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Eurozone Equity Market Diversification: Is It Still Worth?*

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The paper aims at verifying if there still are advantages in diversification inside the Eurozone despite the economic and monetary unification process. The results show unambiguously that notwithstanding the high degree of correlation between the Eurozone stock markets, opportunities for diversification still exist. The introduction of constraints on short selling significantly reduces these benefits. Investors from the European leading countries would have greatly benefitted from a Eurozone portfolio diversification strategy. The advantages of diversification appear to change significantly over time and from country to country. The results are also conclusive in reflecting the instability of the historical mean-variance data.

Keywords: international diversification, Eurozone equity markets, Eurozone diversification, Eurozone efficient frontier, mean variance analysis, European monetary union, Eurozone correlation analysis

Introduction

The economic and monetary union process in the Eurozone and the harmonization of the Euro-countries financial systems has led to an increased integration of the equity markets of the Area. In this context, some previous studies have documented a significant increase in the correlations in the Eurozone (Beckers, 1999; Bekaert, Hodrik, & Zhang, 2008). This can imply that opportunities for portfolio diversification among the Eurozone stock markets may have disappeared or decreased to a negligible level. The aim of this paper is to verify if there still are advantages in diversification inside the Eurozone.

Fooladi and Rumsey (2006) developed a measure, lambda (λ) of the benefits of diversification for an international portfolio. This measure has been tested in Pizzutilo's (2010) finding that λ does not take into account the efficient frontier of investments, and is furthermore unable to allow for constraints on short selling. Pizzutilo (2010) proposes an innovative tool, the *k*-value, as an alternative to λ for giving a more accurate measure of the improvements in risk/return that are afforded by international diversification. The *k*-value is herein employed along with the traditional correlation and efficient frontier analysis.

The classical mean-variance approach was deemed to be the most appropriate for the purposes of the

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research, and the use of historical, unconditional data was preferred. The focus of the paper is on country diversification, with no consideration being given to whether industry international diversification constitutes a better portfolio strategy.

Most studies on the international diversification have adopted the U.S. viewpoint, with relatively little being understood about this topic from a European perspective (Grubel, 1968; Levy & Sarnat, 1970, were among the very firsts; for a review of the literature on the subject see Shawky, Kuenzel, & Mikhail, 1997). By focusing on the markets of the Eurozone, the analysis presented herein fills this gap in the knowledge.

The remainder of the paper is organized as follows. Next section describes the data analysed. In the third section, the correlations between the returns of the equity markets of the European Monetary Union (EMU) are investigated. In the fourth section, the efficient frontier of the Eurozone stock markets is estimated for different time periods. The fifth section contains a quantitative valuation for the benefits of the Eurozone diversification. The last section concludes.

Data Description

To a practical extent, concentrating the analysis on the Eurozone stock markets permits to avoid or reduce some substantial problems that arise when the portfolio diversification profitability is empirically verified (like the exchange rates volatility, differences in expected and unanticipated inflation, divergences in the national tax systems, diversities in stock exchange trading times and bank holidays, restrictions on cross-border trading and investments, transaction costs).

In the analysis carried out in this paper, it is assumed that investors are risk-averse, and that they have preferences characterized by a mean-variance model. It is also assumed that investors are satisfied by investing only in equities and risk-free activities. Other kinds of investment are not considered.

The equity markets of the 11 countries that have adopted the Euro since 1999 are herein considered. Greece has adopted the currency on January 1, 2001 and has recently experienced a great financial crisis. In order to avoid that results could be biased by these circumstances Greece has been excluded from the sample along with the countries that have recently joined the Euro (Slovenia, Cyprus, Malta and Slovakia).

National stock indices are herein used as a close approximation to country-diversified share portfolios and are deemed to be a widely available opportunity of investment (e.g., think about the possibility to invest in exchange-traded funds on national indices).

The analysis covers the period 1999-2007. Late 2007 and the whole of 2008 saw a sharp rise in inflation across the Eurozone. In 2008, markets were subjected to what is now considered the worst period of turmoil since 1929. In the latter part of 2008 and during early 2009, short selling was restricted. In order to avoid these factors having a disproportionate effect on our analysis, data from the years 2008 and 2009 have not been included.

The analysis makes use of total return national indices[1]. This approach permits consideration of the ordinary dividends and reflects the yield of any reinvestment into the same index on the ex dividend date. Total return

[1] For Austria, France, and Italy for the years considered total return indices were computed only for the most liquid stocks. These total return indices have been taken into account in the analysis. The total return indices considered here are: ATX total return, Brussel All Share Total Return Index, OMX Helsinki Gross Index, SBF 250 Global Total Return, CDAX Index Performance, Athens Composite Total Return Index, ISEQ Return Overall, S&P/MIB Total Return, Return Lux General Index, AAX All Share Total Return, PSI General Index, and Bolsa de Madrid Total Index.

indices do not take into account the cost of reinvestment. For the high level of operational efficiency and concurrence in the European payment and clearing industry, it is assumed here that the cost of the dividend reinvestment is negligible. Even if all the indices are weighted on the market capitalization of the constituent shares, there is little difference between the calculation formulae (i.e., the weighting limits). These differences were deemed not to be relevant to the analysis of this paper.

Data were obtained directly from national stock exchanges. All yields are calculated as gross yields and the indices' returns are continuously compounded. All computations are carried out using the indices' closing prices.

Table 1

Correlations Between Austria and Other Euro Stock Markets

	AUT-BEL	AUT-FIN	AUT-FRA	AUT-GER	AUT-IRL	AUT-ITA	AUT-LUX	AUT-NED	AUT-POR	AUT-SPA
1999	0.4506	0.3530	0.5069	0.5372	0.3016	0.3065	0.2627	0.5353	0.2335	0.3913
2000	0.2403	0.2463	0.3385	0.3208	0.2489	0.3313	0.0930	0.3804	0.3023	0.3747
2001	0.4870	0.2368	0.4125	0.3598	0.4111	0.3877	0.2984	0.3756	0.3350	0.4135
2002	0.4768	0.4155	0.4533	0.3865	0.4024	0.3755	0.3314	0.4210	0.3506	0.4414
2003	0.2886	0.2661	0.3265	0.3295	0.2551	0.2867	0.1982	0.3326	0.3543	0.3156
2004	0.5787	0.4052	0.5851	0.6069	0.3830	0.5932	0.2419	0.5482	0.4460	0.5842
2005	0.5411	0.5643	0.5892	0.5393	0.3235	0.5452	0.3493	0.6254	0.3138	0.5290
2006	0.7251	0.7076	0.7242	0.7085	0.6764	0.6493	0.3510	0.7299	0.5247	0.7096
2007	0.7890	0.7783	0.8297	0.8294	0.7479	0.7846	0.3027	0.8293	0.6674	0.7858
1999-2001	0.3876	0.2579	0.4022	0.3921	0.3186	0.3377	0.1961	0.4149	0.2884	0.3885
2002-2004	0.4080	0.3594	0.4184	0.3917	0.3524	0.3697	0.2654	0.3914	0.3758	0.4210
2005-2007	0.7213	0.7089	0.7445	0.7240	0.6379	0.6865	0.3116	0.7520	0.5422	0.7080
2003-2007	0.5643	0.5152	0.5873	0.5430	0.5517	0.5581	0.2874	0.5386	0.4943	0.5911
1999-2007	0.4761	0.3398	0.4806	0.4474	0.4487	0.4161	0.2621	0.4547	0.3747	0.4663

