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Abstract

This paper analyzes whether deregulation, globalization, recent financial crises, the convergence of European economies and the introduction of the euro have produced some effects on the return distribution of the world market index and on the volatility spillover from the world index to European stock markets. Using multivariate switching regime models we test these issues for the world equity index and some European capital market indexes. Our results suggest that in the last five years the world index volatility has increased as has the idiosyncratic German risk factor. Moreover, the volatility spillovers from both the world index and the German market have increased after EMU for most European stock markets.

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Keywords: Stock market volatility, EURO, Switching Regime Models.

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1 Introduction

During the last two decades the world has gone through a period of deregulation, globalization and financial crises. Moreover, Europe has observed a period of extraordinary economic and monetary integration culminating in the introduction of the euro in January 1999. In addition, significant progress has been made in strengthening and deepening the various European capital markets.

The main objective of this study is to shed some light on whether recent financial crises and the efforts for a greater economic, monetary and financial integration have fundamentally altered the sources and intensity of shock spillover to the individual European stock markets in terms of the links (i) with the rest of the world and (ii) between one another.

Concerning the first issue, we would like to analyze whether the EMU has been associated with: (i) a different link with the rest of the world, and (ii) an overall change in the stochastic volatility process of the market.

Concerning the second issue, we would like to analyze whether the convergence of European economies and the EMU have been associated with: (i) a convergence of European stock returns, and (ii) a change in the stochastic volatility process of stock returns.

A good understanding of the origins and transmission intensity of shocks is necessary for many financial decisions including optimal asset allocation, the construction of global hedging strategies, as well as the development of various regulatory requirements, such as capital requirements or capital controls.

In the rest of the paper we refer to the sources of financial integration only in terms of euro introduction. However, since we are unable to perform such case study without considering also the implication of globalization, deregulation and financial crises, our analysis implicitly considers all these effects.

The implications of the EMU on the variances and covariances of European capital market excess returns and with the rest of the world could be studied with standard (linear) econometric methods. Nevertheless, it is a well-established fact that financial volatility is a stochastic process with a non-negligible degree of persistence. To understand the implications of the EMU on volatility spillover more knowledge of the processes that drive volatility is required. For this reason we suggest a new and relatively simple method of analyzing the impact of the EMU on European stock market volatilities: the "switching regime beta approach". This approach is able to allow shifts in the stochastic volatility model driving stock market return and analyze the link between markets, taking into consideration time varying volatility characterized by persistence.

Apart from the focus on Europe, this paper distinguishes itself from other papers (King and Wadhwani (1990), Hamao *et al.* (1990), Lin *et al.* (1994), Karolyi (1995), Koutmos and Booth (1995), Kanas (1998), Ng (2000), Fratzscher (2001)) by analyzing shock spillover using switching regime models.

There are several reasons why regime switching models represent a good approach to analyze volatility spillover. First, this technique makes it possible to take into account the shifts between high and low states of volatility and correlations due to changes in

the economic and financial context. Second, using this methodology, the persistence in second moments is reduced so that the problem of underestimated volatility in the high volatility state or the one of overestimated volatility in the low volatility state are overcome. Third, it allows for the fact that the time-varying character of conditional correlations, which is stressed in several studies (e.g. Bekaert and Harvey (1995), Bekaert and Harvey (1997), Xiong (2001) and Kyle and Xiong (2001)), is due also to regime switches in the spillover parameters.

In the literature there are two previous works that use switching regime models to analyze volatility in the European stock markets: Beltratti and Morana (2000) and Baele (2002). However, these authors are not able to investigate whether most recently after the EMU, Asian crisis and globalization we do observe a break in the structure of volatility spillover from the world market index to European market indexes. In this paper we allow for the presence of a structural break in all or part of the parameters estimated. In particular we do not just investigate whether more recently the market indexes are characterized by high volatility regime but whether, respectively, in the high or low volatility regime we observe a structural break, that is if the high or low volatility parameters have been changed.

To anticipate the main empirical results, the structure of the estimated volatility distribution suggests that in the last four years the world index distribution has observed an increase in the volatility parameter of the low regime. This means that in recent years, when markets are stable they present an higher volatility than before. Concerning the German idiosyncratic risk, the transition probabilities indicate an increase of the frequency of visiting the high volatility regime. Moreover, the link between European countries, which is usually higher when the volatility is high, in recent years has been increased. This means that the importance of the world market index shocks and of the German shocks spillover have increased for the EMU countries.

However, the introduction of the euro has reduced the idiosyncratic volatility and increased the frequency of visiting the low volatility regime for the French and Italian idiosyncratic risk.

The outline of the paper is as follows. We start by presenting the econometric methodology in Section 2. In Section 3 we discuss theoretical models and present in detail the economic meaning of our analysis. In Section 4 we describe the data and present our empirical results. Section 5 concludes.

