Time-varying diversification benefits: impact of capital markets integration on European portfolio holdings

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Abstract
Our paper explores the area of international diversification by examining the issue from the perspective of time-varying benefits that Eurozone investors obtain from holding internationally diversified portfolios. From a theoretical perspective, the introduction of the Euro has an indefinite effect on portfolio decisions of Eurozone investors, as we may expect, on one hand, a reallocation of portfolio's weights in favour of EMU assets as a result of the complete elimination of currency risk, and, on the other hand, a higher weight for assets outside EU, as a direct consequence of increased financial market integration between European Union countries. We measure the benefits of diversification by considering the ratio of the standard deviation of the minimum variance portfolio for a European investor to the average standard deviation of all markets included in the portfolio, and study its trends in two ways: first, we regress gamma against time; second, we conduct a test of the difference between the means of the gamma for three sub-periods that are significant from the point of Eurozone investors. We find that benefits of diversification are still high for a Eurozone investor, but they have slightly diminished after 2004. At the same time, in times of financial crisis, such as the recent one, international diversification may bring attractive benefits in the form of lower volatility, although these benefits are to some extent smaller than in normal times.

Keywords: international diversification, capital market integration, Europe, financial crisis

JEL codes: G11, G15

1. INTRODUCTION

International diversification of portfolio investments has intensified in the past years, as investors were seeking to reduce risk by globally spreading their holdings. The benefits of international diversification were first brought to the attention of international investors by Solnik (1974), who showed there is a limit to the risk reduction that may be achieved on a single domestic market, due to the same macroeconomic factors that influence stock prices. Domestic diversification is capable of almost completely eliminating firm-specific risks but it leaves systematic risks untouched. However, it is possible to attain further risk reduction by adding foreign securities to a domestic portfolio, building on the assumption that economic cycles are not fully synchronised between countries, which is reflected in less than positively correlated financial markets. Although several caveats have to be considered, such as exchange rate risk, the overall risk of an international portfolio, unhedged or hedged against currency risk, has been proved to be lower than that of a comparable domestic portfolio by various studies published afterwards – see, for example, Eaker and Grant (1990), Jorion (1989), and Grauer and Hakkanson (1987). The main sources of diversification benefits are the low correlations between domestic capital markets, as shown by a vast literature in the field.
The benefits that internationally diversified holdings bring to an investor may be analyzed from two perspectives: benefits arising from reduced volatility of international portfolios or benefits observed at the level of higher risk-adjusted returns as compared to a specific benchmark – here, international portfolios may be the minimum variance portfolios or the optimal portfolios, while the benchmark may be represented by a domestic portfolio or an equally or market capitalization weighted international portfolio. Our approach is to consider the benefits associated to holding internationally diversified portfolios from the perspective of their potential lower volatility and time-varying

specificities. Therefore, we explore the time-varying benefits that Eurozone investors obtain from holding internationally diversified portfolios. From a theoretical perspective, the introduction of the Euro has an indefinite effect on portfolio decisions of Eurozone investors, as we may expect, on one hand, a reallocation of portfolio's weights in favor of EMU assets as a result of the complete elimination of currency risk, and, on the other hand, a higher weight for assets outside EU, as a direct consequence of increased financial market integration between European Union countries. The paper is structured as follows: Section 3 presents a review of the literature in the field, Section 3 outlines the data and research methodology, Section 4 analyzes the main results and Section 5 concludes.

2. REVIEW OF RELEVANT LITERATURE

The increase in international economic integration in the past decades, fuelled by amplified cross-country trade and financial flows raised the question of whether the benefits that international investors may obtain from holding internationally diversified portfolios did not diminish. International economic integration, translated in financial markets' integration, is easily observable at the level of increased joint movements of financial markets around the world. In such circumstances, correlations between markets and assets traded in different domestic markets are expected to increase in time because the impediments to international investment are being progressively removed and countries are becoming more integrated, both from a political and economic point of view. Roll (1992) argues that stronger economic integration may lead to lower correlation of asset returns if the integration process is associated with higher industrial specialization, while Heston and Rouwenhurst (1994) identify country effects – fiscal, monetary, legal and cultural differences – as better explanatory factors for the co-movement of stock markets. Tavares (2009) analyzes the impact of economic integration on cross-country co-movements of stock returns, in a large panel of developed and emerging countries, and finds that returns' correlation is pushed up by bilateral trade intensity, while real exchange rate volatility, the asymmetry of output growth and export dissimilarity between countries tend to decrease it. However, although studies generally confirm an upward trend of correlation coefficients among domestic capital markets, their trend over the last 30 to 40 years has been less abrupt than one might expect, because the enhanced competition between national economies has frequently led to specialisation. For example, Solnik et al. (1996) discovered a mean correlation of approximately 0.40 between US and foreign markets for the period between 1958 and 1995. These results were confirmed for the period between 1973 and 1982 by Eun and Resnick (1988). A slightly higher average correlation coefficient between US and foreign markets, of about 0.55, was calculated by Hunter and Cogin (1990) for the period from 1970-1986. More recent studies, such as Lee (2005) find that conditional correlations between the US, Japan, and the Hong Kong stock markets are positive and increasing in the recent years. Overall, the set of evidence regarding the trend of correlations in time remains mixed: for example, Kaplanis (1992) and Ranter (1988) do not find consistent evidence in favour of increased cross-market correlations, but Longin and Solnik (1995) find that correlations have risen between 1960 and 1990. Bekaert and Hodrick (2006) use a risk-based factor model and conclude that no evidence of an upward trend in returns' correlation across countries is observable, except in the case of European stock markets. Their findings are accompanied by research – see, for example, Goetzmann et al. (2001), Ramchand and Susmel (1998), Books and del Negro (2002), Larrain and Tavares (2003), Heaney et al. (2002) – that shows that cross country correlations in stock returns change over time and are generally higher in periods of accentuated integration and of high volatility of returns. But, as Fooladi and Rumsey (2006) point out, "the differences among their results could be the artefact of the time period and need not apply to other times". Besides the findings referring to the value of correlation coefficients and their trend, a number of specificities of international capital markets are noteworthy (see Bracker et al., 1999): countries in proximate geographical areas tend to display greater co-movement than countries farther apart; pairs of national stock indices with similar industrial structure tend to experience more substantive co-movement; when the timing of movements is investigated, several different national markets display a significant relationship within the same 24-hour period, but beyond 24 hours they show few significant responses across markets. Nevertheless, empirical studies identified increased correlations and market interrelations as world capital markets evolved in the '80s and '90s, with a stronger point in the case of economically integrated markets such as European Union.

The extent of integration and its dynamics were investigated through the price differences or co-movements of markets, through the responses to information arrivals, or through the fit of models of capital flows and portfolio allocations. More sophisticated techniques, such as Vector autoregression (VAR), Granger causality tests and cointegration, able to better model market co-movements that the traditional correlation tool, are among the favourite tools in the more recent literature. Kasa (1992) estimates an error-correction VAR model and calculates a common stochastic trend for the equity markets of the United States, Japan, United Kingdom, Germany and Canada. Jeon and Chiang (1991) examine the behaviour of stock prices in New York, Tokyo, London, and Frankfurt stock markets based on univariate and multivariate cointegration techniques, while Chan et al. (1992) and Arshanapalli et al. (1995) study the links between the US and Asian equity markets. More recently, Chen et al. (2002) investigate the dynamic interdependence of the major stock markets in Latin America employing cointegration analysis and error correction VAR techniques. Also, Hassan (2003) uses a multivariate cointegration analysis to test for the existence of a long-term relationship between share prices in the Persian Gulf. In case international capital markets would be cointegrated, this has interesting and concerning implications for international investors, as their efforts to improve the long-run risk-return profile of their investments would have to increase. The reasons of such long-term ties between markets are not easily identifiable, but one can think of the presence of strong economic links and coordination of macroeconomic policies between countries, deregulation and market liberalization measures, and increasing activities of multinational corporations and institutional investors.

The European Union, as the most successful integration attempt so far, has been more and more studied, with results indicating a significant increase of correlations among European markets, both at geographical and industrial level. The introduction of the euro and the subsequent disappearance of exchange rate risk in the EMU area imply that investors should be concerned with the benefits of their diversification strategies, especially when before the introduction of the euro they hold diversified portfolios at the European level. Recently, research on the European economic integration process and its impact on capital markets, including here the introduction of the euro, has flourished. Fratzscher (2001) analyses the integration process of European equity markets since the 1980s, and demonstrates that these markets have become highly integrated only since 1998. This high level of integration between European equity markets is largely explained by the drive towards EMU through the elimination of exchange rate volatility. Reszat (2003) evidences that the contribution of the common currency to financial integration has been stronger the more national markets have in common. On the other hand, Adjaoute and Danthine (2003) reassessed, in the light of modern financial theory, the recent evolution of capital markets in the euro area, and concluded that European capital markets are still segmented, which leads to higher costs for treasuries and taxpayers, urging for measures to be taken in favour of a higher integration of these markets. Garcia Pascual (2003) finds evidence of increasing integration of the French stock market, but not of the British and German markets, while Rangvid (2001) also identifies a rise in the degree of convergence among European stock markets in the last two decades. More recently, Kashefi (2006) studies the effect of the euro introduction on European equity markets and finds a significant increase in correlations among stock returns between pre- and post-euro periods, which shows that diversification opportunities within EMU, at least, have decreased at a country level for post-euro periods.

