Sectoral Equity Returns in the Euro Region: Is There any Room for Reducing the Portfolio Risk?

Faruk Balli and Hatice Ozer-Balli

Massey University Department of Economics and Finance, Massey University Department of Economics and Finance

2009

Sectoral Equity Returns in the Euro Region: Is There any Room for Reducing the Portfolio Risk?*

Faruk Balli
Massey University

Hatice Ozer-Balli
Massey University

September 11, 2009

Abstract

The economic integration among Euro members has important consequences for factors driving asset pricing and asset trading within the financial markets. In particular, since the start of the Euro, cross-country equity index correlations in the region show upward trends and domestic investors allocate their portfolios mostly inside of the region. This paper studies the impact of these recent structural changes on the Euro-wide sectoral equity indices. We model the return and volatility of the Euro sector equity indices between years 1992 and 2007. We find that aggregate world equity or global sector equity indices no longer affect the sector equity indices since the beginning of the Euro. Aggregate Euro stock index, however, still affects most of the sector equity indices, even though its effect declines remarkably for some sectors. In particular, we find that financial sector indices (financial services, insurance, and banking) are being affected increasingly by the aggregate Euro equity index fluctuations after the start of the Euro. However, some "basic industry sector" indices, including basic resources, food and beverage, health-care, retail services, and oil & gas become less dependent to the aggregate Euro index after the start of the Euro, suggesting that diversification across these sectors within the region would be much more effective tool for reducing portfolio risk.

JEL classification: G12; G15
Keywords: Stock Market Correlation, Sector Equity Indices, Euro Portfolio Bias, Euro, GARCH.

*We are grateful to Syed A. Basher, and Ben Marshall for their useful comments on preliminary drafts. The errors that remain are solely ours. The data and computer code are available on request.

1 Introduction

Since late 1990s, equity markets in many developed countries has become increasingly integrated in terms of asset pricing and asset trading. Among those markets, Euro area equity markets is an interesting subject of study due to the rapid changes caused by the unification process and the introduction of the common currency. A large number of studies interpreted the European equity market integration after the start of the monetary union in terms of asset pricing. Some studies analyze the effect of global risk factors on the asset prices across the region (Bekaert and Harvey (1997), Hardouvelis, Malliaropulos, and Priestley (2000), and Stulz and Karolyi (2001), Christiansen (2007)). Other researches focus on the cross-correlations in the equity markets in the region. For example, Adjaout and Danthine (2003) compare correlations among country index returns within two subperiods. They find that cross-country return correlations are significantly higher after the start of the Euro compared to the period before. More recently, Baele et al. (2004) and Bekaert and Ng (2005) also document that the Euro equity markets became more integrated and that cross-country equity return correlations in this region showed upward trends.

The other part of the literature gives evidence of European equity market integration via the volume of asset trading. Adam et al. (2002) interpret the recent decrease in equity and bond home bias as an evidence of further integration in the Euro area. Their study notes that the share of foreign equity holdings among domestic investors was relatively steady prior to the start of the Euro, and it has increased considerably since then. Similarly, Adjaout et al. (2002) and Baele et al. (2004) find higher economic integration in Euro area which leads higher volume of financial asset trading across the borders. Some studies also point out that the decrease in portfolio home bias among the region is accompanied with the tendency in holding foreign portfolio within the region (equity Euro bias).[1] In accordance with those studies, Figure 1 illustrates the Euro share of EMU members' foreign portfolio holdings. It is observed that most of the Euro members are holding more than 50 % of their foreign portfolio within the region.

Overall, both increasing cross-country correlations of equity market returns and increasing

[1]See Lane and Milesi-Ferretti (2005) and Maela (2008).

tendency in allocating portfolio inside the Euro region suggest that diversifying the portfolio across the region has a clear limitation in reducing the portfolio risk. In this paper, we consider the issue for the Euro area stock markets in a different perspective. We consider the Euro region as a whole economy and focus on the Euro-wide sectoral equity indices instead of the national sector indices.

There are many studies on sectoral diversification in the equity markets, however they don't have a consensus on the "true effect" of industrial structure of the domestic economy on equity markets. For example, Heston and Rouwenhorst (1994) find that the industrial structure explains little of the cross sectional difference in country return volatility and low correlation between the countries exists because of the country specific variations. According to Adjaout and Danthine (2001a, 2001b), the dominance of country effects has diminished, but industry factors are still less important than country factors.

On the other hand, Roll (1992) indicates that industrial structure of the domestic economy is essential in explaining the correlations among the country sector indexes. Cavaglia et al. (2000) and Isakov and Sonney (2002) also show that industry factors (almost) match the country factors and expect that industry factors will become even more important in the future. Therefore, there is still strong incentive to see if sectoral diversification matters in Euro region. Summing up, according to the literature, until the end of 1990s, country factors are dominant factors in explaining stock returns, however, more recent studies show that industry effects are increasing as well. For the Euro area, it seems that industrial factors might be favorable after the start of the Euro, even after correcting for the substantial rise in the information technology.

In this paper we contribute to the literature in two-folds. First, we model return and volatility of the Euro-wide sector equity indices by disregarding the national borders in the Euro region and taking into account of effects of aggregate Euro index (regional shocks), aggregate world index and global sector index (global shocks). Second, we use longer data series to observe the sector equity indices fluctuations detached from the effect of technology bubbles on Euro stock markets which took place in the late 1990s.[2]

[2]Brooks and Negro (2004) show that potential benefits of sectoral diversification within Euro region is mostly driven by the technology bubbles in the early years of Euro.

We use $GARCH$ $(1,1)$ process to model the return and volatility of the sector equity indices and measure the magnitudes of spillovers of aggregate Euro equity index, global sector equity index and aggregate world equity index on the volatility of the Euro sector equity indices. Then, we form the volatility spillovers following Bekaert and Harvey (1997), Ng (2000), and Bekaert et al. (2005). We find that spillovers of aggregate world index and global sector equity index diminishe sharply after the start of the Euro. This finding supports Hardouvelis et al. (2000) who claims that European stock market returns are driven by the Europe-wide risk factors instead of the global factors. We also find that aggregate Euro index has different levels of impact on the sectoral equity indices after the start of the Euro. Euro aggregate index is increasingly effective in explaining the volatility of the financial sector indices (banking, financial services and insurance), whereas for the volatility of some "basic industry sector" equity indices (basic resource, food and beverage, health-care, retail services, oil and gas), the effect of aggregate Euro index diminishes considerably after the start of Euro. In fact, previous literature on this issue have different results merely depending on the time interval of the dataset. In the very first years of the Euro, the potential gains of sectoral diversification across all sector indices is measured relatively higher (see Baca et al. (2000), Cavaglia et al. (2000), Kraus (2001), and Moerman (2004)). Our results suggest that potential gains of the sectoral diversification within the region is not all or none game, but the clusters of the sector indices, i.e., financial sectors, TMT, and basic industry sectors have been reacting differently to the aggregate Euro index fluctuations. Among some sectors,-to some extent-, there is still enough potential to reduce the portfolio risk.[3]

The remainder of this paper is organized as follows. Next section discusses the data for Euro sector equity indices along with aggregate Euro and world indices and offers some preliminary analysis of the data. The econometric models of volatility spillovers are set forth in detail in Section 3 and the empirical results are presented in Section 4. Section 5 concludes the paper.

[3]TMT stands for Technology, Media and Telecom. Basic industry sectors include automobile and parts, basic resources, chemistry, construction materials, food and beverage, health-care, industrial goods, oil and gas, non-cycled goods, retail services, travel and leisure, and utility sectors.

2 Data and Descriptive Statistics

We use weekly Euro area equity sector indices taken from the Dow Jones STOXX database. Dow Jones Euro STOXX size indices are derived from Dow Jones STOXX size indices and designed to provide a broad yet liquid representation of large, mid and small capitalization companies in the Euro region. The Euro STOXX indices cover countries Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain. In the data set, we employ weekly prices of 18 leading sector indices including 300 equities issued among Euro members [4]. Indices returns are collected in years between 1992 and 2007 to capture the effect of Euro in a broad sense and minimize the effect of technology bubbles on the equity markets which is in its peak level in late 1990s.