2 Econometric methodology

With our analysis we want to establish implications of the EMU, financial crisis and globalization for time-varying volatility and intra-market dependence among European stock markets and with the rest of the world. Here only a few studies have been conducted. Engle and Susmel (1993) and King *et al.* (1994), Hassler (1995), and Rouwenhorst (1999) estimate multivariate models with common factors.

An often noted observation is that there appear to be regime shifts in the variance-covariance matrix of different national stock market indexes[1]. During periods of high

[1]Among the many authors documenting this include Longin and Solnik (1998, 1995) Das and Uppal

volatility there appears to be a tendency for higher international dependence. This observation calls for an attempt to apply Hamilton's regime switching models (Hamilton (1989), Hamilton Susmel (1994) and Hamilton and Lin (1996)) to a multivariate dataset of stock market returns[2]. Using such a model we can allow discrete shifts in the stochastic volatility model driving the stock markets.

The change in regime should not be regarded as predictable but as a random event. The effect of these risk shifts should be taken into account when the aim of the study is to analyze the stochastic process of equity market volatility and links between markets. For this purpose, the dynamics of the volatility process of the major European stock markets are analyzed using a Markov switching approach.

The advantage of using a Markov chain opposed to a Bernoulli specification for the random discontinuous shift is that the former allows conditional information to be used in the forecasting process. This allows us: (i) to fit and to explain time series dynamics, (ii) to capture the well-known cluster effect, under which high volatility is usually followed by high volatility (presence of persistent regimes), (iii) to generate better forecasts compared to the mixture of distributions, since switching regime models generate a time conditional forecasted distribution rather than an unconditional forecasted distribution.

In this paper we use a Switching Regime Beta Model (see Billio and Pelizzon (2000)) since it is inconclusive to analyze the impact of the EMU on volatility spillover ignoring the fact that European markets are linked to the rest of the world and many other phenomena happened during and after the introduction of the euro.

We assume that the sovranational stock market is driven by a stochastic process with two states, a low volatility and a high volatility state. National stock markets are affected by the sovranational stochastic process and by a domestic idiosyncratic process. Also the volatility of the latter may shift between two regimes.

In particular, we analyze whether the euro, globalization, deregulation and financial crises, have affected the process of the world market index and whether the introduction of the euro has changed the stochastic process of the idiosyncratic factor risk of the European leading country, Germany, and some other European countries such as France, Italy, Spain and the UK. Furthermore, we also shed some light on the link between the leading market (Germany) and other European countries. It is important to stress that we analyze whether the link between the world index and European countries and the integration among the European countries increase when the volatility increases, and also whether the level of such links has a break before and after the EMU.

Financial markets anticipate real economies due to the forward-looking nature of investors who may have set prices even before the end of 1998 with an eye towards the future introduction of the euro. It is conceivable thus that in 1998 there was already an anticipation of the EMU implications on the stochastic process of equity excess returns. For this reason, we test for the change in the distribution parameters at the beginning

(1996), De Santis and Gerard (1997), King *et al.*(1994) and Erb *et al.* (1994).

[2]Switching regime models have been applied to stock market returns, assuming that returns are characterized by a mixture of distributions. This gives rise to a fat-tailed distribution, a feature of the return data which has been extensively documented since the early work by Mandelbrot (1963). Recent estimates of switching regime models of stock returns appear in Ramchand and Susmel (1998) and Hamilton and Lin (1996), Dueker (1997).

of 1998.

2.1 Simple Switching Regime Models

In the literature stock market returns or excess returns are usually modelled with a Simple Switching Regime Model (SSRM), which can be written as:

$$R_t = \mu(s_t) + \Sigma(s_t)\varepsilon_t \tag{1}$$

where $R_t = \ln(P_t/P_{t-1}) - r_t$ is the vector of excess returns of market indexes of dimension N, $\varepsilon_t \sim IIN(0, I)$, P_t is the stock price or the index price and r_t is the interest rate, s_t is a Markov chain with k states and transition probability matrix P. In particular if $k = 2$, we have:

$$R_t = \begin{cases} \mu_0 + \Sigma_0\varepsilon_t \text{ if } s_t = 0 \\ \mu_1 + \Sigma_1\varepsilon_t \text{ if } s_t = 1 \end{cases}$$

and the transition matrix P is:

$$P = \begin{bmatrix} p & 1-p \\ 1-q & q \end{bmatrix} \tag{2}$$

where the parameters p and q represent the probabilities that volatility remains in the same regime. In the model the variance and mean of returns change only as a result of discrete events.

With this model the state is the same for all the stock markets and then the mean and the variance of the vector process R_t change according to a single state variable s_t. On the contrary, it is possible to assume that there are country specific states and that the movements across states are independent. Then each country stock market excess return is described by a univariate SSRM.

We are interested in the link between stock markets and then we need to consider more general switching regime models which allow a better description and understanding of these relations.

