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Abstract

This paper explores the evolution of European stock markets integration with the world stock market after the formation of European Union. To this end, we employ a dynamic version of international CAPM in the absence of purchasing power parity. The estimation of the conditional covariance matrix of asset returns is carried through a parsimonious diagonal BEKK multivariate GARCH-in-mean model. The data sample is daily extending from June 1994 to June 2009. We also investigate the evolution of domestic risk overtime using rolling estimation techniques. Finally, the introduction of world-wide information variables into the system reveal that although the European markets are less integrated with world market, after the monetary union, the members' states domestic market risk have been reduced.

Keywords: Market integration; EMU; MGARCH-M specification;

1. Introduction

This work investigates the effects of European Economic and Monetary Union (EMU) on the integration of members' states stock markets with an index of world stock market. The period covered is from mid-1990's until 2009. There is no doubt that capital market integration was one motivation for the EMU. On January 1, 1999, eleven European Union (EU) countries, namely Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain, formed a monetary union (Note 1). Since then, the exchange rates between the EMU countries have been irrevocably fixed, the euro was introduced as the common currency, the European Central Bank (ECB) began operating, and carrying out the common monetary policy, and all EMU government bills and bonds are denominated in euro. The EMU markets have embarked on a series of reforms in recent years, following an economic, stock market, interest rate and bond market convergence process.

There is a large literature that investigates European stock market integration. One recent example of this literature is Hardouvelis *et al.* (2006). They propose a conditional asset pricing model that allows for a time-varying degree of integration in order to measure the importance of EU-wide risk relative to country-specific risk. The model accounts for intra-European currency risk, time-varying quantities of risk and time-varying prices of risk. The results indicate that the degree of integration is closely related to forward interest differentials vis-a-vis Germany. Moreover, they point out that integration increases substantially over time, especially since 1995, when these differentials began shrinking, and by mid-1998, six months before the official date of EMU launch, stock markets in EMU members' states seem to be almost fully integrated. Many researchers that investigate the level of integration have focused mainly on one source of risk or on the effects of a single market on other stock markets. For example, Hardouvelis *et al.* (2006), Fratzscher (2002) and Kim et al. (2005) ignore currency risk. The introduction of euro as a common currency for the EMU does not eliminate currency risk for out of EMU markets. According to standard portfolio theory if the effect of currency risk does not vanish in well-diversified portfolios, exposure to this factor should command a risk premium in the sense that investors are willing to pay a premium to avoid this systematic risk. On the other hand, if currency risk is diversifiable, investors are not willing to pay a premium for firms with active hedging policies since investors can diversify the currency risk themselves.

Also, Morana and Beltratti (2002), Hardouvelis *et al*. (2006), Fratzscher (2002) and Yang *et al.* (2003) provide empirical evidence on the level of integration only on EMU countries. Moreover, post-euro impacts on international stock markets from European currency unification are not well documented.

Given the facts that currency risk and market integration have important implications in international finance and that previous studies are inconclusive or out of date, thus debatable, the purpose of this paper is to provide further evidence on the pricing of currency risk and market integration in stock markets. In particular, we investigate the evolution of European stock markets integration with world stock market. To achieve these goals, we estimate and test a dynamic market integration model with a parsimonious MGARCH-M parameterization. A parsimonious diagonal BEKK parameterization of the MGARCH-M process is employed to model the conditional covariance matrix of asset returns and common risk factors jointly. The advantage of the multivariate approach is that it utilizes the information in the entire variance–covariance matrix of the errors, which, in turn, leads to more precise estimates of the parameters of the model. In addition, many issues in finance can only be fully addressed within a multivariate framework.

The remainder of this paper is organized as follows. Section 2 motivates the theoretical dynamic ICAPM. Section 3 presents the econometric methodologies used to estimate the model. Section 4 discusses the data and reports the empirical results. Conclusions are offered in Section 5.

