On the robustness of international portfolio diversification benefits to regime-switching volatility[⊙]

Thomas J. Flavin[a,*] , Ekaterini Panopoulou[b]

[a] *Department of Economics, NUI Maynooth, Maynooth, Co. Kildare, Ireland*
[b] *Department of Statistics and Insurance Science, University of Piraeus, Greece*

Abstract

We examine if the benefits of international portfolio diversification are robust to time-varying asset return volatility. Since diversified portfolios are subject to common cross-country shocks, we focus on the transmission mechanism of such shocks in the presence of regime-switching volatility. Generally, market linkages are stable with little evidence of increased market interdependence in turbulent periods. Furthermore, risk reduction is consistently delivered for the US investor who holds foreign equity.

Keywords: Market comovement; Shift contagion; Financial market crises; International portfolio diversification; Regime switching.

JEL Classification: F42; G15; C32

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[*] Corresponding author. Tel.: +353 1 7083369; fax: +353 1 7083934.
Email addresses: thomas.flavin@nuim.ie (T.J. Flavin), apano@unipi.gr (E. Panopoulou).

1. Introduction

We investigate the robustness of equity market linkages and their influence on international portfolio diversification benefits in the presence of regime-switching volatility. International diversification has long been advocated as an effective way to achieve higher risk-adjusted returns than domestic investment alone. The main premise underlying this strategy is that international stocks tend to display lower levels of co-movement than stocks trading on the same market. To the extent that countries are subject to different shocks, international diversification facilitates risk sharing among global investors and idiosyncratic shocks may be diversified away. Empirical evidence in support of international diversification strategies extends back to Grubel (1968) and Levy and Sarnat (1970). Grubel and Fadnar (1971) report that industries within a country are more highly correlated than industries across countries. More recent empirical papers find that these benefits are still present despite increasing integration across financial markets in both stock markets (Grauer and Hakansson, 1987; De Santis and Gerard, 1997) and bond markets (Levy and Lerman, 1988). However, a cautionary note was raised by King and Wadhwani (1990), who found that stock market correlations between the US, UK and Japan increased in the aftermath of the 1987 stock market crash. Lee and Kim (1993) and Longin and Solnik (1995) both show that this finding also applied to a wider range of countries. Butler and Joaquin (2002) show that commonly employed models of returns under-predict stock market correlations during bear markets. These findings have major implications for portfolio management given that if markets display increased co-movement during turbulent periods, then the expected benefits of international diversification will not be delivered when most necessary.

Studies like King and Wadhwani (1990) found a significant increase in the correlation between markets following a period of turbulence and labelled this 'contagion'. However, Forbes and Rigobon (2002) stress the need to distinguish between contagion and interdependence. They show that when markets experience increased volatility, the correlation measure is biased upwards and may lead to an incorrect conclusion of financial market contagion.[1] The heteroscedasticity inherent in asset returns may incorrectly imply contagion even though there has been no

[1] Goetzmann et al (2002) show that episodes of increased cross-market correlation over the past two decades may not be due to increased co-movement alone but also to an expansion of the investment opportunity set.

change in market interdependence. They introduce the term 'shift contagion' to describe a situation when cross-market linkages increase significantly above normal levels of interdependence during a period of market turbulence.

Following Forbes and Rigobon (2001), we argue that portfolio managers should not focus on correlation coefficients but on the stability of the stock market linkages or the presence of 'shift' contagion. Investors who pursue cross-country diversification strategies may eliminate country-specific risks but remain vulnerable to common shocks. Therefore the realization of portfolio diversification benefits depends primarily on the stability of common market linkages over time and states of the world and secondly on the relative size, frequency and persistence of idiosyncratic and common shocks.

Our focus is to ascertain if portfolio diversification benefits are robust to changes in volatility between calm and turbulent equity market regimes. Since diversified portfolios are subject to common cross-country shocks, we focus on the transmission mechanism of such shocks in an environment characterized by regime-switching volatility. If the process governing the diffusion of common shocks is stable between regimes, i.e. no evidence of shift contagion, then international diversification should still be effective in reducing risk during episodes of market turbulence. Conversely, if we find evidence of shift contagion, then international diversification may fail to deliver its promised benefits when most needed.

We take the perspective of a representative US investor who considers international investment opportunities across the G-7 countries. We adopt the methodology of Gravelle et al (2006, henceforth GKM) to provide (as discussed below) an unambiguous test of structural changes in asset return co-movements between regimes. This method has many advantages over and above previous techniques employed to examine asset market contagion. Firstly, the country where the shock originated does not need to be identified or included in the analysis. Generally, studies of contagion tend to concentrate on smaller markets that are geographically close to the source of the shock but a portfolio manager is likely to be more concerned with larger countries that are typically included in asset allocation strategies due to their size and diversity. Hence we focus on the G-7 countries, which account for approximately 80-85% of total world market capitalization. These markets are the main vehicles for portfolio diversification. The methodology still allows us to detect changes in the transmission of shocks that may have originated elsewhere. This is particularly beneficial in the late 1990s when the Asian and Russian crisis occurred. Furthermore, over our sample period, the G7 markets experienced numerous episodes of high volatility e.g. oil price increases in the 1970s, the 1987 stock market crash, the ERM collapse, and the Gulf war in the early 90s , to name but a few key events and not just one specific crisis. Secondly, the regime switches are endogenously determined by the data and crisis dates do not have to be exogenously specified as in Forbes and Rigobon (2002) or the return distribution arbitrarily divided into regimes as in Butler and Joaquin (2002). The exogenous choice of crisis period is often a contentious issue (see Kaminsky and Schmukler, 1999) and may be further compounded by having more than one shock simultaneously impacting on equity markets.

Our results offer support to the robustness of international diversification benefits across different market conditions. We find little statistical evidence of changes in the transmission mechanism of common shocks between volatility regimes. Therefore investors should not fear the impact of common shocks during periods of financial turmoil. Furthermore, we also show that the idiosyncratic shocks that are being hedged are more volatile and more persistent than the common shocks and that over time and market conditions, international diversification strategies deliver risk reduction benefits.

Our paper is organized as follows. Section 2 presents the model. Section 3 describes the data and presents preliminary statistics. Section 4 reports our empirical findings and statistical tests for shift contagion. The economic significance of our results is examined in Section 5 while Section 6 analyses the robustness of our results to employing local currency returns. Section 7 contains our concluding remarks.

2. Econometric Methodology

The model developed by GKM (2006) is ideally suited to testing for stability in the transmission of common shocks between pairs of markets. This bivariate structure allows us to study the interdependence between two stock markets during both calm and turbulent periods and is outlined in this section.[2] Let r_{1t} and r_{2t} represent stock market returns from countries 1 and 2, respectively. These can be decomposed into an expected component, μ_i, and an unexpected one, u_{it}, reflecting

[2] This is an overview of GKM's model and the reader is referred to the original paper for further detail.

unexpected information becoming available to investors, i.e.

$$r_{it} = \mu_i + u_{it}, E(u_{it}) = 0, i = 1,2 \text{ and } E(u_{1t}, u_{2t}) \neq 0. \quad (1)$$

The existence of contemporaneous correlation between the forecast errors u_{1t} and u_{2t} suggests that common structural shocks are driving both returns. Hence, we can decompose the forecast errors into two structural shocks, one idiosyncratic and one common. Let z_{ct} and $z_{it}, i = 1,2$ denote the common and idiosyncratic shocks respectively and let δ_{cit} and $\delta_{it}, i = 1,2$ denote the impacts of these shocks on asset returns. Then the forecast errors are written as:

$$u_{it} = \delta_{cit} z_{ct} + \delta_{it} z_{it}, i = 1,2. \quad (2)$$

Following GKM we allow both the common and the idiosyncratic shocks to switch between two states – high- and low-volatility.[3] Furthermore, we normalize their variances to unity (as in GKM, 2006), which means the impact coefficients may now be interpreted as the standard deviations of the shock. Thus, the structural impact coefficients $\delta_{it}, \delta_{cit}, i = 1,2$ are given by the following:

$$\begin{aligned} \delta_{it} &= \delta_i (1 - S_{it}) + \delta_i^* S_{it}, \ i = 1,2 \\ \delta_{cit} &= \delta_{ci} (1 - S_{ct}) + \delta_{ci}^* S_{ct}, \ i = 1,2 \end{aligned} \quad (3)$$

where $S_{it} = (0,1), i = 1,2,c$ are state variables that take the value of zero in normal times and one in turbulent states. Variables with an asterisk belong to the high-volatility or turbulent regime. To complete the model, we need to specify the evolution of regimes over time. Following the regime-switching literature, the regime paths are Markov switching and consequently are endogenously determined. Specifically, the conditional probabilities of remaining in the same state, i.e. not changing regime are defined as follows:

$$\begin{aligned} \Pr[S_{it} = 0 / S_{it} = 0] &= q_i, i = 1,2,c \\ \Pr[S_{it} = 1 / S_{it} = 1] &= p_i, i = 1,2,c \end{aligned} \quad (4)$$

Furthermore, we relax the assumption of constant expected returns in (1). [4] This specification allows expected returns to be time varying and dependent only on

[3] The heteroskedasticity of the structural shocks ensures the identification of our system (see also Rigobon, 2003). As argued by GKM, only the assumption of regime switching in the common shocks is necessary for the identification of the system. For a detailed description of the identification process, please see GKM.