Global sector equity indices are derived from the Dow Jones STOXX Global 1800 index, a large investable index that comprises the 600 largest stocks by market capitalization from each of three regions: Europe, Americas and Asia/Pacific.[5] [6]

Aggregate Euro equity index, is derived from the Dow Jones STOXX 600 index and it is also designed to provide a liquid representation of large, mid and small capitalization companies of 12 Euro-zone countries. Similarly, the world equity index (Index universe) is a combination of all developed market stocks in the Dow Jones World Index. World, namely a broad market benchmark, covers 47 countries and represents 95% of the market capitalization of emerging markets , 95% of the market capitalization of Europe and 95% of the market capitalization of all other developed markets on a country-by-country basis.

Table 2 contains summary statistics for the returns of the sector equity indices, for the aggregate world equity indices, and for the aggregate Euro equity indices. The average weekly returns of Euro area sector indices are in the range from 0.05% (Basic Resources) to 0.2% (such as Telecom, Technology). The variability of the returns is much more dispersed across the

[4] The name of the sectors are listed in Table 1. The name of the equities listed in the Euro sector equity indices can be obtained from the web-page: *http : //www.stoxx.com*

[5] We employed the same sector indices for the global sector indices as well. The list of the equities in global sector indices can be downloaded from the web-page: *http : //www.stoxx.com*.

[6] Developed markets include for Europe: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, for the Americas: Canada and the United States, and for Asia/Pacific: Australia, Hong Kong, Japan, New Zealand and Singapore.

indices; the standard deviation of the weekly returns is between 1.0% (Construction materials and Utility) and 2.1% (Technology). Generally, the return of the sector equity indices tends to be more variable as its average return gets higher. The return distributions are skewed to the left (except Health-care services, Oil& gas, and Telecom), and all the distributions show excess kurtosis. Accordingly, the Jarque and Bera (1980) test rejects normality for all the series. The last two columns of the tables present the Ljung-Box (1978) portmanteau test statistics Q and Q^2 (for the squared data) to test for first and second-moment dependencies in the distribution of the sector equity indices. [7] For most of the sector equity indices, the Q statistic is significant, suggesting that sector equity indices are serially correlated. The Q^2 statistic is significant for all sectors, providing evidence of strong second-moment dependencies (conditional heteroskedasticity) in the distribution of the sector equity indices.

3 The Volatility-Spillover Model

We form the volatility-spillovers following Bekaert and Harvey (1997), Ng (2000), and Bekaert et al. (2005). To build this empirical model for the Euro-wide sector equity indices, we consider both mean and volatility spillover effects of aggregate world, aggregate Euro index and global sector indices. For the returns of aggregate Euro and aggregate world equity indices, we present a univariate AR-GARCH model. The conditional return of aggregate Euro equity index (eu) and aggregate world equity index (w) are assumed to follow an AR (1) process;

$$R_{\text{eu},t} = a_{\text{eu}} + b_{\text{eu}} R_{\text{eu},t-1} + \varepsilon_{\text{eu},t} \,, \tag{1}$$

$$R_{\text{w},t} = a_{\text{w}} + b_{\text{w}} R_{\text{w},t-1} + \varepsilon_{\text{w},t} \,. \tag{2}$$

The idiosyncratic shocks in equations (1)–(2) are modeled to be independent. To have independent idiosyncratic shocks between residuals in equations(1) and (2), we form a bivariate GARCH model between world aggregate and euro aggregate index, and then returns are

[7] Ljung and Box (1978) tests if any of a group of autocorrelations of a time series are different from zero. The Ljung-Box test is based on the autocorrelation plot. However, instead of testing randomness at each distinct lag, it tests the "overall" randomness based on a number of lags. The null hypothesis is that there is no serial correlation among the series.

estimated. Then the residuals in these equations are orthogonalized, so that the aggregate world and aggregate euro indices' returns are driven by their idiosyncratic shocks.

For modeling the returns of global sector equity indices, we take into account for both volatility and mean spillover effects of aggregate world equity indices as it is intuitive to expect that global sector equity indices are affected by aggregate world equity indices. Namely, residual and the lagged return of aggregate world index from equation (2) are included in to the model of global sector equity indices. Accordingly, the conditional return of the global sector equity index (ws) follows an extended AR (1) process;

$$R_{\mathrm{ws},t} = a_{\mathrm{ws}} + b_{\mathrm{ws}} R_{\mathrm{ws},t-1} + \eta_{\mathrm{w},t-1} R_{\mathrm{w},t-1} + \phi_{\mathrm{w},t-1} \varepsilon_{\mathrm{w},t} + \varepsilon_{\mathrm{ws},t} \ . \tag{3}$$

Finally we model the returns of the Euro-wide sector indices. Both mean and volatility spillover effects of aggregate Euro index, aggregate world index, and global sector indices are included as explanatory variables to the AR-GARCH model of the Euro-wide sector equity indices. Accordingly, the conditional return of Euro sector equity index (s) is described by the following extended AR (1) specification:

$$\begin{aligned} R_{\mathrm{s},t} \quad = \quad & a_{\mathrm{s}} + b_{\mathrm{s}} R_{\mathrm{s},t-1} + \eta_{\mathrm{eu},t-1} R_{\mathrm{eu},t-1} + \eta_{\mathrm{w},t-1} R_{\mathrm{w},t-1} + \eta_{\mathrm{ws},t-1} R_{\mathrm{ws},t-1} \\ & + \phi_{\mathrm{eu},t-1} \varepsilon_{\mathrm{eu},t} + \phi_{\mathrm{w},t-1} \varepsilon_{\mathrm{w},t} + \phi_{\mathrm{ws},t-1} \varepsilon_{\mathrm{ws},t} + \varepsilon_{\mathrm{s},t}. \end{aligned} \tag{4}$$

The conditional return of Euro sector equity index depends on its own lagged return as well as both mean and volatility spillover effects of aggregate Euro equity index, aggregate world equity index, and global sector equity indices. The mean spillover effects (one lagged return of the corresponding equity index) of aggregate Euro, aggregate world, and global sector equity indices returns on each Euro sector equity indices are measured by $\eta_{\mathrm{eu},t-1}$, $\eta_{\mathrm{w},t-1}$, $\eta_{\mathrm{ws},t-1}$, respectively. The volatility-spillover effects are introduced by the variables $\varepsilon_{\mathrm{eu},t}$, $\varepsilon_{\mathrm{w},t}$, and $\varepsilon_{\mathrm{ws},t}$. Hence we measure the volatility-spillover effects by the coefficients $\phi_{\mathrm{eu},t-1}$, $\phi_{\mathrm{w},t-1}$, and $\phi_{\mathrm{ws},t-1}$ respectively.

The idiosyncratic shock in the equation (4), ($\varepsilon_{\mathrm{s},t}$), is assumed to be normally distributed with a zero mean and the conditional variance, and evolves according to the GARCH (1,1)

$$\sigma^2_{\mathrm{s},t} = \omega_\mathrm{s} + \alpha_\mathrm{s}\varepsilon^2_{\mathrm{s},t-1} + \beta_\mathrm{s}\sigma^2_{\mathrm{s},t-1}\,, \tag{5}$$

where ω_s, α_s, and β_s are supposed to be greater than zero and $\alpha_\mathrm{s}+\beta_\mathrm{s}$ is less than or equal to 1. [8]

The idiosyncratic shocks of equation (1)–(4) are assumed to be independent. However, we can't apply this for the unexpected returns. Here we will only model the unexpected returns of Euro sector equity indices which enable us to calculate the conditional variance of the unexpected return of each Euro sector equity index:

$$\epsilon_{\mathrm{s},t} = \phi_{\mathrm{eu},t-1}\varepsilon_{\mathrm{eu},t} + \phi_{\mathrm{w},t-1}\varepsilon_{\mathrm{w},t} + \phi_{\mathrm{ws},t-1}\varepsilon_{\mathrm{ws},t} + \varepsilon_{\mathrm{s},t}. \tag{6}$$