In their search for improved portfolio performance, institutional investors' attention was drawn to emerging markets beginning with the '80s, as these countries were able to provide them with high returns and low correlations with developed markets. From the perspective of European investors in particular, Central and Eastern Europe markets are of interest at least for two reasons: the geographical proximity and their accession to the European Union. As a result, research on the links between this region's capital markets and EU markets has burgeoned, but the effective benefits of diversification received mixed results in the existing literature. Gilmore and McManus (2002) found there is no long-term relationship between major markets in Central Europe, after conducting a co-integration test on stock returns from these markets, while the Granger causality test showed that no causality is present between these markets and the US markets, but evidenced causation between Hungary and Poland. Egert and Kocenda (2007) analyze co-movements among three stock markets in Central and Eastern Europe (Hungary, Poland and Czech Republic) and the interdependence between them and Western European markets (Germany, France, and United Kingdom), using intraday price data, finding no signs of robust cointegration relationships between stock indices in a bivariate or multivariate framework, but discovering short-term spillover effects both in terms of stock returns and stock price volatility. Patev et al. (2006) evaluate the degree of market integration between the US stock market and Central and Eastern European markets, through the use of cointegration, Granger causality and variance decomposition tests, by studying the long-run and short-run convergence among stock prices in Hungarian, Polish, Russian, Czech and US markets. They find that Central and Eastern European markets are segmented, but during the crisis times there is an increase in the co-movements between markets, which leads to a sharp decrease in the diversification benefits for an American investor allocating his funds in the region's stocks. At the same time, the intensity of co-movements between markets decreased after the crisis, which restores the diversification opportunities in Central and Eastern European markets.

The current research continues previous attempts to investigate capital market linkages between Central and Eastern European countries, including Romania, and between them and Western Europe countries, developed by Horobet and Dumitrescu (2009, 2009a), Horobet and Lupu (2009), and Horobet et al. (2010). Horobet and Lupu (2009) analyzed the stock markets of five emerging countries from the CEE region – Czech Republic, Hungary, Poland, Romania and Russia – and contrasted them against four major EU markets – Austria, France, Germany and United Kingdom – over the 2003-2007, aiming at identifying the speed and significance of information transmission among them, as included in stock market returns. Using different return frequencies, after performing cointegration and Granger causality tests, their results indicate that these markets react rather quickly to the information included in the returns on the other markets, and that this flow of information takes place in both directions, from the developed markets to the emerging ones, and vice versa. At the same time, investors on emerging markets seem to take into account information from the other emerging markets in the region. Nevertheless, the results cannot definitely indicate whether there is a direct transmission of information from one market to another or a common reaction of all markets to some other information relevant to them, either on a European or global level. Horobet and Dumitrescu (2009, 2009a) explored the increase in correlations between three emerging markets from the European Union – Czech Republic, Hungary and Poland – and three developed markets from the European Union, namely Austria, France and Germany, as well as the link between correlations and stock market volatilities in this sample of countries. They find that there is an observable and statistically significant positive trend in cross-market correlations after the euro introduction in 1999, which may indicate a higher integration of these capital markets. At the same time, they observe that movements in national stock markets are not fully synchronized, but correlations tend to be high in periods of high market volatility. Pursuing a different approach, Horobet et al. (2010) study the evolution of the financial integration process in Central and Eastern European emerging markets by analyzing a wide range of factors that influence stock market returns in these countries. They find that regional factors have increased in importance, although local risk factors continue to play an important role in explaining the performance of the emerging capital markets. The differences between countries are significant, some of the markets showing a high degree of financial integration with the developed markets, while other markets remain segmented.

Given these realities, it is not irrelevant to ask whether the benefits of international diversification have dramatically diminished in the past 30 years or so, particularly for European investors. Various methodological approaches and measures that show the extent of diversification benefits have been used in the literature so far. We explore few of them and then point out to the improvements that our methodology brings in terms of analysing the time-varying performance of an internationally diversified portfolio from the perspective of a European investor.

The simplest way to measure the extent of diversification benefits is to assess how much international diversification can reduce the variance of a domestic portfolio without changing its return, extended to identifying significant and persistent shifts at the level of the efficient frontier built with domestic assets only. A number of studies have pursued this research direction – see, for example, Grauer and Hakansson (1987), Levy and Lerman (1988), Bailey and Stulz (1992), and Eun and Resnick (1994). More recently, researchers begun to address the question of whether diversification benefits have changed in time, by employing more advanced testing methodologies. Among the first studies in this line of research, Meric and Meric (1989) find evidence that diversification across countries results in higher risk reduction than diversification across industries, but the inter-temporal stability tests applied indicate that the longer the time period considered the better proxies ex-post patterns of co-movement can be for the ex-ante co-movements of international stock markets. De Santis and Gerard (1997) estimate that the expected gains from international diversification for a U.S. investor average 2.11 percent per year and have not significantly declined over the last two decades, by employing a methodology that tests the conditional CAPM for the world's largest equity markets using a parsimonious GARCH parameterization. Ang and Bekaert (2002) offer a solution for the dynamic portfolio choice problem of a US investor faced with a time-varying investment opportunity set which may be characterized by correlations and volatilities that increase in bad times. By using a regime-switching model, they find evidence for the existence of a high volatility regime, in which returns are more highly correlated and have lower means. They show that international diversification is still valuable with regime changes and currency hedging brings further benefit. Fooladi and Rumsey (2006) examine the benefits of international diversification between 1988 and 2000 using a variable constructed as a ratio between the standard deviation of return for an equally weighted internationally diversified portfolio and the average standard deviation of returns for all markets included in this portfolio. They show that despite the international capital markets integration process, the benefits of international diversification measured in US dollars persist because the increase in co-movements between equity market returns measured in local currencies has been counterbalanced by movements in exchange rates. Another measure of diversification benefits has been proposed by Middleton et al. (2008), which examine the potential benefits from investing into eight stock markets of Central and Eastern Europe between 1998 and 2003. The authors examine the mean return per unit of risk (MRPUR) for a portfolio of CEE equities, estimated by calculating the ratio of portfolio's mean return to its standard deviation and reach the conclusion that investing in CEE offers substantial benefits for a European investor, but they accrue more from the geographical spread than from the industrial equity mix.

3. DATA AND RESEARCH METHOLODOGY

We measure the benefits of diversification by considering the ratio of the standard deviation of the minimum variance portfolio (MVP) for a European investor to the average standard deviation of all markets included in the portfolio, which we label *gamma* (γ). The size of gamma, which may vary between zero and one, is inversely correlated to the benefit a European investor derives from international diversification. The MVP includes equities from developed and emerging countries that we include in one of three categories: (1) EU and EMU members – Austria, France, Germany, Italy, Netherlands, Spain; (2) EU but not EMU members – United Kingdom, Czech Republic, Hungary, Poland, Romania; and (3) non-EU members – United States, Japan, Brazil, Russia, India and China. The trend of benefits from international diversification is afterwards examined by studying the changes in gamma over time. We use a period that spans over 135 months, from January 1999 to March 2010 and build a time series with daily values for gamma.

We analyze the trends in gamma in two ways: first, we regress gamma against time; second, we observe the difference between the means and volatilities of gamma for three sub-periods: (1) January 1999 – April 2004; (2) May 2004 – September 2008; (2) October 2008 – March 2010. Each of these sub-periods is significant for the following reasons: May 2004 marks the entrance into the European Union of ten new countries and October 2008 represents the beginning of the current financial turmoil. Therefore, our time test of gamma will offer insight not only on the impact of capital market integration on the benefits of internationally diversified portfolios, but also on the size of diversification benefits in normal versus turbulent times.

Understanding the nature of volatility time dependence is critical for macroeconomic and financial applications and models of conditional heteroskedasticity for return time series are developed for making financial decisions, including portfolio choice decisions, on the basis of the observed asset price data in discrete time. Better able at handling time-varying volatility, ARCH models were proposed by Engle (1982) and generalized as GARCH (Generalized ARCH) by Bollerslev (1986) and Taylor (1986).