Table 2

Correlations Between Belgium and Other Euro Stock Markets

	BEL-AUT	BEL-FIN	BEL-FRA	BEL-GER	BEL-IRL	BEL-ITA	BEL-LUX	BEL-NED	BEL-POR	BEL-SPA
1999	0.4506	0.4590	0.6997	0.6537	0.4750	0.5405	0.1772	0.6429	0.3886	0.5814
2000	0.2403	0.1533	0.2943	0.2470	0.2007	0.2326	0.1661	0.3903	0.1716	0.2670
2001	0.4870	0.4196	0.7066	0.6687	0.5869	0.6992	0.4300	0.7674	0.4859	0.5991
2002	0.4768	0.6842	0.8876	0.7565	0.6300	0.8347	0.3570	0.8963	0.6083	0.8209
2003	0.2886	0.5841	0.8765	0.7390	0.5601	0.7877	0.3612	0.8891	0.4798	0.8059
2004	0.5787	0.5347	0.8311	0.8272	0.5150	0.7705	0.3600	0.7452	0.6099	0.7871
2005	0.5411	0.5963	0.7684	0.7493	0.4523	0.7136	0.4293	0.7643	0.5001	0.7035
2006	0.7251	0.7828	0.9065	0.8741	0.7372	0.8327	0.2806	0.8746	0.5675	0.8596
2007	0.7890	0.7955	0.9066	0.8531	0.7391	0.8703	0.2727	0.9085	0.6496	0.7936
1999-2001	0.3876	0.3078	0.5463	0.5092	0.4210	0.4987	0.2561	0.6064	0.3363	0.4758
2002-2004	0.4080	0.6321	0.8783	0.7566	0.5899	0.8127	0.3558	0.8810	0.5618	0.8089
2005-2007	0.7213	0.7534	0.8817	0.8355	0.6907	0.8281	0.2875	0.8711	0.5961	0.8002
2003-2007	0.5643	0.6442	0.8723	0.7834	0.6093	0.8041	0.2954	0.8558	0.5450	0.7940
1999-2007	0.4761	0.4612	0.7620	0.6879	0.5475	0.6840	0.2856	0.7880	0.4548	0.6717

Correlation Analysis

In order to accurately reflect the relationships among markets, correlation analysis was carried out using

daily data[2]. Returns were calculated on the closing prices on the last day on which both of the markets under comparison were open[3]. Some stocks are listed in more than one exchange, which might influence the correlations positively. Although this overlapping could not be eliminated, it was fortunately limited to a negligible number of stocks. Next tables display the correlations matrices between the stock markets of the Eurozone for each year under analysis and for longer periods.

Table 3

Correlations Between Finland and Other Euro Stock Markets

	FIN-AUT	FIN-BEL	FIN-FRA	FIN-GER	FIN-IRL	FIN-ITA	FIN-LUX	FIN-NED	FIN-POR	FIN-SPA
1999	0.3530	0.4590	0.6276	0.5925	0.4526	0.5033	0.1925	0.6082	0.4344	0.5158
2000	0.2463	0.1533	0.6919	0.6394	0.3803	0.5366	0.4079	0.6454	0.6130	0.6306
2001	0.2368	0.4196	0.6841	0.5924	0.4118	0.5835	0.2051	0.6155	0.5249	0.6146
2002	0.4155	0.6842	0.7902	0.7016	0.5497	0.7487	0.2510	0.7729	0.5690	0.7394
2003	0.2661	0.5841	0.7145	0.6120	0.4431	0.6656	0.3402	0.6941	0.4248	0.6352
2004	0.4052	0.5347	0.6486	0.6400	0.4175	0.5960	0.2972	0.5680	0.4112	0.5534
2005	0.5643	0.5963	0.7221	0.6219	0.4320	0.6536	0.3648	0.6830	0.4227	0.6791
2006	0.7076	0.7828	0.8227	0.8174	0.7577	0.7550	0.2656	0.8192	0.5466	0.8076
2007	0.7783	0.7955	0.8432	0.8150	0.6836	0.7860	0.3037	0.8347	0.5979	0.7680
1999-2001	0.2579	0.3078	0.6765	0.6093	0.3988	0.5413	0.3007	0.6080	0.5426	0.5975
2002-2004	0.3594	0.6321	0.7481	0.6633	0.5014	0.7051	0.2888	0.7207	0.5027	0.6851
2005-2007	0.7089	0.7534	0.8118	0.7749	0.6494	0.7476	0.2907	0.7992	0.5410	0.7631
2003-2007	0.5152	0.6442	0.7421	0.6759	0.5272	0.6865	0.2823	0.7050	0.4691	0.6749
1999-2007	0.3398	0.4612	0.6895	0.6136	0.4424	0.6057	0.2691	0.6350	0.5232	0.6302

Table 4

Correlations Between France and Other Euro Stock Markets

	FRA-AUT	FRA-BEL	FRA-FIN	FRA-GER	FRA-IRL	FRA-ITA	FRA-LUX	FRA-NED	FRA-POR	FRA-SPA
1999	0.5069	0.6997	0.6276	0.8044	0.4887	0.7641	0.1792	0.7696	0.5512	0.7566
2000	0.3385	0.2943	0.6919	0.8375	0.3449	0.7776	0.4036	0.7997	0.6701	0.7911
2001	0.4125	0.7066	0.6841	0.8783	0.6109	0.8935	0.4044	0.9013	0.6552	0.8685
2002	0.4533	0.8876	0.7902	0.8575	0.6659	0.9373	0.3294	0.9574	0.6672	0.9045
2003	0.3265	0.8765	0.7145	0.8521	0.5975	0.9079	0.3469	0.9411	0.5071	0.9032
2004	0.5851	0.8311	0.6486	0.9486	0.5691	0.9040	0.3624	0.8454	0.5886	0.8795
2005	0.5892	0.7684	0.7221	0.9180	0.5791	0.8714	0.3851	0.9051	0.5088	0.8633
2006	0.7242	0.9065	0.8227	0.9614	0.7664	0.9046	0.3180	0.9490	0.5577	0.9215
2007	0.8297	0.9066	0.8432	0.9308	0.7764	0.9339	0.2948	0.9428	0.6868	0.8736
1999-2001	0.4022	0.5463	0.6765	0.8472	0.4856	0.8230	0.3720	0.8329	0.6330	0.8150
2002-2004	0.4184	0.8783	0.7481	0.8648	0.6306	0.9241	0.3391	0.9411	0.6047	0.8998
2005-2007	0.7445	0.8817	0.8118	0.9375	0.7304	0.9115	0.3042	0.9378	0.6090	0.8875
2003-2007	0.5873	0.8723	0.7421	0.8960	0.6467	0.9084	0.3032	0.9201	0.5605	0.8886
1999-2007	0.4806	0.7620	0.6895	0.8673	0.5877	0.8750	0.3248	0.8983	0.6056	0.8590

[2] I agree with the opinion that in the short term, prices can be strongly influenced by such factors as news or speculation, whereas over a longer time period the real factors tend to dominate. Nevertheless, the use of longer term returns for the correlation analysis, involves identifying the optimal time lag, the loss of the data derived from intraperiod variability, and a higher standard error.