The conditional variance of the unexpected return of each Euro sector equity index based on the information available at time $t-1$ (I_{t-1}) is given as follows;

$$h_{\mathrm{s},t} = E(\epsilon^2_{\mathrm{s},t}|I_{t-1}) = \phi^2_{\mathrm{eu},t-1}\sigma^2_{\mathrm{eu},t} + \phi^2_{\mathrm{w},t-1}\sigma^2_{\mathrm{w},t} + \phi^2_{\mathrm{ws},t-1}\sigma^2_{\mathrm{ws},t} + \sigma^2_{\mathrm{s},t}\,. \tag{7}$$

Verbally, conditional variance of the unexpected return of each sector equity index (s) depends on the variance of contemporary aggregate Euro equity index, aggregate world equity index, global sector equity index, and own idiosyncratic shocks. The coefficient ϕ_i, corresponds the volatility spillovers of each market i on Euro sector equity indices. Say, if $\phi_{\mathrm{w},t-1}$ is positive and significant, then the volatility of unexpected returns for sector (s) tends to be higher. Accordingly, the sign and significance of the parameters, $\phi_{\mathrm{eu},t-1}$, $\phi_{\mathrm{w},t-1}$, $\phi_{\mathrm{ws},t-1}$ determine whether volatility-spillover effects from aggregate Euro index, aggregate world index, and global sector equity index respectively, are powerful on explaining the conditional variance of sector equity indices.

The specification of the functions for the spillover parameters; η_eu, η_w, η_ws, ϕ_eu, ϕ_w, and ϕ_ws have different representations with various volatility-spillover models. In some models, the spillover parameters are time-varying and those parameters are explained with other exogenous

[8] This is a necessary condition for time series to be stationary.

factors. In other models, spillover parameters are assumed to be constant throughout the entire sample period. This is called *constant spillover model*. Here we applied the latter methodology where; $X_{a,t} = X_a$ for t=1,2, ...,n, and for any spillover parameter X_a.

3.1 Variance ratio

To measure the magnitude of the global and regional shocks on the volatility of the unexpected return of each sector equity index, we employed the variance ratios;

$$VR_{\mathrm{s},t}^{\mathrm{w,ws}} = \frac{\phi_{\mathrm{w},t-1}^2 \varepsilon_{\mathrm{w},t}^2 + \phi_{\mathrm{ws},t-1}^2 \varepsilon_{\mathrm{ws},t}^2}{h_{\mathrm{s},t}}, \tag{8}$$

$$VR_{\mathrm{s},t}^{\mathrm{eu}} = \frac{\phi_{\mathrm{eu},t-1}^2 \varepsilon_{\mathrm{eu},t}^2}{h_{\mathrm{s},t}}. \tag{9}$$

$VR_{\mathrm{s},t}^{\mathrm{w,ws}}$ measures the effect of global shocks (both aggregate world index and global sector equity index) on the Euro-wide sector equity indices, at time t, whereas $VR_{\mathrm{s},t}^{\mathrm{eu}}$ measures the effect of regional shocks on the Euro sector equity indices.

The variance ratios are helpful to explain how powerful are the spillovers on the unexpected return of each sector equity indices. From the variance ratios we obtain a measure of the impact of global shocks (through aggregate world and global sector indices) and regional shocks (through aggregate Euro index) before and after the start of the Euro. By comparing the simple averages of the variance ratios, we evaluate the magnitude of the regional and global shocks on the volatility of the sector equity indices.

4 Empirical Analysis

4.1 Constant Spillover Model

We estimate the spillover model using the Quasi Maximum Likelihood (QML) method with (univariate) Gaussian likelihood functions. The estimation is conducted using the numerical optimization algorithm of Berndt, Hall, Hall, and Hausman (1974) (hereafter BHHH) . The theoretical framework of GARCH model in this paper is based upon the maximization procedure of BHHH (1974) with Quasi Maximum likelihood methods. The parameters are estimated by maximizing a univariate log likelihood function. Table 3 and 4 report the results from estimating the constant spillover model, for years 1992–1998 and 1999–2007, respectively. AR(1) parameter of each sector equity indices is small, mostly positive, and significant, which implies a weak first-order autocorrelation, mostly consistent with the summary statistics reported in Table 2. Regarding the mean spillovers, for both periods 1992–1998 and 1999-2007, sector equity indices' returns depend strongly on its own lagged values and lag of aggregate Euro index returns, whereas the mean effects of the global factors, i.e, lags of aggregate world index and global sector equity indices, do not have significant effect on explaining the sector equity indices' returns. In both tables, the sum of the α_s and β_s is more than 0.9 but less than 1, which states that the volatility process is highly persistent and stationary. Regarding volatility spillovers effects, for each sector equity index, volatility spillover coefficient of aggregate Euro index, ϕ_{eu}, is positive and significant in both periods, before and after the start of Euro. This result supports the view that sector equity indices are being affected by the aggregate Euro index at all the times. Volatility spillover coefficients of the aggregate world and global sector equity indices, i.e, ϕ_{w} and ϕ_{ws}, are statistically significant in the period of 1992–1998. Nevertheless, those global factors became statistically insignificant and smaller in magnitude in the period of 1999–2007.

Table 5 and 6 provide the robust Wald tests for four different joint hypotheses regarding spillover effects of both regional and global factors. First columns of both tables show the results for testing if there exists mean spillover effects of both global and regional factors on the sector equity indices ($H_o : \eta_{\text{eu}} = \eta_{\text{w}} = \eta_{\text{ws}} = 0$). In both tables, before and after the start of the Euro, for most of the sector equity indices, the mean spillover effects are not statistically significant. The second columns of both tables show the Wald test results for testing if there exists volatility spillover effects ($H_o : \phi_{\text{eu}} = \phi_{\text{w}} = \phi_{\text{ws}} = 0$). There is enough evidence to reject that volatility spillover effects are equal to zero as for all sector equity indices $Wald_2$ statistic is significant at 0.01 level. This is also another way of supporting our previous finding that there exists strong volatility spillover effects on sector equity indices. In the third and fourth columns, we decompose the spillover effects to determine if the shocks are regional (through aggregate Euro index) or global (through aggregate world index and global sector equity indices). As we expected, in both Tables 5 and 6, aggregate Euro index spillovers are very powerful in explaining the fluctuations in Euro equity sector indices returns for both periods; before and after the start of the Euro as for all sector equity indices we strongly reject the null hypothesis of no Euro spillover effects. In the last columns we report the $Wald_4$ statistics for testing if the spillover effects of global factors is significant ($H_o : \eta_{\mathrm{w}} = \eta_{\mathrm{ws}} = \phi_{\mathrm{w}} = \phi_{\mathrm{ws}} = 0$). We observed that before the start of the Euro, for all sector equity indices, global factors are effective and statistically significant, however after the start of the Euro, for almost all sector equity indices (except for technology, telecom, and travel and leisure sector indices) the global factors spillover effects are no longer significant. Overall, all these results support findings of Hardouvelis et al.(2002), that expected returns of sector indices became increasingly determined by EU-wide market risk factor, which might be an indication of the stock market integration in Euro region.

Till now, we have only discussed the sign and significance of the spillover parameters. In fact, the magnitude of the parameters are not particularly relevant to evaluate the quantitative influence of the regional and global factors on sector equity indices. To access the importance of the aggregate Euro index and aggregate world and global sector equity indices, on the volatility of the sector equity indices, the variance ratios $VR_{s,t}^{\mathrm{eu}}$, $VR_{s,t}^{\mathrm{w;ws}}$ are calculated. Table 7 reports the mean and standard deviations of the variance ratios of global factor effects (both aggregate world and global sector equity indices) on sector equity indices before and after the start of the Euro. Table 7 also supports our previous findings that the global factors might have lost their power on explaining both return and volatility of the sector equity indices. There is a substantial decline in the variance ratios of the sector equity indices. In particular, for some sectors including, insurance, media, industrial goods, retail services, non-cycled goods, the decline is extremely remarkable. One can comment on that as the influence of the global factors on the volatility of the all sector equity indices have diminished since the start of the Euro.