If we let (Z_n) be a sequence of i.i.d. random variables such that $Z_n \sim N(0,1)$, then X_t is called a GARCH(q,p) process if

$$X_t = \sigma_t Z_t, \quad t \in \mathbb{Z} \tag{1}$$

where σ_t is a nonnegative process with the following specification:

$$\sigma_t^2 = \alpha_0 + \alpha_1 X_{t-1}^2 + ... + \alpha_q X_{t-q}^2 + \beta_1 \sigma_{t-1}^2 + ... + \beta_p \sigma_{t-p}^2, \quad t \in \mathbb{Z} \tag{2}$$

and $\alpha_0 0, \quad \alpha_i \geq 0, \quad i = 1,..., q, \quad \beta_i \geq 0, \quad i = 1,..., p$.
The simplest GARCH model of conditional variance, GARCH(1,1) may be written as

$$\sigma_t^2 = \omega + \alpha R_t^2 + \beta \sigma_{t-1}^2, \text{ with } \alpha + \beta = 1 \tag{3}$$

The RiskMetrics model is a special case of the GARCH(1,1) if $\alpha = 1 - \lambda$ and $\beta = \lambda$, so that $\alpha + \beta = 1$. Also, $\omega = 0$ in this special case.
First, we estimated simple GARCH(1,1) models on the index return series (in EUR) and generated the series of conditional standard deviations for each country. Second, we applied the Risk-Metrics model (using the value $\lambda = 0.94$) on standardized returns ($z_{it} = R_{it} / \sigma_{it}$, where σ_{it} is the conditional volatility of market index *i* obtained previously) to get the covariances of the standardized return pair $E(z_{it} z_{jt})$. Next, by multiplying the covariances of the standardized return pairs with the conditional volatilities of the respective market indices we obtained estimates of the conditional covariances $\text{cov}(R_{it}, R_{jt}) = \rho_{i,j} \sigma_{it} \sigma_{jt}$. Using the standard approach (see, for example, Huang and Litzenberger (1988), we computed the standard daily deviations of the minimum variance portfolio ($\sigma_{mvp,t}$) and the average daily standard deviation of an equally weighted portfolio $\sigma_{ewp,t}$, assuming pairwise correlations to be 1. Afterwards, we obtained the daily gamma series $\gamma_t = \sigma_{mvp} / \sigma_{ewp}$.
In order to capture gamma trends we regress it on time using the following equation:

$$\gamma_T = \alpha_0 + \alpha_1 T + u_T \tag{4}$$

where, in order to allow for possible serial correlation of the residuals, the residual u_T is assumed to take the form ~

$$u_T = \theta u_{T-1} + \varepsilon_T, \quad \varepsilon_T \sim N(0,1) \tag{5}$$

Regression (4) is run for three structures of the u_t: (1) a standard OLS, and (2) a generalized least squared regression (GLS) with 1 lag (n=1).

4. RESULTS

4.1. Descriptive statistics

The stock market indices denominated in EUR for the entire sample of 17 countries used in our analysis, presented in Appendix 1, show, with few exceptions, the same general evolution pattern between January 1999 and April 2010. In almost all countries one may observe the increase in indices until September 2010, followed by the subsequent dramatic decline induced by the current financial turmoil, and accompanied afterwards by stock market recovery. The exceptions from this pattern are France, United Kingdom, Italy, Japan, Netherlands and the United States, in their cases the main explanation residing in the strong appreciation of the euro against the US dollar and other main currencies until the end of 2000, followed by the later swings of the euro exchange rates. Appendix 2 presents daily returns calculated from the same stock market indices and allows one to notice the well-documented phenomenon of volatility clustering, particularly around the month of October 2008, which represents the culmination of the current financial crisis. From the perspective of any investor, regardless of his nationality, the increased volatility of all these markets does not bring good news, when we think of its impact on portfolio volatility (even in the case when the portfolio is well diversified).

Table 1 shows the descriptive statistics for euro denominated daily returns for all countries included in our analysis, for the overall and also for the three periods that we considered relevant in terms of implications for international diversification benefits. The changing performances during 1999-2010 of all markets are easily observable and also the general behaviour of developed versus emerging markets. Over the entire period and over each of the three sub-periods, emerging countries would have provided Euro-based investors with highest mean returns (Russia has the highest mean return over the entire period and the first sub-period, while China takes its place in the second and third sub-periods) and highest volatility (Russia displays the highest volatility of returns overall and during the first and third sub-periods, replaced by China during the second sub-period). On the other hand, EMU countries or other developed countries have the lowest mean returns and volatilities overall and during each of the three sub-periods, with the notable exception of the Czech Republic whose stock market shows the lowest return volatility during the third sub-period. Another noteworthy observation emerging from our results is that almost all return distributions are negatively skewed and leptokurtic, the Jarque-Berra test confirming non-normally distributed returns.

Table 1. Descriptive statistics for EUR-denominated daily returns, all countries, January 1999 – April 2010

	Austria	Brazil	China	Czech R.	Germany	Spain	France	UK	Hungary	India	Italy	Japan	Neth.	Poland	Romania	Russia	US
Overall period: January 5, 1999 - April 22, 2010																	
Mean	0.0001	0.0006	0.0002	0.0006	0.0000	0.0000	0.0000	-0.0001	0.0003	0.0006	-0.0002	0.0000	-0.0001	0.0002	0.0005	0.0008	-0.0001
Median	0.0006	0.0014	0.0004	0.0007	0.0005	0.0004	0.0004	0.0003	0.0005	0.0010	0.0002	0.0001	0.0002	0.0005	0.0004	0.0013	0.0005
Maximum	0.1203	0.2340	0.1449	0.1779	0.0988	0.1061	0.0963	0.1028	0.1838	0.1904	0.1038	0.1124	0.0901	0.1230	0.1035	0.2309	0.0972
Minimum	-0.1218	-0.1800	-0.1202	-0.1540	-0.0956	-0.0981	-0.0950	-0.0908	-0.1913	-0.1313	-0.0883	-0.0972	-0.0945	-0.1342	-0.1502	-0.2353	-0.0830
Std. Dev.	0.0160	0.0280	0.0212	0.0179	0.0165	0.0154	0.0153	0.0144	0.0212	0.0196	0.0145	0.0155	0.0153	0.0206	0.0196	0.0289	0.0148
Skewness	-0.3261	0.0286	0.0126	-0.1422	-0.0214	-0.0472	-0.0579	-0.1109	-0.1549	-0.0235	-0.1211	-0.0704	-0.1744	-0.1866	-0.3230	-0.1771	-0.0571
Kurtosis	11.7428	9.1103	6.7045	11.9373	6.5302	7.6195	7.5014	8.2691	10.8287	8.7651	8.6532	6.1550	7.6902	6.1078	7.9882	10.7334	6.9215
Jarque-Bera	9441.11	4586.51	1685.80	9821.32	1531.04	2622.36	2490.61	3416.33	7540.03	4082.82	3932.78	1225.11	2717.02	1203.49	3107.66	7361.47	1890.57
Probability	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
First period: January 5, 1999 - April 30, 2004																	
Mean	0.0003	0.0001	-0.0003	0.0006	-0.0002	-0.0001	-0.0001	-0.0001	0.0003	0.0005	-0.0002	0.0000	-0.0003	0.0001	0.0006	0.0015	-0.0001
Median	0.0004	0.0010	-0.0005	0.0005	-0.0002	-0.0002	0.0000	-0.0001	0.0002	0.0005	-0.0001	-0.0001	-0.0002	-0.0001	0.0000	0.0013	0.0003
Maximum	0.0353	0.2340	0.1171	0.0746	0.0707	0.0648	0.0676	0.0719	0.0915	0.1007	0.0642	0.0723	0.0851	0.1035	0.0936	0.1901	0.0717
Minimum	-0.0511	-0.1354	-0.1062	-0.0716	-0.0956	-0.0812	-0.0812	-0.0705	-0.1191	-0.0788	-0.0777	-0.0634	-0.0817	-0.1342	-0.0984	-0.1979	-0.0720
Std. Dev.	0.0106	0.0293	0.0214	0.0163	0.0183	0.0157	0.0159	0.0140	0.0176	0.0182	0.0143	0.0154	0.0162	0.0202	0.0177	0.0307	0.0159
Skewness	-0.2808	0.2745	0.0254	-0.1216	-0.0187	0.0159	-0.0990	-0.0569	-0.1059	-0.1556	-0.1915	0.0037	-0.1234	-0.0619	0.1869	-0.1042	0.0942
Kurtosis	4.4016	7.9495	5.1548	4.3063	4.6759	4.6995	4.7012	4.6372	7.0391	4.9197	4.9963	3.8990	5.6994	5.4615	7.1169	7.0252	4.1390
Jarque-Bera	131.94	1435.25	268.86	102.18	162.62	167.22	169.77	155.88	946.77	218.89	239.13	46.78	425.26	351.55	989.02	940.24	77.13
Probability	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Second period: May 1, 2004 - Sept 30, 2008																	
Mean	0.0001	0.0010	0.0005	0.0009	0.0002	0.0003	0.0001	-0.0001	0.0004	0.0005	-0.0001	-0.0001	0.0001	0.0005	0.0005	0.0003	-0.0001
Median	0.0011	0.0018	0.0013	0.0009	0.0010	0.0008	0.0007	0.0005	0.0011	0.0013	0.0006	0.0001	0.0005	0.0012	0.0006	0.0011	0.0005
Maximum	0.1181	0.1245	0.1201	0.1057	0.0591	0.0790	0.0784	0.0834	0.1128	0.0882	0.0777	0.0473	0.0631	0.0638	0.1021	0.2309	0.0743
Minimum	-0.0879	-0.1468	-0.1202	-0.0703	-0.0724	-0.0794	-0.0675	-0.0597	-0.0708	-0.1313	-0.0509	-0.0816	-0.0816	-0.0748	-0.1193	-0.1473	-0.0781
Std. Dev.	0.0135	0.0233	0.0186	0.0146	0.0109	0.0113	0.0112	0.0112	0.0175	0.0186	0.0101	0.0131	0.0110	0.0163	0.0184	0.0217	0.0111
Skewness	-0.2412	-0.4705	-0.1303	-0.0268	-0.3840	-0.1145	-0.0922	-0.0358	0.0267	-0.6450	-0.0809	-0.4058	-0.4313	-0.2431	-0.3758	0.3569	-0.3665
Kurtosis	11.5233	6.8046	7.9803	8.4006	6.4382	9.8002	7.6901	8.5356	5.1506	7.9433	8.2163	5.3409	8.6322	4.4885	7.1672	18.1373	9.3682
Jarque-Bera	3498.18	737.29	1193.82	1400.10	595.74	2222.19	1057.50	1471.11	222.13	1252.84	1307.31	294.65	1558.38	117.70	860.65	11023.11	1972.35
Probability	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Third period: Oct ober 1, 2008 - April 22, 2010																	
Mean	-0.0005	0.0012	0.0010	-0.0003	-0.0001	0.0000	0.0000	0.0001	0.0002	0.0011	-0.0003	0.0002	0.0003	-0.0002	0.0005	0.0003	0.0002
Median	0.0001	0.0016	0.0002	0.0007	0.0003	0.0008	0.0003	0.0016	0.0012	0.0025	-0.0001	0.0010	0.0003	0.0009	0.0017	0.0027	0.0009
Maximum	0.1203	0.2069	0.1449	0.1779	0.0988	0.1061	0.0963	0.1028	0.1838	0.1904	0.1038	0.1124	0.0901	0.1230	0.1035	0.2050	0.0972
Minimum	-0.1218	-0.1800	-0.1158	-0.1540	-0.0758	-0.0981	-0.0950	-0.0908	-0.1913	-0.0927	-0.0883	-0.0972	-0.0945	-0.1180	-0.1502	-0.2353	-0.0830
Std. Dev.	0.0308	0.0348	0.0269	0.0285	0.0220	0.0226	0.0221	0.0221	0.0367	0.0262	0.0234	0.0210	0.0213	0.0306	0.0278	0.0390	0.0193
Skewness	-0.1854	-0.0344	0.1100	-0.0976	0.1493	-0.0614	0.0271	-0.1792	-0.1813	0.7326	-0.0321	0.0510	-0.1164	-0.2150	-0.6849	-0.5454	-0.1921
Kurtosis	4.7187	10.2185	6.6869	10.3074	6.0988	6.3775	6.9320	6.8108	6.8018	10.4703	6.1628	7.0436	6.5653	4.5792	6.5976	9.4650	7.9593
Jarque-Bera	52.43	883.72	231.34	906.18	164.36	193.71	262.23	248.45	247.35	982.77	169.71	277.46	216.49	45.43	251.31	728.96	419.59
Probability	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