[4] GKM also relax this assumption when modeling the interdependence of bond returns.

the state of the common shock.[5] In this respect, our model suggests that part of the stock market return represents a risk premium that varies with the level of volatility. In particular, expected returns are modeled as follows:

$$\mu_{it} = \mu_i (1 - S_{ct}) + \mu_i^* S_{ct}, \; i = 1,2 \tag{5}$$

Given that idiosyncratic shocks are uncorrelated with common shocks and mainly associated with diversifiable risk, expected returns are not allowed to vary with their volatility state. Assuming that the structural shocks are normally distributed enables us to estimate the full model, given by equations (2)-(5), via maximum likelihood following the Markov-switching methodology described in Hamilton (1989).

The rationale behind detecting and testing for increased comovement due to changes in the transmission of the common shock (see also GKM) relies on the argument that, in its absence, a large common unexpected shock does not change market interdependence. In other words, the observed increase in the variance and correlation of returns during turbulent periods is due to increased impulses stemming from the common shocks and not from changes in their propagation mechanism. To empirically test for changes in the transmission of the common shock, we conduct statistical tests, specifying the null and alternative hypothesis as follows:

$$H_0 \;:\; \frac{\delta_{c1}^*}{\delta_{c2}^*} = \frac{\delta_{c1}}{\delta_{c2}} \text{ versus } H_1 \;:\; \frac{\delta_{c1}^*}{\delta_{c2}^*} \neq \frac{\delta_{c1}}{\delta_{c2}} \tag{6}$$

The null hypothesis postulates that in the absence of shift contagion, the impact coefficients in both calm and turbulent periods move proportionately and hence their ratio should remain unchanged. The likelihood ratio test is the common method for testing restrictions among nested models and follows a x^2 distribution with one degree of freedom corresponding to the restriction of equality of the ratio of coefficients between the two regimes.

3. Data and Preliminary Statistics

Our dataset comprises weekly closing stock market index prices from the exchanges of the G-7 countries. All indices are value-weighted, obtained from Datastream International, and cover approximately 80% of total market capitalization. The Datastream codes have the following structure: TOTMKXX,

[5] Guidolin and Timmermann (2005) find that returns are statistically different across regimes though Ang and Bekaert (2002) fail to reject the equality of mean returns between regimes.

where XX stands for the country code, i.e. CN (Canada), FR (France), BD (Germany), IT (Italy), JP (Japan), UK and US. Our sample spans a period of more than 30 years from 1/1/1973 to 31/12/2005, yielding a total of 1723 observations. All indices are expressed in a common currency, namely US dollars. This allows us to undertake the analysis from the perspective of a representative US investor. We prefer weekly return data to higher frequency data, such as daily returns, in order to reduce the influence of non-synchronous trading across markets. For each index, we compute the weekly return as $ln(p_t)- ln(p_{t-1})$ where p_t denotes the closing index on week *t.*

[TABLE 1 ABOUT HERE]

Table 1 (Panel A) presents descriptive statistics for the weekly returns of all countries, while Panel B provides some preliminary evidence on the cross-country return correlation structure. Mean returns vary across countries ranging from 0.139% in Canada to 0.173% in France. The Japanese market displays the highest volatility, while the US and Canadian markets appear to be the least volatile for the US investor. The Jarque-Bera test rejects normality for all markets, which is usual in the presence of both skewness and excess kurtosis. Specifically, return distributions are negatively skewed for all countries with Canada and the US being the most skewed. The Canadian, UK and US returns exhibit considerable leptokurtosis with the coefficient of kurtosis exceeding 10. These characteristics must be accommodated in any model of equity returns. The high level of kurtosis coupled with the rejection of normality in all markets suggests that the behavior of returns is best modelled as a mixture of distributions, which is consistent with the existence of more than a single volatility regime.

Panel B provides preliminary evidence on the correlation structure between country returns. Correlation coefficients range from 0.205 for the Italy/Japan pair to 0.705 for the Canada/US pair. The average correlation is 0.408. Pairs involving either Japan or Italy tend to have below average correlation; while near neighbors such as France/Germany, US/Canada and long established markets such as US/UK have the highest recorded correlations.

4. Results

4.1 Estimates

Table 2 contains the estimates of model parameters for the expected returns. Specifically, columns 2 and 3 report the mean returns during calm periods with corresponding figures for turbulent periods in columns 4 and 5.

[TABLE 2 ABOUT HERE]

We are presented with a number of striking features. Firstly, the low volatility regime is predominantly characterised with positive mean returns and all are statistically significant at conventional levels. On the contrary, high volatility regimes are associated with negative returns in all cases, though admittedly, many of these are not statistically different from zero. Therefore a feature of the returns behaviour is that crisis (or turbulent) periods generate negative asset returns. Secondly we compute a likelihood ratio statistic to test the hypothesis that means are equal across regimes. In the vast majority of cases (17 of 21), this hypothesis is rejected and is consistent with the findings of Guidolin and Timmermann (2005) for UK assets. Consequently, it is important to account for this difference in means across regimes when modelling the behaviour of returns.

[FIGURES 1 & 2 ABOUT HERE]

As our focus is on the robustness of portfolio diversification benefits, it is useful to examine the filtered probabilities of being in the high-volatility regime before undertaking further statistical tests. International diversification is likely to be most beneficial if the frequency of the high-volatility regime is greater for idiosyncratic shocks than for the common shock. Figure 1 plots the filtered probabilities of the idiosyncratic shocks being in the high-volatility regime.[6] With the exception of the UK and US, which show a period of relative tranquillity post 1994, idiosyncratic shocks are most often in the turbulent state for all countries. This indicates that there is substantial country-specific risk to diversify. In contrast, the frequency of the high-volatility state for the common shock is relatively low. Figure 2 presents the evidence.[7] Almost all market pairs shared high volatility following the 1987 stock market crash – a crisis originating in the US - but again we find a

[6] The figures presented are generated using country *i* (*i* refers to all non-US states) and the US as the market pair and using the UK as the partner for the US. Similar graphs are available for all pairs upon request.

[7] Once more, the graphs presented are for common shocks with the US. Again, graphs for other pairs are available upon request.

sustained period of high volatility in the aftermath of the Asian and Russian crises of the late 1990's – despite these countries not being in our sample. Combining evidence from Figures 1 and 2, it would seem that there are potential benefits to undertaking international diversification strategies. The frequency of the high-volatility regime for the diversifiable shock is much greater than that of the common shock.

[TABLE 3 ABOUT HERE]

Table 3 presents a more detailed description of our results. Firstly, the column labeled 'Unc Prob' reveals the proportion of time that the common shock of each market pair is in the high-volatility state. It is calculated as $\frac{1-P}{2-P-Q}$, where P is the probability that the respective regime will prevail over two consecutive years, e.g. the transition probability from the high volatility regime to the same regime. It varies from a high of 55% in the case of Japan and Italy to a low of 0.77% for Italy and the UK. Without any further analysis, this information is potentially important for a fund manager. The low frequency with which the Italy-UK common shock is in the high-volatility regime, suggests that these markets infrequently suffer bad events simultaneously and hence could be used to provide a hedge against each other's risk. On the other hand, the relatively high frequency of shared market turbulence between Japan and Italy would be worrying for a portfolio manager if, these 'crises' periods led to changes in the transmission of structural shocks. The expected benefits of international diversification would be eroded. The average proportion of time that a pair of markets exhibits high common volatility is 14.3% (roughly 4.75 years), which yields sufficient observations in the high volatility regime to undertake our analysis.[8]

The column labelled 'Duration' measures the time (in years) for which a common shock persists - $Duration = \frac{1}{1-P}$. The persistence of the high-volatility regime for the common shock is quite low. On average, across all pairs, it persists for 0.23 years (or three months). It ranges from periods of approximately one week for Italy/UK, Italy/France and Italy/Japan to a high of over 1.5 years in the case of

[8] A problem with many empirical tests of contagion is one of low power due to the small crisis period, see Dungey et al. (2007).

