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European financial market dependence: An industry analysis

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ABSTRACT

This paper uses a copula model to investigate the degree and determinants of European market dependence across 10 industries in 12 Euro zone and 8 non-Euro zone stock markets during the period 1992–2011. Most of the industries in Euro countries show a dependence increase with the Euro-area after the introduction of the Euro. The effects are strongest in countries with larger market capitalization and in the Financials, Industrials, Consumer Goods, Utilities, Technology and Telecommunications industries. Overall, the export intensity, interest rate sensitivity and competitiveness of an industry and the financial development and economic openness of a country are the most important determinants of changes in equity market dependence. The period around the Lehman collapse also shows higher equity market dependence between European countries, while the lower dependence increase during the period of the recent European sovereign debt crisis suggests that country-specific factors may matter more than before.

1. Introduction and motivation

The recent sovereign debt crisis has renewed the interest in European integration and the Euro by policy makers, central bankers and researchers alike. Although concerns about the future of the common European currency never completely ceased, the crisis has caused an unprecedented challenge to the Euro and has called into question the homogeneity of European countries on which the success of the monetary union is built. Consequently, the crisis is not just a financial crisis but also a crisis of confidence in the strength of the monetary union.

Against this backdrop, this paper investigates the degree and determinants of European market dependence during the period 1992–2011, comprising the introduction of the Euro, the collapse of Lehman Brothers, and the European sovereign debt crisis. Previous studies that investigate European equity market dependence have focused on the country level.[1] However, Tsatsaronis (2001), Galati and Tsatsaronis (2003), Adjaouté and Danthine (2003), and Flavin (2004) suggest that factors at the industry level are likely more important drivers of changes in equity market dependence, particularly after the launch of the Euro. Consequently, we investigate the industry dimension of European equity market dependence. To this end, this paper provides a comprehensive analysis of the stock market dependence across 10 industries in 12 Euro-area and 8 non-Euro-area countries.

In particular, we use a copula-based model to estimate the time-varying dependence for every industry portfolio with its corresponding Euro zone index and determine whether a particular market has experienced a dependence increase with the Euro zone market around the introduction of the common currency. We also look at European equity market dependence in recent years, particularly during the European sovereign debt crisis in 2009–2011. Subsequently, we run cross-sectional regressions to investigate which country and/or industry factors determine changes in dependence.

Copulas offer significant advantages over other econometric techniques in analyzing the comovement of financial time-series.[2] In contrast to many prior studies that have used correlation coefficients to measure financial market dependence, copula functions permit flexible modeling of the dependence between random variables by enabling the construction of multivariate densities that are consistent with the univariate marginal densities without

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[1] Existing evidence on industrial dependence or integration in the literature is limited (Cappiello et al., 2010; Bekaert et al., 2013).

[2] Section 2.2.1 provides details on the advantages of copulas.

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the assumption of normality. Christoffersen et al. (2012) provide strong evidence that the assumption of multivariate normality for international equity returns is inappropriate and, consequently, specify a similar copula-based model with nonlinear dependence and asymmetries. Moreover, as detailed in Embrechts et al. (2002), copula dependence does not suffer from the shortcomings of correlation coefficients. The advantages of copulas compared to other econometric techniques are documented in several studies including Rosenberg (2003) for risk management, Hennessy and Lapan (2002) and Christoffersen et al. (2012) for portfolio allocations, and Bennett and Kennedy (2004) and Rosenberg and Schuermann (2006) for derivatives pricing.

In addition, Pukthuanthong and Roll (2009) identify a fundamental flaw of cross-country linear correlation as a widely used measure of integration since it can be low even for perfectly integrated markets.[3] Consequently, they derive a new integration measure based on the explanatory power of a multifactor model and use it empirically to investigate recent trends in global integration. Since, according to Goetzmann et al. (2005), Cappiello et al. (2006, 2010) and Eiling and Gerard (2014) there exists a positive relation between market dependence and integration,[4] we compare the integration processes of the R-Squared metric to the dependence processes from our copula model and document similar levels and trends when averaging across countries and industries.

Our empirical results for the impact of the introduction of the Euro show that many industries of countries with larger capitalization exhibit a dependence increase with their corresponding Euro-area markets. Specifically, most dependence dynamics of the industries in France, Germany, Italy, the Netherlands and Spain show a clear increase around the introduction of the Euro. Industries in Belgium and Finland have also become significantly more pan-Euro, despite the fact that these countries are relatively small. Furthermore, significant differences exist with regard to the impact of the Euro on industrial sectors. In particular, the Financials, Industrials, Consumer Goods, Utilities, Technology and Telecommunications industries show a significant increase in dependence in most countries. The effects are particularly strong statistically and economically for Financials, Utilities, Technology and Telecommunications, which show a remarkable dependence increase with their corresponding Euro-area indices in almost all countries. By contrast, there is no clear increase for most of the industries in countries outside the Euro area such as Denmark, Sweden, Norway, and the United Kingdom.

With regard to the more recent episode, we observe higher equity market dependence between European countries and industries around the collapse of Lehman Brothers. Moreover, we find that the European sovereign debt crisis substantially slowed the increase in equity market dependence for most industries. The latter holds particularly true for industries in high-risk countries such as Greece, suggesting that country-specific factors may matter more than before.

In order to investigate the increase in market dependence across industries and countries further, we use industry-specific and country-specific variables to assess systematically what factors determine the dependence change. In particular, we consider measures of interest rate sensitivity, internationalization/export intensity, asset intangibility, competitiveness, the importance of an industry in terms of value-added, financial development, the importance of the banking sector, economic development, economic openness, and alignment with the Euro area. Our empirical results show that both industry and country-specific factors play an important role with industry-specific factors dominating country-specific factors.

Specifically, the change of European market dependence depends mainly on an industry's export intensity and interest rate sensitivity, where higher export intensity and interest rate sensitivity are associated with a stronger propensity to exhibit an increase in dependence. In addition, an industry's competitiveness and a country's financial development and economic openness are also (but less strongly) related to the change in cross-market dependence. These results have important policy implications since the identified determinants of dependence such as export intensity, competitiveness or financial development can be affected by policy. To illustrate, the current discussions between the European Union and the United States about the Transatlantic Trade and Investment Partnership (TTIP) should affect the exports and competitiveness of firms in the Euro area and thus the level of dependence or integration.

These new findings with regard to the impact of the Euro on financial market dependence in Europe in general and on different industries in particular complement prior studies on macroeconomic determinants of financial market dependence/integration. For example, Kalemli-Ozcan et al. (2010) and Fratzscher (2002) find that European equity markets have become more integrated since 1996 and that integration is associated with reduced exchange rate volatility and convergence of interest rates. Hardouvelis et al. (2006) examine whether the convergence of European economies towards the EMU and the launch of the Euro have led to an increase in stock market integration and indicate that the interest rate differential plays an important role for the degree of integration. Danthine et al. (2001) show that lower cost of cross-country transactions and improved liquidity, breadth, and depth of markets have advanced the integration of European financial markets. Kim et al. (2005), Bartram et al. (2007), and Cappiello et al. (2010) also find a clear shift in European stock market dependence associated with the introduction of the EMU using different econometric approaches, while Bekaert et al. (2013) dismiss such an effect. Bartram et al. (2007) study changes in the dependence between countries in the context of the Euro using a conditional copula dependence model, but do not analyze industries or potential drivers of dependence.

The remainder of the paper is organized as follows: Section 2 studies the changes in the dependence between European industries over time, while Section 3 investigates the determinants of European market dependence. Section 4 concludes.

2. European equity market dependence

2.1. Related literature and hypotheses

The introduction of the Euro as a common currency was a project drawn up by the leaders of the EU to advance the goal of a closer union among European countries. It was identified by the Delors Report as a further step toward the creation of a single European market in order to create price stability, reduce costs of

[3] Pukthuanthong and Roll (2009) use a two-factor model to show that in the case of perfect integration, the correlation of the returns of two markets is less than 1 if the factor sensitivities of the two returns are not linear to each other for both factors.

[4] Assessing market integration can be based on asset pricing models (see, e.g., Errunza and Losq, 1985; Bekaert and Harvey, 1995; Rockinger and Urga, 2001; Carrieri et al., 2004; Hardouvelis et al., 2006; Cappiello et al., 2008; Pukthuanthong and Roll, 2009) or measures of market comovement or dependence (see, e.g., Dumas et al., 2003; Bekaert et al., 2005; Kim et al., 2005, 2006; Cappiello et al., 2006, 2010; Eiling and Gerard, 2014). While financial market integration is well defined by the existence of a common pricing kernel for all assets, many researchers in economics and finance have established relations between cross-market dependence and equity market integration. Following the theoretical foundations proposed by Dumas et al. (2003), Aydemir (2005), Cappiello et al. (2006, 2010) and Eiling and Gerard (2014) use factor models to link measures of dependence and indicators of financial integration. In addition, Goetzmann et al. (2005) document positive causality from market integration to market dependence. Therefore, a likely source of increases in equity market dependence consists in higher degrees of integration between markets.

business, and promote economic performance by reducing barriers to the flow of labor, goods, services, and, particularly, capital across national borders. The ultimate goal of this process is the creation of one single European economy, where resource allocation across national borders is as easily done as in any other national economy of comparable size (e.g., the U.S. economy), with concomitant benefits in terms of more efficient allocation of resources and risk sharing. As recommended by the Delors Report submitted in 1989 and adopted by the leaders of the EU member states, a multistage process started in 1990, leading to the adoption of the Euro as common currency. The first group of countries to join the Euro was announced in January 1998, and the common currency was introduced in January 1999.

Since its introduction, the Euro has had significant economic effects along many different dimensions. With regard to the real sector, the Euro has been attributed to the promotion of competition (Friberg, 2003), trade (Bayoumi and Eichengreen, 1997; Rose, 2000; Barr et al., 2003; Micco et al., 2003), capital investment (Bris et al., 2009), and the alignment of the national Euro-area business cycles (Frankel and Rose, 1997; Artis and Zhang, 1999; Mélitz, 2004). These effects suggest higher levels of economic integration than prior to the Euro, which has also led to increased cross-border mergers and acquisitions (Corsetti and Pesenti, 1999).

In particular, the introduction of the Euro has caused yield curves to converge within the Euro area (Danthine et al., 2001; Baele et al., 2004). As a result, capital market financing has become more important due to the convergence of nationally segregated financial markets (Corsetti and Pesenti, 1999; Hartmann et al., 2003; Hardouvelis et al., 2006) towards the standards of the most sophisticated, liquid markets (Guiso et al., 2004). The overall effect has been a reduction in the cost of capital within the Euro area, which is typically interpreted as a sign of increasing capital market integration (Bris et al., 2009) and which has been attributed to general reductions in the exposure to exchange rate and market risk (Bartram and Karolyi, 2006). This has led to increased cross-border investment flows within European financial markets (Corsetti and Pesenti, 1999) and the reorganization of hitherto country-based portfolios toward industrial sectors by institutional investors (Tsatsaronis, 2001; Galati and Tsatsaronis, 2003).

The flare-up of the financial and debt crises over the last few years has been a reminder of the vulnerability of the European monetary union, as the fiscal problems of some member countries have not been resolved effectively. For example, the severe fiscal deficit of Greece was not given attention until 2009, although the global financial crisis began in 2008 and badly affected Greece. As a consequence, a break-up of the Euro has become more of a possibility than ever. Therefore, in addition to investigating the degree of European equity market dependence around the period of the launch of the Euro, we also explore the impact of the European sovereign debt crisis on European equity market dependence. We expect European financial market dependence to increase with the introduction of the Euro, while the more recent crisis periods are likely to slow or even reduce dependence between European markets.

2.2. Methodology

2.2.1. Advantages of copula-based approaches

In order to determine changes in the dependence of industry portfolios with their corresponding Euro zone indices, we employ a conditional copula dependence model. Copulas offer significant advantages over other econometric techniques in analyzing the comovement of financial time-series because they model dependence beyond linear correlation and provide a high degree of flexibility in specifying a multivariate distribution (Patton, 2006a,b). In particular, the marginal distributions and the joint distribution can be considered separately, which allows constructing multivariate distribution functions from given marginal distributions without the assumption of normality for either the marginal distributions or their joint distribution function. Christoffersen et al. (2012) provide strong evidence that the assumption of multivariate normality for international equity returns is inappropriate and, consequently, specify a similar copula-based model with nonlinear dependence and asymmetries to investigate the benefits from international portfolio diversification.