[3] If market A is closed on day t and market B is not, the market return of A on day $t + 1$ could be affected by events that occurred on day t as well, but the same events could have affected the day t return of market B but not the return on day $t + 1$. This could cause a misrepresentation of the correlation if (as here) it is calculated using daily data. The approach adopted herein is intended to avoid this problem and is deemed to reflect the co-movements of the market rather better.

Tables 1-11 show that, for an EMU investor who was satisfied with investing only in risk-free assets and equities, it was viable to "Euro-diversify" his portfolio during the period analysed whatever his country of residence. Investors from leading European countries enjoyed greater opportunities for diversification by investing in minor economies, whereas the benefits that derived from investing in other leading markets appear rather small.

Table 5

Correlations Between Germany and Other Euro Stock Markets

	GER-AUT	GER-BEL	GER-FIN	GER-FRA	GER-IRL	GER-ITA	GER-LUX	GER-NED	GER-POR	GER-SPA
1999	0.5372	0.6537	0.5925	0.8044	0.4994	0.6371	0.1779	0.7905	0.4836	0.6760
2000	0.3208	0.2470	0.6394	0.8375	0.3692	0.7786	0.3236	0.7659	0.6807	0.7593
2001	0.3598	0.6687	0.5924	0.8783	0.5596	0.8474	0.3859	0.8351	0.5938	0.7917
2002	0.3865	0.7565	0.7016	0.8575	0.5432	0.8651	0.2161	0.8153	0.6170	0.7820
2003	0.3295	0.7390	0.6120	0.8521	0.4816	0.8225	0.2560	0.8304	0.4715	0.8235
2004	0.6069	0.8272	0.6400	0.9486	0.5688	0.9116	0.3614	0.8474	0.5850	0.8673
2005	0.5393	0.7493	0.6219	0.9180	0.5506	0.8580	0.3558	0.8669	0.4487	0.8486
2006	0.7085	0.8741	0.8174	0.9614	0.7666	0.9203	0.2726	0.9451	0.5401	0.9205
2007	0.8294	0.8531	0.8150	0.9308	0.7342	0.8792	0.3313	0.8974	0.6744	0.8526
1999-2001	0.3921	0.5092	0.6093	0.8472	0.4760	0.7721	0.3255	0.7964	0.5977	0.7530
2002-2004	0.3917	0.7566	0.6633	0.8648	0.5257	0.8532	0.2545	0.8238	0.5630	0.8020
2005-2007	0.7240	0.8355	0.7749	0.9375	0.6927	0.8871	0.3023	0.9061	0.5764	0.8724
2003-2007	0.5430	0.7834	0.6759	0.8960	0.5664	0.8539	0.2691	0.8591	0.5156	0.8384
1999-2007	0.4474	0.6879	0.6136	0.8673	0.5265	0.8157	0.2735	0.8256	0.5593	0.7842

Table 6

Correlations Between Ireland and Other Euro Stock Markets

	IRL-AUT	IRL-BEL	IRL-FIN	IRL-FRA	IRL-GER	IRL-ITA	IRL-LUX	IRL-NED	IRL-POR	IRL-SPA
1999	0.3016	0.4750	0.4526	0.4887	0.4994	0.3816	0.1075	0.4956	0.3462	0.3732
2000	0.2489	0.2007	0.3803	0.3449	0.3692	0.3149	0.2326	0.4355	0.2843	0.3343
2001	0.4111	0.5869	0.4118	0.6109	0.5596	0.5594	0.4237	0.6013	0.3774	0.4861
2002	0.4024	0.6300	0.5497	0.6659	0.5432	0.6095	0.4259	0.6573	0.4813	0.6390
2003	0.2551	0.5601	0.4431	0.5975	0.4816	0.5175	0.3819	0.5933	0.4352	0.5497
2004	0.3830	0.5150	0.4175	0.5691	0.5688	0.5277	0.3075	0.4705	0.3858	0.4957
2005	0.3235	0.4523	0.4320	0.5791	0.5506	0.4760	0.3594	0.5772	0.4176	0.5622
2006	0.6764	0.7372	0.7577	0.7664	0.7666	0.6826	0.2912	0.7481	0.4815	0.7296
2007	0.7479	0.7391	0.6836	0.7764	0.7342	0.7366	0.2444	0.7604	0.6576	0.7055
1999-2001	0.3186	0.4210	0.3988	0.4856	0.4760	0.4362	0.2826	0.5214	0.3328	0.4056
2002-2004	0.3524	0.5899	0.5014	0.6306	0.5257	0.5727	0.3907	0.6091	0.4569	0.5958
2005-2007	0.6379	0.6907	0.6494	0.7304	0.6927	0.6675	0.2669	0.7167	0.5774	0.6826
2003-2007	0.5517	0.6093	0.5272	0.6467	0.5664	0.5928	0.2871	0.5898	0.5204	0.6121
1999-2007	0.4487	0.5475	0.4424	0.5877	0.5265	0.5224	0.3023	0.5767	0.4223	0.5282

Compared with earlier studies of these phenomena, higher correlation may be observed (for specific data on the previous correlations among European equity markets (see Espitia & Santamaria, 1994; Rouwenhorst, 1999;

Kempa & Nelles, 2001; Adjaouté & Danthine, 2004; Flavin, 2004)[4], which points to a reduction in the benefits that may be obtained by spreading the portfolio into the equity markets of the Eurozone.

A generalised upward trend of the correlation is also evident during the period under investigation. Beckers (1999) reports a statistically significant upward trend in the correlations across the markets of EMU countries during the period 1988-1997, with an average increase in correlation coefficient of 0.024 per year. Bekaert, Hodrik, and Zhang (2008) found a significant upward trend in the correlation within Europe that seems to have started around 1986. The results of the correlation analysis conducted here confirm that this upward trend has continued during the first nine years following the introduction of the single European currency.

Table 7

Correlations Between Italy and Other Euro Stock Markets

	ITA-AUT	ITA-BEL	ITA-FIN	ITA-FRA	ITA-GER	ITA-IRL	ITA-LUX	ITA-NED	ITA-POR	ITA-SPA
1999	0.3065	0.5405	0.5033	0.7641	0.6371	0.3816	0.1037	0.6954	0.4219	0.7390
2000	0.3313	0.2326	0.5366	0.7776	0.7786	0.3149	0.2772	0.6965	0.6164	0.7362
2001	0.3877	0.6992	0.5835	0.8935	0.8474	0.5594	0.4332	0.8690	0.6027	0.8209
2002	0.3755	0.8347	0.7487	0.9373	0.8651	0.6095	0.2743	0.9012	0.6236	0.8746
2003	0.2867	0.7877	0.6656	0.9079	0.8225	0.5175	0.2832	0.8803	0.4692	0.8661
2004	0.5932	0.7705	0.5960	0.9040	0.9116	0.5277	0.3153	0.7834	0.5359	0.8633
2005	0.5452	0.7136	0.6536	0.8714	0.8580	0.4760	0.3214	0.8197	0.4854	0.8290
2006	0.6493	0.8327	0.7550	0.9046	0.9203	0.6826	0.2317	0.8994	0.5118	0.8685
2007	0.7846	0.8703	0.7860	0.9339	0.8792	0.7366	0.2535	0.8977	0.6180	0.8415
1999-2001	0.3377	0.4987	0.5413	0.8230	0.7721	0.4362	0.3164	0.7798	0.5535	0.7727
2002-2004	0.3697	0.8127	0.7051	0.9241	0.8532	0.5727	0.2806	0.8820	0.5650	0.8702
2005-2007	0.6865	0.8281	0.7476	0.9115	0.8871	0.6675	0.2493	0.8825	0.5563	0.8478
2003-2007	0.5581	0.8041	0.6865	0.9084	0.8539	0.5928	0.2526	0.8577	0.5186	0.8546
1999-2007	0.4161	0.6840	0.6057	0.8750	0.8157	0.5224	0.2735	0.8291	0.5527	0.8209