2. The dynamic ICAPM

Since the main purpose of this work is to investigate the effects of monetary unification on EMU stock markets integration it would be appropriate to consider a dynamic version of ICAPM. Under the hypotheses of stock market integration and purchasing power parity, a conditional version of the domestic CAPM of Sharpe (1964) and Lintner (1965) can be extended to an international setting. In this case, the conditional version of the model can be formally written as

$$E_{t-1}(r_{i,t}) = \lambda_{w,t-1} Cov_{t-1}(r_{i.t}, r_{w,t}) \forall i \tag{1}$$

$$E_{t-1}(r_{w,t}) = \lambda_{w,t-1} Var_{t-1}(r_{w,t}) \tag{2}$$

where $E_{t-1}(r_{i,t})$ is the expected excess returns of country's i stock market index conditional on the information up to period $t-1$; $E_{t-1}(r_{i,t})$ the conditional expected excess return on a world composite stock market index; $\lambda_{w,t-1}$ the time varying price of world market risk; $Cov_{t-1}(r_{i.t}, r_{w,t})$ the conditional covariance between the excess returns of country i 's market index and the world market index; $Var_{t-1}(r_{w,t})$ is the conditional variance of the excess return on the world market index. Model (1) – (2) supposes that markets are fully integrated and therefore only world risk is priced in global equity markets. The expected returns are not affected by domestic factors.

However, a country may not be fully integrated with global financial market. In this case, Errunza and Losq (1985) extend the international CAPM (ICAPM) to account for mild segmentation between markets. Now, the expected returns become a function of the two risk factors: exposure to world market risk and exposure to non-diversifiable country-specific risk. The conditional version of the model can be written as

$$E_{t-1}(r_{i,t}) = \lambda_{w,t-1} Cov_{t-1}(r_{i.t}, r_{w,t}) + \gamma_i Var_{t-1}(r_{i,t}) \tag{3}$$

Although, many empirical studies (e.g., Ferson and Harvey, 1994; Dumas and Solnik, 1995; De Santis and Gerard, 1998; among others) have documented that, due to the violation of PPP, currency risk is one of the price factors in global financial markets, especially in short horizons (Note 2). In the absence of PPP, international investors will face different real returns when holding the same assets. Therefore, currency risk emerges as another potential priced factor. In this paper, we rely on the ICAPM, which provides us a theoretical basis in selecting the economic fundamentals. The economic fundamentals are the world market and currency risks, so the evidence of integration is based on testing whether idiosyncratic risks, the part that cannot be explained by the world market and currency risks, are significant in describing the return dynamics of both stock and foreign exchange markets for each market. So, the modified conditional ICAPM can now be expressed as

$$r_{i,t} = \lambda_{w,t-1} h_{iw,t} + \lambda_{c,t-1} h_{ic,t} + \gamma_i h_{i,t} + \varepsilon_{i,t} \forall i \tag{4}$$

$$r_{w,t} = \lambda_{w,t-1} h_{w,t} + \lambda_{c,t-1} h_{cw,t} + \varepsilon_{w,t} \tag{5}$$

$$r_{c,t} = \lambda_{w,t-1} h_{cw,t} + \lambda_{c,t-1} h_{c,t} + \varepsilon_{c,t} \tag{6}$$

where r_w is the excess return on the world market index; r_c the return on a currency index; $h_{i,t}$ the conditional variance of country i 's market index; $h_{w,t}$ the conditional variance of the world market index; $h_{c,t}$ the conditional variance of currency returns; $h_{iw,t}$ the conditional covariance between returns on country i 's market index and the world market index; $h_{ic,t}$ the conditional covariance between returns on country i 's market index and the currency index; $h_{cw,t}$ the conditional covariance between currency return and the return on the world market index; With this modified conditional ICAPM, the test of market integration and currency risk pricing can be conducted jointly. That is, we want to see if there is any return variation left that could be explained by the conditional volatility of the underlying market after including potential world market and currency risk premia.