The copula method is a modern technique for measuring time-varying dependence that has significant advantages over traditional linear dependence measures. Shortcomings of correlation coefficients include (1) providing a measure of linear dependence, (2) requiring finite variances, (3) not being invariant under non-linear strictly increasing transformations, and (4) zero correlation not implying independence. Moreover, in contrast to the dependence measures in the copula method, such as Kendall's tau and Spearman's rho, the maximum and minimum attainable correlation coefficients are +1 and −1 only if the marginal distributions are of the same type (Pukthuanthong and Roll, 2009).

In addition, linear correlations also suffer from a volatility bias because theoretically it is a function of the volatility scales of the returns. Specifically, the correlation coefficient $\frac{1}{\sigma(X)\sigma(Y)}\int\int_0^1[C(u,v)-uv]dF^{-1}(u)dG^{-1}(v)$ is a function of the standard deviations $\sigma(X)$ and $\sigma(Y)$ of two variables X and Y, where $C(u,v)$ is the copula function of u and v, which are the cumulative distribution functions of variables X and Y, respectively. By contrast, the dependence measures in the framework of copulas do not depend on the volatilities of the two variables. For example, Kendall's tau is defined as $1-4\int\int_0^1\frac{\partial}{\partial u}C(u,v)\frac{\partial}{\partial v}C(u,v)dudv$, which is independent of the volatilities of the marginal variables. More details about the shortcomings of linear correlation and the advantages of copula dependence can be found in Embrechts et al. (2002).

Many other studies also document the advantages of copulas in various finance applications. Hennessy and Lapan (2002) provide a theoretical framework of portfolio allocations with the multivariate distribution specified by a copula function, which has potential applications in all risk studies whenever a joint distribution is required. Li (2000) suggests that the copula approach is a convenient way to model the joint distribution of survival times or default correlations in credit risk analysis due to its high flexibility in specifying a multivariate distribution. Rosenberg and Schuermann (2006) find that the copula method works well when combining risks for the integrated risk management of financial institutions. Bennett and Kennedy (2004) use copulas for the pricing of foreign exchange rate quanto options and show that it performs better than a well-known ad-hoc adjustment to the Black pricing formula. Rosenberg (2003) proposes a non-parametric copula method to price cross-rate derivatives because the copula method is superior to the lognormal model in terms of pricing accuracy. Patton (2006a,b) provides a comprehensive theoretical framework of time-varying dependence models with copulas and shows that an asymmetric dependence structure is necessary for the joint distribution of foreign exchange rates.

2.2.2. The conditional copula dependence model

To fully take advantage of the copula approach, we employ a conditional copula dependence model with a very flexible process, the GJR-GARCH-MA-skewed t model,[5] for the marginal

[5] The modeling accuracy of a copula-based model depends on the appropriate specification of the marginal processes. However, because the focus of this study is on the dependence structure rather than the marginal distributions, we choose a parsimonious, highly generalized model for all univariate time-series instead of specifying a particular model for every single time-series. In particular, the GJR-GARCH-MA-Skewed t model allows not only for an asymmetric information impact but also for flexibility with regard to the first four moments of the distribution of residuals.

distributions and the Gaussian copula for the joint distribution.[6] By letting $R_{j,t}$ and $h_{j,t}$ denote the log return and conditional variance of industry equity portfolio j at time t, respectively, we obtain the following model:

$$R_{j,t} = \mu_j + \kappa_j \varepsilon_{j,t-1} + \varepsilon_{j,t}, z_{j,t} = \varepsilon_{j,t} \Big/ \sqrt{h_{j,t}} \sim t(\eta_j, \lambda_j)$$
$$h_{j,t} = \omega_j + \alpha_j \varepsilon_{j,t-1}^2 + \alpha_j^- S_{j,t-1} \varepsilon_{j,t-1}^2 + \beta_j h_{j,t-1}, \quad (1)$$

where $S_{j,t-1}$ = 1 when $\varepsilon_{j,t-1}$ is negative and otherwise $S_{j,t-1}$ = 0, and $\varepsilon_{j,t}$ denotes the residual of the index returns. All parameters including the kurtosis parameter η_j and the asymmetry parameter λ_j are estimated by maximizing the log-likelihood function (without subscript j for simplicity):

$$t(z|\eta,\lambda) = \begin{cases} bc\left(1 + \frac{1}{\eta-2}\left(\frac{bz+a}{1-\lambda}\right)^2\right)^{(\eta+1)/2} & z < -a/b, \\ bc(1 + \frac{1}{\eta-2}\left(\frac{bz+a}{1+\lambda}\right)^2\Big)^{\eta+1)/2} & z \geqslant -a/b \end{cases}, \quad (2)$$

where 2 < η < ∞, and $-1 < \lambda < 1$. The constants a, b and c are given by

$$a = 4\lambda c\left(\frac{\eta-2}{\eta-1}\right), \quad b^2 = 1 + 3\lambda^2 - a^2, \quad c = \frac{\Gamma\left(\frac{\eta+1}{2}\right)}{\sqrt{\pi(\eta-2)\Gamma\left(\frac{\eta}{2}\right)}},$$

where $\Gamma(\cdot)$ is the gamma function.[7]

The Gaussian copula density function is the density of (u_t, v_t) with correlation ρ_t between x_t and y_t.[8] With $\psi(.)$ the cumulative density function of the standard normal distribution, $a_t = \psi^{-1}(u_t)$, and $b_t = \psi^{-1}(v_t)$, the Gaussian copula density, is specified as

$$c_t^G(u_t, v_t|\rho_t) = \frac{1}{\sqrt{1-\rho_t^2}} \times \exp\left\{-\frac{1}{2(1-\rho_t^2)}\left[a_t^2 + b_t^2 - 2\rho_t a_t b_t\right] + \frac{1}{2}\left[a_t^2 + b_t^2\right]\right\}. \quad (3)$$

Similar to other studies (e.g., Patton, 2006a,b), the specification of the dependence process ρ_t is given by

$$(1-\beta_1 L)(1-\beta_2 L)\rho_t = \omega + \gamma(u_{t-1} - 0.5)(v_{t-1} - 0.5). \quad (4)$$

The intuition for the use of $(u_{t-1} - 0.5)(v_{t-1} - 0.5)$ is that the dependence increases (decreases) as the product of the de-meaned realized cumulative probabilities becomes larger (smaller).[9] ρ_t is the correlation parameter in the Gaussian density and ranges from -1 to +1 by definition. However, the joint distribution converges to a bivariate Gaussian, and thus ρ_t is identical to the linear correlation coefficient only when both margins are also Gaussian.

According to copula theory, the conditional, bivariate density function of X_t and Y_t is given by the product of their copula density and their two marginal conditional densities, denoted by f_t and g_t, respectively. The contribution to the log-likelihood of all the data made by the two observations at time t is then

$$\log h_t(x_t, y_t|\Phi_{t-1}, \theta) = \log c_t(u_t, v_t|\Phi_{t-1}, \theta_c) + \log f_t(x_t|\Phi_{t-1}, \theta_x) + \log g_t(y_t|\Phi_{t-1}, \theta_y) \quad (5)$$

with $\theta = [\theta_x; \theta_y; \theta_c]$, where θ_x, θ_y, and θ_c denote the separate parameters used in the function f_t, g_t, and c_t, respectively. Therefore, following Patton (2006a,b), we employ a two-stage estimation procedure.[10] In the first stage, the parameters of the marginal distributions are estimated from univariate time-series as

$$\hat{\theta}_x \equiv \arg\max \sum_{t=1}^{n} \log f_t(x_t|\Phi_{t-1}, \theta_x),$$
$$\hat{\theta}_y \equiv \arg\max \sum_{t=1}^{n} \log g_t(y_t|\Phi_{t-1}, \theta_y). \quad (6)$$

With $\hat{\theta}_x$ and $\hat{\theta}_y$ as inputs, the second stage then estimates the dependence parameters as

$$\hat{\theta}_c \equiv \arg\max \sum_{t=1}^{n} \log c_t(u_t, v_t|\Phi_{t-1}, \theta_c, \hat{\theta}_x, \hat{\theta}_y). \quad (7)$$

2.3. Data

The empirical investigation is conducted for 12 Euro-area countries (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain) and 8 countries outside the Euro area (Czech Republic, Denmark, Hungary, Norway, Poland, Sweden, Switzerland, and the United Kingdom).[11] For every country, we obtain the values of the stock market indices for 10 Level-2 industries from DataStream. The stock market indices are weekly total return indices, are market-value-weighted and include dividends. The sample period is from January 1, 1992 to December 31, 2011, which includes the introduction of the Euro, the collapse of Lehman Brothers, and the European sovereign debt crisis. The industries are Financials, Basic Materials, Industrials, Consumer Services, Consumer Goods, Healthcare, Oil & Gas, Utilities, Technology and Telecommunications.[12] For every Euro zone national industry, we also compile its corresponding value-weighted EMU industry index, excluding the examined country, as a proxy for the regional market. To control for a global effect when judging whether the introduction

[6] Because Malevergne and Sornette (2003) demonstrate that returns from most pairs of major stock indices are compatible with the Gaussian copula, we adopt this copula type for simplicity. In terms of the general level of dependence, the dynamic dependence patterns generated by various alternative copula functions (such as Student, Clayton, Gumbel, etc.) are similar and thus yield similar conclusions even though their dependence structures have different properties (Patton, 2006a,b; Bartram et al., 2007). We also compute values of the Akaike Information Criterion (AIC) for the Student, Clayton, and Gumbel copulas and then implement mean and median equality test for each of the three alternative copula against the Gaussian copula. The Gaussian copula fits the data significantly better than both of the Clayton and Gumbel copulas at the 5% and 10% of significance levels, respectively. While the AIC mean and median values are both lowest for the Student copula, the differences with those of the Gaussian copula are statistically insignificant. Therefore, there should be no model selection bias in our empirical analysis. Moreover, the Gaussian copula allows a wide range of dependence levels, while most of the other copulas, such as the Clayton and Gumbel, can model positive dependence only. Because we use a copula-based model to investigate the dynamic process of cross-market dependence rather than try to find the best specified model for cross-market dependence, it appears parsimonious and appropriate to employ the Gaussian copula function to capture the dynamics of the overall dependence level. Our conclusions are unaffected by using Student, Clayton or Gumbel copulas.

[7] Hansen (1994) proposes this distribution, and Christoffersen et al. (2012) also recently adopt it in their dynamic copula model.

[8] x_t and y_t represent the returns of the examined pair of stock indices at time t.

[9] While there are few alternative specifications in the literature to capture the residual part of the AR(1) term, almost all of them are highly correlated with ours with some having differently signed γ. For example, the correlation between $(u_{t-1} - 0.5)(v_{t-1} - 0.5)$ and $|u_{t-1} - v_{t-1}|$ is about -0.88 for a pair of randomly generated samples (1000 observations).

[10] This two-stage procedure makes the estimation much less complicated and more plausible. As proven by Patton (2006a,b), this two-stage estimation procedure is still consistent, although it is less efficient than a one-stage procedure.

[11] Estonia (2011), Slovakia (2009), Cyprus (2008), Malta (2008), and Slovenia (2007) are not included in the analysis because they joined the Euro only recently (as indicated by the year in parentheses). We include only eight non-Euro European countries due to limited data availability during our sample period.

[12] Not all of the industry indices are available for every country. To maximize coverage, we are forced to use rebased stock market indices for industries where the rebased indices have a longer available sample period but are highly correlated with the original indices (correlation greater than 0.8). Although rebased indices are affected by survivorship bias, the high correlations should mitigate this concern. In total, we have 169 country–industry observations. The following indices are not included due to data incompleteness: Healthcare (Greece, Luxembourg, Norway), Oil & Gas (Finland, Germany, Luxembourg, Portugal, Denmark, Sweden, Switzerland), Utilities (Greece, Ireland, the Netherlands, Portugal, Poland), Technology (Austria, Greece, Ireland, Luxembourg, Denmark, Hungary, Poland), and Telecommunications (Austria, Finland, France, Ireland, Luxembourg, Hungary, Norway, Poland, Switzerland).

of the Euro increases market dependence, we also obtain the values of World indices (excluding the EMU) of the same industries from DataStream. All indices are denominated in U.S. dollars.