Table 8

Correlations Between Luxembourg and Other Euro Stock Markets

	LUX-AUT	LUX-BEL	LUX-FIN	LUX-FRA	LUX-GER	LUX-IRL	LUX-ITA	LUX-NED	LUX-POR	LUX-SPA
1999	0.2627	0.1772	0.1925	0.1792	0.1779	0.1075	0.1037	0.2162	0.1753	0.1310
2000	0.0930	0.1661	0.4079	0.4036	0.3236	0.2326	0.2772	0.4478	0.3058	0.3263
2001	0.2984	0.4300	0.2051	0.4044	0.3859	0.4237	0.4332	0.4219	0.2037	0.3314
2002	0.3314	0.3570	0.2510	0.3294	0.2161	0.4259	0.2743	0.3293	0.2925	0.3069
2003	0.1982	0.3612	0.3402	0.3469	0.2560	0.3819	0.2832	0.3651	0.2350	0.3241
2004	0.2419	0.3600	0.2972	0.3624	0.3614	0.3075	0.3153	0.3635	0.2703	0.3526
2005	0.3493	0.4293	0.3648	0.3851	0.3558	0.3594	0.3214	0.4304	0.3184	0.3729
2006	0.3510	0.2806	0.2656	0.3180	0.2726	0.2912	0.2317	0.3188	0.1869	0.2292
2007	0.3027	0.2727	0.3037	0.2948	0.3313	0.2444	0.2535	0.3313	0.1317	0.2133
1999-2001	0.1961	0.2561	0.3007	0.3720	0.3255	0.2826	0.3164	0.3856	0.2407	0.2941
2002-2004	0.2654	0.3558	0.2888	0.3391	0.2545	0.3907	0.2806	0.3440	0.2758	0.3198
2005-2007	0.3116	0.2875	0.2907	0.3042	0.3023	0.2669	0.2493	0.3314	0.1648	0.2329
2003-2007	0.2874	0.2954	0.2823	0.3032	0.2691	0.2871	0.2526	0.3097	0.1868	0.2574
1999-2007	0.2621	0.2856	0.2691	0.3248	0.2735	0.3023	0.2735	0.3281	0.2215	0.2734

[4] The small discrepancies between these data seem to reflect methodological differences and the use of different indices.

Rather interesting the significant reduction in the correlation with other Euro-countries experienced in 2000 by Austria, Belgium and Ireland.

The case of Luxembourg is noteworthy. Correlations with all other stock markets remain low and, above all, at broadly the same level for the whole period examined. Strong differences with other countries exist in terms of corporate and investor taxation, but these do not seem to be the only reason, and a specific investigation could shed more light on this. Nevertheless, Luxembourg made a strong contribution to a diversification strategy in the Eurozone. Moerman (2008) excludes Luxembourg from his data set altogether, which can partially explain his strong evidence that diversification across industries within the Eurozone yields a more efficient portfolio than diversification among individual countries.

Table 9

Correlations Between the Netherlands and Other Euro Stock Markets

	NED-AUT	NED-BEL	NED-FIN	NED-FRA	NED-GER	NED-IRL	NED-ITA	NED-LUX	NED-POR	NED-SPA
1999	0.5353	0.6429	0.6082	0.7696	0.7905	0.4956	0.6954	0.2162	0.4741	0.6890
2000	0.3804	0.3903	0.6454	0.7997	0.7659	0.4355	0.6965	0.4478	0.6222	0.7223
2001	0.3756	0.7674	0.6155	0.9013	0.8351	0.6013	0.8690	0.4219	0.6042	0.8001
2002	0.4210	0.8963	0.7729	0.9574	0.8153	0.6573	0.9012	0.3293	0.6387	0.8736
2003	0.3326	0.8891	0.6941	0.9411	0.8304	0.5933	0.8803	0.3651	0.5278	0.8969
2004	0.5482	0.7452	0.5680	0.8454	0.8474	0.4705	0.7834	0.3635	0.4629	0.7592
2005	0.6254	0.7643	0.6830	0.9051	0.8669	0.5772	0.8197	0.4304	0.4839	0.8061
2006	0.7299	0.8746	0.8192	0.9490	0.9451	0.7481	0.8994	0.3188	0.5510	0.9014
2007	0.8293	0.9085	0.8347	0.9428	0.8974	0.7604	0.8977	0.3313	0.6659	0.8249
1999-2001	0.4149	0.6064	0.6080	0.8329	0.7964	0.5214	0.7798	0.3856	0.5642	0.7460
2002-2004	0.3914	0.8810	0.7207	0.9411	0.8238	0.6091	0.8820	0.3440	0.5728	0.8649
2005-2007	0.7520	0.8711	0.7992	0.9378	0.9061	0.7167	0.8825	0.3314	0.5927	0.8466
2003-2007	0.5386	0.8558	0.7050	0.9201	0.8591	0.5898	0.8577	0.3097	0.5162	0.8369
1999-2007	0.4547	0.7880	0.6350	0.8983	0.8256	0.5767	0.8291	0.3281	0.5474	0.8035

Table 10

Correlations Between Portugal and Other Euro Stock Markets

	POR-AUT	POR-BEL	POR-FIN	POR-FRA	POR-GER	POR-IRL	POR-ITA	POR-LUX	POR-NED	POR-SPA
1999	0.2335	0.3886	0.4344	0.5512	0.4836	0.3462	0.4219	0.1753	0.4741	0.5239
2000	0.3023	0.1716	0.6130	0.6701	0.6807	0.2843	0.6164	0.3058	0.6222	0.7264
2001	0.3350	0.4859	0.5249	0.6552	0.5938	0.3774	0.6027	0.2037	0.6042	0.6666
2002	0.3506	0.6083	0.5690	0.6672	0.6170	0.4813	0.6236	0.2925	0.6387	0.6613
2003	0.3543	0.4798	0.4248	0.5071	0.4715	0.4352	0.4692	0.2350	0.5278	0.5726
2004	0.4460	0.6099	0.4112	0.5886	0.5850	0.3858	0.5359	0.2703	0.4629	0.5529
2005	0.3138	0.5001	0.4227	0.5088	0.4487	0.4176	0.4854	0.3184	0.4839	0.5328
2006	0.5247	0.5675	0.5466	0.5577	0.5401	0.4815	0.5118	0.1869	0.5510	0.5430
2007	0.6674	0.6496	0.5979	0.6868	0.6744	0.6576	0.6180	0.1317	0.6659	0.6839
1999-2001	0.2884	0.3363	0.5426	0.6330	0.5977	0.3328	0.5535	0.2407	0.5642	0.6482
2002-2004	0.3758	0.5618	0.5027	0.6047	0.5630	0.4569	0.5650	0.2758	0.5728	0.6191
2005-2007	0.5422	0.5961	0.5410	0.6090	0.5764	0.5774	0.5563	0.1648	0.5927	0.6125
2003-2007	0.4943	0.5450	0.4691	0.5605	0.5156	0.5204	0.5186	0.1868	0.5162	0.5862
1999-2007	0.3747	0.4548	0.5232	0.6056	0.5593	0.4223	0.5527	0.2215	0.5474	0.6280