US/Japan. However the latter is unusual with the next largest (Germany/US) being little over six months.

The remainder of Table 3 presents our estimates of the impact coefficients of common structural shocks for calm (δ) and turbulent (δ*) times (columns 2-3 and 4-5 respectively) as well as the ratio, γ, (column 6) which allows us to test for shift contagion. For the low volatility regime, the estimated impact coefficients are quite tightly clustered, ranging from 0.45 to 1.78. Furthermore all estimates are statistically different from zero. The average impact across pairs of countries is 1.27 with a standard deviation of 0.32. Turning to the high volatility regime, we see much larger estimates and more dispersion. Both the average impact (3.80) and the standard deviation (1.20) increase threefold. There is also considerable variation across pairs of countries. The impact of a high-volatility common shock for the US/Japan pair results in relatively small increases for both, while large responses are recorded for Italy/UK.

Column 6 of Table 3 reports the ratio of the estimated impact coefficients of common structural shocks. We construct the following statistic:

$$\gamma = \max\left\{\left|\frac{\delta^*_{c1}\delta_{c2}}{\delta^*_{c2}\delta_{c1}}\right|,\left|\frac{\delta^*_{c2}\delta_{c1}}{\delta^*_{c1}\delta_{c2}}\right|\right\}.$$

This reveals whether or not impact coefficients in the high volatility regime are proportional to their corresponding values in the low volatility regime. A ratio of unity indicates that there is no difference in the transmission mechanism of shocks between the high- and low-volatility regimes, whereas deviations from unity would imply shift contagion in the turbulent regime. Presently, we concentrate on the economic significance of the γ ratio but we will later test for its statistical significance.

Even without a formal test, our results suggest that for a large number of country pairs, the transmission mechanism governing common shocks does not experience major changes between high- and low-volatility regimes. Over half of our sample pairs (13 from 21) generate ratios of less than 1.05. If this turns out to be statistically significant evidence of shift contagion, at least it's at a relatively low level. At the other end of the scale, the US/Japan ratio is over 3.3, with seven other pairs generating increases in the ratio in excess of 5%. Ratios of this magnitude would be of concern to a portfolio manager as they indicate adverse movements in stock returns generate unstable market linkages; thereby reducing expected benefits from international diversification. It is also worth noting that comparable levels of the ratio can be arrived at in different ways. For example, Canada/France, Italy/Japan and Germany/Italy all have similar ratios. However, for all three pairs their common shock exerts different influences on stock market returns as we move from the low- to high-volatility regime. The impact of the common shock in turbulent periods increases by three times for Canada/France, 4.7 and 2.8 times for Italy/Japan and Germany/Italy respectively.

Before testing for changes in the transmission of a common shock between each pair of markets, we check if our model is appropriate for the asset returns in our analysis. Table 4 reports results from a number of diagnostic tests. Columns 2 and 3 report the LM test for serial correlation in the standardized residuals of the country pairs examined.[9] For the majority of country pairs, we fail to reject the null of no serial correlation at both one and four lags. Similarly, there is little evidence of ARCH effects at the first lag but it increases as we move to the fourth order (see Columns 3 and 4). However, in the majority of cases, our residuals are well behaved. To test for Normality, we use the Cramer-von Mises test which is based on the overall approximation of the empirical distributions of standardized residuals to the Normal. Our results suggest that the majority of country residuals are Normally distributed[10] (see Column 6). Hence, we argue that our regime-switching model adequately captures the distribution of asset returns. Since both common and idiosyncratic shocks move between two regimes, each country return operates in one of four regimes.

[TABLE 4 ABOUT HERE]

As a measure of our models' regime qualification performance, we employ the Regime Classification Measure (RCM) developed by Ang and Bekaert (2002). According to this measure, a good regime-switching model should be able to classify regimes sharply, i.e. the smoothed (ex-post) regime probabilities, p_t are close to either one or zero. For a model with two regimes, the regime classification measure (*RCM*) is given by:

[9] Please note that all six sets of standardized residuals are reported for each country.
[10] We also employed the Kolmogorov-Smirnov, Lilliefors, Anderson-Darling, and Watson empirical distribution tests, which yielded similar results. These results are available upon request.

$$RCM = 400 * \frac{1}{T} \sum_{t=1}^{T} p_t (1 - p_t),$$

where the constant normalizes the statistic to lie between 0 and 100. A perfect model will have a RCM close to zero, while a model that cannot distinguish between regimes will produce a RCM close to 100. The final three columns of Table 4 report the RCM for the idiosyncratic shocks of both countries and the common shock respectively. Using a cut-off of 50 suggests that in most cases, our regime switching model does a good job in describing the asset return generating process. However, it does perform better in capturing the behaviour of the common shock than the idiosyncratic shocks in most pairs.

4.2. Tests for shift contagion

In testing for changes in the transmission of a common shock between high- and low-volatility regimes (or shift contagion), we focus on the ratio γ, and test whether or not it is statistically different from unity. We perform a likelihood ratio test, whose test statistic has a $\chi^2(1)$ distribution under the null hypothesis. Table 5 presents the results.

[TABLE 5 ABOUT HERE]

The most striking feature of our results is that we find little evidence of shift contagion. In the majority of cases (19 out of 21), we fail to reject the null hypothesis of no change in the ratio of market responses to a common shock. In other words, the mechanism by which common shocks are transmitted is unaffected by the switch from a low- to high-volatility regime. This is reassuring for portfolio managers who undertake international equity diversification as a means of reducing portfolio risk. Market linkages are stable for most pairs of markets implying benefits should be robust to changes in volatility regimes.

For the other 2 pairs – US/UK and France/Germany - we find evidence of shift contagion, which may erode the expected gains from international portfolio diversification. The ratio for the UK/US, though statistically different from unity, is quite low at 1.001. So even if these large, traditionally strong markets show evidence of changes in the transmission mechanism of the common shock, it is unlikely to deter potential investors from holding the equities of the two countries in their portfolio. On the other hand, the ratio for France/Germany is 1.146, representing quite a large shift in the diffusion process of the common shock. Consequently, US investors may need to be wary of holding French and German equities in their portfolios, as there is evidence of levels of comovement in excess of normal interdependence during turbulent market conditions. This may reduce the expected diversification benefits of simultaneously holding both assets.

5. Economic significance of portfolio diversification

Having found little statistical evidence of increases in the ratio of market sensitivities to regime switches in the volatility of common shocks, we now turn to the economic significance of our results. Firstly, we compare the relative importance of the common shock with the idiosyncratic shocks that the investor seeks to diversify away. We have already seen in Figure 1, that the idiosyncratic shocks for pairs involving the US tend to be in the high-volatility regime with far greater frequency than the common shock for each corresponding pair. The evidence presented in Table 6 verifies this finding for all possible market pairs. As for the common shock, we present the proportion of time the idiosyncratic shock spends in the turbulent regime and the persistence of the shock. We find that, on average, the idiosyncratic shock is in the high-volatility state 41.5% of the time (roughly 13.5 years). This number is almost three times greater than that for the common shock. Likewise, the persistence of the country-specific shock is much greater, with an average of 1.5 years, approximately 6 times that of the common shock. In columns 2-5, we also report the impact coefficients for the idiosyncratic shocks. There is greater variation in the coefficients with some spectacular increases from calm to turbulent markets, e.g. for the Japan/UK pairing, the impact of the idiosyncratic shock is over 45 times greater for the UK in the high- compared to the low-volatility regime. Thus the evidence presented in Figures 1 & 2 and Table 6 indicate that idiosyncratic shocks occur more frequently and display greater persistence than common shocks.