Table 8 reports the mean and standard deviations of the variance ratios of aggregate Euro index on the volatility of the sector equity indices. At first glance, it seems that the aggregate Euro index is still affecting the volatility of the sector indices returns significantly. In particular, for the financial sector indices (banking, financial service, and insurance sectors), the variance ratios of aggregate Euro index have remarkably increased after the start of the

Euro. Compared to other sector equity indices, the level of variance ratio of aggregate Euro index on the volatility of the financial sector equity indices is much higher.[9] At the same time, for some basic industry sectors, including basic resources, food and beverage, health-care, oil-gas, retail services, and utility, the variance ratio of Euro aggregate index has decreased sharply. These findings argue that the effect of the aggregate Euro index on basic industry sector indices has been diminishing lately, which may be considered as the initial appearances of "independent" sector equity indices inside of the Euro region.[10]

4.2 Correlation Changes

Table 9 reports the change in cross-correlations between sector equity indices before and after the start of the Euro. We found that the change in cross correlations are negative and statistically significant, stating that the cross-correlations between sector equity indices has decreased after the start of the Euro.[11] [12] Interestingly, we also observed that the decrease in cross correlations between sector equity indices are relatively bigger if one of the pairs in the correlation set is a "basic industry" sector equity indices. In other words, "basic industry" sector equity indices have become much less correlated with other sector equity indices after the start of the Euro. Table 9 also provides additional information about the cross-correlations between the sector equity indices. For instance, the cross correlations between technology, media and telecom sector equity indices and other indices have changed extraordinarily after the start of the Euro. In particular, the change in cross correlations between Technology and Basic Resource equity indices is -1.02, stating that not only the correlations between those sector equity indices decreases but it becomes negative. These results, confirm the findings of Krause (2001) who stated that sector equity indices in the Euro region are observed to have

[9] For financial sectors, the average level of variance ratio of aggregate Euro index after the start of the Euro is around 38%, whereas for the rest of the sectors it is 22%.

[10] Harmonization of fiscal and monetary policies within the European Monetary Union has influenced financial sectors more, and they become increasingly integrated with the aggregate output movements. However,-to some extent-"basic industry sectors" become relatively less dependent to the aggregate Euro index. Given that specialization in output across leads sectoral output production would fluctuate independently from the aggregate output production; "less dependent industry sector indices" might be an important sign for the increase in specialization in output across Euro region.

[11] We exploit from Fisher's Z-transformation to test the difference between correlation coefficients. The application of the test has been discussed further in the Appendix.

[12] In Table 9, for the sake of brevity, we did not report the significance levels of the change in cross-correlations, most of the negative coefficients are statistically significant at 1% level.

clusters and become super sectors such as TMT (Technology, Media, and Telecom), Financial services, and Basic Industries, and they move independently from each other. In particular, TMT sector indices correlate very less with other sector indices after the start of the monetary union. Brooks and Negro (2004) provide an explanation for why TMT sectors are not correlated with other sectors. They claim that those sectors have been identified in financial circles as being central to the stock market bubble that took place in the Euro region, and the stock market bubble did not affect other sector equity indices in the same level.

4.3 Sensitivity Analysis

In this section, we further compare our results by employing the same period of dataset with the previous literature (Krause (2001) and Moerman (2004)), who claimed that there is greater potential in reducing the equity portfolio risk with Euro-wide sectoral diversification. We re-performed the GARCH (1,1) model with spillover extensions and reported the variance ratios of the aggregate Euro index on the volatility of sector equity indices in Table 10. We found that excluding financial sector indices and TMT, the variance ratios of aggregate Euro index on the sector equity indices are remarkably lower in magnitude, compared to the variance ratios in the second column of Table 8. To make a rough comparison, the average variance ratio of aggregate Euro index on the volatility of sector equity indices (excluding financial sectors and TMT), is around 15%, between years 1999 and 2002. The same ratio is around 31% between years 1992 and 1998.

In addition, we reconstruct the change in correlation matrix in Table 11. We find that differences of the change in the correlations of the sector equity returns, is highly negative and significant.[13] We also observed the negative sign in the change in correlations of the sector equity indices returns for periods 1992-1998, and 1999-2007 (in Table 9), but neither signs nor magnitudes are as sharp as our findings in Table 11.

Overall, both the results in Table 10 and 11 support the views of previous literature that there are greater potentials in reducing risk of a portfolio when the assets are diversified within Euro-wide sectors in the early years of Euro. However, our findings with longer dataset, point

[13] We didn't mark the significance levels of the changes in correlations in Table 11. However, almost all changes in correlations of sector pairs are highly significant at 1% level and negative.

that creating a portfolio from various Euro-wide sectors (excluding some basic industry sectors discussed previously) might not reduce the overall risk of the portfolio.

5 Concluding Remarks

In this paper, we provided some crucial results for the portfolio holders that have Euro equity bias. We document that Euro area sector indices are not driven by the global factors, after the start of the Euro. Aggregate Euro index is still strong and significant in explaining most of the sector equity returns. We observed that financial sector indices (banking, financial services and insurance) are being affected more by the aggregate Euro index after the start of the Euro. And some basic industry sectors, i.e., basic resources, food and beverage, health-care, utility, retail services, and oil-gas has become less dependent to the aggregate Euro index. Our results are different from the existing literature which point greater potentials of sectoral diversification within the Euro region in the early years of Euro. Mainly, we found that diversification within some Euro-wide basic industry sectors (basic resources, food and beverage, health-care, retail services, and oil & gas) might be much effective to reduce the portfolio risk. We limited our dataset to be same with the previous studies' ones and showed that our methodology gave similar results with the previous studies, which makes our results more robust.

6 Appendix

6.1 Testing the difference between correlation coefficients

We exploit from Fisher's Z-transformation to test the difference between correlation coefficients before and after the start of monetary union. To test the hypothesis, $H_o : \rho_1 = \rho_2$, the z-test is employed:

$$z = \frac{Z_1 - Z_2}{\sigma_{Z_1 - Z_2}} \tag{10}$$

where Fisher's Z-transformation and the standard error of the difference between Fisher Z's are:

$$\begin{aligned} Z_i &= 0.5 * Ln(\frac{1 + |r_i|}{1 - |r_i|}) \\ \sigma_{Z_1 - Z_2} &= \sqrt{\sigma^2_{Z_1} + \sigma^2_{Z_2}} = \sqrt{\frac{1}{n_1 - 3} + \frac{1}{n_2 - 3}} \end{aligned}$$

where r_i is the sample correlation coefficient referring to the sector indices and n is the sample size of each set of indices. The observed z-ratio is compared with the critical values in standard Z-Table.

References

Adjaout, K., and J.P. Danthine (2001a). EMU and portfolio diversification opportunities, Discussion paper series No: 2962, Centre for Economic Policy Research.

Adjaout, K., and J.P. Danthine (2001b). Portfolio diversification: alive and well in Euroland!, Discussion paper series No: 3086, Centre for Economic Policy Research.

Adam, K., T. Jappelli, A. Menichini, M. Padula, and M. Pagano (2002). Analyse, compare, and apply alternative indicators and monitoring methodologies to measure the Evolution of capital market integration in the European Union, Report to the European Commission.

Adjaout, K., and J.-P Danthine (2003). European financial integration and equity returns: A Theory-Based Assessment, in Gaspar, V. *et al*, The transformation of the European financial system, ECB, Frankfurt.

Adjaout, K., and L. Botazzi, J.Danthine, A. Fischer, R. Hamaui, R. Portes (2002). EMU and portfolio adjustment, CEPR Policy Paper No: 5.

Baca, S. P., B. Garbe, and R. A. Weiss (2000). The rise of sector effects in major equity markets, Financial Analysts Journal, September-October, pp. 35–40.

Baele, L., A. Ferrando, P. Hördahl, E. Krylova, and C. Monnet (2004). Measuring financial integration in the Euro area, European Central Bank, Occasional Paper No: 14.

Bekaert, G., and C. R. Harvey (1997). Emerging equity market volatility, Journal of Financial Economics 43, pp. 29-77.

Bekaert, G., C. R. Harvey and A. Ng (2005). Market integration and contagion, Journal of Business, 78, pp. 39–69.