2.2 Switching Regime Beta Models

The SSRM does not provide an explicit link between the stock excess return of one country and the stock excess return of a leading country (or of a sovranational market). Following Billio and Pelizzon (2000), we consider the Switching Regime Beta Model (SRBM), which is a sort of one-factor model where the excess return of a country i is characterized by the regime switching of the leading market index and the regime switching of the specific risk of the country. The SRBM can be written as:

$$\begin{cases} R_{mt} &= \mu_m(s_{mt}) + \sigma_m(s_{mt})\varepsilon_t, & \varepsilon_t \sim IIN(0,1) \\ R_{it} &= \mu_i(s_{it}) + \beta_i(s_{mt}, s_{it})R_{mt} + \sigma_i(s_{it})\varepsilon_{it}, & \varepsilon_{it} \sim IIN(0,1) \end{cases} \tag{3}$$

where s_{mt} and s_{it} are two independent Markov chains and ε_{it} and ε_t are independently distributed.

In such a framework the conditional mean of the single market is given by $\mu_i(s_{it})$, which is specific, plus the factor loading $(\beta_i(s_t, s_{i,t}))$ for the conditional mean of the factor. The factor loading compensates for the risk of the single market which depends on the factor: higher covariances demand higher risk premiums. The variance is the sum of the variance of the leading or sovranational market weighted by the factor loading and the variance of the idiosyncratic risk.

The SRBM considers only a single asset, but can be generalized for a vector of excess return taking into account the correlation between different markets.

2.3 Multivariate Switching Regime Model

The generalized version of the SRBM, considering N markets, that we call the Multivariate Switching Regime Model (MSRM), can be written as:

$$\begin{cases} R_{mt} &= \mu_m(s_{mt}) + \sigma_m(s_{mt})\varepsilon_t, & \varepsilon_t \sim IIN(0,1) \\ R_{1t} &= \mu_1(s_{1t}) + \beta_1(s_{mt}, s_{1t})R_{mt} + \sigma_1(s_{1t})\varepsilon_{1t}, & \varepsilon_{1t} \sim IIN(0,1) \\ R_{2t} &= \mu_2(s_{2t}) + \beta_2(s_{mt}, s_{2t})R_{mt} + \sigma_2(s_{2t})\varepsilon_{2t} & \varepsilon_{2t} \sim IIN(0,1) \\ \vdots & & \\ R_{Nt} &= \mu_N(s_{Nt}) + \beta_N(s_{mt}, s_{Nt})R_{mt} + \sigma_N(s_{Nt})\varepsilon_{Nt}, & \varepsilon_{Nt} \sim IIN(0,1) \end{cases} \tag{4}$$

where s_{mt} and s_{jt}, $j = 1, ..., N$ are independent Markov chains, ε_t and ε_{jt}, $j = 1, ..., N$, are independently distributed.

Using this approach we are able to take into account the correlation between different assets. In fact, if we consider $k = 2$, two stock market returns, and, for example, $s_{mt} = s_{1t} = 0$ and $s_{2t} = 1$, the variance-covariance matrix between the two markets is:

$$\Sigma(0,0,1) = \begin{bmatrix} \beta_1^2(0,0)\sigma_m^2(0) + \sigma_1^2(0) & \beta_1(0,0)\beta_2(0,1)\sigma_m^2(0) \\ \beta_2(0,1)\beta_1(0,0)\sigma_m^2(0) & \beta_2^2(0,1)\sigma_m^2(0) + \sigma_2^2(1) \end{bmatrix} \tag{5}$$

then the correlation between different assets is given by β's parameters and the leading or sovranational market variance.

In this model the covariance between market 1 and market 2 depends on the extent to which each market is linked, through the factor loading β to the leading or sovranational market index.

3 Regime switching models and tests

Factor models break down the returns of securities into two components. The excess return of each risky investment is determined by: a relatively small number of common factors, which are proxies for those events in the economy that affect a large number of different investments, and a risk component that is unique to the investment. The

simplest possible factor model is a one-factor model. It is often convenient to think of this one factor as the excess world index return and to refer to the model as the market model.

With the conditional version of this model based on switching regimes in volatility we would like to analyze the implications of the EMU on European stock market volatilities and correlations. Our purpose is only positive, we do not attempt to analyze the implications of the EMU on the world equity price. Nevertheless, the switching regime models presented in the previous section offer a number of testable implications concerning the impact of the EMU on the risk premia. First, with the SSRM we can analyze any possible change (structural break) in the stochastic switching regime process of the world-wide market before and after the EMU. In particular we evaluate whether we observe a structural break in the high and low volatility parameters, i.e. whether for example the high volatility parameter after December 1997 has been higher or lower than before[3]. We are conscious that this analysis will provide only some insights about this issue since we are unable to study the world-wide portfolio process before and after the EMU maintaining the rest of the world *ceteris paribus*. We cannot ignore the financial crisis that we observed during and after the introduction of the EMU (Asian Crisis, Russian crisis, "Hi-tech revolution"). Nevertheless, our analysis is important since it shows whether the stochastic process of the world index and European stock market indexes have been changed over the last four years.