To model the time-varying world market and currency risk prices, their dynamics are chosen according to the theoretical asset-pricing model developed by Merton (1980). In his model, the price of world market risk is the coefficients of risk aversion of investors, and thus is expected to be positive. Since the theoretical model does not restrict the price of currency risk to be positive we use an exponential function to model the dynamics of $\lambda_{w,t-1}$ and a linear specification to model the dynamics of $\lambda_{c,t-1}$. As a result, the dynamics of risk prices can be described as $\lambda_{w,t-1} = \exp(\phi_w' z_{t-1})$ and $\lambda_{c,t-1} = \phi_c' z_{t-1}$, where z_{t-1} = {DUSTP, USDP, WORLD} is a vector of instruments observed at the end of period $t-1$ and ϕ 's are time-invariant vectors of weights. One-month Eurodollar interest rate is used as the risk-free rate to compute excess returns on all indices. In particular, the excess stock return is computed as $r_{i,t} = \ln(p_t / p_{t-1}) - 1/365(\ln(1 + i_{t-1}^{US\$})$ where p_t is either the market total return index or Datastream world market total return index (dividend included) expressed in US dollars at time t and $i_{t-1}^{US\$}$ is the annualized 1-month Eurodollar interest rate known at time $t-1$. Furthermore, the log first difference of the trade-weighted U.S. dollar price of the currencies of major industrialized countries (TWFX) is used to proxy the currency risk. We select a set of instrumental variables that have been widely used in the international asset pricing literature (see e.g., Bekaert and Harvey, 1995; De Santis and Gerard, 1995; 1998; Tai, 2007; Harvey, 1991; Bekaert and Hodrick, 1992; Ferson and Harvey, 1993; among others). Namely are the change in the US term premium, measured by the first difference of the yield difference between 10-year Treasury constant maturity rate and 1-month Eurodollar rate (USTP), the US default premium, measured by the yield difference between Barclay's BBB rated and AAA-rated U.S. corporate bonds (USDP), the lagged excess return on world market index (WORLD). Finally all instruments are used with a one lag, relative to the excess return series. Under full market integration, γ_i should not be statistically significant, otherwise there are evidence of partial, at least, market integration. Partial integration exists if currency and/or world risk are statistically significant.

3. Econometric methodology

To model the conditional variances and co-variances, several multivariate GARCH models have been proposed such as the diagonal VECH model of Bollerslev, Engle and Wooldridge (1988) the constant correlation (CCORR) model of Bollerslev (1990), the factor ARCH (FARCH) model of Engle and Rothschild (1990), and the BEKK model of Engle and Kroner (1995). Among these four popular MGARCH models, a specification of BEKK model, which assumes that A and B matrices are diagonal (Note 3) is selected. The diagonal BEKK model is preferred because not only yields a positive definite covariance matrix for all values of ε_{t-1}, but also economizes on parameters relative to other MGARCH processes (Ding and Engle, 2001). In this case the conditional variance–covariance matrices of the asset returns is given by

$$H_t = \Omega\Omega' + A\varepsilon_{t-1}\varepsilon'_{t-1} A' + B\, H_{t-1} B' \tag{7}$$

where Ω is lower triangular matrix of constants and A and B are $N \times N$ diagonal parameter matrices. We focus on a GARCH (1,1) specification (Note 4) since it has been shown to be a parsimonious representation of conditional variance that can adequately fit the data under examination. We utilize the full information maximum likelihood (FIML) to estimate Eqs. (4), (5) and (6).

4. Econometric estimation of ICAPM

Daily US-dollar denominated returns (Note 5) on stock indices for twelve EMU markets and a value-weighted world market index for the period from June 1994 to June 2009 are employed. The twelve EMU stock market indices are from the following markets: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain and one Datastream world total market return index (WORLD) which is the proxy for the world market risk factor.

The daily data ranges from June 1994 to June 2009 and is a 3896-data-point time series. We worked with rates of return while instrumental variables are first differenced and then lagged once. All the data are extracted from Datastream.

The dynamic ICAPM with time-varying world market and currency risk prices are stated in Eqs. (4)–(6). Estimation results are reported in Table 1. Our target is to investigate the evolution of integration of the twelve EMU markets with the world stock market as well as the influence of monetary union on integration. So, in order to examine the impacts of monetary union in integration process we split our data set in two sub-periods. The first sub-period is before and the second after the formation of monetary union. Table 1 reports the results of dynamic ICAPM. The statistics reported in Panel A show that most selected instruments are statistically significant explaining the risk prices $\lambda_{w,t-1}$ and $\lambda_{c,t-1}$. Also, there is evidence of dependence of all markets with the world and currency risk measures (Note 6). Panel B of Table 1 states estimates of parameter γ_i. For the whole period only France has no statistically significant γ_i, reflecting full integration with world stock market, while all other EMU markets are partial integrated.

However, there are some striking changes in the degree and nature of integration over the two sub-periods. During the first sub-period only Spain, Belgium, Greece and Austria have significant γ_i, this reflects partial integration with world stock market. The other EMU markets are totally integrated with world stock market. In the second period only France is totally integrated with world stock market. These results illuminate the significant role of monetary union played on market integration. There are few explanations about this particular evolution of integration. First, after the formation of monetary union the elimination of inter-European exchange risk lifted barriers for investors who are averse to this risk source and as such provided a much-expanded 'domestic' market. Secondly, the adoption of a common monetary policy and the greater alignment of fiscal policy across members' states, together with fewer legal or institutional barriers to investment served to increase the interdependencies between EMU markets. So, EMU became less integrated with world stock market due to these reasons.