Berndt, E. R., B. H. Hall, R. E. Hall, and J. A. Hausman (1974). Estimation and inference in nonlinear structural models, Annals of Economics and Social Measurement, 3, pp. 653–666.

Brooks, R., and M. D. Negro (2004). The rise in co-movement across national stock markets: Market integration or IT bubble?, Journal of Empirical Finance, 11, pp. 659–680.

Cavaglia, S., C. Brightman and M. Aked (2000). The increasing importance of industry factors, Financial Analyst Journal, September-October, pp. 41–54.

Christiansen, C. (2007). Volatility-Spillover effects in European bond markets, European Financial Management, 13, pp. 923–948.

Doyle, B., and J. Faust (2002). Breaks in the variability and co-movement of G-7 Economic Growth, Board of Governors of the Federal Reserve Working paper.

Griffin, J.M., and G.A. Karolyi (1998). Another look at the role of the industrial structure of markets for international diversification strategies, Journal of Financial Economics, 50, pp. 351–373.

Glass, G. V., and K. D. Hopkins (1996). Statistical Methods in education and Psychology, copyright by Allyn and Bacon.

Hardouvelis, G., D. Malliaropulos, and R. Priestley (2000). EMU and European Stock Market Integration, CEPR Discussion Paper No: 2124.

Heston, S.L., and K.G. Rouwenhorst (1994). Does industrial structure explain the benefits of international diversification? Journal of Financial Economics, 36, pp. 3–27.

Isakov, D., and F. Sonney (2002). Are practitioners right? On the relative importance of industrial factors in international stock returns. Swiss Journal of Economics and Statistics, 140, pp. 355–379.

Jarque, C. M., and A. K. Bera (1980). Efficient Tests for Normality, Economics Letters, 6, pp. 255-259.

Kraus, T. (2001). The impact of EMU on the structure of European equity returns: An empirical Analysis for the first 21 months. IMF Working Paper 01/84.

Lane, P., and Milesi-Ferretti, G., (2005). The International Equity Holdings of Euro Area Investors The Institute for International Integration Studies Discussion Paper Series No:104

Lewis, K. (1999). Trying to explain home bias in equities and consumption, Journal of Economic Literature, 37, pp. 571–608.

Ljung, G. M. and G. E. P. Box (1978). On a measure of lack of fit in time-series models, Biometrika, 65, pp. 297–303.

Maela, G., 2008. EMU Effects on Stock Markets: From Home Bias to Euro Bias. International Research Journal of Finance and Economics 15, 136–158.

Moerman, G. A. (2004). Diversification in Euro area stock markets: Country versus industry, ECB Working Paper, No: 327.

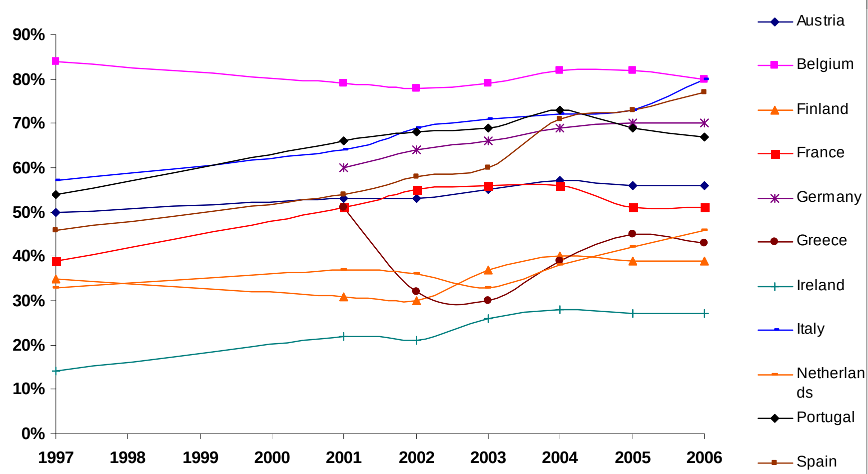
Ng, A. (2000). Volatility spillover effects from Japan and the US to the Pacific-Basin, Journal of International Money and Finance, 19, 207-233.

Roll, R. (1992). Industrial structure and the comparative behavior of international stock market indices, The Journal of Finance, 47, pp. 3–41

Rouwenhorst, K.G. (1999). European equity markets and the EMU, Financial Analyst Journal, 55, pp. 57–64

Stulz, R. M., and G. A. Karolyi (2001). Are financial assets priced locally or globally? in G.M. Constantinides, M. Harris, R. M. Stulz (ed.) Handbook of the Economics of Finance, 16, pp. 975–1020.

Figure 1: Euro Share Among Euro Members' Foreign Equity Holdings



Data Source: IMF's Coordinated Portfolio Integrated Survey (CPIS) database for years 1997, 2001-2006.
The graph illustrates the euro share in each euro member's foreign equity holdings.

Table 1: **The List of Sector Indices**

Auto and Parts (AUT)
Banking (BNK)
Basic Resources (BSRS)
Chemistry (CHM)
Construction and Materials (CNS)
Financial Services (FNSR)
Food and Beverages (FOOD)
Health Care (HTH)
Industrial Goods (IDS)
Insurance (INSR)
Media (MED)
Oil and Gas (OIL)
Non-Cycled Goods (PRHGD)
Retail Services (RTL)
Technology (TECH)
Telecom (TEL)
Travel and Leisure (TRV)
Utilities (UTI)

Table 2: **Descriptive Statistics for years 1992-2007.**

	Mean	STD	Skew	Kurt	Q(1)	Q(4)	$Q^2(1)$	$Q^2(4)$
AUT	0.08	1.71	–0.50	7.64	0.05***	0.05***	0.20***	0.20**
BNK	0.11	1.38	–0.44	6.98	0.07***	0.03***	0.21***	0.27***
BSRS	0.05	1.22	–0.59	7.12	0.10***	0.01***	0.12***	0.15***
CHM	0.12	1.36	–0.24	4.74	0.04***	−0.02	0.16***	0.23***
CNS	0.06	1.02	–0.57	5.74	0.05***	0.01***	0.16***	0.23***
FNSR	0.16	1.18	–0.48	6.58	0.08*	0.03**	0.21***	0.23***
FOOD	0.12	1.32	–0.45	6.11	0.01*	0.01	0.16***	0.17**
HTH	0.12	1.18	0.004	6.01	−0.03	−0.01	0.24***	0.16***
IDS	0.14	1.32	–0.44	5.53	0.07**	0.03***	0.11***	0.11***
INSR	0.06	1.38	–0.27	5.35	0.07**	0.03***	0.21***	0.25***
MED	0.15	1.47	–0.52	10.22	0.11***	−0.01	0.27***	0.17***
OIL	0.06	1.46	0.25	3.94	0.01*	0.01	0.25***	0.17***
PRHGD	0.08	1.44	–0.29	5.35	0.01	−0.02	0.20***	0.14***
RTL	0.16	1.18	–0.16	5.33	0.04**	0.01***	0.16***	0.11***
TECH	0.22	2.14	–0.88	9.27	0.06***	0.04*	0.13***	0.15*
TEL	0.24	1.81	0.03	5.56	0.07***	0.02***	0.17***	0.19***
TRV	0.08	1.37	–0.21	5.29	0.10***	0.02*	0.25***	0.14***
UTI	0.08	1.04	–0.08	4.26	0.01	0.01	0.23***	0.17***
EURO	0.13	1.04	–0.11	4.21	0.03***	0.03***	0.17***	0.19***
WORLD	0.05	0.07	–0.17	3.65	0.05**	0.01***	0.21***	0.20***

Notes: The table reports the summary statistics for the weekly returns (in %) of Euro sector equity indices. The following statistics are reported: Mean, standard deviation (STD), skewness (Skew), kurtosis (Kurt), autocorrelation of order 1 and 4 (Q(1)-Q(4)), and autocorrelation of the squared time series of order 1 and 4 ($Q^2(1)$-$Q^2(4)$). *, **, and *** indicate that the Ljung and Box (1978) test statistic is significant at 10%, 5%, and 1% levels respectively.