Second, SRBM could be a useful tool to analyze the implication of the EMU on the link between the European Stock Markets and the rest of the world. In particular we examine whether there is any evidence of change in the link (beta parameters) between the European markets and the world index.

The beta parameter is the ratio of the covariance between the European stock return and the world market portfolio return and the variance of the latter. The world market return seems to be weakly affected by the European convergence process, given the weight of the European stock markets on the world portfolio, currently lower than 20% (the loss in terms of diversification is low). The covariance can be thought as the product of the correlation coefficients and the standard deviation of the two returns. If the correlation coefficient is constant or weakly higher, then a decrease in variance associated with the elimination of the exchange risk may reduce the beta. However, if the volatility of the European stock market is higher then the beta may be higher.

The introduction of the euro may affect the volatility of the overall European market and could also modify the volatility of the idiosyncratic (countries) risk factors.

We analyze the implications of the introduction of the euro on the link between the world index and respectively Germany, France, Italy, Spain and the UK, which are the most capitalized stock markets in Europe.

Moreover, concerning France, Italy and Spain we also analyze whether the introduction of the euro has changed the stochastic process of the European equity markets (i.e. the link with the Germany market, the frequency of visiting the high volatility regime or the level of the volatilities), using the German market as factor in a SRBM

[3]It is worthwhile to stress that we do not just analyze whether we observe a change in the volatility regime after December 1997.

	World	Germany	France	Italy	Spain	UK
Mean	0,000752	0,001321	0.001517	0.000381	0.000718	0.000708
Standard deviation	0,021863	0,026473	0.026183	0.033988	0.031080	0.023131
Skewness	-0,53876	-0,37392	-0.226849	-0.119887	-0.559065	0.118444

Table 1: Summary statistics

model. In fact, the introduction of the euro may give rise to a double effect. First, the adoption of a single currency is likely to have a significant impact on European equity markets and in particular on their correlation. For example it is often argued that the convergence of economic structures and policies, the existence of a single currency and identical interest rates will increase correlations among the European stock markets, and, as a consequence, reduce the benefits of portfolio diversification. The implication of the increase of correlation is a potential increase of the beta[4] (the ratio between the covariance of the stock market and the German market over the variance of the German market). As already stressed, the covariance increases with the monetary union, because the introduction of the euro could initially cause a greater uncertainty and a higher volatility. This implies that the betas, respectively in the high and low volatility regime, could remain stable or increase depending on which of the two effects (increase in correlation or increase in volatility) dominates. We study this phenomenon with a SRBM model with dummies for betas $(\beta_{\mathbf{0},0}, \beta_{\mathbf{0},1}, \beta_{\mathbf{1},0}, \beta_{\mathbf{1},1})$ and sigmas $(\sigma_{\mathbf{0}}, \sigma_{\mathbf{1}})$ and test if betas and volatilities have changed with the EMU process. In this way we are able to verify whether there are any statistical significant changes, before and after the EMU introduction in the betas and volatility parameters that characterize the equity returns in the high and the low volatility regimes respectively.

4 Data description, estimation and tests

We use weekly returns on stock indexes for five continental European countries (Germany, France, Italy, Spain, and the UK) plus a value-weighted world index. All the indexes are obtained from Morgan Stanley Capital International (MSCI) and are converted into Deutsche Marks. The sampling period (January, 1988 to February, 2001) covers 687 observations. To determine the equity excess return we use Eurocurrency rates offered on the interbank market in London for one week deposits in Deutsche Marks (summary statistics are reported in table 1). The switching regime models described in Section 2 with structural breaks in the parameters offer a number of testable implications presented in Section 3 which are of primary interest in our study.

[4]We expect to observe this phenomenon both for the unstable (e.g. Italy and Spain) and the stable countries (e.g. France).

4.1 The world index

Our first analysis is whether world-wide market risk premia volatility did change after December 1997. As we have pointed out in the introduction, it is not sufficient a test for a reduction in the unconditional variance of stock return after the date of the introduction of the euro by means of a dummy variable due to the forward-looking nature of investors who may have set prices even before the end of 1998 with an eye towards the future introduction of the euro. In fact, financial markets anticipate real economies, so that it is conceivable that in 1998 there was already an anticipation of EMU implications on the stochastic process of equity excess returns.

We use the SSRM in order to analyze any difference in the stochastic process of the world-wide market before and after December 1997. First we estimate the model with all the available data and make the inference of being in one of the two volatility regimes for each date of the sample using the Hamilton filter and smoothing algorithm (Hamilton, 1994). Figure 1 shows the resulting series. From it we observe that in the last part of the sample the world index returns are frequently characterized by high volatility. This outcome is generated mainly by the high instability of the financial markets in the last years starting from the Asian crisis up to the high-tech revolution and the latest Japanese crisis of March 2001.