We present in Table 2 the average correlations between pairs of countries by taking into account the three categories of countries defined in Section 3: EMU countries, EU non-EMU countries and outside EU countries[1]. All average correlations show increased values from the first to the third

[1] We computed these correlations starting from the pairwise correlations of daily returns, shown in Appendix 3.

period, but the overall correlation coefficients are rather small, with the exception of correlations between EMU countries (0.762) and between EMU and EU non-EMU countries (0.5135). When interpreting the increased correlations from the first to the third sub-period one should be careful of not taking the higher correlation values for the third period as an indication of possible higher levels of market integration, but mostly as the effect of financial turbulences that debuted at the end of 2008. At the same time, our results signify that Eurozone and EU investors benefit from diversification opportunities outside their regions, on one hand, and that these benefits within their region have declined in time, on the other hand.

Table 2. Cross-country correlations of daily returns between groups of countries

	Overall period: Jan 5, 1999 - Apr 22, 2010	*First period: Jan 5, 1999 - Apr 30, 2004*	*Second period: May 1, 2004 - Sept 30, 2008*	*Third period: Oct 1, 2008 - Apr 22, 2010*
EMU-EMU	0.7621	0.6614	0.8423	0.8561
EU non-EMU - EU non-EMU	0.4453	0.2881	0.4622	0.6334
Outside EU	0.2973	0.2714	0.3134	0.3337
EMU - EU non-EMU	0.5135	0.3649	0.5561	0.6864
EMU - Outside EU	0.3441	0.2738	0.3956	0.4275
EU non-EMU - Outside EU	0.3033	0.2410	0.3111	0.4047

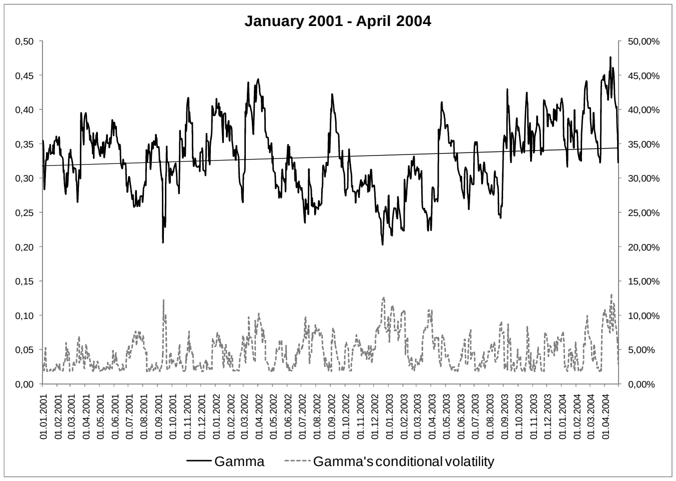
4.2. Analysis of diversification benefits

Figure 1 shows the gamma evolution in time and its trend over the three periods we analyzed: (a) January 2001 – April 2004, (b) May 2004 – August 2008 and (c) September 2008 – April 2010, as well as gamma's conditional volatility[2], while Table 3 presents the descriptive statistics for gamma. To generate the gamma series, we used rolling expected returns for the market indices in the sample, computed as simple averages $e_T = \frac{1}{T}\left(\sum_{t=1}^{T} r_t\right)$ for $T = \overline{1,N}$, where N denotes the number of days in the entire period from 1999 to 2010 (2948 observations) . We reported the results for gamma starting in January 2001 to eliminate the high volatility present in the expected return series low values of *T*. The expected return series can be found in Appendix 5.

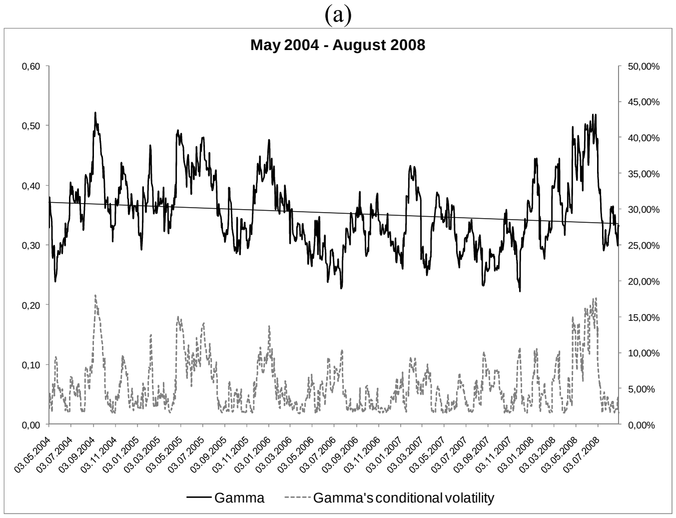
Overall, gamma values indicate that a Eurozone investor holding the minimum variance portfolio (MVP) obtains significant benefits in terms of volatility, but these benefits are highly variable from one day to the other. Over the entire period, gamma has a mean of 0.316 and a standard deviation of 0.053, which suggests that MVP has a volatility that is approximately one third of an equally weighted portfolio constructed from the 17 countries assuming correlations of one among them. When we split the period over the three sub-periods, we observe that gamma means change in time, but the changes are rather small, maybe a more interesting observation referring to the changing volatility in gamma over time. Moreover, gamma's volatility is lower and its means are higher during the first and the third period compared to the second period. At least for what concerns the third period, we may interpret this result as showing that diversification benefits diminish in turbulent times, although not dramatically, and are more concentrated, which may indicate lower incentives for portfolio rebalancing in such times. To some extent, the results for gamma during the first period – which includes the turbulent years at the beginning of the 21st century marked by the "dot-com" bubble and corporate restructuring crisis – may confirm our findings for the third period.