Table 3: **Constant Spillover Model for the Sector Indices in Euro Region for the Period 1992–1998.**

	b_s	η_{eu}	η_w	η_{ws}	ϕ_{eu}	ϕ_w	ϕ_{ws}	α_s	β_s
AUT	0.08***	−0.08***	0.02*	0.02	0.79***	0.08***	0.10***	0.07***	0.90***
BNK	0.03***	−0.03*	0.02	0.02	0.35***	0.03**	0.04***	0.07**	0.89***
BSRS	0.04**	−0.06**	0.01*	0.01	0.71***	0.05***	0.13***	0.05***	0.90***
CHM	0.04**	−0.06**	0.01*	0.01	0.71***	0.05***	0.13***	0.05***	0.90***
CNS	−0.01	0.02**	−0.01	−0.07**	0.45***	0.11***	0.18***	0.08***	0.91***
FNSR	−0.01	0.02	−0.01	0.05***	0.44***	0.10***	0.11***	0.08**	0.87***
FOOD	−0.11***	0.02	−0.01	0.01	0.51***	0.05**	0.18***	0.07***	0.87***
HTH	−0.05	0.01	0.02	0.01	0.43***	−0.02	0.23***	0.09***	0.77***
IDS	−0.07**	−0.08***	−0.01	0.08***	0.51***	0.09**	0.18***	0.05***	0.92***
INSR	0.06**	−0.08**	0.04**	0.01	0.60***	0.08***	0.20***	0.07***	0.87***
MED	−0.13***	0.02	−0.04**	0.03**	0.46***	0.04***	0.20***	0.07***	0.85***
OIL	0.07**	−0.10***	0.02	0.01	0.61***	0.02*	0.03*	0.07***	0.82***
PRHGD	0.08***	−0.07**	0.002	0.001	0.75***	0.01*	0.14***	0.02*	0.87***
RTL	0.13***	−0.09***	0.001	0.001	0.55***	0.02	0.18***	0.10**	0.68***
TECH	0.07***	0.01	0.06**	−0.03**	0.70***	0.001	0.10***	0.04*	0.93***
TEL	0.17***	−0.07***	0.08**	−0.01**	0.75***	−0.02	0.08***	0.07**	0.91***
TRV	0.12***	0.01	0.18***	−0.01	0.55***	0.09*	0.18***	0.06**	0.91***
UTI	−0.14***	0.08***	−0.01	0.05**	0.37***	−0.04*	0.22***	0.06**	0.84***

Notes: The constant spillover model for Euro sector equity indices is defined as follows;

$R_{s,t} = a_s + b_s R_{s,t-1} + \eta_{eu,t-1} R_{eu,t-1} + \eta_{w,t-1} R_{w,t-1} + \eta_{ws,t-1} R_{ws,t-1} + \epsilon_{s,t}$ where $\epsilon_{s,t} = \phi_{eu,t-1}\varepsilon_{eu,t} + \phi_{w,t-1}\varepsilon_{w,t} + \phi_{ws,t-1}\varepsilon_{ws,t} + \varepsilon_{s,t}$.

$R_{s,t}$ is the weekly return of each Euro sector equity indices in Euro area. η_{eu}, η_w, and η_{ws} are the mean spillover effects of the returns of aggregate Euro index, aggregate world index and global sector index, respectively. ϕ_{eu}, ϕ_{ws}, and ϕ_w are the volatility spillover effects of the returns of aggregate Euro index, aggregate world index and global sector index, respectively. $\varepsilon_{s,t}$ has zero mean and conditional variance of $\sigma^2_{s,t} = \omega_s + \alpha_s \varepsilon^2_{s,t-1} + \beta_s \sigma^2_{s,t-1}$.

Constants of each variance equation and mean equation are not reported for the sake of brevity. *, **, and *** indicate that the relevant coefficient is significant at 10%, 5%, and 1% levels, respectively.

Table 4: **Constant Spillover Model for the Sector Indices in Euro Region for the Period 1999–2007.**

	b_{s}	η_{eu}	η_{w}	η_{ws}	ϕ_{eu}	ϕ_{w}	ϕ_{ws}	α_s	β_s
AUT	0.07***	−0.05	−0.001	0.004	0.75***	0.01	0.001	0.07***	0.90***
BNK	0.05***	−0.03*	0.01	0.001	0.75***	0.001	0.001	0.07**	0.90***
BSRS	0.04**	−0.06**	0.01*	0.01	0.71***	0.05***	0.13***	0.05***	0.90***
CHM	0.04**	−0.02	0.01	−0.01	0.45**	0.001	0.003	0.02*	0.97***
CNS	0.01	0.03**	−0.001	−0.001	0.43***	0.02	0.01	0.08***	0.88***
FNSR	0.02	0.05***	0.02	−0.01	0.63	0.001	0.001	0.07	0.91***
FOOD	0.02*	−0.03***	−0.002	0.001	0.38***	−0.001	−0.001	0.04*	0.91***
HTH	−0.001	−0.03*	0.004	0.007	0.40***	0.02	−0.01	0.03*	0.86***
IDS	−0.02	0.05***	−0.02*	0.01	0.66***	0.01	0.02	0.06**	0.86***
INSR	0.02	0.06***	−0.06*	0.01	0.56***	0.001***	0.02*	0.06***	0.92***
MED	0.06***	0.01	0.02	0.02	0.48***	−0.04	0.001	0.07***	0.82***
OIL	0.11**	0.08*	0.001	0.001	0.46***	0.001	0.001	0.06**	0.93***
PRHGD	0.06***	−0.04**	0.001	0.001	0.58***	−0.002	0.02*	0.04**	0.94***
RTL	0.07**	−0.05***	0.03	0.001	0.48***	−0.001	0.03	0.04*	0.85***
TECH	0.10***	−0.08***	−0.01	−0.02	0.67***	0.06	−0.01	0.05*	0.94***
TEL	0.13*	−0.12**	−0.02	−0.02	0.48***	0.07*	−0.01	0.05**	0.94***
TRV	0.05***	0.03*	0.04*	0.01	0.46***	0.004	0.003	0.07**	0.90***
UTI	0.05**	0.03**	−0.001	0.001	0.66***	0.004	0.003	0.07**	0.91***

Notes: The constant spillover model for Euro sector equity indices is defined as follows;

$R_{\mathrm{s},t} = a_{\mathrm{s}} + b_{\mathrm{s}} R_{\mathrm{s},t-1} + \eta_{\mathrm{eu},t-1} R_{\mathrm{eu},t-1} + \eta_{\mathrm{w},t-1} R_{\mathrm{w},t-1} + \eta_{\mathrm{ws},t-1} R_{\mathrm{ws},t-1} + \epsilon_{\mathrm{s},t}$ where $\epsilon_{\mathrm{s},t} = \phi_{\mathrm{eu},t-1}\varepsilon_{\mathrm{eu},t} + \phi_{\mathrm{w},t-1}\varepsilon_{\mathrm{w},t} + \phi_{\mathrm{ws},t-1}\varepsilon_{\mathrm{ws},t} + \varepsilon_{\mathrm{s},t}$.

$R_{\mathrm{s},t}$ is the weekly return of each Euro sector equity indices in Euro area. η_{eu}, η_{w}, and η_{ws} are the mean spillover effects of the returns of aggregate Euro index, aggregate world index and global sector index, respectively. ϕ_{eu}, ϕ_{ws}, and ϕ_{w} are the volatility spillover effects of the returns of aggregate Euro index, aggregate world index and global sector index, respectively. $\varepsilon_{\mathrm{s},t}$ has zero mean and conditional variance of $\sigma^2_{\mathrm{s},t} = \omega_{\mathrm{s}} + \alpha_{\mathrm{s}}\varepsilon^2_{\mathrm{s},t-1} + \beta_{\mathrm{s}}\sigma^2_{\mathrm{s},t-1}$.

Constants of each variance equation and mean equation are not reported for the sake of brevity. *, **, and *** indicate that the relevant coefficient is significant at 10%, 5%, and 1% levels, respectively.