Table 11

Correlations Between Spain and Other Euro Stock Markets

	SPA-AUT	SPA-BEL	SPA-FIN	SPA-FRA	SPA-GER	SPA-IRL	SPA-ITA	SPA-LUX	SPA-NED	SPA-POR
1999	0.3913	0.5814	0.5158	0.7566	0.6760	0.3732	0.7390	0.1310	0.6890	0.5239
2000	0.3747	0.2670	0.6306	0.7911	0.7593	0.3343	0.7362	0.3263	0.7223	0.7264
2001	0.4135	0.5991	0.6146	0.8685	0.7917	0.4861	0.8209	0.3314	0.8001	0.6666
2002	0.4414	0.8209	0.7394	0.9045	0.7820	0.6390	0.8746	0.3069	0.8736	0.6613
2003	0.3156	0.8059	0.6352	0.9032	0.8235	0.5497	0.8661	0.3241	0.8969	0.5726
2004	0.5842	0.7871	0.5534	0.8795	0.8673	0.4957	0.8633	0.3526	0.7592	0.5529
2005	0.5290	0.7035	0.6791	0.8633	0.8486	0.5622	0.8290	0.3729	0.8061	0.5328
2006	0.7096	0.8596	0.8076	0.9215	0.9205	0.7296	0.8685	0.2292	0.9014	0.5430
2007	0.7858	0.7936	0.7680	0.8736	0.8526	0.7055	0.8415	0.2133	0.8249	0.6839
1999-2001	0.3885	0.4758	0.5975	0.8150	0.7530	0.4056	0.7727	0.2941	0.7460	0.6482
2002-2004	0.4210	0.8089	0.6851	0.8998	0.8020	0.5958	0.8702	0.3198	0.8649	0.6191
2005-2007	0.7080	0.8002	0.7631	0.8875	0.8724	0.6826	0.8478	0.2329	0.8466	0.6125
2003-2007	0.5911	0.7940	0.6749	0.8886	0.8384	0.6121	0.8546	0.2574	0.8369	0.5862
1999-2007	0.4663	0.6717	0.6302	0.8590	0.7842	0.5282	0.8209	0.2734	0.8035	0.6280

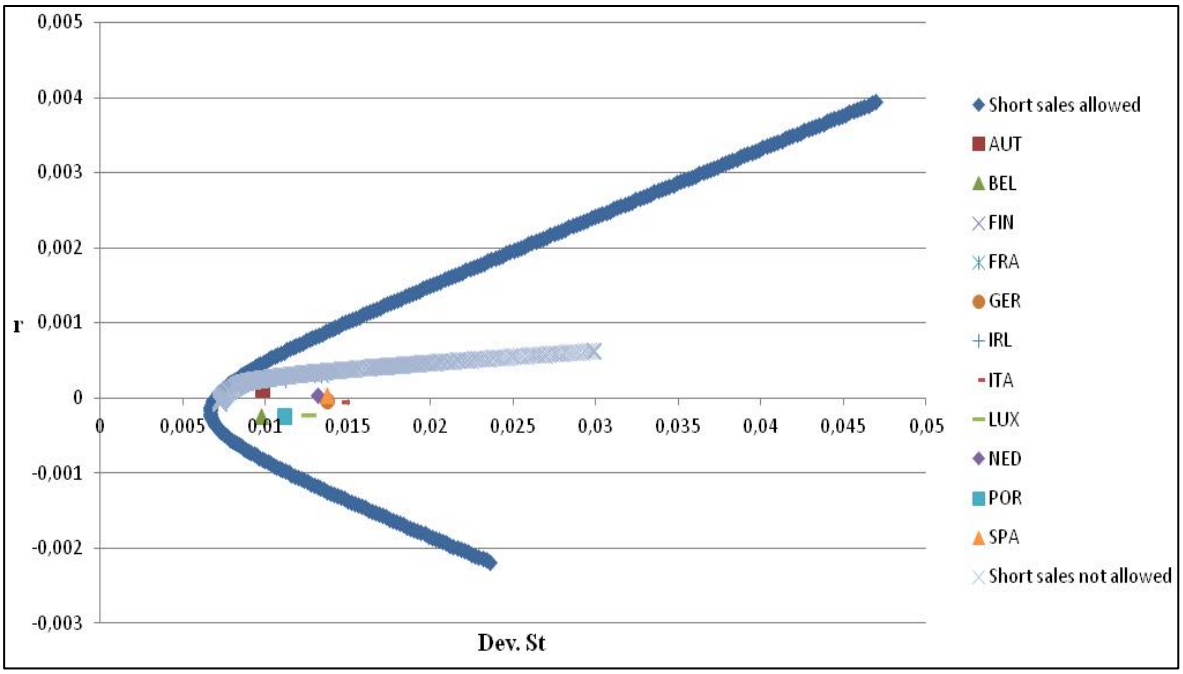

Figure 1. Subperiod 1999-2001. The envelope of feasible portfolios for investment in the national stock markets of the Eurozone when short selling is allowed (dark curve) and when it is forbidden (bright curve); years from 1999 to 2001.

Portfolio Efficient Frontier Analysis

The power of international diversification can be verified through the analysis of the efficient frontier. Figures 1-4 clearly shows the dominance of Euro-diversified portfolios over national ones in the period under examination. The dark curves in Figures 1-4 have been traced assuming that short selling is allowed and that the proceeds are entirely available and reinvested. In reality, this may not be the case. Chiou, Lee, and Chang (2009) recently

showed that additional constraints of short-selling and over-weighting significantly reduce, although do not completely eliminate, the benefits of diversification in international investments. Thus the profitability of the diversification among the Euro stock markets was also verified assuming that short selling is forbidden (bright curve in Figures 1-4). Even in this case, international diversification has continued to pay off but to a lesser degree.