Table 1 presents summary statistics of the industry portfolio returns (calculated as changes in the logarithms of the indices) of the European countries by industry (Panel A), by country (Panel B), and by region (Panel C). In general, the return series are negatively skewed, leptokurtic and do not have a high first-lag autocorrelation coefficient. While the average returns and the other moments are similar across regions, they exhibit some variation across industries and countries.

2.4. Empirical results

We begin by using the conditional copula dependence model detailed in Section 2.2.2 in order to estimate the dependence dynamics for the industry portfolios of different countries with their corresponding EMU index for all industries and then perform statistical tests in order to determine whether dependence increased significantly in the year of the introduction of the Euro along with graphs plotting dependence over time. In addition, we also investigate the changes in the extent of European market dependence in the more recent period, comprising the collapse of Lehman Brothers and the European sovereign debt crisis.

2.4.1. The introduction of the Euro

Because the modeling accuracy of a copula-based model depends on the appropriate specification for marginal processes, because the asymmetric impact of information on equity returns is well documented, and because some return series exhibit high first-order autocorrelations, we specify the marginal processes as a GJR-GARCH-MA-skewed t model when implementing the conditional copula dependence model. Panel A of Table 2 provides summary statistics of the parameter estimates across both industry and country. Consistent with the findings for equity returns in previous studies, almost all return series have a significant β (GARCH), α (ARCH) and η (kurtosis), while ω is extremely close to zero. At the 5% significance level, 50.5% of the return series have a significant conditional skewness (λ), and 68.1% have a significant α^- (leverage effect), while only 35.1% have a significant κ (autocorrelation).[13]

Next, we estimate the Gaussian conditional copula dependence process for every country return series with its corresponding EMU indices (excluding the examined country) and for every EMU return series with its corresponding World (excluding EMU) indices. Panel B of Table 2 provides summary statistics for the estimates of the four parameters used to specify the dependence dynamics. Consistent with the findings in previous studies, almost all β_1 estimates are positive and highly significant, while almost all β_2 estimates are insignificant. At the 5% of significance level, 77.7% of γ estimates are positively significant. Thus, in general, the specification of the dependence process is appropriate for most index series. The statistics show that cross-market dependence is highly persistent and mainly influenced by its level in the previous period, and that the closer (farther) the percentiles of the de-meaned returns of a pair of stock indices, the higher (lower) the dependence is.

Fig. 1 shows the estimated conditional dependence processes for the available countries in each industry, with the left vertical solid line indicating the time when the Euro was officially introduced (i.e., January 1, 1999). For each industry, we group countries by similar time-series patterns. The industries Financials (Panel A), Technology (Panel I) and Telecommunications (Panel J) show clear evidence of increased dependence for most countries. Although the model is estimated and the figure is drawn for the entire sample period, we focus here on the dependence patterns of the period of 1992–2005 to discuss the impact of the introduction of the Euro in 1999.[14] In Financials, Technology and Telecommunications, almost all of the national indices demonstrate a remarkable increase in dependence with their corresponding EMU indices around the year of the introduction of the Euro. In contrast, the effects for the sectors Basic Materials, Consumer Services, Healthcare and Oil & Gas are less clear. Considering the results along the country dimension, many industries in France, Germany, Italy, the Netherlands, and Spain, which are countries with larger capitalization, show a dependence increase with their corresponding Euro-area markets. By contrast, there is no clear increase for most industries in the eight European countries that are not part of the Euro.

While the results in Fig. 1 suggest that the dependence of many industries increased with the introduction of the Euro in 1999 for Euro area countries compared to non-Euro area countries, more formal tests are required to establish whether the visual pattern can also be confirmed statistically. Moreover, in order to attribute the effect to the introduction of the Euro, other effects need to be controlled for, since increasing dependence could simply reflect the effect of globalization or a volatility bias (Forbes and Rigobon, 2002; Bartram and Wang, 2005). Therefore, our tests include both a global trend in dependence as well as conditional industry volatility.[15]

In particular, in order to test empirically whether the dependence change for a particular industry in a particular country is significantly driven by the introduction of the Euro, we employ the following two-stage testing procedure. In the first stage, the time-varying dependence level is regressed on the dummy variable D_{98}, which equals zero before 1998, and 1 otherwise. In this regression, we include the dependence between the returns of the EMU and World (excluding EMU) stock indices of the industry as a control variable, to ensure that an increase in dependence is not the result of a global trend. In addition, we also include the conditional volatility of the returns of the industry index generated from the marginal model to control for the potential concern about the volatility bias raised by Forbes and Rigobon (2002).[16] If the dummy variable is not significant at the 5% level, it is replaced by an alternative variable, D_{99}, which equals zero before 1999, and 1 otherwise.[17]

If we find a significant dummy coefficient at the 5% significance level from either test, we investigate in a second stage whether the annually averaged dependence levels of the following five years are also at a level that is not lower than that of the year with a significant first-stage dummy. In particular, we average the weekly dependence levels for each of the five years and test the equality of the five averages one by one against the average dependence level

[13] Modeling dependence with conditional copula densities first requires appropriate specifications for the marginal densities. To this end, we use the diagnostic test of Berkowitz (2001) to evaluate the goodness-of-fit of our marginal return densities, specified by the GJR-GARCH-MA-skewed t model. The residual series pass the goodness-of-fit test at the 10% level for all industrial stock indices.

[14] Although the Euro was officially introduced in 1999, membership had been determined in early 1998. Therefore, the sample period for the investigation of the impact of the Euro introduction includes six years before and after the reference period of 1998 and 1999, respectively.

[15] According to Hardouvelis et al. (2006), Cappiello et al. (2010), and Eiling and Gerard (2014), global effects are the most important concern in the analysis of cross-market dependence or integration. Although Bekaert et al. (2013) suggest that membership in the EU has significantly influenced European stock market integration, we are unable to control for this effect with our methodology directly, but do so in a robustness test using panel regressions.

[16] Potential concerns are the stability of model parameters and the existence of structural changes during our sample period. Controlling for the volatility effect can potentially address these concerns since it represents a time-varying proxy for market conditions.

[17] Although the Euro officially started to serve as a common currency on January 1, 1999, membership was determined in late 1997/early 1998. Therefore, following the literature, our tests are based on two alternative effective dates: January 1998 and 1999. For Greece, the alternative effective dates are January 2000 and 2001 because it joined the Euro area in 2001.

Table 1
Summary statistics of stock index returns.

	Mean	Median	Std. Dev.	Skewness	Kurtosis	Minimum	Maximum	AR(1)
Panel A: By Industry								
Financials	0.0013	0.0030	0.0424	−0.3950	7.5667	−0.2317	0.2159	−0.0405
Basic Materials	0.0016	0.0029	0.0417	−0.4228	6.7235	−0.2227	0.1845	−0.0096
Industrials	0.0014	0.0034	0.0408	−0.4403	7.4808	−0.2244	0.1802	−0.0262
Cons. Goods	0.0016	0.0024	0.0421	−0.1203	7.0763	−0.2114	0.2208	−0.0336
Cons. Services	0.0013	0.0023	0.0392	−0.3456	6.5848	−0.2071	0.1866	−0.0278
Healthcare	0.0014	0.0027	0.0389	−0.2614	6.1927	−0.1937	0.1749	−0.0485
Oil & Gas	0.0023	0.0033	0.0441	−0.2661	5.9311	−0.2247	0.2004	−0.0371
Utilities	0.0017	0.0023	0.0376	−0.2470	7.1543	−0.2103	0.1821	−0.0065
Technology	0.0012	0.0025	0.0523	−0.2115	6.5976	−0.2641	0.2477	0.0066
Telecom	0.0015	0.0023	0.0460	−0.2189	5.7003	−0.2210	0.2017	−0.0465
Panel B: By Country								
Austria	0.0011	0.0028	0.0420	−0.6868	8.9247	−0.2598	0.2014	−0.0273
Belgium	0.0018	0.0023	0.0370	−0.3259	7.1130	−0.2119	0.1765	−0.0133
Finland	0.0026	0.0038	0.0440	−0.3569	6.1910	−0.2212	0.1984	−0.0322
France	0.0014	0.0030	0.0363	−0.4234	6.1030	−0.1927	0.1665	−0.0740
Germany	0.0016	0.0031	0.0358	−0.4807	6.6318	−0.1868	0.1753	−0.0441
Greece	0.0009	0.0017	0.0533	−0.0843	5.1542	−0.2261	0.2217	0.0321
Ireland	0.0013	0.0024	0.0482	−0.1943	6.9946	−0.2451	0.2461	−0.0164
Italy	0.0004	0.0018	0.0411	−0.3415	5.7021	−0.2168	0.1681	−0.0130
Luxembourg	0.0015	0.0013	0.0356	−0.0718	12.5022	−0.2304	0.2234	0.0061
Netherlands	0.0015	0.0033	0.0413	−0.3724	7.4033	−0.2183	0.2110	−0.0584
Portugal	−0.0002	0.0006	0.0438	−0.0317	7.1642	−0.2193	0.2185	−0.0275
Spain	0.0015	0.0025	0.0372	−0.2325	5.9304	−0.1959	0.1666	−0.0264
Czech Republic	0.0020	0.0028	0.0490	−0.1141	7.9386	−0.2588	0.2403	0.0216
Denmark	0.0015	0.0019	0.0431	−0.2075	7.5298	−0.2417	0.2203	−0.0714
Hungary	0.0017	0.0024	0.0521	−0.0727	6.7029	−0.2474	0.2752	0.0099
Norway	0.0021	0.0040	0.0469	−0.4126	6.2858	−0.2533	0.2225	−0.0458
Poland	0.0009	0.0035	0.0515	−0.4177	5.7824	−0.2487	0.2202	0.0095
Sweden	0.0024	0.0039	0.0440	−0.2038	5.7528	−0.2172	0.1995	−0.0776
Switzerland	0.0017	0.0032	0.0341	−0.4043	5.6546	−0.1762	0.1475	−0.0096
UK	0.0016	0.0027	0.0337	−0.3775	6.2119	−0.1754	0.1516	−0.0522
Panel C: By Region								
EMU	0.0015	0.0035	0.0318	−0.6246	6.5907	−0.1784	0.1351	−0.0486
World (ex EMU)	0.0014	0.0030	0.0252	−0.7460	7.6207	−0.1772	0.1012	−0.0043

The table presents summary statistics of the weekly industrial stock index returns of the 12 Euro zone and 8 non-Euro zone national markets, and the EMU and World (excluding EMU) markets. All indices are denominated in U.S. dollars. The sample period is from January 1, 1992 to December 31, 2011. Panels A and B report summary statistics across countries and industries, respectively. Panel C reports summary statistics for two regional indices across industries. AR(1) represents the average of the 1st-lag autocorrelation coefficient of returns.

in 1998 or 1999. If a dependence time-series has a significant positive dummy coefficient in the first stage and none of the test statistics in the second stage are negatively significant, it is classified as having experienced a significant increase after the introduction of the Euro.

Table 3 presents a summary of the estimation results of our two-stage approach, indicating significant increases in dependence after the introduction of the Euro of an industry index in a particular country.[18] The test results are largely consistent with the visual inspection of the graphs in Fig. 1, but with a few exceptions. For example, the tests for the industries Basic Materials and Consumer Services in France and Germany indicate the absence of a significant increase in dependence with the Euro markets after controlling for the global effect and the volatility effect. In contrast, at least 8 out of 10 industry portfolios for Spain and Italy exhibit a significant increase, suggesting that the industries in these two countries have become significantly more pan-Euro and, therefore, particularly benefited from the introduction of the Euro.

While often the dependence increase is significant for countries with larger market capitalization, more than 50% of the industry portfolios in Belgium and Finland also exhibit a significant increase.[19]

According to the test results for the Euro zone countries, the industries in which more than half of the countries show a significant dependence increase are Financials, Industrials, Consumer Goods, Utilities, Technology and Telecommunications. In contrast, most industries in the countries outside the Euro area experience no significant increase in dependence after controlling for global and volatility effects, although some exceptions apply (such as the industries Financials and Technology).[20]

Because Bekaert et al. (2013) report evidence for an impact of EU membership on European stock market integration, one may argue that the identification of the Euro effect in Table 3 is insufficient. While we are unable to include an appropriate control for this effect in our methodology, we can consider an EU effect in panel regressions using the dependence level of industry index returns with the corresponding EMU index returns as the dependent variable. The estimation of this panel regression for both Euro and non-Euro countries allows for a standard

[18] The coefficient estimates of the first-stage dummy variables and the second-stage test statistics of the five average-equality tests are available upon request.

