-0.520	-0.522	1.529	-3.590	2.517	0.358
$\gamma_{3,2,1,inc}$	-2.217	-2.204	1.345	-4.789	0.529	0.049
$\gamma_{4,2,1,inc}$	1.743	1.787	1.377	-0.762	4.595	0.910
$\gamma_{5,2,1,inc}$	-0.324	-0.311	0.993	-2.194	1.676	0.354
$\gamma_{6,2,1,inc}$	0.538	0.530	1.151	-1.765	2.764	0.693
$\gamma_{7,2,1,inc}$	2.219	2.190	1.069	0.018	4.188	0.976
$\gamma_{8,2,1,inc}$	-3.671	-3.638	1.450	-6.434	-0.747	0.007
$\gamma_{1,2,2,inc}$	0.002	-0.005	1.861	-3.783	3.684	0.500
$\gamma_{2,2,2,inc}$	-0.741	-0.653	2.291	-5.057	4.088	0.369
$\gamma_{3,2,2,inc}$	-0.486	-0.515	2.159	-4.854	3.699	0.407
$\gamma_{4,2,2,inc}$	-1.500	-1.488	1.936	-5.286	2.375	0.213
$\gamma_{5,2,2,inc}$	0.191	0.180	2.727	-5.225	5.538	0.528
$\gamma_{6,2,2,inc}$	-0.421	-0.403	2.247	-4.784	4.119	0.423
$\gamma_{7,2,2,inc}$	-1.633	-1.641	2.497	-6.593	3.282	0.253
$\gamma_{8,2,2,inc}$	-0.537	-0.548	1.789	-4.149	2.963	0.375
$\gamma_{1,2,3,inc}$	1.204	1.162	1.210	-1.452	3.534	0.858
$\gamma_{2,2,3,inc}$	-1.621	-1.622	1.475	-4.633	1.398	0.117
$\gamma_{3,2,3,inc}$	1.092	0.981	1.436	-2.282	3.519	0.788
$\gamma_{4,2,3,inc}$	0.198	0.153	1.464	-3.009	3.090	0.565
$\gamma_{5,2,3,inc}$	-1.641	-1.464	1.378	-3.689	2.143	0.118
$\gamma_{6,2,3,inc}$	-1.054	-1.222	1.414	-4.518	1.111	0.179
$\gamma_{7,2,3,inc}$	0.597	0.616	1.275	-1.962	3.343	0.718
$\gamma_{8,2,3,inc}$	-1.752	-1.724	1.278	-4.265	1.021	0.079
$\varphi_{world,1}$	0.038	0.038	0.075	-0.110	0.185	0.693
$\varphi_{world,2}$	0.110	0.108	0.089	-0.074	0.277	0.889
Φ_{Europe}	0.014	0.014	0.062	-0.108	0.136	0.590

a. $\gamma_{\cdot j,k}$ indicates parameter value in the *j*th regime for the *k*th common factor (*k*=1 for first global factor, *k*=2 for second global factor, *k*=3 for European factor).
b. $\gamma_{\cdot j,inc}$ is the incremental parameter for factor *k* (*k*=1 for first global factor, *k*=2 for second global factor, *k*=3 for European factor)

Appendix C

Table C1 *Parameter statistics regarding global sensitivity to macroeconomic variables and global persistence (Naive model 1)*

Variable	*Median*	*Mean*	*Std. Dev.*	*95% BCI*		*Pr>0*
γ_1	-0.362	-0.361	0.169	-0.690	-0.027	0.017
γ_2	-0.340	-0.341	0.154	-0.647	-0.042	0.013
γ_3	0.484	0.485	0.159	0.173	0.800	0.999
γ_4	-0.617	-0.617	0.164	-0.943	-0.295	0.000
γ_5	-0.164	-0.168	0.174	-0.525	0.161	0.163
γ_6	-0.013	-0.012	0.158	-0.320	0.301	0.466
γ_7	0.203	0.204	0.168	-0.122	0.539	0.889
γ_8	-0.128	-0.129	0.161	-0.448	0.183	0.212
φ	0.070	0.069	0.057	-0.044	0.180	0.888

Table C2 *Parameter statistics regarding global sensitivity to macroeconomic variables and global persistence (Naive model 2)*

Variable	*Median*	*Mean*	*Std. Dev.*	*95% BCI*		*Pr>0*
γ_1	-0.353	-0.353	0.171	-0.687	-0.016	0.020
γ_2	-0.332	-0.333	0.155	-0.642	-0.031	0.015
γ_3	0.485	0.486	0.159	0.177	0.803	0.999
γ_4	-0.609	-0.610	0.165	-0.937	-0.289	0.000
γ_5	-0.164	-0.170	0.179	-0.540	0.168	0.167
γ_6	-0.014	-0.013	0.157	-0.320	0.298	0.465
γ_7	0.212	0.214	0.170	-0.117	0.550	0.897
γ_8	-0.118	-0.119	0.162	-0.442	0.195	0.232
φ	0.069	0.069	0.057	-0.043	0.180	0.885

Table C3 *Parameter statistics regarding common sensitivity to macroeconomic variables and common persistence (Naive model 3)*