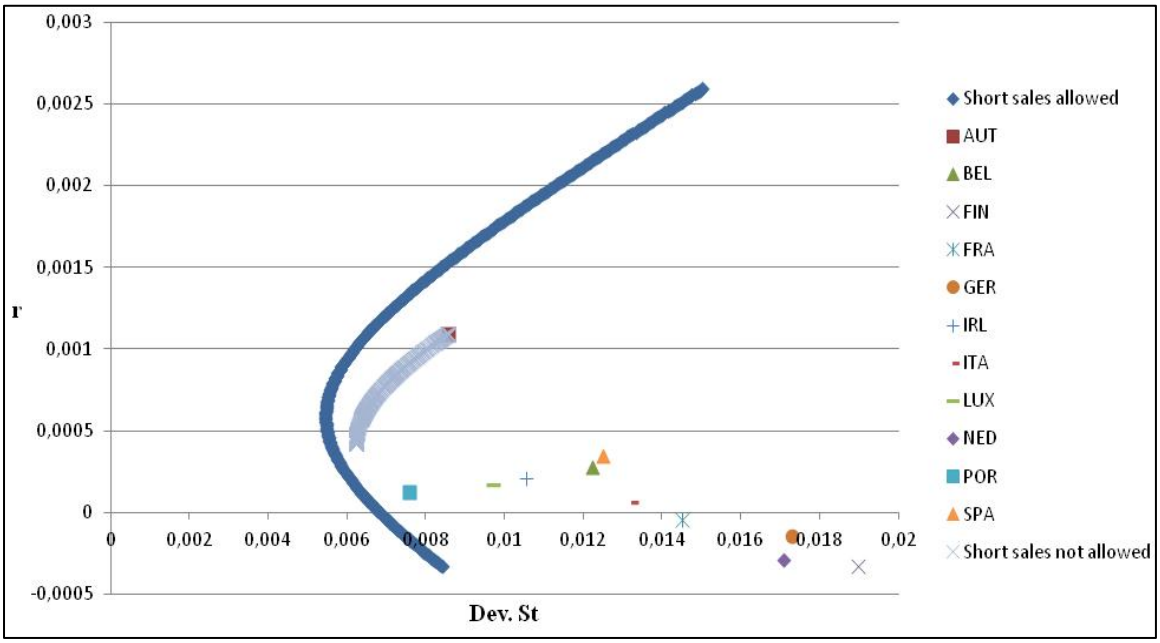

Figure 2. Subperiod 2002-2004. The envelope of feasible portfolios for investment in the national stock markets of the Eurozone when short selling is allowed (dark curve) and when it is forbidden (bright curve); years from 2002 to 2004.

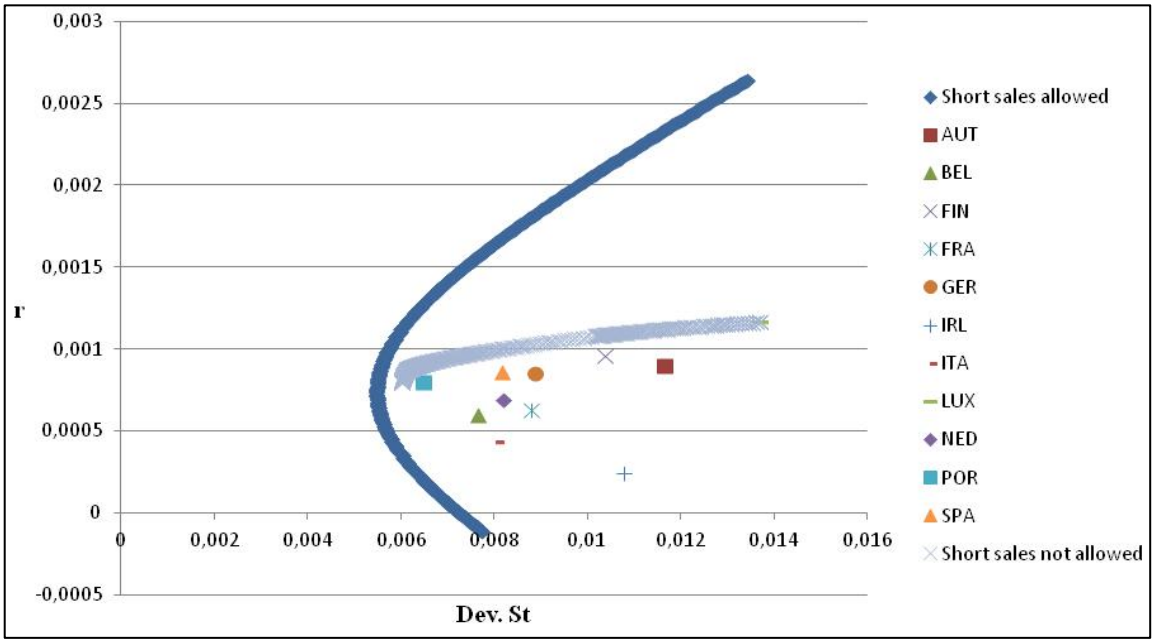

Figure 3. Subperiod 2005-2007. The envelope of feasible portfolios for investment in the national stock markets of the Eurozone when short selling is allowed (dark curve) and when it is forbidden (bright curve); years from 2005 to 2007.

For the construction of the efficient frontiers in Figures 1-4, the classical approach to portfolio selection by Markowitz (1959) was adopted. In the short selling allowed hypothesis, following Sharpe (1970) and Black (1972), the envelope of feasible portfolios was computed as the convex combination of two given envelopes of portfolios[5]. The variance-covariance matrix was calculated using the data described in previous sections, whose methodological assumptions and limits apply here. No corrections or shrinkages were operated to modify the matrix. Even though unconditional historical data are in general inadequate as economical and statistical estimates, and the use of an unconditional portfolio strategy is not appropriate for capturing the time variation in the conditional correlations, this is not the case here. The aim of this section is to assess whether diversification among national markets would have paid off in the period 1999-2007, and not to verify the value of an ex ante investment strategy. When restrictions on short selling are imposed it is no longer possible to determine the efficient frontier as a convex combination of any two envelopes of portfolios. The bright curves in Figures 1-4 have been traced by plotting a large number of efficient portfolios. The nonlinear optimisation used meets the Karush-Kuhn-Tucker conditions.