[19] To support the relation between dependence increase and market size statistically, we regress the proportion of industries in a country with a significant increase in dependence on the market capitalization of a country's equity market. The regression coefficient is positive and significant at the 1% significance level and the adjusted R^2 is 0.50. Excluding Greece, the adjusted R^2 is 0.73.

[20] For the industry Financials, the Euro effect applies to most of the examined countries. As suggested by Cappiello et al. (2010), this is consistent with the progress of European financial integration enhanced by the financial services action plan (FSAP) launched in 1999. Similarly, the EU liberalized the market for telecommunications terminal equipment in the years prior to the introduction of the Euro, in order to abolish special or exclusive rights to import, market, connect, bring into service, and maintain telecommunications terminal equipment. This could also contribute to an EU effect in the industry Technology, since Telecommunications equipment is the largest subsector in the Technology stock index (ca. 58% in 1999). Moreover, the millennium risk commonly affected firms in the sectors computer service, internet, software, hardware, electronic office equipment, semiconductors, and telecommunication equipment in all countries before the year 2000.

Table 2
Estimates of the GJR-GARCH-MA-Skewed t copula dependence model.

	Mean	Std. Dev.	Minimum	Maximum	% of $p < 0.01$	% of $p < 0.05$	% of $p < 0.1$
Panel A: The Marginal Model							
μ	0.002	0.001	−0.003	0.006	48.9	72.3	78.7
κ	−0.033	0.046	−0.220	0.090	21.2	35.1	42.0
ω	6E−5	6E−5	5E−6	5E−4	90.4	98.9	100.0
β	0.867	0.056	0.571	0.955	100.0	100.0	100.0
α	0.069	0.050	3E−12	0.323	70.2	81.4	85.6
α^-	0.073	0.056	8E−15	0.495	54.8	68.1	72.3
η	7.322	3.009	2.274	20.429	96.8	100.0	100.0
λ	−0.089	0.079	−0.263	0.090	43.1	50.5	59.0
Panel B: The Dependence Model							
ω	0.004	0.006	−0.001	0.050	13.5	27.4	35.8
β_1	0.974	0.036	0.587	0.999	99.3	99.7	100.0
β_2	0.014	0.044	1E−7	0.587	0.0	0.0	0.1
γ	0.182	0.107	0.016	0.576	59.1	77.7	85.5

The table presents summary statistics of the parameter estimates of the GJR-GARCH-MA-Skewed t copula dependence model. The marginal (the GJR-GARCH-MA-Skewed t) model is estimated for weekly industrial stock index returns of 12 Euro zone and 8 non-Euro zone national markets as well as EMU and World (excluding EMU) markets. The dependence (the Gaussian copula) model is estimated for weekly industrial stock index returns of 12 Euro zone and 8 non-Euro zone national markets against the returns of the EMU stock index and for weekly returns of 10 EMU industrial indices against the returns of their corresponding World (excluding EMU) indices. For the dependence estimation of the 12 Euro zone markets, the EMU indices are the value-weighted EMU index excluding the examined countries. All indices are denominated in U.S. dollars. The statistics are summarized across both industries and countries (or regions). The last columns show the percentage of coefficient estimates with p-values lower than 0.01, 0.05, and 0.1, respectively. The sample period is from January 1, 1992 to December 31, 2011. The marginal process is the GJR-GARCH-MA-Skewed t model specified as

$$R_t = \mu + \kappa\varepsilon_{t-1} + \varepsilon_t, z_t = \varepsilon_t/\sqrt{h_t} \sim t(\eta,\lambda)$$
$$h_t = \omega + \alpha\varepsilon_{t-1}^2 + \alpha^- S_{t-1}\varepsilon_{t-1}^2 + \beta h_{t-1}.$$

In the dependence model, the bivariate density $h(x,y)$ depends on the Gaussian copula function $c(u,v)$ defined by Eq (3) with correlation parameter ρ_t given by $(1-\beta_1 L)(1-\beta_2 L)\rho_t = \omega + \gamma(u_{t-1}-0.5)(v_{t-1}-0.5)$.

difference-in-differences identification of the Euro effect. In addition to the global and volatility effects that have been considered in our previous analysis, we also include country, industry, and year fixed effects. We estimate regressions for the same country-industry observations using alternatively balanced and unbalanced samples.[21] To understand how our main results might be affected if the EU effect is accounted for, we estimate regressions with and without controlling for the EU effect, respectively. As reported in Table 4, the results show that the dependence of Euro area countries increases significantly more with the introduction of the Euro compared to non-Euro area countries, which is consistent with our main findings from the two-stage identifying approach. The Euro effect is robust to controlling for EU membership, which only marginally increases the adjusted R-squares. Thus, the introduction of the Euro has had an important effect on industries in the Euro area, but with variation across industries and countries. The effect exists over and above an EU and volatility effect, a global trend and several other effects, and it is largely not present in countries outside the Euro zone.[22]

2.4.2. The recent financial crises

Although the introduction of the Euro has generally led to an increase in European equity market dependence, the recent financial and debt crises have revived concerns about the vulnerability of the monetary union. As such, we further explore market dependence during the periods of the collapse of Lehman Brothers and the European sovereign debt crisis, respectively. Since the eight examined non-Euro zone countries do not show clear signs of stronger dependence after the introduction of the Euro, we only focus on the Euro zone countries to investigate how these financial crises affect regional market dependence.

To this end, we define the pre-crisis, crisis and post-crisis periods for the collapse of Lehman Brothers as January 1, 2007 to September 12, 2008; September 15, 2008 to October 27, 2008; and October 28, 2008 to February 29, 2009, respectively. Since the recent European sovereign debt crisis turned severe in April 2010 and may still be ongoing at the end of our sample period, we only define the pre-crisis and crisis periods as March 1, 2009 to March 31, 2010 and April 1, 2010 to December 31, 2011, respectively.

Fig. 1 shows the dependence patterns of all industry portfolios with their corresponding EMU indices around the occurrence of the recent crises. The second and third vertical lines indicate the dates of the collapse of Lehman Brothers and the European sovereign debt crisis, respectively. In addition, Tables 5 and 6 show statistics on the levels and changes in dependence levels of the industry portfolio returns of the 12 Euro-area markets with regard to the corresponding EMU industry indices for the respective subperiods.

The results in Table 5 pertain to the collapse of Lehman Brothers in September 2008. Results are shown by industry (Panel A), by country (Panel B), and pooled (Panel C). Results by industry show that the Lehman collapse is associated with a significant dependence increase, not only in Financials, but also all other industries, with almost all dependence levels exceeding 0.5 in the post-crisis period. Note that the crisis period is defined as the period of the Lehman collapse. Consequently, it is not surprising that dependence in the period after this event is still high and often at similar levels to those in the heat of the crisis. To illustrate, the dependence increase in Consumer Goods is 13.0% and 20.4% for the crisis and post-crisis periods, respectively. The majority of industries in a country as well as countries in an industry have a dependence

[21] The estimation using balanced samples is conducted on a shorter sample period to retain several countries in the sample that joined the EU late in the sample period (such as Poland or the Czech Republic). Estimating the balanced sample over the same period as the unbalanced sample leads to an insignificant EU effect (but significant Euro effect).

[22] Bekaert et al. (2013) use the divergence in valuations of industries between country pairs as a measure of equity market segmentation and find that EU membership reduces equity market segmentation between member countries independent of whether members have also adopted the Euro. Their results suggest that the Euro adoption as well as the anticipation of the Euro adoption has minimal effects on market integration. Although this topic is not the focus of our paper, we use the national stock market indices of the same 16 European countries to compare the effects of the EU and Euro on the regional equity market dependence using our methodology over the same period 1990–2007. We use a balanced panel to regress the copula dependence levels with the EMU stock market index on dummy variables indicating the dates of countries joining the EU and Euro, respectively. The results show evidence of both an EU and Euro effect and are robust to alternative data frequencies and the inclusion of year and country fixed effects. In fact, controlling for EU membership appears to improve the identification of the Euro effect, suggesting that our main results are robust even though we are unable to control for this effect.

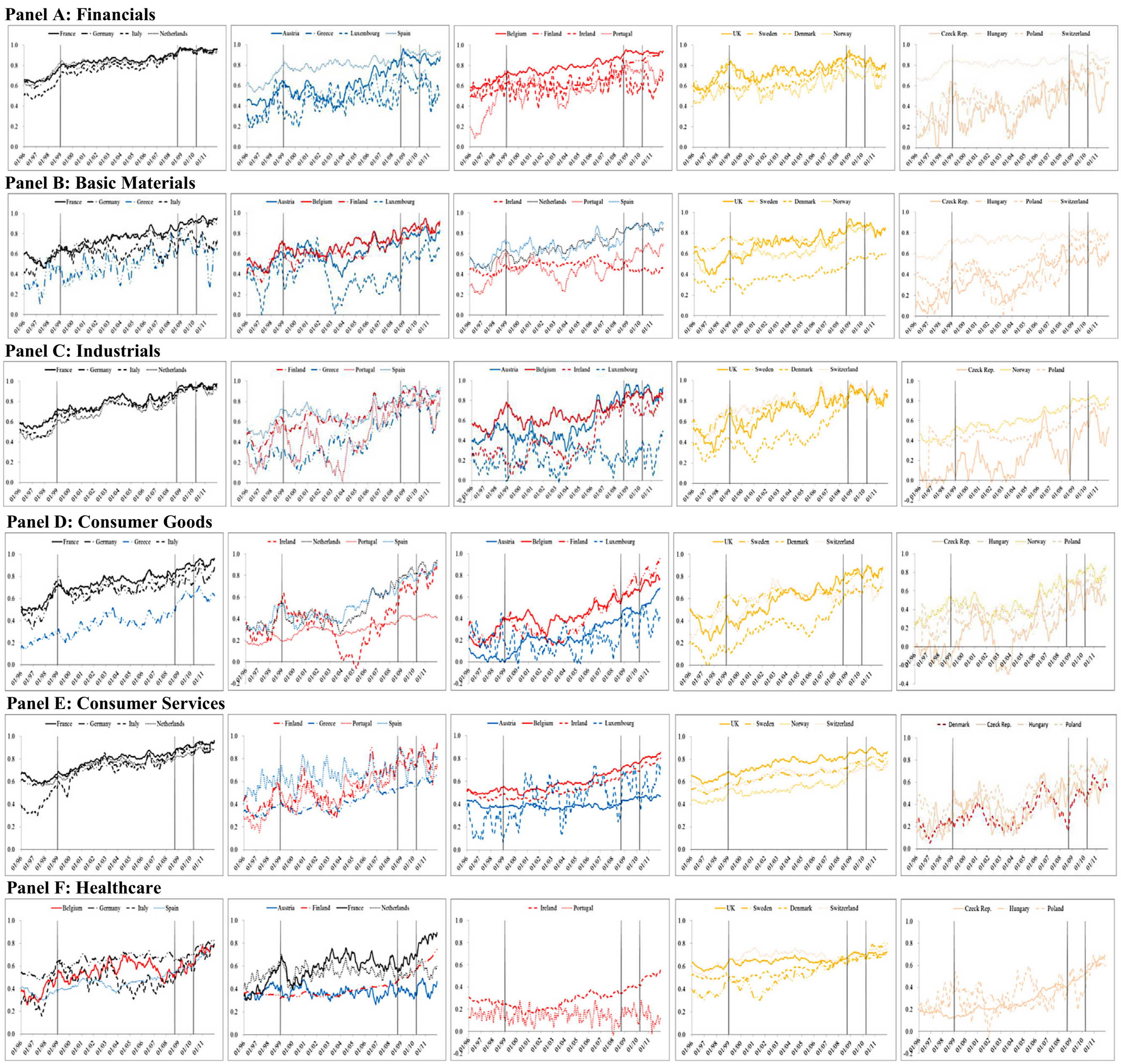

Fig. 1. Time series of dependencies between country indices and Euro zone market indices. This figure presents the time series of the conditional dependences between the 12 Euro zone and 8 non-Euro zone country indices and their corresponding Euro zone market indices excluding the examined country. All indices are denominated in U.S. dollars. The full sample period used for the estimation is from January 1, 1992 to December 31, 2011, excluding holidays. However, because some indices are not available until late 1995, the time series presented in the figure commence from January 1, 1996 for consistency across countries and industries. The vertical solid lines in each graph indicate from left to right the dates when the Euro was officially introduced (January 1, 1999), when the Lehman crisis began (September 15, 2008), and when the European sovereign debt crisis commenced (April 1, 2010), respectively.