To assess the risk reduction benefits of international diversification, we compare the risk of a domestic US portfolio with a portfolio comprising of US and foreign equity. We use our model to compute the time-varying covariance matrix. Recall from (2), that the aggregate shock of each country return is decomposed into an idiosyncratic and common shock. Both common and idiosyncratic shocks are allowed to switch between high and low-volatility states, which are assumed to be independent. Hence, our model encompasses 8 states of nature, ranging from the state when all shocks are in the low volatility regime to one when all shocks display high volatility. Each state generates a different variance-covariance matrix, which is uniquely calculated from the model given by (2)-(5). For example, the variance covariance matrices associated with the extreme states are as follows:

$$\Sigma_1 = \begin{bmatrix} \delta_1^2 + \delta_{c1}^2 & \delta_{c1} * \delta_{c2} \\ \delta_{c1} * \delta_{c2} & \delta_2^2 + \delta_{c2}^2 \end{bmatrix}$$

$$\Sigma_8 = \begin{bmatrix} \delta^{*2}_{1} + \delta^{*2}_{c1} & \delta_{c1}^{*} * \delta_{c2}^{*} \\ \delta_{c1}^{*} * \delta_{c2}^{*} & \delta^{*2}_{2} + \delta^{*2}_{c2} \end{bmatrix} \quad (7)$$

We compute the time-varying conditional covariance matrix of returns by weighting these state matrices by the estimated filter probabilities for each type of shock (see Figures 1 and 2). Figure 3 presents the time-varying conditional correlation of each market with the US. There is considerable time variation in the correlation with a noticeable increase around financial market crises.

We then compare the risk of a US portfolio versus a portfolio with x% invested in a foreign equity and the remainder in US equity. Figure 4 presents the risk reduction benefits of international portfolio diversification with 10% of funds invested in the foreign country. Given the relative size of markets and the observed home bias in asset holdings (French and Poterba, 1991; Cooper and Kaplanis, 1994), 10% is probably a realistic estimate of the foreign asset holdings of US investors. Figure 4 portrays the variance of the internationally diversified portfolio as a proportion of the variance of the US only portfolio. We can see immediately that at this level of foreign asset holding, international diversification delivers considerable reduction in risk for the US investor. The ratio is always less that unity and delivers average risk reduction ranging from 5.5% for Canadian investment up to 11.5% for diversification into Italian equity. Risk reduction is relatively stable over time and shows little sign of collapsing during market turbulence. In fact, diversification benefits were large in the aftermath of the 1987 crash when the US investor most needed protection. This may not be surprising given that this shock originated in the US, but we also see that diversification benefits were delivered during the Asian crisis, even for the US/Japan portfolio. Therefore high-volatility regimes do not appear to erode diversification benefits. Table 7 generalizes the above analysis by reporting the average risk reduction (Panel A) associated with different levels of foreign diversification and the proportion of time (Panel B) when the diversified portfolio was more risky than its domestic counterpart. Again the evidence strongly supports the proponents of diversification across international markets. In general, the average risk reduction increases with the level of diversification. For example, a US investor who allocates her wealth between domestic and Italian assets reaps benefits ranging from a 6.3% decline in risk for holding 5% of the portfolio in the foreign equity to a fall of almost 20% for allocating 25% of wealth to the Italian asset. Though smaller in magnitude, this pattern is repeated for all countries. Even the UK, for which we found a statistically significant increase in its comovement with the US market, delivers risk reduction benefits for all plausible levels of diversification.[11] Furthermore, Panel B of Table 7, shows us that risk reduction achieved on average, also manifests in the majority of individual time periods. When allocating up to 10% of the fund to foreign assets, the US investor always enjoys lower portfolio risk. Increasing the allocation to non-domestic equity may reduce average risk but it also produces some periods when the diversified portfolio is more risky. However, the number of such time periods is small and even for funds with 20% held in foreign assets, the maximum proportion of time that fails to deliver risk reduction is 6% (for French equity), while investments in Canada, Germany and Italy still deliver lower risk portfolios in every period. Consequently, we conclude that international diversification consistently delivers reduced portfolio risk for US investors.

Therefore, we argue that the benefits of hedging idiosyncratic risks outweigh the burden of bearing common shocks. We find little statistically significant evidence of shift contagion, which implies that turbulent periods are characterised by levels of market interdependence similar to those in calm periods. Idiosyncratic shocks are found to be more frequent, more persistent and larger in magnitude than the common shock. Both our statistical and economic results reinforce the belief that international portfolio diversification strategies are worthwhile and provide the investor with insurance against domestic risk in all market conditions. Our results

[11] Of course, given the bivariate structure of our model, we limit ourselves to two-country diversification. Therefore these numbers may be viewed as lower bounds to the potential benefits available for a multi-country diversification strategy.

show that the US investor should allocate funds to international assets without the fear of changes in market linkages during periods of global market turbulence.

6. Robustness

We check the robustness of our statistical results by repeating the analysis for equity returns expressed in their local currency. Though improbable in practice, this is akin to holding a portfolio where foreign exchange risk has been completely eliminated. Consequently, these results apply to an investor from any G7 country. Table 8 reports the impact coefficients for the common shock, the ratio measuring changes in the transmission mechanism and results of the likelihood ratio test for statistical significance. While we find more statistical significance of increased comovement, the majority of pairs (13 of 21) still fail to reject the null hypothesis of no change in the transmission mechanism of the common shock. From the perspective of the US investor, only Canada shows evidence of shift contagion. Given our results for the common currency returns and that we fail to reject the null hypothesis of no increased comovement for over 60% of the market pairs expressed in local currency, we conclude that results are generally supportive of the notion that the process governing the diffusion of the common shock is relatively stable between regimes and hence the benefits expected to accrue from international diversification in tranquil markets should also be manifest during periods of market turbulence.

7. Conclusion

We investigate if stock market linkages are stable across volatility regimes and hence if portfolio managers should be concerned by the influence of shift contagion on international diversification strategies. Investors diversify to eliminate idiosyncratic shocks but remain vulnerable to common shocks. Therefore we concentrate on testing for changes in the transmission mechanism of the common shock. The stability of markets linkages between calm and turbulent conditions will dictate the effectiveness of diversification strategies. We employ the methodology of GKM to test for shift contagion between pairs of G7 equity markets.

We report a number of interesting findings. Firstly, we find that expected stock returns are statistically different between regimes. Calm markets are associated with significantly positive returns while turbulent markets are characterised by negative mean returns. Secondly, our model seems to capture the features of return distributions quite well and we find that common market shocks are, on average, in a high-volatility regime about 23% of the time. Thirdly, we find little evidence of changes in the process governing the diffusion of common shocks between the pairs of markets under review. In 90% (19 of 21) of cases, we fail to reject the hypothesis of no shift contagion. Though not as strong, the majority of local currency return pairs are also consistent with this finding.

Having found little statistical evidence of increased cross-market linkages, we examine the economic significance of our results. We find that relative to the common shock, the idiosyncratic shocks are more frequently in the high-volatility regime and exhibit more persistence in this state. Hence diversifiable risks represent a greater risk than common risks and thus favours international diversification. To confirm, we examine the risk reduction achieved by a US investor who allocates wealth between a foreign and domestic equity. For realistic levels of diversification, we find that risk is substantially lower in the vast majority of cases. More importantly, risk reduction appears to be robust to market conditions.

In summary, we find strong support for the stability of market linkages and the robustness of international diversification strategies across volatility regimes. There is little evidence of shift contagion. Furthermore, the risk reduction benefits appear to be robust to changes in volatility and indeed were manifest in the aftermath of the 1987 crash when US investors were most vulnerable. Consequently, fund managers should pursue international diversification strategies without fear of potential benefits being eroded during periods of high volatility, such as those associated with bear markets.