In order to evaluate the change in the stock market volatility after December 1997, we analyze the behavior of the world index by allowing all parameters to change and perform the corresponding Likelihood Ratio (LR) test. Table 2 provides the test results. The LR test does not reject the null hypothesis of no change in the parameters of the distribution of the excess return of the world index. Nevertheless, a test which only considers a change in the parameters that characterize the time varying volatility evidences a structural break on the value of the volatility in the low volatility regime[5]; in particular the volatility parameter is higher in the high state of volatility. Figure 1 and table 2 suggest that it is not only in the last four years that the world index has been frequently characterized by the high volatility state, but that the volatility parameter in the low volatility state is now higher. This means that even when the market could be considered relatively stable, the volatility parameter is now higher.

As we have stressed above, from 1997 many events have affected the world financial markets. Because of those events, we are unable to disentangle whether the EMU has produced any minimal effect on the world index volatility distribution. Our finding suggests that the new-economy, the explosion of the hi-tech market, all the different financial crises and the introduction of the euro have generated a structural change in the world financial market index in terms of an increase of the volatility parameter in the low volatility regime (the high volatility regime has remained almost the same). This means that tranquil periods are now characterized by a higher volatility even if the EMU may have reduced the world index volatility by eliminating one source of risk: the exchange rate.

[5]The univariate tests are significance tests and are bilateral. For example at a confidence level of 5%, the null hypothesis is rejected if the p-value is higher than 0.95 or is lower than 0.05. If the p-value is close to 1 it means that the parameter has increased after the EMU. If it is close to zero, the parameters have decreased.

	World Index (univariate)	Germany (univariate)
All parameters	0.16	**0.008**
Test on sigmas		
$\sigma_0 = \sigma_{0d}$	0.053	**0.99**
$\sigma_1 = \sigma_{1d}$	**1.00**	**1.00**
Transition probabilities	0.18	**0.01**

Table 2: Univariate switching regime models, p-value test statistics. The label 0 indicates high volatility and 1 low volatility. Bold figures indicate the rejection of the null hypothesis at the confidence level of 5%.

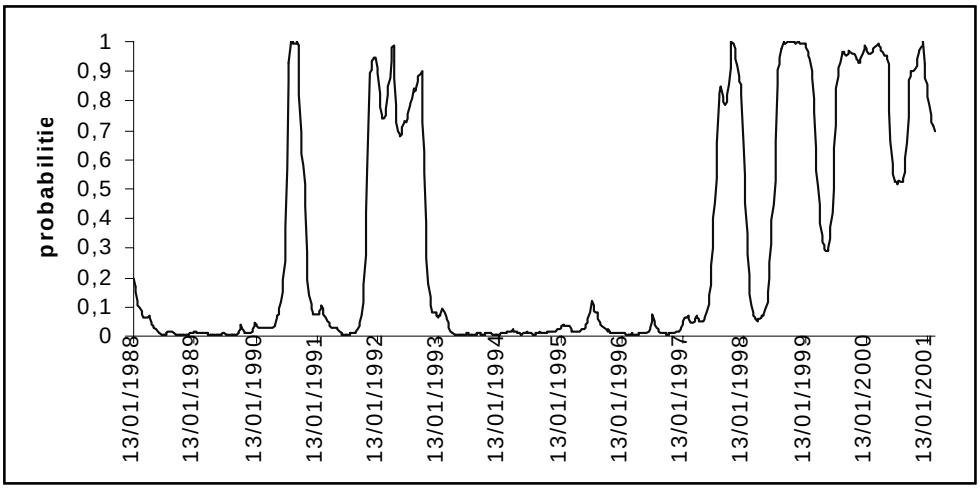

Figure 1: Univariate switching regime models. Smoothed probabilities of the high volatility regime for the world index.

4.2 The world index and the European capital markets

One of the main purposes of the paper is to investigate whether the efforts for more economic, monetary and financial integration and the financial crises have fundamentally altered the sources and intensity of shock spillover to the individual European stock markets. In particular, it is useful to analyze the implications of the EMU on (i) the link between the world index and European equity markets and (ii) the idiosyncratic volatility of the European markets.

We consider the model (3) where R_{mt} is the return of the world index and R_{it} is the return of the i European capital market. The variables s_{mt} and s_{it} can take two values: 0 indicates high volatility and 1 low volatility.

Figure 2 and 3 show the smoothed probabilities of being on the high volatility regime for the world index and for the idiosyncratic German risk. For the world index, figures 1 and 2 indicate that the probability estimated with the SSRM is almost the same as that estimated with the SBRM: we observe that the world index is frequently in the high volatility regime in the last part of the sample. On the other hand, for Germany, the idiosyncratic risk, which may represent the implication of the EMU on the volatility of this market, indicates that the EMU may have increased the frequency of being in the high volatility regime for the idiosyncratic risk volatility of the German market.

Table 3 contains the level of significance to evaluate different hypotheses of structural break ((i) in all the parameters; (ii) in betas and volatilities; (iii) in the transition probabilities) for the German, French, Italian, Spanish and UK markets (joint with the world index). With the only exception of the French market, the test statistics reject the null hypothesis of no change in the parameters. The same applies to the joint test for changes in betas and volatilities. This means that either the link between the European markets and the world index, or the volatility of the European markets, or both the link and the volatility have changed after December 1997. Some tests on betas and on volatilities are performed to verify for which parameters the change has really occurred.