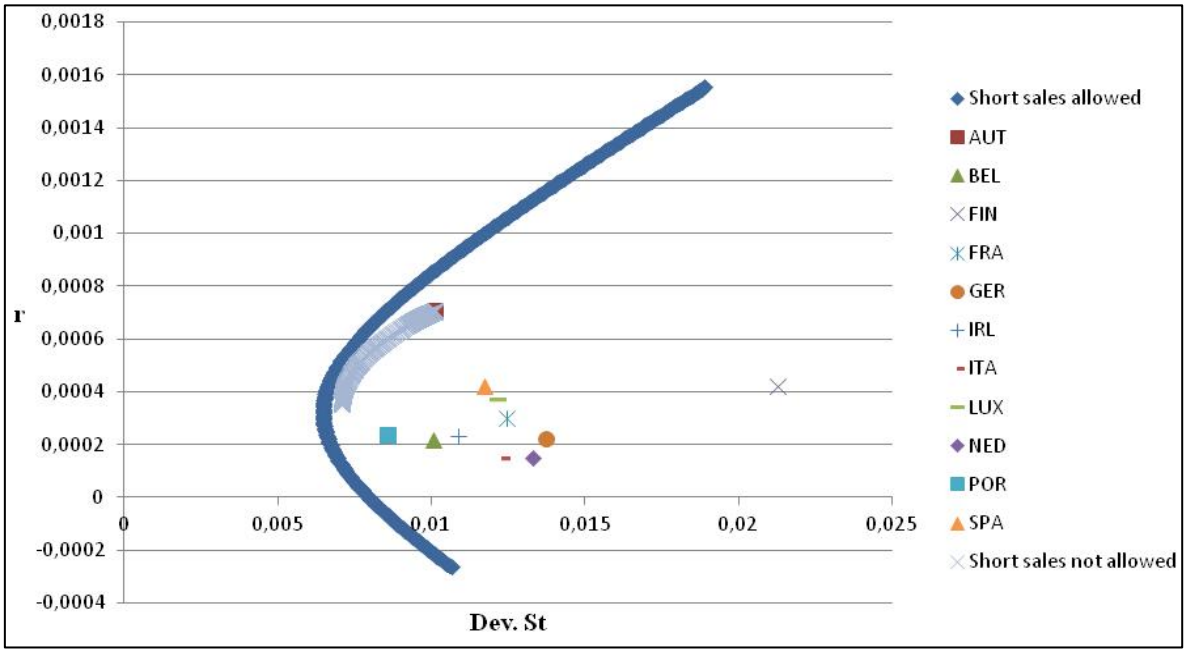

Figure 4. Subperiod 1999-2007. The envelope of feasible portfolios for investment in the national stock markets of the Eurozone when short selling is allowed (dark curve) and when it is forbidden (bright curve); years from 1999 to 2007.

Tables 12 and 13 show the returns, the standard deviations and the composition of the minimum variance portfolios of the efficient frontiers traced in Figures 1-4. They have been calculated according to Merton (1972).

[5] The two initial portfolios were derived by finding the vector z that solves the systems of simultaneous linear equations $E(r) - c = Sz$, where $E(r)$ is the vector of expected daily returns of the 12 indices, c is a constant, S is the variance-covariance matrix, and (x_{AUT}, x_{BEL}, …, x_{SPA}) the row matrix of the weights of the indices AUT, BEL, …, SPA invested in the envelope portfolio X where

$$x_i = \frac{z_i}{\sum_{j=1}^{n} z_j}.$$

The minimum variance portfolios do not include huge short or long positions in any of the indices. This is a remarkable point, and shows that the MVP would have represented a practicable investment even in the short selling allowed hypothesis.

Table 12

Composition of the MVP, Short Seles Allowed

Years	AUT	BEL	FIN	FRA	GER	IRL	ITA	LUX	NED	POR	SPA	Return	St. Dev.
99-01	28.4%	28.0%	-7.2%	-4.7%	-0.7%	18.2%	2.2%	18.5%	-13.5%	31.6%	-0.8%	-0.00017	0.00667
02-04	26.9%	16.8%	-3.3%	-22.1%	-7.1%	11.7%	32.8%	20.2%	-24.4%	45.0%	3.4%	0.00059	0.00545
05-07	-15.2%	37.9%	-6.5%	-58.3%	-3.6%	-8.0%	38.0%	11.9%	19.1%	63.2%	21.5%	0.00074	0.00549
99-07	18.5%	31.4%	-6.8%	-19.1%	-4.2%	12.2%	17.4%	18.1%	-18.9%	49.3%	1.9%	0.00032	0.00648

Note. Returns and standard deviations espressed using daily data.

Table 13

Composition of the MVP, Short Seles Not Allowed

Years	AUT	BEL	FIN	FRA	GER	IRL	ITA	LUX	NED	POR	SPA	Return	St. Dev.
99-01	29.9%	23.2%	0.0%	0.0%	0.0%	13.1%	0.0%	16.0%	0.0%	17.8%	0.0%	-0.00007	0.00723
02-04	29.6%	0.0%	0.0%	0.0%	0.0%	2.8%	0.0%	23.0%	0.0%	44.6%	0.0%	0.00043	0.00621
05-07	0.0%	13.2%	0.0%	0.0%	0.0%	0.0%	11.6%	10.2%	0.0%	65.1%	0.0%	0.00077	0.00601
99-07	20.1%	12.3%	0.0%	0.0%	0.0%	6.9%	0.0%	17.9%	0.0%	42.8%	0.0%	0.00035	0.00709

Note. Returns and standard deviations espressed using daily data.

Larger short and long positions must be retained in order to achieve higher levels of return and risk. It is also remarkable that none of the efficient portfolios in the short selling allowed hypothesis, for any of the four periods examined, include long positions in all 12 indices. It is noteworthy that in the short selling not allowed hypothesis Germany and the Netherlands are not included in any of the efficient portfolios for the four periods examined. Significant changes in national index weights may be observed when the efficient portfolios of the four periods are compared.

The Value of the Eurozone Diversification

Pizzutilo (2010) has recently developed a measure to quantify the benefits of the international diversification, the κ value:

$$\kappa = \sqrt{\frac{\sigma_n - \sigma_{\Pr n}}{\sigma_n} \cdot \frac{\left| r_n - r_{P\sigma n} \right|}{\left| r_n \right|}}$$

where σ_n and r_n are the standard deviation and the return of a national equity market index, respectively, σ_{Prn} is the standard deviation of the efficient portfolio with the same return as the national index if $r_n \geq r_{MVP}$, or is the standard deviation of the MVP if $r_n < r_{MVP}$, and $r_{P\sigma n}$ is the return of the efficient portfolio with the same standard deviation as the national index. If the national index is efficient, then both terms are null, $k = 0$, and no diversification benefits may be expected from an international investment strategy. If it is not efficient, k assumes a positive value, which denotes that opportunities may be derived from diversification. The lower the value of k, the lower the expected improvements that may, in relative terms, be derived from diversification. k can then be

interpreted as a measure of the joint risk-return improvement that can arise from diversification, consistently with portfolio theory, which explains the results of diversification in terms of risk reduction and/or increase in return. *k* is independent of the time unit used to express return and volatility and is usefully employable to measure the potential of international diversification both where short selling is permitted and where it is not[6]. The *k*-value can be usefully employed to distinguish the effects of where short selling is permitted and where it is not.

This measure has been here utilised in order to quantify the potentiality of a diversification strategy among the Eurozone stock markets. Tables 13 and 14 show the *k*-values for the stock markets of the Eurozone. Coherently with the efficient portfolio analysis in previous section, the *k*-values have been calculated for the overall period 1999-2007 and the three-year sub-periods.

The *k*-value analysis confirms that significant improvements in performance may be expected by investors in all Euro-countries. The benefits of international diversification would had been significantly reduced if constraints on short selling were there. Austrian investors were the people that had took less advantage from the diversification in the Eurozone stock markets. Investors from the European leading countries would had greatly benefitted from a Eurozone portfolio diversification strategy. Despite the conclusions that could have been drawn from the correlation analysis, the benefits of the diversification had not showed a constant reduction in the years. Actually, they significantly rose during the years 2002-2004.