Table 2 reports diagnostic testing performed on the standardized residuals for the purpose of assessing the fit of the dynamic ICAPM with MGARCH-M specification. In panel C, Ljung–Box Portmanteau statistics tests the null hypothesis of zero autocorrelation in the standardized residuals. The test statistics LB(656) are reported in Panel C of Table 2. In all significance levels the null hypothesis is accepted indicating that the volatility process is correctly specified.

However, as suggested by Engle and Ng (1993), the Ljung–Box test may not have much power in detecting misspecifications related to the asymmetric effects. For this purpose we employ the set of diagnostics proposed by Bollerslev (1986) (Note 7). These tests are based on the news impact curve implied by a particular ARCH-type model. The premise being that if the volatility process is correctly specified, then the standardized residuals should not be predictable based on observed variables. The results reported at Panel C show that the test statistics are not statistically significant, suggesting no strong evidence of misspecification.

In Panel D, the parameters of the conditional mean process are all statistically significant at 1% level, indicating that the MGARCH process is well specified. The condition for covariance stationarity is satisfied in all cases (Note 8).

To present a more analytical view of the time variation of the integration process we use a rolling estimation technique. For the rolling estimation, we set a one-year period window, starting from June 1994 and moving the window forward by one day at a time.

Figure 1, shows parameter estimates of γ_i, for a one-year rolling window, for equations (4)-(6). By comparing the parameter estimates is clear that using the rolling estimation we are able to unravel more information about the time variation of γ_i. The estimates of the one-year rolling window show high volatility before the formation of EMU and a more stable environment after that. In the aftermath of the severe and costly EMU crisis over 1992 – 1993, regional stock markets became more volatile, with high values of γ_i coefficients.

Furthermore, the period from 1997 to late 1998 coincided with the final stages of the treaty of Amsterdam in which political and institutional conditions were created to enable the EU to meet the challenges of the future. In this period the values of γ_i coefficients were decreasing, signalling a lower impact of domestic risk. After the formation of EMU almost all EU markets are more stable with lower values of domestic risk. Only Spain, Austria and Greece face a more volatile environment, with high values of γ_i. For Greece and Austria this could be explained by their relative low capitalization of their stock markets. For Spain this can be due to internal political reasons (Note 9). In all other markets the value of parameters γ_i are more stable after the formation of EMU, which is an evidence of lower market risk. As a result EMU markets became less integrated with world stock market after the formation of EMU and their domestic risk is taken into account from domestic investors (see Table 1).

Finally, after 2007 i.e. when the USA originated financial crisis started, the estimates of γ_i coefficients tend to zero in all EMU markets. This could be explained by the decreasing role of domestic risk in periods of crisis.

5. Conclusions

This paper empirically investigates EMU markets integration with world stock market. The empirical results show that EMU stock markets have become less integrated after monetary union. These findings suggest that EMU become an expanded "domestic" market which is, however, interdependent with the world stock market. Furthermore, rolling estimation techniques show that, after the formation of monetary union, stock market domestic risk has been stabilized at lower levels. Lower integration with international markets implies more opportunities for international investors and in combination with a less volatile domestic risk, makes EMU a more attractive international market for portfolio diversification.

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Notes

Note 1. Greece fulfilled the EMU criteria and entered to EMU at 1/1/2001.

Note 2. Rogoff (1996) provide a detailed discussion on the issue of PPP.

Note 3. In a diagonal system with N assets, the number of unknown parameters in the conditional variance equation is reduced from $2N^2+(N(N+1))/2$ under full BEKK specification to $2N+(N(N+1))/2$ under the diagonal BEKK specification.

Note 4. However, we estimate the model with different lags. According to Akaike information criteria the results are similar and available upon request.

Note 5. As suggested by Bekaert and Harvey (1995), calculating the returns in U.S. dollars eliminates the local inflation.

Note 6. It is interesting that DUSTP and USDP of currency risk became statistically significant after monetary union. This fact could be explained by the increasing interdependencies between euro and US dollar.