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Table 1: Summary Descriptive Statistics

Panel A: Full sample US dollars (1/1/73-31/12/2005)

	Canada	*France*	*Germany*	*Italy*	*Japan*	*UK*	*US*
Mean	0.139	0.173	0.150	0.150	0.132	0.146	0.141
Median	0.236	0.288	0.246	0.000	0.186	0.194	0.294
Maximum	12.862	12.448	12.225	15.772	14.824	22.346	12.302
Minimum	-24.492	-19.214	-15.032	-18.605	-21.361	-24.357	-27.090
Std. Dev.	2.312	2.946	2.608	3.010	3.519	2.735	2.300
Skewness	-0.932	-0.462	-0.504	-0.031	-0.174	-0.141	-1.050
Kurtosis	11.916	5.752	5.676	5.379	4.842	10.759	15.779
Jarque- Bera	5952.841 (0.000)	604.682 (0.000)	586.868 (0.000)	406.267 (0.000)	252.181 (0.000)	4324.721 (0.000)	12033.400 (0.000)

Panel B: Correlations

Market	*Canada*	*France*	*Germany*	*Italy*	*Japan*	*UK*	*US*
Canada	1.000	0.437	0.434	0.301	0.282	0.468	0.705
France		1.000	0.625	0.339	0.408	0.525	0.437
Germany			1.000	0.367	0.422	0.488	0.432
Italy				1.000	0.205	0.318	0.282
Japan					1.000	0.366	0.278
UK						1.000	0.456
US							1.000

Table 2. Estimates of mean returns across regimes

Country pairs	μ_1	μ_2	μ^*_1	μ^*_2	*LR*	*p-val*
Canada/US	0.199	0.216	-0.760	-0.427	4.738*	0.094
	(0.049)	(0.047)	(0.677)	(0.659)		
France/US	0.306	0.232	-0.596	-0.425	7.703**	0.021
	(0.061)	(0.046)	(0.195)	(0.172)		
Germany/US	0.282	0.230	-0.390	-0.124	7.476**	0.024
	(0.058)	(0.047)	(0.138)	(0.150)		
Italy/US	0.243	0.221	-0.720	-0.367	8.491**	0.014
	(0.067)	(0.048)	(0.291)	(0.309)		
Japan/US	0.251	0.220	-0.176	-0.006	6.216**	0.045
	(0.101)	(0.051)	(0.246)	(0.096)		
UK/US	0.214	0.204	-0.590	-0.309	4.513	0.105
	(0.057)	(0.049)	(0.284)	(0.327)		
Canada/UK	0.213	0.203	-0.876	-0.750	5.099*	0.078
	(0.051)	(0.058)	(0.645)	(0.627)		
France/UK	0.328	0.254	-0.835	-0.511	11.579***	0.003
	(0.066)	(0.058)	(0.364)	(0.320)		
Germany/UK	0.255	0.186	-0.606	-0.195	8.295**	0.016
	(0.055)	(0.056)	(0.389)	(0.269)		
Italy/UK	0.168	0.239	-4.142	-4.664	2.221	0.329
	(0.075)	(0.062)	(0.666)	(0.821)		
Japan/UK	0.189	0.231	-0.839	-0.676	7.764**	0.021
	(0.078)	(0.056)	(0.377)	(0.422)		
Canada/Japan	0.229	0.160	-1.171	-0.980	6.887**	0.032
	(0.044)	(0.070)	(1.404)	(1.591)		
France/Japan	0.316	0.215	-0.698	-0.568	7.312**	0.026
	(0.065)	(0.076)	(0.325)	(0.314)		
Germany/Japan	0.258	0.189	-0.529	-0.320	7.551**	0.023
	(0.057)	(0.075)	(0.257)	(0.219)		
Italy/ Japan	-0.112	0.619	0.313	-0.195	9.150***	0.010
	(0.208)	(0.194)	(0.196)	(0.187)		
Canada/Italy	0.212	0.196	-1.260	-0.615	3.776	0.151
	(0.049)	(0.060)	(0.518)	(0.065)		
France/ Italy	0.416	0.093	-2.767	1.004	5.161*	0.076
	(0.081)	(0.153)	(0.817)	(0.782)		
Germany/ Italy	0.283	0.177	-0.657	-0.006	8.644**	0.013
	(0.060)	(0.066)	(0.287)	(0.013)		
Canada/Germany	0.209	0.230	-0.584	-0.919	7.184**	0.028
	(0.051)	(0.058)	(1.013)	(1.212)		
France/Germany	0.274	0.272	-0.160	-0.248	4.536	0.104
	(0.062)	(0.056)	(0.180)	(0.174)		
Canada/France	0.229	0.293	-0.742	-1.015	9.135**	0.010

Notes: Standard errors in parentheses below coefficients. Likelihood ratio statistic is for the null of equality of mean returns across the regimes. The test statistic has a $\chi^2(2)$ distribution under the null hypothesis. *** denotes significance at 1% level, ** denotes significance at 5% level, and * denotes significance at 10% level.

Table 3. Estimates of impact coefficients of common shocks

Country pairs	δ_{c1}	δ_{c2}	δ^{*}_{c1}	δ^{*}_{c2}	γ	*Unc. Prob.*	*Duration*
Canada/US	1.453	1.523	4.284	4.482	1.001	7.05%	0.12
	(0.099)	(0.104)	(0.441)	(0.479)			
France/US	1.124	1.370	2.941	3.914	1.092	13.12%	0.28
	(0.087)	(0.062)	(0.386)	(0.288)			
Germany/US	0.930	0.976	2.719	2.868	1.004	21.28%	0.54
	(0.028)	(0.087)	(0.199)	(0.151)			
Italy/US	0.720	1.130	2.398	3.765	1.000	11.02%	0.27
	(0.127)	(0.091)	(0.313)	(0.341)			
Japan/US	1.460	0.637	1.723	2.487	3.304	30.45%	1.57
	(0.182)	(0.090)	(0.200)	(0.133)			
UK/US	1.175	1.290	3.889	4.272	1.001	9.10%	0.17
	(0.120)	(0.103)	(0.381)	(0.400)			
Canada/UK	1.367	1.211	4.384	3.883	1.001	7.09%	0.11
	(0.100)	(0.121)	(0.491)	(0.582)			
France/UK	1.599	1.471	4.183	3.846	1.001	16.02%	0.15
	(0.126)	(0.099)	(0.347)	(0.285)			
Germany/UK	1.502	1.266	3.879	3.303	1.011	14.90%	0.17
	(0.058)	(0.078)	(0.349)	(0.320)			
Italy/UK	1.261	1.544	5.308	9.387	1.444	0.77%	0.02
	(0.236)	(0.283)	(1.863)	(2.639)			
Japan/UK	1.346	1.680	3.244	4.480	1.107	11.23%	0.18
	(0.086)	(0.055)	(0.348)	(0.381)			
Canada/Japan	1.407	0.936	4.539	3.885	1.287	6.24%	0.09
	(0.049)	(0.044)	(0.387)	(0.262)			
France/Japan	1.678	1.783	4.346	3.649	1.265	14.34%	0.14
	(0.082)	(0.095)	(0.299)	(0.171)			
Germany/Japan	1.601	1.629	3.755	3.650	1.047	16.31%	0.31
	(0.055)	(0.065)	(0.254)	(0.219)			
Italy/ Japan	0.450	0.441	2.111	2.053	1.008	55.09%	0.03
	(0.613)	(0.979)	(0.149)	(0.168)			
Canada/Italy	1.150	0.891	5.295	3.506	1.170	4.06%	0.07
	(0.060)	(0.109)	(0.718)	(0.646)			
France/ Italy	1.288	1.619	3.567	4.644	1.036	6.96%	0.03
	(0.146)	(0.187)	(0.646)	(0.795)			
Germany/ Italy	1.262	1.050	3.535	2.939	1.000	14.64%	0.12
	(0.119)	(0.092)	(0.472)	(0.336)			
Canada/Germany	1.138	1.137	3.787	3.840	1.016	8.06%	0.16
	(0.357)	(0.191)	(1.701)	(1.033)			
France/Germany	1.636	1.589	3.382	3.768	1.146	23.30%	0.30
	(0.067)	(0.064)	(0.150)	(0.194)			
Canada/France	1.295	1.188	3.912	3.602	1.004	9.43%	0.13
	(0.111)	(0.130)	(0.475)	(0.403)			

Notes: Standard errors in parentheses below coefficients. "Duration" refers to the duration of the high volatility common shock expressed in years. "Unc. Prob." refers to the unconditional probability of the high volatility regime expressed in percentage.