increase that is significant at the 5% level. For a given industry (country), 70% (71%) or more of the countries (industries) have a significant dependence increase. Due to a lower base level, countries with smaller market capitalization such as Austria, Ireland, Luxemburg, and Portugal exhibit a higher percentage increase in dependence. Relative to levels before the crisis, Euro zone equity market dependence increases overall by 9% during the crisis period and by 15% in the post-crisis period.[23]

Table 6 shows dependence levels and changes in dependence for the period of the European sovereign debt crisis, separately for the entire Euro area, for high-risk countries (Greece, Ireland, Italy, Portugal, and Spain), and for Greece on its own. Panels A, B, and C show averages by industry, country, and pooled results, respectively.[24] Compared to the percentage changes in dependence for a similar length of time (3 years) around the introduction of the Euro (1997–1999) and the collapse of Lehman Brothers (2007–2009), the change in dependence during the recent European

[23] As a robustness check, we also control for the global effect by regressing the time-varying dependence level on the dependence between the returns of the EMU and World (excluding EMU) stock indices of the industry and two dummy variables, which equal zero before the crisis and post-crisis periods, respectively, and one otherwise. These regressions yield similar patterns of changes in cross-market dependence. In particular, the regression results show a significant dependence increase during the crisis period across countries and industries and a further increase in dependence during the post-crisis period.

[24] As a robustness test, we also investigate the dependence change of the industry portfolios of high-risk countries when excluding not only the examined country (as in all other tests) but also all other high-risk countries from the corresponding EMU industry indices. The results of this alternative specification are qualitatively very similar.

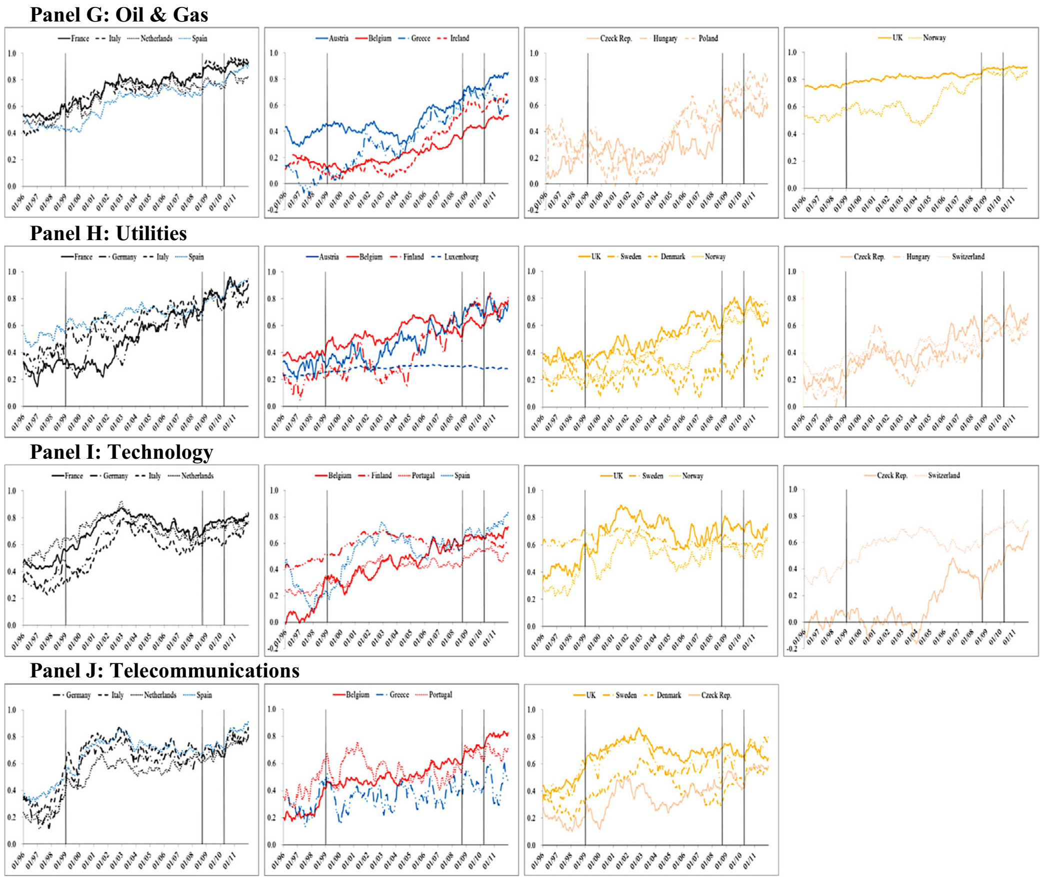

Fig. 1 (*continued*)

sovereign debt crisis is small, both for cross-country and cross-industry results. In fact, the change in Basic Materials is close to zero, and the changes in Financials and Industrials are slightly negative. Overall, the market dependence for the Euro area increases by 5.1% over this period, while the increases for the other two periods are more than 20%.

For the group of high-risk countries, the sovereign debt crisis is particularly severe, where changes in dependence are lower and even negative in several major industries including Financials, Basic Materials, and Industrials. For Greece, as the most affected country, dependence in the industries Basic Materials, Industrials, Financials, and Oil & Gas decreased significantly at the 1% level, with reductions of more than 10% in the first three industries. Although dependence of the remaining industries in Greece increased during the crisis period relative to the pre-crisis period, the effect is relatively small, compared to the general levels in the Euro area.[25]

From the period of the introduction of the Euro, European equity market dependence has generally increased over time and reached the highest level in the Fall of 2008, which was followed by the global financial crisis. Furthermore, the recent European sovereign debt crisis revealed and magnified the heterogeneity among Euro member countries, emphasizing the vulnerability of the monetary union. The indications of lower market dependence of high-risk countries, especially Greece, with the Euro area reflects that country-specific factors may matter more during the crisis than before.

2.4.3. Comparison with R^2 integration measure

Since Goetzmann et al. (2005), Cappiello et al. (2006, 2010) and Eiling and Gerard (2014) suggest a relation between market dependence and integration, it is interesting to investigate how European equity market dependence is related to market integration.[26] Therefore, we compare our copula dependence measure with the integration measure proposed by Pukthuanthong and Roll (2009). In particular, we run rolling regressions with weekly returns of industry portfolios on out-of-sample principal components over estimation windows of 52 weeks to obtain a series of adjusted R-squares for each country–industry observation. The principal component analysis is performed for each rolling sample. Once the eigenvectors are computed, principal components are estimated from returns in the subsequent (non-overlapping) estimation window as an out-of-sample period. The first principal components that account

[25] In order to control for global effects, we also run regressions of the time-varying dependence level on the dependence between the returns of the EMU and World (excluding EMU) stock indices of the industry and a dummy variable, which equals zero before the crisis period, and one otherwise. The average coefficient for high-risk countries is lower than that for other countries in most industries. In particular, the dummy coefficient is negative for five out of seven Greek industries, which indicates a decrease in dependence with the Euro zone.

[26] In particular, the integration measure proposed by Cappiello et al. (2006, 2010) coincides with linear correlation coefficients. They analyze the integration between markets i and j. The return on market i is modelled as $r_i = \omega_{ij} G_{ij,t} + e_{i,t}$, where $\omega_{ij,t}$ is the exposure at time t of market i to the common factor $G_{ij,t}$ and $e_{i,t}$ is the idiosyncratic risk of market i assumed to be orthogonal to the common factor and to market j idiosyncratic risk. Note that $G_{ij,t}$ includes all the common components specific to markets i and j and thus different market pairs may have distinct common factors. With this setting, the variance of country i's returns can be decomposed as $\sigma^2_{r_{i,t}} = \omega^2_{ij,t}\sigma^2_{G_{ij,t}} + \sigma^2_{e_{i,t}}$ and the share of volatility explained by the common factor is $\phi_{ij,t} \equiv (\omega_{ij,t}\sigma_{G_{ij,t}})/\sigma_{r_{i,t}}$. Cappiello et al. (2006, 2010) propose to measure the integration between markets i and j as $\Phi_{ij,t} \equiv \phi_{ij,t}\phi_{ji,t}$, which is bounded between -1 and 1, and link the linear correlation coefficient to the integration measure as $\rho_{ij,t} = \frac{\sigma_{r_i r_j,t}}{\sigma_{r_{i,t}}\sigma_{r_{j,t}}} = \Phi_{ij,t}$, where $\sigma_{r_i r_j,t} = \omega_{ij,t}\omega_{ji,t}\sigma^2_{G_{ij,t}}$.

Table 3
Tests for dependence change around the introduction of the Euro.

Country/Industry	Financials	Basic Materials	Industrials	Consumer Goods	Consumer Services	Healthcare	Oil & Gas	Utilities	Technology	Telecommunications
Austria								Yes	NA	NA
Belgium	Yes			Yes		Yes		Yes	Yes	Yes
Finland	Yes	Yes	Yes				NA	Yes	Yes	NA
France	Yes		Yes	Yes			Yes	Yes	Yes	NA
Germany	Yes		Yes	Yes		Yes	NA		Yes	Yes
Greece		Yes	Yes	Yes		NA		NA	NA	
Ireland		Yes						NA	NA	NA
Italy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Luxembourg						NA	NA	Yes	NA	NA
Netherlands	Yes		Yes				Yes	NA	Yes	Yes
Portugal	Yes	Yes		Yes	Yes		NA	NA		
Spain	Yes	Yes	Yes	Yes	Yes			Yes	Yes	Yes
Czech Republic	Yes		Yes		Yes		Yes	Yes		
Denmark	Yes						NA		NA	
Hungary	Yes		NA					Yes	NA	NA
Norway	Yes					NA			Yes	NA
Poland	Yes							NA	NA	NA
Sweden	Yes			Yes			NA		Yes	
Switzerland	Yes	Yes	Yes	Yes		Yes	NA	Yes	Yes	NA
UK	Yes								Yes	Yes

In the first stage, the time-varying dependence level is regressed on the dummy variable D_{98}, which equals zero before 1998, and 1 otherwise, controlling for the dependence between the returns of the EMU and World (excluding EMU) stock indices of the industry and the conditional volatility of the returns of the examined industrial index. If the dummy coefficient is not significant at the 5% significance level, the dummy variable is replaced by an alternative dummy variable D_{99}, which equals zero before 1999, and 1 otherwise. For Greece, the alternative effective dates are 2000 and 2001. If we find a significant dummy coefficient at the 5% of significance level from either test, we test in the second stage whether the annually averaged dependence levels of each of the following five years still sustain a level which is not lower than that of the year corresponding to the significant dummy found in the previous stage. Once a dependence time series is found to have a significant positive dummy coefficient in the first stage and none of the test statistics in the second stage is negatively significant, it is regarded as having experienced a significant increase after the Euro introduction, which is indicated by "Yes". The unavailability of data is indicated by 'NA'.

Table 4
Panel regressions for dependence change around the introduction of the Euro.