[2] Appendix 4 also presents the conditional variances of daily returns over the entire period.

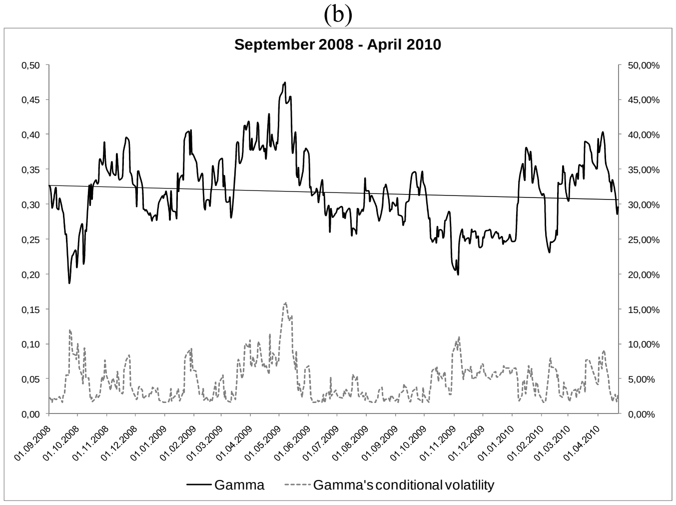
Figure 1. Time-varying gamma and conditional volatility estimated with a GARCH(1,1) model for the three periods analyzed.



(a)



(b)



(c)

Table 3. Descriptive statistics for the γ series.

	γ		
	1st period	2nd period	3rd period
Mean	0.330	0.354	0.317
Median	0.330	0.347	0.315
Maximum	0.476	0.522	0.474
Minimum	0.203	0.223	0.187
Std. Dev.	0.051	0.061	0.053
Skewness	0.084	0.456	0.271
Kurtosis	2.502	2.652	2.878

Note: The 1st period starts in January 2001 and ends in April 2004, the 2nd period starts in May 2004 and ends in August 2008, and the 3rd period starts in September 2008 and ends in April 2010

The results of gamma regressions on time are presented in Table 4. When using OLS gamma has a slightly positive or negative statistically significant trend, for the overall period and for all of the sub-periods, but when the autocorrelation in residuals is taken into account by the use of GLS the trends become statistically insignificant (see the p-values for α_1 parameters and the high statistically significant values for θ). This means that from a European investor point of view the diversification benefits have not diminished or increased dramatically in time and when the trend is removed the gamma series is mean-stationary.

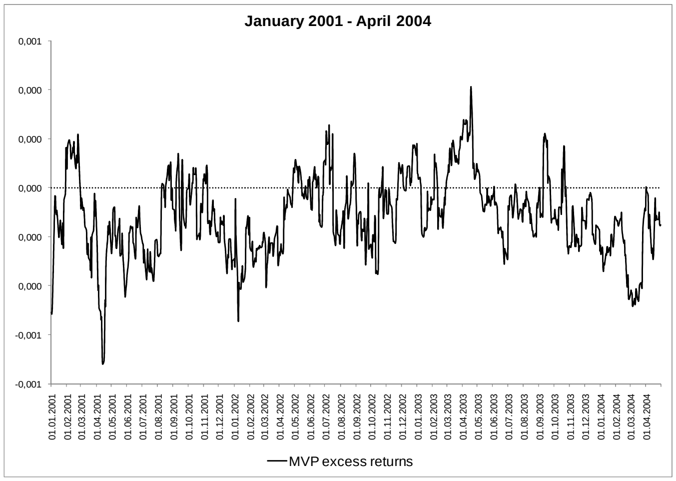
Table 4. Results of regression analysis for the overall period and the three sub-periods using standard OLS and GLS

	Model	α_0	p-value	α_1	p-value	θ	p-value	R^2
1st period	OLS	0.3014	0.0000	0.000031	0.0000			2.23%
	GLS	0.2990	0.0000	0.000032	0.4115	0.9397	0.0000	88.58%
2nd period	OLS	0.4147	0.0000	-0.000031	0.0000			2.79%
	GLS	0.4275	0.0000	-0.000037	0.3310	0.9598	0.0000	92.40%
3rd period	OLS	0.4510	0.0000	-0.000049	0.0165			1.34%
	GLS	0.4578	0.1477	-0.000052	0.6515	0.9384	0.0000	88.20%
Total period	OLS	0.3281	0.0000	0.000004	0.0001			0.05%
	GLS	0.3350	0.0000	0.000000	0.8951	0.9493	0.0000	90%

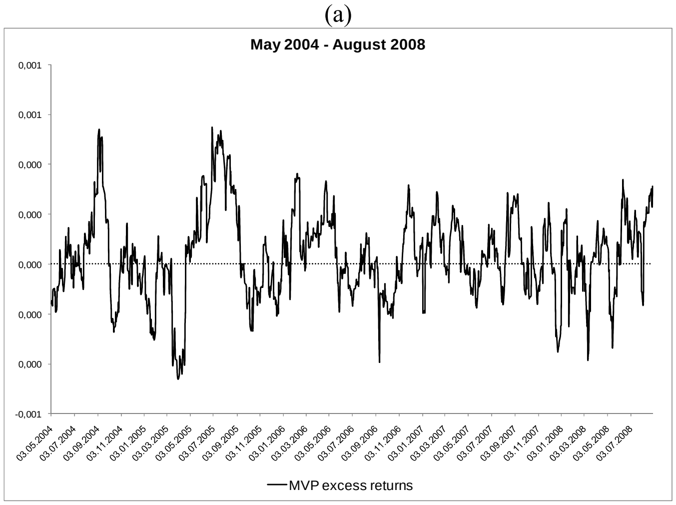
Regression results for $\gamma_T = \alpha_0 + \alpha_1 T + u_T$, where γ_T is the ratio of the standard deviation of the minimum variance portfolio to the average standard deviation of all markets included in the portfolio, estimated for day T. The residual u_T takes the form $u_T = \theta u_{T-1} + \varepsilon_T, \quad \varepsilon_T \sim N(0,1)$.

When judging the overall diversification benefit we need a measure of comparison not only for volatility, but also for returns. Therefore, we computed the daily MVP excess returns over the risk-free rate and plotted their values over the three sub-periods in Figure 2. The risk-free rate we used is the three-month interbank deposit rate in the Eurozone. Values above zero indicate higher MVP returns than the risk-free rate, while values below zero indicate a better performance in terms of returns for the risk-free securities. We observe that excess returns are volatile and variable among the three sub-periods. Over the entire period, the MVP excess return has a monthly mean of -0.001095, but the mean is negative over the first and third sub-periods (-0.00254 and -0.00298, respectively) and positive over the second sub-period (0.000738). Moreover, in the first and third sub-periods, 24.02% and 24.48% of excess returns are positive, while in the second sub-period more then fifty percent of excess returns (55.75%) are positive. These results imply that during the second sub-period investors will most likely obtain higher Sharpe ratios for their optimal portfolios than in the other two sub-periods. This is not a surprising result, as years between 2004 and 2008 have seen high returns and lower volatility in all stock markets around the world, afterwards both corrected since October 2008.

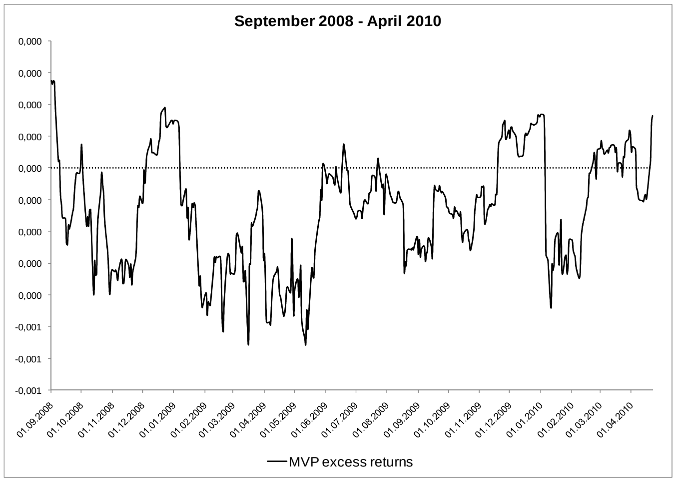
Figure 2. Minimum variance portfolio excess returns



(a)



(b)



(c)

5. CONCLUSIONS

From a theoretical perspective, the introduction of the Euro has an indefinite effect on portfolio decisions of Eurozone investors, as we may expect, on one hand, a reallocation of portfolio's weights in favour of EMU assets as a result of the complete elimination of currency risk, and, on the other hand, a higher weight for assets outside EU, as a direct consequence of increased financial market integration between European Union countries. We measure the benefits of diversification by considering the ratio of the standard deviation of the minimum variance portfolio (MVP) for a European investor to the average standard deviation of all markets included in the portfolio, which we label *gamma* (γ). The size of gamma, which may vary between zero and one, is inversely correlated to the benefit a European investor derives from international diversification. The MVP includes equities from seventeen developed and emerging countries that we include in one of three categories: EU and EMU members; EU but not EMU members; and non-EU members. The trend of benefits from international diversification is afterwards examined by studying the changes in gamma over time and between three sub-periods: January 1999 – April 2004, May 2004 – September 2008 and October 2008 – April 2010. Each of these sub-periods is significant for the following reasons: May 2004 marks the entrance into the European Union of ten new countries and October 2008 represents the beginning of the current financial turmoil. Therefore, our time test of gamma offers insight not only on the impact of capital market integration on the benefits of internationally diversified portfolios, but also on the size of diversification benefits in normal versus turbulent times.