Table 5: **Tests for Spillover Effects for Years 1992–1998**

	$Wald_1$	$Wald_2$	$Wald_3$	$Wald_4$
AUT	3.35	837.22***	840.42***	118.11***
BNK	17.99***	469.33***	400.32***	33.25***
BSRS	8.15***	277.39***	240.84***	44.80***
CHM	4.76	287.26***	259.05***	41.51***
CNS	0.32	461.39***	361.15***	118.18***
FNSR	2.25	349.33***	224.28***	169.14***
FOOD	5.86*	392.11***	259.11***	174.01***
HTH	1.01	142.32***	97.43***	38.11***
IDS	8.14**	531.11***	518.55***	14.11***
INSR	2.80	486.66***	399.71***	90.31***
MED	2.85	406.11***	242.22***	93.05***
OIL	13.33***	312.11***	143.21***	163.22***
PRHGD	8.14**	374.12***	301.14***	57.33***
RTL	2.12	312.11***	271.32***	31.45***
TECH	7.14*	313.44***	185.21***	125.31***
TEL	1.52	150.31***	116.32***	39.21***
TRV	0.32	178.32***	107.43***	35.21***
UTI	0.33	177.32***	165.32***	35.21***

Notes: The table reports the joint robust Wald test statistics for the following null hypotheses regarding the spillover effects in the constant spillover model:

$Wald_1 : H_o : \eta_{\text{eu}} = \eta_{\text{w}} = \eta_{\text{ws}} = 0$ (No mean spillover effects)
$Wald_2 : H_o : \phi_{\text{eu}} = \phi_{\text{w}} = \phi_{\text{ws}} = 0$ (No volatility spillover effects)
$Wald_3 : H_o : \eta_{\text{eu}} = \phi_{\text{eu}} = 0$ (No Euro spillover effects)
$Wald_4 : H_o : \eta_{\text{w}} = \eta_{\text{ws}} = \phi_{\text{w}} = \phi_{\text{ws}} = 0$ (No global factor spillover effects)

*, **, and *** indicate that the relevant coefficient is significant at 10%, 5%, and 1% levels, respectively.

Table 6: **Tests for Spillover Effects for Years 1999–2007**

	$Wald_1$	$Wald_2$	$Wald_3$	$Wald_4$
AUT	4.08	517.13***	524.21***	4.67
BNK	3.61	1340.32***	1301.65***	3.76
BSRS	8.73**	238.44***	241.33***	1.13
CHM	6.75*	813.23***	800.21***	1.17
CNS	0.80	654.12***	660.85***	2.69
FNSR	0.25	634.81***	630.11***	4.67
FOOD	3.39	201.19***	188.21***	3.27
HTH	4.00	174.12***	176.87***	2.12
IDS	5.15	188.65***	169.01***	3.11
INSR	1.40	603.15***	594.33***	4.76
MED	0.87	257.65***	236.82***	2.93
OIL	2.36	247.21***	242.73***	1.26
PRHGD	1.58	778.51***	776.37***	2.87
RTL	3.32	570.64***	541.92***	3.48
TECH	6.20*	529.68***	510.21**	3.61***
TEL	5.91*	320.14***	328.67***	3.92***
TRV	10.81**	364.83***	332.48***	9.19*
UTI	7.49*	541.54***	551.22***	0.41

Notes: The table reports the joint robust Wald test statistics for the following null hypotheses regarding the spillover effects in the constant spillover model:

$Wald_1 : H_o : \eta_{\mathrm{eu}} = \eta_{\mathrm{w}} = \eta_{\mathrm{ws}} = 0$ (No mean spillover effects)
$Wald_2 : H_o : \phi_{\mathrm{eu}} = \phi_{\mathrm{w}} = \phi_{\mathrm{ws}} = 0$ (No volatility spillover effects)
$Wald_3 : H_o : \eta_{\mathrm{eu}} = \phi_{\mathrm{eu}} = 0$ (No Euro spillover effects)
$Wald_4 : H_o : \eta_{\mathrm{w}} = \eta_{\mathrm{ws}} = \phi_{\mathrm{w}} = \phi_{\mathrm{ws}} = 0$ (No global factor spillover effects)

*, **, and *** indicate that the relevant coefficient is significant at 10%, 5%, and 1% levels, respectively.

Table 7: **Variance Ratio: World Aggregate Index and Global Sector Index**

	1992–1998		1999–2007		
	$Mean_1$	STD	$Mean_2$	STD	$t-test$
AUT	0.02	0.01	0.001	0.03	12.84***
BNK	0.01	0.01	0.002	0.02	7.54***
BSRS	0.21	0.03	0.005	0.01	125.26***
CHM	0.08	0.05	0.01	0.01	26.34***
CNS	0.17	0.11	0.01	0.01	27.70***
FNSR	0.09	0.01	0.001	0.005	155.60***
FOOD	0.06	0.08	0.001	0.04	12.89***
HTH	0.18	0.08	0.001	0.001	42.74***
IDS	0.21	0.11	0.0001	0.0001	36.46***
INSR	0.34	0.11	0.08	0.01	45.01***
MED	0.21	0.13	0.01	0.03	28.80***
OIL	0.18	0.04	0.04	0.04	50.17***
PRHGD	0.38	0.05	0.01	0.04	115.55***
RTL	0.30	0.05	0.06	0.11	42.04***
TECH	0.04	0.07	0.01	0.11	4.79***
TEL	0.03	0.05	0.001	0.03	9.80***
TRV	0.14	0.05	0.01	0.001	49.67***
UTI	0.01	0.01	0.001	0.02	8.49***

Notes: The table reports the mean and the standard deviation of the sector indices' variance ratios for the constant spillover model within different sub-samples. The variance ratio for both the aggregate world index and global sector equity indices' spillover effect on the volatility of the sector equity index return is formulated as;

$VR_{\mathrm{s},t}^{\mathrm{w,ws}} = \frac{\phi_{\mathrm{w},t-1}^2 \varepsilon_{\mathrm{w},t}^2 + \phi_{\mathrm{ws},t-1}^2 \varepsilon_{\mathrm{ws},t}^2}{h_{\mathrm{s},t}}$ where $h_{\mathrm{s},t} = \sigma_{\mathrm{s},t}^2 + \phi_{\mathrm{eu},t-1}^2 \sigma_{\mathrm{eu},t}^2 + \phi_{\mathrm{w},t-1}^2 \sigma_{\mathrm{w},t}^2 + \phi_{\mathrm{ws},t-1}^2 \sigma_{\mathrm{ws},t}^2$.

The last column of the table report the t-statistics for the null hypothesis that $Ho : Mean_1 - Mean_2 = 0$ against the alternative hypothesis that $Ho : Mean_1 - Mean_2 > 0$. *, **, and *** indicate that the relevant coefficient is significant at 10%, 5%, and 1% levels, respectively.

Table 8: **Variance Ratio: Euro Aggregate Index**

	1992–1998		1999–2007		
	$Mean_1$	STD	$Mean_2$	STD	$t - test$
AUT	0.29	0.06	0.26	0.06	7.17***
BNK	0.31	0.11	0.40	0.09	−12.68
BSRS	0.28	0.04	0.18	0.10	19.74***
CHM	0.28	0.07	0.28	0.16	0.00
CNS	0.32	0.14	0.30	0.15	1.98**
FNSR	0.27	0.04	0.34	0.05	−22.47
FOOD	0.32	0.08	0.16	0.11	24.32***
HTH	0.28	0.04	0.15	0.10	25.66***
IDS	0.33	0.10	0.36	0.11	−4.12
INSR	0.27	0.06	0.38	0.06	−26.28
MED	0.28	0.14	0.26	0.08	2.44***
OIL	0.26	0.11	0.15	0.04	18.19***
PRHGD	0.43	0.11	0.29	0.06	21.92***
RTL	0.32	0.05	0.18	0.12	22.87***
TECH	0.23	0.04	0.30	0.10	−13.82
TEL	0.22	0.03	0.27	0.03	−23.89
TRV	0.25	0.05	0.17	0.10	15.08***
UTI	0.33	0.10	0.22	0.10	15.77***

Notes: The table reports the mean and standard deviation of the sector indices' variance ratios for the constant spillover model within different sub-samples. The variance ratio for aggregate Euro index's spillover effect on the volatility of the sector equity index return is formulated as;

$VR^{\text{eu}}_{\text{s},t} = \frac{\phi^2_{\text{eu}}\varepsilon^2_{\text{eu},t}}{h_{\text{s},t}}$ where $h_{\text{s},t} = \sigma^2_{\text{s},t} + \phi^2_{\text{eu},t-1}\sigma^2_{\text{eu},t} + \phi^2_{\text{w},t-1}\sigma^2_{\text{w},t} + \phi^2_{\text{ws},t-1}\sigma^2_{\text{ws},t}$.
The last column of the table report the t-statistics for the null hypothesis that $Ho : Mean_1 - Mean_2 = 0$ against the alternative hypothesis that $Ho : Mean_1 - Mean_2 > 0$. *, **, and *** indicate that the relevant coefficient is significant at 10%, 5%, and 1% levels, respectively.