Note 7. Engle and Ng (1993) asymmetric tests include the sign bias, the negative size bias, and the positive size bias tests. The sign bias test examines the impact of positive and negative innovations on volatility not predicted by the model. The squared standardized residuals are regressed against a constant and a dummy S_t^- that takes the value of unity if ε_{t-1} is negative, and zero otherwise. The test is based on the t statistic for S_t^-. The negative (positive) size bias test examines how well the model captures the impact of large and small negative (positive) innovations, and it is based on the regression of the squared standardized residuals against a constant and $S_t^-\varepsilon_{t-1}((1-S_t^-)\varepsilon_{t-1}$. The computed t-statistic for $S_t^-\varepsilon_{t-1}((1-S_t^-)\varepsilon_{t-1}$ is used in this test.

Note 8. For the conditional covariance process H_t to be covariance stationary, the condition $a_i a_j + b_i b_j < 1 \forall i, j$ has to be satisfied. (see, e.g., Bollerslev, 1986; De Santis and Gerard, 1997; Bekaert and Harvey, 1995).

Note 9. After 2004 Spain had exhibited an increasing loss of competitiveness, against its main trading partners, an increasing inflation rate and growing government indebtedness.

Table 1: FIML estimation of Dynamic ICAPM for EMU Markets.

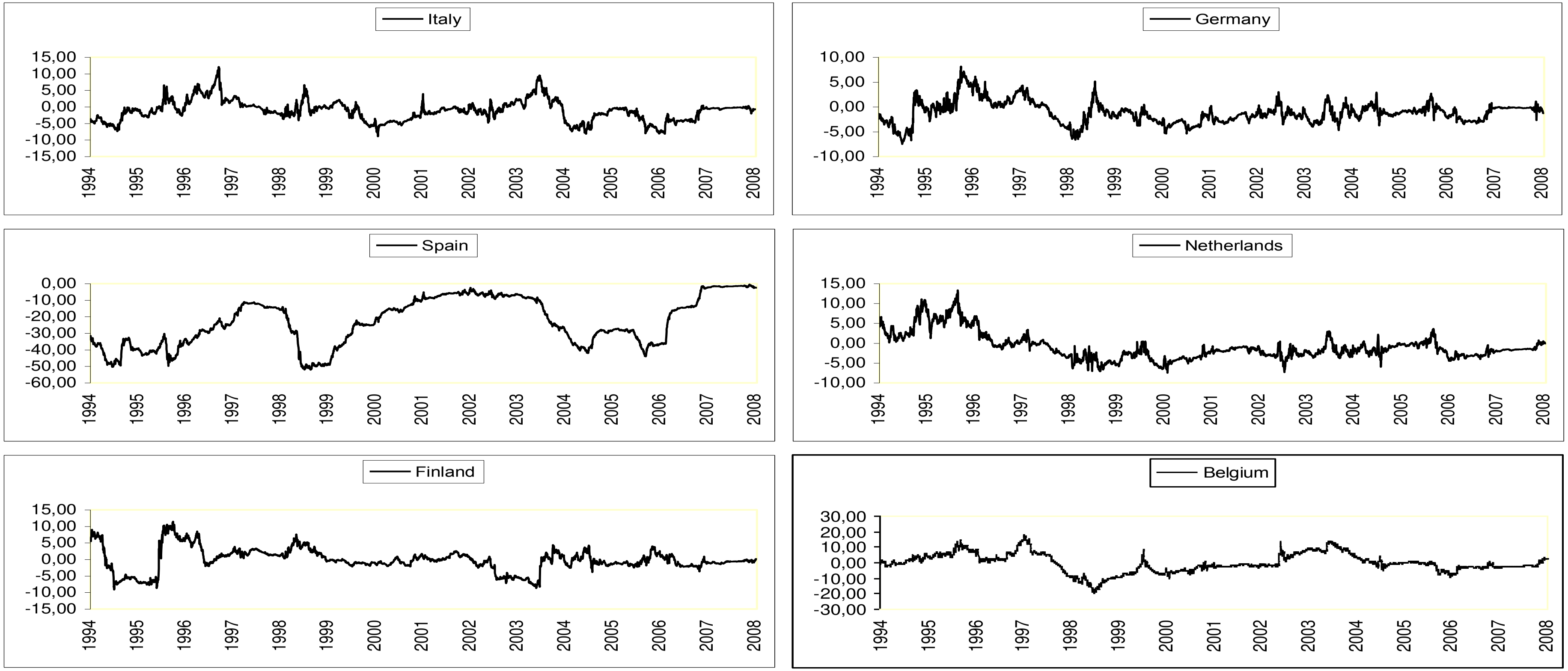
Coefficient estimates of ICAPM: Eqs. (4),(5) and (6)						
Periods of estimation:	Total period		1st period		2nd period	
Time varying price of risk (Panel A)	6/1994 -	6/ 2009	6/1994 -	1/1999	1/1999 -	6/2009
Φ_w (World risk)	coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
DUSTP	70.0147***	0.0000	-265.3775***	0.0001	-18.8975	0.5421
USDP	-14.8139***	0.0000	-142.7316***	0.0000	-15.5409***	0.0000
WORLD	-25.5158***	0.0000	-82.3932***	0.0000	-26.5950***	0.0000
Φ_c (Currency risk)	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
DUSTP	16282.2200***	0.0000	4737.2980	0.5760	10884.3300***	0.0000
USDP	-142.9427***	0.0054	-222.0221	0.4095	-136.6532**	0.0180
WORLD	1384.5620***	0.0000	9529.3860***	0.0000	709.3007***	0.0008
(Panel B)						
γ_ι (World risk)	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
Italy	-1.5042***	0.0001	-0.4005	0.7623	-1.5944***	0.0000
Germany	-0.9978***	0.0002	-0.8094	0.5409	-0.9232***	0.0023
Spain	-8.2019***	0.0000	-1.9603***	0.0000	-6.5788***	0.0000
Netherlands	-2.4895***	0.0000	-0.7109	0.5626	-2.4589***	0.0000
Finland	-0.5115*	0.0750	-0.1027	0.9231	-0.6078*	0.0847
Belgium	-3.0935***	0.0000	3.4648*	0.0588	-3.0275***	0.0000
Portogal	-2.6274***	0.0000	-0.1492	0.9028	-3.0080***	0.0000
Greece	-1.1944**	0.0029	2.2536**	0.0234	-2.0794***	0.0000
France	-0.4576	0.1396	-0.1567	0.9288	-0.2210	0.4721
Austria	-4.3379***	0.0000	-5.9496***	0.0027	-4.1470***	0.0000
Ireland	-2.7846***	0.0000	2.2639	0.1835	-2.8114***	0.0000
luxemburg	2.3773***	0.0000	2.2223	0.3629	2.4446***	0.0000