Gamma behavior over time values indicates that a Eurozone investor holding the minimum variance portfolio obtains significant benefits in terms of volatility, but they are highly variable from one day to the other. We find that gamma's volatility is lower and its means are higher during the first and the third period compared to the second period. At least for what concerns the third period, we may interpret this result as showing that diversification benefits diminish in turbulent times, although not dramatically, and are more concentrated, which may indicate lower incentives for portfolio rebalancing in such times.

In order to better identify the overall diversification benefit we also computed the daily MVP excess returns over the risk-free rate. These excess returns are are volatile and variable among the three sub-periods, but their value indicate that during the second of our three sub-periods investors will most likely obtain higher Sharpe ratios for their optimal portfolios than in the other two sub-periods. This is not a surprising result, as years between 2004 and 2008 have seen high returns and lower volatility in all stock markets around the world, afterwards both corrected since October 2008.

Our results show that diversification benefits are still high for a Eurozone investor, but they have slightly diminished after 2004. At the same time, in times of financial crisis, such as the recent one, international diversification may bring attractive benefits in the form of lower volatility, although these benefits are to some extent smaller than in normal times. To better understand the time-varying specificities of benefits derived from holding international portfolios the analysis needs to further address the changes in countries' weights in the minimum variance portfolio, as well as the pervasive impact of exchange rate risk and we intend to continue our research in both directions.

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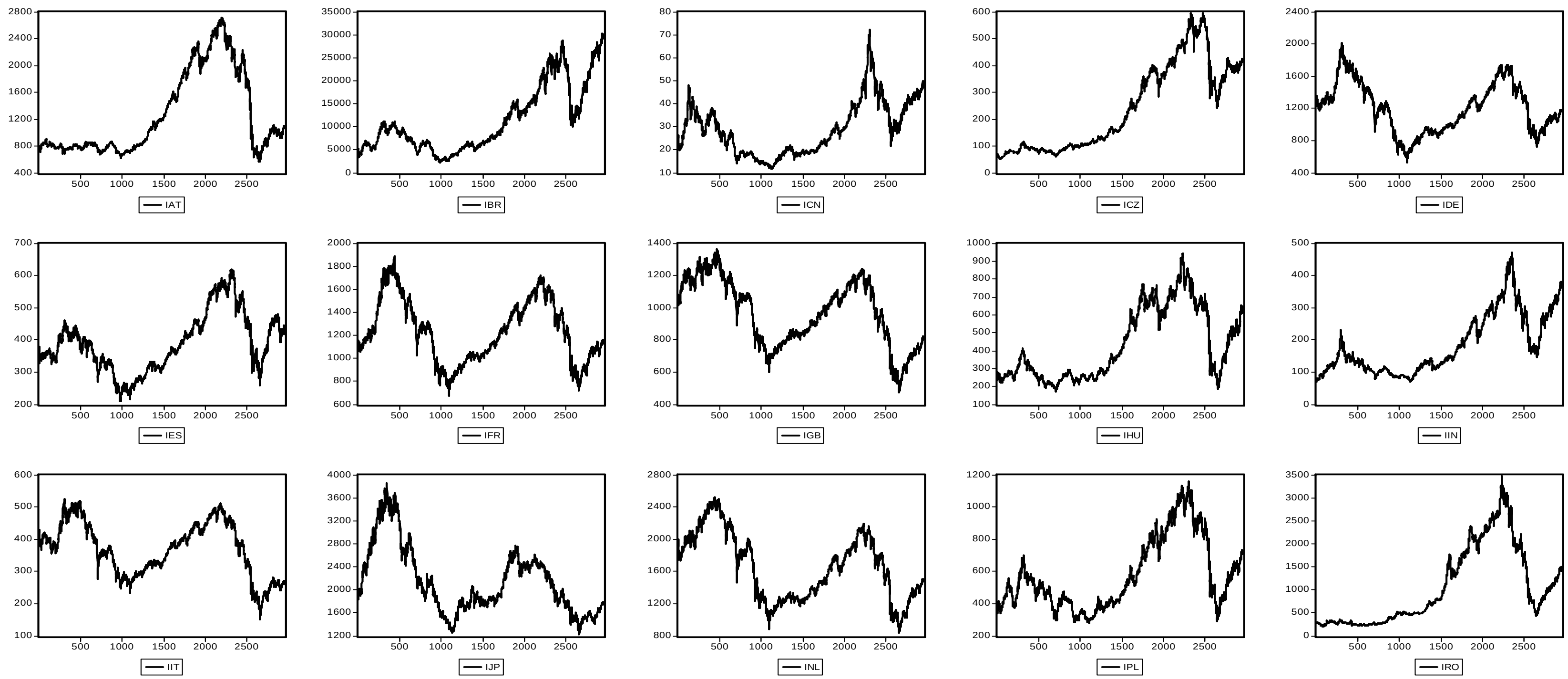
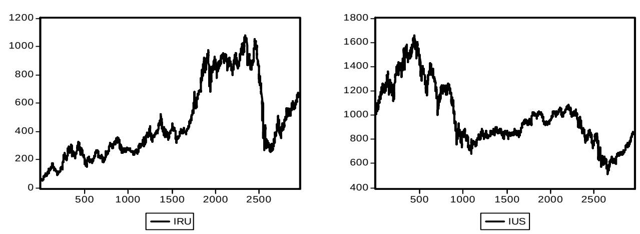
Appendix 1