Table 4. Diagnostic tests on standardized residuals and model specification

Country pairs	*LM(1)*	*LM(4)*	*ARCH(1)*	*ARCH(4)*	*Normality*	*RCM₁*	*RCM₂*	*RCM₃*
Canada/US	5.286	8.194	3.645	3.747	0.149	50.17	32.93	14.43
	6.472	9.629	0.178	0.686	0.310*			
France/US	2.052	8.248	8.781*	24.446*	0.062	47.53	34.47	21.68
	6.512	11.389	0.010	1.002	0.275*			
Germany/US	0.738	5.896	5.450	28.836*	0.138	56.56	23.70	28.78
	6.097	9.807	0.303	1.278	0.256*			
Italy/US	0.550	4.412	4.789	10.692	1.105*	61.21	46.85	19.35
	6.500	10.058	0.029	0.741	0.354*			
Japan/US	0.021	18.621*	8.571*	45.912*	0.047	48.72	1.38	26.96
	6.294	9.261	1.612	4.332	0.356*			
UK/US	1.218	6.593	0.011	9.564	0.086	32.49	49.14	17.06
	6.763*	10.963	0.055	0.756	0.406*			
Canada/UK	4.439	6.765	1.029	1.797	0.113	36.13	35.79	14.93
	1.954	8.586	0.028	32.713*	0.092			
France/UK	1.527	5.989	1.409	9.803	0.192*	33.78	16.95	30.29
	0.467	8.023	0.053	20.162*	0.037			
Germany/UK	0.917	4.737	0.503	20.284*	0.200*	48.30	24.75	28.85
	1.620	11.094	1.855	24.696*	0.106			
Italy/UK	0.772	3.638	2.982	5.462	0.098	49.59	37.22	1.89
	1.774	9.785	0.237	0.843	0.157			
Japan/UK	0.000	18.197*	7.410*	49.955*	0.035	46.69	22.67	21.59
	0.204	7.221	0.061	5.364	0.069			
Canada/Japan	3.881	6.407	0.764	1.091	0.118	36.46	48.01	13.93
	0.044	21.110*	6.452	44.493*	0.052			
France/Japan	0.777	6.019	1.565	15.602*	0.151	40.84	24.06	30.08
	0.010	18.044*	5.416	41.226*	0.068			
Germany/Japan	1.378	4.974	2.189	19.756*	0.155	44.01	14.16	27.70
	0.049	20.633*	13.512*	63.177*	0.122			
Italy/ Japan	0.670	3.000	4.973	9.267	0.083	53.38	47.12	82.32
	0.088	11.398	2.368	15.790*	0.079			
Canada/Italy	4.207	7.414	0.797	1.628	0.162	39.65	57.51	9.77
	0.760	5.027	5.050	11.556*	1.255*			
France/ Italy	0.766	4.292	1.062	24.964*	0.229*	39.57	58.61	33.68
	0.631	5.615	3.234	8.644	1.212*			
Germany/ Italy	0.546	4.409	4.970	43.308*	0.196*	32.26	50.25	16.64
	0.293	2.953	0.017	5.979	0.056			
Canada/Germany	5.294	8.176	3.532	4.624	0.152	40.34	47.17	15.69
	0.548	3.351	6.772*	14.724*	0.166			
France/Germany	1.331	8.528	8.351*	18.888*	0.046	32.72	41.75	36.02
	1.880	6.090	6.605	47.320*	0.124			
Canada/France	4.360	7.440	1.829	2.848	0.101	53.16	36.35	19.57
	1.616	6.949	7.199*	16.364*	0.044			

Notes: LM(*k*) is the Breusch-Godfrey Lagrange Multiplier test for no serial correlation up to lag *k*, ARCH(*k*) is the Lagrange Multiplier test for no ARCH effects of order *k*, Normality is the Cramer-von-Mises test for the null of Normality, RCM*i* is the Regime Classification Measure, where i=1,2,3 for the idiosyncratic shock of the first, second and the common shock, respectively. * denotes significance at 1% level. LM(k) and ARCH(k) have a $\chi^2(k)$ distribution under the null hypothesis. The Cramer-von-Mises test has a non-standard distribution and the cut-off value for RCM is 50.

Table 5. Likelihood ratio tests for increased comovement

Market	*Canada*	*France*	*Germany*	*Italy*	*Japan*	*UK*	*US*
Canada	---	0.000 (0.991)	0.000 (0.983)	0.008 (0.927)	0.001 (0.977)	0.000 (0.995)	0.001 (0.973)
France		---	6.219** (0.013)	0.001 (0.972)	0.193 (0.660)	0.000 (0.983)	0.354 (0.552)
Germany			---	0.000 (1.000)	0.008 (0.927)	0.001 (0.972)	0.000 (0.987)
Italy				---	0.000 (0.995)	0.928 (0.335)	0.000 (0.996)
Japan					---	0.862 (0.353)	1.321 (0.250)
UK						---	4.000** (0.046)
US							----

Notes: Likelihood ratio statistic is for the null of no increased comovement against the alternative of increased comovement for the indicated country pairs. The test statistic has a $\chi^2(1)$ distribution under the null hypothesis. *** denotes significance at 1% level, ** denotes significance at 5% level, and * denotes significance at 10% level. *p*- values are reported in parentheses below coefficients.

Table 6. Estimates of impact coefficients of idiosyncratic shocks

Country pairs	δ_1	δ_2	δ^*_1	δ^*_2	*Unc. Prob./ Duration (1)*	*Unc. Prob./ Duration (2)*
Canada/US	0.898	0.704	1.924	1.754	36.06%	33.03%
	(0.140)	(0.200)	(0.158)	(0.113)	0.52	1.62
France/US	1.767	0.037	3.708	1.500	29.26%	66.55%
	(0.060)	(0.102)	(0.213)	(0.091)	0.25	4.93
Germany/US	1.455	1.259	2.753	2.656	39.65%	16.64%
	(0.121)	(0.026)	(0.112)	(0.150)	0.48	1.07
Italy/US	1.722	1.075	3.657	2.163	46.55%	34.87%
	(0.092)	(0.067)	(0.153)	(0.126)	0.25	1.17
Japan/US	1.728	1.524	4.108	10.147	49.25%	0.54%
	(0.117)	(0.050)	(0.154)	(3.321)	0.53	0.03
UK/US	1.549	0.827	3.495	1.881	23.86%	47.19%
	(0.082)	(0.139)	(0.191)	(0.119)	0.46	1.36
Canada/UK	1.128	1.527	2.204	3.516	21.39%	25.24%
	(0.089)	(0.105)	(0.236)	(0.225)	0.98	0.42
France/UK	1.338	0.752	3.674	2.255	19.08%	45.13%
	(0.136)	(0.166)	(0.282)	(0.099)	0.26	7.75
Germany/UK	0.768	1.048	2.088	2.794	51.57%	44.66%
	(0.143)	(0.138)	(0.059)	(0.092)	1.19	2.65
Italy/UK	1.742	0.531	3.337	2.173	62.67%	49.48%
	(0.064)	(0.889)	(0.261)	(0.198)	1.00	1.51
Japan/UK	1.743	0.045	3.949	2.094	52.09%	53.87%
	(0.081)	(0.113)	(0.157)	(0.113)	0.61	6.20
Canada/Japan	0.984	2.034	2.152	4.326	26.52%	44.50%
	(0.032)	(0.092)	(0.212)	(0.118)	1.37	0.46
France/Japan	0.984	0.484	2.796	3.201	38.15%	74.14%
	(0.009)	(0.190)	(0.201)	(0.106)	1.26	2.64
Germany/Japan	0.729	0.674	2.190	3.453	44.01%	59.56%
	(0.162)	(0.155)	(0.070)	(0.074)	1.32	8.11
Italy/ Japan	1.402	1.627	3.379	3.874	59.40%	43.45%
	(0.082)	(0.169)	(0.161)	(0.190)	0.60	0.53
Canada/Italy	1.297	1.613	2.466	3.508	25.12%	51.96%
	(0.088)	(0.057)	(0.173)	(0.124)	0.80	0.35
France/ Italy	1.220	1.074	2.767	3.028	45.77%	62.63%
	(0.140)	(0.245)	(0.167)	(0.156)	2.58	0.82
Germany/ Italy	1.150	1.436	2.423	3.318	43.19%	52.36%
	(0.093)	(0.126)	(0.208)	(0.137)	2.04	0.34
Canada/Germany	1.305	1.462	2.524	2.961	23.77%	29.97%
	(0.152)	(0.250)	(0.677)	(0.215)	0.52	0.41
France/Germany	0.848	0.003	2.935	1.476	40.89%	73.43%
	(0.053)	(0.020)	(0.114)	(0.070)	0.78	2.02
Canada/France	1.093	1.755	2.126	3.711	30.41%	25.63%
	(0.081)	(0.110)	(0.200)	(0.221)	0.62	0.50

Notes: Standard errors in parentheses below coefficients. "Duration" refers to the duration of the high volatility regime of the idiosyncratic shock expressed in years. "Unc. Prob." refers to the unconditional probability of the high volatility regime expressed in percentage.