*denotes 10% statistical significance, **denotes 5% statistical significance, ***denotes 1% statistical significance

Table 2: Diagnostic Tests and Conditional Variance Process for Dynamic ICAPM

Market Diagnostic Tests	ITA	GER	SPA	NETH	FIN	BEL	PORT	GRE	FRA	AUST	IRE	LUX
Engle and Ng Test	*(Panel C)*											
Sign Bias Test	1.86	3.73	-3.07	5.48***	0.00***	3.06**	4.00***	3.73	2.08	4.92***	4.43**	-5.43
(t-stat.)	(0.98)	(1.51)	(-0.17)	(2.76)	(3.23)	(2.07)	(2.57)	(1.51)	(1.16)	(2.84)	(1.98)	(-0.71)
Positive S.B.T	0.03	0.19***	0.04*	0.08***	0.07***	0.15***	0.08***	0.19***	0.04**	0.27***	0.17***	0.11***
(t-stat.)	(1.53)	(8.76)	(1.86)	(3.02)	(2.87)	(6.38)	(2.96)	(8.76)	(1.97)	(10.50)	(5.57)	(6.77)
Negative S.B.T	0.23***	0.13***	0.17***	0.2***	0.12***	0.24***	0.12***	0.13***	0.21***	0.25***	0.15***	0.28***
(t-stat.)	(10.72)	(5.93)	(8.86)	(10.04)	(6.44)	(12.17)	(6.22)	(5.93)	(9.57)	(13.61)	(8.46)	(7.04)
Ljung Box test (Total period)	EMU markets											
L-B(656) [Q-stat]	128971.6	[0.1216]										
Cond/nal Variance Process (Eq.7)	*(Panel D)*											
a_i	0.26***	0.17***	0.23***	0.26***	0.18***	0.25***	0.23***	0.26***	0.24***	0.22***	0.22***	0.29***
(t-stat)	(40.16)	(32.35)	(45.91)	(42.00)	(42.80)	(43.64)	(51.34)	(38.60)	(40.21)	(38.37)	(32.65)	(97.47)
b_i	0.96***	0.98***	0.96***	0.96***	0.98***	0.96***	0.96***	0.96***	0.96***	0.96***	0.97***	0.96***
(t-stat)	(653.81)	(899.78)	(772.18)	(524.64)	(1610.4)	(591.24)	(819.23)	(533.55)	(545.57)	(582.14)	(608.85)	(1349.26)