	Unbalanced (1992–2011)		Balanced (1996–2011)	
	(1)	(2)	(3)	(4)
$D_{EuroCountry}$	0.027*** (0.005)	0.034*** (0.005)	0.015** (0.008)	0.029*** (0.008)
D_{EU}		0.038*** (0.006)		0.066*** (0.008)
EMUWD	0.407*** (0.018)	0.405 (0.018)	0.407*** (0.018)	0.402*** (0.018)
VOL	−0.001 (0.001)	−0.001 (0.001)	−0.001 (0.001)	−0.001 (0.001)
Intercept	0.299*** (0.015)	0.257*** (0.017)	0.303*** (0.017)	0.223*** (0.020)
Country Dummies	Yes	Yes	Yes	Yes
Industry Dummies	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes
Adjusted R-squared	0.708	0.709	0.708	0.710

This table reports the estimation results of panel regressions with 20 countries (i.e. Euro and non-Euro countries). The dependent variable is the dependence level of industry portfolio returns with the corresponding EMU index returns. The independent variables include the Euro country dummy ($D_{EuroCountry}$), with a value of 1 if the country index is for a Euro-zone country in the observation week, and zero otherwise. We also include the dependence between the EMU and World (excluding EMU) stock index returns (*EMUWD*) and the conditional volatility of the industry index returns (*VOL*) as control variables. Moreover, the EU, country, industry and year dummy variables are also included in alternative specifications. The models are estimated for an unbalanced sample with all available data as well as for a balanced sample. The numbers in parentheses are Newey–West standard errors. ** and *** indicate significance at the 5% and 1% levels, respectively.

for at least 90% of the cumulative eigenvalues are used as factors in the multifactor model to obtain the regression R-squares.

Fig. 2 plots the R-squares (similar to Fig. 4 in Pukthuanthong and Roll, 2009) as well as the Gaussian copula dependence averaged across all observations.[27] Overall, the average copula dependence is very similar to the average R-squares both in terms of levels and trend, and the correlation between the two series is 0.97.[28] Thus, measuring dependence using our copula model appears qualitatively similar to measuring integration using the R-squares approach. At the same time, in many cases the time-series pattern of R-squares for individual countries/industries exhibits significant time-series variation, whereas copula dependence tends to be more stable over time. In particular, as shown in Fig. 3, the R-square is about two to three times more volatile across all industries. On average, the ratio of the standard deviation (coefficient of variation) of

[27] As noted by Pukthuanthong and Roll (2009), the R-square may not necessarily measure the actual level of integration, but still provides "an acceptable and informative ordinal ranking" with an upper bound of 1 (p. 219). In order to compare the trends of our dependence and their integration measures (as opposed to their levels), the figures are plotted with separate y-axes for the R-square and copula measures. The results from the comparison based on the measures averaged across countries are similar.

[28] Rank correlations of the measures averaged across countries and industries are even higher (0.99). In addition, the rank correlations of cross-country averages range from 0.80 to 0.97. Therefore, the ranking of the R-square integration measure is similar to that of our copula dependence.

Table 5
Dependence change during the Lehman collapse.

	Pre-Crisis	Crisis Period	Post-Crisis	% Change	
	1/01/07–9/12/08	9/15/08–10/27/08	10/28/08–2/29/09	Crisis	Post-crisis
Panel A: Results By Industry					
Financials	0.763	0.855	0.865	12.1 (100)	13.4 (92)
Basic Materials	0.640	0.693	0.748	8.3 (83)	16.9 (92)
Industrials	0.710	0.786	0.835	10.7 (92)	17.6 (100)
Cons. Goods	0.539	0.609	0.649	13.0 (92)	20.4 (92)
Cons. Services	0.652	0.725	0.751	11.2 (92)	15.2 (100)
Healthcare	0.455	0.472	0.486	3.7 (60)	6.8 (70)
Oil & Gas	0.616	0.695	0.731	12.8 (100)	18.7 (100)
Utilities	0.602	0.638	0.692	6.0 (50)	15.0 (100)
Technology	0.594	0.624	0.660	5.1 (75)	11.1 (100)
Telecom.	0.589	0.619	0.667	5.1 (43)	13.2 (86)
Panel B: Results By Country					
Austria	0.568	0.648	0.680	14.1 (100)	19.7 (100)
Belgium	0.618	0.654	0.697	5.8 (80)	12.8 (100)
Finland	0.622	0.680	0.718	9.3 (75)	15.4 (100)
France	0.778	0.816	0.847	4.9 (89)	8.9 (89)
Germany	0.740	0.770	0.794	4.1 (67)	7.3 (78)
Greece	0.684	0.747	0.789	9.2 (86)	15.4 (100)
Ireland	0.525	0.601	0.602	14.5 (100)	14.7 (71)
Italy	0.707	0.768	0.798	8.6 (90)	12.9 (100)
Luxembourg	0.318	0.400	0.484	25.8 (50)	52.2 (83)
Netherlands	0.709	0.747	0.774	5.4 (67)	9.2 (78)
Portugal	0.484	0.558	0.582	15.3 (88)	20.2 (100)
Spain	0.672	0.755	0.787	12.4 (90)	17.1 (100)
Panel C: Overall Results					
	0.616	0.672	0.708	9.0 (81)	15.0 (93)

This table presents the average dependence levels of the industrial stock index returns of the 12 Euro zone national markets with regard to their corresponding EMU industry indices excluding the examined markets, for the period of the collapse of Lehman Brothers. The pre-crisis, crisis, and post-crisis sample periods are 1/01/2007–9/12/2008, 9/15/2008–10/27/2008, and 10/28/2008–2/29/2009, respectively. Panels A and B report cross-country and cross-industry averages, respectively. Panel C reports averages across both countries and industries. The % change is the change in dependence for the period relative to the level of the pre-crisis period. The numbers in parenthesis are the percentage of available industries or countries with a significantly higher (lower) dependence at the 5% level if the % change is positive (negative).

the R-square to that of the copula dependence measure is 1.96 (2.84), and very few ratios are less than 1.[29]

Finally, we compare the copula dependence to correlation coefficients (estimated over rolling 52-week windows) and dynamic conditional correlations (DCC) of Engle and Sheppard (2001) that are frequently used to measure market co-movement. As shown in Fig. 4, the levels and time-series patterns of copula dependence, DCC and correlation are similar, which is consistent with the robustness analysis of Bartram et al. (2007). At the same time, DCC and correlations are also more volatile than copula dependence (Fig. 5).

3. Determinants of changes in European market dependence

3.1. Literature and hypotheses

The literature suggests several factors as important drivers of dependence or integration of economies and markets. In particular, among the most important determinants of changes in dependence following the introduction of the Euro are the degree of alignment of national economies with the rest of the Euro area prior to 1999 (Bayoumi and Eichengreen, 1997), economic openness (Dornbusch et al., 1998; Hummels et al., 2001), industry structure (Walz, 1998), export specialization of national industries (Plümper and Graff, 2001), internationalization of industries (Forbes, 1993; Ferreira and Ferreira, 2006), prior export activity (Bun and Klaassen, 2007), relative financial and technological development (Walz, 1998; Guiso et al., 2004; Baele, 2005; Kim et al., 2005; Carrieri et al., 2007; Connor and Suurlaht, 2013), difficulties accessing bank loans (Rusek, 2004), and the degree of vertical specialization within each economy (Flam and Nordström, 2003).[30]

Empirical studies that investigate European financial market dependence need to account for potentially time-varying country and industry effects. For instance, the coordination of economic and monetary policy that is a crucial part of the Euro is reflected in the increasing correlation of the Euro-area business cycles (Frankel and Rose, 1997; Artis and Zhang, 1999; Mélitz, 2004). As a result, the importance of country-specific factors in explaining activity in the real sector has declined, while individual industries have become increasingly important (Ramos et al., 2003). The shift in the organization of professional investment management along the industry dimension as opposed to the country dimension reflects the general decline in the relative importance of national borders for financial markets (Ramos et al., 2003; Ferreira and Ferreira, 2006; Eiling et al., 2012). As a consequence, empirical studies of Euro-area economies need to consider industry-level differences in the response to Euro-area dependence following the introduction of the Euro.

To this end, we expect to see an increase in Euro-area dependence of interest-rate sensitive industries after the introduction of the Euro as interest rates have been determined at the European level since 1999.[31] Moreover, to the extent that

[29] This result may reflect differences in the estimation procedure as R-square measures are estimated individually over a short time window (e.g., one year), whereas copula dependence is estimated simultaneously in a conditional model based on the entire sample period of data. Moreover, the impact of particular events is more easily identified with copulas, while Carrieri et al. (2013) note that the rolling window estimation of R-squares makes it challenging to account for the breaks generated from the introduction of a particular event.

[30] The term *vertical specialization* was coined by Hummels et al. (2001) and applies to situations where "a good is produced in two or more sequential stages, two or more countries provide value-added during the production of the good, at least one country must use imported inputs in its stage of the production process, and some of the resulting output must be exported" (p. 77).

[31] Interest rate-sensitive industries have been identified to be partly responsible for the heterogeneous response to changes in interest rates across Euro member states (e.g., Arestis et al., 2002).

Table 6
Dependence changes during the European sovereign debt crisis.

	Euro Area						High–risk Countries						Greece		
	Pre-Crisis	Crisis Period	% Change				Pre-Crisis	Crisis Period	% Change				Pre-Crisis	Crisis Period	% Change
	3/01/09–3/31/10	4/01/10–12/31/11	Sovereign Crisis		2007–2009	1997–1999	3/01/09–3/31/10	4/01/10–12/31/11	Sovereign Crisis		2007–2009	1997–1999	3/01/09–3/31/10	4/01/10–12/31/11	Sovereign Crisis
Panel A: Results by Industry															
Financials	0.834	0.821	−1.6	(33)	11.7	23.6	0.789	0.764	−3.2	(20)	13.7	18.9	0.749	0.601	−19.8*
Basic Materials	0.752	0.757	0.7	(58)	19.3	25.3	0.671	0.647	−3.6	(40)	24.9	25.3	0.687	0.581	−15.4*
Industrials	0.817	0.805	−1.5	(50)	19.3	24.8	0.822	0.794	−3.4	(60)	23.1	18.2	0.769	0.688	−10.5*
Cons. Goods	0.665	0.730	9.8	(92)	26.5	43.9	0.668	0.718	7.5	(80)	45.2	34.0	0.629	0.636	1.1
Cons. Services	0.733	0.766	4.5	(83)	14.4	15.4	0.721	0.760	5.4	(80)	14.1	7.1	0.575	0.616	7.1*
Healthcare	0.512	0.605	18.2	(90)	13.4	18.3	0.438	0.511	16.7	(75)	9.8	3.4			
Oil & Gas	0.719	0.767	6.7	(88)	16.0	10.6	0.738	0.773	4.7	(75)	21.9	5.5	0.679	0.645	−5.0*
Utilities	0.703	0.747	6.3	(63)	17.8	8.7	0.820	0.908	10.7	(100)	10.6	14.2			
Technology	0.672	0.692	3.0	(63)	13.0	33.3	0.615	0.651	5.9	(67)	4.9	5.1			
Telecom.	0.654	0.732	11.9	(86)	8.1	86.6	0.634	0.698	10.1	(75)	19.6	53.8	0.435	0.456	4.8
Panel B: Results by Country															
Austria	0.661	0.688	4.1	(70)	21.3	13.9									
Belgium	0.705	0.764	8.4	(80)	16.4	40.7									
Finland	0.748	0.784	4.8	(63)	22.2	22.7									
France	0.863	0.905	4.9	(89)	12.5	22.6									
Germany	0.805	0.847	5.2	(89)	11.7	21.4									
Greece	0.646	0.603	−6.7	(57)	22.3	24.7									
Ireland	0.587	0.640	9.0	(71)	18.4	−0.9									
Italy	0.803	0.846	5.4	(80)	17.8	46.8									
Luxembourg	0.428	0.452	5.6	(50)	39.8	9.3									
Netherlands	0.788	0.816	3.6	(56)	13.6	24.1									
Portugal	0.581	0.578	−0.5	(38)	30.3	34.9									
Spain	0.776	0.833	7.3	(70)	15.9	24.1									
Panel C: Overall Results															
	0.706	0.742	5.1	(65)	20.2	23.7									

This table presents cross-country averages of the dependence levels of the industrial stock index returns of the 12 Euro zone national markets with regard to their corresponding EMU industry indices excluding the examined market, for the period of the European sovereign debt crisis. The pre-crisis and crisis sample periods are 3/01/2009–3/31/2010 and 4/01/2010–12/31/2011, respectively. Panel A reports cross-country averages, where high-risk countries are Greece, Ireland, Italy, Portugal, and Spain. Panel B reports cross-industry averages. Panel C reports averages across both countries and industries. The numbers in parenthesis are the percentage of available countries with a significantly higher (lower) dependence at the 5% level if the % change is positive (negative). '*' indicates the significance of % change at the 1% level for Greek industry indices. We also report the average percentage change of dependence levels for 3 years before the European sovereign debt crisis (2007–2009) and before the introduction of the Euro (1997–1999).