As previous authors have pointed out, we find a higher correlation during periods of high volatility (beta are higher when the world index is in the high volatility regime). Our estimated parameters confirm this result[6]. However, our results show that there is a break in betas when both the German and the world market index are in the high or in the low volatility regime and the new betas $(\beta_{\mathbf{0,0}}, \beta_{1,1})$ are higher. These results suggest that the link with the world index and the German market has increased when the two markets are both in the high and in the low volatility regimes. As a consequence, the increase of volatility spillover from the world market index to the economic leader of the European markets after December 1997 is confirmed. We do not observe the same effect for the other European markets. Indeed, volatility spillovers increase only when the world index is in the high volatility regime. This means that after December 1997 the European markets are more affected by the instability of the rest of the world with respect to before December 1997. We are unable to verify whether this is generated by the EMU; however we suspect that this effect is more attributable to globalization.

For volatility, we have already observed that the world market volatility shows an increase in the low volatility parameter. This result is confirmed using the SRBM. Regarding the idiosyncratic volatility we observe a change in the volatility parameter of the low volatility regime only for Germany and Spain.

Even more interesting for our purposes is the result that the main change we observe in the stochastic process of the German market is the change in transition probabilities as reported in table 2 and confirmed in table 3. We observe that the euro introduction has increased the frequency of visiting the high volatility regime for the traditionally stable German market.

The previous outcome suggests that the hypothesis of the euro as a close substitute for the currency of the leading country (Germany) has to be rejected. Our empirical finding opens the issue if the euro has indeed modified the stochastic processes of domestic

[6]Estimation results are provided upon request.

	Germany	France		Italy		Spain		UK	
	with World Index	with World Index	with Ger. Mkt	with World Index	with Ger. Mkt	with World Index	with Ger. Mkt	with World Index	with Ger. Mkt
All parameters	**0.00**	0.12	**0.01**	**0.00**	**0.01**	**0.01**	0.07	**0.02**	**0.00**
Betas and volatilities	**0.03**	0.68	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.05**	**0.00**
Betas									
β_{00}=β_{00d}	**1.00**	0.33	**1.00**	0.22	**1.00**	0.29	0.84	0.65	**0.97**
β_{01}=β_{01d}	**0.00**	**1.00**	0.63	0.49	0.63	**1.00**	0.57	**0.99**	0.13
β_{10}=β_{10d}	0.54	0.38	0.79	0.21	0.79	0.51	0.41	0.48	0.71
β_{1}=β_{11d}	**1.00**	0.06	0.19	**0.99**	0.19	**0.00**	0.72	0.17	0.23
Sigmas									
σ_{m0}=σ_{m0d}	0.83	0.58	0.93	0.82	0.93	0.67	**0.99**	0.62	**0.97**
σ_{m1}=σ_{m1d}	**1.00**	**1.00**	**1.00**	**0.98**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
σ_{i0}=σ_{i0d}	0.67	0.85	0.38	**0.00**	0.38	0.93	0.09	0.11	**0.00**
σ_{i1}=σ_{i1d}	**1.00**	0.77	**0.02**	0.76	**0.02**	**0.99**	0.28	0.79	**1.00**
Transition probabilities	**0,001**	**0.00**	**0.05**	**0.01**	**0.05**	**0.05**	0.12	**0.02**	**0.02**

Table 3: Switching regime beta model, p-value test statistics. The label 0 indicates high volatility and 1 low volatility. Bold figures indicate the rejection of the null hypothesis at the confidence level of 5%.

fundamentals for the leading country. We leave to further research the issue whether the euro is a good substitute of the Deutsche Mark.

Regarding the other European countries, we find ambiguous results. France and the UK do not show evidence of any significant change in the volatility distribution of the idiosyncratic factor; Italy shows a reduction of volatility in the high volatility regime, and Spain an increase of volatility parameters in both the cases.

From the estimation of the SRBM model with a dummy for the transition probabilities, we can observe that only for Spain there is no change in the transition probabilities after December 1997.

All these results confirm that in stable countries like France and the UK, equity markets do observe an increase in visiting the high volatility regime and a higher link between the different markets. The idiosyncratic part is not affected by this phenomenon. On the contrary, for Italy we observe a reduction of the volatility of the idiosyncratic risk factor.