Table 7. Risk reduction benefits accruing to international diversification

x%	Canada	France	Germany	Italy	Japan	UK
Panel A						
5	3.0%	4.2%	5.3%	6.3%	5.3%	4.4%
10	5.5%	7.4%	9.8%	11.5%	9.1%	8.0%
15	7.8%	9.7%	13.6	15.2%	11.2%	10.8%
20	9.6%	11.1%	16.5%	17.8%	11.7%	12.8%
25	11.1%	11.5%	18.7%	19.2%	10.5%	14.0%
Panel B						
5	0%	0%	0%	0%	0%	0%
10	0%	0%	0%	0%	0%	0%
15	0%	2%	0%	0%	0%	0%
20	0%	6%	0%	0%	5%	3%
25	0%	15%	0%	1%	21%	7%

Notes: Panel A presents the average risk reduction achieved by a US investor who holds x% of funds in the foreign asset and the remainder in domestic equity. Panel B reports the proportion of time that the diversified portfolio is more risky than the US portfolio.

Table 8. Estimates of impact coefficients of common shocks (local currency)

Country pairs	δ_{c1}	δ_{c2}	δ^*_{c1}	δ^*_{c2}	γ	*LR.*	*p-val*
Canada/US	1.080 (0.025)	1.667 (0.033)	1.961 (0.077)	3.325 (0.072)	1.099	2.784*	0.095
France/US	1.424 (0.192)	1.187 (0.075)	3.446 (0.742)	3.930 (0.475)	1.368	0.000	1.000
Germany/US	1.020 (0.004)	0.832 (0.056)	3.060 (0.184)	2.507 (0.166)	1.004	0.000	0.996
Italy/US	0.671 (0.060)	1.219 (0.029)	2.171 (0.266)	4.045 (0.321)	1.026	0.000	0.994
Japan/US	1.374 (0.019)	0.671 (0.010)	1.851 (0.388)	2.473 (0.242)	2.736	1.156	0.282
UK/US	1.078 (0.071)	1.259 (0.056)	3.266 (0.317)	3.816 (0.303)	1.000	0.000	0.996
Canada/UK	0.921 (0.054)	1.421 (0.058)	2.041 (0.191)	4.963 (0.312)	1.576	2.941*	0.086
France/UK	1.420 (0.068)	1.334 (0.037)	4.802 (0.399)	4.545 (0.340)	1.007	0.011	0.916
Germany/UK	0.577 (0.074)	1.469 (0.045)	3.095 (0.192)	2.412 (0.133)	3.267	10.793***	0.001
Italy/UK	0.719 (0.124)	0.805 (0.117)	2.411 (0.247)	2.716 (0.434)	1.006	0.000	0.986
Japan/UK	1.306 (0.091)	1.321 (0.044)	3.655 (0.905)	4.812 (0.361)	1.302	6.898***	0.009
Canada/Japan	1.024 (0.162)	1.157 (1.067)	4.003 (1.348)	4.617 (0.386)	1.021	6.483***	0.011
France/Japan	1.594 (0.061)	1.511 (0.094)	4.410 (0.340)	3.876 (0.301)	1.079	0.025	0.874
Germany/Japan	0.383 (0.051)	2.885 (0.091)	2.905 (0.652)	3.159 (0.145)	6.927	44.648***	0.000
Italy/ Japan	1.428 (0.051)	0.683 (0.099)	8.887 (2.697)	0.698 (0.177)	6.090	0.760	0.383
Canada/Italy	0.904 (0.038)	0.696 (0.099)	4.196 (0.717)	2.895 (0.467)	1.116	0.000	1.000
France/ Italy	0.572 (0.073)	1.035 (0.046)	1.247 (0.114)	2.679 (0.111)	1.187	0.000	1.000
Germany/ Italy	0.675 (0.234)	0.613 (0.104)	2.352 (0.142)	2.113 (0.163)	1.011	0.000	1.000
Canada/Germany	1.189 (0.099)	0.637 (0.069)	1.934 (0.114)	2.862 (0.161)	2.762	3.710*	0.054
France/Germany	1.459 (0.064)	1.073 (0.070)	3.189 (0.172)	3.504 (0.149)	1.494	2.707*	0.100
Canada/France	0.953 (0.124)	1.254 (0.215)	2.748 (0.240)	3.599 (0.278)	1.005	0.000	0.987

Notes: Columns and tests defined as in Table 5.