Stock market indices January 1999 – April 2010; Daily values, in EUR

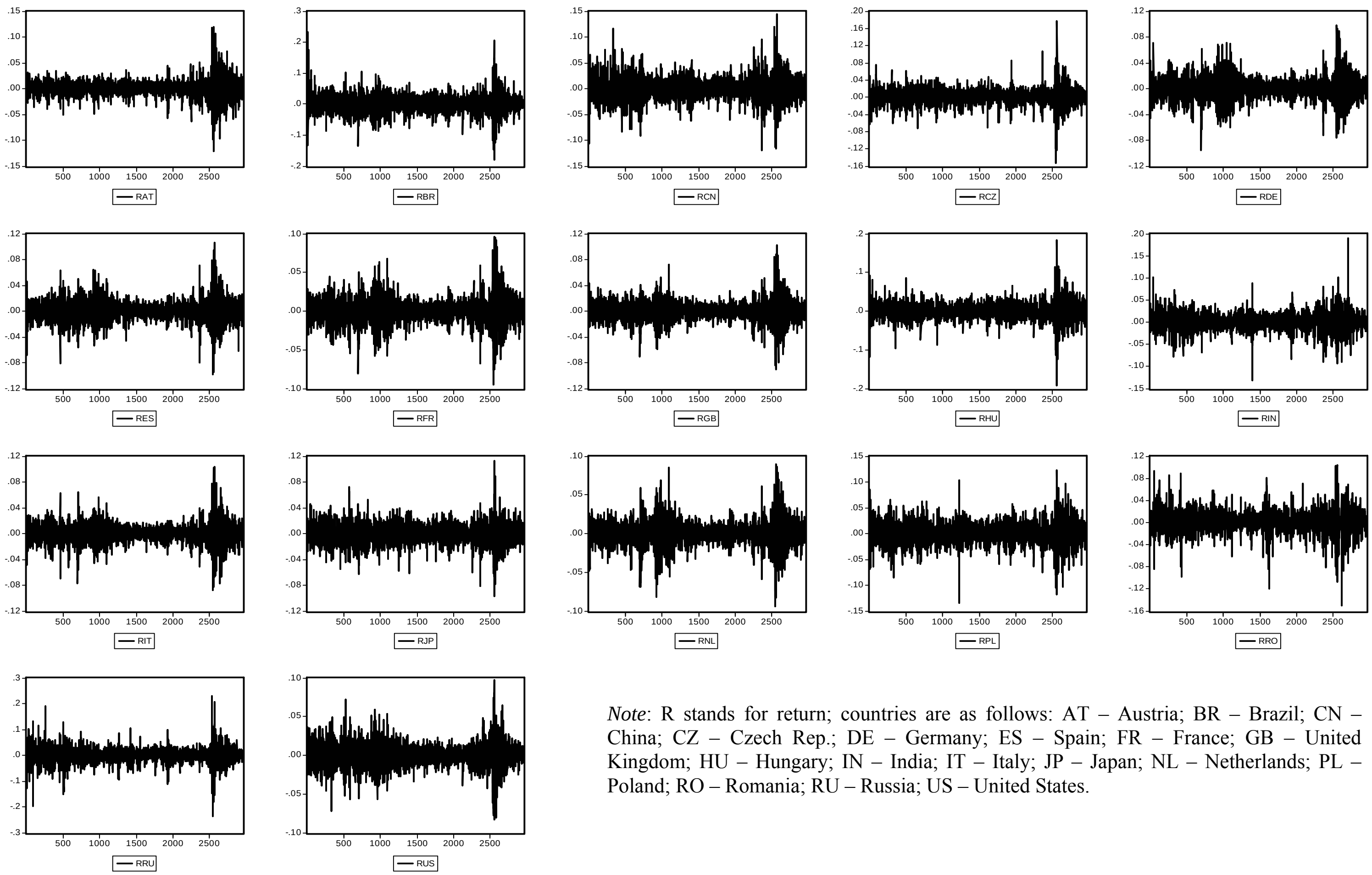




Note: I stands for stock market index; countries are as follows: AT – Austria; BR – Brazil; CN – China; CZ – Czech Rep.; DE – Germany; ES – Spain; FR – France; GB – United Kingdom; HU – Hungary; IN – India; IT – Italy; JP – Japan; NL – Netherlands; PL – Poland; RO – Romania; RU – Russia; US – United States.

Appendix 2

Stock market returns January 1999 – April 2010; Daily values, in EUR



Note: R stands for return; countries are as follows: AT – Austria; BR – Brazil; CN – China; CZ – Czech Rep.; DE – Germany; ES – Spain; FR – France; GB – United Kingdom; HU – Hungary; IN – India; IT – Italy; JP – Japan; NL – Netherlands; PL – Poland; RO – Romania; RU – Russia; US – United States.

Appendix 3

Cross-market correlations of daily returns

Overall period: January 5, 1999 - April 22, 2010

	Austria	Brazil	China	Czech R.	Germany	Spain	France	UK	Hungary	India	Italy	Japan	Neth.	Poland	Romania	Russia	US
Austria	1																
Brazil	0.311	1															
China	0.306	0.246	1														
Czech R.	0.498	0.274	0.319	1													
Germany	0.556	0.449	0.289	0.466	1												
Spain	0.602	0.414	0.286	0.495	0.793	1											
France	0.612	0.434	0.309	0.522	0.882	0.868	1										
UK	0.601	0.446	0.341	0.505	0.782	0.781	0.857	1									
Hungary	0.537	0.305	0.300	0.554	0.498	0.514	0.534	0.517	1								
India	0.298	0.216	0.444	0.304	0.301	0.299	0.320	0.341	0.298	1							
Italy	0.607	0.414	0.277	0.499	0.823	0.822	0.882	0.800	0.528	0.311	1						
Japan	0.208	0.096	0.462	0.217	0.186	0.180	0.208	0.230	0.182	0.285	0.187	1					
Neth.	0.585	0.420	0.310	0.491	0.833	0.820	0.906	0.836	0.500	0.320	0.842	0.206	1				
Poland	0.494	0.311	0.353	0.525	0.483	0.493	0.514	0.510	0.588	0.341	0.488	0.215	0.488	1			
Romania	0.353	0.195	0.258	0.326	0.250	0.277	0.272	0.298	0.320	0.261	0.283	0.141	0.271	0.309	1		
Russia	0.418	0.321	0.326	0.467	0.420	0.417	0.453	0.471	0.440	0.319	0.429	0.213	0.431	0.461	0.245	1	
US	0.292	0.558	0.242	0.224	0.566	0.469	0.516	0.527	0.288	0.264	0.478	0.158	0.508	0.272	0.180	0.311	1

First period: January 5, 1999 - April 30, 2004

	Austria	Brazil	China	Czech R.	Germany	Spain	France	UK	Hungary	India	Italy	Japan	Neth.	Poland	Romania	Russia	US
Austria	1																
Brazil	0.160	1															
China	0.147	0.210	1														
Czech R.	0.235	0.184	0.224	1													
Germany	0.375	0.404	0.223	0.357	1												
Spain	0.405	0.369	0.219	0.357	0.738	1											
France	0.387	0.368	0.240	0.394	0.846	0.819	1										
UK	0.362	0.395	0.263	0.365	0.736	0.699	0.803	1									
Hungary	0.279	0.198	0.246	0.438	0.374	0.380	0.392	0.391	1								
India	0.098	0.173	0.286	0.196	0.206	0.195	0.224	0.236	0.226	1							
Italy	0.353	0.368	0.196	0.348	0.789	0.748	0.835	0.731	0.381	0.205	1						
Japan	0.194	0.181	0.377	0.161	0.216	0.183	0.236	0.257	0.214	0.265	0.206	1					
Neth.	0.370	0.371	0.263	0.359	0.802	0.771	0.883	0.806	0.370	0.221	0.799	0.234	1				
Poland	0.244	0.236	0.333	0.340	0.344	0.336	0.369	0.369	0.420	0.279	0.331	0.267	0.356	1			
Romania	0.106	0.131	0.118	0.142	0.096	0.104	0.098	0.142	0.132	0.108	0.091	0.083	0.109	0.142	1		
Russia	0.197	0.258	0.246	0.331	0.307	0.307	0.331	0.362	0.339	0.256	0.300	0.202	0.332	0.335	0.092	1	
US	0.269	0.501	0.254	0.264	0.619	0.503	0.559	0.578	0.291	0.259	0.530	0.286	0.541	0.304	0.208	0.316	1

Second period: May 1, 2004 - September 30, 2008

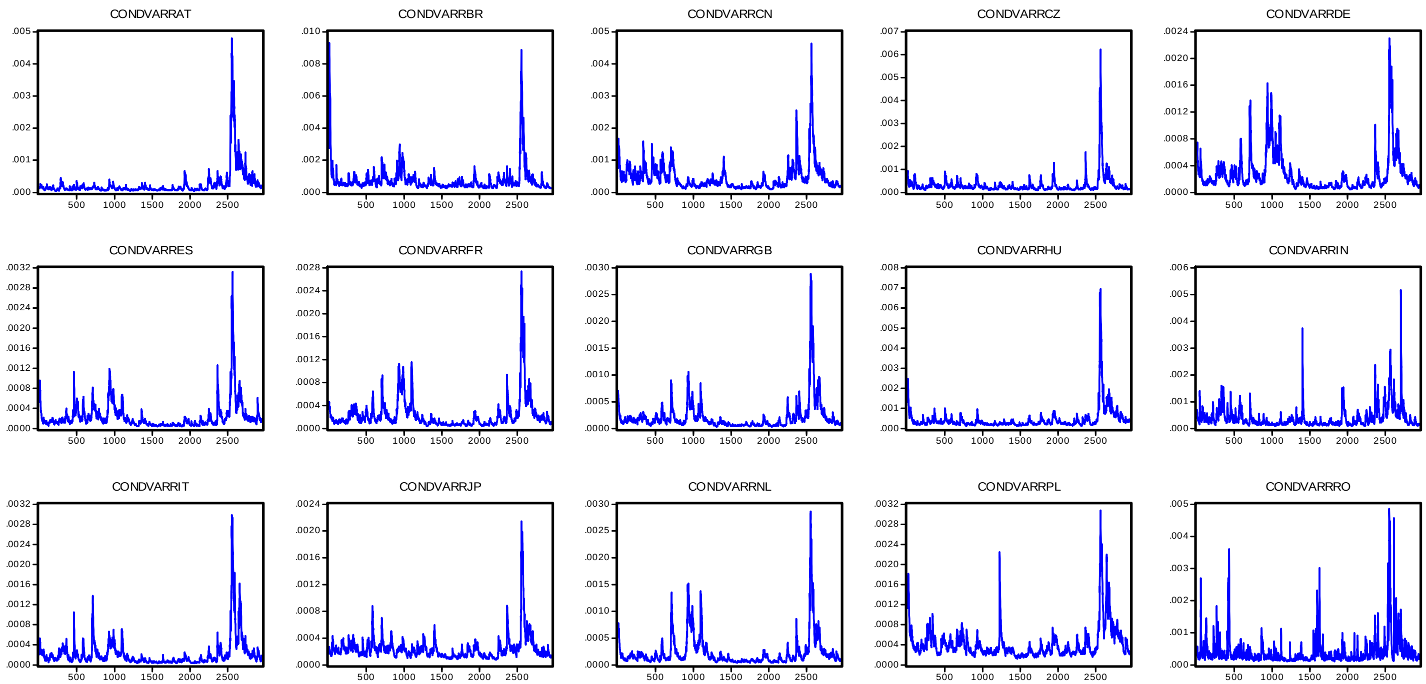
	Austria	Brazil	China	Czech R.	Germany	Spain	France	UK	Hungary	India	Italy	Japan	Neth.	Poland	Romania	Russia	US
Austria	1																
Brazil	0.405	1															
China	0.461	0.218	1														
Czech R.	0.541	0.298	0.320	1													
Germany	0.730	0.450	0.349	0.514	1												
Spain	0.730	0.436	0.319	0.488	0.888	1											
France	0.767	0.479	0.361	0.515	0.942	0.904	1										
UK	0.765	0.465	0.385	0.491	0.848	0.831	0.898	1									
Hungary	0.602	0.347	0.360	0.561	0.552	0.543	0.580	0.562	1								
India	0.426	0.175	0.579	0.299	0.395	0.383	0.407	0.418	0.325	1							
Italy	0.747	0.436	0.336	0.478	0.885	0.864	0.909	0.840	0.541	0.395	1						
Japan	0.269	0.061	0.537	0.249	0.240	0.206	0.227	0.226	0.214	0.398	0.203	1					
Neth.	0.742	0.449	0.339	0.479	0.895	0.855	0.919	0.861	0.530	0.405	0.858	0.212	1				
Poland	0.587	0.357	0.358	0.556	0.580	0.567	0.600	0.591	0.700	0.337	0.561	0.190	0.565	1			
Romania	0.363	0.110	0.309	0.284	0.282	0.283	0.294	0.315	0.273	0.290	0.301	0.175	0.293	0.290	1		
Russia	0.552	0.354	0.387	0.533	0.480	0.474	0.525	0.530	0.498	0.343	0.485	0.228	0.477	0.499	0.249	1	
US	0.332	0.581	0.197	0.141	0.447	0.437	0.477	0.491	0.234	0.244	0.443	0.103	0.494	0.232	0.023	0.296	1