Fig. 2. Comparison of copula dependence and *R*-square over time. This figure presents the time series of the integration measure estimated from the *R*-square approach by Pukthuanthong and Roll (2009) and the dependence measure estimated from the Gaussian copula method. The red dotted line is for the *R*-square integration measure with the left-hand-side *y*-axis, while the solid blue line is for the copula dependence measure with the right-hand-side *y*-axis. We show the time series of the averages across all observations.

multinational companies are priced internationally (Cavaglia et al., 2001) and country-factors are losing importance, the number of multinational firms within a national industry may have an effect on its Euro-area dependence. Similarly, industries with a high degree of export intensity (e.g., that export a large share of their production or that have a high absolute level of exports) and with a high degree of vertical specialization are likely to have their competitiveness at least partly linked to the Euro (e.g., via the foreign exchange market). Therefore, portfolio returns of these sectors should show a higher degree of Euro-area dependence after the introduction of the Euro. Finally, industries with a high level of intangible assets can tap a consolidated market after 1999 because they tend to strongly rely on financial markets for funds, which should translate into a higher degree of Euro-area dependence for these industries. Industries that are internationally competitive and make up an important part of the national economy are also expected to show an increased Euro-area dependence after the Euro is introduced.

Even though the effect of country-level factors has been declining, it is still important to include them in the analysis to create a comprehensive understanding of the impact that the introduction of the Euro had on the financial market dependence of each member state. Following the literature, we hypothesize that economies that are less financially and economically developed, more open, less economically aligned with the Euro area, and more dependent on bank loans will experience a stronger increase in the Euro-area dependence of their national industries.[32]

3.2. Methodology and data

In order to test our hypotheses on the determinants of changes in dependence, we collect data that characterize industries in different countries along several dimensions. In particular, we obtain annual data on exports, imports, value-added, and production from the STAN, UNIDO, ITCS and GGDC databases, development indicators from the World Bank, and benchmark bond yields from DataStream. Moreover, we aggregate firm-level data on sales, total assets, intangible assets as well as segment data for the universe of firms covered by the WorldScope database by country and industry.[33]

For an industry, the interest rate sensitivity is measured as the absolute slope coefficient of regressing industry portfolio returns on benchmark bond yields. The importance of international business for an industry is measured by the ratios of exports over value-added.[34] The contribution to the manufacturing trade balance is a measure of competitive advantage: positive (negative) values indicate a structural surplus (deficit), with the sum across industries being zero. As a proxy for the relative importance of an industry, we use the ratio of value-added of an industry to total value-added. A final measure of industry characteristics is the average ratio of intangible assets to total assets of companies in an industry, which is compiled from firm-level data.

At the country level, we proxy for the level of equity market development with the market capitalization of listed companies.[35] Similarly, the ratio of domestic credit provided by the banking sector to GDP is used as a measure of the importance of the banking sector. GDP per capita is a general measure of economic development, and economic openness is proxied with the ratio of intra-industry trade to total trade. Finally, we use the inverse of the absolute difference of GDP per capita from the Euro-area average to measure the alignment of a country's economy with the Euro area.[36] Table 7 summarizes the

[32] Competition among banks will increase across borders for bank-based financial systems. More firms in these countries may shift toward capital market financing because these countries are usually smaller and thus gain access to a larger financial market. However, as suggested by Fecht et al. (2012), the need for risk sharing increases the risk of cross-border contagion, although banks can share risks in a complete interbank market after integration.

[33] All raw input data are winsorized at the top and bottom 1% if they are larger/smaller than the 1st or 99th percentile or if they are more than 5 standard deviations from the median. Negative nonmissing values of the geographic segment data for assets and sales are set to zero.

[34] Alternative measures are the ratios of exports over value-added; exports over GDP; foreign sales over total sales; the number of geographic foreign segments based on sales, assets, or income; and the unrelated entropy measure based on segment sales.

[35] Alternative measures are the ratio of market capitalization of listed companies to GDP, the ratio of domestic credit to the private sector to GDP, and the ratio of insurance and financial service exports over total service exports.

[36] Alternative measures are the inverse of the absolute difference of GDP per capita from the Euro-area average, and the inverse of the difference of GDP growth from the Euro-area average.

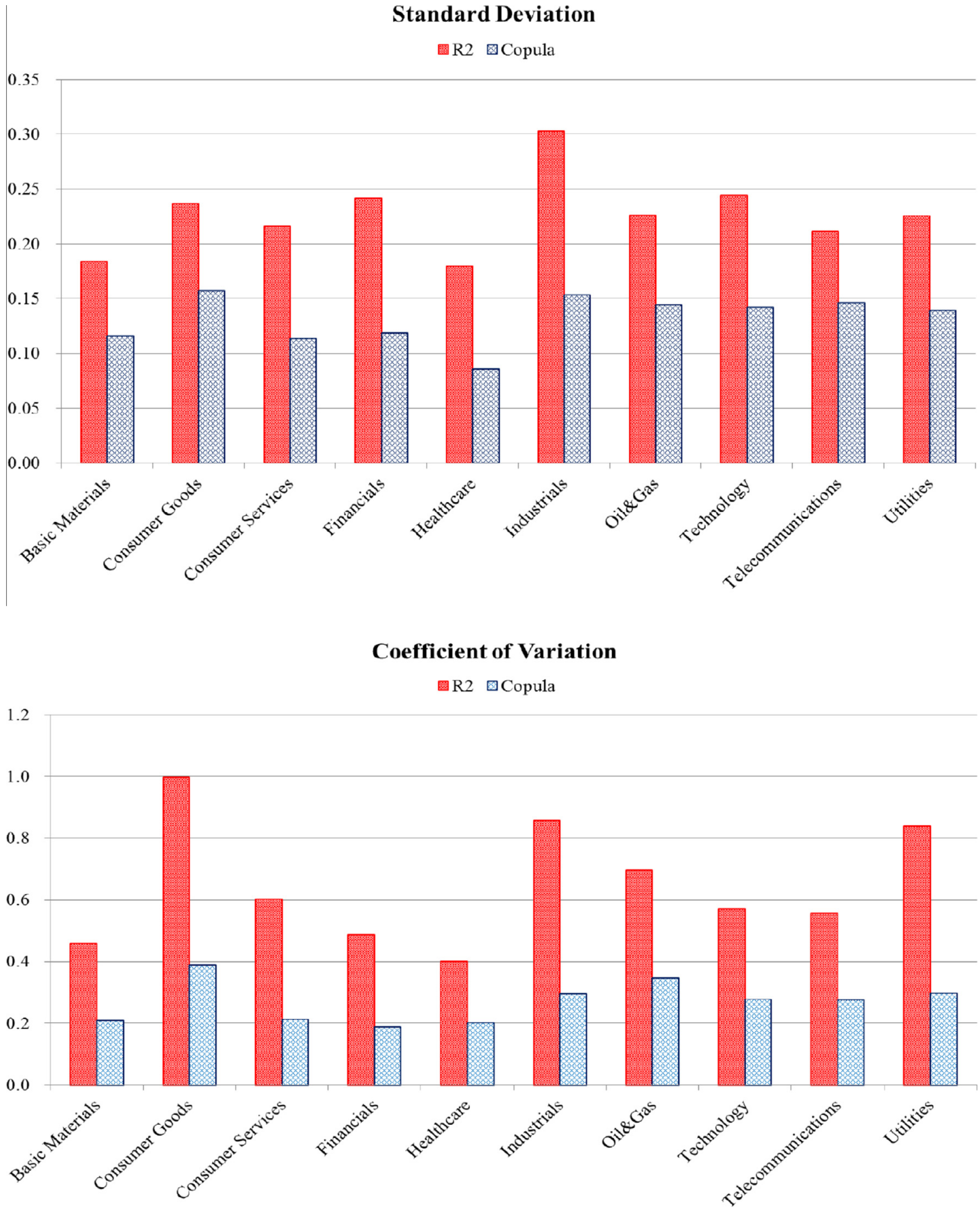

Fig. 3. Variation of *R*-square and copula measures. The figure presents the standard deviations (coefficients of variation) of the *R*-Square and the copula measure, respectively, for all industries averaged across countries. The coefficient of variation is defined as the standard deviation divided by the mean of the respective series. For consistency, the calculations are based only on country-industry observations with data available through the full sample period (January 1, 1992 to December 31, 2011).

hypotheses developed earlier as well as the variables for testing them and their expected signs, and provides summary statistics. We run cross-sectional regressions to investigate which factors at the country and/or industry level are important drivers of the change in financial market dependence.

3.3. Empirical results

Given the differential effect of the Euro on industries, it is interesting to investigate more systematically what determines whether an industry is significantly affected by the introduction of the Euro.[37] To this end, we estimate a probit model based on a dummy variable that equals 1 if an industry in a particular country experienced a significant increase in dependence after the introduction of the Euro, and zero otherwise. Column (1) in Table 8 stacks the results of regressions with only one independent variable. It reports the coefficients, marginal effects and corresponding significance

[37] We follow Cappiello et al. (2010) and focus on the 12 Euro zone countries. Moreover, the determinants for the impact of the introduction of the Euro on the dependence of countries inside and outside the Euro area can be very different.

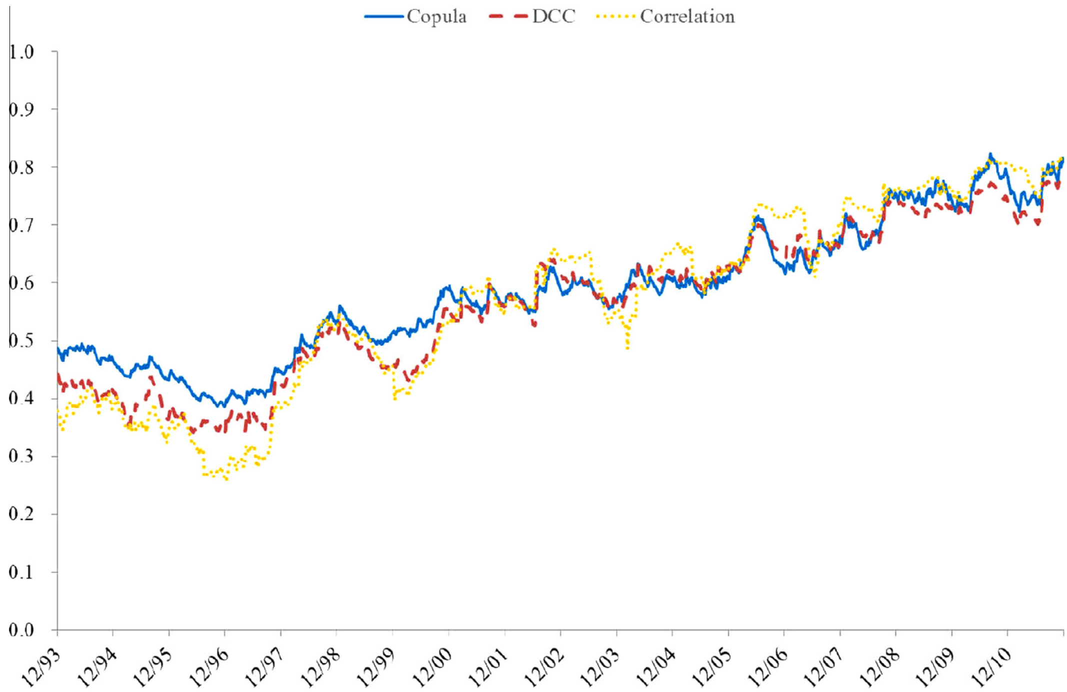

Fig. 4. Comparison of copula dependence and correlation coefficients over time. This figure presents the time series of the dependence measure estimated from the Gaussian copula method and the correlation coefficients estimated from the DCC model and a 52-week rolling sample. We show the time series of the averages across all observations.