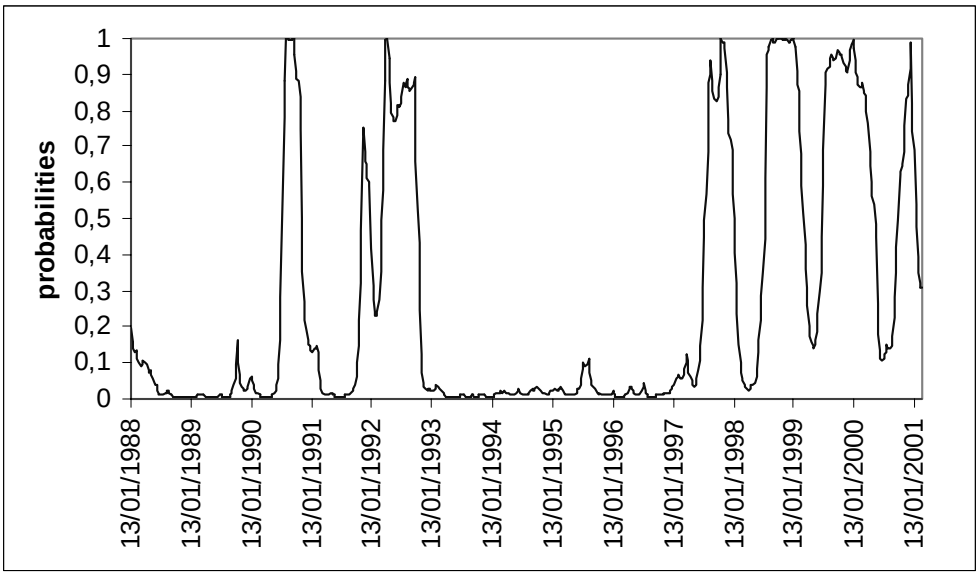

Figure 2: Switching regime beta model. Smoothed probabilities of the high volatility regime for the world index chain when estimated joint with Germany.

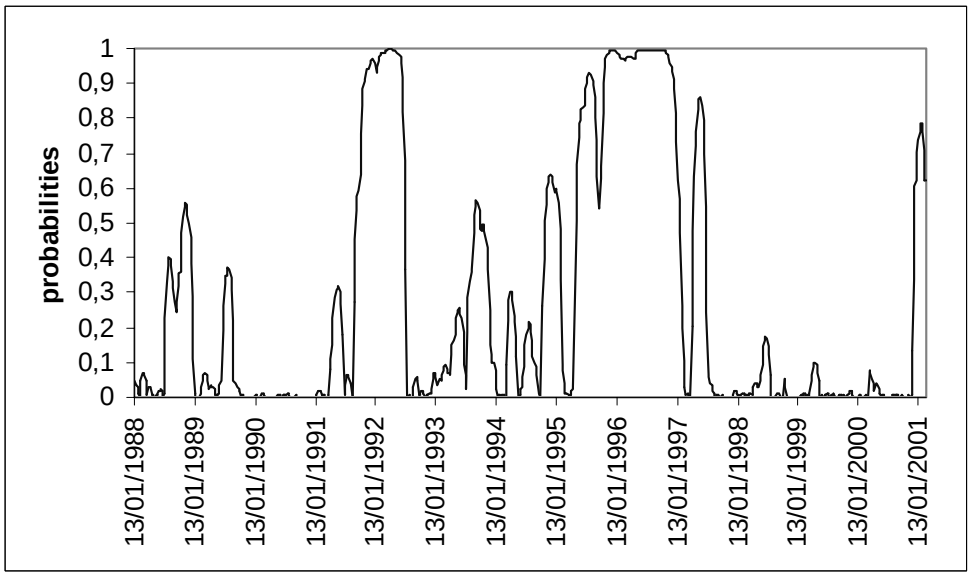

Figure 3: Switching regime beta model. Smoothed probabilities of the low volatility regime for the German idiosyncratic risk chain when estimated jointly with the world index.

4.3 The link between the European markets

In the previous section we have analyzed the change in the volatility spillover from the world index to European stock markets. In this section we study whether the importance of EU shocks has increased for most markets after the EMU. To analyze the link between European countries we use the following model:

$$\begin{cases} R_{Gt} &= \mu_G(s_{Gt}) + \sigma_G(s_{Gt})\varepsilon_t, & \varepsilon_t \sim IIN(0,1) \\ R_{it} &= \mu_i(s_{it}) + \beta_i(s_{Gt}, s_{it})R_{Gt} + \sigma_i(s_{it})\varepsilon_{it}, & \varepsilon_{it} \sim IIN(0,1) \end{cases} \tag{6}$$

where R_{Gt} is the return of the German market and R_{it} is the return of the other European markets. The variables s_{Gt} and s_{it} can take two values: 0 (high volatility regime) and 1 (low volatility regime). In this model the link with the rest of the world is characterized by the German market that represents the market portfolio and even the systematic risk corresponding to the European market. Clearly this cannot be considered true for the UK. For this reason we analyze the UK market only as a control country.

Table 2 shows that Germany has observed an increase of volatility parameters in both the high and low volatility regime as have the transition probabilities.

The LR test for the SRBM model (joint with German market) with a change in all the parameters, reported in table 3, rejects the null hypothesis of no change in all the parameters after the introduction of the euro for all the European markets considered.

The statistical analysis for the SRBM model with a dummy for betas and volatilities rejects the hypothesis of stability for all the European countries considered. To analyze which regime the change of betas has occurred in, we test the hypothesis of stability between the betas before and after the introduction of the euro.