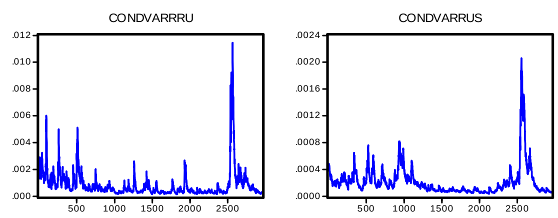
Third period: October 1, 2008 - April 22, 2010

	Austria	Brazil	China	Czech R.	Germany	Spain	France	UK	Hungary	India	Italy	Japan	Neth.	Poland	Romania	Russia	US
Austria	1																
Brazil	0.446	1															
China	0.376	0.365	1														
Czech R.	0.674	0.413	0.479	1													
Germany	0.746	0.568	0.393	0.637	1												
Spain	0.758	0.492	0.390	0.697	0.846	1											
France	0.787	0.535	0.400	0.719	0.922	0.925	1										
UK	0.727	0.536	0.441	0.691	0.846	0.872	0.915	1									
Hungary	0.656	0.443	0.338	0.664	0.683	0.669	0.697	0.630	1								
India	0.386	0.363	0.559	0.465	0.423	0.398	0.410	0.433	0.369	1							
Italy	0.764	0.498	0.375	0.698	0.869	0.909	0.943	0.870	0.680	0.413	1						
Japan	0.203	-0.042	0.544	0.272	0.086	0.153	0.143	0.194	0.127	0.179	0.151	1					
Neth.	0.773	0.506	0.385	0.714	0.858	0.885	0.942	0.878	0.677	0.432	0.914	0.151	1				
Poland	0.673	0.414	0.389	0.745	0.683	0.685	0.686	0.649	0.704	0.452	0.660	0.155	0.660	1			
Romania	0.560	0.427	0.441	0.603	0.523	0.543	0.537	0.504	0.569	0.457	0.537	0.196	0.535	0.575	1		
Russia	0.602	0.432	0.441	0.641	0.631	0.582	0.634	0.617	0.558	0.428	0.613	0.219	0.598	0.658	0.514	1	
US	0.345	0.673	0.268	0.238	0.544	0.432	0.465	0.477	0.352	0.311	0.428	-0.047	0.448	0.254	0.310	0.312	1

Appendix 4

Conditional variances of daily returns January 1999 – April 2010

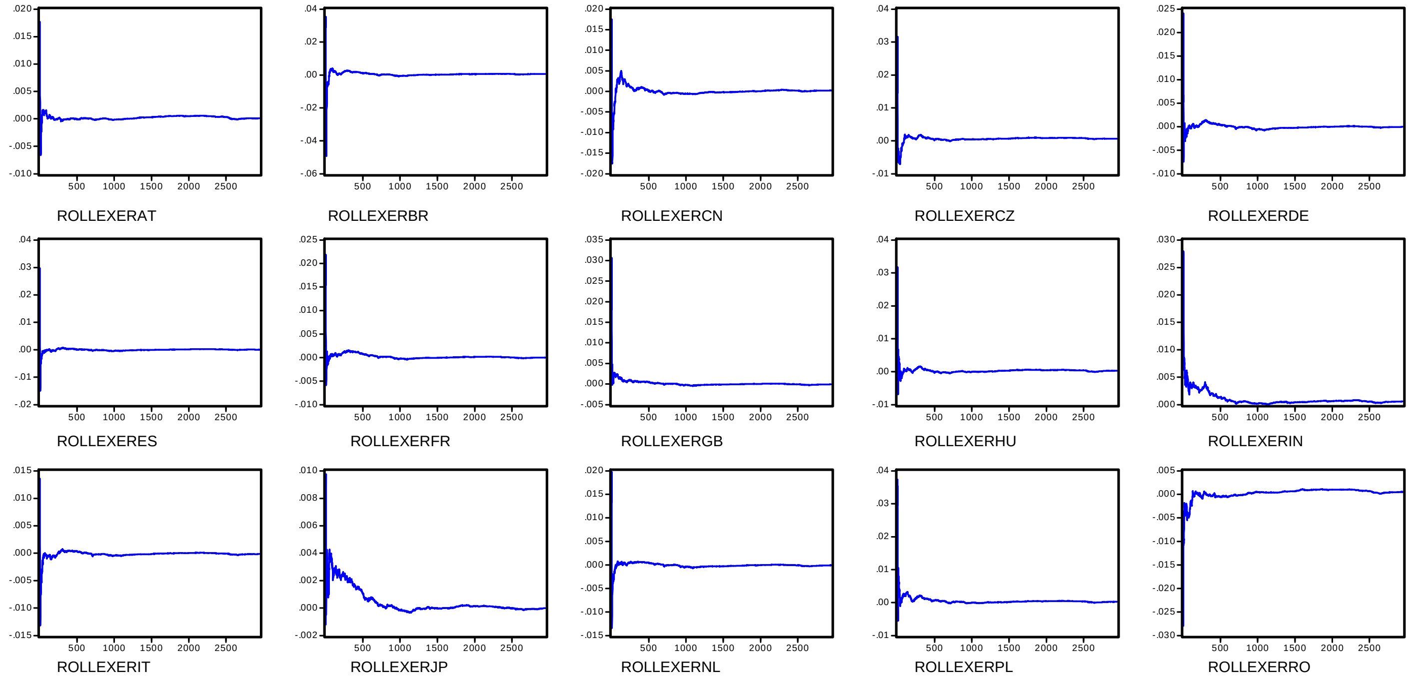


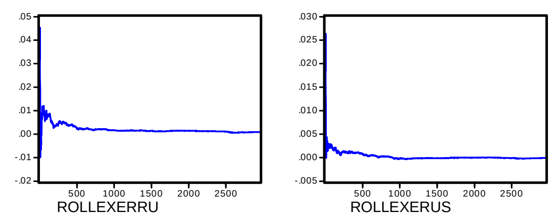


Note: CONDVARR stands for conditional variances; countries are as follows: AT – Austria; BR – Brazil; CN – China; CZ – Czech Rep.; DE – Germany; ES – Spain; FR – France; GB – United Kingdom; HU – Hungary; IN – India; IT – Italy; JP – Japan; NL – Netherlands; PL – Poland; RO – Romania; RU – Russia; US – United States.

Appendix 5

Rolling expected returns, January 2001 – April 2010





Note: ROLLEXR stands for rolling expected return; countries are as follows: AT – Austria; BR – Brazil; CN – China; CZ – Czech Rep.; DE – Germany; ES – Spain; FR – France; GB – United Kingdom; HU – Hungary; IN – India; IT – Italy; JP – Japan; NL – Netherlands; PL – Poland; RO – Romania; RU – Russia; US – United States.