Table 9: **Changes in Correlations (1992–1998, 1999–2007)**

	AUT	BNK	BSRS	CHM	CNS	FNSR	FOOD	HTH	IDS	INSR	MED	OIL	PRHGD	RTL	TECH	TEL	TRV
BNK	–0.09																
BSRS	–0.02	0.07															
CHM	–0.02	0.03	0.03														
CNS	–0.09	0.01	0.06	0.06													
FNSR	–0.10	0.00	0.03	0.00	0.00												
FOOD	–0.07	–0.12	–0.25	–0.11	–0.12	–0.23											
HTH	–0.25	–0.29	–0.23	–0.19	–0.15	–0.22	–0.18										
IDS	–0.17	–0.12	–0.12	–0.12	–0.18	–0.15	–0.19	–0.16									
INSR	–0.46	–0.53	–0.58	–0.50	–0.69	–0.53	–0.58	–0.24	–0.30								
MED	–0.80	–0.79	–0.97	–0.93	–0.97	–0.85	–0.97	–0.64	–0.40	–0.14							
OIL	–0.11	–0.32	–0.33	–0.24	0.04	–0.21	–0.32	–0.15	–0.15	–0.57	–0.93						
PRHGD	–0.16	–0.09	–0.19	–0.17	–0.18	–0.14	–0.17	–0.15	0.00	–0.21	–0.44	–0.19					
RTL	–0.54	–0.69	–0.78	–0.78	–0.83	–0.73	–0.85	–0.70	–0.50	–0.07	–0.24	–0.89	–0.48				
TECH	–0.89	–0.92	–1.02	–0.95	–1.09	–0.96	–1.01	–0.65	–0.47	–0.20	0.03	–0.98	–0.45	–0.20			
TEL	–0.80	–0.83	–0.93	–0.92	–0.98	–0.89	–1.01	–0.79	–0.45	–0.30	–0.05	–0.95	–0.49	–0.22	–0.05		
TRV	–0.06	–0.05	–0.04	–0.01	–0.11	–0.04	–0.27	–0.08	–0.08	–0.29	–0.59	–0.07	–0.03	–0.43	–0.71	–0.67	
UTI	–0.01	0.01	0.09	0.02	0.04	–0.01	–0.24	–0.21	–0.14	–0.55	–0.88	–0.02	–0.14	–0.72	–0.91	–0.85	–0.04

Note: The table reports the changes in correlations for the weekly returns (in %) of the sector equity indices between two periods: 1992–1998 and 1999–2007.

Table 10: **Variance Ratio: Euro Aggregate Index**

	1992–1998		1999–2002		
	$Mean_1$	STD	$Mean_2$	STD	$t-test$
AUT	0.29	0.06	0.20	0.14	12.53***
BNK	0.31	0.11	0.40	0.10	−12.20
BSRS	0.28	0.04	0.16	0.15	16.60***
CHM	0.28	0.07	0.18	0.11	15.98***
CNS	0.32	0.14	0.20	0.14	12.29***
FNSR	0.27	0.04	0.40	0.11	−23.68
FOOD	0.32	0.08	0.09	0.11	34.96***
HTH	0.28	0.04	0.13	0.12	25.35***
IDS	0.33	0.10	0.33	0.11	0.00
INSR	0.27	0.06	0.31	0.12	−6.29
MED	0.28	0.14	0.27	0.15	0.99
OIL	0.26	0.11	0.12	0.12	17.53***
PRHGD	0.43	0.11	0.20	0.19	21.93***
RTL	0.32	0.05	0.18	0.12	22.87***
TECH	0.23	0.04	0.37	0.13	−22.04
TEL	0.22	0.03	0.38	0.07	−44.56
TRV	0.25	0.05	0.16	0.11	15.76***
UTI	0.33	0.10	0.20	0.11	17.83***

Notes: The table reports the mean and the standard deviation of the sector indices' variance ratios for the constant spillover model within different sub-samples. The variance ratio for Euro aggregate index's spillover effect on the volatility of the sector equity index return is formulated as;

$VR_{s,t}^{eu} = \frac{\phi_{eu}^2 \varepsilon_{eu,t}^2}{h_{s,t}}$ where $h_{s,t} = \sigma_{s,t}^2 + \phi_{eu,t-1}^2 \sigma_{eu,t}^2 + \phi_{w,t-1}^2 \sigma_{w,t}^2 + \phi_{ws,t-1}^2 \sigma_{ws,t}^2$.

The last column of the table report the t-statistics for the null hypothesis that $Ho : Mean_1 - Mean_2 = 0$ against the alternative hypothesis that $Ho : Mean_1 - Mean_2 > 0$. *, **, and *** indicate that the relevant coefficient is significant at 10%, 5%, and 1% levels, respectively.

Table 11: **Changes in Correlations (1992–1998, 1999–2002)**

	AUT	BNK	BSRS	CHM	CNS	FNSR	FOOD	HTH	IDS	INSR	MED	OIL	PRHGD	RTL	TECH	TEL	TRV
BNK	–0.35																
BSRS	–0.73	–0.59															
CHM	–0.52	–0.17	–0.31														
CNS	–0.49	–0.21	–0.13	–0.01													
FNSR	–0.43	–0.04	–0.70	–0.17	–0.26												
FOOD	–0.81	–0.42	–0.32	–0.12	–0.19	–0.38											
HTH	–0.68	–0.17	–0.52	–0.16	–0.13	–0.10	–0.18										
IDS	–0.66	–0.13	–0.68	–0.43	–0.37	–0.23	–0.60	–0.37									
INSR	–0.30	–0.06	–0.73	–0.27	–0.34	–0.03	–0.57	–0.20	–0.20								
MED	–0.58	–0.16	–0.86	–0.66	–0.48	–0.28	–0.85	–0.54	–0.03	–0.16							
OIL	–0.68	–0.19	–0.39	–0.14	–0.08	–0.22	–0.12	–0.16	–0.32	–0.33	–0.55						
PRHGD	–0.58	–0.04	–0.67	–0.37	–0.27	–0.14	–0.47	–0.31	–0.03	–0.12	–0.13	–0.26					
RTL	–0.26	–0.34	–1.05	–0.88	–0.71	–0.43	–1.23	–0.90	–0.48	–0.21	–0.35	–0.91	–0.52				
TECH	–0.64	–0.19	–0.87	–0.59	–0.54	–0.27	–0.79	–0.46	–0.03	–0.19	0.03	–0.47	–0.05	–0.30			
TEL	–0.63	–0.37	–1.03	–0.93	–0.77	–0.52	–1.17	–0.84	–0.18	–0.34	–0.05	–0.82	–0.29	–0.24	–0.06		
TRV	–0.22	–0.03	–0.60	–0.18	–0.24	–0.06	–0.46	–0.22	–0.23	–0.05	–0.25	–0.26	–0.14	–0.29	–0.29	–0.44	
UTI	–0.33	–0.13	–0.79	–0.53	–0.39	–0.19	–0.75	–0.40	–0.19	–0.06	–0.14	–0.50	–0.21	–0.26	–0.15	–0.24	–0.15

Note: The table reports the changes in correlations for the weekly returns (in %) of the sector equity indices between two periods: 1992–1998 and 1999–2002.