Figure 1. Filter Probabilities of high volatility idiosyncratic shocks

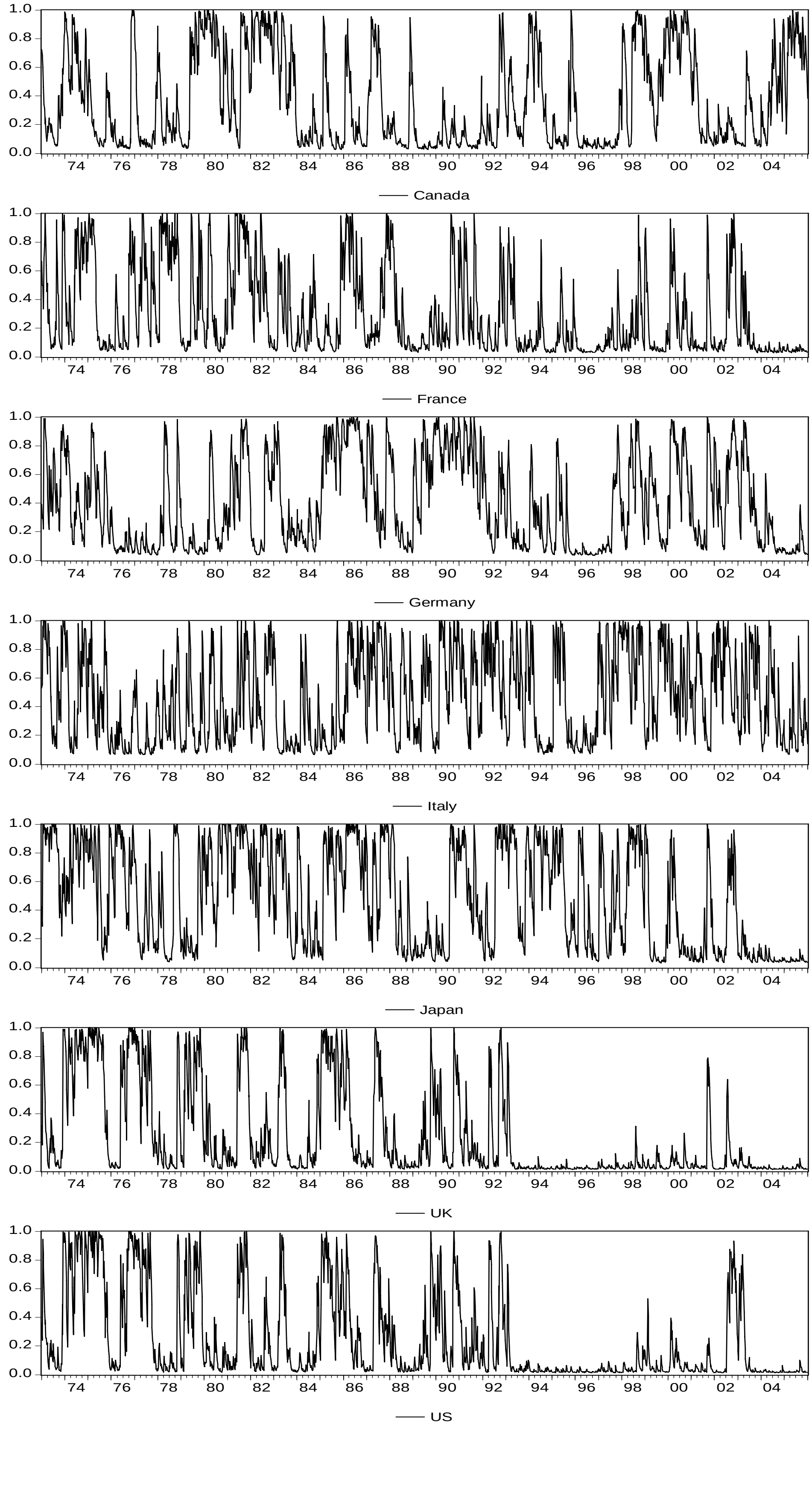

Figure 2. Filter probabilities of high volatility common shocks

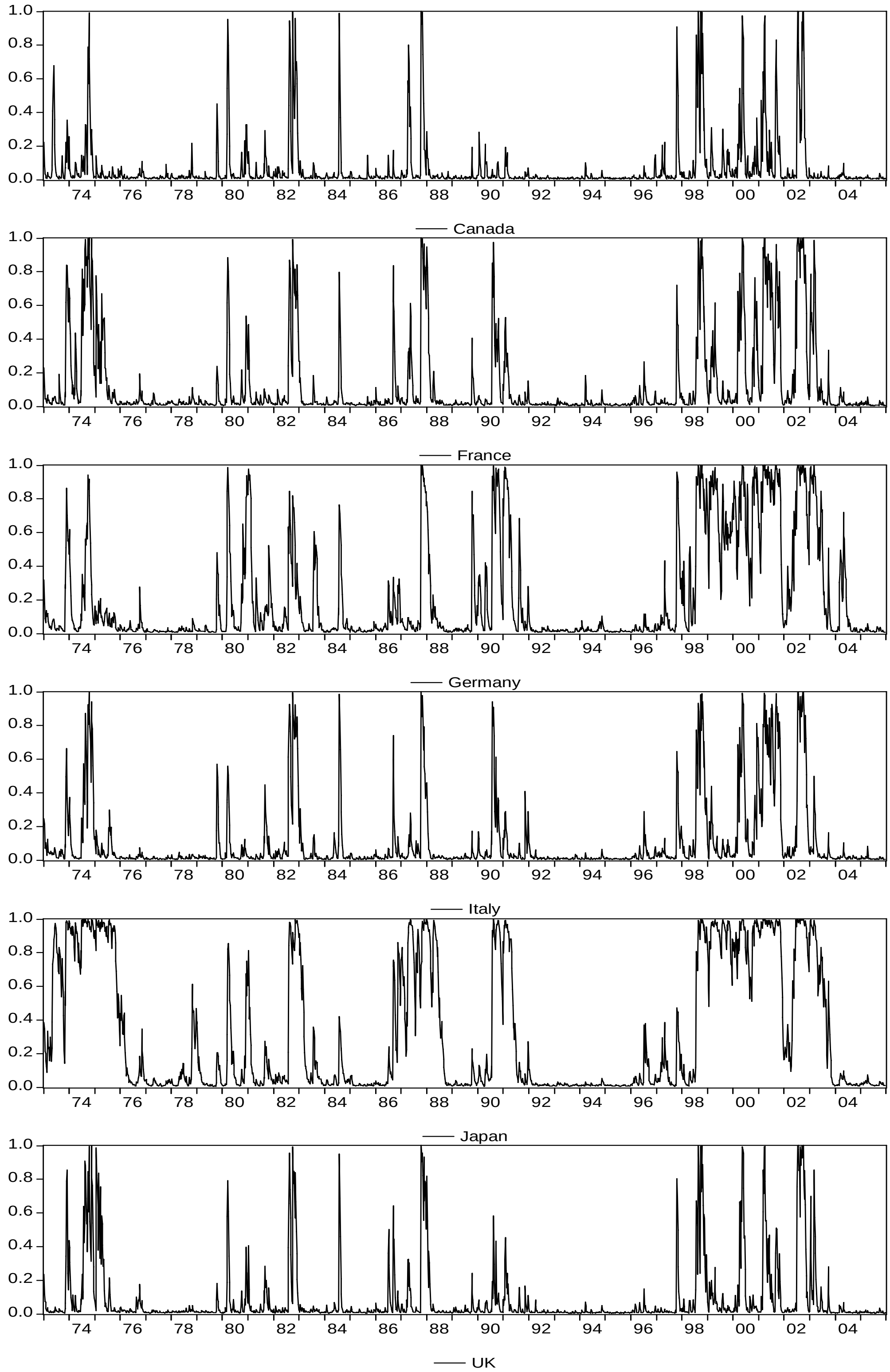

Figure 3. Conditional Correlations

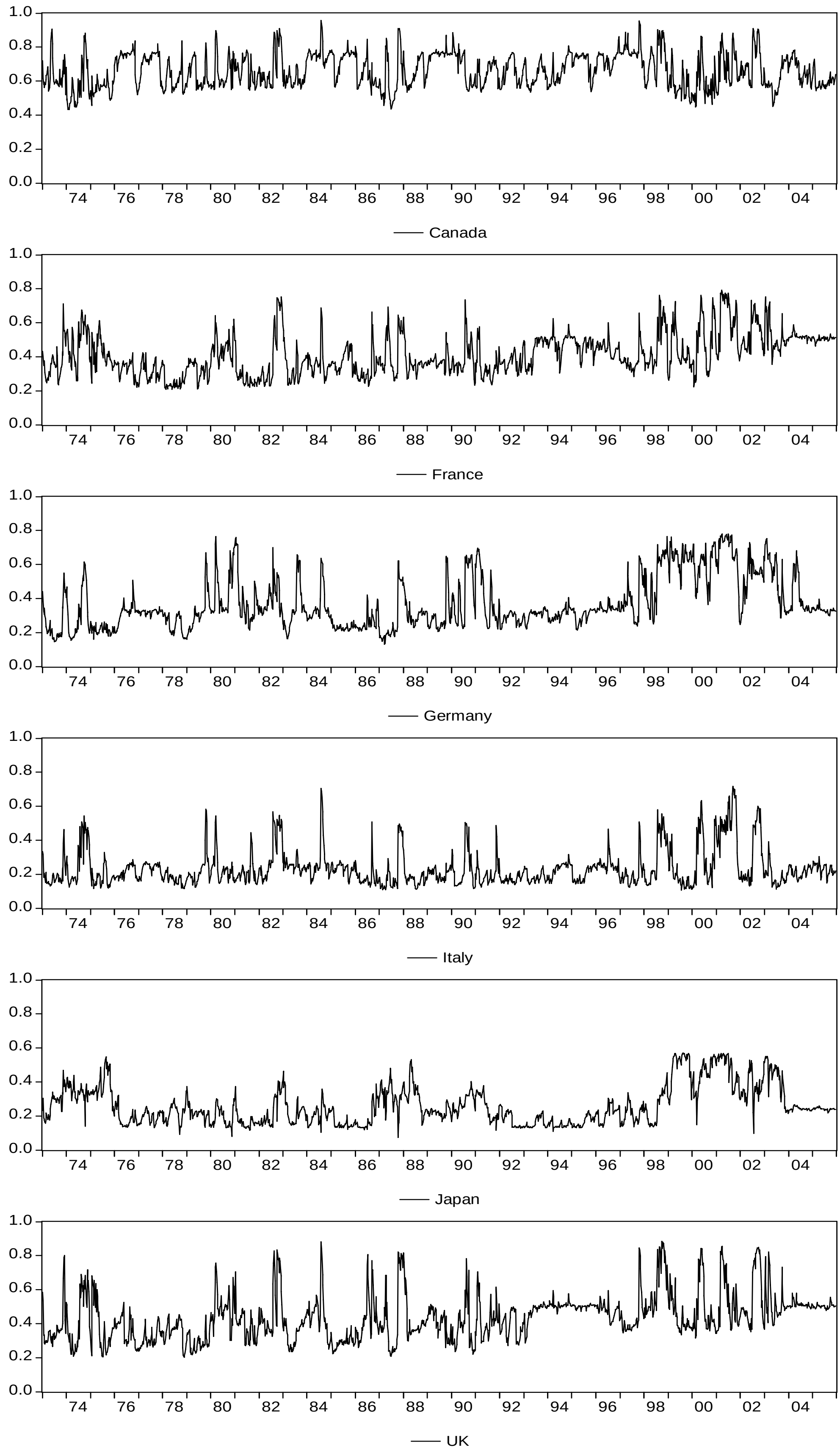

Figure 4. Risk reduction benefits from international diversification