Variable	*Median*	*Mean*	*Std. Dev.*	*95% BCI*		*Pr>0*
$\gamma_{1,1}$	-0.224	-0.224	0.186	-0.587	0.140	0.114
$\gamma_{2,1}$	-0.411	-0.411	0.170	-0.744	-0.078	0.008
$\gamma_{3,1}$	0.501	0.502	0.174	0.163	0.848	0.998
$\gamma_{4,1}$	-0.536	-0.536	0.185	-0.902	-0.175	0.002
$\gamma_{5,1}$	0.174	0.172	0.179	-0.187	0.517	0.834
$\gamma_{6,1}$	0.165	0.166	0.175	-0.176	0.511	0.830
$\gamma_{7,1}$	-0.006	-0.003	0.200	-0.389	0.397	0.488
$\gamma_{8,1}$	-0.050	-0.050	0.187	-0.418	0.314	0.395
$\gamma_{1,2}$	-0.324	-0.327	0.263	-0.849	0.183	0.106
$\gamma_{2,2}$	-0.071	-0.072	0.236	-0.539	0.388	0.381
$\gamma_{3,2}$	0.242	0.241	0.242	-0.238	0.714	0.840
$\gamma_{4,2}$	-0.380	-0.380	0.248	-0.866	0.106	0.062
$\gamma_{5,2}$	-0.872	-0.873	0.265	-1.398	-0.356	0.000
$\gamma_{6,2}$	-0.384	-0.385	0.243	-0.865	0.091	0.056
$\gamma_{7,2}$	0.323	0.325	0.238	-0.141	0.792	0.915
$\gamma_{8,2}$	-0.520	-0.522	0.247	-1.008	-0.041	0.017
φ_{world}	0.111	0.110	0.059	-0.008	0.225	0.967
φ_{Europe}	0.040	0.040	0.067	-0.092	0.171	0.726

$\gamma_{\cdot,k}$ indicates parameter value for the *k*th common factor (*k*=1 for global factor, *k*=2 for European factor).

Table C4 *Parameter statistics regarding common sensitivity to macroeconomic variables and common persistence (Naive model 4)*

Variable	*Median*	*Mean*	*Std. Dev.*	*95% BCI*		*Pr>0*
$\gamma_{1,1}$	-0.055	-0.058	0.165	-0.389	0.262	0.365
$\gamma_{2,1}$	-0.092	-0.093	0.161	-0.415	0.218	0.281
$\gamma_{3,1}$	0.208	0.212	0.193	-0.157	0.601	0.865
$\gamma_{4,1}$	-0.301	-0.309	0.187	-0.699	0.035	0.040
$\gamma_{5,1}$	-0.029	-0.032	0.184	-0.403	0.323	0.435
$\gamma_{6,1}$	0.133	0.137	0.161	-0.169	0.468	0.805
$\gamma_{7,1}$	0.007	0.011	0.189	-0.349	0.393	0.515
$\gamma_{8,1}$	-0.012	-0.017	0.169	-0.365	0.301	0.471
$\gamma_{1,2}$	-0.202	-0.200	0.214	-0.617	0.227	0.172
$\gamma_{2,2}$	-0.391	-0.390	0.199	-0.778	0.002	0.026
$\gamma_{3,2}$	0.307	0.309	0.197	-0.071	0.703	0.944
$\gamma_{4,2}$	-0.318	-0.320	0.201	-0.716	0.074	0.055
$\gamma_{5,2}$	0.275	0.275	0.191	-0.100	0.651	0.926
$\gamma_{6,2}$	-0.020	-0.021	0.181	-0.379	0.332	0.456
$\gamma_{7,2}$	0.035	0.036	0.178	-0.311	0.388	0.579
$\gamma_{8,2}$	-0.090	-0.090	0.204	-0.492	0.311	0.327
$\gamma_{1,3}$	-0.476	-0.479	0.261	-1.000	0.023	0.031
$\gamma_{2,3}$	-0.213	-0.215	0.230	-0.673	0.231	0.174
$\gamma_{3,3}$	0.371	0.372	0.241	-0.099	0.848	0.939
$\gamma_{4,3}$	-0.640	-0.643	0.248	-1.135	-0.164	0.004
$\gamma_{5,3}$	-0.739	-0.743	0.290	-1.319	-0.188	0.004
$\gamma_{6,3}$	-0.217	-0.218	0.244	-0.702	0.257	0.185
$\gamma_{7,3}$	0.377	0.378	0.243	-0.099	0.854	0.940
$\gamma_{8,3}$	-0.469	-0.471	0.255	-0.977	0.026	0.032
$\varphi_{world,1}$	0.111	0.112	0.086	-0.055	0.283	0.906
$\varphi_{world,2}$	0.092	0.091	0.078	-0.067	0.240	0.881
φ_{Europe}	0.029	0.029	0.061	-0.091	0.149	0.684

$\gamma_{\cdot,k}$ indicates parameter value for the kth common factor (k=1 for first global factor, k=2 for second global factor, k=3 for European factor).

Table C5 *Posterior probability for the hypothesis* $\psi_i > 0$

Market	*Model 1*	*Model 2*	*Model 3*	*Model 4*
Belgium	0.848	0.850	0.810	0.879
France	0.733	0.735	0.682	0.620
Germany	0.359	0.360	0.293	0.337
Italy	0.298	0.302	0.195	0.204
Netherlands	0.057	0.058	0.067	0.040
Spain	0.757	0.758	0.745	0.705
Sweden	0.363	0.365	0.352	0.207
Switzerland	0.448	0.447	0.311	0.468
U.K.	0.420	0.423	0.430	0.731
Canada	0.522	0.519	0.344	0.200
U.S.	0.060	0.059	0.064	0.062
Australia	***0.003***	***0.003***	***0.020***	0.046
Hong Kong	0.927	0.926	0.646	0.665
Japan	0.815	0.812	0.764	0.784
Singapore	***0.984***	***0.984***	0.932	0.893

Values outside the range (0.025, 0.975) are highlighted as significant.

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