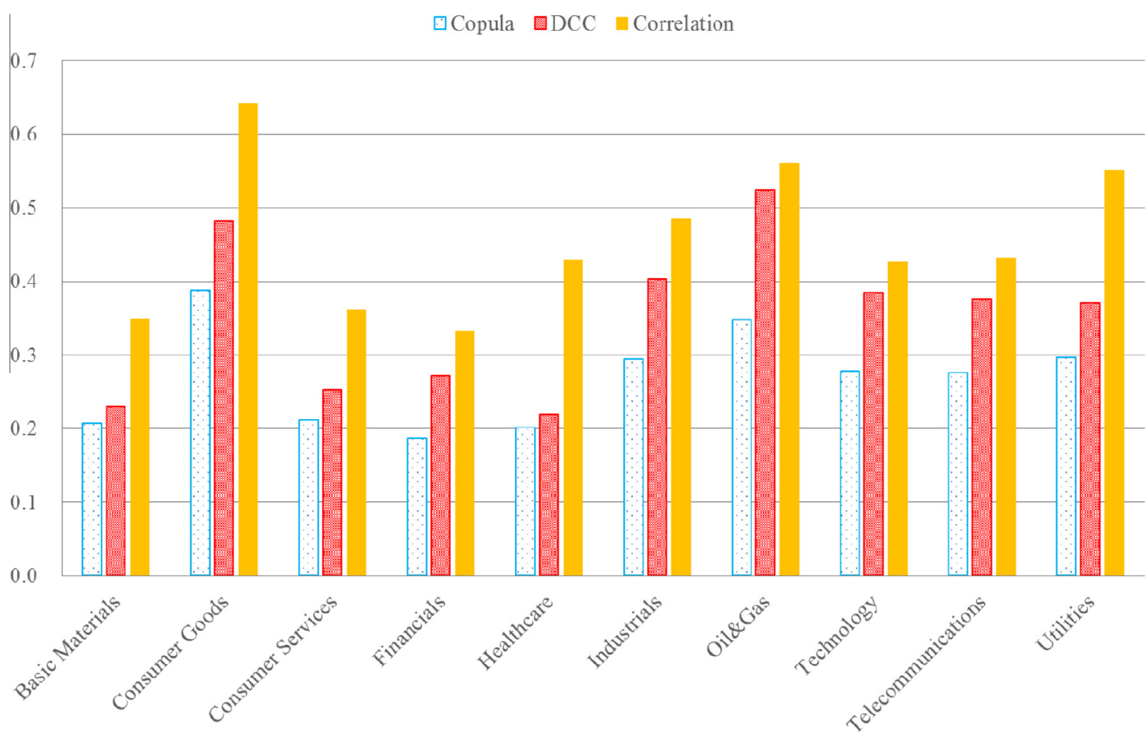

Fig. 5. Variation of copula dependence and correlation coefficients. The figure presents the coefficients of variation of the dependence measure estimated from the Gaussian copula method and the correlation coefficients estimated from the DCC model and a 52-week rolling sample, for all industries averaged across countries. The coefficient of variation is defined as the standard deviation divided by the mean of the respective series. For consistency, the calculations are based only on country-industry observations with data available through the full sample period (January 1, 1992 to December 31, 2011).

levels of the regressors, as well as averages across regressions of the intercepts, McFadden R^2 and the number of observations.

The regression coefficient of interest rate sensitivity is positive and significant at the 1% level, which is consistent with expectations. Export intensity has a positive coefficient that is significant at the 5% level. In addition, the relation between competitiveness and dependence is positive and significant at the 10% level, which is consistent with our prediction. The

Table 7
Summary statistics of determinants of dependence.

Category	Variable Description	Exp. Sign	No. of Obs.	Mean	Std. Dev.	Min	Q1	Q2	Q3	Max.
Interest Rate Sensitivity	Absolute slope coefficient from regression of index returns on benchmark bond yields	+	88	0.570	0.287	0.015	0.383	0.572	0.757	1.251
Internationalization	Ratio of exports to value–added	+	77	0.070	0.070	0.000	0.005	0.051	0.121	0.279
Competitiveness	Contribution to manufacturing trade balance	+	77	−0.001	0.013	−0.048	−0.008	−0.000	0.002	0.040
Importance of Industry	Ratio of industry value–added to total value–added	+	101	0.115	0.105	0.001	0.028	0.079	0.173	0.420
Asset Intangibility	Ratio of intangible assets to total assets	+	93	0.053	0.054	0.000	0.016	0.037	0.076	0.296
Financial Development	Market capitalization of national listed companies (in trillions of U.S. Dollars)	–	101	0.229	0.228	0.025	0.034	0.121	0.401	0.691
Importance of Banking Sector	Ratio of domestic credit provided by banking sector to GDP	+	101	1.051	0.236	0.610	0.923	0.997	1.265	1.500
Economic Development	GDP per capita (in ten thousands of U.S. Dollars)	–	101	2.834	0.529	1.546	1.979	2.330	2.451	3.944
Economic Openness	Ratio of intra–industry trade to total trade	+	95	0.837	0.113	0.556	0.813	0.864	0.933	0.949
Euro–area Economic Alignment	Inverse of absolute difference of GDP per capita from Euro–area average (times 100)	–	101	0.035	0.030	0.008	0.013	0.030	0.049	0.116

This table presents the definitions of the variables used in the empirical analysis, their expected signs and summary statistics. In total we have 101 country-industry observations as some industry indices are not available for some countries.

Table 8
Determinants of dependence.

Category	Model																				
	(1)			(2)			(3)			(4)			(5)			(6)			(7)		
	Coeff.	MarEff	*P* value	Coeff.	MarEff	*P* value	Coeff.	MarEff	*P* value	Coeff.	MarEff	*P* value	Coeff.	MarEff	*P* value	Coeff.	MarEff	*P* value	Coeff.	MarEff	*P* value
Interest rate sensitivity	1.27	0.14	(0.01)	1.03	0.12	(0.09)				1.13	0.13	(0.14)							1.24	0.14	(0.05)
Internationalization	5.02	0.14	(0.02)	4.45	0.12	(0.11)				4.61	0.13	(0.15)				5.17	0.14	(0.02)	5.28	0.15	(0.04)
Competitiveness	22.24	0.12	(0.06)	12.71	0.07	(0.35)				9.52	0.05	(0.55)	21.01	0.11	(0.07)						
Importance of Industry	−0.88	−0.04	(0.47)																		
Asset Intangibility	0.14	0.01	(0.96)																		
Financial Development	1.19	0.11	(0.07)				0.33	0.03	(0.68)	0.97	0.09	(0.40)	0.74	0.07	(0.33)				1.10	0.10	(0.16)
Importance of Banking	−0.18	−0.02	(0.74)																		
Economic Development	−0.38	−0.08	(0.16)																		
Economic Openness	2.65	0.12	(0.05)				2.23	0.10	(0.18)	0.20	0.01	(0.95)				1.76	0.08	(0.27)			
Economic Alignment	−6.22	−0.07	(0.17)																		
Intercept	−0.07		(0.26)	−0.72		(0.11)	−1.77		(0.19)	−1.23		(0.66)	−0.04		(0.86)	−1.71		(0.22)	−1.21		(0.02)
McFadden R^2		0.0244			0.0851			0.0426			0.1080			0.0480			0.0667			0.1023	
No. of observations		93			72			95			72			77			77			72	

This table reports results of probit regressions of dependence increase on industry and country characteristics. In particular, the table presents the coefficient estimates, marginal effects and associated *p*-values (in parentheses) of each variable. Marginal effects are calculated as the change in the probability of having a dependence increase that comes from a change in the exogenous variable of interest from (mean – 0.5 StdDev.) to (mean + 0.5 StdDev.), where all other variables are evaluated at the mean. Standard errors are generated by the bootstrap method with 1000 replications. For every regression model, the McFadden R-square and the number of available observations are also provided. Column (1) stacks results of regressions with one explanatory variable; the intercepts, McFadden R^2 and number of observations are averaged across all regressions in that column. Columns (2)–(7) show results of regressions with combinations of several explanatory variables.

remaining industry-specific variables are not statistically significant.

With regard to country-specific variables, several interesting results emerge. In particular, economic openness is significant at the 5% level, with the predicted positive sign. In addition, the financial development of equity markets is also important. The market capitalization of nationally listed companies shows a significant, positive relation to dependence, which, however, contradicts predictions. In contrast, the importance of the banking sector, economic development, and economic alignment with the Euro area are not important empirically in these univariate regressions.

More reliable inferences can be gained from multivariate analyses because they account for the interactions between different effects. In these specifications we choose variables from different groups and consider the correlations among variables in order to avoid multicollinearity, focusing on those that previously seemed important in their relation to dependence changes. Specifications (2) and (3) employ the groups of industry and country-specific variables that are found to matter in the univariate regressions, respectively, while Specification (4) includes the variables of both groups. We employ these models to examine the explanatory power of the two groups of variables rather than to focus on the significance of individual variables, since these specifications include some variables with higher correlations. Overall, industry-specific variables are more informative than country-specific variables, and both groups of variables jointly explain about 10% of the dependence changes.

Models (5) through (7) offer alternative specifications that include both important industry and country-specific variables while considering the correlations between variables.[38] The results show that the ratio of exports to value-added has a significant coefficient with a positive sign, as in the univariate regressions. Thus, consistent with expectations, the introduction of the Euro significantly increased Euro-area equity market dependence for industries that were more internationalized and export-intensive before the Euro. With a common currency across countries, these previously more international industries have become more pan-European. Similarly, the variables measuring the interest rate sensitivity and industry competitiveness also have significant coefficients with the expected positive sign. However, both financial development and economic openness turn insignificant when they are considered together with industry-specific variables in multivariate regressions. Thus, the importance of industry-specific factors dominates that of country-specific factors.

Beyond the statistical significance of the coefficients, we can use the marginal effects to assess the relative economic importance of the regressors. For most models, the export intensity and the interest rate intensity of the industry are by far economically most important, followed by industry competitiveness, economic openness, and financial development at a distance. However, the importance of the latter group of variables is less robust when included with other variables. The McFadden R^2s of the regressions including the five most important variables are about 0.10.

In summary, several factors at the industry and country level play an important role for the impact of the introduction of the Euro on industry dependence. Most important are an industry's export intensity and interest rate intensity. In addition, an industry's competitiveness and a country's financial development and economic openness are also important. The higher the export intensity, interest rate sensitivity, industry competitiveness, financial development or economic openness, the more likely the industry shows a significant increase in equity market dependence. Based on their statistical significance and marginal effects, industry effects dominate country effects. Overall, these findings are consistent with evidence in Tsatsaronis (2001), Adjaouté and Danthine (2003), Galati and Tsatsaronis (2003), and Ferreira and Ferreira (2006), indicating that industry factors, in addition to country factors, are increasingly important drivers of stock prices in the Euro-area firms after the introduction of the Euro.[39]

4. Concluding remarks

We investigate the degree and determinants of the European equity market dependence using a conditional copula dependence model. The analysis of 10 industries across 12 Euro zone and 8 non-Euro zone countries during the years surrounding the introduction of the Euro suggests that most of the industries of countries with larger capitalization show a dependence increase with their corresponding Euro-area market. Moreover, across industry sectors, Financials, Industrials, Consumer Goods, Utilities, Technology and Telecommunications show an economically and statistically significant increase in dependence. Several factors at the industry and country level are important for the impact of the Euro on industry dependence. Specifically, the interest rate sensitivity and export intensity of an industry are important determinants of an increase in dependence. In addition, an industry's competitiveness and a country's financial development and economic openness are also (but to a lesser extent) related to the change in cross-market dependence.

We also observe higher equity market dependence between European countries around the collapse of Lehman Brothers. In contrast, compared to the fast increasing dependence around the introduction of the Euro and the collapse of Lehman Brothers, the European sovereign debt crisis entails substantially lower dependence increases for most industries, particularly in high-risk countries such as Greece, suggesting that country-specific factors may matter more during this crisis than before. These findings are important for portfolio diversification and asset management, risk management and international asset pricing. Future research should consider how financial dependence relates to financial instability, why the financial and debt crises have slowed dependence, and whether these effects are likely to be long lasting or temporary.

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[38] The correlations of economic openness with interest rate sensitivity, competitiveness, and financial development are 0.31, 0.30, and 0.64, respectively, and thus economic openness can only be used in alternative specifications. In Models 5–7, the VIF numbers of all variables are close to 1.

[39] In particular, Ferreira and Ferreira (2006) find that there is an increasing importance of industry effects relative to country effects in the EMU equity markets in the 1990s and that the trend continues in the post-Euro period.

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