*denotes 10% statistical significance, **denotes 5% statistical significance, ***denotes 1% statistical significance.


Italy
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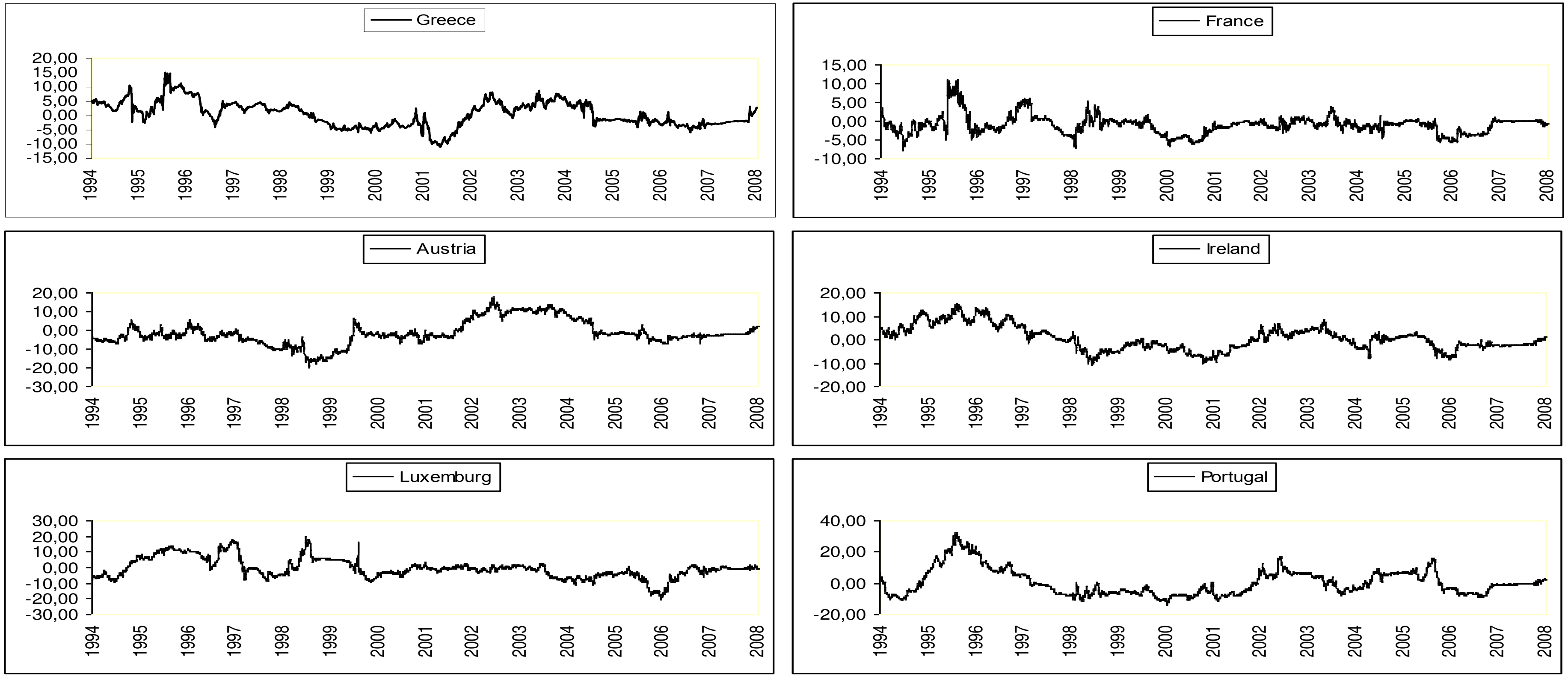
2003
2004
2005
2006
2007
2008



Fiq.1 - Time-Varying domestic risk of EMU Stock Markets: γ_i estimates.