We observe significant changes in the correlation coefficients between the German and the French, Italian and UK markets when the markets are in the high volatility regime (see table 3). This result shows that when the volatility is high in both markets, the integration between the markets, usually higher with respect to the low volatility regime, has observed a strong increase after the EMU. It is important to stress that not only do we find a higher correlation when the markets are in the high volatility regime, coherent with previous empirical findings (see King and Wadhwani (1990), King *et al.* (1994), Longin and Solnik (1995) and De Santis and Gerard (1997)), but also that the EMU has increased this effect, i.e. there is a structural break. It is surprising that even the UK market seems more integrated with the German one. A potential explanation of this result is the higher coordination in terms of economic policy in the European Community. This result suggests that even volatility spillover from EU shocks has increased. To analyze which regime the change of volatilities has occurred in, we test the hypothesis of no change of volatilities before and after the introduction of the euro.

All estimations show that there is a significant increase in the level of volatility of the leader market. We find a significant reduction in the volatility distribution of the French and Italian idiosyncratic factors when the French and Italian markets are in the low volatility regime. The results regarding the UK are ambiguous since we observe a reduction of volatility in the low volatility regime and an increase in the high one.

Finally, from the SRBM model with a dummy for the transition probabilities we can observe that there is a change in the transition probabilities after the introduction of the euro for France, Italy and the UK.

5 Conclusion

In this paper we analyze the variances and covariances of four major European markets and their links with the world equity market. The aim of the paper is to evaluate the changes in the correlation and volatility distribution brought about by the introduction of the euro, deregulation, globalization and financial crises in the last five years. Theory suggests that stock excess returns are influenced by the systematic risk of the asset, as measured by its covariance with a market-wide portfolio return, and a risk component that is unique to the market. Economic asset pricing theory suggests that the introduction of the euro may modify the world index volatility (because of the reduction of currency risk factors).

For this purpose we estimate and statistically compare several models. First we analyze whether the EMU has in some way affected the distribution of the world index. Our tests suggest that the volatility parameter of the world index in the high volatility regime has statistically increased from January 1998. Nevertheless, we observe from smoothed probabilities that during the EMU, the world excess return has been characterized by a high volatility regime mainly because of the recent crisis in the financial markets (clearly unrelated with the EMU). This means that, if theoretically the euro may generate a reduction of the world volatility, empirically we demonstrate that this effect is not so significant or that it has been offset by other effects.

Second we study the link between the world index and the German market, and its idiosyncratic risk. In this case we find a change in the parameter distribution. In particular, we find an increase in the link with the world index. Moreover, the transition probabilities have changed. In fact, we observe an increase in the frequency of visiting the high volatility regime by the German idiosyncratic risk. This result may confirm the theoretical implication that the euro could be not a proper substitute of the Deutsche Mark, and that after 1998 we observe a stronger volatility spillover from the world index to the German market.

Concerning the French market, the results show that the main change is the increase in the link with the world index and the German market when the markets are in the high volatility regime. Again this confirms that after 1998, the volatility spillover have increased. The idiosyncratic risk does not show any significant change with respect to the world index. However, when the European factor has been introduced the French idiosyncratic risk shows a reduction in the volatility parameter in the high volatility regime.

Italy shows a general increase in the betas and even a change in the transition probabilities. In particular, we find that the correlation has increased and that the probability of visiting the low volatility regime for the idiosyncratic chain has grown. This suggests that, as far as the convergence process is concerned, there are indeed signs of a stabilization of the Italian stock markets.

Spain shows an increase in the link with the world index and an increase in the volatility of the idiosyncratic chain. However, by introducing the European risk factor this effect disappears and most of the increase in volatility on the Spanish market has been captured by the European factor.

Regarding the UK, again we find an increase in the link with the world index and even with the German market. However, if we consider only the German risk factor, we are unable to capture the change in the UK idiosyncratic volatility parameter.

In summary, our results suggest that the volatility spillover from both the world and the German markets have increased after the EMU for most European stock markets. However, we are unable to identify which of the two forces has becomes dominant for volatility spillover.

These results have various implications. From the point of view of stock market efficiency, European stock markets have indeed reacted in the way predicted by fundamentals in terms of volatilities and correlation, and they suggest that macroeconomic variables are important risk factors for stock prices. The results seem to be relevant also for investors.

Moreover, we do observe an increase in the link between European capital markets. Nevertheless, it may seem premature to declare the death of country diversification within Europe to support the introduction of sector diversification. From our analysis, in fact, we observe an increase of the correlation only in some states of the world, while in some other regimes we observe a reduction of correlation. Implications for portfolio diversification, contagion and economic growth have to be taken into account by investors, risk managers and regulatory and monetary authorities.

Finally, the successful modelling of volatility as a switching regime Markov process is another confirmation of the inappropriateness of the standard practice of estimating variance-covariance matrices on the basis of historical data without considering time-varying volatility.

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