Table 14

k-Values for the Euro-Area National Stock Markets When Short Sales Are Supposed to Be Allowed

	1999-2007	1999-2001	2002-2004		2005-2007	
	k	*k*	*k*	$Dk = k_{02\text{-}04}\text{-}k_{99\text{-}01}$	*k*	$Dk = k_{05\text{-}07}\text{-}k_{02\text{-}04}$
AUT	0.1869441	0.8687816	0.3103606	-0.5584210	0.9153849	0.6050244
BEL	1.0167459	0.9675604	1.9154170	0.9478566	0.6783035	-1.2371135
FIN	1.4605990	1.3288830	2.7850819	1.4561989	0.7367408	-2.0483411
FRA	1.1066985	0.7946291	6.2259073	5.4312782	0.8362511	-5.3896562
GER	1.4855958	3.6503788	3.8348121	0.1844333	0.6546903	-3.1801219
IRL	1.1023078	0.6591533	1.9679448	1.3087916	1.9897922	0.0218473
ITA	1.6707880	3.3203678	4.4384682	1.1181004	0.9375914	-3.5008768
LUX	0.9083784	1.4494113	2.0108281	0.5614169	0.8480263	-1.1628018
NED	1.8321186	2.9180744	2.7616066	-0.1564677	0.6938170	-2.0677896
POR	0.7078858	1.1886253	1.6502850	0.4616597	0.2972474	-1.3530375
SPA	0.7712081	3.0680552	1.7252090	-1.3428462	0.5533061	-1.1719029
Mean	1.1135700	1.8376291	2.6932655	0.8556364	0.8310137	-1.8622518

Notes. σ_{Prn} and $r_{P\sigma n}$ have been estimated with an approximation of 0.0000001 and tolerance of 0.001%. The last row shows the average *k*-value for any period and the average variation of the *k*-value from the previous subperiod.

The advantages appear to change significantly over time and from country to country. This is a remarkable point because it implies that while international diversification pays off, the settlement of ex ante efficient investment strategies is a complex matter.

[6] In order to determine *k* when short selling is assumed not to be allowed, it is necessary for r_{Pn} to be the return on the efficient portfolio with the same standard deviation as the national index if $\sigma_n \leq \sigma_{HVP,}$ or the return of the maximum variance efficient portfolio if $\sigma_n > \sigma_{HVP}$, where HVP denotes the efficient portfolio with the highest variance. The introduction of constraints on short selling implies that at least the highest return market lies on the efficient frontier (then its $k = 0$).

Table 15

k-Values for the Euro-Area National Stock Markets When Short Sales Are Supposed to Be Not Allowed

	1999-2007	1999-2001	2002-2004		2005-2007	
	k	*k*	*k*	$Dk = k_{02\text{-}04} - k_{99\text{-}01}$	*k*	$Dk = k_{05\text{-}07} - k_{02\text{-}04}$
AUT	0	0.48954575	0	-0.48954575	0.33986266	0.33986266
BEL	0.807116474	0.736923566	1.18907404	0.452150474	0.37084636	-0.81822768
FIN	0.667105061	0	1.718572493	1.718572493	0.202896197	-1.515676296
FRA	0.765939541	0.137964644	3.973407597	3.835442953	0.447073971	-3.526333625
GER	1.017606143	2.309005713	2.351998666	0.042992953	0.258708508	-2.093290158
IRL	0.844445795	0.191004187	1.320428193	1.129424005	1.258545778	-0.061882415
ITA	1.243301561	2.076727681	2.853165469	0.776437788	0.56854578	-2.284619689
LUX	0.610365955	1.031836861	1.398729699	0.366892838	0	-1.398729699
NED	1.316712546	1.747359911	1.755597904	0.008237993	0.351439122	-1.404158783
POR	0.524688136	0.881694514	1.065470372	0.183775858	0.098200382	-0.96726999
SPA	0.509386373	1.811657965	1.033469177	-0.778188788	0.20433402	-0.829135157
Mean	0.755151599	1.037610981	1.696355783	0.658744802	0.372768434	-1.323587348

Notes. σ_{Prn} and $r_{P\sigma n}$ have been estimated with an approximation of 0.0000001 and tolerance of 0.001%. The last row shows the average *k*-value for any period and the average variation of the *k*-value from the previous subperiod.

In order to facilitate the ex ante portfolio optimization process, the stability over the time of the correlations and the variance-covariance matrices plays a critical role. To gain more insight into this phenomenon, for the years and for the stock markets under investigation in this paper, the equality of the year by year and three-year by three-year correlation matrices was investigated using the widely recognised Jennrich (1970) test. The results, presented in Table 16, in agreement with Adjaouté and Danthine (2004), show that the stability hypothesis must be rejected. Even if the Jennrich test is confined to the leading five countries (Germany, France, Italy, Spain, and the Netherlands) or just to the leading three, the stability hypothesis must be rejected at the 1% confidence level. Furthermore the Box-M test rejects the null hypothesis of stability of the covariance matrices over both a yearly and a three-year time-span. While it seems that international diversification pays off, it is difficult to settle ex ante efficient strategies for international diversification, particularly if they are based on historical data.

Table 16

Jennrich Test of Stability, Hypothesis H0: Correlation Matrices of Periods R1 and R2 Are Not Significantly Different. Degrees of Freedom: 55

*R*1	*R*2	Jennrich test value	*p*-value
'99-'01	'02-'04	348,569	(0.0000)
'02-'04	'05-'07	347,443	(0.0000)
1999	2000	299,195	(0.0000)
2000	2001	383,902	(0.0000)
2001	2002	362,512	(0.0000)
2002	2003	258,712	(0.0000)
2003	2004	609,330	(0.0000)
2004	2005	357,698	(0.0000)
2005	2006	488,004	(0.0000)
2006	2007	481,176	(0.0000)

Conclusions

The aim of this paper was to examine the effectiveness of equity portfolio diversification into the Eurozone stock markets, despite the monetary unification process.

The results have clearly shown that diversification into Eurozone equities pays off. The introduction of constraints on short selling significantly reduces the potential gains from diversification. For asset managers and practitioners, this implies that, despite the unification process, and notwithstanding the high correlations between the European stock markets, opportunities for diversification within the Eurozone still exist. This appears to be true, even for the leading countries whose stock markets show very high correlations with each other.

The results are conclusive in reflecting the instability of the historical mean-variance data. From a practical standpoint, this implies that while international diversification pays off its benefits vary between years and the settlement of ex ante efficient investment strategies is a complex matter.

Pizzutilo's (2010) *k*-value has been utilised to measure the benefits of the Eurozone diversification. If just 25% of the gains measured using the *k*-value for the years 1999-2007 could have been achieved implementing an ex ante portfolio strategy, this would have resulted in a significant improvement in terms of risk/return for an EMU investor. The open question relates to the possibility of obtaining an ex ante optimal portfolio diversification strategy; it is thus desirable for portfolio theory to address this matter.

A growing trend in the correlation between the stock markets of the Eurozone is apparent, even though it is not clear whether the advantages of diversification have decreased. As argued by Goetzmann and Jorion (1997) the boost to the opportunity investment set may have, in part, offset the effect of the increased correlations and/or the time-varying volatility of the market could have had a significant influence on the value of diversification.

Most of the previous literature on international diversification has adopted an U.S. viewpoint. Relatively little was known about this subject from a European perspective. By focusing the analysis on the markets of the Eurozone, this paper has also filled this gap in the knowledge.

Diversely from most of the previous literature, the analysis here conducted has shown the overall benefits of international diversification, representing its performance from the point of view of investors in all the countries under investigation.

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